Munitions Response Work Plan

Remedial Investigation/Feasibility Study

Culebra Island Site, Puerto Rico

Volume I of II

Contract No. W912DY-04-D-0006
Task Order No. 0022

Prepared For
U.S. Army Engineering & Support Center, Huntsville

Geographical District:
U.S. Army Corps of Engineers, Jacksonville

Prepared By
USA Environmental, Inc.
720 Brooker Creek Boulevard, Suite 204
Oldsmar, Florida 34677

Reviewed By

Robert D. Crownover

Robert Crownover
Corporate Quality Manager

Final

10 February 2011

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ACRONYMS AND ABBREVIATIONS

APP	Accident Prevention Plan
ARAR	Applicable or Relevant and Appropriate Requirement
BATF	Bureau of Alcohol, Tobacco, Firearms and Explosives
BIP	Blow in place
BMP	Best Management Practices
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulation
CIP	Community Involvement Plan
CSM	Conceptual Site Model
DDESB	Department of Defense Explosives Safety Board
DERP-FUDS	Defense Environmental Restoration Program for Formerly Used Defense Sites
DGM	Digital Geophysical Mapping
DGPS	Differential GPS
DMM	Discarded Military Munitions
DOD	Department of Defense
DOT	Department of Transportation
DQO	Data Quality Objective
EA	Environmental Assessment
EE/CA	Engineering Evaluation/Cost Analysis
EOD	Explosive Ordnance Disposal
EQB	Environmental Quality Board
ESQD	Explosives Safety Quantity Distance
ESS	Explosives Safety Submission
EZ	Exclusion Zone
°F	Degrees Fahrenheit
FLEX	Fleet Exercises
GIS	Geographical Information System
GPS	Global Positioning System
HA	Hazard Assessment
HE	High Explosive
HEAT	High Explosive Anti-Tank
HERO	Hazards of Electromagnetic Radiation to Ordnance
HFD	Hazardous Fragmentation Distance
in/ft	Inches per foot
MC	Munitions Constituents
MEC	Munitions and Explosives of Concern
MFD	Maximum Fragment Distance
MGFD	Munition with the Greatest Fragmentation Distance
MPPEH	Material Potentially Presenting an Explosive Hazard
MRS	Munitions Response Site
MSDS	Material Safety Data Sheet

NEW	Net Explosive Weight
NOFA	No Further Action
NOSSA	Naval Ordnance Safety and Security Activity
OD	Open Detonation
OSHA	Occupational Safety and Health Administration
PAL	Project Action Limit
PPE	Personal Protective Equipment
PR	Puerto Rico
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QCP	Quality Control Plan
RAB	Restoration Advisory Board
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SI	Site Inspection
SOP	Standard Operating Procedure
SUXOS	Senior Unexploded Ordnance Supervisor
TP	Technical Paper
UFP	Uniform Federal Policy
USACE	U.S. Army Corps of Engineers
USAE	USA Environmental, Incorporated
USEPA	U.S. Environmental Protection Agency
USMC	U.S. Marine Corps
UXO	Unexploded Ordnance
UXOQCS	Unexploded Ordnance Quality Control Specialist
UXOSO	Unexploded Ordnance Safety Officer
UXOTI	Unexploded Ordnance Technician I
UXOTII	Unexploded Ordnance Technician II
UXOTIII	Unexploded Ordnance Technician III
WP	Work Plan

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1.0 INTRODUCTION

1.1 PROJECT AUTHORIZATION

USA Environmental (USA) has prepared this Work Plan (WP) for Culebra Island, Puerto Rico (Formerly Used Defense Site (FUDS) Project Number I02PR0068) under Contract No: W912DY-04-D-0006 Task Order No. 0022, from the U.S. Army Corps of Engineers, Engineering and Support Center, Huntsville (USAESCH).

1.2 PURPOSE AND SCOPE

The primary purpose and scope is to perform an in-depth study designed to gather the data necessary to determine the nature and extent of MEC and MC contamination on Culebra Island Munitions Response Sites (MRSs) 13, 10, 11, 06, 09, and, 08, to assess risk to human health and the environment; and establish remediation criteria for each MRS. This WP has been prepared to address the land portions of all six MRS sites. Specific project tasks are listed in Table 1-1. Detailed task descriptions can be reviewed in the Performance Work Statement (PWS) attached as Appendix A.

Table 1-1: Project Tasks

Task	Subtask	Task Description
1		**Technical Project Planning (TPP)**
	1a	Planning Site Visit
2	--	RI/FS Work Plan
	2a	Explosives Safety Submission Amendment
3	--	Geospatial Data
	3a	Landowner Database and Right of Entry (ROE)
4	--	RI/FS Field Activities
	4a	MRS 13 Cayo Luis Pena Impact Areas
	4b	MRS 10 Defensive Firing Area No. 1
	4c	MRS 11 Defensive Firing Area No. 2
	4d	MRS 06 Artillery Firing Area
	4e	MRS 09 Soldado Point Mortar and Bombing Area
	4f	MRS 08 Cayo Norte Impact Area
5	--	RI Report
6	--	FS Report
7	--	Proposed Plan (PP)
8	--	Decision Document (DD)
9	--	Community Relations Support
10	--	Public Involvement Plan
11	--	Administrative Record
12	--	Environmental Sampling and Analysis
13	--	Beach Monitoring

All activities involving work in areas potentially containing MEC hazards will be conducted in full compliance with U.S. Army Engineering and Support Center, Huntsville (USAESCH), USACE, Department of the Army (DA), and Department of Defense (DoD) requirements regarding personnel, equipment, and procedures, and with Occupational Safety and Health Administration (OSHA) Standard 29 Code of Federal Regulation (CFR) Part 1910.

1.3 WORK PLAN ORGANIZATION

1.3.1 GUIDANCE DOCUMENTS

This Work Plan (WP) follows the directions of DID MR-001, Type I Work Plan. DIDs followed in the preparation of the WP and sub plans are listed in Table 1-2.

Table 1-2: Data Item Descriptions

DID	DID Title
MR-001	Type I Work Plan
MR-005-02	Technical Management Plan
MR-005-03	Explosives Management Plan
MR-005-04	Explosives Siting Plan
MR-005-05.01	Geophysics
MR-005-06	Accident Prevention Plan
MR-005-07.01	Geospatial Information and Electronic Submittals
MR-005-10.01	Munitions Constituents Chemical data Quality Deliverables
MR-005-11	Quality Control Plan
MR-005-12	Environmental Protection Plan
MR-045	Report/Minutes, Record of Meeting
MR-055	Telephone Conversations/Correspondence Records
MR-085	Project Status Report

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1.3.2 WP ORGANIZATION

This RI/FS Work Plan has been divided into Chapters 1 through 11 with associated documents provided either as appendices herein or as standalone documents. Together, the WP and associated documents present the project history, work elements, and requirements in an organized manner. Table 1-3 describes the general structure and organization of this WP. References are frequently made between various sections in the WP and the associated documents.

Table 1-3: RI/FS Work Plan Structure

Chapter Number	Descriptor	Information
1	**Introduction**	A statement of the project objectives, project authorization, purpose and scope; summary of work plan organization, project location, site descriptions and history, land use, and initial summary of MEC risks.
2	Technical Management Plan	Summary of project objectives, project organization, communication and reporting, project deliverables, project schedule, public relations support, subcontractor management, and management of field operations.
3	Field Investigation Plan	Describes the approach and procedures that will be followed in performing the field investigation and reporting activities, and includes discussion of site characterization goals, data quality objectives, MEC exposure analysis, geophysical planning, intrusive investigation, and MC sampling.
4	Quality Control Plan	Describes the standard processes that will be used to monitor, inspect, and control daily field activities to ensure quality performance, processes to correct quality issues, quality control of contract deliverables, and QC reporting requirements.
5	Explosives Management Plan	Describes procedures that will be followed to manage explosives onsite and includes license/permitting requirements, acquisition and receipt of explosives, storage magazine, transportation, inventory, reporting lost or stolen explosives, and disposal of remaining explosives
6	Explosives Siting Plan	Describes the safety criteria used for planning and siting explosives operations and includes minimum separation distances, footprint areas (Blow-in-place, collection points, consolidated shots, type of storage magazines, listing of planned explosives, and site map.
7	Environmental Protection Plan	Describes the approach, methods and operational procedures that will be employed during onsite activities to protect the natural environment.
8	Property Management Plan	This chapter is not used. The Property Management Plan is not required for this Task Order.
9	Interim Holding Facility Siting Plan for Recovered Chemical Warfare Materiel	This chapter is not used. The Interim Holding Facility Siting Plan for Recovered Chemical Warfare Materiel is not required for this Task Order.
10	Physical Security Plan for Recovered Chemical Warfare Sites	This chapter is not used. The Physical Security Plan for Recovered Chemical Warfare Sites is not required for this Task Order.
11	References	Citation of documents referenced within this Work Plan

The following appendices are included in this WP:

APPENDIX A	Task Order Performance Work Statement
APPENDIX B	Site Maps
APPENDIX C	Local Points of Contact
APPENDIX D	Accident Prevention Plan
APPENDIX E	Munitions Constituents Sampling and Analysis Plan
APPENDIX F	USA Forms
APPENDIX G	MSD Calculation Sheets
APPENDIX H	Resumes
APPENDIX I	Technical Project Planning Minutes
APPENDIX J	Project Schedule
APPENDIX K	Standard Operating Procedures
APPENDIX L	Licenses and Permits
APPENDIX M	Standard Operating Procedures for Endangered Species Conservation
APPENDIX N	Reserved
APPENDIX O	Geophysical Data Quality Objectives
APPENDIX P	Explosives Site Plan
APPENDIX Q	Conceptual Site Models

1.4 PROJECT LOCATION

Project location is Culebra Island (MRS 06, 09, 10, and 11), approximately 17 miles east of the main island of Puerto Rico and also includes surrounding islands Cayo Luis Pena (MRS 13), located approximately three-quarter mile off the western coast of Culebra Island and Cayo Norte (MRS 08), located approximately one-half mile off the northeast coast of Culebra Island. Culebra Island and the surrounding cays are part of the Commonwealth of Puerto Rico.

1.5 SITE DESCRIPTION

1.5.1 LOCATION

Site location is described in section 1.4 and shown in Figure 1-1.

1.5.2 TOPOGRAPHY

Culebra Island and the surrounding cays are comprised of sandy beaches, irregular rugged coastlines, lagoons, coastal wetlands, steep mountains, and narrow valleys. Ninety percent of the island is mountainous. The highest point on Culebra is Mount Resaca at approximately 630 feet above sea level.

Culebra Island is underlain by both intrusive and extrusive volcanic rock of Upper Cretaceous age. The volcanic rock exhibits little or no porosity because of compaction and filling of the pores with quartz and calcite.

Cayo Luis Pena (MRS 13) is comprised of sandy beaches, irregular rugged coastlines and steep mountains. A peak of 476 feet above sea level is located in the center of the Cayo and a smaller peak of 171 feet above sea level exists on the northern peninsular of the Cayo.

Cayo Norte (MRS 08) is a generally flat island with several hills on the western side. The elevation ranges from 80 feet above sea level to 300 feet above sea level. The shoreline on the north side of the island consists of cliffs dropping off to the water. The southern side slopes down to the water and contains beaches. The island consists of light to moderate vegetation with large open areas. There is one body of water on the south side of the island that is connected to the beach- it is most likely a large brackish tidal pool.

1.5.3 CLIMATE

The weather on Culebra Island is generally warm year round due to its tropical marine climate. Yearly average rainfall is approximately 36 inches. The months of August through November are considered the wet season, and the driest months are January through April. Yearly average daily temperatures average 80°F year round with an average maximum of 86°F and an average low of 74°F. Winds are generally from the east-northeast during November through January and from the east during February through October. Yearly average wind speed is 8 knots. Hurricane season is from June through November, and severe hurricanes hit Culebra every 10 to 20 years. The yearly average rainfall for Culebra is provided in Table 1-4.

Table 1-4: Average Rainfall, Culebra Island

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
mm	48.6	34.6	37.7	51.7	91.2	80.9	78.5	98.2	119.1	122.6	104.2	62.8	931.1
inches	1.9	1.4	1.5	2.0	3.6	3.2	3.1	3.9	4.7	4.8	4.1	2.5	36

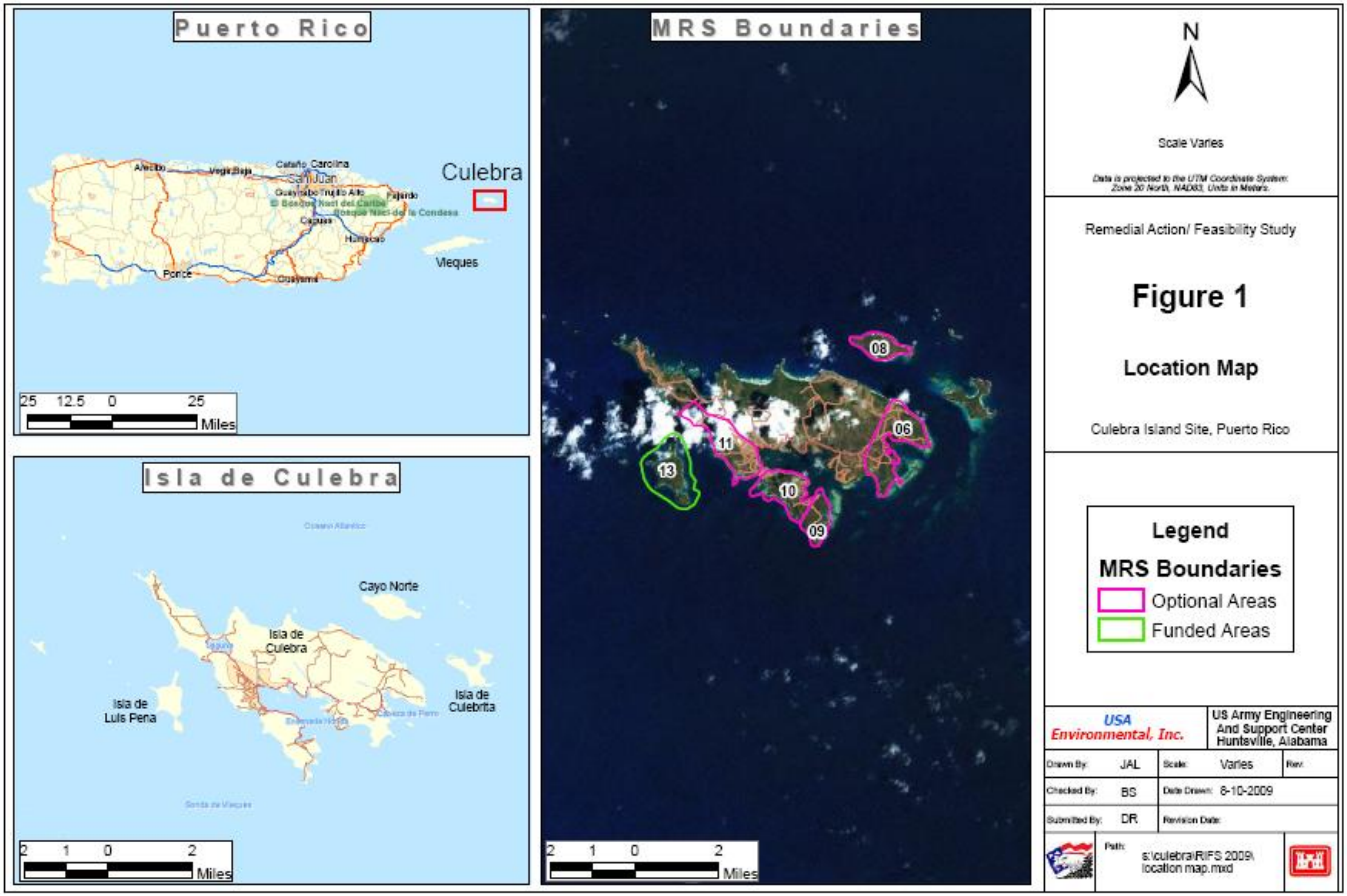

Figure 1-1: Location Map of Culebra, PR and MRS Boundaries

1.5.4 VEGETATION

Vegetation is moderately to extremely dense on undeveloped portions of Culebra, Luis Pena, Northeast Cay, and Culebrita; however, vegetation is sparse or absent on many of the smaller cays as most are rocky with very little soil. Hazardous vegetation include the Mesquite acacia or thorny brush, which may be present on Culebra and all of the surrounding cays, and the poisonous Manchineel tree (also called Manzanillo Tree on Culebra), which is known to be present on Northwest peninsula and near Flamenco Lagoon. Endangered vegetation includes the spineless Culebra Island cactus (Leptocereus grantianus).

1.5.5 GEOLOGY

Culebra Island and the surrounding cays are part of the Culebra Archipelago. The rocks are predominantly intrusive or extrusive volcanic rocks consisting of andesite lava and tuff. The rocks in the north-central portion of Culebra and on the east side of Cayo Luis Pena contain diorite porphyry inclusions and have little to no porosity due to compaction and quartz and calcite growth in the pore space.

1.5.6 SOILS

Soils are generally shallow and rocky and consist mostly of silts and clays. Loamy organic-rich soils are found in areas of dense vegetation and grasses, while sandy soils are found on tidal flats or areas near the beach. Many of the beaches on Culebra and the surrounding cays have clean white to tan sand, while other beaches are rocky with a mix of cobbles and pieces of dead coral reef.

1.5.7 HYDROLOGY

There are no permanently flowing surface water streams on Culebra; potable water is obtained from a desalinization plant. Three large ephemeral streams drain the hills north of Great Harbor to the south, and one large ephemeral stream has developed along an old, washed-out jeep road on the north side of the island toward Brava Beach. These ephemeral streams generally only carry water after heavy precipitation. There are many small ephemeral gullies and ditches throughout the island, and several lagoons are present on Culebra as well as Culebrita, Cayo Norte (MRS 08), and Cayo Luis Pena (MRS 13).

1.5.8 HYDROGEOLOGY

Ground water in Culebra occurs in alluvial deposits and in the volcanic and plutonic rocks. Alluvial deposits are located along major stream valleys that reach the coast. The alluvium is mostly composed of silt and clay with limited quantities of sand and gravel. Fractures and joints within the volcanic and plutonic rock formations store water in small quantities. Most of these fractures and joints diminish in number and size with depth and pinch out at about 300 feet below land surface. Water-table conditions prevail in the bedrock aquifer.

1.5.9 SENSITIVE ENVIRONMENTS

The main island of Puerto Rico and its associated islands support 75 federally listed threatened and endangered species consisting of 26 animals and 49 plants. Among this diverse group of fauna and flora are multiple species that are known to exist, potentially exist, or temporarily use areas within the Culebra Island, such as migratory birds. Of the 75 federally listed species, nine are known or are suspected to occupy Culebra Island and/or the associated cays. In addition to the federally listed species, 13 state-listed species are known to occupy Culebra Island and/or the associated cays. The federally and state-listed species includes both terrestrial and marine life. The federally listed species of most concern for the wildlife refuge are the Culebra Island giant anole, Virgin Islands tree boa, roseate tern, brown pelican, green sea turtle, hawksbill sea turtle, leatherback sea turtle, loggerhead sea turtle, Leptocereus grantianus (cactus), and Wheeler's peperomia. Due to declining populations, the elkhorn and staghorn corals in the surrounding waters are proposed to be federally listed threatened and endangered species.

According to the National Wildlife Refuge System (NWRS), portions of Culebra Island and 22 of the associated cays are considered National Wildlife Refuge area. The three largest cayos are Culebrita, Cayo Norte, and Luis Pena. These resemble Culebra in that they all have sandy beaches, rugged coastline, and gentle to steep hills. Vegetation ranges from moderate to extremely dense. The smaller cays are primarily solid rock with sparse or no vegetation. A few of the smaller cays have small beaches; however, most are rugged rock all around.

According to the DNER, the conservation priority areas for Culebra and associated cays are as follows:

- All of the lagoons on Culebra
- Monte Resaca
- All beaches around Culebra
- The designated critical habitat area for the Virgin Islands Boa
- Flemenco Peninsula
- Puerto del Manglar
- Los Canos
- Punta Soldado
- Bahia (also called “Ensenada”) Cementerio
- All cayos and cays around Culebra
- The Culebra National Wildlife Refuge
- The Canal Luis Pena Natural Reserve

1.6 SITE HISTORY

Spain ceded all of Puerto Rico to the United States in 1898 following the Spanish American War. The public lands in the Culebra Island Archipelago were placed under the control of the U.S. Department of Navy in 1901. The Culebra Island Archipelago was used for training purposes by the U.S. Navy and U.S. Marines, and was later used by the North Atlantic Treaty Organization (NATO). The U.S. Marines used portions of Culebra Island as a training facility from 1902 through 1941. Culebra Island was used as a bombing and gunnery range from 1935 through 1975. To support the increased training needs during Viet Nam operations, the Navy acquired additional training areas on cays east and west of Culebra Island for use as air-to-ground ranges. Live ordnance operations reached their peak in 1969 as the fleet was training pilots for Viet Nam. Aircraft bombing and strafing of the Flamenco Peninsula ended around 1970, while the use of live rounds for naval gunfire support training ended in 1971. Subsequent naval support training was conducted using quieter practice rounds until ordnance use was terminated on September 30, 1975. Between 1975 and 1982, the facilities were turned over to the General Services Administration (GSA).

During military use of the land, the island was inhabited by many residents centralized around the town of Dewey on the west central portion of the island. Currently, the site includes municipal, residential, and recreational areas. Most of the main island of Culebra, as well as Cayo Norte, are privately owned, while the surrounding cays are managed by the U.S. Fish and Wildlife Service (USFWS). The Puerto Rico Department of Natural and Environmental Resources (DNER) also manages land on Culebra. Access is unrestricted on most of the island, although natural barriers such as dense vegetation and rocky cliffs make access to many areas difficult. Portions of the island are also used for cattle grazing.

1.7 CURRENT AND PROJECTED LAND USE

1.7.1 MRS 13 CAYO LUIS PENA IMPACT AREAS

MRS 13 covers all of Cayo Luis Pena. The Cayo is managed by the USFWS and DNER as part of the Culebra National Wildlife Refuge. Residential areas do not exist on Cayo Luis Pena but have been developed on the main island immediately across the channel. The site has no barriers to access. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility.

1.7.2 MRS 10 DEFENSIVE FIRING AREA NO. 1

MRS 10 is almost entirely privately owned except for municipal lands such as the police and fire stations. Residential areas have been developed on the hills overlooking the mortar impact areas. Additional homes could be developed in the area of the firing points, but development is not expected in the impact zone. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. Seasonal surf action could cause changes in the bottoms of the surrounding waters. The water area adjacent to this shore is generally not used for recreational activities.

1.7.3 MRS 11 DEFENSIVE FIRING AREA NO. 2

Most of the southern portion of MRS 11 has been extensively developed for residential use. The areas along the beach and the west side of this site are less developed. The land is privately owned with some municipal properties such as the school, hospital, and government buildings. Residential areas have been developed on the hills overlooking the mortar impact areas. Development could occur throughout the site. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. The immediate offshore waters are part of the Luis Pena Water Refuge.

1.7.4 MRS 06 ARTILLERY FIRING AREA

MRS 06 is almost entirely privately owned except for the water line, which is owned by the DNER and USFWS. This tract contains several residential areas. Portions of this tract are currently being developed with others listed for sale for potential development. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility.

1.7.5 MRS 09 SOLDADO POINT MORTAR AND BOMBING AREA

MRS 09 is managed by the DNER and residential development is not supposed to be allowed on the site. Public area structures could be developed at some point in the future. There are no restrictions for using the beach areas or entering the surrounding waters for recreation activities. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. Seasonal surf action could cause changes in the bottoms of the surrounding waters.

1.7.6 MRS 08 CAYO NORTE IMPACT AREA

MRS 08 covers all of Cayo Norte, a privately owned island with no barriers to access. Plans exist for residential development. Site conditions could change in the future with potential impact on land use. Examples might include excessive soil erosion on beaches or streams, or the increase in land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility

1.8 PREVIOUS SITE INVESTIGATIONS

1.8.1 1991-INVENTORY PROJECT REPORT (INPR), CULEBRA, PUERTO RICO, PROPERTY NO. I02PR0068, ORIGINAL MAY 1991.

The original INPR qualified 2660 acres of Culebra as eligible for consideration under the Environmental Restoration Program (DERP) for Formerly Used Defense Sites (FUDS). The INPR, signed on 24 December 1991, established the Culebra Island site as a FUDS, defined a site boundary, and assigned FUDS Project No. I02PR006800. The Findings and Determination of Eligibility (FDE) concluded that “the site, except for 87.5 acres still under control of the Navy, has been determined to be formerly used by the Department of Defense. It is therefore eligible for the Defense Environmental Restoration Program (DERP).”

1.8.2 1995-ARCHIVES SEARCH REPORT, FINDINGS, ORDNANCE AND EXPLOSIVE WASTE, CULEBRA ISLAND NATIONAL WILDLIFE REFUGE, CULEBRA, PUERTO RICO, FEBRUARY 1995.

The Archives Search Report (ASR) presented the findings of an historical records search and site inspection for MEC presence in the Culebra Island National Wildlife Refuge. As part of the ASR, a site visit was conducted in October 1994, during which the team identified munitions debris (MD) on Cayo Botella, Cayos Geniqui, and Cayo del Agua. In addition, MD was identified on Flamenco Beach, Flamenco Peninsula, and the hillside near Cerro Balcon. The ASR listed several ordnance items verified on site by either explosive ordnance disposal (EOD) personnel or the ASR field team. The ASR covered the entire land area of Culebra Island and the nearby keys, about 7300 acres of land, and also included 85,200 acres of surrounding water. The report included site history, site descriptions, real estate ownership information, and confirmed the presence of ordnance based on available records, interviews, and site inspections.

1.8.3 1995-INTERIM REMEDIAL ACTION

An Interim Remedial Action on 3.66 acres of Flamenco Bay Campground (MRS 02) near Flamenco Beach was completed in 1995 by MTA, Inc. The action was to remove and dispose of UXO within 2 feet of the ground surface. Work was conducted on the site between 12 May and 26 May 1995. MTA found 11 items of MEC and munitions debris.

1.8.4 1996-FINAL ENGINEERING EVALUATION/COST ANALYSIS, CULEBRA, PUERTO RICO, 1996.

Environmental Science and Engineering (ESE) completed an Engineering Evaluation/Cost Analysis (EE/CA) in 1996. ESE characterized the type of ordnance found and assessed the exposure potential at each of the sites based on the statistical sampling of randomly placed grids at each of 11 sites. Several remedial action alternatives were evaluated based on CERCLA evaluation criteria. The selected remedial alternatives included clearance for use at Flamenco Beach and the Northwest Peninsula, and surface clearance of MEC and munitions constituents at Cerro Balcon, Isla Culebrita, and the adjacent cays, including Cayo Botela, Cayo Tiburon, Los Gemelos, Cayo del Agua, Cayos Genequi, Cayo Lobo, and Cayo Alcarraza. An EE/CA Action Memorandum (ESE 1997) was filed which identified cleanup options and was approved by Department of Defense.

1.8.5 2004-SITE-SPECIFIC FINAL REPORT, UXO CONSTRUCTION SUPPORT, CULEBRA ISLAND WILDLIFE REFUGE, CULEBRA ISLAND, PUERTO RICO

The Site-Specific Final Report (for) UXO Construction Support was submitted In June 2004, by Ellis Environmental Group, LC (Ellis). The report documented clearance efforts conducted by Ellis on the Northwest Peninsula. Ellis performed four phases of clearance from January 2001 to February 2004. Phase I consisted of construction support by clearing roadways, a wind generator foundation, a desalination plant foundation, and regrading the site. Phase II of the construction support was not exercised. Phase III included surface clearance of 70 acres of bird nesting area and 4-foot-depth subsurface clearance of roadways, firebreaks, and an observation post. Phase IV consisted of demilitarization of scrap, construction of a fence and information kiosk, and development of public awareness information. The public awareness information included a video, UXO safety poster, and UXO safety brochure. During the UXO Construction Support project, Ellis recovered 15,479 pounds of scrap metal and 249 UXO items.

1.8.6 2004-ARCHIVES SEARCH REPORT SUPPLEMENT

In 2004, an ASR supplement was completed by the USACE Rock Island District as an addition to the 1995 ASR. The report provides details of aerial training conducted by the Navy between 1935 and 1975 and identifies the following range areas:

- Mortar Range: This area is also called Cerro Balcon and is part of MRS 02. The following munitions may have been used in this area: Mk1 3-inch HE mortar and M329A1 4.2-inch HE mortar.
- Airfield Rifle Range: This small arms range in MRS 14 is seen on historic maps in the vicinity of the airport. Suspect munitions include general small arms.

- Aerial Mining Range: Practice mines were dropped in the water-covered portion of this area and then cleared by divers or minesweepers.
- Water Mine Field: The water area is suspected to have been used for mine training.
- Water West: Part of this area is included in MRS 12. A local diver reported underwater ordnance in this area. Suspect munitions include Mk II 6-inch HE projectiles.
- Water Center: This area is included in MRS 12. A local diver reported underwater ordnance in this area. Suspect munitions include Mk II 6-inch HE projectiles.
- Water South: This water area includes the small bay north of Soldado Point (part of MRS 09). A local diver reported underwater ordnance in this area. Suspect ordnance includes Mk II 6-inch HE; however, other ordnance types are suspected due to use as 1936 aerial target and 1938 mortar boat firing exercises.
- Shark Rock: Part of MRS 02, also known as Cayo Tiburon, this area was used as a target for aerial gunnery with bombs and rockets. Suspected ordnance includes Mk82 general purpose 500-pound HE bombs and 5-inch Zuni rockets.
- Palada Cay: Part of MRS 02, also known as Cayos Geniqui, this area was used as a target for aerial gunnery with bombs and rockets. Suspected ordnance includes Mk82 general purpose 500-pound HE bombs and 5-inch Zuni rockets.
- Ladrone Cay: Part of MRS 02, also known as Cayo Botella, this area was used as a target for aerial gunnery with bombs and rockets. Suspected ordnance includes Mk82 general purpose 500-pound HE bombs and 5-inch Zuni rockets.
- Culebrita Strafing Range: This strafing range target was on the north side of Culebrita and is part of MRS 07. Suspected munitions include general small arms, .50-caliber small arms, and MKI 20mm HEI.
- Culebrita Torpedo Range: Firing at this range from the water north of Culebrita targeted the sheer cliffs of Cayos Geniqui, part of MRS 02. Suspected munitions include the Navy's general torpedo.
- Naval Gunfire Target Area: This range was a naval gunfire and air-to-ground range with its target located on Northwest Peninsula, MRS 02. Munitions included general small arms, .50-caliber small arms, Mk80s series general purpose bombs, M1 105mm HE, Mk21 8-inch armor piercing (AP), Mk5 16-inch AP, 2.75-inch rockets, and the 11.75-inch Tiny Tim rocket.
- Twin Rocks: This area, also known as Los Gemelos, is part of MRS 02. These cays were used as targets for aerial bombs and rockets. Munitions included Mk80s series general purpose bombs, 5-inch Zuni rockets, and Mk8 5-inch practice rockets.
- Fungy Bowl: This area, also known as Alcarazza, is part of MRS 02. This large rock was used as a target for aerial bombs and rockets. Suspected munitions include Mk80s series general purpose bombs and 5-inch Zuni rockets.
- Cross Cay: This area, also known as Cayo Lobo, is part of MRS 02 and was used as a strafing and bombing target. Munitions included general small arms, .50-caliber small arms, Mk80s series general purpose bombs, and Mk I 20mm HEI.
- Agua Cay: This area, also known as Water Key, is part of MRS 02 and was used as a target for bombing and rocket fire. Munitions include Mk80s series general purpose bombs and 2.75-inch rockets.
- Air-to-Ground North: This target, at the northern tip of Northwest Peninsula, is part of MRS 02. Munitions used include general small arms, .50-caliber small arms, Mk82 500-pound general purpose bombs, 2.75-inch rockets, and 11.75-inch Tiny Tim rockets.
- Air-to-Ground South: This target was located at the northern tip of Northwest Peninsula and is part of MRS 02. Munitions used include general small arms, .50-caliber small arms, Mk82 500-pound general purpose bombs, 2.75-inch rockets, and 11.75-inch Tiny Tim rockets.
- Rifle Range South: This small arms range is believed to be located on undeveloped land near the southern tip of the island in MRS 09. This range has not been confirmed; however, munitions used at this range would have included only general small arms.

1.8.7 2005-INVENTORY PROJECT REPORT (INPR), ORIGINAL MAY 1991, REVISED JULY 2005 (FINAL)

The original INPR was revised in 2005, clarifying the military use of the Island of Culebra and divided the original site, Property No I02PR0068, into 14 separate MRSs. One hazardous and toxic waste (HTW) project was identified and assigned the number 00, and 13 MMRP project areas were identified and assigned Risk Assessment Code (RAC) scores. MRS 01 was not defined.

The following MMRP projects and RAC scores were listed:

- MRS 02 – Culebra and Cays, RAC 1
- MRS 03 – Flamenco Bay Water Area, RAC 1
- MRS 04 – Flamenco Lagoon Maneuver Area, RAC 1
- MRS 05 – Mortar and Combat Range Area, RAC 1
- MRS 06 – Artillery Firing Area, RAC 3
- MRS 07 – Culebrita Artillery Impact Area, RAC 1
- MRS 08 – Cayo Norte Impact Area, RAC 3
- MRS 09 – Soldado Point Mortar and Bombing Area, RAC 2
- MRS 10 – Defensive Firing Area No. 1, RAC 2
- MRS 11 – Defensive Firing Area No. 2, RAC 1
- MRS 12 – Luis Pena Channel Water Areas, RAC 1
- MRS 13 – Cayo Luis Pena Impact Area, RAC 1
- MRS 14 – Airfield and Camp Area, RAC 3

1.8.8 2005-SUPPLEMENTAL ARCHIVES SEARCH REPORT, CULEBRA, PUERTO RICO, SEPTEMBER 2005.

USACE St. Louis District prepared the Supplemental ASR in 2005 as an addition to the 1995 ASR. The Supplemental ASR is the source of most of the historical information pertaining to site operations and identified the key areas of focus for the subsequent Site Inspection (SI). This document provided a detailed summary of military activities conducted on Culebra Island and the surrounding cays. The document summarized planned and/or executed maneuvers and training conducted at the site, including specific time periods, locations, and munitions used.

1.8.9 2007-SITE INSPECTION REPORT, CULEBRA ISLAND SITE, PUERTO RICO, FUDS PROJECT NO. I02PR006802 THROUGH 14, 2007

Parsons Infrastructure and Technology Group (Parsons) completed a site inspection of the Island and published a Final SI Report in September 2007. Parsons concluded that the potential for MEC to pose a human health risk existed within 12 of the 13 MRSs, but that there was no evidence to indicate that MRS 14 had potential MEC contamination. Parsons further concluded that although there was potential for MEC to pose a risk at the Culebra Island sites, since the field team did not identify an imminent threat to the public, a TCRA was not necessary. However, due to the presence of munitions debris and MEC at several areas within the site, Parsons recommended these sites proceed to the remedial investigation/feasibility study (RI/FS) status.

1.8.10 2009-NON-TIME CRITICAL REMOVAL ACTION, CULEBRITA AND CULEBRA BEACHES, FEBRUARY 2009.

In 2008-2009, USA completed a NTCRA on Flamenco Beach located on Culebra Island and five beaches along Culebrita isle located east of Culebra Island. USA performed digital geophysical mapping of 12.3 acres and reacquired target anomalies. Findings included 6 munitions debris (MD) items and 2 UXO items (5” projectiles) on Flamenco Beach, and 12 MD (20mm, 75mm), 6 UXO (20mm) and 6 items classified as material potentially presenting an explosive hazard (MPPEH) (20mm) on one of the five beaches on Culebrita.

1.9 INITIAL SUMMARY OF RISK FROM MEC

1.9.1 MRS 13 CAYO LUIS PENA IMPACT AREAS

Cayo de Luis Pena, with 484 acres of land and 864 total MRS acres, is about one quarter mile off the western coast of Culebra. The northern tip of this island was used as a firing target during Marine exercises conducted between 1924 and 1941. Records show that 75mm projectiles were fired at the Cayo in 1924 and that 155mm, 37mm, 8-inch, and 6-inch rounds may have also been used. In the 1960s, an observation point was erected on the hill top on Luis Pena, including a run-in line, helipad, and living quarters. Cayo de Luis Pena is managed by the USFWS as part of the Culebra National Wildlife Refuge.

1.9.2 MRS 10 DEFENSIVE FIRING AREA NO. 1

This area consists of 547 acres on the southwest peninsula of Culebra, south of the town of Dewey and north of MRS 09. Marines conducted amphibious landing and ground maneuver training using 81mm mortars on the beaches and hills in this area from the 1920s through the 1940s. Specifically, the hill on the north end of the MRS has been listed as a 1935 area of direct fire from 3” Common projectiles, and Snug Bay was shown as a 1935 water area for direct fire. Additionally a 1924 outpost and ammunition storage area is located on the north end of the MRS near Snug Bay. MRS 10 has many residents and businesses. Most of the development is near the town of Dewey on the north end of the site; however, houses are scattered throughout the southeastern side of this MRS. This MRS is almost entirely privately owned except for municipality lands such as the police and fire stations.

1.9.3 MRS 11 DEFENSIVE FIRING AREA NO. 2

MRS 11 is located on the west side of Culebra between Northwest Peninsula and the town of Dewey. The property was part of the land leased from Mr. Jesus Nieves on 7 November 1923. The area is approximately 719 acres, and most of the southern portion of this MRS has been extensively developed for residential use. The areas along the beach and the west side of this site are less developed. The land is privately owned with some municipality properties such as the school, hospital, and government buildings. Several training exercises were conducted in this area, including 75mm and 155mm firing from Firewood Bay at Mono Cay and portions of Cayo de Luis Pena in 1924; FLEX No. 4 with firing of small arms and 81mm mortars in 1936; and FLEX No. 7 in 1941 with boat-to-beach firing of 5-inch and 6-inch projectiles.

1.9.4 MRS 06 ARTILLERY FIRING AREA

MRS 06 is on the eastern end of Culebra extending from a point at the most northern tip of Mosquito Bay, northeast to a point just west of Duck Point, and east to the end of the island. This area consists of 826 acres and was used by the Marines for artillery firing points for exercises conducted between 1922 and the 1940s. Exercises involving small arms, Stokes mortars, 75mm pack howitzers, 3-inch mortars, and 37mm HE rounds were conducted in Mosquito Bay in 1936. Beginning in 1936, the Marines fired 75mm projectiles from a firing point inland of Mangrove Bay at Weather Channel near Culebrita. Additionally, 1937 U.S. FLEX No. 4 involved use of the lagoon area at the back of Mosquito Bay. In 1939, the Marines fired from 1,000 yards northeast of Mosquito Bay toward the cays to the east. From Mosquito Bay, 37mm rounds were fired west to water targets between Point Vaca and Snapper Shoal.

The property of MRS 06 was leased from the Vieques Sugar Company and Mr. A Lugo in 1924. Mr. Lugo’s lease was terminated in 1939; however, there is no record of the termination on the property owned by the Vieques Sugar Company. Currently, this MRS is almost entirely privately owned except for the water line, which is owned by the DNER and USFWS.

1.9.5 MRS 09 SOLDADO POINT MORTAR AND BOMBING AREA

This area consists of 328 acres on the very southern tip of the southwestern peninsula of Culebra. In 1914, a 5-inch battery was established on Soldado Point. Several training exercises including mortar firing, aerial bombing, and strafing were conducted on Soldado Point and the bay northwest of Soldado point during the 1930s and 40s. The Supplemental Archives Search Report (ASR) mentions that 30- and 1,000-pound bombs were dropped in this area (USACE 2005c). Munitions used in the bay included 30-pound fragmentation bombs, 100-pound demolition bombs, 81mm mortars, and small arms.

This piece of property was accepted in a quitclaim deed from the Secretary of the Interior by the Governor of Puerto Rico in 1982. This property is managed by the DNER; however, several shacks have been built along the water at Sueno cove.

1.9.6 MRS 08 CAYO NORTE IMPACT AREA

MRS 08 includes only Cayo Norte and covers approximately 306 acres of land. Cayo Norte was leased by the Marines for training; however, it cannot be determined from records whether the site was ever used for training. The property was leased from Mrs. Alma Hasselroth in 1924 for erecting artillery targets for 75 mm artillery practice. This lease was ended as part of the agreement between the Navy and Mayor of Culebra in 1971. Notes on FLEX No. 5 indicate that impact of Cayo Norte was planned but that difficulties clearing people and cows from the island kept it from being used for an impact area. The surrounding waters to the east of the Cayo Norte may contain suspected 5” HVAR from adjacent MRSs. No UXO has been identified on Cayo Norte. Cayo Norte is privately owned with plans for residential development.

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2.0 TECHNICAL MANAGEMENT PLAN

2.1 PROJECT OBJECTIVES

The objective of this Remedial Investigation/Feasibility Study (RI/FS) is to obtain acceptance of Decision Documents for each Munitions Response Site (MRS) that meet the requirements of Engineer Regulation 200-3-1 and Interim Guidance Document (IGD) 06-04, Engineer Pamphlet 1110-1-18 Military Munitions Response Process.

The overall objective of the RI/FS process is to identify and recommend a feasible and cost effective response alternative for MEC and MC related problems affecting human use of the site; determine and recommend areas that should receive response actions using the risk reduction option selected by the Government; perform risk evaluation of the site based on the potential response action options; and provide a convenient record of the process for use in final decision making that is protective of human health with respect to the intended future land use at the site.

2.2 PROJECT ORGANIZATION

For the RI/FS process to be successful, close coordination and cooperation between the stakeholders, community, regulators, and technical support personnel must occur. Figure 2-1 depicts the organizational structure of the USA project team with respect to the USACE. Other team members include the Culebra site stakeholders. The roles of these team members are described below.

2.2.1 U.S. ARMY CORPS OF ENGINEERS (USACE), JACKSONVILLE DISTRICT

USACE Jacksonville District is the project management and funding agency for this project. USACE Jacksonville District responsibilities include review of project plans and documents, obtaining rights-of-entry for properties in the investigation areas, coordinating with the news media and the public, and coordinating with national, state and local regulatory agencies on issues pertaining to protection of ecological and cultural resources

2.2.2 U.S. ARMY ENGINEERING AND SUPPORT CENTER, HUNTSVILLE (USAESCH)

USAESCH is the lead technical agency for this project. USAESCH responsibilities include procurement of contract services, review and coordination of project plans and documents, and supporting USACE Jacksonville District in working with the news media, the public, and the regulators. USAESCH provides technical expertise for MEC and MC activities. As the technical Project Manager, USAESCH is responsible for controlling the budget and schedule. As the contracting agency, USAESCH is responsible for directing the RI/FS contractor.

2.2.3 USA ENVIRONMENTAL, INC.

USA is the prime contractor to USAESCH for this project. USA will provide staff to perform all aspects of sample collection and provide oversight of field sampling activities. USA will assign project personnel based on management and technical experience and abilities. USA will contract TestAmerica for chemical analytical, APPL for QA analysis, and LDC for data validation. USA will prepare and submit data reports in accordance with (IAW) relevant USACE guidance. The USA Project Manager (PM) is Mr. Brian Skubin. The USA Quality Manager is Mr. Robert Crownover.

2.2.4 RTI LABORATORIES, DETROIT, MICHIGAN

RTI Laboratories (RTI) is the analytical laboratory subcontractor for this project. The RTI Customer Services Manager will coordinate with the USA QC Manager and PM on all issues concerning laboratory sample handling, analysis, analytical results, work scheduling, and laboratory QA/QC such that all environmental samples are analyzed according to appropriate methods and within specified holding times. The RTI QA Manager is responsible for oversight of data processing, data processing QC, and performance and system audits.

2.2.5 LABORATORY DATA CONSULTANTS

LDC is the chemical data validation subcontractor for this project. LDC will validate the analytical data submitted by Test America, Denver IAW USACE EM 200-1-1. The LDC Data Validator is Stella Cuenco.

2.2.6 TESTAMERICA DENVER

TestAmerica is the independent laboratory subcontractor to analyze the QA samples for this project. The results of the QA sample analysis are sent directly to USAESCH IAW the PWS. The TestAmerica QC Officer is responsible for oversight of data processing, data processing QC, and performance and system audits.

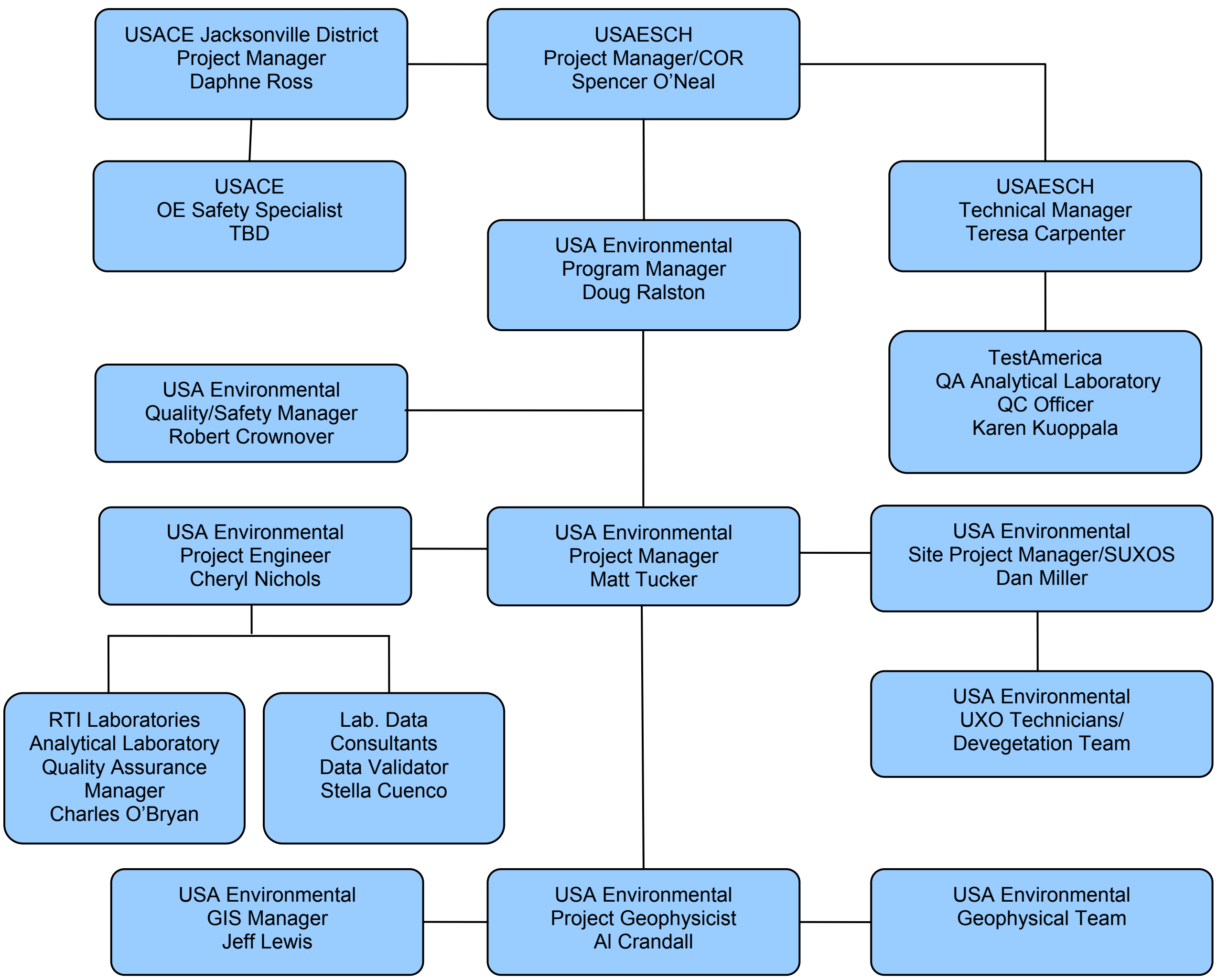

Figure 2-1: Project Management Organization

2.2.7 CULEBRA AREA STAKEHOLDERS

The stakeholders are the individuals and organizations directly impacted by the RI/FS activities and the final MMRP response actions selected for the site. Stakeholders include (but are not limited to):

- Puerto Rico Department of Natural and Environmental Resources (PR DNER)
- Puerto Rico Environmental Quality Board (PR EQB)
- United States Environmental Protection Agency (EPA)
- Culebra National Wildlife Refuge
- US Fish and Wildlife Service
- National Oceanic and Atmospheric Administration (NOAA)
- Restoration Advisory Board (RAB)
- Individual Leaseholders.

2.2.8 USA ENVIRONMENTAL, INCORPORATED (USA)

USA is the prime contractor to USAESCH. USA provides comprehensive engineering, project management, and quality control (QC) support services for the RI/FS. USA is responsible for managing the schedule and budget to ensure timely completion of the tasks detailed in the Performance Work Statement (PWS). USA properly trained and qualified unexploded ordnance (UXO) personnel and geophysical professionals will conduct escort and visual MEC removal of access routes and areas designated for geophysical investigation, perform the necessary vegetation removal/ geophysical survey activities, and perform necessary intrusive investigation of detected anomalies to characterize the MEC risk at the project site. USA will also collect MC composite soil samples at suspect MEC locations for analysis at TestAmerica Laboratories, Inc. The USA GIS Manager will incorporate collected real estate and geophysical investigation data into the existing GIS database. USA will provide the Senior UXO Supervisor (SUXOS), the UXO Quality Control Specialist (UXOQCS), and the UXO Safety Officer (UXOSO) for the field activities. USA will also conduct a MEC risk impact analysis and a baseline risk assessment for MC as part of the RI/FS work. The USAESCH Contracting Officer will direct all work performed by USA and its subcontractors. Key USA positions are described below and Resumes of key USA management and field personnel are presented in Appendix H.

2.3 PROJECT PERSONNEL

2.3.1 USA PROJECT MANAGER

The Project Manager is responsible for monitoring overall progress of the Task Order, reviewing monthly progress reports, and ensuring that resources are available. The Project Manager maintains close communication with USAESCH to assess client satisfaction with USA performance on this Task Order.

2.3.2 USA QUALITY MANAGER

The Quality Manager is responsible for reviewing and updating the Quality Control Plan and verifying compliance with the plan. The Quality Manager verifies compliance with the Quality Control Plan by auditing project activities and instituting corrective actions.

2.3.3 USA SAFETY MANAGER

The Safety Manager develops and coordinates the Accident Prevention Plan (APP). The Safety Manager is the contact for regulatory agencies on matters of health and safety. For this project, the Quality Manager also serves as the Safety Manager.

2.3.4 USA ENVIRONMENTAL ENGINEER

The Environmental Engineer provides technical, analytical, and report writing support to ensure the technical quality of deliverables to USAESCH.

2.3.5 USA GEOGRAPHICAL INFORMATION SYSTEMS (GIS) MANAGER

The GIS Manager is responsible for management and control of the project GIS. The GIS Manager will direct GIS operations occurring locally and remotely, and is responsible for control of data included in and used as part of the project GIS.

2.3.6 USA PROJECT GEOPHYSICIST

The Project Geophysicist provides oversight and direction for all geophysical activities. The Project Geophysicist is responsible for selection of the detection equipment to be used and for the quality and interpretation of the geophysical data collected.

2.3.7 USA SITE PROJECT MANAGER/SUXOS

The USA SITE PROJECT MANAGER/SUXOS is responsible for onsite administration, coordination, and site operations. He will manage all field operations, including site preparation, environmental surveys, and support for GPO and DGM to ensure the mapping is completed in a timely manner to allow the anomaly resolution phase to commence. The SUXOS will be the primary facilitator on site to coordinate with USFWS, the Refuge Manager, and local Culebra agencies for site control, environmental surveys, and demolition operations.

2.3.8 UXO QUALITY CONTROL SPECIALIST (UXOQCS)

The UXOQCS is responsible for monitoring and ensuring that all site MEC activities are conducted in accordance with this Work Plan. The UXOQCS will conduct Quality Control (QC) inspections of all MEC and explosives operations for compliance with established procedures and direct and approve all corrective actions to ensure all MEC-related work complies with contractual requirements.

2.3.9 UXO SAFETY OFFICER (UXOSO)

The UXOSO will implement the Site Safety and Health Plan (SSHP) and APP and verify compliance with applicable health and safety (H&S) requirements. The UXOSO will also implement the explosives safety program in compliance with all DoD, federal, state, and local statutes and codes; analyze MEC and explosives operational risks, hazards, and safety requirements; establish and ensure compliance with all site-specific safety requirements for MEC and explosives operations; and enforce personnel limits and safety exclusion zones (EZs) for MEC clearance operations and explosives transportation, storage, and destruction.

2.3.10 UXO/ VEGETATION REMOVAL TEAMS

Each UXO team shall consist of one UXO Technician III and six or less team members. UXO teams shall have a minimum of two UXO qualified personnel, one of which shall be the UXO Technician III. The term *UXO_Qualified Personnel* applies only to personnel meeting the requirements for the positions of UXO Technician II, UXO Technician III, UXO Safety Officer, UXO Quality Control Specialist, and Senior UXO Supervisor.

The UXO Technician I assists fully qualified personnel (UXO Technician II and above) in the conducting reconnaissance and classification of MEC; identifying all munitions and associated components; locating subsurface MEC; performing excavation procedures on subsurface MEC; locating surface MEC by visual means; transporting MEC and demolition materials; preparing firing systems, both electric and non-electric, for destruction operations; operating Personnel Decontamination Stations (PDS); inspecting salvaged MEC-related material and erection of MEC-related protective works; and donning and doffing personnel protective equipment. The UXO Technician I shall not determine if OE items are moveable.

USA SUXOS shall supervise all UXO related tasks and UXO teams. This individual may supervise other than UXO teams such as vegetation removal teams. When non-UXO teams are under the direct supervision of someone other than a UXO Technician III, the teams shall be accompanied by a UXO Technician II who will provide UXO avoidance support.

Vegetation removal teams will conduct vegetation removal activities in coordination with the sub-contracted botanist.

The USA SUXOS will maintain personnel files on each employee. These records will include copies of licenses, training records and certificates of qualifications that support the employee's placement and position. Prior to the employee's initial assignment or any change in duties/assignment, the USA SUXOS will physically review the employee's licenses, training records and certificates to ensure that the employee is qualified.

2.3.11 REMOTELY OPERATED VEHICLE (ROV) OPERATOR

The ROV Operator will be qualified to operate the ROV and will undergo site-specific training prior to underwater anomaly investigation activities.

2.3.12 BOAT SUPPORT PERSONNEL

Personnel assigned to support operations consist of the following positions:

- Boat captain and crew

The boat captain and crew personnel will be provided by a local subcontractor identified to provide water transportation services.

2.3.13 SUBCONTRACTORS

2.3.13.1 Sea Ventures

USA will subcontract with Sea Ventures to provide water transportation support. Sea Ventures operates out of Marina Puerto Del Rey, Fajardo, Puerto Rico and operates boats that are inspected and licensed by the United States Coast Guard and the Puerto Rico Public Service Commission. USA will rely on Sea Ventures to provide water transport of explosives when the only access route is by sea and rubber dinghies for access into shallow water areas.

2.3.13.2 Biologist

As an optional task, USA will subcontract the services of a local qualified Project Biologist for daily beach monitoring prior to MEC intrusive investigation activities as described in the *Standard Operating Procedures for Endangered Species Conservation and their Habitat on DERP-FUDS Project No. I02PR006802.Culebra, Puerto Rico* (Appendix O). The Project Biologist’s background includes 2 to 4 years of experience in related work, working independently under general supervision. The Project Biologist qualification is equivalent to industry Biologist II.

2.3.13.3 Botanist (optional)

If authorized, USA will contract with a local botanist for approval of any trimming of vegetation. The botanist or their designated botany technician would be on site and approve any vegetation that was required to be trimmed by the vegetation removal teams to allow DGM survey in close proximity to beach areas.

2.3.13.4 Laboratory Data Consultants

Laboratory Data Consultants, Inc. (LDC) is the chemical data validation subcontractor for this project. LDC validates the analytical data submitted by TestAmerica IAW USACE EM 200-1-1.

2.3.13.5 RTI Laboratories

RTI Laboratories will provide analysis of environmental samples. The RTI Project Manager coordinates with the USA QC Manager and USA Project Manager on all issues concerning laboratory sample handling, analysis, analytical results, work scheduling, and laboratory QA/QC such that all environmental samples are analyzed according to appropriate methods and within specified holding times. The RTI QC

Officer is responsible for oversight of data processing, data processing QC, and performance and system audits.

2.3.13.6 TestAmerica

TestAmerica is the independent laboratory subcontractor to analyze the QA samples for this project. The results of the QA sample analysis are sent directly to USAESCH IAW the PWS. The TestAmerica Project Manager coordinates with the USA QC Manager and Project Manager on all issues concerning laboratory sample handling, analysis, analytical results, work scheduling, and laboratory QA/QC such that all environmental samples are analyzed according to appropriate methods and within specified holding times. The TestAmerica QC Officer is responsible for oversight of data processing, data processing QC, and performance and system audits.

2.4 PROJECT COMMUNICATION AND REPORTING

Communications for this project will generally flow along the lines established by the organization depicted previously in Figure 2-1. All communications between USA and the USAESCH will primarily be directed through the respective USAESCH Project Manager or Contracting Officer. Communication directly between USA and other government entities associated with this project will only occur with USAESCH concurrence.

2.4.1 PROJECT INTERNET WEB PAGE

USA will utilize a dedicated Internet Web page to disseminate information to the project team and the public. This Web page will be updated periodically with new information about the project and will be used to post copies of monthly reports, documents, and other correspondence as desired by USAESCH. Some of the access will be password protected as determined necessary by USAESCH. The USA project Website address is http://www.usaprojecthost.com.

2.5 PROJECT DELIVERABLES

This section provides a brief description of the required deliverables for this RI/FS. A detailed description of project deliverables is provided in the PWS (Appendix A). Deliverable data will be submitted to USAESCH and USACE Jacksonville District (CESAJ) no later than the close of the business day indicated in the project schedule. Electronic data will be submitted in formats consistent with USAESCH software and systems, as defined in the PWS.

2.5.1 RI/FS WORK PLAN

A Draft, Draft Final, and Final RI/FS Work Plan will be prepared using DID MR-001 as guidance. USA team members will perform a peer review of each section of the WP followed by an overall review by the USA QC Manager prior to submittal to confirm the overall quality and completeness of each document. Review comments received on the Draft and Draft Final versions will be incorporated and formal, annotated responses will be provided for each comment. USA will submit the Draft Final and Final versions no later than 14 days following receipt of comments. USA will include a CD with each hard copy document submitted.

2.5.2 TECHNICAL PROJECT PLANNING (TPP) MEMORANDUM

A Draft and Final TPP Memorandum will be prepared and submitted. The memorandum will contain Data Quality Objectives (DQOs) and other results of the TPP meetings, including a conceptual site model (CSM).

2.5.3 PUBLIC INVOLVEMENT PLAN (PIP)

USA will update the existing PIP and submit draft and final versions prepared in accordance with EP 1110-3-8. The draft submission will be prepared after the first TPP meeting, following an assessment of stakeholder and public preferences. Review comments will be incorporated and formal, annotated responses will be provided for each comment. The Final PIP will be submitted no later than 14 days following receipt of comments. USA will include a CD with each hard copy document submitted.

2.5.4 REMEDIAL INVESTIGATION (RI) REPORT

A Draft, Draft Final, and Final RI Report will be prepared following the guidance in EM CX Interim Guidance 06-04. The report will document data collected during the RI field activities, the results of a baseline risk assessment, and conclusions that contribute to evaluation and selection of the most appropriate remedy for each MRS. The RI report includes an updated Conceptual Site Model (CSM); Baseline Human Health and Ecological Risk Assessment IAW EPA Risk Assessment Guidance for Superfund (RAGS) and USACE EM 200-1-4; and a determination of the MRS priority for each MRS using the Munitions Response Site Prioritization Protocol (MRSPP) worksheets.

The Draft RI Report will be submitted within 60 days completion of all fieldwork. USA will attend a teleconference on-board review after receiving comments on the Draft RI Report and will submit a Draft Final no more than 14 days later. USA will coordinate the third Technical Project Planning (TPP) meeting with the Project Delivery Team (PDT) to verify that all identified data gaps have been filled. Following receipt of all comments, the Final RI Report will be submitted within 14 days.

2.5.5 FEASIBILITY STUDY (FS) REPORT

A Draft, Draft Final, and Final FS Report will be prepared following the guidance in EM CX Interim Guidance 06-04. The report will document the screening of treatment technologies, the development of remedial options, the identification of Preliminary Remediation Goals (PRGs), RAOs and ARARs, and the evaluation of appropriate remedial alternatives. Following submittal of the Draft report and receipt of comments USA will attend an onboard meeting (via teleconference) to discuss the comments. A Draft Final FS Report will be submitted no more than 14 days later. The Final FS Report will be submitted within 14 days following receipt of comments on the Draft Final FS Report.

2.5.6 PROPOSED PLAN

A Draft and Final Proposed Plan will be submitted. The Draft Proposed Plan will be prepared following approval of the Final FS Report. The plan will be developed to summarize the remedial alternatives proposed for the project and to specify the preferred cleanup method. The Plan will be written in non-technical language and be understandable by the general community. The Proposed Plan explains why the preferred remedial alternative is most appropriate for the site. Upon USAESCH approval of the Proposed Plan, it will be posted on the project website (http://www.usaprojecthost.com) and in the Administrative Record for public review. USA will issue a public notice with local media to announce the availability of the Proposed Plan, and coordinate and facilitate a public meeting to familiarize the public with the site and initiate the public comment period. The public will have 30 days to provide verbal or written comments on the Proposed Plan. The comments generated during the public comment period will be addressed in the Responsiveness Summary in the Decision Document.

2.5.7 DECISION DOCUMENT

Within 14 days following approval of the Final Proposed Plan, a Draft Decision Document will be developed to document the remedial alternative chosen and the public comments and community concerns. The Decision Document will be prepared for <u>each</u> MRS to gain acceptance IAW ER 200-3-1 FUDS Program Policy, MM CX Interim Guidance 06-04, and Appendix B. Appendix B provides new formatting requirements for the Decision Document and supersedes the MM CX Interim Guidance 06-04 for formatting of the Decision Document. A Draft Final will be submitted within 7 days receipt of comments on the draft and a Final version will be submitted within 7 days following receipt of comments on the Draft Final.

2.5.8 ADMINISTRATIVE RECORD

An Administrative Record will be established and maintained for each MRS. USA will closely coordinate with the USAESCH and CESAJ to establish and maintain an Administrative Record IAW the guidance given in EP 1110-3-8, Chapter 4 (Establishing and Maintaining Administrative Records) and Standard Operating Procedure for Formerly Used Defense Sites (FUDS) Records Management, Revision 5, dated January 2008. A separate Administrative Record will be maintained for each MRS. USA will secure a place to establish and house the Administrative Record in the local community of the project site (e.g., local public library). All required documents to the Administrative Record will be secured and incorporated into the Administrative Record. All final documents will be provided on CD/DVD to USAESCH and CESAJ for archival and placement onto the Project Information Retrieval System (PIRS). Two copies will be submitted to each of USAESCH and CESAJ.

2.6 PROJECT SCHEDULE

The project schedule presents the logical sequence of tasks, deliverable due dates, and anticipated number of days to complete each task. The schedule will be updated monthly and included in the Monthly Progress Status reports prepared and submitted IAW DID MR-085. The schedule is included in Appendix J.

2.7 PERIODIC REPORTING

Project Status Reports will be prepared IAW DID MR-085. This report will be submitted monthly when fieldwork is not being performed, and weekly when fieldwork is underway.

2.8 COSTING AND BILLING

The budget for the project was negotiated with the USAESCH pursuant to contract number W912DY-04-D-0006 Task Order No. 0022. USA will submit a monthly invoice to the USAESCH. The USA Project Manager is responsible for submitting monthly reports to the USAESCH Project Manager along with the invoice that documents the work performed during the corresponding billing period. Requests for payment will be based on completion of performance milestones as defined in the monthly Project Status Report.

2.9 PROJECT PUBLIC RELATIONS SUPPORT

Public relations support will include participation in up to three public meetings to be held on the Isla Culebra. These meetings are in addition to the TPP meetings. USA will prepare and deliver briefings, graphics, maps, posters, presentations, and support of question and answer sessions. When required, USA will prepare invitation letters, fact sheets, and meeting notices. USA will obtain the meeting sites, perform public notification and prepare any correspondence necessary to meeting the objectives of this task. USA will also maintain a project website for viewing by the public and PDT members. To ensure the quality of public meetings, USA will coordinate with the USACE public relations officer or other appropriate USACE representative on all matters of public relations.

2.10 SUBCONTRACT MANAGEMENT

Before subcontract work is performed at the site, USA will negotiate and prepare subcontracts that will detail all necessary and appropriate terms and conditions, including the statement of work (SOW). Once the subcontract is executed, USA will perform periodic reviews to ensure that contractual requirements and milestones are met. These reviews will cover contractual progress, technical progress, and cost and schedule status. USA technical staff will review data generated by the subcontractor as part of subcontract deliverables.

USA will maintain overall supervisory responsibility for all operations. Subcontractors will work under the direction and oversight of USA's Site Project Manager/SUXOS and will be monitored by USA's UXOQCS. The SUXOS will schedule all operational activities and a strict accounting will be made of actions performed and activities completed. Throughout their operations, subcontractors will coordinate their operational schedules with USA's SUXOS, and strictly adhere to this Work Plan and associated APP.

2.11 MANAGEMENT OF FIELD OPERATIONS

During reconnaissance and MEC sampling efforts, the USA Site Project Manager/SUXOS will manage field operations from outside the exclusion zone at a command post established in the vicinity of the project site. Unauthorized personnel will not be allowed to access work areas.

The USA Safety Manager and Quality Manager will remain off site but will be available by telephone for consultation on issues of safety or quality. The USA UXOSO will be dual-hatted as the UXO Quality Control Specialist, and will be on site during field activities to ensure all activities comply with the APP and to conduct QC inspections of field activities.

The USA GIS Manager, who is responsible for control of data included in and used as part of the project GIS, will also be available by telephone for consultation.

3.0 FIELD INVESTIGATION PLAN

3.1 OVERALL APPROACH TO MUNITIONS RESPONSE ACTIVITIES

3.1.1 SITE CHARACTERIZATION GOALS

Identifying characterization goals is critical within the Technical Project Planning (TPP) process to ensure appropriate planning activities. Goals are defined by current and future land use, regulatory compliance, and budget and schedule requirements and limitations.

Preliminary project goals have been developed in accordance with USACE Interim Guidance for TPP. The project team will continue to develop and refine project goals to guide the site characterization efforts. The preliminary project goals are presented in the TPP Memorandum for Record (MFR) Worksheet (Appendix I). The sole preliminary project goal is to determine if the land and surrounding coastal waters within each MRS site is safe for continued use by property owners and the public. Based on this preliminary project goal, site characterization goals may include:

- Document available information pertaining to the nature and extent of MEC within each MRS;
- Identify areas where further investigation is warranted;
- Conduct a field investigation of each MRS to characterize the nature and extent of MEC and MC within the MRS; and
- Perform qualitative assessment of MEC and MC risk at each MRS.

3.1.2 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQO) are qualitative and quantitative statements derived from the TPP process that clarify study objectives, define the appropriate type of data, and specify the tolerable levels of potential decision errors that are used as the basis for establishing the quality and quantity of data needed to support decisions. These project specific statements describe the intended data use; the data need requirements; and the means to achieve acceptable data quality for the intended use. DQOs produced through the TPP process meet the U.S. Environmental Protection Agency (EPA) *QA/G-4HW Guidance's* definition of a DQO. The following subsections describe project DQOs that have been developed for this RI/FS.

3.1.2.1 Project Data Quality Objectives

Project DQOs have been developed IAW the US Army RI/FS Study Guidance (November 2009) and EM 1110-1-4009 to ensure that collected data allows for the adequate characterization of MEC at the Culebra MRSs as established during the TPP process. These DQOs exhibit the overall data requirements to accomplish the characterization goals for each MRS based on future land use, potential receptors, and accessibility. The data collected IAW the DQOs will be used to update the conceptual site models (CSM) for each MRS, as required. Table 3-1 shows the Project DQOs for MEC and MC characterization at the identified Culebra MRSs.

Table 3-1: Project Data Quality Objectives for MEC and MC

DQO STEPS	MRS LOCATIONS
MRS 13 Cayo Louis Pena Impact Areas	
1. State Problem(s)	• Define the nature and extent of MEC contamination relative to future land use, potential receptors, and accessibility within MRS 13, Cayo Luis Pena. • Define the nature and extent of MC contamination relative to future land use, potential receptors, and accessibility within MRS 13, Cayo Luis Pena.
2. Identify the Decision	• Determine where *surface* MEC contamination along *accessible trails* poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where *surface* and *subsurface* MEC contamination on *accessible beach areas* poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where suspected underwater MEC contamination in *accessible water areas* poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where surface soil, subsurface soil, surface water, and sediment MC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary. * *For the purposes of this DQO: "accessible" means that access has not been hindered by slopes in excess of 33 degrees, dense vegetation, fences/natural barriers, or any combination of the above.*
3. Identify the Inputs	• Future Land Use, Potential Receptors, and Access* (CSM), • Historical Records (SI & ASR), • Presence of MEC items on the *surface* along accessible* trails, • Presence of MEC items on the *surface* and *subsurface* within the accessible* beach areas, • Presence of suspected MEC items on the seafloor within *accessible water areas,* no further than 100 yards seaward from the mean high tide mark, • Presence of MC related metals detected with handheld metals analyzer, • Concentration value of MC taken from discrete surface soil, subsurface soil, surface water, and sediment samples, including step-out areas if applicable. One (1) discrete sample per applicable media, per location.
4. Define the Study Boundary	The MRS boundary defines the population to be sampled and the decision unit to which the data will be applied. The populations MEC to be sampled is on the surface and subsurface (accessible beach areas) within the MRS. The populations to be sampled for MC are surface and subsurface soil, surface water, and sediment. MEC: • Locations on the surface and subsurface (accessible beach areas) within the MRS, • Locations on the seafloor within the *accessible water areas,* no further than 100 yards seaward from the mean high tide mark,

DQO STEPS	MRS LOCATIONS
	<u>MC:</u> • Surface and subsurface soil sampling locations will be established based on locations of MEC/MD discovered during the geophysical investigation. Surface water samples will be collected in areas near streams and shorelines down gradient from areas containing MEC/MD discovered during the geophysical investigation, • Surface water and Sediment samples will be collected from down gradient streams and depositional areas downgradient from areas containing MEC/MD discovered during the geophysical investigation.
5. Develop a Decision Rule	The following decision rules will be applied to the MEC population and decision unit: • If MEC is discovered on the surface, subsurface (accessible beach areas), or the seafloor (within the underwater investigation boundary) of the MRS then a baseline MEC Hazard Analysis (MEC HA) based on future land use, potential receptors, and access will be performed and presented to the project team for further evaluation. • The MEC investigation will be halted if and when project objectives are met, (e.g. nature and extent of MEC has been determined for an MRS or a portion of an MRS*.) If the project objectives for MEC have not been met, grid or transecting step out processes will be implemented to collect additional data required to further bound the nature and extent of MEC contamination. * Criteria taken from EM-110-1-4009, Chapter 7, Site Characterization. The following decision rules will be applied to the MC population and decision unit: <u>Surface and Subsurface Soil</u>: If MC concentrations for each sample site are less than the screening values identified in Worksheet #15 of the UFP QAPP, then no further action for that area will be considered as it is delineated. If MC concentrations for each sample site are greater than the screening values identified in Worksheet #15, Step-out sampling will be conducted IAW the Step-out procedure Flow Chart included in the Sampling and Analysis Plan (SAP) in Appendix E. Step-out sampling will continue until MC concentration is at or below screening criteria, in which the contamination shall be delineated. <u>Surface water and sediment:</u> If MC concentrations for all sample sites are less than the screening values identified in Worksheet #15, then surface water at that site will not be considered to impact surface water or sediments within the MRSs. If a concentration exceeds the screening values for a given location, additional downstream samples will be collected until MC concentration is at or below screening criteria, in which the contamination shall be delineated.
6. Specify Limits on Decision Errors.	Measurable decision errors are limited to the field and analytical QC processes. The analytical requirements for MC are defined on Worksheet #12 of the UFP QAPP.
7. Optimize the Design for Obtaining Data	Data collection procedures and associated QC for MEC are included in the RI/FS Work Plan. MC sample design and rationale is listed on Worksheet #17 of the UFP QAPP.

DQO STEPS	MRS LOCATIONS
MRS 10 Defensive Firing Area No. 1	
1. State Problem(s)	• Define the nature and extent of MEC contamination relative to future land use, potential receptors, and accessibility within MRS 10, Defensive Firing Area No. 1. • Define the nature and extent of MC contamination relative to future land use, potential receptors, and accessibility within MRS 10, Defensive Firing Area No. 1.
2. Identify the Decision	• Determine where *surface and subsurface* MEC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where suspected underwater MEC contamination in *accessible water areas* poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where surface soil, subsurface soil, surface water, and sediment MC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary. * *For the purposes of this DQO: "accessible" means that access has not been hindered by slopes in excess of 33 degrees, dense vegetation, fences/natural barriers, or any combination of the above.*
3. Identify the Inputs	• Future Land Use, Potential Receptors, and Access (CSM), • Historical Records (SI & ASR), • Presence of MEC items on the surface or subsurface in prescribed transects and grids, • Presence of suspected MEC items on the seafloor within *accessible water areas,* no further than 100 yards seaward from the mean high tide mark, • Presence of MC related metals detected with handheld metals analyzer, • Concentration value of MC taken from discrete surface soil, subsurface soil, surface water, and sediment samples, including step-out areas if applicable. One (1) discrete sample per applicable media, per location.
4. Define the Study Boundary	The MRS boundary defines the population to be sampled and the decision unit to which the data will be applied. The populations MEC to be sampled is on the surface and subsurface within the MRS. The population to be sampled for MC are surface and subsurface soil, surface water, and sediment. MEC: • Locations on the *surface* and *subsurface* within the MRS, • Locations on the seafloor within the *accessible water areas,* no further than 100 yards seaward from the mean high tide mark, MC: • Surface and subsurface soil sampling locations will be established based on locations of MEC/MD discovered during the geophysical investigation. Surface water samples will be collected in areas near streams and shorelines downgradient from areas containing MEC/MD discovered during the geophysical investigation, • Surface water and Sediment samples will be collected from down gradient streams and depositional areas downgradient from areas containing MEC/MD discovered during the geophysical investigation.

<table>
<tr><th>DQO STEPS</th><th>MRS LOCATIONS</th></tr>
<tr><td>5. Develop a Decision Rule</td><td>The following decision rules will be applied to the MEC population and decision unit:
If MEC is discovered on the surface, subsurface, or the seafloor (within the underwater investigation boundary) of the MRS then a baseline MEC Hazard Analysis (MEC HA) based on future land use, potential receptors, and access will be performed and presented to the project team for further evaluation.
The MEC investigation will be halted if and when project objectives are met, (e.g. nature and extent of MEC has been determined for an MRS or a portion of an MRS*.) If the project objectives for MEC has not been met, grid or transecting step out processes will be implemented to collect additional data required to further bound the nature and extent of MEC contamination.
* Criteria taken from EM-110-1-4009, Chapter 7, Site Characterization.

The following decision rules will be applied to the MC population and decision unit:
<u>Surface and Subsurface Soil</u>:
If MC concentrations for each sample site are less than the screening values identified in Worksheet #15 of the UFP QAPP, then no further action for that area will be considered as it is delineated. If MC concentrations for each sample site are greater than the screening values identified in Worksheet #15, Step-out sampling will be conducted IAW the Step-out procedure Flow Chart included in the Sampling and Analysis Plan (SAP) in Appendix E. Step-out sampling will continue until MC concentration is at or below screening criteria, in which the contamination shall be delineated.
<u>Surface water and sediment:</u>
If MC concentrations for all sample sites are less than the screening values identified in Worksheet #15, then surface water at that site will not be considered to impact surface water or sediments within the MRSs. If a concentration exceeds the screening values for a given location, additional downstream samples will be collected until MC concentration is at or below screening criteria, in which the contamination shall be delineated.</td></tr>
<tr><td>6. Specify Limits on Decision Errors.</td><td>Measurable decision errors are limited to the field and analytical QC processes. The analytical requirements for MC are defined on Worksheet #12 of the UFP QAPP.</td></tr>
<tr><td>7. Optimize the Design for Obtaining Data</td><td>Data collection procedures and associated QC for MEC are included in the RI/FS Work Plan.

MC sample design and rationale is listed on Worksheet #17 of the UFP QAPP.</td></tr>
<tr><td colspan="2">MRS 11 Defensive Firing Area No. 2</td></tr>
<tr><td>1. State Problem(s)</td><td>Define the nature and extent of MEC contamination relative to future land use, potential receptors, and accessibility within MRS 11, Defensive Firing Area No. 2.
Define the nature and extent of MC contamination relative to future land use, potential receptors, and accessibility within MRS 11, Defensive Firing Area No. 2.</td></tr>
<tr><td>2. Identify the Decision</td><td>Determine where surface and subsurface MEC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary,
Determine where suspected underwater MEC contamination in accessible water areas poses an unacceptable risk to human health and the environment and</td></tr>
</table>

DQO STEPS	MRS LOCATIONS
	requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where surface soil, subsurface soil, surface water, and sediment MC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary. * *For the purposes of this DQO: "accessible" means that access has not been hindered by slopes in excess of 33 degrees, dense vegetation, fences/natural barriers, or any combination of the above.*
3. Identify the Inputs	• Future Land Use, Potential Receptors, and Access (CSM), • Historical Records (SI & ASR), • Presence of MEC items on the surface or subsurface in prescribed transects and grids, • Presence of suspected MEC items on the seafloor within *accessible water areas,* no further than 100 yards seaward from the mean high tide mark, • Presence of MC related metals detected with handheld metals analyzer, • Concentration value of MC taken from discrete surface soil, subsurface soil, surface water, and sediment samples, including step-out areas if applicable. One (1) discrete sample per applicable media, per location.
4. Define the Study Boundary	The MRS boundary defines the population to be sampled and the decision unit to which the data will be applied. The populations MEC to be sampled is on the surface and subsurface within the MRS. The population to be sampled for MC are surface and subsurface soil, surface water, and sediment. MEC: • Locations on the *surface* and *subsurface* within the MRS, • Locations on the seafloor within the *accessible water areas,* no further than 100 yards seaward from the mean high tide mark, MC: • Surface and subsurface soil sampling locations will be established based on locations of MEC/MD discovered during the geophysical investigation. Surface water samples will be collected in areas near streams and shorelines downgradient from areas containing MEC/MD discovered during the geophysical investigation, • Surface water and Sediment samples will be collected from down gradient streams and depositional areas downgradient from areas containing MEC/MD discovered during the geophysical investigation.
5. Develop a Decision Rule	The following decision rules will be applied to the MEC population and decision unit: • If MEC is discovered on the surface, subsurface, or the seafloor (within the underwater investigation boundary) of the MRS then a baseline MEC Hazard Analysis (MEC HA) based on future land use, potential receptors, and access will be performed and presented to the project team for further evaluation. • The MEC investigation will be halted if and when project objectives are met, (e.g. nature and extent of MEC has been determined for an MRS or a portion of an MRS*.) If the project objectives for MEC has not been met, grid or transecting step out processes will be implemented to collect additional data required to further bound the nature and extent of MEC contamination. * Criteria taken from EM-110-1-4009, Chapter 7, Site Characterization.

DQO STEPS	MRS LOCATIONS
	The following decision rules will be applied to the MC population and decision unit: Surface and Subsurface Soil: If MC concentrations for each sample site are less than the screening values identified in Worksheet #15 of the UFP QAPP, then no further action for that area will be considered as it is delineated. If MC concentrations for each sample site are greater than the screening values identified in Worksheet #15, Step-out sampling will be conducted IAW the Step-out procedure Flow Chart included in the Sampling and Analysis Plan (SAP) in Appendix E. Step-out sampling will continue until MC concentration is at or below screening criteria, in which the contamination shall be delineated. Surface water and sediment: If MC concentrations for all sample sites are less than the screening values identified in Worksheet #15, then surface water at that site will not be considered to impact surface water or sediments within the MRSs. If a concentration exceeds the screening values for a given location, additional downstream samples will be collected until MC concentration is at or below screening criteria, in which the contamination shall be delineated.
6. Specify Limits on Decision Errors.	Measurable decision errors are limited to the field and analytical QC processes. The analytical requirements for MC are defined on Worksheet #12 of the UFP QAPP.
7. Optimize the Design for Obtaining Data	Data collection procedures and associated QC for MEC are included in the RI/FS Work Plan. MC sample design and rationale is listed on Worksheet #17 of the UFP QAPP.
MRS 06 Artillery Firing Area	
1. State Problem(s)	• Define the nature and extent of MEC contamination relative to future land use, potential receptors, and accessibility within MRS 06, Artillery Firing Area. MEC contamination • Define the nature and extent of MC contamination relative to future land use, potential receptors, and accessibility within MRS 06, Artillery Firing Area. MEC contamination
2. Identify the Decision	• Determine where *surface and subsurface* MEC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where suspected underwater MEC contamination in *accessible water areas* poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where surface soil, subsurface soil, surface water, and sediment MC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary. * *For the purposes of this DQO: "accessible" means that access has not been hindered by slopes in excess of 33 degrees, dense vegetation, fences/natural barriers, or any combination of the above.*

DQO STEPS	MRS LOCATIONS
3. Identify the Inputs	• Future Land Use, Potential Receptors, and Access (CSM), • Historical Records (SI & ASR), • Presence of MEC items on the surface or subsurface in prescribed transects and grids. • Presence of suspected MEC items on the seafloor within *accessible water areas,* no further than 100 yards seaward from the mean high tide mark, • Presence of MC related metals detected with handheld metals analyzer, • Concentration value of MC taken from discrete surface soil, subsurface soil, surface water, and sediment samples, including step-out areas if applicable. One (1) discrete sample per applicable media, per location.
4. Define the Study Boundary	The MRS boundary defines the population to be sampled and the decision unit to which the data will be applied. The populations MEC to be sampled is on the surface and subsurface within the MRS. The population to be sampled for MC are surface and subsurface soil, surface water, and sediment. MEC: • Locations on the *surface* and *subsurface* within the MRS, • Locations on the seafloor within the *accessible water areas,* no further than 100 yards seaward from the mean high tide mark, MC: • Surface and subsurface soil sampling locations will be established based on locations of MEC/MD discovered during the geophysical investigation. Surface water samples will be collected in areas near streams and shorelines downgradient from areas containing MEC/MD discovered during the geophysical investigation, • Surface water and Sediment samples will be collected from down gradient streams and depositional areas downgradient from areas containing MEC/MD discovered during the geophysical investigation.
5. Develop a Decision Rule	The following decision rules will be applied to the MEC population and decision unit: • If MEC is discovered on the surface, subsurface, or the seafloor (within the underwater investigation boundary) of the MRS then a baseline MEC Hazard Analysis (MEC HA) based on future land use, potential receptors, and access will be performed and presented to the project team for further evaluation. • The MEC investigation will be halted if and when project objectives are met, (e.g. nature and extent of MEC has been determined for an MRS or a portion of an MRS*.) If the project objectives for MEC has not been met, grid or transecting step out processes will be implemented to collect additional data required to further bound the nature and extent of MEC contamination. * Criteria taken from EM-110-1-4009, Chapter 7, Site Characterization. The following decision rules will be applied to the MC population and decision unit: Surface and Subsurface Soil: If MC concentrations for each sample site are less than the screening values identified in Worksheet #15 of the UFP QAPP, then no further action for that area will be considered as it is delineated. If MC concentrations for each sample site are greater than the screening values identified in Worksheet #15, Step-out sampling will be conducted IAW the Step-out procedure Flow Chart included in the Sampling and Analysis Plan (SAP) in Appendix E. Step-out sampling will continue until MC concentration is at or below screening criteria, in which the contamination shall be delineated.

DQO STEPS	MRS LOCATIONS
	<u>Surface water and sediment:</u> If MC concentrations for all sample sites are less than the screening values identified in Worksheet #15, then surface water at that site will not be considered to impact surface water or sediments within the MRSs. If a concentration exceeds the screening values for a given location, additional downstream samples will be collected until MC concentration is at or below screening criteria, in which the contamination shall be delineated.
6. Specify Limits on Decision Errors.	Measurable decision errors are limited to the field and analytical QC processes. The analytical requirements for MC are defined on Worksheet #12 of the UFP QAPP.
7. Optimize the Design for Obtaining Data	Data collection procedures and associated QC for MEC are included in the RI/FS Work Plan. MC sample design and rationale is listed on Worksheet #17 of the UFP QAPP.
MRS 09 Soldado Point Mortar and Bombing Area	
1. State Problem(s)	• Define the nature and extent of MEC contamination relative to future land use, potential receptors, and accessibility within MRS 09, Soldado Point Mortar and Bombing Area. • Define the nature and extent of MC contamination relative to future land use, potential receptors, and accessibility within MRS 09, Soldado Point Mortar and Bombing Area.
2. Identify the Decision	• Determine where *surface and subsurface* MEC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where suspected underwater MEC contamination in *accessible water areas* poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where surface soil, subsurface soil, surface water, and sediment MC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary. * *For the purposes of this DQO: "accessible" means that access has not been hindered by slopes in excess of 33 degrees, dense vegetation, fences/natural barriers, or any combination of the above.*
3. Identify the Inputs	• Future Land Use, Potential Receptors, and Access (CSM), • Historical Records (SI & ASR), • Presence of MEC items on the surface or subsurface in prescribed transects and grids. • Presence of suspected MEC items on the seafloor within *accessible water areas,* no further than 100 yards seaward from the mean high tide mark, • Presence of MC related metals detected with handheld metals analyzer, • Concentration value of MC taken from discrete surface soil, subsurface soil, surface water, and sediment samples, including step-out areas if applicable. One (1) discrete sample per applicable media, per location.

DQO STEPS	MRS LOCATIONS
4. Define the Study Boundary	The MRS boundary defines the population to be sampled and the decision unit to which the data will be applied. The populations MEC to be sampled is on the surface and subsurface within the MRS. The population to be sampled for MC are surface and subsurface soil, surface water, and sediment. MEC: • Locations on the *surface* and *subsurface* within the MRS, • Locations on the seafloor within the *accessible water areas,* no further than 100 yards seaward from the mean high tide mark, MC: • Surface and subsurface soil sampling locations will be established based on locations of MEC/MD discovered during the geophysical investigation. Surface water samples will be collected in areas near streams and shorelines downgradient from areas containing MEC/MD discovered during the geophysical investigation, • Surface water and Sediment samples will be collected from down gradient streams and depositional areas downgradient from areas containing MEC/MD discovered during the geophysical investigation.
5. Develop a Decision Rule	The following decision rules will be applied to the MEC population and decision unit: • If MEC is discovered on the surface, subsurface, or the seafloor (within the underwater investigation boundary) of the MRS then a baseline MEC Hazard Analysis (MEC HA) based on future land use, potential receptors, and access will be performed and presented to the project team for further evaluation. • The MEC investigation will be halted if and when project objectives are met, (e.g. nature and extent of MEC has been determined for an MRS or a portion of an MRS*.) If the project objectives for MEC has not been met, grid or transecting step out processes will be implemented to collect additional data required to further bound the nature and extent of MEC contamination. * Criteria taken from EM-110-1-4009, Chapter 7, Site Characterization. The following decision rules will be applied to the MC population and decision unit: Surface and Subsurface Soil: If MC concentrations for each sample site are less than the screening values identified in Worksheet #15 of the UFP QAPP, then no further action for that area will be considered as it is delineated. If MC concentrations for each sample site are greater than the screening values identified in Worksheet #15, Step-out sampling will be conducted IAW the Step-out procedure Flow Chart included in the Sampling and Analysis Plan (SAP) in Appendix E. Step-out sampling will continue MC concentration is at or below screening criteria, in which the contamination shall be delineated. Surface water and sediment: If MC concentrations for all sample sites are less than the screening values identified in Worksheet #15, then surface water at that site will not be considered to impact surface water or sediments within the MRSs. If a concentration exceeds the screening values for a given location, additional downstream samples will be collected until MC concentration is at or below screening criteria, in which the contamination shall be delineated.
6. Specify Limits on Decision Errors.	Measurable decision errors are limited to the field and analytical QC processes. The analytical requirements for MC are defined on Worksheet #12 of the UFP QAPP.

DQO STEPS	MRS LOCATIONS
7. Optimize the Design for Obtaining Data	Data collection procedures and associated QC for MEC are included in the RI/FS Work Plan. MC sample design and rationale is listed on Worksheet #17 of the UFP QAPP.
MRS 08 Cayo Norte Impact Area	
State Problem(s)	• Define the nature and extent of MEC contamination relative to future land use, potential receptors, and accessibility within MRS 08, Defensive Cayo Norte Impact Area. • Define the nature and extent of MC contamination relative to future land use, potential receptors, and accessibility within MRS 08, Defensive Cayo Norte Impact Area.
2. Identify the Decision	• Determine where *surface and subsurface* MEC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where suspected underwater MEC contamination in *accessible water areas* poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary, • Determine where surface soil, subsurface soil, surface water, and sediment MC contamination poses an unacceptable risk to human health and the environment and requires further consideration or a response action, or recommended that no further investigation is necessary. * *For the purposes of this DQO: "accessible" means that access has not been hindered by slopes in excess of 33 degrees, dense vegetation, fences/natural barriers, or any combination of the above.*
3. Identify the Inputs	• Future Land Use, Potential Receptors, and Access (CSM), • Historical Records (SI & ASR), • Presence of MEC items on the surface or subsurface in prescribed transects and grids, • Presence of suspected MEC items on the seafloor within *accessible water areas,* no further than 100 yards seaward from the mean high tide mark, • Presence of MC related metals detected with handheld metals analyzer, • Concentration value of MC taken from discrete surface soil, subsurface soil, surface water, and sediment samples, including step-out areas if applicable. One (1) discrete sample per applicable media, per location.
4. Define the Study Boundary	The MRS boundary defines the population to be sampled and the decision unit to which the data will be applied. The populations MEC to be sampled is on the surface and subsurface within the MRS. The population to be sampled for MC are surface and subsurface soil, surface water, and sediment. MEC: • Locations on the *surface* and *subsurface* within the MRS, • Locations on the seafloor within the *accessible water areas,* no further than 100 yards seaward from the mean high tide mark,

<table>
<tr><th>DQO STEPS</th><th>MRS LOCATIONS</th></tr>
<tr><td></td><td><u>MC:</u>
Surface and subsurface soil sampling locations will be established based on locations of MEC/MD discovered during the geophysical investigation. Surface water samples will be collected in areas near streams and shorelines downgradient from areas containing MEC/MD discovered during the geophysical investigation,
Surface water and Sediment samples will be collected from down gradient streams and depositional areas downgradient from areas containing MEC/MD discovered during the geophysical investigation.</td></tr>
<tr><td>5. Develop a Decision Rule</td><td>The following decision rules will be applied to the MEC population and decision unit:
If MEC is discovered on the surface, subsurface, or the seafloor (within the underwater investigation boundary) of the MRS then a baseline MEC Hazard Analysis (MEC HA) based on future land use, potential receptors, and access will be performed and presented to the project team for further evaluation.
The MEC investigation will be halted if and when project objectives are met, (e.g. nature and extent of MEC has been determined for an MRS or a portion of an MRS*.) If the project objectives for MEC has not been met, grid or transecting step out processes will be implemented to collect additional data required to further bound the nature and extent of MEC contamination.
* Criteria taken from EM-110-1-4009, Chapter 7, Site Characterization.

The following decision rules will be applied to the MC population and decision unit:
<u>Surface and Subsurface Soil</u>:
If MC concentrations for each sample site are less than the screening values identified in Worksheet #15 of the UFP QAPP, then no further action for that area will be considered as it is delineated. If MC concentrations for each sample site are greater than the screening values identified in Worksheet #15, Step-out sampling will be conducted IAW the Step-out procedure Flow Chart included in the Sampling and Analysis Plan (SAP) in Appendix E. Step-out sampling will continue until MC concentration is at or below screening criteria, in which the contamination shall be delineated.
<u>Surface water and sediment:</u>
If MC concentrations for all sample sites are less than the screening values identified in Worksheet #15, then surface water at that site will not be considered to impact surface water or sediments within the MRSs. If a concentration exceeds the screening values for a given location, additional downstream samples will be collected until MC concentration is at or below screening criteria, in which the contamination shall be delineated.</td></tr>
<tr><td>6. Specify Limits on Decision Errors.</td><td>Measurable decision errors are limited to the field and analytical QC processes. The analytical requirements for MC are defined on Worksheet #12 of the UFP QAPP.</td></tr>
<tr><td>7. Optimize the Design for Obtaining Data</td><td>Data collection procedures and associated QC for MEC are included in the RI/FS Work Plan.

MC sample design and rationale is listed on Worksheet #17 of the UFP QAPP.</td></tr>
</table>

3.1.3 DATA INCORPORATION INTO THE RI REPORT

Field data and GIS data will be incorporated into the RI Report in accordance with DID MR 005-07.01. Maps will be submitted which show the locations of the areas searched, the search pattern, and the significant findings, as well as significant surface features within and adjacent to each MRS. Personal Digital Assistant (PDA) GPS/Data Collection equipment will be used to record location, terrain and vegetation data. A waypoint, brief description, and digital photograph will be electronically recorded for any MEC related items and significant metal detector responses. Locations and descriptions of ground scars, craters, vegetation, and terrain will also be recorded, and a tabulated list of MEC items located in the field will be provided.

3.1.4 EXPOSURE ANALYSIS

Once the nature and extent of MEC and MC hazards are characterized, the potential risk due to exposures to MEC and MC hazards will be assessed. Potential MEC risk for each MRS will be determined by evaluating the ordnance, site characteristics, and human exposure pathways. The ordnance category includes the type of MEC identified, the level of sensitivity (i.e., the potential adverse health effects associated with exposure to the specified MEC), the density of MEC in a specified area, and the depth of the MEC.

Initial Conceptual Site Models (CSMs) were prepared for each of the Culebra MRSs as part of the 2007 Final Site Inspection Report (Parsons). Three dimensional and wire-frame CSMs for the Culebra MRSs covered under this work plan have been updated IAW guidance document *EM-1110-1-100 Engineering and Design – Conceptual Site Models for Ordnance and Explosives (OE) and Hazardous, Toxic, and Radioactive Wastes (HTRW) Projects (2003)* and are included in Appendix Q. The CSMs may be updated as part of the RI/FS activities and final CSMs will be included in the RI/FS Report. A Potential MC Risk Assessment will follow EPA Risk Assessment Guidance for Superfund (RAGS) and USACE guidance in EM 200-1-4.

3.1.5 TIME CRITICAL REMOVAL ACTIONS

The procedures outlined in this Work Plan apply to a RI/FS. Should circumstances justify the need for a Time Critical Removal Action (TCRA), USA will develop procedures in accordance with USACE guidance.

3.1.6 FOLLOW-ON ACTIVITIES

The project will be closed upon USAESCH acceptance of the Decision Document and subsequent acceptance of the final invoice. At the time of the development of this Work Plan, the schedule projects the completion of the RI/FS with the Decision Document in June 2011.

3.2 IDENTIFICATION OF AREAS OF CONCERN

Each MRS is considered an area of concern (AOC). Within each MRS subareas indicative of the different types of ordnance training operations and ordnance types have been identified. Table 3-2 lists each AOC and subareas. The AOCs are described in the following sections.

Table 3-2: Areas of Concern and Subareas

AOC	Subarea	MEC Concerns
MRS 13- Cayo Luis Pena Impact Areas	See Figure B-3	
	Northern Island Impact Area	75mm MKI HE
	Underwater Area	5” HVAR MK 1
	Southern Island	5” MK 41
MRS 10- Defensive Firing Area No. 1	See Figure B-4	
	Beach Defensive Area	81mm M43 HE
	Direct Fire Area	3” Common MK 3 Mod 7

AOC	Subarea	MEC Concerns
	Underwater Area	81mm M43 HE
MRS 11- Defensive Firing Area No. 2	See Figure B-5	
	Mortar Boat Firing Area	4.2" M3A1 HE
	Beach Defensive Area	81mm M43 HE
	Direct Fire Area	3" Common MK 3 Mod 7
	Underwater Area	81mm M43 HE
MRS 06- Artillery Firing Area	See Figure B-6	
	Land Impact Area	37mm MK II
	Beach Defensive Area #1 & #2	81mm M43 HE
	Water Impact Area	37mm MK II
MRS 09- Soldado Point Mortar and Bombing Area	See Figure B-7	
	Mortar Boat Firing Area	4.2" M3A1 HE
	Aircraft Bombing Target	100lb AN-M30A1 HE
	Direct Fire Area	3" Common MK 3 Mod 7
	Water Target	37mm MK II
MRS 08- Cayo Norte Impact Area	See Figure B-8	
	Land Impact Area	75mm MKI HE
	Water Impact Area	5" HVAR MK 1

3.2.1 MRS 13 CAYO LUIS PENA IMPACT AREAS

MRS 13 has been subdivided into Northern Island Impact Area, Underwater, and Southern Island based on information provided in the Supplemental ASR (Supplemental Archives Search Report, Culebra, Puerto Rico, September 2005) regarding ordnance training histories. The northern tip of this island (Northern Impact Area) was used as a firing target during Marine exercises conducted between 1924 and 1941. Records show that 75mm projectiles were fired at the Cay in 1924 and that 155mm, 37mm, 8-inch, and 6-inch rounds may have also been used. In the 1960s, an observation point was erected on the hill top on Luis Pena, including a run-in line, helipad, and living quarters. Cayo de Luis Pena is managed by the USFWS as part of the Culebra National Wildlife Refuge.

3.2.2 MRS 10 DEFENSIVE FIRING AREA NO. 1

MRS 10 is located on the southwest peninsula of Culebra, south of the town of Dewey and north of MRS 09. It covers 547 acres and extends seaward 100 yards from mean high tide. The MRS has been subdivided into Direct Fire Area, Beach Defensive Area, and Underwater based on information provided in the Supplemental ASR (Supplemental Archives Search Report, Culebra, Puerto Rico, September 2005) regarding ordnance training histories. Marines conducted amphibious landing and ground maneuver training on the beaches and hills in this area from the 1920s through the 1940s. Specifically, the hill on the north end of the MRS has been listed as a 1935 area of direct fire from infantry and tanks, and Snug Bay was shown as a 1935 water area for direct fire. A 1924 outpost and ammunition storage area is located on the north end of the MRS near Snug Bay. MRS 10 has many residents and businesses. Most of the development is near the town of Dewey on the north end of the site; however, houses are scattered throughout the southeastern side of this MRS. This MRS is almost entirely privately owned except for municipality lands such as the police and fire stations MRS 06 Artillery Firing Area.

3.2.3 MRS 11 DEFENSIVE FIRING AREA NO. 2

MRS 11 is located on the west side of Culebra between Northwest Peninsula and the town of Dewey, and has been subdivided into Mortar Boat Firing Area, Beach Defensive Area, Direct Fire Area, and Underwater Area based on information provided in the Supplemental ASR regarding ordnance training histories (Supplemental Archives Search Report, Culebra, Puerto Rico, September 2005). The area is approximately 719 acres and extends seaward 100 yards from mean high tide. Most of the southern portion of this MRS has been extensively developed for residential use. The areas along the beach and the west side of this site are less developed. The land is privately owned with some municipality properties such as the school, hospital, and government buildings. Several training exercises were conducted in this area, including 75mm and 155mm firing from Firewood Bay at Mono Cayo and portions of Cayo de Luis Pena in 1924; FLEX No. 4 with firing of small arms and 81mm mortars in 1936; and FLEX No. 7 in 1941 with boat-to-beach firing of 5-inch and 6-inch projectiles.

3.2.4 MRS 06 ARTILLERY FIRING AREA

MRS 06 is on the eastern end of Culebra extending from a point at the most northern tip of Mosquito Bay, northeast to a point just west of Duck Point, and east to the end of the island. The MRS has been subdivided into Beach Defensive Area 1 and 2, Land Impact Area, and Water Impact Area based on information provided in the Supplemental ASR regarding ordnance training histories (Supplemental Archives Search Report, Culebra, Puerto Rico, September 2005). It covers 826 acres of land and extends seaward 100 yards from mean high tide. MRS 06 was used by the Marines for artillery firing points for exercises conducted between 1922 and the 1940s. Exercises involving small arms, Stokes mortars, 75mm pack howitzers, 3-inch mortars, and 37mm HE rounds were conducted in Mosquito Bay in 1936. Beginning in 1936, the Marines fired 75mm projectiles from a firing point inland of Mangrove Bay at Weather Channel near Culebrita. Additionally, 1937 U.S. FLEX No. 4 involved use of the lagoon area at the back of Mosquito Bay. In 1939, the Marines fired from 1,000 yards northeast of Mosquito Bay toward the cays to the east. From Mosquito Bay, 37mm rounds were fired west to water targets between Point Vaca and Snapper Shoal.

3.2.5 MRS 09 SOLDADO POINT MORTAR AND BOMBING AREA

MRS 09 is located on the very southern tip of the southwestern peninsula of Culebra and has been subdivided into Mortar Boat Firing Area, Aircraft Bombing Target, Direct Fire Area, and Water Target based on information provided in the Supplemental ASR regarding ordnance training histories (Supplemental Archives Search Report, Culebra, Puerto Rico, September 2005). It covers 328 acres and extends seaward 100 yards from mean high tide. In 1914, a 5-inch battery was established on Soldado Point. Several training exercises including mortar firing, aerial bombing, and strafing were conducted on Soldado Point and the bay northwest of Soldado point during the 1930s and 40s. The Supplemental ASR mentions that 30- and 1,000-pound bombs were dropped on targets near the Point Soldado, however supporting documentation did not indicate whether the bombs were live or practice. Munitions used in the bay included 30-pound fragmentation bombs, 100-pound demolition bombs, 81mm mortars, and small arms. This property is managed by the DNER; however, several shacks have been built along the water at Sueno cove.

3.2.6 MRS 08 CAYO NORTE IMPACT AREA

MRS 08 is located off the northeast coast of Culebra Island and has been subdivided into Land Impact Area and Water Impact Area based on information provided in the Supplemental ASR regarding ordnance training histories (Supplemental Archives Search Report, Culebra, Puerto Rico, September 2005). It includes Cayo Norte, which covers approximately 306 acres of land and extends seaward 100 yards from mean high tide. Cayo Norte was leased by the Marines for training; however, it cannot be determined from records whether the site was ever used for training. The property was leased in 1924 for erecting artillery targets for practice. The lease was ended in 1971. Notes on FLEX No. 5 indicate that impact of Cayo Norte was planned but that difficulties clearing people and cows from the island kept it from being used for an impact area. No UXO has been identified on Cayo Norte. Cayo Norte is privately owned with plans for residential development.

3.3 GEOPHYSICAL PROVE-OUT (GPO) PLAN AND REPORT

Based on previous agreement obtained during the project kickoff meeting, a GPO will not be required and has been replaced with a Geophysical System Test Strip Plan and Report.

3.3.1 GEOPHYSICAL SYSTEM TEST STRIP PLAN AND REPORT

In lieu of a GPO, daily analog and digital instrument response tests will be performed each morning. A combination of small Industry standard Objects (ISOs), intended to simulate 37mm projectiles, and large ISOs, intended to simulate 105mm projectiles or 4.2 inch mortars, will be used in each test strip. The response curves for these ISOs are well documented for both the best case orientation (vertical) and the worst case orientation (horizontal). Four of each ISO will be used; two horizontal at depths 3 and 7 times ISO diameter, and two vertical at the same 3 and 7 times diameter depth. EM61-MK2 responses for each seed item will be compared to published response curves to ensure the equipment is performing as designed. There is no need to bury test objects at their deepest detectable depths. A dynamic background line will be acquired in each MRS to establish Root Mean Square (RMS) noise levels for each time gate. An initial anomaly selection threshold, 5 to 6 times the RMS noise level will define the depth detection limits for each MRS. An example plot of the EM61-MK2 time gate 2 small ISO detection response curves is provided below. An ideal background RMS noise level of 1 mV and an Anomaly Selection Threshold of 5 mV are shown. Note for this example, the small ISO is detectable to 8.66 inches in its worst case orientation and to 25.59 inches in its best case orientation. Actual distances between test strip seed items may vary, based on background anomalies. Final seed item depths may be limited by bedrock or water intrusion or analog detection limits over the smallest expected MEC within the MRS (i.e., 75mm projectile for Cayo de Luis Pena) buried horizontal at its typical maximum detection depth (11 times diameter or the maximum consistent analog detection depth) or the maximum depth obtainable, if limited by bedrock or water infiltration. A medium Industry Standard Object (ISO) will also be included in the daily instrument test strip. Although the medium ISO (2" x 8" pipe nipple) is smaller than a 75mm projectile, its detection response curves for these ISOs are well documented and will be used to assess daily EM61-MK2 performance. The location of the response test strip will be varied from MRS to MRS and may even vary within an MRS to ensure that local geological, vegetation, and terrain variations are considered. The response test strip will be used in the daily morning and afternoon DGM latency tests or the morning analog system tests near the start and end of each day's survey.

Table 3-3: Example Test Strip Design

Culebra RI/FS Test Strip Design				
Seed Item	X (ft)	Y (ft)	Depth to object center	Orientation
Start	0.00	0.0	0"	Vertical
Small ISO	10.00	0.0	3"	Horizontal
Small ISO	20.00	0.0	3"	Vertical
Small ISO	30.00	0.0	7"	Horizontal
Small ISO	40.00	0.0	7"	Vertical
Large ISO	50.00	0.0	12"	Horizontal
Large ISO	60.00	0.0	12"	Vertical
Large ISO	70.00	0.0	28"	Horizontal
Large ISO	80.00	0.0	28"	Vertical
End	90.00	0.0	0"	Vertical

This space is intentionally left blank.

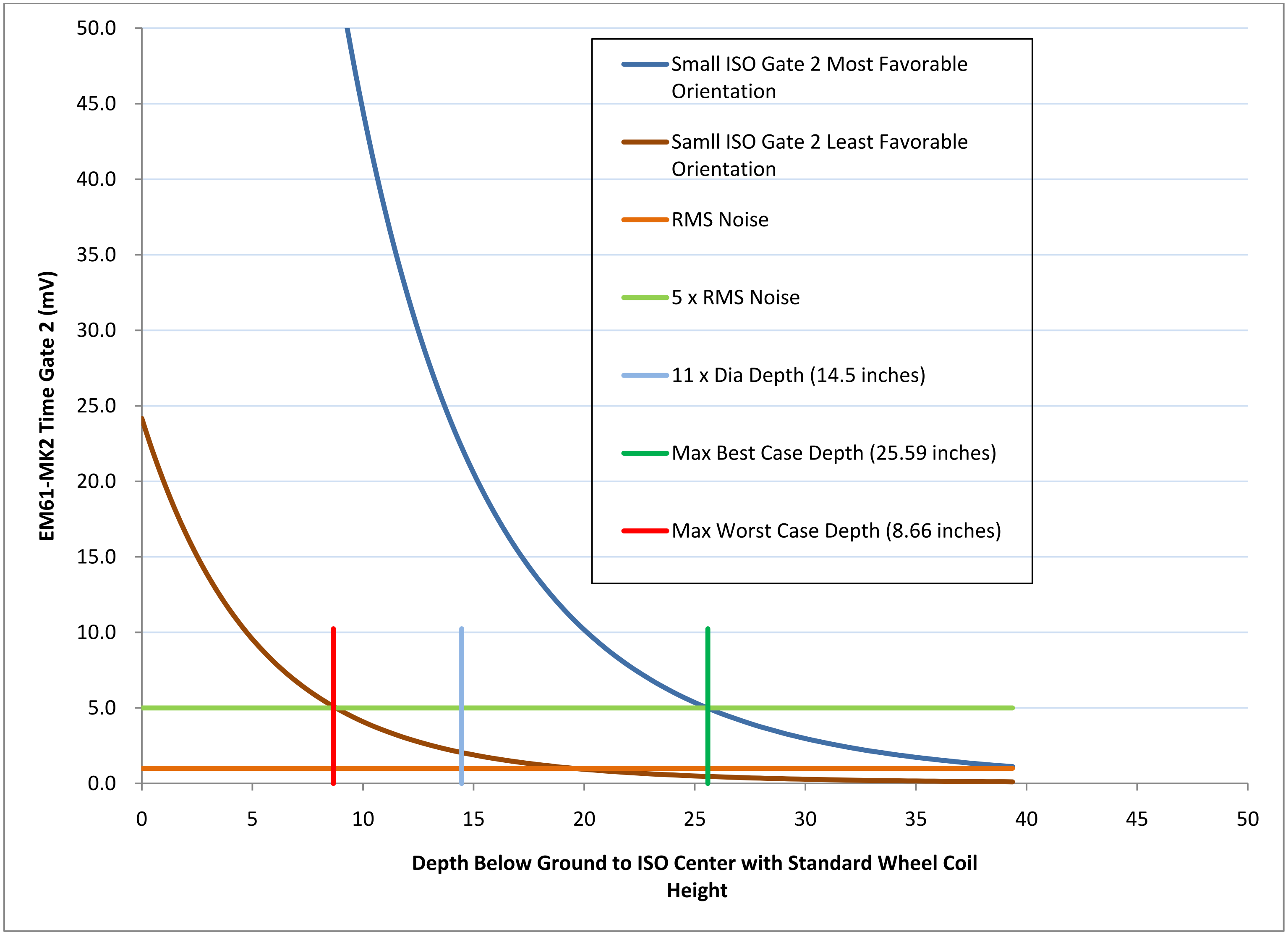

Figure 3-1: Example Small ISO EM61-MK2 Time Gate 2 Response Curves

Naval Research Laboratory Report NRL/MR/6100—09-9183 EM61-MK2 Response of Three Munitions Surrogates dated March 12, 2009

USA believes this approach will provide better transect anomaly selection metrics (peak amplitude and anomaly width [e.g., full width of peak at half maximum]), as the deepest anomalies will be along beaches or other deep soil areas, and the shallowest anomalies will be along rocky portions of the each MRS such as upland mountains and rocky portions of beaches.

In order to evaluate DGM grid survey line spacing (e.g. every 2.5 ft), the initial test strip will include a set of DGM transects, parallel to the test strip centerline. This simulated grid data will also provide a database to evaluate grid anomaly selection criteria (e.g. Sensor time gate, anomaly selection threshold, Signal to Noise Ratio (SNR), Signal Strength, and anomaly size. Combinations of these anomaly characteristics may be used to classify grid anomalies as MEC-like or Not MEC like.

In addition to the simulated grid, the initial test strip survey will include multiple passes over the test strip centerline, and several half-line spacing offsets to document the range of dynamic detection seed item responses. All of these will be documented in the IVS/geophysical report.

USA uses Standard Operating Procedures (SOPs), included in Appendix K, for geophysical use, processing and analysis, and anomaly reacquisition. USA demonstrates DGM anomaly reacquisition at the initial instrument response test strip with the Trimble's Pathfinder Pro XRT, or equivalent hand held DGPS with external antenna, and the EM61-MK2 operating in real time monitor mode. This will include stakeout of test strip centerline transect anomalies, as will be performed on MRS 13, Cayo de Luis Pena, as well as the simulated grid anomalies, as will be performed on all other MRSs. Note that the daily analog checks over the geophysical test strip are used to verify the detection performance of the White all metals detector, model Surf PI Dual Field or DXF 300 All Metals Detector, with enhanced hot rock rejection capabilities, or other analog instrument shown to provide reliable results at the test strip being used for analog transects. Geophysical task-specific data quality objectives (DQOs) are provided in Appendix O.

The test strip results and anomaly selection criteria will be provided to USACE's geophysicist prior to starting field work. Any recommended changes to the anomaly selection criteria will be discussed with USACE's geophysicist prior to implementing.

Initial test strip results will be used to establish the range of dynamic ISO responses. These will be compared to the published static ISO responses as a general performance check. If the initial test strip results fail to approximate published responses, a root cause analysis will be performed and a recommended corrective action proposed that may include equipment repair/replacement, more operator training/replacement, and the test strip repeated. Daily test strip results will be compared to the initial test strip response values. If the daily tests strip results fail to match the initial test strip results, then the same root cause analysis will be performed and a recommended response action proposed/implemented. The failing daily test strip will be repeated, and any data collected with a failed system will be recollected.

Blind seed items (BSIs), placed by USA's UXOQCS, will be used in all DGM grids, following standard anomaly avoidance procedures. BSIs are not included along transects, as no intrusive operations are planned along them. Transect data are used to develop anomaly density maps which will help place DGM grids to determine the nature and extent of potential MEC contamination in each high density area. The small ISO (37mm projectile simulant) will be used as BSIs and will be buried at depths between 3.9" (3 x dia.) and 9.2" (7 x dia.) measured from ground surface to item center and a variety of orientations. The range of small ISO responses at the test strip will be used to establish the expected range of BSI responses in production DGM grids.

USA will document the results of the initial instrument response test strip in a Geophysical System Test Strip letter report that will document test strip setup, analog and digital geophysical detection results, grid line spacing test results, initial grid anomaly selection criteria, and DGM anomaly reacquisition results and recommended final performance metrics. The initial test strip will be established in a typical challenging wooded portion of the MRS to verify acceptable geophysical system performance. Assuming the geophysical systems are performing as designed, USA expects same-day review of the initial test strip results, finalization of project geophysical metrics, and concurrence to proceed immediately to production DGM.

Although the high resolution underwater video camera and the VideoRay remote operated vehicle (ROV) and smart tether are not strictly a geophysical system, they will be used to collect visual data for underwater MEC, critical habitat and endangered species investigations around all MRSs. The underwater video camera and ROV are checked each morning at its initial transect marking buoy clump. The underwater transect is marked with a peanut buoy and weight (clump) that is positioned with the Trimble GeoXH, or equivalent, with an external antenna. Once the transect point is marked, the buoy line is plumbed and an actual DGPS location is recorded. The underwater video camera and ROV use the clump to verify visual detection and to measure the clump's location. The measured clump location is compared to the surface DGPS location for accuracy within 2m.

3.4 GEOPHYSICAL INVESTIGATION PLAN

Upon acceptance of the geophysical system verification, USA proceeds to collect land transect data to satisfy the project DQOs of the RI. Transects acres were converted to miles, using the PWS provided, 2.75 miles per transect acre as the conversion factor. All required grid acres were assigned to land portions of each MRS. The PWS coverage for each MRS has been divided equally between land and water resulting in 8.25 miles of land transects and 8.25 miles of underwater transects, Underwater data collection is to be included in future efforts. The left portion of Table 3-4 below summarizes the PWS coverage requirements and the Land/Underwater split.

Land transects include upland transects that will be characterized using DGM techniques and beach transects that will be characterized using analog and dig techniques. Transects were planned for each MRS, focusing on historical munitions use areas, yet covering the entire MRS, including all beach areas. MRS terrain maps were used during the transect planning to follow MRS elevation contours as much as possible and to avoid slopes greater than 30 degrees. All DGM transect data will be analyzed for potential MEC anomalies. These potential MEC anomalies will be imported into the project GIS to create anomaly density maps, using ESRI's Spatial Analyst, for each MRS. High anomaly density areas that exceed background density by a factor of 5 or more will be considered potential MEC firing points or target areas.

The assigned number of grids was put onto each MRS map simply as place holders. The final grid locations will be decided, based on DGM transect anomaly density maps to refine the nature and extent of each high density area. At least one grid will be placed at the maximum density portion of each high density area to provide better RI follow on removal action cost data. Additional grids will be spaced around each high density area to better define the nature and extent of MEC contamination The right portion of Table 3-4 below summarizes the investigation design (acres of DGM transects, acres of analog transects, plus acres of DGM grids. The geophysical investigation total is compared to the MRS acreage to assess the percentage of MRS investigation coverage. The mean transect spacing is included for each MRS as a reference. The total MRS coverage is also compared to the PWS coverage requirement to ensure the investigation design meets or exceeds PWS requirements, See North, Land, Beach, and Underwater Transect Maps (Appendix B) for the idealized transect design. Appendix B contains the investigation design maps for each MRS. A summary coverage table is included on each map.

USA follows DID MR-005-05.01 Geophysics to collect, assess, process, analyze, and deliver geophysical data.

Table 3-4: MRS Design Coverage

MRS	Land Acres	Water Acres	DGM Transect Acres	DGM Grid Acres	Analog Transect Acres	Water Video Transect Acres	Geophysical Acres	MRS Coverage
13	484.00	380.00	0.00	0.00	2.00	9.24	11.24	1.30%
10	522.00	25.00	4.18	0.98	0.29	3.34	8.78	1.61%
11	694.00	25.00	4.55	0.98	1.06	3.98	10.56	1.47%
6	826.00	0.00	3.02	1.00	1.05	4.07	9.14	1.11%
9	203.00	125.00	1.08	0.98	0.15	3.10	5.31	1.62%
8	306.00	0.00	1.44	0.50	0.35	2.02	4.31	1.22%

3.4.1 UPLAND DGM TRANSECTS AND GRIDS

Upland transects will require devegetation prior to DGM. The devegetation crew will use the Trimble Pro XRT DGPS, or equivalent, to follow each transect, following a path of least resistance to help minimize devegetation and avoiding all properties where a Right of Entry (ROE) has not been signed. A certified botanist/biologist will accompany the devegetation crew to ensure critical habitat or endangered species are avoided (see Section 7.2). Along upland transects where vegetation clearance is to be minimized, transects will be cleared with a machete, or equivalent, to a width of 1.5m (about 5 ft) to allow passage of the 1m wide EM61-MK2 coil, to a height of 6 ft One member of the devegetation crew will mark each transect with surveyor tape, approximately every 100 feet. On upland locations, the digital sensor will be an EM61-MK2 in either the standard wheel mode or in stretcher mode. Along upland transects, the EM61-MK2 will be deployed with the wide (1m) edge forward and positioned with a Trimble Pro XRT, or equivalent, with an external antenna (see Figures 3-1 and 3-2). During upland DGM transects, a UXO technician will guide the DGM operator along each planned transect using a second GeoXH for guidance, following the path cleared and marked by the devegetation crew. The third member of the land DGM team will maintain the field log book, and help lift the EM61-MK2 over any obstacles or help carry the EM61 in stretcher mode. Selected DGM transect anomalies will be loaded into the project GIS database and used to create anomaly density maps for each MRS. Initial upland transects were selected based on topography and an attempt to cover most of the each MRS. These locations have been revised based on subsequent input from the TPP and a post-award site visit. DGM performance metrics will follow those listed in the PWS Table 7-1 Performance Requirements for RI/FS using DGM Methods (Appendix A For purposes of data quality acceptance, the morning and afternoon transect data collections are considered two (2) lots of DGM data.

On MRS 13, instrument assisted reconnaissance will be performed along all known trails and roads to identify surface MEC.

On all other MRSs, 50-ft x 50-ft grids, or equivalent rectangular areas, will be established in each high anomaly density area to provide the necessary data to establish the nature and extent of MEC contamination. Grid locations will be selected with one grid at the center or peak of the high density areas to provide better removal action cost estimates. Other grids overlapping the edges of the high density area will be used to better document MEC extent at each high density area. DGM grid locations will be staked out using the Pro XRT with the external antenna mounted to a telescoping range pole, capable of extending 25-ft. Each grid area will be surveyed by the project botanist/biologist to avoid all critical habitat and endangered species. Once a grid is established and accepted by the biologist/botanist, it will be devegetated the same as the transects were, with the edges of each grid extended approximately 5-ft to allow the DGM sensor/operator to safely turn around. The cleared grid will then be seeded with a dynamic repeatability item (small ISO buried 3 to 7 times its diameter), and surveyed with the EM61-MK2, positioned with the Pro XRT, or traditional line, station, fiducials, if DGPS proves to be inadequate. Grid survey line spacing, necessary to reliably detect objects as small as a 37mm projectile are planned to be every 2.5 ft. Expected grid coverage is 95% or greater at the 2.5 ft line spacing. All unavoidable obstacles in any grid will be located with the Pro XRT and documented in the DGM maps. Grid anomalies will be selected, as approved at the initial test strip. Dig lists and target maps for each DGM grid will be provided to the project PDT for review and approval. USA will recommend a set of anomalies to intrusively investigate in each MRS, up to the allotted amount of digs in the PWS. Grid DGM anomalies will be reacquired using the same positioning system used to survey the grid (e.g. Pro XRT DGPS or tape measures). The EM61-MK2 will be used to refine each anomaly, as well as providing post-intrusive assurance that the anomaly source has been successfully identified and removed. For purposes of data quality acceptance, each DGM grid is considered a lot of DGM data.

Survey speeds are designed to be 3.4 miles per hour or less. DGM transect repeatability is documented at the geophysical test strip each morning and afternoon. DGM anomaly selections are based on daily test strip results. Geodetic positioning is provided by the Trimble's Pathfinder Pro XRT GeoXH, or equivalent, with an external antenna. The average position accuracy provided by the Trimble GeoXH Pro XRT is expected to be within 1m in open areas and within 2m in heavily wooded areas. Dynamic DGM detection metric for grids is: Test item characteristics (peak response and size) repeatable with allowable variation of +/-25%. Dynamic DGM detection metric for transects is: Test item in test strip anomaly characteristics (peak response and size) repeatable with allowable variation +/-25%. Dynamic DGM positioning metric for grids is: Position offset of test item target <=35cm + ½ line spacing (e.g. <=2.4 ft for 2.5 ft line spacing) or <=50cm + ½ line spacing (e.g. <=2.9 ft for 2.5 ft line spacing) for fiducially positioned data. Dynamic DGM positioning metric for transects is: Test item position offset <=2m. Dynamic Analog detection repeatability metric is: Repeat a segment transect and show extra flags not greater than the greater of 20% or 8 flags, or within range of adjacent segment. The transect guidance Trimble Geo XH, with internal antenna, is expected to provide accuracies within 2.5m in heavily wooded areas, however, upland transects will be clearly marked and devegetated.

In the event DGPS proves to be unreliable in positioning the EM61-MK2, the EM61-MK2 may be used in the EM and flag mode. The operator monitors the EM61-MK2 output in real time, flags all anomalies that exceed selection threshold, and uses the DGPS telescoping range pole to document the location of each flagged anomaly.

3.4.2 ANALOG BEACHES

On the accessible beaches in each MRS, USA will use an analog sensor (e.g. White's Surf PI Dual Field or DXF300 All Metals Detector, or other analog instrument shown to provide reliable results at the test strip)in the traditional Analog and Flag mode, marking each anomaly with a large metal washer tagged with surveyor tape. During beach and beach buffer area transects, a UXO technician will guide the Analog operator along each transect using a Geo XH Pro XRT DGPS, or equivalent, for guidance. The field team leader will follow the instrument operator to help ensure transect coverage, and to record the location of each flagged anomaly using a second Pro XRT. Initial beach and beach buffer area transects are selected from aerial photographs and an assessment of beach access. Beach transect locations may be revised based on subsequent TPP input or the post-award site visit. Any beach that requires access from the water is clearly marked on each MRS map. All precautions necessary to avoid critical habitat or endangered species and safe boat operations will be followed.

3.4.3 ANOMALY SELECTIONS

DGM data is processed on-site by USA's Site Geophysicist, as demonstrated at the initial geophysical test strip. Based on the initial instrument response over the background portion of each test strip on each MRS, the dynamic background RMS noise levels will be determined. An initial anomaly selection threshold of 5 times the RMS noise level and spatial extent (e.g. full width at half maximum) needed to select all test strip seed items will be established over the smallest expected MEC item (e.g. a 75mm projectile) buried horizontal at its typical maximum detection depth (e.g. 11 times diameter = 32 inches), an anomaly selection threshold and spatial extent (e.g. full width at half maximum) is determined for DGM transect anomaly selection.

All transect anomalies are forwarded and imported into the project GIS database and an anomaly density map is created for each MRS.

Grid anomalies are selected using the same selection threshold as the transect anomalies in each MRS and classified as MEC like or Not MEC like using the classification criteria established at the initial test strip, and documented in the initial test strip report. The selections are reviewed by the Site Geophysicist and the Corps' representative. If the total number of grid anomalies is below the PWS number of digs, all grid anomalies will be investigated. If the number of grid anomalies exceeds the PWS number of digs and an on-site determination is made as to which of the selected anomalies will be intrusively investigated by the PDT.

See Table 3-5 below for the number of digs in each MRS. The split between DGM digs and analog digs is 90% DGM and 10% analog.

Table 3-5: PWS Digs in each MRS with Split Between DGM and Analog

MRS	PWS Digs	DGM Digs	Analog Digs
13	350	0	350
10	350	315	35
11	400	360	40
6	450	405	45
9	200	180	20
8	250	225	25

3.4.4 ANOMALY INVESTIGATION APPROACH

For the Culebra RI/FS, the total amount of anomalies to be investigated for each MRS is based on the funded amount stated the PWS. In most MRSs, anomalies selected for investigation will be selected from a combination of DGM grids and analog beach transect surveys. During the initial TPP, it was decided that there will be no underwater intrusive investigation until after a formal consultation with the USFWS is completed. Our approach for distributing intrusive investigations over the MRS is to distribute 90% to DGM Grid anomalies and 10% to analog transect anomalies. Any future underwater intrusive investigations will be addressed under a separate mobilization, unless otherwise directed.

If a selected anomaly proves to be inaccessible (e.g. below bedrock or under seeping water), it will be noted on the dig list and another anomaly in that MRS DGM grid or Analog transect is selected. If the selected anomaly proves to be a Blind Seed Item, an alternate anomaly will be selected.

If sufficient intrusive results have been acquired to characterize the nature and extent of MEC contamination in an area/grid/transect, USA will notified the PDT and request confirmation to halt further anomaly investigations in that area/grid/transect. If the PDT determines that a data gap still remains, then the anomaly investigation in that area/grid/transect will continue as designed.

If sufficient data for establishing the nature and extent of MEC contamination has not been achieved (e.g. impacted MEC is discovered within 15 feet of an MRS boundary or high density area), a step-out procedure will be implemented. This may include additional analog transects along MRS beaches or additional DGM transects or grids. Step-out transects or grids will be designed to document the extent of MEC contamination from the step-out trigger point. Step-outs will be limited to no more than 3 step-outs per event.

3.4.5 GEOPHYSICAL DATA DELIVERY

Digital and analog geophysical data and QC information will be submitted in accordance with DID MR-005-05.01 (e.g. Access Database).

3.5 UNDERWATER VISUAL INVESTIGATION

USA will conduct an underwater visual survey along transects within 100 yards seaward of mean high tide in order to collect data that satisfy the project DQOs. Investigation depth will not exceed recreational diving depths (120ft) Visual and positioning data related to suspected MEC items will be collected using a combination of a GPS-integrated underwater video system and VideoRay ROV system.

Where water depths and site conditions allow access by small boat, a pole/hull-mounted underwater video camera will be deployed and monitored as the vessel progresses down each transect. The boat will be accurately maneuvered through use of a GPS-integrated Personal Digital Assistant (PDA) displaying the transect line, while a UXO Technician monitors the video display. Digital video footage is recorded onto a lap top computer, noting the latitude and longitude of the camera position. The UXO technician will note suspected areas of interest along transects. In addition, a post survey review of the video footage will be conducted by a UXO Technician to identify suspected MEC items along the seafloor.

Items that reflect characteristics of MEC items will be required and investigated further with the ROV as required in order to capture video footage of the item and the surrounding underwater environment. Procedures for ROV operations are detailed in the ROV SOP located in Appendix K.

Where water depths and site conditions do not allow access by small boat, a visual survey will be completed using the VideoRay ROV deployed from shore, or support boat situated in deeper surrounding waters.

3.5.1 UNDERWATER STEP OUT PROCEDURE

In the event that a suspected MEC item is encountered along each transect, an expanded survey will be completed within an estimated 100-foot radius of the item (200 ft diameter; 31,415 sq ft; 0.72 acres). The expanded survey is intended to identify any additional MEC items located in close proximity, which may indicate the previous presence of a waterborne target or concentrated aiming point.

If an additional item/s is located, one additional 100-foot radius will be surveyed (from the position of the item most distant from the initial point) in order to characterize the boundary of the potential area of concentration. The step out process will continue out as far as the 100 yard seaward mean high tide mark.

3.6 GEOSPATIAL INFORMATION AND ELECTRONIC SUBMITTALS

This chapter details procedures that USA will use to perform mapping and GIS integration during the RI/FS. USA developed this plan in accordance with DID MR-005-07.01.

3.6.1 ACCURACY

USA will establish survey control on the site using Class I, Third Order control monuments. The horizontal control will be based on either the English or the metric system and referenced to the NAD83 and the UTM Grid System. Vertical control is not required for this project. Any control points established or recovered will be constructed of iron or steel pins, concrete monuments, or other permanent construction method meeting the standards found in EM 1110-1-1002. This construction will ensure recoverability for any current or future work at the site. USA will use a professional licensed surveyor (PLS) registered in Puerto Rico to complete all surveying requirements, which include: installing control points, internal grid corners, and site boundaries. The northing and easting (X and Y) coordinates for all control points, grid corners, and project boundaries will be presented in a certified letter or drawing at the completion of the MR. The PLS will provide all required data and include the project-specific coordinate system, datum, and units (e.g., UTM Coordinate System, Zone 17 North, NAD83, and units in meters).

3.6.2 GIS INCORPORATION

The GIS database will be maintained at the USA corporate office located in Oldsmar, Florida. The GIS Manager will manage the database, which is used to store preliminary and final or published versions of project GIS data. It is the official project repository of GIS data, including unprocessed feature and attribute data sources that may be used outside the GIS. The Oldsmar-based database is the main location for processing data sources into draft and final GIS products, as well as for production work.

USA will produce ArcGIS Projects in accordance with the PWS and DID MR-005-07.01, and will update the GIS as often as necessary to enable planning and coordination of daily, weekly, and monthly activities. Acreage clearance estimates will be prepared and revised based on the latest design drawings provided to USA. The ArcGIS project will be prepared in ArcGIS 9.x format and be compatible with ArcGIS 9.1.

MEC items that are found and either moved or BIP will have the original coordinates documented within the GIS. The layers will be completely independent, and produce a concise picture of all clearance activities completed during this contract. Supporting tabular data will be provided in Microsoft Excel and/or Microsoft Access format at the completion of the project.

Throughout the project, USA will build the GIS database upon existing data and integrate the field data into the system. To enhance accuracy of the field data, USA will collect the field data using a ruggedized handheld GPS and electronic data collection system. These data will be downloaded on site on a daily basis and digitally transferred to USA's Corporate Headquarters on at least a weekly basis. Upon receipt of the field data, the GIS Manager will perform an accuracy inspection of the data and import this data into the project GIS.

All GIS data will be in ESRI Shapefile or Geodatabase format. Raster data such as orthophotography will be in Tagged Image File Format (TIFF) or MrSID- compliant format. Associated databases will be in Microsoft Excel format.

3.6.3 PLOTTING

All control points recovered or established will be plotted at the appropriate scale for the parcel being described. Parcels less than 10 acres will be plotted at 1:200. Parcels 10-100 acres will be plotted at 1:600 (1" = 50'). Parcels larger than 100 acres will be plotted at 1:2400 (1" = 200'). A sheet index for the project will be prepared that includes enough of the planimetric data to indicate the sheet's geographical location in the project area. This index will be shown on each map with the current sheet crossed-hatched or heavily outlined. If required, a separate sheet file may be utilized for the index.

3.6.4 MAPPING

The location, identification, coordinates, and elevations of all control points recovered or established at the site will be plotted on a map. Each control point will be identified on the map by its name and number and the final adjusted coordinates and elevations. The coordinates for grid corners will be shown to the closest 1.0 ft. Locations of individual recovered MEC items will be located to a horizontal accuracy of plus or minus 1 ft within the grid and plotted on a map. Maps will have a revision block, title block, index sheet layout, legend, grid lines, scale bar, and a true north arrow. In general, the direction of north will run from the bottom of the file to the top, with no skew. A legend showing the standard symbols used for mapping will be on the map as well as a map index showing the site in relation to all other sites within the project boundary.

3.6.5 DIGITAL DESIGN DATA

All GIS Data will be delivered in ESRI Shapefile format. A READ ME file will be included with delivered data, which will contain basic information about each Shapefile.

3.6.6 COMPUTER FILES AND DIGITAL DATA SHEETS

All final document files will be delivered to USAESCH in IBM and MS Office compatible formats. The drawing and plot data will be provided in the UTM Coordinate System, NAD83, and units in meters. GIS data will be submitted in ESRI Arc Map-compatible format. Raster data, such as USGS Topographic Quadrangles or Orthophotography will be provided in either TIFF or MrSID format. All ArcGIS project files (.mxd) will be supplied with the appropriate final report. In addition to GIS data and project files, maps will be delivered in PDF format for viewing without modification.

All final GIS data generated from this project will conform to the Spatial Data Standards for Facilities, Infrastructure and Environment.

3.7 INTRUSIVE INVESTIGATION

3.7.1 GENERAL METHODOLOGY

Intrusive investigations are currently planned on the land and portions of each MRS. General and specific methods planned for use during intrusive investigations are discussed in the following sections. In addition, the methods for documenting MEC items are described as well as the required qualifications of personnel involved in the investigation and disposal of MEC. All intrusive activities, including recovery, management, storage and disposal of MEC items are performed in compliance with applicable DOD and Army requirements, including DOD 6055.9-M, *Ammunition and Explosive Safety Standards,* TM 60A 1-1-31*, Explosive Ordnance Disposal Procedures,* AR 385-64, *Ammunition and Explosives Safety Standards,* EM 385-1-1, *Safety and Health Requirements Manual,* DDESB TP-18*, Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel.*

3.7.2 ACCOUNTABILITY AND RECORDS MANAGEMENT FOR MEC

A detailed account of all MEC and non-MEC materials encountered during the investigation will be maintained. A log entry of all MEC related materials located in a transect or grid will be made in the database indicating amount, identification, condition, depth, and disposition. A log entry will be made for non-MEC materials, indicating the general types of materials encountered and pounds excavated. Digital and analog geophysical data and QC information will be submitted in accordance with DID MR-005-05.01 (e.g. Access Database).” will be included.

USA will not remove scrap small arms cartridge cases during any excavation. Munitions Debris and cultural debris may be stored in the same general area in separate, lockable (sealed) containers but not commingled. Certification by the UXOQCS and SUXOS that the Munitions Debris are inert and free of energetic material will be made on DD Form 1348-1A.

All land excavations will be filled in and tamped to the approximate consistency of the surrounding soil. The excavation site shall be returned as nearly as feasible to an undisturbed condition.

3.7.3 PERSONNEL QUALIFICATIONS

3.7.3.1 UXO Team Personnel

UXO teams will consist of qualified personnel approved by USACE. Non-UXO qualified personnel will not perform any excavation or handle MEC. As required by the specific task, all USA personnel on this project will complete the Occupational Safety and Health Administration (OSHA) 40-hour training course for hazardous waste site workers and an 8-hour refresher course as appropriate. Management and supervisory personnel will also complete supervisory training and refresher training as required by CFR 1910.120 e (4) & (8). Additional site-specific training, in accordance with 29 CFR 1910.120, EM 385-1-1 (USACE Safety and Health Requirements Manual), and ER 385-1-92 (Safety and Occupational Health Document Requirements for Hazardous, Toxic, and Radioactive Waste (HTRW) Activities) will be provided to all personnel upon their initial mobilization. A Medical Surveillance Program is in place with the latest examination within the last 12 months.

All personnel must meet the requirements set forth in DDESB Technical Paper (TP) 18, Personnel/Work Standards. UXO personnel will be U.S. citizens and graduates of the U.S. Naval EOD School, Eglin AFB, Florida; the U.S. Army Bomb Disposal School, Aberdeen Proving Ground, Maryland; the U.S. Naval Explosive Ordnance Disposal (EOD) School, Indian Head, Maryland; the EOD Assistants Course, Redstone Arsenal, Alabama; the EOD Assistants Course, Eglin AFB, FL or a DOD-Certified equivalent course. Credit for the EOD experience while assigned to the National Guard or Reserve will be based on the actual documented time spent on active duty, not on the total time of service.

3.7.4 MEC SAMPLING LOCATIONS AND PROCEDURES

Each MRS includes land investigation sampling locations include transect anomalies in MRS 13.Sampling locations for all other MRSs will be on both transect and grids. Underwater visual surveys will be conducted in locations where suspect MEC items are discovered along transects.

3.7.4.1 Land Investigation

Based on historical data including the Ordnance and Explosives Waste Archives Search Report (Feb 1995), Inventory Project Report (INPR) (USACE, July 2005), Supplemental Archive Search Report (USACE, Sept 2005), and Final Site Inspection Report (USACE, Sept 2006), transects will be located across the each MRS in areas that will be accessible by foot following any necessary brush removal activities. To the extent practical transects will be spread evenly across the entire MRS. Geophysical investigation will proceed with transects. Following geophysical investigation of transects, to create anomaly density maps, and grids, to establish the nature and extent of potential MEC contamination in each high density area, the team will coordinate with the PDT to select upland anomalies for intrusive investigation. Selection of anomalies to investigate will give full consideration to potential impact on sensitive habitats within the MRS. Note that beach analog and dig anomalies will be selected and investigated the same day by the analog team leader. Upland DGM transect anomalies will be available for review the same week as the DGM survey, but this review needs to done immediately so that intrusive operations can begin the next week, as only a single mobilization is planned.

All anomalies identified for sampling will be intrusively investigated, unless removal of surface metallic debris can be verified as accounting for the mapped geophysical anomaly. The MEC teams will provide a description of the item to include recovery depth and item orientation in a handheld personal data assistant (PDA). Intrusive investigation excavations will continue until the anomaly source has been positively identified. Excavation of anomaly locations will be performed in accordance with the procedures outlined in the following subsections. Delayed excavations will be reported to the Site Project Manager/SUXOS and scheduled for future excavation.

Anomalies within 3 feet of the surface will be excavated using hand tools. Anomalies close to the surface will be excavated by carefully removing the earth overburden using a hand shovel/trowel or other small digging implement. Throughout the excavation, the UXO Technicians will use a hand-held Whites Surf PI Dual Field Metal Detector to check and verify the proximity of the anomaly.

Anomalies deeper than 3 feet may require excavation using heavy equipment (e.g., backhoe); applies to areas were access is available. For these excavations, personnel will coordinate equipment operating requirements with the SUXOS. Prior to the arrival of the heavy equipment, the UXO Technician III will ensure that a cleared entrance and egress path is available for the heavy equipment. The UXO Technician III will designate one person to direct the heavy equipment operator. Heavy equipment (operated by a qualified UXO Technician) or manual digging tools will be used to excavate the earth overburden in 6-inch lifts. After each lift, the anomaly location will be redefined with appropriate instrumentation and the anomaly source investigated using hand tools. This process will continue until the source of the anomaly has been uncovered and identified.

Before entering an excavation, the UXO Technician must make eye contact with the backhoe operator. When a UXO Technician is checking backhoe excavations for suspected MEC-source proximity, the backhoe bucket will be placed on the ground and the operator will keep his/her hands clear of the operating controls. The backhoe operator will resume excavation operations only after visually verifying that all personnel are clear of the excavation and outside of the bucket swing area.

Equipment requirements for this activity includes: instrumentation used for the instrument-assisted ground reconnaissance, including hand-held Minelab Explorers II and Trimble GeoXH, or equivalent, DGPS/Data Collection tool and miscellaneous common hand tools (e.g., screwdrivers, digging implements). A backhoe and demolition equipment and explosives required for MEC disposal may be necessary.

3.7.4.1.1 MRS 13 Cayo Luis Pena Impact Areas

In MRS 13, MEC sampling will be limited to investigations along accessible trails and beach areas. In order to minimize vegetation removal within the National Wildlife Refuge, only transect sampling will be employed, as opposed to grid sampling, which typically requires more extensive vegetation removal than transects. To satisfy the MEC component of the DQO for MRS 13, only surface MEC sampling will occur along the accessible portions of the existing trails on Cayo Luis Pena. MEC sampling for accessible beach areas will consist of surface and subsurface analog investigations.

3.7.4.1.2 MRSs 10, 11, 6, 9, and 8

The investigation approach of these MRS sites is to collect analog and digital transect data, use this transect anomaly data to produce anomaly density maps. Reposition investigation grids in and around each high density area (greater than 5 times background density). Collect all grid data and analyze for MEC-like anomalies, based on simulated grid test strip data. Intrusively investigate grid anomalies to establish the nature and extent of MEC contamination.

3.7.5 MUNITION WITH GREATEST FRAGMENTATION DISTANCE (MGFD)

The MGFD for each MRS are shown in Table 3-6 below.

3.7.6 MINIMUM SEPARATION DISTANCES (MSD)

The MSD for each MRS are shown in Table 3-6 below.

Table 3-6: MGFDs and MSDs

MRS	Subarea	MGFD	MSD (HFD[1]/ MFD[2])
MRS 13- Cayo Luis Pena Impact Areas	Northern Island Impact Area	75mm MKI HE	239 ft / 1,873 ft
	Underwater Area	5” HVAR MK 1	349 ft/ 2,328 ft
	Southern Island	5” MK 41	359 ft / 2,377ft
MRS 10- Defensive Firing Area No. 1			
	Beach Defensive Area	81mm Mortar	247 ft/ 1,579 ft
	Direct Fire Area	3” Common MK 3 Mod 7	126 ft / 1,700 ft
	Underwater Area	81mm Mortar	247 ft/ 1,579 ft
MRS 11- Defensive Firing Area No. 2			
	Mortar Boat Firing Area	4.2” M3A1 HE	316 ft / 1,670 ft
	Beach Defensive Area	81mm Mortar	247 ft/ 1,579 ft
	Direct Fire Area	3” Common MK 3 Mod 7	126 ft / 1,700 ft
	Underwater Area	81mm Mortar	247 ft/ 1,579 ft
MRS 06- Artillery Firing Area			
	Land Impact Area	37mm MK II	90 ft / 982 ft
	Beach Defensive Area #1 & #2	81mm Mortar	247 ft/ 1,579 ft
	Water Impact Area	37mm MK II	90 ft / 982 ft
MRS 09- Soldado Point Mortar and Bombing Area			
	Aircraft Bombing Target	100lb AN-M30A1 HE	413 ft/ 1,833
	Direct Fire Area	3” Common MK 3 Mod 7	126 ft / 1,700 ft
	Water Target	37mm MK II	90 ft / 982 ft
MRS 08- Cayo Norte Impact Area			
	Land Impact Area	75mm MKI HE	239 ft / 1,873 ft
	Water Impact Area	5” HVAR MK 1	349 ft/ 2,328 ft

1. HFD= Hazardous Fragmentation Distance
2. MFD= Maximum Hazardous Distance

3.7.7 MEC IDENTIFICATION

Any suspected or known MEC encountered during excavation will be clearly marked and its position annotated on the Trimble GeoXH, or equivalent, and other appropriate site maps. The UXO Technician III will evaluate the item found and immediately report the condition of the item to the SUXOS. No UXO will be moved without positive identification as acceptable to move, an evaluation of its condition, and approval has been received from the SUXOS and UXOSO or the item has been identified as non-UXO.

3.7.8 MEC REMOVAL

3.7.8.1 Land

If an excavated item is considered MEC, it shall be uncovered sufficiently to obtain a positive identification of the item and to determine whether or not it is fuzed. It is preferred that unfuzed MEC be Blown-in-Place but can be removed and consolidated with other items previously located or if the item is located within a sensitive habitat area. A separate determination on disposal will be made by the SUXOS with concurrence of the USACE OE Safety Specialist.

Fuzed UXO will not be removed unless it has been determined to be acceptable to move by the SUXOS and UXOSO. The SUXOS will make a determination in each case on how best to dispose of the UXO. If the UXO cannot be safely disposed of under the existing conditions, the USACE OE Safety Specialist will be notified. In no case shall the SUXOS authorize or undertake destruction of UXO when there is sufficient reason to believe that the disposal action will result in personnel casualties or property damage.

3.7.8.2 Water

Suspected MEC located during the underwater visual survey will be left in place. Underwater demolition is not currently authorized as part of the RI.

3.7.9 MEC STORAGE

MEC will not be stored. MEC items will be left in place for later disposal by blow-in-place or, if acceptable to move, later removed, consolidated with other MEC items and disposed of in accordance with MEC Disposal operations. MEC items discovered on the main island of Culebra (MRS-06, 09, 10, 11) and left in place for later disposal, will have a guard posted to prevent public contact until the item is disposed. For MEC items left in place on Cayo Luis Pena (MRS 13) or Cayo Norte (MRS 08) USA will coordinate with the onsite USACE Safety Specialist to determine the need for a guard. Due to the low number of inhabitants and limited access, a guard should not be necessary.

3.7.10 MEC DISPOSAL

This WP includes procedures for disposal of MEC recovered during intrusive investigation activities. Disposal may be through destruction using one of the following methods:

- **In-Place Destruction.** USA will destroy in place all MEC that is identified as unacceptable to move; this method is commonly known as BIP. The USA SUXOS and UXOSO will follow the procedures in sections 3.6.9.3.6 Evacuation and Site Control; 3.6.9.3.7 Fragmentation Distance; 3.6.9.3.10 Blow-in-Place Procedures; and 3.6.9.3.11 Operations in Populated/Sensitive Areas when destroying MEC in place. When this technique is employed, engineering controls may be used to minimize the blast effects.
- **On-Site Destruction.** USA will use the on-site destruction method to move MEC items that are acceptable to move to a central location for destruction within the same area. Procedures in this WP for Evacuation and Site Control, Fragmentation Distances, and Operations in Populated/Sensitive Areas will be followed. When this technique is employed, engineering controls may be used to minimize the blast effects.

During In-Place or On-Site disposal of MEC and related material, safety is the primary concern. The most obvious requirements are to protect personnel, the public, and the environment from fire, blast, noise, fragmentation, and toxic releases. Planned detonation of explosives requires more stringent safety distance requirements than those for ordnance in storage, and such detonation shall be conducted in accordance with the requirements outlined in DOD 6055-9-M, EM385-1-97, p.1.2.C.3, EM1110-1-17 App D, and the latest approved version of the Explosives Siting Plan (USA, 2011).

USA intends to use electrical disposal procedures. Depending on local explosives availability, USA may use (with concurrence of the OE Safety Specialist) a Shock Tube Firing System (Non-EL) in accordance with USA Standard Operating Procedures (SOP) in Appendix L. All personnel directly or indirectly engaged in UXO operations are thoroughly trained and capable of recognizing hazardous explosive exposures. All personnel are required to read, become familiar with, and adhere to the requirements contained in this chapter to ensure that all general safety regulations and safe work practices are observed at all times.

All USA personnel engaged in UXO demolition activities will utilize these procedures. However, situations may warrant additional safety measures, such as fire trucks, medical personnel, and protective clothing. The SUXOS has the overall responsibility to comply with the minimum requirements listed below and has the authority to upgrade the requirements as the situation dictates.

All MEC and MPPEH related material containing explosives or hazardous material will be disposed of by detonation using standard demolition procedures as outlined in Technical Manual (TM) 60A-1-1-31 and USA's SOPs in Appendix L of this WP. USA will use electric or Non-EL firing procedures for positive control of demolition operations. If these methods of disposal are determined to be impractical, USA will notify the on-site USACE OE Safety Specialist, who will request local military EOD support. The following paragraphs describe the procedures USA will use to detonate MEC and MPPEH related items.

Throughout MEC disposal operations the Standard Operating Procedures for Endangered Species Conservation and their Habitat on DERP-FUDS Project No. I02PR006802.Culebra, Puerto Rico (Appendix M) will be followed to minimize the impact on the environment. USA will implement a daily survey for turtle nesting by a biologist 75 days prior to any underwater work commencing.

3.7.10.1 MEC/MPPEH Procedures

USA will dispose of MEC and MPPEH related materials after notification of the agencies listed in section 3.6.9.3.6 Evacuation and Site Control, which allows Notification to Airmen (NOTAM), Notice to Mariners (NOTM), and notification of the local police. USA will use off duty police officers or a local security service to provide security of the items located on land during the notification phase in conjunction with coordination with the USACE OE Safety Specialist. Demolition operations will begin at a work site when all nonessential personnel are out of the minimum separation distance (MSD) of the ordnance being detonated. The MSD will be in accordance with Table 7-1 Minimum Separation Distance of the Explosives Site Plan. UXO that is acceptable to move may be consolidated within an area to reduce the number of shots and lessen environmental damage. To the greatest extent possible, all items will be BIP to reduce the risk inherent in handling and movement. Demolition shots may require engineering controls to meet the MSD requirements stated in Table 7-1 of the Explosives Site Plan.

Demolition operations will not begin in a work site until all non-essential personnel are outside of the Exclusion Zone (EZ) established for the ordnance being detonated. MEC that is unacceptable to move (e.g., fuzed items) must be BIP.

3.7.10.1.1 Coordination and Supervision

The on-site disposal will be under the direct control of an experienced and trained UXO Team Leader charged with the responsibility for all demolition activities within the area. The Team Leader, assigned by the SUXOS, will be responsible for training all personnel regarding the nature of the materials handled, the hazards involved, and the precautions necessary, and will be present during all on-site disposal operations. The Team Leader will also maintain custody of the blasting machine or Non-EL initiator. The SUXOS and Team Leader will ensure that the appropriate local authorities are notified prior to daily on-site demolitions (see section 3.6.9.3.6 Evacuation and Site Control for list of local authorities to notify).

The SUXOS and UXOSO will be on site at all times during disposal operations. The operation is performed under the direction and supervision of the SUXOS, who is charged with the responsibility to ensure that procedures contained in this WP and referenced documents are followed. The UXOSO monitors compliance with the safety measures contained in the WP and associated documents, and in case of noncompliance, is vested with the authority to stop or suspend operations. Individuals will report the completion of tasks to the SUXOS. The following tasks are required.

- Secure all access roads to the area.
- Visually check demolition site for any unauthorized personnel.
- Check firing wire for continuity and shunt.
- Prepare designated shots.
- Check continuity of detonators.
- Secure the detonators in a safe location.
- Place charge in desired location.

3.7.10.1.2 Detonation Operations

Prior to conducting a disposal operation, the Team Leader will conduct a safety briefing to the members of the demolition team. This safety briefing will include, at a minimum the following topics:

- Phases of the operation

- Review of explosive handling and precautions
- Location of safe area
- Emergency notification procedures
- Site specific characteristics
- Type of UXO being destroyed
- Placement and quantity of counter charge
- Misfire procedures
- Post-detonation cleanup of the site
- Care and handling of explosive materials
- Personal hygiene
- Two person rule
- Potential trip/fall hazards
- Location of the vehicle
- Wind direction (toxic fumes) and
- Location of first aid kit and fire extinguisher.

The vehicle engine will be started prior to initiating priming procedures and will be kept running.

Telephone or radio communication will be established with emergency response personnel. No radio or cellular telephone transmissions will take place in the vicinity during the positioning or connecting of electrical initiating devices. Additional safety precautions for demolition operations include:

- Conduct operations in accordance with Army TM 60A 1-1-31 (Explosive Ordnance Disposal Procedures).
- During demolition operations, designate an emergency vehicle (in addition to the vehicle associated with the demolition team) that will remain in the area.
- Keep blasting caps in approved containers, located at least 50 ft downwind from other explosives, until they are needed for priming.
- Always point the explosive end of blasting caps, detonators, and explosive devices away from the body and other personnel during handling. This will minimize injury should the item explode.
- Do not bury blasting caps used for initiation of explosive charges.
- If explosive charges are to be covered or tamped with earth, fit the charges with detonating cord leads that protrude 1.8 meters (6 ft) from the earth.
- Do not use blasting caps less than the equivalent of a commercial No. 8 cap unless used with commercial explosives and approved by the explosives manufacturer.
- Transport to the disposal site only those explosives or initiators needed to meet the requirement of the operation.
- Do not surrender the blasting machine or activating device to the individual designated to fire the shot until the SUXOS is assured that the area is clear.
- Clear an appropriate distance (50 ft) around the demolition site of dry grass, leaves, and other extraneous combustible materials.
- Provide a minimum delay time of 30 seconds for electric operations between detonations.
- If MEC cannot be BIP and must be removed, it will be disposed of after proper notifications. Depending on the amount of UXO encountered, a daily schedule may be established for detonation of UXO on site to allow the site personnel to clear the area and to not alarm the public. The detonation time will be announced to the agencies concerned to enhance public relations.

3.7.10.1.3 General Detonation Safety Procedures

Disposal activities are inherently hazardous and require strict adherence to approved safety and operational procedures. During disposal operations, USA will ensure that the following safety measures:

- Personnel working with electric blasting caps or other electro-explosive devices will not wear static-producing clothing such as nylon or silk.
- Prior to making connection with the electric blasting cap, the firing circuit will be continuity tested.
- All parts of the firing circuit will be kept insulated from the ground or other conductors such as bare wires, rails, pipes, or other paths of stray current.
- Electric blasting caps will be connected to the firing circuit before connection to the main initiation charge.
- Electric blasting caps of different manufacturers or types will not be used in the same system.
- The shunt will not be removed from the wires until the individual performing the operation has been grounded.
- The electric blasting caps will be tested for continuity with a galvanometer at least 50 ft downwind from any explosives prior to connecting them to the firing circuit. After the testing is completed, the lead wires will be short-circuited by twisting the bare ends of the wires together. The wires will remain shunted until ready to connect to the firing circuit.
- The electrical lead wires of electric blasting caps, detonators, or other electro-explosive devices should not be pulled; detonation may occur.
- The legs of the blasting cap should be unrolled so that the cap is as far as possible from the operator and pointing away from him.
- The blasting cap will be placed in a hole or behind a barricade before removing the shunt and testing for continuity. The cap should not point toward other personnel or explosives.
- Only authorized and serviceable testing equipment will be used.
- The blasting machine will not be connected to the firing wires until all pre-firing tests have been completed, and all preparations have been made to fire the charge.
- The blasting cap will not be held directly in the hand when uncoiling the leads. The wires will be held approximately 6 inches from the cap. This will minimize injury should the cap explode. The lead wires should be straightened by hand and not thrown, waved, or snapped to loosen the coils.
- The shunt will not be removed from the lead wires of blasting caps except when testing for continuity or actual connection into the firing circuit. The individual removing the shunts should be grounded prior to performing this operation to prevent accumulated static electricity from firing the blasting cap.
- Keep both ends of the firing wires shorted or twisted together except for testing or firing. The blasting caps will not be connected to the firing circuit unless the power end of the firing circuit leads is shorted.

3.7.10.1.4 Electric Firing Procedures

Procedures for electrical firing are provided in OPS-03 Demolition/Disposal Operations (Appendix K).

3.7.10.1.5 Electrical Misfires

Procedures for electrical misfires are provided in OPS-03 Demolition/Disposal Operations (Appendix K).

3.7.10.1.6 Shock Tube (Non-EL) demolition Operations

Procedures for Non-EL are provided in OPS-03 Demolition/Disposal Operations (Appendix K).

3.7.10.1.7 Evacuation and Site Control

USA will notify the following agencies at least 36 hours in advance of performing any demolition operations:

- US Coast Guard A.M. Schmidt, LTJG, USCG or Mr. John Reyes Marine Information Specialist (787) 729-5381), Sector San Juan AtoN & WWM Officer 787-289-2086 fax 729-2377. This is for a Broadcast to Mariners of the scheduled demolition shot. Alison.M.Schmidt@uscg.mil.
- FAA Coordination Facility for a Notice to Airmen on flight restriction above the demolition area. (787) 253-8664 Mr. Gilberto Iglesias or Mr. Felipe Fraticelli, www.nes.notams.faa.gov.
- Municipal Police, (787) 742-0106 for any activity on Culebra. USA SUXOS or UXOSO will coordinate directly with the police department to overcome any language difficulties on demolition operations.
- Puerto Rican State Police (787) 742-3501 for any activities on Culebra. USA SUXOS or UXOSO will coordinate directly with the police department to overcome any language difficulties on demolition operations.

Control of the demolition site must be maintained during demolition operations. All personnel who are not essential to demolition operations must evacuate to a safe area. Access roads entering the blast area will be blocked during explosive disposal operations to ensure that unsuspecting individuals are not placed in jeopardy by the explosion. The Team Leader will ensure the area is clear of unauthorized personnel and equipment prior to permitting attachment of the initiation devices to the priming charge.

An observer will be stationed at a location where there is a good view of the air and surface approaches to the demolition site. It shall be the responsibility of the observer to notify the Team Leader to suspend firing if any aircraft, vehicle, or personnel are sighted approaching the general demolition site.

A minimum of two UXO qualified personnel, one of whom will be the Team Leader, will conduct demolition operations. An electrical firing system provides better control of the demolition activities. Control of initiation devices will remain with the Team Leader until attachment to the firing circuit.

Local fire departments may need to be alerted to standby during demolition operations (see Appendix D APP, for telephone numbers). In the event of a fire or unplanned explosion, site personnel will be responsible to extinguish the fire. If unable to do so, they will notify the local fire department and evacuate the area. NOTE: Do not attempt to fight explosive fires.

Prevailing weather condition information will be obtained from a reliable source; this data will be logged before each on-site detonation. Demolition charges will not be primed or connected for electrical firing during the approach or presence of a thunderstorm. Other weather conditions (high winds, dust storms, temperature inversions, low altitude clouds, or cloud coverage of more than 50%) may adversely impact planned demolition operations. The SUXOS will consider these conditions when determining whether or not to conduct demolition operations. If weather conditions preclude the disposal by BIP, USA personnel will secure and cover the UXO with sandbags and properly mark the area, until favorable conditions allow the demolition. Personnel will remain at the site as long as the possibility of fire exists as the result of a demolition operation.

Depending on the location of the anomaly, the MGFD, and the MSD, it will be necessary to use engineering controls and/or evacuations to protect non-essential personnel during intrusive investigations.

USA will use engineering controls (in accordance with HNC-ED-CS-S-98-7) to reduce fragmentation distances of demolition shots. A copy of HNC-ED-CS-S-98-7 will be on site and available to site personnel. Additional engineering controls that may be used include the buried explosion module IAW Department of Defense Explosives Safety Board (DDESB) TP-16 and water mitigation IAW HNC-ED-CS-S-00-3. In areas where an acceptable fragmentation distance cannot be achieved, items acceptable to move may be moved to the approved demolition area, with the concurrence of the USACE OE Safety Specialist. If these methods of disposal are determined to be impractical, USA will notify the on-site USACE OE Safety Specialist.

USA will use a seismograph to record and document the seismic event and blast effect of on land detonations when housing is in close proximity to the detonation.

3.7.10.1.8 Fragmentation Distance

Fragmentation distances and overpressure distances are based upon the net explosive weight (NEW) of a single demolition item plus the donor charge as outlined in the Explosive Site Plan (see Appendix P), the MSD calculations in Appendix G or Chapter 9 of DOD 6055.9-M. The calculation of fragmentation and overpressure distances is important in order to ensure the safety of not only site personnel, but also the public; these distances will be calculated using DDESB Technical Paper 16. The fragmentation ranges are for open, un-barricaded shots.

Detonating multiple shots will be sequentially timed to ensure they are not simultaneous. USA ensures that all shots are within the appropriate fragmentation and K328 range. If this is not possible, use tamping or other engineering controls.

3.7.10.1.9 Comparison of Barricades

USA will compare the six barricades listed in HNC ED-CS-S-96-8 publication to determine the most appropriate barricade for the location and type of MEC items being blown-in-place. This will minimize the impacts to listed species and their habitat. Once the MEC item is known a map will be created to show the habitat that needs to be protected from fragments. USA will determine the 95% confidence level fragment range to show that a barricade is required.

3.7.10.1.10 Barricade Siting and Selection Procedure

The following is the process for determining the barricade to be used:

- Location of Ordnance and Protection Area
- Maximum Fragment Distance
- Selection of Fragment Mitigating Material
- Terrain Limitations
- Reduced Fragment Range with Barricade
- Horizontal Coverage

3.7.10.1.11 Blow-In-Place Procedures

The UXO team will evaluate the unexploded ordnance and either detonates it in place or relocate the ordnance to a designated area within the site. No fuzed ordnance will be moved unless it is deemed acceptable to move by the UXOSO or is directed to do so by the OE Safety Specialist. Detonations will occur only after all unnecessary personnel have left the area, road guards have been posted, and the required personnel have been notified. USA personnel not involved in the disposal operation will act as perimeter guards, as directed by the SUXOS. USA will use our subcontractor, Sea Ventures, to provide a boat to enforce the EZ on adjacent water areas. A UXO Technician, stationed on the craft at the appropriate distance will notify the UXOSO if any craft enter the area in turn enabling Marine Radio to be used to warn the unauthorized craft away from the area.

3.7.10.1.12 Operations in Populated/Sensitive Areas

Some areas may require evacuations because of the proximity of residences, and the use of engineering controls is not possible. USA will request assistance from the local authorities on Culebra to notify residents at least 36 hours prior to performing any operations at these sites. If for any reason the resident(s) refuse or do not evacuate, USA will move to an alternate location and notify USACE. USA will coordinate with USACE for notification using the RAB and other regulatory agencies before a demolition event.

Evacuation of the public during the demolition of a UXO item is a last resort if all other engineering controls are not adequate. USA will conduct demolition operations only after all personnel protective measures have been completed and reported to the SUXOS. USA will take property protective measures such as, but not limited to: sandbagging, tamping with earth, and barricading. Personnel will be permitted to re-enter the area only after the demolition point has been inspected and the “all clear" has been given by the SUXOS.

3.7.10.2 Material Potentially Presenting an Explosive Hazard (MPPEH)

USA UXO technicians will inspect all tentative MPPEH items to determine if the items present an explosive hazard. USA UXO technicians will classify these items as MPPEH, Munitions Debris (MD), range related debris, or MEC. USA will classify items of undetermined explosive hazard as MPPEH and will dispose and/or vent the item with other demolition shots. All MEC and MPPEH containing explosives will be disposed of by detonation utilizing the standard demolition procedures outlined in Technical Manual (TM) 60A-1-1-31 and procedures described in section 3.6.9 MEC Disposal of this WP.

3.7.10.3 Munitions Debris

Within or adjacent to each operating section, the UXO Team will establish temporary MD collection points. During intrusive operations, debris will be inspected by a UXO Technician II and segregated into the following three categories:

1. Other Scrap (e.g., nails, wire, tin cans, etc.).
2. Munitions debris
3. Material Potentially Presenting an Explosive Hazard (MPPEH)-Scrap requiring venting to determine if it is free of explosive hazards.

Upon completion of daily operations, the team will collect the material in these temporary collection points for transport to the debris holding area. As the material is being loaded, the UXO Technician III will perform a second inspection of the material to ensure it is segregated correctly.

The debris holding area is within the fenced area of the explosive Type II magazine area and will be set up to maintain the segregation of metal scrap into separate locked containers. The keys to these containers will be maintained by the SUXOS. Other scrap will be placed in a locked dumpster for local disposal. Munitions debris will be placed in 55-gallon drums (open-top type) fitted with a lock. Each drum will be labeled with its contents and each container will be marked with a unique identification number. MPPEH requiring venting will be temporarily stored in a 55-gallon drum (open-top type) fitted with a lock. This container will also be marked with its contents.

Inspection and classification is a critical aspect of MEC operations and only personnel qualified as a UXO Technician II or above perform these inspections. The total weight of munitions debris will be documented during certification and verified upon receipt by the recycle facility. Each container is closed and sealed, after all materials are loaded into the container and it has passed the certification/verification process. Each container is closed in a manner that requires that the seal be broken to gain access to the interior of the container. The material will be shipped to a recycle facility at the end of the project or periodically, as required. Upon turn-in of the scrap, the SUXOS completes a DD Form 1348-1A and follows current guidance from USAESCH on handling and certification of MPPEH. USA ensures that the materials are inspected on the exterior and interior surface to be certain that these items do not present an explosive hazard. USA employs a four-level process for the inspection of MPPEH and range residue: 1) Inspection by the UXO team at the time of excavation; 2) Inspection by the UXOQCS during daily audits of the procedures used by UXO teams and individuals for processing MPPEH or range residue; 3) UXOQCS ensures the procedures and responsibilities for processing MPPEH and range residue for certification as scrap metal are being followed and performs random checks of processed MPPEH and range residue; 4) SUXOS is responsible for ensuring WP and QC Plan detail the specifics of the procedures to be followed to process MPPEH and range residue; completes the DD Form 1348-1A and performs random checks that the munitions debris and range residue are free from explosive hazard; ensures all inspection, certification, and final disposition procedures meet the requirements of the WP.

Munitions debris will be packaged, sealed, and shipped to a recycling facility for final disposal. USA plans to use Timberline Environmental Services (TES) for final disposal. USA will maintain the chain of custody of the sealed package shipped to TES. As an element of cradle-to-grave documentation, TES will ensure the continued chain of custody, provide USA and the Government with signed copies of receipt documents and certificates of destruction verifying that the contents have been smelted, shredded, or flashed and are only identifiable by their basic content. This documentation will be included in the RI Report. Shipments to TES will be made at the end of the project or periodically if required.

3.7.10.3.1 Personnel Responsibilities

- UXO Technicians II: Check, classify and segregate all scrap as they recover it.
- UXO Technicians III: Re-inspect all scrap, as it is loaded for transport to the scrap holding area.
- The UXOQCS:
  - Conducts daily audits of the scrap metal handling process
  - Randomly inspects and documents a minimum of 10% of the scrap being processed to ensure the handling procedures are being followed.
- The UXOSO:
  - Ensures that specific procedures for scrap metal processing are being followed, performed safely, consistent with applicable regulations, and in accordance with the WP.
  - Performs random checks to ensure all scrap is being handled correctly.
- SUXOS:
  - Ensures that specific procedures for scrap metal processing are being followed, performed safely, consistent with applicable regulations, and in accordance the project WP
  - Performs random checks to ensure all scrap is being handled correctly
  - Certifies that all scrap metal is free from explosive hazards
  - Takes responsibility for ensuring all inspected materials are secured in locked containers while awaiting shipment off site
  - Ensures that prior to shipping material off site, inspected materials are in a closed, labeled, and sealed container and documented as follows:
    - Unique label including "USACE/ Culebra Site/USA Environmental, Inc./Container # (e.g., 0001)/Seal Number"

USA will include a documented description of each container that will be provided for the disposal facility with the following information: contents, weight, location where scrap was obtained, name of contractor, names of certifying and verifying individuals, container identification number, and seal identification.

3.7.10.3.2 Certification and Verification

The SUXOS will certify and the USACE Safety Specialist will verify that the scrap metal is free of explosives hazards. A DD Form 1348-1A will be used as the certification/verification documentation and will state the following information:

- Basic material content
- Estimated weight

- Unique identification/seal numbers for each container
- Location where scrap was obtained.

The following certification/verification will be entered on the DD 1348-1A and be signed by the SUXOS and USACE OE Safety Specialist:

This certifies and verifies that the material listed has been 100 percent inspected and to the best of our knowledge and belief, are inert and/or free of explosives and related materials."

3.7.11 DISPOSAL ALTERNATIVES

USA intends to perform all MEC disposal onsite. Offsite disposal will not be considered. However, when MEC disposal cannot be performed onsite, USA will request U.S. Navy assistance to render safe, the MEC item. Other alternatives (e.g., controlled detonation chamber or water jets) are considered impractical due to lack of suitable access and other logistical constraints.

3.8 MUNITIONS CONSTITUENTS (MC) SAMPLING

MC sampling includes collection and analysis of discrete surface and subsurface soil samples, discrete surface water and sediment samples, and pre and post detonation composite soil samples. The objective of MC sampling is to determine the presence of, and the nature and extent of MCs that are detected above the applicable regulatory criteria. The sampling and analysis results are then used to support an ecological and human health risk assessment IAW the EPA RAGS and USACE EM 200-1-4, Volumes I and II.

MC sampling will be performed in accordance with the Sampling and Analysis Plan (SAP), which includes a field sampling plan and a Quality Assurance Project Plan, prepared in accordance with DID MR-005-10.01 and UFP QAPP. The SAP plan describes the approach to sampling and addresses contaminants of interest and the sample media (soil, sediment, and surface water). The SAP is included as Appendix E to this WP. Any deviations from the SAP will be documented in the Daily Quality Control Reports (DQCRs).

3.9 INVESTIGATIVE DERIVED WASTE PLAN

Previous investigations and records detailing historical use of the MRS sites have not identified Recovered Chemical Warfare Materiel (RCWM) or any other hazardous material contamination at the project site. As a result, the project team does not anticipate recovery, handling, or disposal of Investigative Derived Waste (IDW) during the course of the RI/FS investigations.

3.10 RISK CHARACTERIZATION AND ANALYSIS

3.10.1 MEC RISK

For the MEC risk characterization and assessment element, the MEC Hazard Analysis (MEC HA) will be used. The MEC HA evaluates the level of risk to the public in terms of the likelihood of exposure and the severity of exposure to MEC. The MEC HA process entails definition of risk factors, MEC risk assessment, and assessment of response alternatives.

3.10.1.1 Definition of MEC Risk Factors

The potential risk posed by MEC at a site may be characterized by evaluating the likelihood of exposure to MEC, the severity of the exposure, and the likelihood of detonation. These three components can be evaluated using the following basic risk factor categories.

- **MEC Factors**: This category covers the physical characteristics (MEC Type, MEC Sensitivity) and location/extent (MEC Potential, MEC Depth Range) of MEC at a given site;
- **Site Characteristics Factors**: This category refers to the physical conditions of the site and natural events that may occur at the site (Site Accessibility, Site Stability); and

- **Human Factors**: This category refers to the types of activities (Site Activities) that exist on the site, the number of people (Site Population) that may have access and the frequency of the access to the site on a daily basis.

For example, the likelihood of exposure may be evaluated by considering the MEC potential (based on results of the RI field investigation), the number of people using the site, the type of activities conducted at the site, and the accessibility of the site. Similarly, the type of MEC and its sensitivity must be considered to evaluate the likelihood of detonation and severity of exposure. These risk factors are described in the following sections.

3.10.1.2 MEC Baseline Risk Assessment

The MEC Risk Assessment is the second step in the OERIA process. The project team will perform this baseline risk assessment by evaluating the basic risks factors for each OERIA evaluation area. This risk evaluation uses data collected from the remedial investigation, data from previous investigations, documented reports of discovered MEC, current and future land uses and the basic risk factors to assess the overall MEC hazard level for each of the response alternatives.

3.10.1.3 MEC Assessment of Response Alternatives

The third and final step of the OERIA process is the assessment of response alternatives. After completing the baseline risk assessment, the response action alternatives are assessed using the basic risk factors and baseline risk assessment data for each of the OERIA evaluations areas.

The response action alternatives are analyzed and ranked using each risk factor identified in the baseline risk assessment. Each response action alternative is assigned an impact evaluation score of ‘No Impact’ or an alphabetical rank from ‘A’ to ‘D’ representing the relative impact of the response action alternative – with ‘A’ being the highest impact and ‘D’ being the lowest. This comparison provides a qualitative indication of the change in the potential for harm and level of protectiveness at the site for each response action alternative that could be implemented.

The project team will assign an overall alphabetical rank to each response action alternative based upon the impact ranks for each factor. The response action alternative that provides the greatest impact on risk from MEC (i.e., achieves the most reduction of the risks posed by the site) is assigned an ‘A’.

The OERIA results are further applied to the evaluation of removal alternatives for the project and serve as input to the evaluation of the Effectiveness Criteria for Alternatives Evaluation in the Feasibility Study.

3.10.2 MC RISK

MC sampling and analysis results will be used to characterize the human health and ecological risks presented by the presence of MC. MC sampling and analysis was previously performed as part of the Site Inspection (Parsons, 2007). Samples were collected at each MRS and analyzed for MC metals and explosives. The 2007 Site Inspection (Parsons, 2007) confirmed the presence of MC metals in soil and sediment samples within each of the MRS addressed in this WP. MC explosives were not detected during soil and sediment sampling. Based on a screening level risk assessment, the SI concluded that the soil and surface water / sediment migration pathways were complete, but that none of the metals detected resulted in unacceptable risk to human health. In contrast, a screening level ecological risk assessment concluded that unacceptable ecological risk could not be ruled out at MRSs 06, 09, 10, and 13 due to metals in soil. Surface water / sediment was not sampled at MRS 06, but there is historical evidence that direct fire may have contaminated the lagoon at Mosquito Bay within this MRS; therefore, risk to human health and ecological receptors at MRS 06 cannot be ruled out. Additionally, ecological risk is possible due to metals migration from soil at six MRS 06, 09, 10, and 13.

Using the analytical data, the project team will perform the human health and ecological risk assessment in accordance with EPA RAGS and USACE EM 200-1-4, to include the exposure assessment, toxicity assessment, risk characterization, and evaluation of uncertainties and limitations. For example, the human health risk assessment will compare the estimated upper-bound excess lifetime cancer risks for each MRS to the EPA target risk range of $1x10^{-6}$ to $1x10^{-4}$ for health protectiveness at CERCLA response action sites. The estimated, non-carcinogenic hazard indices would be compared to 1. Hazard indices greater than 1 would indicate a potential for adverse health effects.

3.11 DISCUSSION ON THE ANALYSIS OF INSTITUTIONAL CONTROLS

USA will conduct an Institutional Analysis in accordance with EP 1110-1-24 as part of the RI/FS. As Institutional Controls rely on existing powers and authorities of various government agencies to protect the public from MEC risks, government agencies having jurisdiction over properties containing MEC will be identified and their appropriateness, capability, and willingness to assert controls will be assessed.

For each institution selected for review, USA will collect the following information:

- Name of Agency
- Origin of Institution
- Basis of Authority
- Sunset Provisions
- Geographic Jurisdiction
- Public Safety Function
- Land Use Control Function
- Financial Capability
- Desire to participate in the Institutional Control Program
- Constraints to Institutional Effectiveness.

An Institutional Analysis Report will be prepared to document feasible local initiatives that will be used to support development of alternative plans of action. The report will identify and analyze the institutional framework that supports the development of institutional controls for the site. The report will address local initiative strategies available to control or limit access to different areas within the project site or strategies to implement public safety awareness actions regarding the site. The Institutional Analysis will include discussions with state and local agencies, and with private parties having interests in the sites.

Following the Institutional Analysis and preparation of the Institutional Analysis Report, a draft Institutional Control Plan will be included in the draft RI Report, detailing the Institutional Control Alternatives recommended based on their apparent ability to satisfy project objectives.

3.12 DISCUSSION ON THE PREPARATION OF THE RECURRING REVIEW PLAN

Recurring reviews are required for OE response actions to determine if a response action continues to minimize explosives safety risks and continues to be protective of human health, safety, and the environment. The reviews also provide an opportunity to assess the applicability of new technology for addressing previous technical impracticability determinations. Recurring reviews are conducted under the Long Term Management phase once a Formerly Used Defense Site (FUDS) achieves Response Complete and satisfies the CERCLA requirement for reviews no less than every five years.

The scope of the reviews is site specific and depends on the response objectives and the specific responses implemented. The review evaluates site specific factors that may have impact on the continued effectiveness of the response. Example factors include changes in physical conditions, public accessibility and land use. The proposed frequency and duration of recurring reviews is documented in the Feasibility Study report in a draft Recurring Review Plan.

USA will prepare the draft Recurring Review Plan following the guidance of EP 75-1-4. The draft plan will be included as an appendix to the FS report. The plan will reflect the recommended response action alternatives contained in the FS report. The plan will be developed with full involvement of the project delivery team (PDT) and in coordination with the regulators and stakeholders. The plan will include MRS site descriptions; details regarding frequency of reviews; documents to be reviewed; methodologies to be used during the recurring review site visits; and a discussion on terminating recurring reviews at the MRS sites.

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4.0 QUALITY CONTROL PLAN

4.1 INTRODUCTION

The USA QC process provides a permanent and workable system that allows each employee to understand the job performance expected within the assigned task. The USA QC and improvement process ensures that the training, actions, procedures, and tools support every employee according to the requirements and in such a manner that we protect the environment and minimize the impact of the project activities. Checklists have been developed to ensure that critical elements are addressed and that QC checks are documented for compliance with the WP, SOPs, policies and procedures. By promoting teamwork and by focusing attention on the solutions, the quality of work can is increased and assured throughout the project.

This Quality Control Plan (QCP) provides the procedures and methods to be used for the MEC RI activities and DGM tasks within the selected work areas. This plan addresses organization and responsibilities, DQOs, QC test methods audit procedures and pass/fail criteria, digital geophysical operations, anomaly acquisition and reacquisition, field operations, equipment testing maintenance and calibration, QC inspections, and of generated records reporting procedures. The QCP outlines procedures to ensure all personnel meet the qualification requirements and receive the site-specific training to perform the duties of the job for which they were hired and site-specific training requirements for visitors. The QCP also describes how lessons learned are captured, documented and submitted to the Government.

Due to the various aspects of the DGM operations to be performed at different levels on this project, this QCP contains specific DGM requirements starting in Section 4.11 and 4.12.

USA will use the data collected during the overall MEC response investigation for inclusion in the Final RI Report at the completion of the project.

4.2 QUALITY MANAGEMENT STRUCTURE

The following paragraphs describe the organizational structure of the USA Quality Management Team during operations at the project site. Names and qualifications of site personnel will be provided prior to mobilization.

4.2.1 CORPORATE QUALITY CONTROL MANAGER (QCM)

The USA Corporate QCM has is responsible for USA's QC program. The Corporate QCM reports directly to the President of USA Environmental, Inc., on matters of effectiveness, adequacy and status of QC methods and procedures. He maintains an alternate line of communication to the President of USA Environmental, Inc. The Corporate QCM has the following responsibilities:

- Preparation of USA QC policies and procedures
- Ensuring timely submission of contract deliverables
- Providing training and assistance to the site project UXOQCS
- Reviewing employee qualification records to ensure accuracy
- Conducting periodic field audits of sites, programs, and projects project activities to ensure QC compliance.

4.2.2 PROJECT GEOPHYSICIST

The USA Project Geophysicist is responsible for the overall performance of the DGM services and data review and anomaly selection during this project. The USA Project Geophysicist will develop the DGM requirements and checks necessary for this project. The USA Project Geophysicist has the following responsibilities:

- Monitoring project DGM performance
- Preparation of DGM QC policies and procedures
- Analyzing any failures and implementing corrective actions

- Establishing additional guidelines to assist in the development of site and task specific policies and procedures
- Ensuring timely submission of contract deliverables.

4.2.3 SENIOR UXO SUPERVISOR

The SUXOS is responsible for the day-to-day field operations at the project site. The SUXOS reports directly to the USA Project Manager (PM) and has the following responsibilities:

- Implementation of work plan and QC policies and procedures
- Reporting to the PM on effectiveness, adequacy, and status of the project
- Ensuring the timely submission of contract deliverables
- Coordinating with project personnel for site tasking and schedules
- Reviewing any failures and implementing corrective actions
- Implementing additional guidelines used to assist in the development of site and task specific policies and procedures.

4.2.4 SITE GEOPHYSICIST

The USA Site Geophysicist is responsible for the overall performance of the DGM services and data review and anomaly selection at the project level. The Site Geophysicist will assist the Project Geophysicist in the development and implementation the DGM requirements and checks necessary for this project. The Site Geophysicist has the following responsibilities:

- Planning and monitoring project level DGM performance
- Preparation of DGM checklist and reports
- Acquiring, transferring, processing, analyzing, and managing all field DGM data
- Analyzing any failures and implementing identified corrective actions
- Implementing additional guidelines for the development of site and task specific policies and procedures
- Ensuring timely submission of contract deliverables
- Reporting directly to the Project Geophysicist.

4.2.5 USA QUALITY CONTROL SPECIALIST (UXOQCS)

The UXOQCS is responsible for the enforcement of the site QCP. The UXOQCS coordinates with the SM / SUXOS and Site Geophysicist for daily operations and reports directly to the Corporate QCM. The UXOQCS is responsible for the QCS and DGMQCS functions for both land and water-borne operations. The UXOQCS has the following responsibilities:

- Conducting a formal, systematic audit throughout the project. The audit will be prepared IAW the PWS, the DQOs in Section 4.3 and Appendix O, the Definable Features of Work (DFW) in Table 4-1, and the Work Plan, and will be developed in conjunction with the Corporate QC Manager, Project Manager, and Geophysicists.
- Reviewing, implementing, and enforcing the QCP for land and water-borne operations, including:
  - Proper DGM equipment setup and operation
  - Proper DGM QC testing
  - Implementation and monitoring of the Blind blind/test seed item program.
- Coordinating with project personnel to ensure QC procedures are demonstrating validity sufficient to meet QC objectives
- Conducting an inspection/audit of work being performed throughout the project. The inspection/audit procedures listed in Table 4-1, were prepared for each definable feature of work

(DFW), providing the audit procedures, the QC phases (preparatory, initial, and follow-up), the frequency of the audits, the pass/fail criteria and the actions required in the event a failure occurs. The UXOQCS will use the QC Surveillance Forms (located in Appendix F) to conduct the audits and document whether the subtasks pass or fail the QC inspection QC inspections of the DFW listed in Table 4-1 (audits of documents, work in progress, work performed, and monitoring work practices); recording and reporting the results to the appropriate personnel

- Coordinating with the USACE QA representative to ensure QC objectives are appropriate for the task being performed
- Ensuring classification of MEC-related items is accurate and consistent IAW Table 4-2
- Inspecting a minimum 20% of scrap material for proper classification
- Preparing Deficiency Notices (DN) on all QC failures and tracking corrective actions to closure on the Deficiency Notice Log
- Conducting analysis to determine the root cause of process failures as they occur
- Recommending to the SM / SUXOS any actions to be taken in the event of a QC failure
- Recommending corrective actions to the SM and Site Geophysicist for failures contributed to DGM operations (e.g., missed blind QC seed test items)
- Advising the DGM, Dive and MEC Teams on all QC-related site matters
- Reporting non-compliance with QC criteria to the project personnel
- Has STOP WORK authority for issues regarding QC at the project site.

4.3 GEOPHYSICAL DATA QUALITY OBJECTIVES

Data obtained during MEC operations must support the decision-making process. Consequently, data must be of a sufficient quantity and quality to make defensible decisions to provide an acceptable level of certainty for the decision maker(s).

4.3.1 DATA QUALITY OBJECTIVES PROCESS

The DQO process, as defined in EPA QA/G-4W, Data Quality Objectives Process for Hazardous Waste Site Investigations, is iterative and is normally applied to operations requiring the application of data gathered as a result of the conduct of analytic sampling. The output from one step may lead to the reconsideration of prior steps. This iteration leads to more efficient design of data collection operations. Data users, relevant technical experts and members of the QC staff will participate in the DQO process planning to ensure that their specific needs are included prior to the data collection.

DQOs provide the objective basis for quantitative definition of project requirements. DQOs shall are developed and used to ensure that the amount, type, and quality of data obtained during a field sampling project are adequate to support project decisions with a known level of confidence. Project DQOs for this RI/FS are located in Table 3-1.

The DQO process will includes the following steps:

1. State the problem
2. Identify the decision
3. Identify inputs to the decision
4. Define the study boundaries
5. Develop a decision rule
6. Specify limits of decision errors
7. Optimize the design for obtaining data.

4.3.2 SPECIFIC ANALYTICAL OR STATISTICAL GEOPHYSICAL DQOS

The following Geophysical DQOs, with full sheets in Appendix O (see Appendix O for the detailed Geophysical DQOs), have been developed for the RI/FS for the Culebra Island Site, Puerto Rico:

- DQO for Geophysical Equipment Performance
- DQO for Survey/Location Equipment Performance
- DQO for Data Collection
- DQO for MEC Identification
- DQO for Data Management
- DQO for Operational Verification of Survey/Investigation Equipment
- DQO for Detector Team Performance Evaluation
- DQO for Analog Instrument System Performance

4.4 QUALITY CONTROL TEST METHODS AND AUDIT PROCEDURES

This section discusses QC methods and procedures used during project operations.

4.4.1 INSPECTIONS

USA will conduct inspections to verify whether quality-related activities comply with this QC Plan. A list of the audit procedures based on the DFWs is provided in Table 4-1. Internal inspections will address activities performed by the project team. External inspections will address activities performed by project subcontractors, laboratories, and equipment and material suppliers.

The UXOQCS will implement the three-phase control process for each of the DFWs in Table 4-1 to audit/inspect the subtasks for compliance with the approved WP, SOPs and Geophysical DQOs. The three-phase control process includes the preparatory, initial and follow-up phase audits/inspections. The inspections are documented using the QC Surveillance Forms prepared for each DFW (located in Appendix F).

4.4.1.1 Preparatory Phase

A preparatory phase inspection is performed prior to the beginning of work on each DFW. The UXOQCS will review the DFW scope and applicable specifications (Geophysical DQOs) and verify that the necessary resources, controls and conditions are in place and compliant with the WP before the work activities begin.

4.4.1.2 Initial Phase

The UXOQCS performs an initial phase inspection for each DFW once a representative sample of the work has been completed. The purpose of this inspection is to check the preliminary work for compliance with procedures and contract specifications, to verify through inspection and testing the acceptable level of workmanship. The UXOQCS will review the preparatory phase QC Surveillance Forms to check for omissions and resolve any differences of interpretation by project personnel and the contract requirements.

4.4.1.3 Follow-up Phase

The UXOQCS performs a follow-up phase inspection periodically while work progresses for each DFW. The frequency of the follow-up phase is specified in Table 4-1 by DFW. The purpose of the inspection is to ensure continuous compliance and an acceptable level of workmanship. The UXOQCS will observe the same activities as under the initial inspection and ensure that discrepancies between site practices and approved specifications are identified and resolved. Corrective actions for unsatisfactory conditions or practices will be verified by the UXOQCS prior to continuing work on the affected DFW.

The inspection program is established to provide the following:

- An objective and independent evaluation of compliance with established policies and procedures (Work Plan, SOPs, AHAs, etc.)
- A mechanism for verifying the implementation of corrective actions recommended as the result of inspections.

Personnel performing QC inspections are knowledgeable about and have received training in QC techniques and methodologies, this QC Plan, and applicable regulations. They will also be technically knowledgeable of the processes being inspected. Inspections will be performed in accordance with written procedures or checklists. Personnel performing QC inspections will not have direct responsibilities in the areas they are assessing.

System and performance inspections will be undertaken. System inspections will evaluate the components of the QC system including evaluating items such as approach and adequacy of the preparation step, inspection of the schedules and plan delivery dates, and tracking systems for QC activities. Performance inspections evaluate actual QC activities such as design control, on-site data gathering, calibration and control, inspection and testing activities, and documentation.

Inspecting QC personnel will document inspection results, which will be reviewed by the Project Manager. When unsatisfactory or nonconforming conditions or items are found, the responsible organization will implement corrective actions in a timely manner. Previously unsatisfactory areas will be re-inspected to ensure that satisfactory corrective actions have been completed. The results of the inspections will be shared with the team with regard to needed rework and lessons learned.

Records of all inspections will be maintained and controlled as QC records.

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Table 4-1: Definable Features of Work Audit Procedures

Definable Feature of Work	Reference	Audit Procedures	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
1. Mobilization of Equipment, Supplies, and Personnel & Site Training	WP Sections 2.2.4 and 3.6.3	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	All personnel required for the work activities have been identified, are available, and meet the requirements and qualifications for the positions or waivers from the USAESCH have been obtained.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance before personnel are assigned project tasks
	WP Sections 2.2.4 and 3.6.3	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	All personnel are properly trained and certified to operate equipment and machinery.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance before personnel operate equipment and machinery
	WP and APP	Document Review	PP/IP/FP	Once and Follow-up as Personnel are added	All field personnel have reviewed the RI Work Plan and the Accident Prevention Plan.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance before personnel commence assigned project tasks
	APP	Document Review	PP/IP/FP	Once and Follow-up as Personnel are added	All personnel have signed the Employee Sign-off Forms for the Site Health and Safety Plan, the Certificate of PPE training and that all Activity Hazard Analyses have been completed.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance before personnel commence assigned project tasks
	APP	Document Review	PP/IP/FP	Once and Follow-up as Material is Introduced to Project	Material Safety Data Sheets are available onsite for all hazardous materials used or encountered onsite	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance before personnel are exposed to the hazardous material of concern
	WP Section 2.6 Project Schedule	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	All equipment is received on island as needed to support the project schedule.	Document deficiency and report to SUXOS for resolution
	WP Section 3.1.2	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	All required equipment is functional, properly calibrated, and complies with contract specifications.	Document deficiency, ensure any faulty equipment is pulled from service and report to SUXOS for resolution, follow-up to verify compliance

Definable Feature of Work	Reference	Audit Procedures	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
	WP Section 2.2	Document Review	PP/IP/FP	Once	Coordination is performed with personnel on Culebra, FWS, DNER, PREQB, the U.S. Coast Guard, FAA and USAESCH.	Document deficiency and report to SUXOS for resolution prior to initiating project tasks
	WP Section 5.4 and Puerto Rico Explosives Law	Document Review	PP/IP/FP	Once and Follow-up as Required	Transportation support for the movement of hazardous cargo is coordinated prior to the scheduled event in accordance with the dangerous cargo regulations.	Document deficiency and report to SUXOS for resolution prior to movement of hazardous cargo
2. Preparation of the Work Areas and Staging Areas	WP Section 2.10	Document Review	PP/IP/FP	Once and Follow-up as Required	Coordination with support facilities has been conducted.	Document deficiency and report to SUXOS for resolution prior to initiating project tasks
	SSHP	Visual Observation and Document Review	PP/IP/FP	Daily	Work zones and exclusion zones are properly established.	Document deficiency and report to SUXOS for resolution prior to initiating project tasks
	SSHP	Visual Observation and Document Review	PP/IP/FP	Weekly	Break and rest areas established in accordance with reference.	Document deficiency and report to SUXOS for resolution prior to initiating project tasks
3. Set-up of Test Strip	WP Section 3.3.1	Visual Observation and Document Review	PP/IP/FP	Initially and on each occurrence as Test Strip is relocated	Test Strip location represents, as closely as possible, actual site conditions (e.g., terrain, vegetation, background noise, geology, infrastructure, etc.).	Document deficiency and report to SUXOS for resolution prior to testing equipment in the Test Strip
	WP Sections 3.3.1	Visual Observation and Document Review	PP/IP/FP	Once	Test Strip is seeded with four ISOs (two small and two large), two horizontal at depths 3 and 7 times the ISO diameters, and two vertical at the same 3 and 7 times diameter depth	Document deficiency and report to SUXOS for resolution prior to testing equipment in the Test Strip

Definable Feature of Work	Reference	Audit Procedures	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
	WP Sections 3.3.1 and Geophysical DQO for operational verification of survey/investigation equipment	Visual Observation and Document Review	PP/IP/FP	Once	The capabilities and limitations of each sensor and positioning system to detect the seed items in the Test Strip are established and documented.	Document deficiency and report to SUXOS for resolution prior to using equipment on project tasks, follow-up to verify compliance
	WP Sections 3.5 and Geophysical DQOs for Data Collection and Management	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	Data transfer, processing, analysis, and reacquisition are in accordance with the Geophysical DQOs	Document deficiency and report to SUXOS for resolution prior to incorporation of data into project data base
	WP Section 3.4 and Geophysical DQO for Detector Team Performance Evaluation	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	The background noise, sample density, MEC detection, false positives, positioning accuracy, reacquisition, anomaly selection, and data management are established or refined in accordance with the Geophysical DQO	Document deficiency and report to SUXOS for resolution prior to using equipment on project tasks
4. Explosives Management	WP Section 5.4 and SOP OPS-07	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	The Type II Magazine is properly grounded in accordance with National Fire Protection Association requirements, and that lightning protection systems are in place and functioning properly.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance prior to placing explosive in the magazine
	WP Section 5.5 and SOP OPS-07	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	Explosives are transported IAW DOT regulations.	Document deficiency and report to SUXOS for resolution prior to movement of explosives

Definable Feature of Work	Reference	Audit Procedures	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
	WP Section 5.4 and SOP OPS-07	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	The proper fire extinguishers are present in the magazines area and that the land surrounding the magazines is clear of combustible materials for a distance of at least 50 ft.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance prior to placing explosive in the magazine
	WP Section 5.3 and SOP OPS-07	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	The cargo manifests are correct and the explosives received match.	Document deficiency and report to SUXOS for resolution prior to acceptance of the explosives shipment
	WP Section 5.5 and SOP OPS-07	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	The explosives routes to/from the Type II Magazine are followed.	Document deficiency and report to SUXOS for resolution prior to the movement of explosives
	WP Section 5.4 and SOP OPS-07	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	Explosives are properly stored IAW applicable ATF regulations.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	WP Section 5.7 and SOP OPS-07	Visual Observation and Document Review	PP/IP/FP	Weekly	Stock and inventory procedures for explosive materials are followed.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	WP Section 3.6.10 and SOP OPS-03	Visual Observation and Document Review	PP/IP/FP	Per Demolition Operation	Demolition procedures are followed during demolition operations.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
5. Vegetation Clearance	SOP OPS-21	Visual Observation and Document Review	PP/IP/FP	Once and Follow-up as Required	Vegetation clearance equipment is available, properly operated and maintained.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	SOP OPS-21 and APP	Visual Observation and Document	PP/IP/FP	Per Occurrence	PPE is properly worn and maintained.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance

Definable Feature of Work	Reference	Audit Procedures	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
		Review				
	WP Section 3.4.1 and SOP OPS-21	Visual Observation	PP/IP/FP	Once and Follow-up as Required	Vegetation clearance meets the project requirements.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance prior to commencing DGM tasks
6. DGM Operations	WP Section 3.4 and SOP OPS-05	Visual Observation and Document Review	PP/IP/FP	Daily	Daily testing of instruments (EM61-MK2, positioning equipment, survey equipment, etc.) is performed prior to conducting DGM field activities.	Document deficiency, report to Project Geophysicist and SUXOS for resolution, follow-up to verify compliance
	PWS, Table 7-1	Visual Observation and Document Review	PP/IP/FP	Daily	Static Repeatability (instrument functionality): Response (mean static spike minus mean static background) meet the PWS requirements	The day's data fails, unless seed item is mapped that day with repeatable anomaly characteristics. Document deficiency, report to Project Geophysicist and SUXOS, follow-up to verify compliance
	PWS, Table 7-1	Visual Observation and Document Review	PP/IP/FP	By dataset	The Along Line Measurement Spacing: 98% ≤ 25cm along line	The dataset submittal fails Document deficiency, report to Project Geophysicist and SUXOS, follow-up to verify compliance
	PWS, Table 7-1	Visual Observation and Document Review	PP/IP/FP	By dataset or grid	Verify grid Coverage: >90% coverage >90% at a 2.5 -ft line spacing	By Grid Dataset Submittal fails unless gaps filled or additional data collected. Document deficiency, report to Project Geophysicist and SUXOS, follow-up to verify compliance — Inspected by UXOQCS
	PWS, Table 7-1	Visual Observation and Document Review	PP/IP/FP	One test item per grid or dataset	The Dynamic Detection Repeatability (Grids): The test item anomaly characteristics (peak response and size) are repeatable within the allowable variation, ± 25%	Submittal fails. Document deficiency, report to Project Geophysicist and SUXOS, follow-up to verify compliance
	PWS, Table 7-1	Visual Observation and Document Review	PP/IP/FP	Repeat test strip once per system, per lot[1] or daily	The Dynamic Detection Repeatability (Transects): a. #anomalies on repeat segment within ±20% or ±8 of original or	Lot or day's data fails. Document deficiency, report to Project Geophysicist and SUXOS, follow-up to verify compliance

Definable Feature of Work	Reference	Audit Procedures	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
					within range of adjacent sections	
	PWS, Table 7-1	Visual Observation and Document Review	PP/IP/FP	One test item per grid or dataset	The Dynamic Positioning Repeatability (Grids):Position offset of test item target ≤ 35cm +1/2 line spacing (≤ 50cm +1/2 line spacing for fiducially positioned data)	Submittal fails. Document deficiency, report to Project Geophysicist and SUXOS, follow-up to verify compliance
	PWS, Table 7-1	Visual Observation and Document Review	PP/IP/FP	Two test items per system, per lot (can be same as detection repeatability test items)	The Dynamic Positioning Repeatability (Transects): The test item anomaly characteristics (peak response and size) are repeatable within the allowable variation, ± 25% and the position offset is ≤ 2 meters.	Lot submittal fails. Document deficiency, report to Project Geophysicist and SUXOS, follow-up to verify compliance
	PWS, Table 7-1	Visual Observation and Document Review	PP/IP/FP	By dataset	Target Selection: All dig list targets are selected according to the project design	Submittal fails. Document deficiency, report to Project Geophysicist and SUXOS, follow-up to verify compliance
	PWS, Table 7-1	Visual Observation and Document Review	PP/IP/FP	By MRS allocation of anomaly excavations[2]	Anomaly Resolution: If MEC, 70% confidence < 10% unresolved. If no MEC 90% confidence < 5% unresolved	Lot submittal fails. Document deficiency, report to Project Geophysicist and SUXOS, follow-up to verify compliance
	PWS, Table 7-1	Visual Observation and Document Review	PP/IP/FP	Daily	Geodetic Equipment Functionality: Check geodetic equipment position offset of known/temporary control point is within expected range as listed in the WP	Redo affected work or re-process affected data. Document deficiency, report to Project Geophysicist and SUXOS, follow-up to verify compliance

Definable Feature of Work	Reference	Audit Procedures	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
7. Analog Operations	PWS, Table 7-2	Visual Observation and Document Review	PP/IP/FP	Daily	Instrument Functionality: Analog instruments detect all items in the test strip	Replace faulty equipment, remedial training. Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	PWS Table 7-2	Visual Observation and Document Review	PP/IP/FP	Per lot[1]	Dynamic Repeatability (transect used only for density estimates): Repeat a segment of transect & show number of counts repeated within the greater of ±20% or ±8 digs/flags	Redo lot. Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	PWS Table 7-2	Visual Observation and Document Review	PP/IP/FP	Per lot[1]	Dynamic Repeatability (transects with digging): Repeat a segment of the transect & show extra flags/digs not greater than the greater of 20% or 8 digs/flags	Redo lot. Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	PWS Table 7-2	Verify that all blind seeds are included on analog dig list Visual Observation and Document Review	PP/IP/FP	Per operator/per lot: 1 large/deep blind seed item/ISO (BSI/ISO) and 1 small/ shallow BSI/ISO	All BSI/ISO are included on the analog dig list	Redo lot. Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	PWS Table 7-2	Visual Observation and Document Review	PP/IP/FP	Per operator/per lot: 1 large/deep BSI/ISO and 1 small/shallow BSI/ISO	Detection and Recovery: BSI/ISO recovered – 80% if MEC, 100% if no MEC	Redo lot. Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	PWS Table 7-2	Visual Observation and Document	PP/IP/FP	By MRS allocation of anomaly	Anomaly Resolution: If MEC, 70% confidence < 10% unresolved. If no MEC 90%	Redo lot. Document deficiency and report to SUXOS for resolution, follow-up to verify compliance

Definable Feature of Work	Reference	Audit Procedures	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
		Review		excavations[2]	confidence < 5% unresolved	
	PWS Table 7-2	Visual Observation and Document Review	PP/IP/FP	Daily	Geodetic Equipment Functionality: Position offset of known/temporary control point is within expected range as listed in the WP	Redo affected work. Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
8. Underwater Visual Investigation	WP Section 3.5	Visual Observation and Document Review	PP/IP/FP	Daily as Required	Pre-operations checks performed on ROV and other equipment used to collect underwater data	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	WP Section 3.5	Visual Observation and Document Review	PP/IP/FP	Daily as Required	Expanded survey conducted on MEC like items using the ROV	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	WP Section 3.5	Visual Observation and Document Review	PP/IP/FP	Daily as Required	Post-operations checks performed on ROV and other equipment used to collect underwater data	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
9. Intrusive Operations	WP Sections 3.7, SSHP	Visual Observation and Document Review	PP/IP/FP	Daily	Site security features and Exclusion Zones around beaches to be excavated have been erected and are maintained.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	SSHP	Visual Observation and Document Review	PP/IP/FP	Daily	All health and safety equipment and supplies are complete and all personnel are aware of its location in the operations area.	Document deficiency and report to SUXOS for resolution prior to commencing/continuing project activities, follow-up to verify compliance
	APP	Visual Observation and Document Review	PP/IP/FP	Daily	Team safe separation distances are in place and complied with.	Document deficiency and report to SUXOS for resolution prior to commencing/continuing project activities, follow-up to verify compliance

Definable Feature of Work	Reference	Audit Procedures	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
10. MPPEH Management	WP Section 3.7	Visual Observation and Document Review	PP/IP/FP	Daily as Required	UXO Technician II and UXO Technician III are conducting independent, 100% inspections of all recovered items to determine if free of explosives hazards engine fluids, illuminating dials or other visible liquid HTRW materials.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	WP Section 3.7	Visual Observation and Document Review	PP/IP/FP	Daily as Required	Random sampling of all MPPEH collected finds no items contain an explosive hazard, engine fluids, illuminating dials or other visible liquid HTRW materials.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	WP Section 3.7.10 and 5.2	Visual Observation and Document Review	PP/IP/FP	Prior to Shipment	All documents for shipment of MPPEH are properly completed.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	WP Section 3.7.10	Visual Observation and Document Review	PP/IP/FP	Prior to Shipment	Chain of custody and final disposition of MPPEH documentation is filed and incorporated into the RI Report.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
11. Demobili-zation	WP Section 2.0	Visual Observation and Document Review	PP/IP/FP	Prior to Demobili-zation	All equipment and files are packaged and shipped to corporate headquarters, all leased/rented equipment is returned off lease/rental and all project support agreements are terminated.	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
	WP Section 2.0	Visual Observation and Document Review	IP/FP	End of Field Tasks	A walkthrough of the project area is conducted to ensure all excavations have been backfilled and no equipment remains onsite	Document deficiency and report to SUXOS for resolution, follow-up to verify compliance
12. Project	WP Section	Visual	PP/IP/FP	Weekly	Project Status Reports are	Document deficiency and report to SUXOS for resolution,

Definable Feature of Work	Reference	Audit Procedures	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
Reporting and Submittals	2.5 and PWS	Observation and Document Review			reviewed for accuracy and thoroughness IAW the PWS	follow-up to verify compliance
	WP Section 2.5 and PWS	Visual Observation and Document Review	PP/IP/FP	Prior to submittal of report	The records of telephone conversations, written correspondence concerning this Task Order and meeting minutes are attached to the Project Status Report in accordance with DID MR-045 and MR-055	Document deficiency and report to SUXOS and PM for resolution, follow-up to verify compliance

[1]See Subsection 4.4.3 for the definition of a lot
[2]See Subsection 4.4.3 for the anomaly dig allocations by MRS

4.4.2 TEST AND BLIND SEED ITEMS/INDUSTRY STANDARD OBJECTS

Test items are employed to verify the DGM performance requirements for dynamic detection and positioning repeatability as described in Table 4-1 for DGM Operations DFW. For the Analog Operations DFW, BSI/ISOs are used per Table 4-1 to verify coverage and detection along the beach transects.

4.4.3 ANOMALY RESOLUTION

The UXOQCS will verify anomaly resolution of both the DGM and analog digs base on the allocation of investigations by MRS. Table 4-2 below outlines the number of digs allocated for DGM and analog, and the number of QC checks required for both to achieve a 70% confidence that there are <10% unresolved anomalies if MEC is detected and a 90% confidence that there are <5% unresolved anomalies if no MEC is detected as prescribed in the PWS, Tables 7-1 and 7-2. The number of QC checks in Table 4-2 is based on the calculations in Table 7-3 of the PWS, Acceptance Sampling Table for Anomaly Resolution.

Table 4-2: QC Anomaly Resolution Requirements by MRS

MRS	DGM Digs Allocated[1]	Analog Digs Allocated[1]	QC Checks of DGM Digs If MEC[2]	QC Checks of DGM Digs If No MEC[2]	QC Checks of Analog Digs If MEC[3]	QC Checks of Analog Digs If No MEC[3]
13	284	66	12	42	11	33
10	333	17	12	42	9	16
11	339	61	12	43	11	32
6	412	38	12	43	11	34
9	176	24	12	40	10	21
8	227	23	12	41	10	20

[1] Digs are allocated in proportion to the design coverage
[2] The DGM lot size is defined as a grid approximately 2500 sq ft in size
[3] The analog lot is defined as the beach area investigated

4.4.4 DEFICIENCY MANAGEMENT

All deficiencies or nonconforming conditions (as defined in the pass/fail criteria in Table 4-1) discovered during inspections or other QC functions will be noted on a Deficiency Notice (DN) form. The DN will identify, at a minimum, any corrective action required, the individuals reviewing and approving the actions, and the actions taken to prevent recurrence. A Deficiency Notice Log will be maintained to document and track corrective actions to closure and be included in the RI report. The UXOQCS will be responsible for tracking deficiencies to closure and reporting their status on daily reports and log forms (see Appendix F for the DN and Deficiency Notice Log forms).

4.4.4.1 Root Cause Analysis

The UXOQCS will conduct a Root Cause Analysis to determine if the failure is the result of the process, procedures, equipment and/or personnel and to what extent of previously performed work may have been affected by the failure. The UXOQCS will provide his findings to the PM, Corporate QC Manager and SUXOS with suggested or required corrective actions. Once approved by management, the team will implement the corrective actions. The Root Cause Analysis and corrective actions will be attached to the weekly QC report. All target reacquisition and intrusive quality control measures and metrics will be documented, with copies sent to the appropriate personnel for review and inclusion into other documents as deemed necessary. Figure 4-1 illustrates the flow of the root cause and effect process that the UXOQCS will use to determine failure causes.

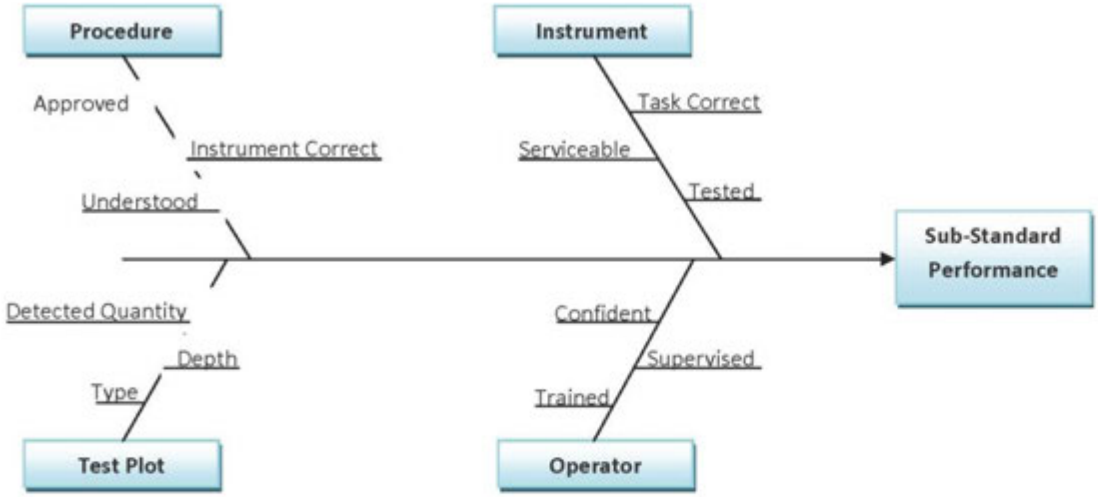

Figure 4-1: Cause and Effect Process

4.4.4.2 Corrective Actions

Following the root cause analysis and approval of corrective actions by management, project personnel will implement these actions to correct the problem. Potential remedies to be considered may include the following:

- Supplemental training of personnel
- Changes of equipment or modification of equipment currently in use
- Acquisition of supplemental equipment
- Implementation of new procedures or modification of existing procedures
- Changes in QC procedures.

The UXOQCS will document the application of the corrective actions on the DN. Through follow-up phase surveillance, the UXOQCS will verify that the corrective action implemented has rectified the deficient condition and is sufficient to prevent recurrence.

4.5 FIELD QUALITY CONTROL INSPECTIONS, AUDITS AND REPORTS

The UXOQCS is responsible for verifying that site personnel perform operational checks of instruments and equipment prior to using them onsite. The UXOQCS will periodically check the project logbooks listed below to ensure the log entries are complete and accurate. Inspections will be performed daily at random, with unscheduled checks of the site in general to ensure personnel accomplish all work as specified in the Work Plan. The UXOQCS will utilize the process outlined in Figure 4-2, Quality Control Process, and Table 4-1, Definable Features of Work Audit Procedures, to ensure all field tasks meet quality standards prior to submittal for the Quality Assurance process. The UXOQCS will submit a report to the Site Manager detailing the results of these checks.

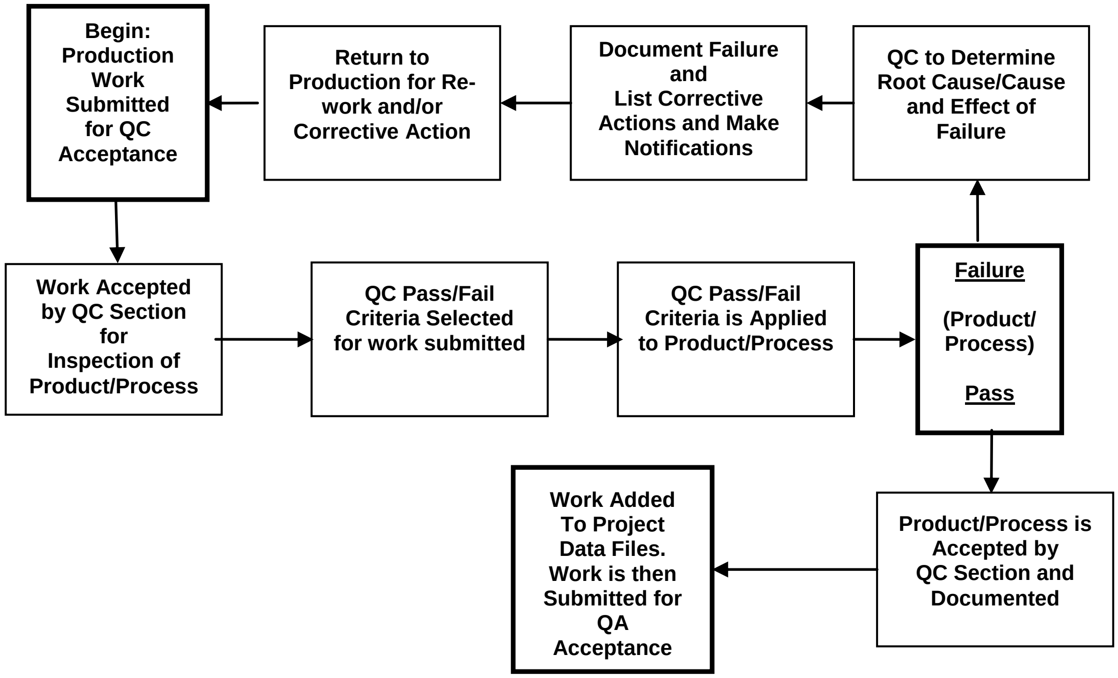

Figure 4-2: Quality Control Process

4.5.1 EQUIPMENT TESTING PROCEDURES AND FREQUENCY

Instruments and equipment, such as geophysical/navigational, video, and data analysis and transfer systems, used to gather and generate site specific data, e.g. GPS, noise, and data sampling densities, to support the field activities, will be tested with sufficient frequency and in such a manner as to ensure that accuracy and reproducibility of results are consistent with the manufacturer's specifications. Instruments or equipment failing to meet the standard will be repaired, recalibrated, or replaced. Replaced instruments or equipment must meet the same specifications for accuracy and precision as the item removed from service. Operator proficiency will also be evaluated regularly for proper instrument set up, operation, survey technique, and data transfer. The Site Geophysicist will conduct training refreshers, if necessary.

Equipment to be tested for use at the project site includes but is not limited to the EM61-MK2, hand-held detectors and the DGPS. Items such as cellular telephones and radios will be tested for serviceability at the start of each workday. Results of these tests will be recorded in the Daily Log. Items failing these tests will be repaired or replaced prior to operations commencing.

4.5.2 CALIBRATION

The UXOQCS will check to ensure that instruments and equipment are calibrated or recalibrated in accordance with the manufacturer’s recommendation or owner’s manual. Calibrations will be completed on a prescribed schedule and the calibration results recorded in the daily field logbook.

If necessary, each DGM Instrument Operator will re-null the EM61-MK2, if the operator observes a shift in local background conditions or any other cause for instrument drift prior to opening and beginning any DGM survey file. The EM61-MK2 operator **will not** re-null the instrument during any DGM survey. No other calibration is expected.

Recalibration will be performed as necessary with the reason for the recalibration and the results recorded in the daily field logbook.

4.5.3 MAINTENANCE

The UXOQCS will check field logbooks to ensure that maintenance of vehicles and equipment are performed on a regular schedule and in accordance with the manufacturer's recommendation or owner's manual for equipment requiring regular upkeep.

USA will coordinate scheduled maintenance of the following equipment in accordance with manufacturer recommendations or the owner's manual.

- Vehicles
- Personal Protective Equipment
- Communications Equipment
- Geophysical, Navigational Equipment, and Personal Digital Assistant (PDA)
- Handheld Sensors
- Emergency Equipment.

Replacement equipment will meet the same specifications for accuracy and sensitivity as the equipment removed from service. Geophysical instruments will be checked on the test strip daily and after any repairs. They will be required to demonstrate a consistent detection rate for all seed items and any identified background anomalies. Repair or replacement of parts will meet the manufacturer specifications and recommendations. The UXOQCS will document and maintain records pertaining to the testing, repair, and/or replacement of equipment on site.

Repair or replacement parts will meet the manufacturer's requirements and be installed by personnel authorized to replace parts or make repairs. Records pertaining to the testing, repair, or replacement of instruments and equipment will be maintained on site by the UXOQCS.

4.5.4 LOGS AND RECORDS

Activity Logs will be maintained daily, as applicable; all entries will be in ink. Logbooks will be bound and pages consecutively numbered. Logbooks and records may be supplemented by the use of preprinted forms (e.g., safety inspection forms, tailgate safety briefings, etc). These forms help to ensure uniformity of activities being conducted, inspected, and reviewed. Forms are located in Appendix F of the work plan. The following logbooks and records will be maintained on site and are subject to inspection by the UXOQCS.

4.5.5 UXO QUALITY CONTROL REPORT

The UXOQCS prepares daily QC Report and a weekly QC Report (the report forms are located in Appendix F). These documents are kept on-site. The weekly QC report is submitted to the PM for distribution to the appropriate personnel. This report includes the following information:

- The periodic assessments of work performed
- Significant QA/QC problems and corrective actions taken
- Conformance or non-compliance issues
- Work progress
- Lessons learned, and change recommendations
- Signature of the UXOQCS.

4.5.5.1 Daily Journal

The Daily Journal will be maintained by the SUXOS; this journal provides a summary of all operations conducted on site, to include:

- Date and recorder of information
- Start and end time of work activities

- Work stoppage
- Visitors and escorts
- Weather conditions
- Changes to the work plan, SSHP, policies or procedures
- Injuries and /or illnesses
- Safety briefings
- MEC encountered
- Relevant events and training
- Signature of the SUXOS.

4.5.5.2 Field Logbooks

The Field Logbooks are maintained by the Supervisory Personnel. These logbooks are used to record site activities and field data. Logbooks are maintained in a neat and legible manner and provide an historic record of site activities, to include:

- Date and team location
- Personnel and work performed
- Equipment and instrument checks
- Injuries and/or illnesses
- Changes to work instructions
- Work stoppage
- Visitors
- Other relevant events
- Signature of Supervisor.

4.5.5.3 Safety Logbook

The site UXOSO will maintain the Safety Logbook. This logbook is used to record all safety matters associated with the project site, including:

- Safety briefings and/or meetings
- Training
- Safety inspections and audits performed
- Work stoppage due to safety issues
- Visitors
- Accidents, incidents, and near misses with corrective action taken
- Site control measures (e.g., EZ, TSD, MFR)
- Other relevant events
- Date and teams checked
- Signature of the UXOSO.

4.5.5.4 Quality Control Logbook

The Quality Control Logbook will be maintained by the UXOQCS. This logbook is used to record all QC matters associated with the project site, including:

- Equipment testing and results
- QC inspections performed,
- Locations and identification numbers of emplaced BSI/ISOs

- Work stoppage due to QC issues
- Equipment monitoring results
- Non-conformance reporting
- Other relevant events
- Date and teams checked
- Signature of UXOQCS.

4.5.5.5 Training Records

Training records will be maintained by the PM. These records contain any licenses, permits, certificates, or other qualifying data, to include:

- Date and nature of training
- Personnel attending and instructor(s)
- Visitor training and briefings
- Signature of instructor and SUXOS, UXOSO or UXOQCS.

4.5.5.6 MEC and Anomaly Excavation Records

The MEC and anomaly records are individually prepared records for each operating team. These records are prepared by the team supervisor, and are used to record data on anomaly excavations and MEC encountered. These records also include:

- Date and target identifier
- Identification of item(s) located
- Classification
- Distance from marked target location and depth encountered
- Type, condition, depth, and location of any MEC encountered
- Disposition of MEC
- Location and identification number of recovered BSI/ISOs
- Other relevant data
- Signature of Supervisor.

4.5.5.7 DGM

The DGM Logbook will be maintained by the Site Geophysicist. This logbook is used to record all DGM matters associated with the project site, including:

- Equipment testing and results
- DGM inspections performed
- Work stoppage due to DGM issues
- Non-conformance reporting
- Other relevant events
- Date and teams checked
- Signature of Site Geophysicist.

4.5.5.8 DGM Report

The Site Geophysicist and UXOQCS will prepare a weekly DGM Quality Control Report. The UXOQCS will keep the original on-site and submit a copy to the PM for distribution to the appropriate personnel. This report will include:

- A summary of daily instrument Test Results

- Evaluation of all DGM data against project metrics (e.g. noise, sample spacing, data processing);
- DGM work progress
- Lessons learned, and change recommendations (e.g. document any QC failures and the action taken)
- Signature of the Site Geophysicist and the UXOQCS.

4.5.5.9 Photographic Logbook

The Photographic Logbook will be maintained by the SUXOS. This logbook is used to record all photographs taken on the project site. These photographs are used to document MEC encountered, and before, during, and after work and/or site conditions. Photographs will include:

- Date and time taken
- Unique identifying number(s) relating to the Photographic Logbook
- Location photograph was taken
- Brief description of the subject matter.

4.5.6 DAILY REVIEW OF FIELD DATA

During daily field activities or at least once daily, the UXOQCS will review field data to ensure accurate classification and documentation of recovered MEC related items. This review will allow for reconstruction of what an item was and whether or not its classification is correct.

4.6 CONTRACT SUBMITTAL QUALITY CONTROL PROCESS

Documents required under this contract will be developed and maintained by a project team consisting of the USA Project Manager, Project Engineer, Project Geophysicist, GIS Manager, and Corporate QCM. These team members will contribute their corporate knowledge and experience to the documents to ensure technical quality.

- The USA Project Manager will take the lead in development of contract documents, and will schedule a peer review and a QC review in sufficient time to meet project milestones for delivery of submittals
- The Project Engineer will provide technical writing support to develop the documents, and will review completed documents to ensure accuracy and completeness
- The PM will review and supply information and documents to ensure accuracy and completeness of procedures and reports
- The Project Geophysicist will ensure a technically sound approach to fieldwork, and accuracy and completeness of reporting on geophysical data
- The GIS Manager will develop digital database and maps, overlays of beaches and exclusion zones, and other spatial data. The GIS Manager will prepare all drawings or maps needed for submittals, and will perform QC of civil survey data
- After the project team has performed a review of documents, the Corporate QC Manager and UXOQCS will perform a QC review to ensure overall quality and completeness.

Comments on submitted documents will be directed by project personnel to the appropriate subject matter expert for resolution.

Changes to final work plans will be submitted to the PM immediately upon approval. The PM will be responsible for ensuring that the changes are posted to the hard copy on file and that all field personnel are made aware of the changes.

4.7 FIELD QUALITY CONTROL INSPECTIONS, AUDITS, AND REPORTS

Project QC inspections, audits, and reports are divided into MEC intrusive and DGM operations at the site. Personnel responsible for the inspections, reviews, corrections, and reports are identified in the following paragraphs.

The UXOQCS is responsible for the accomplishment of operational checks of instruments and equipment by site personnel. The appropriate log entries will be made. Inspections will be performed daily at random, with unscheduled checks of the site in general to ensure personnel accomplish all work as specified in the Work Plan. The UXOQCS will utilize the process outlined in Figure 4-2, Quality Control Process, and Table 4-1, Definable Features of Work, to ensure all field tasks meet quality standards prior to submittal for the Quality Assurance process. The UXOQCS will submit a report to the Site Manager detailing the results of these checks.

4.7.1 UXO QUALITY CONTROL REPORT

The UXOQCS prepares daily information and a weekly QC Report. These documents are kept on-site. The weekly QC report is submitted to the PM for distribution to the appropriate personnel. This report includes the following information:

- The periodic assessment of performed
- Significant QA/QC problems and corrective actions taken
- Conformance or non-compliance issues
- Work progress
- Lessons learned, and change recommendations
- Signature of the UXOQCS.

4.7.2 CLASSIFICATION OF MEC-RELATED ITEMS

To ensure accurate classification of MEC-related items (with respect to their explosive hazard), as the information is used to make decisions about the response action, USA will inspect suspect MEC and classify these items in accordance with Table 4-3. The list is not all inclusive, but reflects the types of MEC related material that may be encountered at the project site. The numbers in the table refer to footnotes that are found on the next page. It is important to read the footnotes, as they provide additional information of importance to understanding.

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Table 4-3: Classifications of MEC-Related Items

	Classification Following Inspection:					
	Presents Explosive Hazards			Does Not Present Explosive Hazards		
	MEC					
Type of Material	UXO	DMM [(1)]	MC [(2)]	MC [(3)]	Munitions Debris	Other
Used military munitions, on a range, fired	X				X	
Unused military munitions, on a range, apparently discarded		X			X	
Used military munitions, in a burial pit, on a former range	X[(4)]				X	
Unused military munitions, in a burial pit on a former range		X[(4)]			X	
Explosives in the soil			X[(5)]	X		
Target from a range (other than small arms range)	X[(6)]	X[(6)]	X[(6)]			X[(7)]
Remnants of munitions from a former range	X[(8)]	X[(8)]	X[(8)]		X[(9)]	

Footnotes:

(1) Discarded Military Munitions (DMM): Munitions generally considered as DMM include: buried munitions; un-recovered kick outs from open detonations; munitions left behind or discarded accidentally during munitions-related activities; munitions intentionally disposed of without authorization during munitions-related activities. Munitions removed from storage for the purpose of disposal that are awaiting disposal are not DMM.

(2) Munitions Constituents: MC is both (a) an explosive; and (b) present in sufficient concentrations to present explosive hazards.

(3) This is MC that is either (a) not an explosive (e.g., lead, beryllium, and cadmium); or (b) an explosive not present in sufficient concentrations to present explosive hazards.

(4) Although military munitions in a burial pit will normally be DMM, some may be UXO. For explosives safety reasons, munitions in a burial pit should be approached as UXO until assessed by technically qualified personnel (e.g., Explosive Ordnance Disposal (EOD) personnel, UXO-qualified personnel) and determined that they are not UXO or that they do not present explosive hazards similar to UXO.

(5) Explosive soil is typically found in sumps and settling lagoons for explosives-laden wastewater, and in and around drainage ditches and pipes that carry the wastewater to such sumps and lagoons.

(6) A target is a type of range-related debris. Although a target is not MEC, it may contain UXO, DMM, or MC. Prior to its release from DoD control, its explosives safety status must be documented.

(7) A target's explosives safety status must be documented and any demilitarization required to remove its military characteristics must be performed prior to its release from DoD control.

(8) UXO, DMM, or MC may be found on operational ranges and on former ranges (previously referred to as closed, transferring or transferred ranges). An inspection of the material will determine into which category this material falls. For example, if a projectile breaks apart on impact, one could find (a) a sheared-off fuze, which would be UXO or (b) explosive filler, which would be MC that broke away from the projectile's open body. If during an open detonation of an unserviceable munitions that is conducted on an operational range, the donor charge detonates, but the munitions being destroyed breaks up, but does not detonate, the remnants of the munitions would be DMM or, if explosive residue (e.g., clumps of TNT), MC.

(9) Fragments, while munitions debris, may be evidence of HE usage at the site. For such fragments, USA will indicate evidence of HE in its classification. After determination of its explosives safety status, scrap metal from used munitions on a range that is documented as safe would, after any demilitarization required removing its military characteristics, be available for release from DoD control. In additions to these DoD requirements, other regulatory criteria may apply.

4.8 QUALIFICATIONS AND TRAINING

4.8.1 EMPLOYEE QUALIFICATIONS

The PM will maintain personnel files on each employee at the project site. These files include copies of necessary license, permits, training records, certificates of qualifications, and resumes that support the employee's placement and position. Prior to an employee's initial assignment or before any change in duties or assignment the PM will review the employee's files to ensure necessary qualifications are met. All site records and documentation are subject to inspection and review by the UXOQCS.

- Site UXO personnel must meet the minimal qualifications as outlined in DDESB TP-18, dated 20 December 2004.
- Dive personnel must also meet the requirements set forth in the PWS, USACE requirements, and applicable sections of 29 CFR 1910.120, Subpart T.
- Personnel assigned to DGM operations as operators, QC, and geophysicist have received additional training necessary to carry out requirements found in Chapter 3 of this work plan.

4.8.2 EMPLOYEE TRAINING AND SITE SPECIFIC REQUIREMENTS

USA ensures that only qualified and properly trained personnel are assigned to positions on project sites. Prior to mobilization of personnel, USA ensures that training required by USA, OSHA 29 CFR 1910.120, and the EM 385-1-1 has been completed for all personnel assigned to the project as shown in Table 4-4 below.

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Table 4-4: Training

Training Course	Personnel Attending
40-Hour HAZWOPER Training	All personnel who have not previously received this training or who do not qualify for certification through documented experience or training equivalent to that in paragraphs (e)(1) through (e)(4) of 29 CFR 1910.120.
8-Hour Supervisor Course	All USA management and supervisory personnel. This includes the SUXOS, UXOSO, UXOQCS, and UXO Technicians III (UXOTIIIs).
8-Hour Refresher Course	All site personnel, except those who have completed their initial 40-Hour HAZWOPER training within the past year.
First Aid and Cardiopulmonary Resuscitation (CPR) Training	At least two site personnel will have current first aid and CPR training.
30-Hour OSHA Construction Safety Course	Training Requirement for UXOSO IAW with EM 385-1-1, Section 01.A.17

In addition, prior to the start of operations all personnel will receive the following as a minimum:

- Familiarization with the Work Plan and its policies and procedures
- APP/SSHP/AHA/SOP orientation
- Emergency Response Plan training
- PPE training
- Environmental considerations peculiar to the operations on the project site
- Instruction and training on equipment usage and safe work practices
- Daily safety training outlining the day's activities.
- Visitors to the site will be provided with a site orientation and safety briefing prior to entering the exclusion area (while onsite, visitors will be escorted at all times by a UXO technician).

Training is conducted by the SUXOS, UXOSO/UXOQCS, or other designated personnel and records of attendance are maintained on site. Certificates of Training are issued when applicable.

4.8.3 DGM EQUIPMENT OPERATOR TRAINING

USA will field only qualified DGM equipment operators to ensure quality work and quality data. The Site Geophysicist will be trained in instrument set-up and operation and in survey management. Personnel will be qualified and experienced in positioning sensor data with line/station/fiducials and RTK-DGPS, data transfer, DGM quality control, data processing, data analysis with anomaly selection and categorization, data delivery and reporting, and in anomaly reacquisition; including the set up and operation of the RTS. The Site Geophysicist will manage all DGM operational personnel and equipment.

The Project Geophysicist will conduct the training at the project site. Previous experience will be reviewed, documented, and verified with practical exercises at instrument test strip. All trained personnel will be issued a certificate of training, signed by USA's Project Geophysicist.

4.8.4 UXOQCS

The UXOQCS will have experience providing QC support on MR projects. The UXOQCS has received additional corporate training and has experience inspecting DGM team operations as well as all facets of an MEC project. Training includes the placement of QC BSI/ISOs, and the set up and use of the RTS to determine BSI/ISO locations in both local and State Plane coordinates. The UXOQCS is also experienced in the use of all analog sensors that may be used on this project.

4.8.5 SITE GEOPHYSICIST

USA's Site Geophysicist will have a degree in geophysics, engineering geophysics, or closely related field and will have directly related MEC geophysical experience. The Site Geophysicist will report to the Project Geophysicist and work closely with the site UXOQCS during DGM operations.

4.8.6 PROJECT GEOPHYSICIST

USA's Project Geophysicist will have a minimum of five years' experience in all aspects of DGM in support of the RI. The Project Geophysicist will have oversight of all DGM operations, personnel training and certification, data formatting and delivery, and project DGM reporting. The Project Geophysicist will work closely with the Corps' Project Geophysicist and USA's Site Geophysicist on all project DGM operations, quality control metrics, and DGM decisions and recommendations. They will work with the site UXOQCS to document the detection of emplaced test items.

4.9 EQUIPMENT TESTS, FUNCTIONAL CHECKS, CALIBRATION, AND MAINTENANCE

4.9.1 TESTING PROCEDURES AND FREQUENCY

Instruments and equipment, such as geophysical/navigational, video, and data analysis and transfer systems, used to gather and generate site specific data, i.e. GPS, noise, and data sampling densities, to support the field activities, will be tested with sufficient frequency and in such a manner as to ensure that accuracy and reproducibility of results are consistent with the manufacturer's specifications. Instruments or equipment failing to meet the standard will be repaired, recalibrated, or replaced. Replaced instruments or equipment must meet the same specifications for accuracy and precision as the item removed from service. Operator proficiency will also be evaluated regularly for proper instrument set up, operation, survey technique, and data transfer. The Site Geophysicist will conduct training refreshers, if necessary.

Equipment to be tested for use at the project site is identified in Chapter 5 of this work plan. This includes but is not limited to the EM61-MK2 and the DGPS.

Items such as cellular telephones and radios will be tested for serviceability at the start of each workday. Results of these tests will be recorded in the Daily Log. Items failing these tests will be repaired or replaced prior to operations commencing.

4.9.2 ROUTINE EQUIPMENT CHECKS

Each DGM team will follow the equipment SOPs (see Appendix K) for set up, operation, and data transfer. These SOPs include all QC checks. Specific QC tests include:

- DGPS Reoccupation QC Test any day the DGPS is used (offset < 2m)
- Initial 6-line Test whenever a new DGM team arrives (appropriate data processing for repeatable amplitude response +/- 20% from previous measurements, and accurate peak positioning within 0.66 ft (0.2 m)
- Daily Equipment Warm-up (e.g. a minimum of 5 minutes)
- AM and PM Static QC Tests: <2.5mV p-p on Time Gate 3, +/-20% Spike response, no cable related problems, and operator noise is <2mV on time gate 3; check all time gates.
- AM and PM Repeat QC Tests: < +/- 25% amplitude and size variation, and < 2m location offset
- Anomaly selection review, including all anomaly decision tools
- BSI detection results
- Any analog sensors will be tested over a known object each day they are used. The known anomaly will be a seed item that meets the size and depth requirements necessary to determine the serviceability of the instrument.

- DGM Reacquisition QC tests will include a positioning system reoccupation test each day of reacquisition, and verification by the UXOQCS that any refined anomaly offset from the reported anomaly location does not exceed 2m.

4.10 CALIBRATION

The UXOQCS will check to ensure that instruments and equipment are calibrated or recalibrated in accordance with the manufacturer's recommendation or owner's manual. Calibrations will be completed on a prescribed schedule and the calibration results recorded in the daily field logbook.

If necessary, each DGM Instrument Operator will re-null the EM61-MK2, if the operator observes a shift in local background conditions or any other cause for instrument drift prior to opening and beginning any DGM survey file. The EM61-MK2 operator **will not** re-null the instrument during any DGM survey. No other calibration is expected.

Recalibration will be performed as necessary with the reason for the recalibration and the results recorded in the daily field logbook.

4.10.1 MAINTENANCE

The UXOQCS will check field logbooks to ensure that maintenance of vehicles and equipment are performed on a regular schedule and in accordance with the manufacturer's recommendation or owner's manual for equipment requiring regular upkeep.

USA will coordinate scheduled maintenance of the following equipment in accordance with manufacturer recommendations or the owner's manual.

- Vehicles
- Personal Protective Equipment
- Communications Equipment
- Geophysical, Navigational Equipment, and Personal Digital Assistant (PDA)
- Handheld Sensors
- Dive Equipment
- ROV
- Emergency Equipment.

Replacement equipment will meet the same specifications for accuracy and sensitivity as the equipment removed from service. Geophysical instruments will be checked on the test strip daily and after any repairs. They will be required to demonstrate a consistent detection rate for all seed items and any identified background anomalies. Repair or replacement of parts will meet the manufacturer specifications and recommendations. The UXOQCS will document and maintain records pertaining to the testing, repair, and/or replacement of equipment on site.

Repair or replacement parts will meet the manufacturer's requirements and be installed by personnel authorized to replace parts or make repairs. Records pertaining to the testing, repair, or replacement of instruments and equipment will be maintained on site by the UXOQCS.

4.11 ACCURACY

The Site Geophysicist will verify accurate sensor positioning is being maintained primarily by the AM and PM Repeat QC Test results and positioning system Reoccupation QC Test results. The UXOQCS will perform weekly reviews of the MEC data to ensure accurate categorization of munitions related items encountered and to ensure that all MEC items are accounted for on site documents/registers. The UXOQCS will evaluate the accuracy of all project GIS, e.g. project map, before posting to the project web site.

PWS coverage will be evaluated by the UXOQCS to determine if the geographic features are correct. Errors found will be corrected and noted in the operations field logbook. The accuracy of any grid corners that are established for Line/Station/Fiducial positioning will be to the closest 0.3m. A detected error will result in the data being examined and the correct location and place points will then be determined in the project GIS data set to represent identifiable elements of the feature (i.e., corners or intersections).

4.12 QUALITY CONTROL OF FIELD PROCEDURES

4.12.1 DGM - INTERIOR

The UXOQCS will perform a QC Inspection of a minimum of 20% of the anomalies selected for investigation. For QC inspections, the UXOQCS will use an EM61-MK2. All QC inspections will be documented for acceptance or non-acceptance of the work performed.

MEC detection acceptance standards for this project are based on the known site anomalies previously identified and then reacquired and the site-specific test strip results. Any portion of the process or analysis not consistent with the Geophysical DQO (see Appendix O), DFW (see Table 4-1), or Section 3 is considered a quality failure if meeting the criteria for selection, reacquisition and investigation. USA will correct the quality deficiency and perform QC reviews on the affected area before submitting to the Government for verification and acceptance.

See Table 4-1 and the Geophysical DQO for Performance and Acceptance Criteria.

4.12.2 ANALOG – BEACHES

The UXOQCS will perform a QC Inspection of a minimum of 20% of the completed lot. For QC inspections, the UXOQCS will use the handheld analog sensor selected and that has been tested against the known site anomalies. All QC inspections will be documented for acceptance or non-acceptance of the work performed.

USA will employ QC blind seed items (BSI) at the minimum rate consistent with the requirements found in Table 4-1 per lot in the work areas as an additional quality check of the investigative process. The BSI will be industry standard objects that meet the criteria outlined in the PWS, buried at detectable depths. In the event that a BSI is not flagged, the UXOQCS will initiate an immediate root cause analysis (Figure 4-1) to document the cause of the failure, estimate the impact on previous work. The UXOQCS will provide his findings to the PM and SUXOS with suggested or required corrective actions. Once the corrective actions are approved by management, the UXO Teams will implement them. The root cause analysis and corrective actions will be attached to the weekly QC reports.

MEC detection depths for this project are based on the PWS stated depth and the ITP results. Any item remaining in a selected anomaly location (flagged position) after excavation is considered a quality failure if it meets the criteria for prosecution by depth and selection. USA will correct the quality deficiency, re-sweep, and perform QC reviews on the affected area before submitting to the Government for verification and acceptance.

The UXOQCS will perform a QC Inspection of a minimum of 20% of the analog surface and subsurface clearance areas. For QC inspections, the UXOQCS will use a handheld sensor as appropriate. All QC inspections will be documented for acceptance or non-acceptance of the work performed.

See Table 4-1 and the Geophysical DQO for the Performance and Acceptance Criteria.

4.13 DIGITAL GEOPHYSICAL MAPPING QUALITY CONTROL

Quality Control for DGM covers all aspects of DGM operations, from equipment set up, operation, surveying, data processing and analysis, data management and reporting/delivery, as well as operator training. Most of these DGM QC checks are part of the SOPs and are included in Appendix K. This section describes USA's DGM QC methods and procedures that are specific to the UXOQCS and the Project Geophysicist. They include:

- Verifying operator training
- Test Item placement and evaluation
- Routine checks and audits to ensure that the DGM teams are following the approved work plan and DGM SOP and Checklists

- DGM data quality checks, including RTK-DGPS Reoccupation accuracy, sensor static and dynamic noise, repeat response amplitude and position, sampling density down-line (e.g. speed) and across-line
- DGM anomaly selection checks
- Anomaly Reacquisition and Intrusive QC checks
- Post intrusive DGM checks.

4.13.1 OPERATOR TRAINING

USA will field only qualified DGM personnel to ensure quality work and quality data. The Site Geophysicist will be fully trained in instrument set up and operation and in survey management. Personnel will be fully qualified and experienced in positioning sensor data with line/station/fiducials and RTK-DGPS, data transfer, DGM quality control, data processing, data analysis with anomaly selection and categorization, data delivery and reporting, and in anomaly reacquisition; including the set up and operation of the RTS.

The Site Geophysicist will manage all DGM operational personnel and equipment. The geophysical instrument operators will be fully trained and experienced in instrument set up, operation, routine quality control tests, and data acquisition with real time quality monitoring and positioning with either line/station/fiducials or RTK-DGPS. They will as well be fully trained and experienced in data transfer, data preprocessing and delivery of the data to the Site Geophysicist. They will also be trained and experienced in anomaly reacquisition. The UXO technicians on each DGM team will be trained in the instrument set up and operation, including sensor positioning with line/station/fiducials or RTK-DGPS. They will be experienced in hand held instruments used for sensing and flagging anomalies in areas that are not suitable for DGM, and will be capable of operating the RTS in support of establishing the location of the flags they placed, and anomaly reacquisition.

4.13.2 CORPORATE TRAINING

Most training will be performed at the USA Corporate office in Oldsmar, Florida. Previous experience will be reviewed, documented, and verified with practical exercises at an exercise area convenient to the Oldsmar office. All trained personnel will be issued a certificate of training, signed by USA’s Senior Geophysicist.

4.13.3 UXOQCS

The UXOQCS will have experience providing QC support on MR projects. The UXOQCS will be familiar with and experienced checking DGM teams using the DGM SOP and Checklists. Training will include the placement of QC BSI, and the set up and use of the RTS to determine BSI locations in both local and State Plane coordinates. They will also be experienced in the use of all analog sensors that may be used on this project. The UXOQCS will work with the project PLS to get the location of each BSI.

4.13.4 PROJECT GEOPHYSICIST

USA’s Project Geophysicist will have a minimum of five years’ experience in all aspects of DGM in support of munitions response projects. The Project Geophysicist will have oversight of all DGM operations, personnel training and certification, data formatting and delivery, and project DGM reporting. The Project Geophysicist will work closely with the Corps’ Project Geophysicist and USA’s Site Geophysicist on all project DGM operations, quality control metrics, and DGM decisions and recommendations. They will work with the site UXOQCS to document the detection of QC BSIs.

4.13.5 ON-SITE PROFICIENCY DEMONSTRATION

All DGM field personnel and equipment will demonstrate their ability to meet Geophysical DQOs on the existing Test Strip prior to any field work. This will include the initial mobilization of each team and will be repeated, as necessary, when personnel are replaced or equipment is replaced or repaired. The UXOQCS will observe all of these activities to ensure both the Work Plan and DGM SOPs are being followed.

4.14 PERIODIC CHECKS AND AUDITS

4.14.1 DAILY UXOQCS CHECKS

USA's UXOQCS will conduct audits of operational checks to ensure the DGM teams are following the Work Plan requirements and SOPs. DGM SOPs and Checklists include:

- Out of the Box Tests
- EM61-MK2 SOP
- DGPS SOP
- Daily Static, Dynamic Repeat, and Position QC Tests
- Daily Position Reoccupation Accuracy Test
- Data Storage and Transfer Checklist
- Checklist for Field Editing and Processing
- Data Management Checklist
- Anomaly Reacquisition SOP.

4.14.2 DAILY DGM DATA QC

The Project Geophysicist will review each day's DGM data for completeness. Project Geophysicist will review the QC Test data and compare the results to those provided by the Site Geophysicist. Any discrepancies will be resolved prior to data submittal. Project Geophysicist will randomly select, process and analyze 10% of selected survey data and compare the results to those provided by the Site Geophysicist.

4.14.3 QC BLIND SEED ITEMS (BSIS)

USA's UXOQCS will place QC BSIs at the minimum rate of two BSIs per lot for analog operations. These items will be appropriate simulants within the range of expected MEC. The UXOQCS will establish the location of each BSI using the DGPS, the Laser Distance Meter, or Tape Measures, and will forward those locations to the Project Geophysicist after the generation for inclusion into the data. The UXOQCS will report the QC BSI detection results in the weekly QC report.

4.14.4 CORRECTIVE ACTION, IF REQUIRED

Any QC test failure or failure to detect and report a QC BSI will result in the initiation of a root cause analysis to document the cause of the failure, assess any impact of previous work, and initiate a corrective action, including:

- Verifying BSI burial depth and location accuracy
- Training refresher
- Equipment repair/replacement
- QC BSI failure
  - BSI location error
  - BSI behind obstruction and not covered by the sensor
  - BSI buried too deep
  - Data processing positioning error
  - Data analysis and anomaly selection error.

4.14.5 ANALOG RESOLUTION QC

Following the location of anomalies, a review of flag/anomaly selection will be made, typically this will be based on evenly spacing the selection along transect for analog.

4.14.6 REACQUISITION QC

The UXOQCS will monitor and verify that the reacquisition teams are following the approved Work Plan and SOPs. Routine reacquisition QC tests will include:

- Positioning system Reoccupation QC Test (offset +/<0.5 ft (0.15 m); Compare reacquisition anomaly peak is within +/-20% of reported peak.

The reacquisition team will verify that all reacquisition QC test results meet project objectives. The UXOQCS will verify that the Dig Lists are being updated with the reacquisition peak response values and location offsets are within Geophysical DQO tolerances of the reported anomaly location or as established at the test strip.

4.14.7 POST-INTRUSIVE OBJECT/ANOMALY CHECK

The intrusive teams will investigate each refined anomaly location and report their findings on the Dig List (captured on PDA). In addition to the standard field QC checks on the intrusive results, the UXOQCS will verify the Project Geophysicist’s 100% review of the reported anomaly results. If the recovered object matches the data signature, the anomaly will “pass” and be recorded in the results of the Dig List. If the recovered anomaly does not match the data, he or she will:

- Check the processed data
- Check reacquisition accuracy and refinement;
- Require the intrusive team to reinvestigate the anomaly.

4.15 DGM QC REPORTS

The Site Geophysicist will generate and maintain a daily DGM report. Daily reports will be summarized into a weekly report that will include a DGM QC section. The weekly DGM QC report section will:

- Document any DGM QC failures, their root cause analysis, impact assessment on previous work, resulting corrective action(s), and any rework results
- Summarize all daily QC reports.

This weekly report will be signed by the Site Geophysicist and UXOQCS, and submitted with the weekly data delivery.

4.16 LESSONS LEARNED PROGRAM

As required by ER 1110-1-12, USA will develop a Lessons Learned Program (LLP) to provide for the exchange of information regarding problems that may occur during the response RI activities on this project site.

4.16.1 LESSONS LEARNED OBJECTIVE

The objective of the LLP is to capture and share experience or recognized potential problems or better business practices to:

- Prevent the recurrence of repetitive design/execution deficiency
- Clarify interpretation of regulations or standards
- Reduce the potential for mistakes in high risk/probability areas of concern
- Pass on information specific to an installation or project
- Promote a good work practice that should be ingrained for repeat application
- To promote efficient and cost-effective business practice.

4.16.2 TEAM RESPONSIBILITIES

The USA project team will be responsible for identifying and submitting lessons learned for review and approval. Throughout this the MEC response activity, USA project team members will consider how their experiences might be appropriate for the LLP.

4.16.3 PROJECT MANAGEMENT RESPONSIBILITY

The PM will review and approve all lessons learned for submittal to the Corps PM for potential discussion with the project development team during After Action Reviews.

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5.0 EXPLOSIVES MANAGEMENT PLAN

5.1 GENERAL

This plan outlines the procedures USA will use to complete the RI/FS at Culebra Island Site. The procedures are in accordance with the following regulations and TMs:

- DOD 4145.26-M, Contractor's Safety Manual for Ammunition and Explosives
- DOD 6055.9-M, DoD Ammunition and Explosives Safety Standards
- Applicable Sections of the Department of Transportation (DOT), 49 CFR Parts 100-199
- Army Regulation (AR) 385-64, Ammunition and Explosives Safety
- AR 190-11, Physical Security of Arms, Ammunition and Explosives
- Engineer Manual (EM) 1110-1-4009 Engineer Manual, Ordnance and Explosives
- EP 1110-1-18 Engineer Pamphlet, Ordnance and Explosives Response
- Explosive Law for Commonwealth of Puerto Rico
- USACE EM 385-1-97, Explosives Safety and Health Requirements Manual
- USACE EM 385-1-1, Safety and Health Requirements Manual
- Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) Publication 5400.7, Federal Explosives Laws and Regulations.

5.2 ACQUISITION

USA will use commercial explosives obtained through a local explosives supplier for disposal and venting of MEC. USA has an ATF permit (see Appendix L) to purchase, store, and use explosives and will supply commercial demolition material for disposal and venting operations. USA personnel have a letter of clearance from the BATFE for the use of explosives. As required by Commonwealth of Puerto Rico, USA will have a Blaster's License issued for the RI/FS. USA will provide the explosives distributor a certified statement of the intended use of the explosive material. The ATF permit will be posted on site and will be available for Federal, state, or local inspection.

5.2.1 DESCRIPTION AND ESTIMATED QUANTITIES

USA will store explosives on-site in the Type II magazine approved in Amendment 1 to the Explosive Safety Submission. USA will store less than 100 pounds of bulk and initiating explosives on site.

5.2.2 ACQUISITION SOURCE

USA will purchase explosives from licensed commercial suppliers such as Austin Powder Company on the Puerto Rico main island. The SUXOS will be authorized in writing to request and receive explosives from the commercial suppliers.

5.2.3 LISTING OF PROPOSED EXPLOSIVES

Table 5-1 lists the types and quantities of explosives that may be used.

Table 5-1: Typical Explosives and Quantities for RI/FS

Type of Explosive	Descriptions	Quantity
1 lb	Booster Black Cap	20 ea
Electric Caps	Rock Star Detonators	100 ea
Detonating Cord	80 Grain	1 roll 500 Ft
Perforators	19.5 gram Shaped Charges	50 ea

5.3 INITIAL RECEIPT

Shipments of explosives will be by commercial carrier from the explosives supplier. The explosive supplier is responsible for all permits and documentation required by Federal, Commonwealth of Puerto Rico, and local regulations for movement of explosives to the air terminal. USA will coordinate with the Mayor's Office and the Puerto Rico State Police to receive and transport the explosives to the Type II magazine.

5.3.1 PROCEDURES FOR RECEIPT OF EXPLOSIVES

On receipt, the type, quantity, and lot number of each explosive item will be checked against the shipping manifest and recorded on the USA Explosives Usage Form and the Daily Operations Journal (see Appendix F USA Forms).

5.3.2 PROCEDURES FOR RECONCILING DISCREPANCIES IN QUANTITIES SHIPPED AND RECEIVED

The SUXOS will reconcile the delivery shipping documentation with the requested amounts ordered and received. The SUXOS will not sign for or accept shipments with shortages or overages until the discrepancies are corrected.

5.4 STORAGE

On-site storage of explosives is anticipated.

5.4.1 ESTABLISHMENT OF STORAGE FACILITIES

USA will store explosives in the existing ATF Type II magazine, previously sited on Culebra. USA will comply with ATF, Federal, and local storage and compatibility criteria and procedures, including the required USAESCH approved Explosive Siting Plan (ESP).

USA will maintain the magazine to comply with the magazine criteria and quantity distance (QD) requirements established in ATF Regulation ATF P 5400.7 and DOD 6055.9-M, DOD Ammunition and Explosives Safety Standards.

Figure 5-1: Site of Type II Magazine

5.4.2 PHYSICAL SECURITY OF STORAGE FACILITIES

The magazine will be locked with high security padlocks (2) meeting ATFP 5400.7 Section 55.208 (a) and is enclosed by a chain link fence, IAW 6055-9 M, and EM 1110-1-4009. The magazine will remain locked except when receipts and issues are being made. The two locks on the magazine will require two different keys. One key will be kept by the SUXOS and the second key will be kept by the UXOQCS. The SUXOS will maintain the key to the fence enclosing the magazine. The magazine storage area will be inspected each work week by the SUXOS and UXOSO/UXOQCS to ensure the integrity of the enclosure.

5.5 TRANSPORTATION

Transportation of MEC and explosives will comply with all Federal, state, and local regulations. Permits are not required under CERCLA for on-site or on Federal installations for transportation of explosives or conventional MM. USA will request permission from the Mayor's Office to use the docks at DNER or the

Ferry Dock in the City of Dewey, Culebra, PR. Coordination will be made with the Puerto Rican State Police to provide an escort during transport of any explosives to or from the magazine to each MRS on the island or to the docks on the island. From the docks explosives will be transported by water to Cayo Luis Pena (MRS 13) or Cayo Norte (MRS 08). USA plans to transport all explosives to the island of Culebra using helicopters.

5.5.1 PROCEDURES FOR TRANSPORTATION FROM STORAGE TO DISPOSAL LOCATION

IAW with DOT regulations, USA will transport explosives in IME-22 containers for transportation of explosives to the disposal sites. USA will comply with the following:

- Initiating explosives, such as blasting caps, will remain separated at all times. Blasting caps may be transported in the same vehicle as long as they are in a separate IME-22 container (49 CFR 173.63) and secured away from other items.
- Compatibility requirements will be observed.
- Only UXOTIII's and above may be issued and transport explosive materials. The receiving party shall sign the receipt documents for accountability.
- Operators transporting Hazard Division (49 CFR 173.50) 1.1 explosives will have a valid driver's license.
- Drivers will comply with posted speed limits but will not exceed a safe and reasonable speed for conditions. Vehicles transporting explosives off-road will not exceed 25MPH.
- Personnel will not ride in the cargo compartment with explosives or MEC.

5.5.2 EXPLOSIVE TRANSPORTATION VEHICLE REQUIREMENTS

Explosives will be transported in closed containers in the beds of vehicles whenever possible. The load shall be well braced and, except when in closed vehicles, covered with a fire-resistant tarpaulin or placed in an appropriate shipping container.

- Initiating explosives, such as blasting caps, will remain separated at all times. Blasting caps may be transported in the same vehicle as long as they are in a separate container and secured away from other items.
- Compatibility requirements will be observed.
- Only UXO Technicians III and above may be issued explosive materials and transport them. The receiving party shall sign the receipt documents for accountability;
- Operators transporting explosives will have a valid driver's license;
- Drivers will comply with posted speed limits but will not exceed a safe and reasonable speed for conditions. Vehicles transporting explosives off-road will not exceed 25 MPH.
- Personnel will not ride in the cargo compartment with explosives or MEC.
- Vehicles transporting explosives or MEC will be inspected prior to load out using the Motor Vehicle Inspection form DD FORM 626 (Appendix F), and will be properly placarded.
- Vehicle engine will not be running and the wheels will be chocked when personnel are loading/unloading explosives.
- Beds of vehicles will have a bed liner, dunnage, or sand bags to protect the explosives from contact with the metal bed and fittings.
- Vehicles transporting explosives will have a first aid kit, two 10-BC rated fire extinguishers, and a means of communications.

5.5.3 TRANSPORTATION BY VESSEL

Movement of explosives from Culebra to Cayo Luis Pena will require the use of a contracted and licensed vessel. Transport of explosives by waterborne vessel requires adhering to the applicable sections contained in 49 CFR (DOT) and U.S. Coast Guard directives.

Specifics, such as safety requirements, placarding, stowage, security, personnel, and emergency procedures are detailed in the SOP Explosives Transportation –Open Water Vessels, contained in Appendix K.

5.6 RECEIPT PROCEDURES

The SUXOS will strictly control access to all explosives. All receipts, issues, and usage of explosives will be properly documented and verified, through physical count, by the UXOQCS.

5.6.1 RECORDS MANAGEMENT AND ACCOUNTABILITY

On receipt, the type, quantity, and lot number of each explosive item will be checked against the manifest and recorded on the Explosives Usage Form (Appendix F). The original receipt documents and an inventory will be maintained on file by the SUXOS. All original explosive records will be forwarded to USA Oldsmar for archive in accordance with ATF regulations and requirements. ATF requires USA to maintain explosive records for commercial purchases for a period of 5 years. Copies of all records will be maintained on site by the SUXOS and be available for inspection by authorized agencies. Their respective lot number will track explosive items until the item is expended or transferred to Government control and accountability.

5.6.2 AUTHORIZED INDIVIDUALS

USA is required to provide commercial suppliers with documentation of individuals authorized to request and receive explosives. The individual authorized to receive and issue explosives is the USA SUXOS and in some cases, if the SUXOS is not available, the UXOQCS. On site, the SUXOS will designate, in writing, the individual who is authorized to transport and use explosives.

5.6.3 CERTIFICATION

The SUXOS and UXO Technician III team leader performing demolition will sign and date the explosives usage form certifying that the explosives were used for their intended purpose.

5.6.4 PROCEDURES FOR RECONCILING RECEIPT DOCUMENTS

The SUXOS and UXOQCS will be responsible for performing a review of the explosives usage record. If there is a discrepancy between the amount received and the amount of explosives consumed, then these individuals will review the receipt documentation to see if the records are correct. If the records review does not reconcile the discrepancy, then it will be reported to the Contracting Officer and USA-Oldsmar for investigation.

5.7 INVENTORY SCHEDULING

Explosives will be inventoried at least weekly by the SUXOS (or approved designee), the UXOQCS, and a Team Leader. Complete inventories will also be conducted after any issues/turn-ins of demolition material.

5.7.1 STORAGE FACILITY PHYSICAL INVENTORY PROCEDURES

The SUXOS will strictly control access to all explosives. All issues and turn-ins of explosives will be properly documented and verified, through physical count, by the SUXOS or his approved designee. On receipt, the type, quantity, and lot number of each explosive item is recorded on the Magazine Data Card (see Appendix F).

The SUXOS will review all requests for explosives from the individual operating sites and only sufficient explosives for the day's operations will be requested and issued. Issues of explosives will be recorded on Explosives Usage Records, deducted from the Magazine Data Cards, and annotated in the daily journal. This procedure will ensure that the issued explosives are accounted for while they are in the possession of individual users. The end user of explosives shall certify on the Explosives Usage Record that the explosives were used for their intended purpose. Entries made on the Explosives Usage Records and Magazine Data Cards will be verified through physical count by the UXOTIII when drawing or turning-in the explosives and verified by the UXOQCS.

- At the end of each disposal operation the UXOQCS and the Demolition Team UXOTIII will reconcile the entries on each Explosives Usage Record, and will turn these records over to the SUXOS. The record of ordnance items destroyed with the explosives consumed will be kept in the SUXOS daily log.
- Entries made on the Explosives Usage Records and Magazine Data Cards will be verified through physical count by the Demolition Team UXOTIII when drawing or turning-in the explosives and the UXOQCS will verify the record.

5.7.2 PROCEDURES FOR RECONCILING INVENTORY DISCREPANCIES

The SUXOS, UXOQCS, and a UXOTIII will be responsible for performing a weekly inventory of the explosives within the magazine. If there is a discrepancy between the inventory and the volume of explosives within the magazine, then they will review the Magazine Data Card and Explosives Usage Record to see if the inventory records are current. If the records review does not reconcile the discrepancy, then it will be reported to the USACE OE Safety Specialist, Contracting Officer, and USA PM for investigation.

5.7.3 INVENTORY SCHEDULING

SUXOS, UXOQCS, and a UXOTIII will perform weekly inventories of the explosives within the magazine.

5.7.4 REPORTING LOSS OR THEFT OF EXPLOSIVE MATERIALS

If it is confirmed that ordnance or explosives are missing, then the SUXOS will contact the Contracting Officer immediately by telephone and in writing within 24 hours. The USACE OE Safety Specialist and USA-Oldsmar will be notified following the notification of the Contracting Officer. USA-Oldsmar will notify ATF and immediately begin an investigation.

5.7.5 PROCEDURES FOR RETURN TO STORAGE OF EXPLOSIVES NOT EXPENDED

Explosives that were issued for use, but were not expended will be returned daily to the magazines, at the completion of disposal operations. The Demolition Team UXOTIII will return the unused explosives to the storage magazine and record the items on the Magazine Data Card and Explosives Use Record.

5.8 DISPOSAL OF REMAINING EXPLOSIVES

ATF requires an accounting of all explosives purchased and used; therefore, at project completion all unused explosives still in the sealed containers will either be disposed of by detonation, or by transferring custody and accountability to an incoming contractor, a Government agency, or returned to the distributor.

5.9 ECONOMIC ANALYSIS

Because of ATF requirements and prohibition for returning used open packaging, these explosives will be consumed at the site. An economic analysis of the explosives disposal alternatives will not be required.

5.10 FORMS

USA will use internal USA forms Magazine Data Card and Explosives Usage Record for explosives receipt, issue, inventory, and DD Form 626 for vehicle inspections. These forms are in Appendix F.

6.0 EXPLOSIVES SITE PLAN

The Explosives Site Plan was prepared as a separate document and is included in Appendix P.

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7.0 ENVIRONMENTAL PROTECTION PLAN

7.1 GENERAL

This Environmental Protection Plan (EPP) has been specifically developed to address environmental protection issues associated with performing DGM, Anomaly Resolution, and Intrusive Investigation during the RI at the Culebra Island site. Specifically, this plan is intended to provide adequate procedures to safeguard the environmental condition of land and water in and around each MRS, beaches and access routes, and to mitigate and/or minimize the environmental impact from USA's operations.

Tables 7-1 and 7-2 list the federally protected plant and animal species that are known to occur or that have the potential to occur on Culebra and the surrounding cays.

Appendix M contains the document *Standard Operating Procedures for Endangered Species Conservation and their Habitat on DERP-FUDS Project No. I02PR006802 Culebra, Puerto Rico*. This SOP provides specific procedures currently approved by FWS for DERP-FUDS operations in Culebra and surrounding cays and is being incorporated into this EPP.

7.1.1 DEFINITIONS

For the purposes of this plan, the definitions of “Environmental Protection” and “Environmental Impact” are as follows:

- **Environmental Protection:** Preservation of the environment in its natural state to the greatest extent possible.
- **Environmental Impact:** Disturbance, damage, and/or contamination of the soil, air, and/or water. (Engineering Evaluation/Cost Analysis (EE/CA) Former Culebra Island Naval Facility Culebra Island, Puerto Rico, Site Number: I02PR006802, dated 27 June 2006, stated in paragraph 7.5.1.4, Short Term Effectiveness: “In the event that MEC is discovered and detonation is the preferred disposal option, the area may be affected by noise and ground shock. Environmental impacts from clearance should be minimal.”)

7.1.2 ENVIRONMENTAL GOALS

The work at the Culebra MRS sites is being performed to gather the data necessary to determine the nature and extent of MEC and MC contamination on the Culebra Island Munitions Response Sites (MRS) 06, 09, 10, and 11; the Cayo Norte Impact Area (MRS 08); and the Cayo Luis Pena Impact Area (MRS 13), in order to assess the risk to human health and the environment due to the presence of MEC and MC, and to establish criteria for cleaning up each MRS. The following are environmental goals of the project:

- Perform operations in a manner that minimizes the disturbance of soil, water, and vegetation
- Leave the land in as near a natural condition as operationally possible.

To accomplish these goals, USA will implement procedures to control air and/or noise pollution; manage site-wastes; and control water pollution throughout this project. These procedures will focus on preventing contaminants from leaving the source, from entering potential contaminant transport pathways, and from reaching receptors.

7.1.3 ENVIRONMENTAL COORDINATION

USA's SUXOS will coordinate all land resources management, waste management, pollution control, and abatement activities with the on-site USACE OE Safety Specialist and the FWS.

7.2 ENVIRONMENTAL RESOURCES AND EFFECTS

7.2.1 ENVIRONMENTAL SURVEY

Prior to beginning site activities, USA's SUXOS and UXOSO, along with a representative of the Refuge Manager for FWS and the USACE OE Safety Specialist, will conduct a joint environmental survey, and develop a layout plan of the operating area on each MRS to document conditions of areas in and adjacent to the site of the work, storage areas, and access routes. The following items shall also be identified on the layout plan: wetlands endangered and protected species or habitats, and cultural or historical resource areas.

7.2.2 ENVIRONMENTAL SURVEY RECORDS

USA will record the results of environmental surveys both photographically and in writing. During the survey, photographs of each site and the surrounding area will be taken to document conditions prior to work activities. This includes taking generally representative photographs of the site and photographs of areas that will be used for administrative support, storage, and/or stockpiles. During the survey USA will prepare environmental analysis worksheets that identify the nature and cause of the environmental impact, and the procedures, equipment, and training required to mitigate/eliminate the adverse impact.

7.2.3 ENDANGERED /THREATENED SPECIES

Federally endangered and threatened species found on Culebra and surrounding cays are listed in Tables 7-1 and 7-2.

Table 7-1: Rare and Endangered Terrestrial and Amphibious Wildlife, Puerto Rico

Species	Common Name	Status
Sphaerodactylus roosevelti *[O]	Littoral Lizard	Rare
Epicrates monensis granti	Virgin Island Tree Boa	Endangered
Anolis roosevelti	Culebra Giant Anole	Endangered
Anolis cuvieri *[O]	Puerto Rican Giant Anole	Rare or Extinct
Mabuya sloanii *[O]	Slippery Black Skink	Rare or Extinct
Typholps [O]	Worm Snake	Rare
Alsophis antillensis [O]	Ground Snake	Rare or Extinct
Pseyudemys rtejnegeri *[O]	Antillean Painted Turtle	Rare
Chelonia mydas [■O]	Green Sea Turtle	Endangered
Dermochelys coriacea[■O]	Leatherback (Sea Turtle)	Endangered
Caretta caretta [■O]	Loggerhead (Sea Turtle)	Endangered
Eretmochelys imbricata [■O]	Hawkbill (Sea Turtle)	Endangered
Trimeresurus	Fer-De-Lance	Rare or Extinct

* = Endangered in Puerto Rico
■ = Federally classified endangered species
O = Not observed during study
Source: Ecology and Environment, Inc., 1978

Table 7-2: Rare and Endangered Terrestrial Plant Species

Name	Growth Form	Habitat
Amaranthaceae Celiosia virgata	Herb	Upland Forest
Bignonaiceae Enallagma latifolia	Tree	Lowland Forest
Bromeliaceae Tillandsia lineatispica	Epiphyte	Lowland Forest
Witmackia lingulata	Epiphyte	Lowland Forest
Caesalpiniaceae Caesalpinia bunduc	Tree	Beach Scrub
Stahlia monosperma *	Tree	Lowland Forest
Capparidaceae Morisonia americana	Tree	Upland Forest
Celastraceae Maytenus cymosa	Shrub	Lowland Forest
Compositae Baccharis dioica	Sedge	Evergreen Scrub
Cyperaceae Bulbostylis pauciflora	Sedge	Pastures
Cyperus urbani	Tree	Pastures
Flacourtiaceae Prockia cruis	Tree	Upland Forest
Leptocereus grantianus	Cacti	Varies
Malpighiaceae Malpighia fucata *	Tree	Beach Scrub
M. infectissima	Tree	Beach Scrub
M. linearis *	Tree	Beach Scrub
M. shaferi	Tree	Lowland Forest
Tetrapteris inaequalis	Woody Vine	Beach Scrub
Myrtaceae Calyptranthes thomasiana	Tree	Upland Forest
Olcaceae Schoepfia schreberi	Tree	Upland Forest
Orchidaceae Epidendrum bifidum	Epiphyte	Evergreen Scrub
Papilionaceae Sophora tomentosa	Scrub	Beach Scrub
Pereomia wheeleri	Ground Herb	Upland Forest
Piperaceae Peperomia myrtifolia	Herb	Upland Forest
Polypodiaceae Adiantum villosum	Fern	Gallery Forest
Solanaceae Brunfelsia americania	Tree	Upland Forest
Urticaceae Pouzolzia occidentalis	Shrub	Upland Forest
Zygophyllaceae Guaiacum officinale	Tree	Beach Scrub

Source: Wodbury, Roy, et al.1975, Rare and Endangered Plants of Puerto Rico, a Committee Report, U.S. Department of Agriculture, Soil Conservation Service.

*Observed during Environmental Impact Study (Tamsand Ecology and Environment, Inc., 1980)


Figure 7-1: Hawksbill Sea Turtle

The USACE document Standard Operating Procedures for Endangered Species Conservation and their Habitat on *DERP-FUDS Project No. I02PR006802.Culebra, Puerto Rico* (Appendix M) provides a series of SOPs to avoid or minimize impacts to threatened and endangered species during DERP-FUDS work at locations on Culebra Island and adjacent cays and in surrounding waters that serve as habitat for these species. These SOPs "are in accordance with on-going communication with staff from the U.S. Fish and Wildlife Service (FWS), the National Marine Fisheries Service (NMFS) and the Puerto Rico Department of Natural and Environmental Resources (DNER), as well as pursuant to the Interim Guidelines provided by FWS to work on lands of Culebra National Wildlife Refuge, with the U.S. Army Corps of Engineers (USACE) Regulations and Environmental Operating Principles". Species specifically referenced in the SOP include the endangered hawksbill (Eretmochelys imbricata) and leatherback (Dermochelys coriacea) sea turtles, the threatened green sea turtle (Chelonia mydas) and its designated critical habitat 3 nautical miles around Culebra and its surrounding islands and cays, the threatened elkhorn (Acropora palmata) and staghorn corals (Acropora cervicornis), the West Indian manatee (Trichechus manatus), and avian species.


Figure 7-2: Leatherback Turtle

The document provides information on the nesting habits and nesting seasons for the *endangered* hawksbill and leatherback sea turtles and the *threatened* green sea turtle and proscribes specific measures to be taken to avoid or minimize possible impacts resulting from munitions clearance and detonation activities, specifically addressing vegetation removal, beach monitoring for turtle nesting activities, and designation of beach zones based on sea turtle nesting data, and site inspections to ensure sea turtle nest protection during vegetation removal and munitions detonation activities.

The document also includes Vessel Strike Avoidance Measures and Reporting for National Marine Fisheries Service (NMFS) protected species, specifically addressing recommended training in identification of protected species, vessel strike avoidance procedures, and reporting requirements for injured or dead protected species.


Figure 7-3: Green Sea Turtle

7.2.3.1 Mitigation Measures

7.2.3.1.1 Beach Monitoring

Prior to commencement of clearance activities, including vegetation removal and removal of unexploded ordnance, on Culebra, Cayo Norte and Cayo Luis Peña USA will contract with a fully qualified and independent Project Biologist (biologist) to conduct beach monitoring surveys. The biologist's qualifications will be submitted in advance to the contracting officer and the FWS for approval. All beach clearance activities, including vegetation removal and removal or detonation of MEC, will be closely coordinated with FWS. The biologist will perform morning beach surveys prior to and during the nesting season, before crews commence daily activities, to determine whether sea turtle nesting has occurred and to ensure that activities may be accommodated in a window of time when no nests are present.

If sea turtle nests are found on beaches being cleared of MEC, the biologist, the UXO supervisor, and/or monitoring personnel will communicate daily with the FWS Boqueron Endangered Species Specialist and the Culebra Islands NWR Refuge Manager as to whether new nests have been located, and their locations within the work area. If agreed upon by FWS, nest locations will be clearly marked to ensure clearance personnel avoid nests and no clearance activities will take place in the area until the hatchlings emerge and vacate the nest. Otherwise, nests will be relocated to a safe beach within 6-12 hours following nesting. The relocation program will be carried out by the biologist and experienced personnel with the required DNER endangered species permits. This approach has been utilized by DNER personnel on Vieques from 1990-2000 to protect sea turtle nests from military operations with a hatching success of relocated nests of over 80%.

The biologist will provide training to beach clearance crews prior to the initiation of clearance activities regarding the importance of endangered species, in particular the status of sea turtles at this location; the potential penalties associated with violations of the ESA, measures for crawl and nest identification, and sea turtle biology.

7.2.3.1.2 Designation of Beach Zones for Vegetation Removal and Munitions Detonation

The information contained in this section was provided by the USFWS based on zones established during clearing activities for a Navy-led project in Vieques. The designation of zones based on number of nests, restrictions within the zones, etc. must be developed in coordination with the FWS to be specific to Culebra. USA, through the biologist, will establish three work zones, based on sea turtle nesting data, and site inspections to ensure sea turtle nest protection during vegetation removal, anomaly investigations, and munitions detonation activities. The biologist will obtain specific nesting data for the beach areas planned for work. USA understands that this data can be obtained from the FWS Ecological Services Office in Cabo Rojo or the DNER office on Culebra or Fajardo. The proposed work zones and supporting rationales used in Vieques, are described below. USA will follow these same zone delineations and associated restrictions to the maximum extent practicable, consistent with safe execution of operations.

Zone 1 No Restrictions. **Sea turtle nesting is not expected** within the area (rocky shore, no sand, etc).

Zone 2 Minor Restrictions. **Low historical sea turtle nesting events** (fewer than 4 nests per year have occurred within the zone). Zone 2, beaches will be surveyed twice a week, 75 days prior to the activity by experienced and qualified personnel. Surveys should cover both the open sand and the area below the vegetation. No driving on the beach will occur. If no nests are found, cutting of trees smaller than 3 inches in diameter may occur. Manual cutting using machetes is the preferred alternative to allow for re-growth. If power tools such as chain saws are required, the FWS recommended pruning low branches instead of removing the trees (except for mesquite trees). Both techniques would allow for re-growth of suitable habitat. Mechanized removal of vegetation using mowers or vehicles should not be used near beach areas. When nests are found, a protection or exclusion zone of 8m should be designated around the nest and marked with flagging tape. Vegetation removal outside of the exclusion zone may occur if conducted manually. Vegetation removal within the nest area should be postponed until 5 days after hatching is documented, unless UXO is found in the vicinity of the nest. Vegetation removal within the hawksbill sea turtle nesting habitat should not occur from June to mid December (peak of the nesting season). Hawksbill sea turtle nesting habitat varies from 10 m to 25m from the edge of the woody vegetation.

<u>Zone 3: Major Restrictions</u>. **Four or more historical sea turtle nesting events** have occurred within the zone. Zone 3 beaches will be surveyed every morning by a qualified biologist utilizing pedestrian surveys beginning 75 days prior to the scheduled start date of the project and until ordnance or vegetation removal actions are completed. Minimizing the amount of woody vegetation such as sea grape cleared would help minimize impacts to nesting hawksbill sea turtles. The rest of the conditions are the same as Zone 2. When no nests are found on Zone 3 beaches, vegetation cutting may be conducted outside of the peak nesting season of the hawksbill sea turtle. A protection zone of 10 meters (measured landward from the edge of the woody vegetation) should be established to protect leatherback and green sea turtle nesting habitat. If leatherback and/or green sea turtle nests are left in situ (in place), vegetation removal activities should not occur within 10 meters of the landward edge of the nest track. The preferred alternative for cutting the vegetation, if nests are in situ, is hand cutting using machetes or power tools.

The document *Standard Operating Procedures for Endangered Species Conservation and their Habitat on DERP-FUDS Project No. I02PR006802.Culebra, Puerto Rico* (Appendix M) also included the following decision tree prepared by the FWS to provide further guidance on the sequence of events during ground-intrusive beach work applicable to work in zones 2 and 3. Minor discrepancies between zone restrictions and the decision tree are exist regarding required beach monitoring times prior to ground intrusive activities and the protective radius around nests. USA will follow the more restrictive requirement in either case.

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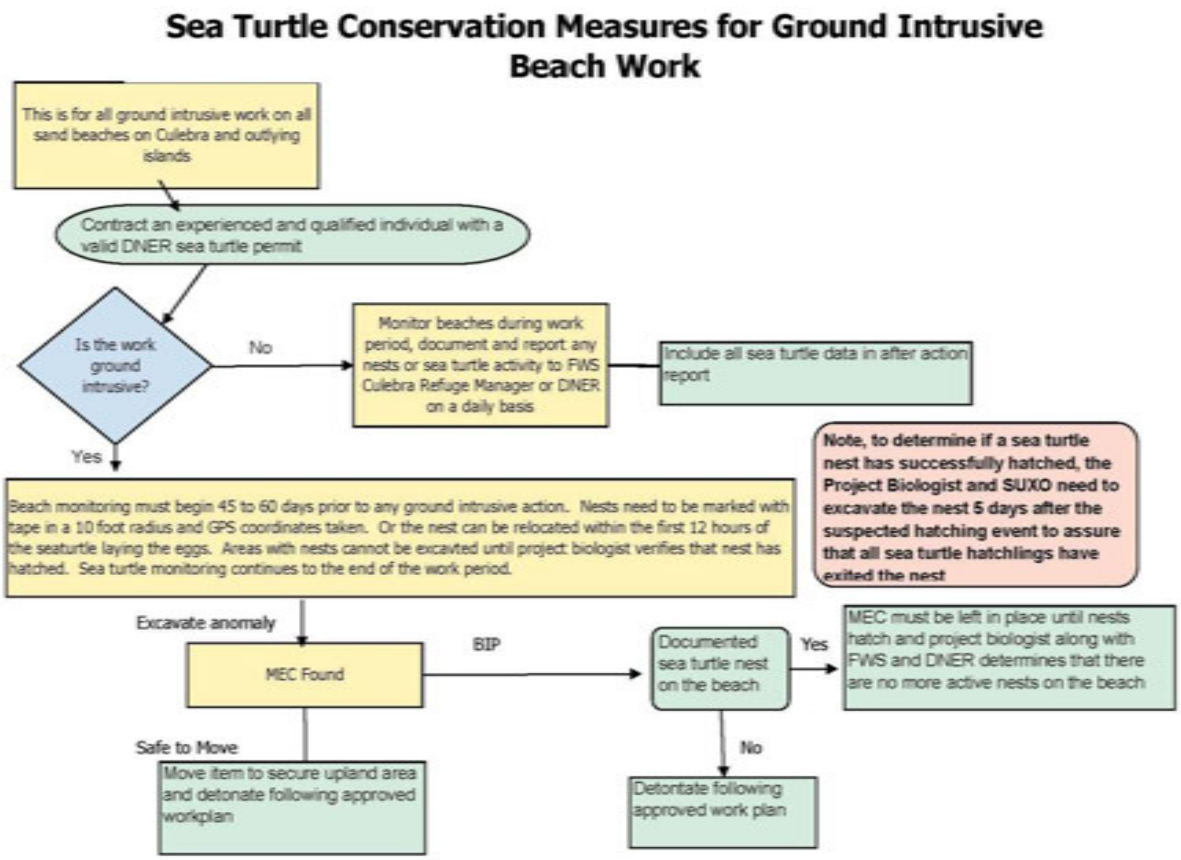

Figure 7-4: Sea Turtle Conservation Measures for Ground Intrusive Beach Work

To the maximum extent practicable, USA will not schedule detonation activities during sea turtle nesting season or when hatchlings are present on the beaches. To the maximum extent practicable, USA will not schedule ground intrusive activities, including detonation, to occur during the peak nesting season from March to November.

The following are specific issues concerning habitat, sea turtle nesting, and jurisdiction of the beaches on Culebra and surrounding cays.

- Beaches on Culebra and Cayo Norte provide nesting habitat for threatened or endangered sea turtles. The Endangered Species Act speaks particularly about adverse modification of Critical Habitat.

- Sea turtle nesting beaches are under the jurisdiction of the FWS.
- The waters around Culebra out to three nautical miles (from mean high water line) are Federally Designated Critical Habitat for sea turtles.
- Two coral species are listed as threatened: the Elkhorn and Staghorn coral. They are shallow water species and are found in the shallow waters around Culebra beaches and the surrounding cays; boat moorings and beach landings must take into consideration the location of the coral and avoidance and training of personnel.

Figure 7-5: Staghorn Coral

Cayo Luis Pena is a National Wildlife Refuge and access needs to be coordinated with the Refuge Manager. The beaches are relatively narrow, with scrub/shrub vegetation. There are always sea turtles in the bay and the beach is used by sea turtles for nesting. Access is by boat only and the area is a well-known weekend spot for local boaters. Establishing an EZ here will require the cooperation of local government.

Figure 7-6: Elkhorn Coral

The primary means of reducing impact on any species will be avoidance, if at all possible. When avoidance is not possible, MEC operations will be conducted, giving as much consideration to non-disturbance as is consistent with safely accomplishing the objectives of the project. USA establishes work zones around beaches to ensure sea turtle nest avoidance during vegetation removal and munitions detonations. USA will request a site inspection by the FWS to prepare beach-specific comments for each beach area.

- USA plans monitoring of the beaches with the designation of an EZ (protection zone) during vegetation removal and MEC activities to minimize possible adverse effects to sea turtle species. USA will minimize the amount of sea grape cleared to help curtail possible effects on the hawksbill sea turtle.
- During intrusive investigations of beach areas the use of vehicles and or equipment may be necessary. USA plans to minimize the amount of driving required to the minimum for intrusive operations.
- USA will coordinate directly with FWS when operations, e.g., DGM or Disposal of MEC, will be conducted in areas near known sea turtle nests. The requirement for BIP of MEC near sea turtle nests may require the FWS to relocate the nest to allow the disposal to be performed. The Engineering Evaluation/Cost Analysis (EE/CA) Former Culebra Island Naval Facility Culebra Island, Puerto Rico, Site Number: I02PR006802, dated 27 June 2006, stated in paragraph 7.5.1.4, Short Term Effectiveness, that, “In the event that MEC is discovered and detonation is the preferred disposal option, the area may be affected by noise and ground shock. Environmental impacts from clearance should be minimal.”
- The USA PM will coordinate through the USACE OE Safety Specialist, the local agencies, FWS, and the Corps of Engineers USAESCH Office, whenever cutting of trees or vegetation is required or intrusive work is necessary in or near pools, ponds, or wetlands. This coordination should be initiated by the USA PM enough in advance to allow for the formulation and implementation of any specific impact reduction measures necessary.
- If excavation is required in an area of endangered plants, animals or vernal pools, excavation will proceed only after approval is obtained from the local agencies, Corps of Engineers USAESCH, and the USACE OE Safety Specialist. Should excavation of anomalies not be allowed, the area will be so annotated. Likewise, if the Investigation team is not allowed into a section, that section will be annotated.

7.2.3.1.3 Vessel Strike Avoidance Measures

Collisions with vessels can injure or kill protected species (e.g., endangered and threatened species, and marine mammals). The Standard Operating Procedures for Endangered Species Conservation and their Habitat on DERP-FUDS Project No. I02PR006802.Culebra, Puerto Rico (Appendix M) provides measures to be implemented to reduce the risk associated with vessel strikes or disturbance of these protected species. Based on this SOP document, USA and its supporting boat subcontractor will implement the measures described below, when consistent with safe navigation:

1. Vessel operators and crews will maintain a vigilant watch for marine mammals and sea turtles to avoid striking sighted protected species.

2. When whales are sighted, maintain a distance of 100 yards or greater between the whale and the vessel.

3. When sea turtles or small cetaceans are sighted, attempt to maintain a distance of 50 yards or greater between the animal and the vessel whenever possible.

4. When small cetaceans are sighted while a vessel is underway (e.g., bow-riding), attempt to remain parallel to the animal's course. Avoid excessive speed or abrupt changes in direction until the cetacean has left the area.

5. Reduce vessel speed to 10 knots or less when mother/calf pairs, groups, or large assemblages of cetaceans are observed near an underway vessel, when safety permits. A single cetacean at the surface may indicate the presence of submerged animals in the vicinity; therefore, prudent precautionary measures should always be exercised. The vessel should attempt to route around the animals, maintaining a minimum distance of 100 yards whenever possible.

6. Whales may surface in unpredictable locations or approach slowly moving vessels. When an animal is sighted in the vessel's path or in close proximity to a moving vessel and when safety permits, reduce speed and shift the engine to neutral. Do not engage the engines until the animals are clear of the area.

Vessel crews will report sightings of any injured or dead protected species to the USA site manager, who will then report the sighting as follows:

Marine Mammal:	Southeast U.S. Stranding Hotline: 877-433-8299
Sea turtle:	NMFS Southeast Regional Office: 727-824-5312

In the event that an injury or death of a marine mammal is caused by collision with a USA support vessel, the crew will immediately notify the USA site manager and be made available to assist the respective salvage and stranding network as needed. The USA site manager will immediately notify the NMFS Southeast Regional Office by email (takereport.nmfsser@noaa.gov).

7.2.3.1.4 Avoidance of Birds, Reptiles and Manatees

USA and its subcontractors will avoid contact with any bird or reptile found injured or otherwise in the way of the cleanup activities, until adequate coordination is done with FWS and DNER. To the maximum extent practicable, consistent with safety concerns, detonation of UXO on cays will not be conducted during seabird nesting season. In the event an item needs to be detonated near nests, the birds will be captured and held, prior to the blow-in-place detonation. This effort will be coordinated with the biologist, FWS and DNER. In the event of a manatee sighting in the vicinity of a work area, USA work will stop work until the animal(s) are at a safe distance.

7.2.3.1.5 Site-Specific Training

USA will provide site specific training on identification and recognition of protected species (plant and animal), as well as mitigation measures to prevent disturbance, injury or death to protected animal species and habitats. Particular emphasis will be placed on the status of sea turtles on Culebra; the potential penalties associated with violations of the ESA, measures for crawl and nest identification, and sea turtle biology. This will include a review of pertinent laws and acts, guidelines to reduce impact, and points of contact to report encounters with protected or endangered species. Applicable aspects of this training will be correlated with the Accident Prevention Plan and Site Safety and Health Plan (Appendix D). This training will be provided by the biologist prior to the initiation of clearance activities.

Site specific training will also be provided to vessel crews, emphasizing identification of protected species that might be encountered in the waters surrounding Culebra and the cays, vessel strike avoidance measures, migratory routes and seasonal abundance, and recent sightings of protected species.

7.2.3.2 Wetlands and Riparian Areas

No on-site wetlands are expected to be impacted by the project. In the event that wetlands are to be impacted, the FWS Refuge Manager will be contacted. In such a case, mitigation measures will be taken to reduce the impact on the wetland ecosystem.

7.2.3.3 Cultural or Historical Resources

Based on available data, the probability that significant cultural or archaeological resources are located within the project area appears low. Because of the nature of the proposed work, any cultural or archaeological resources that may exist within the project area are not expected to be impacted. If any cultural or archaeological materials or resources are discovered within the project area, USA's SUXOS will immediately report the find to the on-site USACE OE Safety Specialist so a qualified archaeologist can be notified and will provide guidance on performing further work in the area. Site work will be suspended and will resume only after obtaining approval from USAESCH. Cultural and archaeological issues will be addressed by contacting the State Historic Preservation Office (SHPO) at 787-721-3737. A review/training of potential archeological items that may be present will be conducted for all personnel to assist with identifying items if encountered.

7.2.3.4 Water Resources

Based on available aerial photography, no water resources appear to be located within the project area, except for the Caribbean Sea to the north, south, west, and east and several lagoons spread along the coast. No inland water resources are expected to be impacted by the project.

7.2.3.5 Coastal Zones

Narrow beach areas of varying widths and lengths exist along the coastal zones of each MRS site. DGM and intrusive investigations will be performed in selected areas. For MRS 13, Cayo Luis Pena, preliminary locations for DGM and intrusive investigations have been selected (see Figures B-9, 10 and 11, Appendix B). Potential beach areas for DGM and intrusive investigations at the optional MRS sites have not been determined.

USA will perform some vegetation clearance and DGM on access routes to these beaches which will impact the areas landward of the shoreline.

7.2.3.6 Trees and Shrubs

During the On Board Review for the previous N-TCRA on Culebra and Culebrita, it was decided that a Botanist would be on site and approve any vegetation that was required to be trimmed to allow DGM survey of the beach areas. USA assumes the same will apply to this RI/FS action and that the FWS or USACE will provide the botanist.

Any vegetation clearance required will consist of hand clearing to the extent necessary to facilitate investigation operations. The removal of trees will be avoided. If it is decided that a tree must be removed, advance justification will be provided to the FWS or other appropriate agencies monitoring the site. Commonwealth, FWS or DNER must then provide ***written*** permission before the field crew can remove the tree.

The proposed work will involve trimming of shrubs, undergrowth, and small trees within the project area. The vegetation will be removed only on an as-needed basis.

7.2.3.7 Existing Waste Disposal Sites

There are no known waste disposal sites at the project area.

7.2.3.8 Compliance with ARARs

No ARAR's have been identified.

7.3 SITE DISTURBANCE MITIGATION PROCEDURES

All soil disturbance activities will be accomplished as specified in the WP. Any deviations from this plan will be performed only upon authorization from the on-site USACE OE Safety Specialist.

Prior to initiation of the proposed work, the USA PM will coordinate with the FWS to provide instructions to field personnel regarding the protection of on-site environmental resources. Such protective measures will include, but are not limited to, the following:

- Avoid contact with any specimen of the *Cobana negra* (*Stahlia monosperma)* tree or any other federally protected plant that is found within the project area. Flag specimens within the project area for easy identification.
- Avoid any sea turtles or sea turtle nests that are encountered. All sea turtle nests that are located during the project will be marked by flagging and an EZ will be set up around the nests in accordance with the SOP for Endangered Species Conservation and their Habitat (Appendix M) to prevent potential impacts. All sea turtle tracks sighted within the project area will be reported to the PM.
- Any MEC found within or near a wetland will be identified and removed, if deemed safe to do so, without impacts to wetland soil, vegetation, or hydrology.
- If any cultural or archaeological material/resource is discovered within the project area, a qualified archaeologist will be notified to provide guidance on performing further work in the area.
- MEC found in the immediate vicinity of a water body will be identified and removed, if deemed safe to do so, without impacts to the water resource.
- MEC found near the coastal zone will be identified and removed, if deemed safe to do so, without impacts to the coastal environment.

The PM will seek the guidance of the FWS to determine appropriate mitigation measures in the event that the performed work activities result in impacts to any environmental resource.

7.3.1 MEC INTRUSIVE INVESTIGATION AND BIP APPROACH TO MINIMIZE IMPACTS TO SEA TURTLES AND NESTING AREAS

The primary approach to conducting intrusive investigations and BIP actions at the beach areas identified as sea turtle nesting areas will require that a FWS biologist be consulted and the location of the proposed activity be examined by the U.S. FWS biologist to determine whether impacts to sea turtles and/or nests are imminent. If it is determined that no impacts will occur, the activities will be carried out in consultation with the U.S. FWS biologist.

If MEC are discovered in active nesting areas and the MEC presents a hazard requiring immediate disposal, a U.S. FWS biologist will be consulted and it will be determined if relocating the sea turtle nest is necessary. In cases where the sea turtle nests are required to be relocated, the Puerto Rico Department of Natural and Environmental Resources will be procured to perform the nest relocation.

It is anticipated that after consultation with U.S. FWS biologists, intrusive and/or BIP operations, if necessary, will be able to be carried out in these locations without impacts to sea turtles or nests during the appropriate time of the year.

7.3.2 ALL WASTE DISPOSAL

All detected metal that has been cleared as other waste materials that are generated by the clearance action will be inspected and classified before being sent to a commercial or municipal landfill for proper disposal. These wastes will consist primarily of waste paper, food and beverage containers, and expendables such as uncontaminated but used protective clothing.

7.3.3 ALL BURNING ACTIVITIES

Burning activities will be limited to the open detonation of MEC. All detonations will be performed in conformance with the safety measures presented in Chapter 3 and USA SOPs (Appendix K). Holes in the soil that result from detonations will be filled in and the ground restored to its previous condition. Open fires such as campfires or fires to dispose of cut brush will not be permitted during the performance of this project. Smoking will be restricted to within closed automobiles or other designated areas. Smoking areas will be designated by the UXOSO.

In all cases, cigarette butts and matches *must* be disposed either in an automobile ashtray or in a metal butt can. Cigarette butts and matches may not be tossed from car windows or discarded onto the ground surface.

7.3.4 DUST AND EMISSION CONTROL

Dust sources during operations may result from vehicular traffic on dirt roads, and dust from the detonation of UXO. Dust control measures will include the following.

- To the maximum practical extent, travel will be performed on paved roads. To minimize dust generation on dirt roads, speeds will be restricted to the speed limit.
- Best management practices for the control of dust generation will be observed during the detonation of UXO. These practices are described in Chapter 3.
- Emissions sources will include vehicles, including automobiles used to travel within the FUDS. All vehicles and equipment will be in good working order and will meet applicable vehicle emissions requirements.

7.3.5 SPILL CONTROL AND PREVENTION

All fueling and maintenance of vehicles will be performed offsite at appropriate commercial or private facilities. If a severe leak of fuel or other fluids such as antifreeze or transmission fluid occurs in the field because of a tank puncture or a ruptured line, the following procedures should be implemented.

- Promptly berm the site with dirt so that the fuel or fluid does not spread along the ground surface.
- Apply oil-absorbing material such as sawdust or kitty litter to the spill.

- Report the spill to appropriate state and local agencies and follow their instructions for cleanup. It is anticipated that this cleanup usually will involve digging up and drumming contaminated soil, and subsequently disposing of it in an approved landfill. Spills of 204 lb (32 gallons) of gasoline will be reported to the EPA or State EPA through approved channels.
- The fuel tank will not be filled to more than about three-quarters full to prevent overfilling in the field.

7.3.6 ALL STORAGE AREAS

No storage areas are anticipated within any of the MRS.

7.3.7 ACCESS ROUTES

USA crews entering and exiting the work sites will use existing roads and easements. Off-road vehicle travel will be kept to a minimum, and prior to establishing any off-road routes necessary to gain access to sites, consideration will be given to the possible consequences resulting from the channeling of run-off water in ruts. Additionally, local agencies, FWS, and the USACE OE Safety Specialist will be notified and approval from proper authority will be obtained prior to initiating off-road travel or operations. In such cases, the following measures will be taken to minimize the environmental effects.

- Personnel will remain at the off-road site until investigations there are completed for the day. For example, field crews will not start work at an off-road site, leave for a lunch break, and subsequently return to finish the job.
- Any ruts or new roads or tracks that are created by field activities will be restored. The ruts will be filled in and leveled.
- In a situation where the area is wet and rut damage to the environment is certain, the crews should drive on roads and paths to a point as close to the site as possible, and then walk the remaining distance to the site.

7.3.8 TREES AND SHRUBS PROTECTION AND RESTORATION

Protection of trees and shrubs is described in Section 7.2.3.6. It is unlikely that any trees will be removed during the MEC Investigation. Therefore, no provisions for tree restoration are required.

Brush clearing will be restricted to the minimum necessary to effectively investigate and identify anomalies. Demolition and excavation holes will be backfilled.

7.3.9 CONTROL OF WATER RUN-ON AND RUN-OFF

Vegetation clearance may alter drainage patterns. The use of berms, dikes, and barriers with plastic sheeting may be employed as needed to control water run-on/run-off and sediment or siltation migration. All sediment and erosion control measures will be monitored and properly maintained as long as their need exists.

7.3.10 MANIFESTING AND TRANSPORTATION OF WASTES

Wastes that could require transportation potentially include MEC and scrap metal. Any off-site transportation of UXO will be performed by USA in accordance with EPA and DOT regulations. Transportation of scrap metal does not require manifesting.

7.3.11 TEMPORARY FACILITIES

USA will not establish a site trailer command post. Trash will be collected and dumpsters will be dumped or removed, as appropriate.

7.3.12 DECONTAMINATION AND DISPOSAL OF EQUIPMENT

Except for MEC, this project does not involve any hazardous materials or hazardous wastes. Any MEC that is found will be disposed of by detonation. Mitigation will involve filling in any holes resulting from detonation and restoring the disturbed area. Disposal of non-hazardous materials and equipment is described in paragraph 7.3.2 and will not require decontamination or mitigation.

7.3.13 MINIMIZING AREAS OF DISTURBANCE

Procedures for minimizing areas of disturbance are described throughout this environmental protection plan and include such measures as:

- Driving on roads as much as possible and limiting off-road travel
- Complying with the SOP in Appendix M
- Performing minimum necessary vegetation clearance and excavation in wetlands and riparian areas
- Replacing soil into holes that result from the detonation of UXO.

7.4 PROCEDURES FOR POST-ACTIVITY CLEANUP

All wastes will be removed from each site immediately upon completion of each day's field activities. Therefore, no post-activity cleanup will be required.

7.5 AIR MONITORING PLAN

Air monitoring is not being performed during this investigation. USA work procedures are designed to minimize vapors, gases, and particulate emissions. Control of fugitive emissions will involve measures such as watering down dry or barren areas, roadways and soil disturbance areas; and covering of spoils piles and stockpiled soil with plastic/tarp. Throughout operations, the UXOSO and UXOTIII will continually monitor the production of dust which, if produced in significant quantities, will dictate the donning of protective masks by on-site personnel.

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8.0 PROPERTY MANAGEMENT PLAN

NOT APPLICABLE

This plan is required only when government property is used. USA will not use government property in the execution of this Task Order.

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9.0 INTERIM HOLDING FACILITY SITING PLAN FOR RECOVERED CHEMICAL WARFARE MATERIEL

NOT APPLICABLE

Not authorized by the Performance Work Statement.

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10.0 PHYSICAL SECURITY PLAN FOR RECOVERED CHEMICAL WARFARE MATERIEL SITES

NOT APPLICABLE

Not authorized by the Performance Work Statement.

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11.0 REFERENCES

The following are references applicable to this project. USA will comply with applicable Federal, State, and local requirements. Following all applicable requirements and regulations listed in the following publications will ensure the safety and health of onsite personnel and the local community.

11.1 U.S. ARMY CORPS OF ENGINEER REPORTS

- DERP FUDS Culebra, Puerto Rico, Property No. I02PR0068, Inventory Project Report (INPR), CULEBRA, PUERTO RICO, PROPERTY NO. I02PR0068, MAY 1991.
- DERP FUDS Culebra, Puerto Rico, Property No. I02PR0068, Inventory Project Report (INPR), Revised July 2005 (Final).
- Archives Search Report, Findings, Ordnance and Explosive Waste, Culebra Island National Wildlife Refuge, Culebra, Puerto Rico, February 1995.
- Archives Search Report Supplement, Findings, Ordnance and Explosive Waste, Culebra Island National Wildlife Refuge, Culebra, Puerto Rico,2004.
- Supplemental Archives Search Report, Culebra, Puerto Rico, Property Number I02PR0068, dated September 2005.
- Final Engineering Evaluation/Cost Analysis, Culebra, Puerto Rico, Environmental Science & Engineering, 1996.
- Site-Specific Final Report, UXO Construction Support, Culebra Island Wildlife Refuge, Culebra Island, Puerto Rico, Ellis Environmental Group, 2004.
- Site Inspections Project, Final Site Inspection Report, Culebra Island, Puerto Rico, FUDS Project No. I02PR006802, Parsons Infrastructure & Technology, 2007.

11.2 U.S. ARMY CORPS OF ENGINEER GUIDANCE DOCUMENTS

- EM 200-1-4. Environmental Quality - Risk Assessment Handbook, 1999.
- EM 1110-1-1002. Engineering and Design - Survey Markers and Monumentation, 1990.
- EM 1110-1-4009. Engineering and Design - Military Munitions Response Actions, 2007.
- EM-1110-1-100 Engineering and Design – Conceptual Site Models for Ordnance and Explosives (OE) and Hazardous, Toxic, and Radioactive Wastes (HTRW) Projects, 2003.
- EM 385-1-97 Explosives Safety and Health Requirements Manual
- EM 385-1-1. Safety and Health Requirements Manual, 2008.
- ER 200-3-1. Environmental Quality - Formerly Used Defense Sites (FUDS) Program Policy, 2004.
- ER 385-1-92. Safety - Safety and Occupational Health Requirements for Hazardous, Toxic, and Radioactive Waste (HTRW) Activities, 2007.
- ER 1110-1-12. Engineering and Design - Quality Management, 2006.
- EP 1110-1-18. Military Munitions Response Process, 2006.
- EP 1110-3-8. Engineering and Design - Public Participation in the Defense Environmental Restoration Program (DERP) for Formerly Used Defense Sites (FUDS), 2004.
- EP 1110-1-24. Establishing and Maintaining Institutional Controls for Ordnance and Explosives Projects, 2000.

- EP 75-1-2. Munitions and Explosives of Concern (MEC) Support During Hazardous, Toxic, and Radioactive Waste (HTRW) and Construction Activities
- EP 75-1-4. Recurring Reviews on Ordnance and Explosives (OE) Response Actions, 2003.

11.3 U.S ARMY DOCUMENTS

- Army MMRP, Remedial Investigation / Feasibility Study Guidance, 2009.
- TM 60A 1-1-31, Explosive Ordnance Disposal Procedures, 1994.
- AR 385-64, Ammunition and Explosives Safety Standards, 1999.
- AR 190-11, Physical Security of Arms, Ammunition and Explosives, 2006.

11.4 DEPARTMENT OF DEFENSE DOCUMENTS

- DOD 6055.9-M, *Ammunition and Explosive Safety Standards*
- DOD 4145.26-M, *Contractor's Safety Manual for Ammunition and Explosives*

  DOD 4160-21-M, Defense Demilitarization Manual
- DDESB TP-18, Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel

11.5 OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

Occupational Safety and Health Administration (OSHA) 1994 *General Industry Standards*, 29 CFR 1910 and *Construction Industry Standards*, 29 CFR 1926; especially 1910.120/29CFR 1926.65-*Hazardous Waste Site Operations and Emergency Response*.

11.6 U.S. ENVIRONMENTAL PROTECTION AGENCY

Risk Assessment Guidance for Superfund (RAGS), 1989.

11.7 FEDERAL REGULATION

- Code of Federal Regulations (CFR)
  - 33 CFR 320 Wetlands Protection Act
  - 40 CFR 300.430 National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 1993.
  - 40 CFR Part 261.23 Resource Conservation and Recovery Act.
  - 49 CFR Parts 100-199 Transportation.
  - 62 Federal Register 6622, 1997 Military Munitions Rule.
- Fish and Wildlife Coordination Act 16 U.S.C. 661 et seq.
- Endangered Species Act 16 U.S.C. 1531-154.
- Migratory Bird Treaty Act 16 U.S.C. 703-712.
- National Historic Preservation Act 16 U.S.C. 1470.
- Clean Water Act 33 U.S.C. 1151 et seq., 1251 et seq., 40 U.S.C. 3906 et seq.
- Comprehensive Environmental Response, Compensation, and Liability Act 42 U.S.C. 9601-11050.
- U.S. Fish & Wildlife Service, Culebra National Wildlife Refuge, undated.

- Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) Publication 5400.7, Federal Explosives Laws and Regulations
- NFPA 780. Standard for the Installation of Lightning Protection.

11.8 OTHER DOCUMENTATION/SURVEYS AND STUDIES

- Soil Survey of Humaco Area of Eastern Puerto Rico, United States Department of Agriculture, Soil Conservation Service, dated January 1977.
- Puerto Rico Water – Use Program: Public-Supply Water Use and Wastewater Disposal During 1990, U.S. Department of the Interior – U.S. Geological Survey, dated 1 May 1966.
- Atlas of Ground-Water Resources in Puerto Rico and the U.S. Virgin Islands, U.S. Geological Survey, Water-Resources Investigation Report 94-4198, dated 1996.

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APPENDIX A. PERFORMANCE WORK STATEMENT (PWS)

Performance Work Statement
Remedial Investigation / Feasibility Study
at Culebra Island Site, Puerto Rico
I02PR0068
10 June 2009
Revision: 2
Revision Date: ~~12 June 2009~~ 16 June 2009

The purpose of this revision dated 12 June 2009 is to affect the following changes:
Text was added to paragraph 3.11 to include an administrative record for each individual MRS.
Incorporate evacuations as part of Task 4, par 4.1and renumber subparagraphs.
Task 12, Environmental Sampling & Analysis has been changed to Firm-Fixed Price/Unit Price
Correct Appendix A Price Spreadsheet.

1.0 OBJECTIVE: The objective of this task order is to obtain acceptance of a Decision Document meeting the requirements of ER 200-3-1 and CX Interim Guidance 06-04. Work to be accomplished includes the conduct of a Remedial Investigation (RI), Feasibility Study (FS) and all necessary activities required to accomplish this objective.

2.0 BACKGROUND: Work required under this Performance Work Statement (PWS) falls under the Formerly Used Defense Sites (FUDS), Military Munitions Response Program (MMRP). Munitions and Explosives of Concern (MEC) are a safety hazard and may constitute an imminent and substantial endangerment to site personnel. Applicable provisions of Chapter 29 of the Code of Federal Regulations (CFR) 1910.120 apply. The Contractor shall perform all work in a manner consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104 and the National Contingency Plan (NCP), Sections 300.120(d) and 300.400(e). All activities involving work in areas potentially containing MEC hazards shall be conducted in full compliance with United States Army Corps of Engineers (USACE), United States Army Engineering and Support Center Huntsville (USAESCH), Department of the Army (DA), Active Installation, and Department of Defense (DOD) safety regulations. All MEC encountered during this munitions response shall be destroyed on-site in coordination with the Unites States Coast Guard (USCG) and local environmental agencies.

2.1 Location: The Culebra Island Site, Formerly Used Defense Site, is located east of the main island of Puerto Rico and is part of the Commonwealth of Puerto Rico.

2.2 History: Culebra came under Navy control in 1901, and the Navy built a small base that same year and an airfield about 20 years later. The Navy used the area for fleet exercises from 1902 until 1975. The Navy began surface and aerial bombing of the Flamenco Peninsula in 1935, and expanded the range to include eastern and western cays (small islands surrounding Culebra) in the early 1960s. Ordnance firing ended in September 1975

2.2.1 The Culebra Island National Wildlife Refuge is administered by the U.S. Fish and Wildlife Service (FWS) and encompasses approximately 1500 acres of the Island of Culebra, and about 23 surrounding cays. The remaining acreage is owned by the Commonwealth of Puerto Rico, primarily the Department of Natural and Environment Resources (DNER).

2.3 Previous Investigations:

1991 Inventory Project Report
1995 Archives Search Report
1997 Final Engineering Evaluation/Cost Analysis
2004 UXO Construction Support
2004 Archives Search Report Supplement
2005 Revised Inventory Project Report
2005 Supplemental Archives Search Report
2007 Site Inspection Report

3.0 SPECIFIC TASKS: Methods to be used to achieve task order objectives at the specified level of performance shall be determined by the Contractor. The Contractor will be evaluated periodically during each of the following tasks to ensure compliance with the PWS and to document that quality objectives, delivery schedule, and the overall completion date are being met. This evaluation will be performed according to a Quality Assurance Surveillance Plan (QASP). A programmatic QASP modified for the specific task order requirements will be provided by the government. The QASP will be updated upon acceptance of the Contractor's Quality Control Plan (QCP). Failure to adequately complete any service or submittal to at least a satisfactory level of quality or timeliness may result in a repeat of the work, or a poor performance evaluation, or both. Performance metrics are provided in Section 6.0. Minimum requirements for contractor performance and QC are provided in Section 7.0.

3.1 Task 1, Technical Project Planning (TPP): This is a Firm Fixed Price/Unit Price task. The objective of this task is for the Contractor to implement the TPP process IAW EM 200-1-2, and Interim Guidance Document 01-02. Disputes between the Project Delivery Team (PDT) and the regulators regarding the adequacy of DQO will be resolved by the USACE Project Manager. The Contractor shall anticipate 3 meetings to be conducted in the San Juan area. Meetings shall be for 1 day each plus travel. The Contractor shall plan for meetings to occur as follows: first meeting, pre-Work Plan with resulting TPP Memorandum; second meeting, to finalize Work Plan; third meeting, verify all data gaps have been filled and finalize Remedial Investigation Report. The Contractor shall also provide a unit price per TPP meeting in the event more meetings are necessary. The Contractor shall organize and coordinate all meetings. The Contractor shall identify and involve all stakeholders, upon approval by the Government, to be included in the TPP process. The Contractor shall be responsible for the logistics of these meetings to include but not limited to, providing a facilitator, obtaining meeting location, sending invitation letters (after government review and acceptance). The Contractor shall prepare, submit for review and gain acceptance of a TPP memorandum containing the DQO's and other results of the TPP meetings, including a conceptual site model (CSM). The conceptual site model will be compatible with current GIS standards

3.1.1 Task 1a, Planning Site Visit (Optional): This task allows the contractor to attend a site visit to Culebra, PR to observe the area and gather pertain data to assist in preparations for writing the advanced package for the TPP. If a site visit is planned, the Contractor shall prepare and submit for acceptance an Abbreviated Accident Prevention Plan (AAPP).

3.2 Task 2, RI/FS Work Plan (WP): This is a Firm Fixed Price task. The objective of this task is the Contractor to prepare, submit and gain acceptance of a WP that is a detailed and comprehensive plan covering <u>all</u> aspects of the site characterization in accordance with data item description (DID) MR-001 and EM 1110-1-4009. An Explosive Safety Submission (ESS) has been prepared for Culebra. The government will amend the ESS and it shall be referenced in the WP.

3.2.1 Task 2a, Explosives Safety Submission Amendment (Optional): The contractor shall amend the current ESS and submit for acceptance in accordance with DID MR-060 and referenced in the WP.

3.3 Task 3, GeoSpatial Data: This is a Firm Fixed Price task. The objective of this task is for the Contractor to utilize GIS in the development of the Conceptual Site Model (CSM). The Government will provide an existing GIS data available. The GIS will be used to build upon and managed IAW DID MR-005-07.01. A pre and post-project response action geospatial data analysis shall be performed using a GIS. All available existing data that is applicable to the project shall be consolidated into the GeoDatabase and analyzed to relay pertinent information to the PDT. The analysis of data from the GIS shall support all conclusions of the CSM. The information attained through the pre-RI analysis shall be documented in the work plan. The information attained in the post-RI and FS analysis shall be documented in the RI and FS reports. The pre-RI analysis shall encompass social, environmental and/or economic entities that will be or may be impacted by response-action activities. The post-RI and FS analysis shall detail entities impacted by RI/FS activities and impacts of future response action activities (if applicable). The pre and post-RI and FS analysis may detail the fieldwork strategies, areas of concern, survey requirements, environmental concerns, milestones and/or other factors that affect product delivery and future action planning. Entities that may be affected by response actions include but are not limited to: landowners, homeowners, rental tenants, schools, utilities, roads, businesses, recreational areas, air traffic, water bodies and/or industries. The GeoDatabase shall be a living repository that is refined throughout the life of the project. The Contractor shall incorporate layers that overlay on maps of the site that identify physical features, and MPPEH/MD and Range-Related Debris found during the investigation. Examples include: streets, anomalies, MEC positively identified, identifiable MD, sampling location, cultural resources, environmental, biological, and socio-economic variables. Archeological site location(s) will not be released to the public without written permission from USACE. The Contractor shall perform civil surveys IAW EM 1110-1-4009 and DID MR-005-07.01.

3.3.1 Task 3a, Landowner database and ROE (Optional): The contractor shall obtain property GIS data for all landowners with in the project boundaries. The contractor shall maintain property ownership data in the GIS, track and assist in obtaining property Right –of –Entry

3.4 Task 4, RI/FS Field Activities: This task is a Firm Fixed Price/Unit Price.

3.4.1 The objective of this task is for the Contractor to perform all necessary field activities to meet the overall objective of this task order and the DQOs established for this project. The Contractor shall characterize the nature and extent, per agreed upon requirements during TPP, of MEC contamination at the required munitions response sites (MRS) for the purpose of developing and evaluating effective remedial alternatives. This task shall include all field activities necessary to execute this task except MC sampling. MC sampling requirements are covered under the Environmental Sampling & Analysis task. All DGM shall be IAW DID MR-005-05.01 and requirements listed in Table 7-1 to 7-3. For this task order 1 acre of transects equals 14,520 feet (2.75 miles) of transects 3 feet wide. One acre's worth of grids equals seventeen (17) 50' x 50' grids or seventy (70) 25' x 25' grids. A pricing schedule is provided in Appendix A for unit price which will be used for price increase or decrease based on the final level of effort determined during TPP. The Government is responsible for the price of evacuation. The contractor shall be responsible for the coordination of evacuations.

3.4.1.2 Task 4a MRS 13 Cayo Luis Pena Impact Areas
The Cayo de Luis Pena Impact area consists of 342 land acres and 864 total MRS acres. The MRS is approximately one-quarter mile off the western coast of Culebra. The contractor shall perform 4 acres of DGM transects and 2 acres of grids. The contractor shall investigate 350 anomalies and perform 3 demolition shots. The contractor shall investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

3.4.1.3Task 4b MRS 10 Defensive Firing Area No. 1 (Optional)
This area consists of 547 acres on the southwest peninsula of Culebra, south of the town of Dewey and north of MRS 09. The contractor shall perform 5 acres of DGM transects and 1 acre of grids. The contractor shall investigate 350 anomalies and perform 3 demolition shots. The contractor shall investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

3.4.1.4 Task 4c MRS 11 Defensive Firing Area No. 2 (Optional)
The Defensive Firing Area No. 2 is located on the west side of Culebra between Northwest Peninsula and the town of Dewey. The MRS consists of 719 acres. The contractor shall perform 6 acres of DGM transects and 1 acre of grids. The contractor shall investigate 400 anomalies and perform 3 demolition shots. The contractor shall investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

3.4.1.5 Task 4d MRS 06 Artillery Firing Area (Optional)
The Artillery Firing Area (MRS 06) consists of 826 acres and is located on the eastern end of Culebra extending from a point at the most northern tip of Mosquito Bay, northeast to a point just west of Duck Point, and east to the end of the island. The contractor shall perform 6 acres of DGM transects and 2 acre of grids. The contractor shall investigate 450 anomalies and perform 4 demolition shots. The contractor shall investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

3.4.1.6 Task 4e MRS 09 Soldado Point Mortar and Bombing Area (Optional)
This area consists of 328 acres on the southern tip of the southwestern peninsula of Culebra. The contractor shall perform 2 acres of DGM transects and 1 acre of grids. The contractor shall investigate 200 anomalies and perform 2 demolition shots. The contractor shall investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

3.4.1.7 Task 4f MRS 08 Cayo Norte Impact Area (Optional)
The Cayo Norte Impact Area includes only Cayo Norte and covers approximately 306 acres. The contractor shall propose on 3 acres of DGM transects, and one acre of grids. The contractor shall investigate 250 anomalies and perform 3 demolition shots. The contractor shall investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

3.4.1.8 MEC Disposal: The Contractor shall be responsible for the destruction of all MEC encountered during project activities.

3.4.2 Backfilling Excavations: All access/excavation/detonation holes shall be backfilled by the Contractor. The Contractor shall restore such areas to their prior condition.

3.4.3 MEC Accountability: The Contractor shall maintain a detailed accounting of all MEC items/components encountered. This accounting shall include the amounts of MEC, nomenclature and condition, location and depth of MEC, and disposition. The accounting system shall also account for all demolition materials utilized to detonate MEC on site. The Contractor shall take digital photographs of identifiable MEC found during the investigation.

3.4.4 Disposal/Disposition of MPPEH: All MPPEH and munitions debris shall be handled in accordance with Chapter 14, EM 1110-1-4009 and Errata Sheet No. 2.

3.5 Task 5, Remedial Investigation (RI) Report: This task is a Firm Fixed Price task. The objective of this task is for the Contractor to prepare, submit and gain acceptance of a RI report in accordance with EM CX Interim Guidance 06-04. The Contractor also shall incorporate all available data and data from previous reports into this RI. The Contractor shall prepare/update as an appendix to this report a determination of the Munitions Response Site (MRS) priority for each MRS covered under this task order using the Munitions Response Site Prioritization Protocol (MRSPP) worksheets. The Contractor shall attend, by teleconference, an onboard review after receiving comments on the draft RI Report.

3.6 Task 6, Feasibility Study (FS) Report: This task is a Firm Fixed Price task. The objective of this task is for the Contractor to prepare, submit and gain acceptance of a FS report in accordance with EM CX Interim Guidance 06-04. The Contractor shall attend, by teleconference, an onboard review after receiving comments on the draft RI Report.

3.7 Task 7, Proposed Plan: This task is a Firm Fixed Price task. The objective of this task is for the Contractor to prepare, submit and gain acceptance of a Proposed Plan IAW ER 200-3-1 FUDS Program Policy and MM CX Interim Guidance 06-04. The draft version of the Proposed Plan will be subject to a minimum 30-day public review.

3.8 Task 8, Decision Document: This task is a Firm Fixed Price task. The objective of this task is for the Contractor to prepare, submit and gain acceptance of a Decision Document for **each** MRS in accordance with ER 200-3-1 FUDS Program Policy and MM CX Interim Guidance 06-04 and Appendix B. Appendix B provided new formatting requirements for the Decision Document and supersedes MM CX Interim Guidance 06-04 for formatting of Decision Documents.

3.9 Task 9, Community Relations Support: This task is a Firm Fixed Price/Unit Price task. The objective of this task is for the Contractor to successfully complete public meetings and support the Jacksonville District with community relations. The Contractor shall attend and participate in 3 public meetings. These meetings are different and in addition to TPP meetings. These meetings will be held on Isla Culebra. The Contractor shall provide a unit price per meeting for possible additional meetings. The support shall include, but is not limited to: preparation and delivery of briefings, graphics, maps, posters, and support of question and answer sessions. The Contractor shall also obtain the meeting site, perform public notification and prepare any correspondence necessary to meeting the objectives of this task. The USACE shall approve all correspondence, public notices and other materiel being presented to the public before use. These actions are independent of the field activities that involve interaction with the community. The meeting for the Proposed Plan shall be covered under this task. Transcripts of the public meeting for the Proposed Plan shall be prepared and submitted with the Final Proposed Plan. The Contractor shall also develop and maintain a project website for viewing by the public and PDT members. The Contractor shall maintain this website for the 24 month period of performance. The Contractor shall provide a monthly unit price to maintain the site.

3.10 Task 10, Public Involvement Plan (PIP): The objective of this task is for the Contractor to update, submit and gain acceptance of the PIP in accordance with EP 1110-3-8.

3.11 Task 11, Administrative Record: This task is a Firm Fixed Price task. The objective of this task is for the Contractor to establish and maintain ***a separate*** Administrative Record for ***each MRS***, for the on-going project in accordance with the guidance given in EP 1110-3-8, Chapter 4 (Establishing and Maintaining Administrative Records) and Standard Operating Procedure for Formerly Used Defense Sites (FUDS) Records Management, Revision 5, dated January 2008. This task requires close coordination with the Jacksonville District (CESAJ) and USAESCH to secure all required documents to support the Administrative Record. The Contractor will secure a place to establish and house the Administrative Record in the local city or community of the project. The Contractor shall provide all final documents in the Administrative Record on CD/DVD to USAESCH and Jacksonville District**.** These files shall be suitable for placement on the PIRS web site. The Contractor shall submit 2 copies each to USAESCH and Jacksonville District.

3.12 Task 12, Environmental Sampling & Analysis: This task is a Firm-Fixed Price/Unit Price ~~***Time and Materials, Unit Price***~~ task. ~~***The task may be converted to firm fixed price after the completion of the TPP process.***~~

3.12.1 The objective of this task is for the Contractor to determine the presence of and the nature and extent of, the munitions constituents (MC) that are detected above the applicable regulatory criteria and to perform an ecological and human health risk assessment in accordance with the EPA Risk Assessment Guidance (RAGS) and USACE EM 200-1-4, Volumes I and II. Existing site data shall be reviewed and evaluated. Sampling shall be conducted to support the MC baseline risk assessment. The Contractor shall prepare and submit for acceptance a single sampling and analysis plan (SAP) that shall include a field sampling plan and a quality assurance project plan in accordance with DID MR-005-10.01 and UFP QAPP that describes their phased approach and addresses contaminants of interest and sample media (soil/groundwater/sediment/surface water). The price of the SAP shall be firm fixed price and shall be covered under the Work Plan Task. The contractor shall propose the analytical methodology, media and analytical parameters including QC and QA requirements for determination of explosives and MC related metals in soil, sediment and water samples which will be used to execute this Task order. The contractor shall provide an independent laboratory to analyze QA samples separate from the contractor's primary laboratory. Data from the QA laboratory will be sent directly to the government. For the price proposal the contractor shall provide prices for 70 discrete samples for surface soil, 30 discrete samples for subsurface soil, and 20 discrete samples each for sediment and surface water. For background the contractor shall provide price for 20 discrete samples each for surface and subsurface soil, and 10 discrete samples each for sediment and surface water. The government does not intend to install monitoring wells. The contractor shall provide price for 10 each pre and post-detonation composite samples based on the CRREL 7-sample wheel approach (as described in ERDC SR96-15). Additionally, a price spreadsheet is provided in Appendix A for unit price required for this task order and will be used to increase or decrease the scope of the Task Order based on the final level of effort determined during TPP.

3.12.2 The SAP and the data deliverables shall be performed and submitted in accordance with DID MR-005-10.01 and acceptance be gained from the Government. The Contractor shall also provide a discussion on data evaluation and fate and transport analysis. The potential for fate and transport shall address all transport pathways, and it should also address future degradation products resulting from biodegradation, photolysis, and chemical reactions.

3.12.3 Any deviations from the accepted SAP shall be documented in the Daily Quality Control Reports (DQCR). Any deviations that may affect Data Quality Objectives (DQO's) shall be conveyed to USAESCH personnel [project manager (PM), project engineer (PE), project chemist, etc.] immediately.

3.13, Beach Monitoring (optional) Fixed Unit Price
The Contractor shall provide a qualified Project Biologist for daily beach monitoring prior to intrusive ordnance activities as described in the Standard Operation Procedure for Endangered Species Conservation, USACE, Jacksonville District. Project Biologist qualifications shall reflect 2-4 years experience in related work, working independently under general supervision (equivalent to industry Biologist II).

4.0 SUBMITTALS AND CORRESPONDENCE:

4.1 Computer Files: All final text and spreadsheet files generated by the Contractor under this task order shall be furnished to the Contract Officer in **MS Office Suite 2003 compatible format**. Other computer files shall be in accordance with the DIDs. All computer files shall be submitted on CD or DVD.

4.2 PDF Deliverables: In addition to the paper and digital copies of submittals, all versions of any and all reports and/or plans shall be submitted in their entirety (including appendices), uncompressed, on CD or DVD in Adobe Portable Document Format (PDF) format along with a linked table of contents, linked tables, linked photographs, linked graphs and linked figures, all of which shall be suitable for viewing on the Internet. In the case of large reports, the appendices can be provided as one .pdf file separate from the narrative .pdf file. PDF files shall be produced from source documents wherever possible.

4. 3 Identification of Responsible Personnel: Each submittal shall identify the specific members and title of the Contractor's and subcontractor staff that had significant input into the report's preparation or review. All submittals shall be signed by a registered Professional-In-Charge.

4.4 Public Affairs: The Contractor shall not publicly disclose any data generated or reviewed under this contract. The Contractor shall refer all requests for information concerning site conditions to the Jacksonville District PAO with a copy furnished to the USAESCH Project Manager. Reports and data generated under this contract are the property of the DoD and distribution to any other source by the Contractor, unless authorized by the Contracting Officer, is prohibited.

4.5 Submittals: The Contractor shall furnish copies of the plans, maps, and reports as identified in Table 4-1 to each addressee listed below in the quantities indicated in the Submittal Guidance table, Table 4-2. The Contractor shall submit 1 copy on CD with each hard copy of all submittals (WPs, Reports, Plans, etc) in accordance with paragraphs computer files and PDF Deliverables.

4.6 Addressees:

US Army Engineering & Support Center, Huntsville
Attn: CEHNC-OE-DC, (Spencer O'Neal)
PO Box 1600
Huntsville, AL 35807-4301
4820 University Square
Huntsville, AL 35816-1822

Commander
U.S. Army of Corps of Engineers, Jacksonville District
Attn: DESAJ-DP-S (Daphne Ross)
701 San Marco Blvd.
Jacksonville, FL 32207

Note: Addresses shall be verified by the Contractor.

4.7 Submittals and Due Dates.

Table 4-1 List of Deliverables

Submittals	**Due Dates (Calendar days)**
AAPP	14 days prior to site visit
Explosives Siting Plan	Separate MACOM approval before intentional physical contact with MEC on site
Proposed schedule	7 days after kick-off conference call
GIS on CD/DVD	3 weeks after NTP
Advanced TPP package & CSM	14 days before 1st TPP
Draft TPP Memorandum	TBD
Final TPP Memorandum	14 days after comments
Draft Public Involvement Plan	TBD
Final Public Involvement Plan	14 days after receipt of comments
Draft Work Plan	21 days after DQOs are determined (TPP)
Draft Final Work Plan	14 days after receipt of comments
Final Work Plan	14 days after receipt of comments
Draft RI Report w/ GIS on CD/DVD	60 days after completion of fieldwork
Draft Final RI Report	14 days after receipt of comments
Final RI Report	14 days after on board Review
Draft FS Report	TBD
Draft Final FS Report	14 days after receipt of comments
Final FS Report	14 days after on board Review
Draft Proposed Plan	14 days after receipt of acceptance of the FS Report
Final Proposed Plan	7 days after receipt of comments
PP Meeting Transcripts	with final Proposed Plan
Responsive Summary	With Decision Document
Draft Decision Document	14 days after acceptance of Proposed Plan

Draft Final Decision Document	7 days after receipt of comments
Final Decision Document	7 days after receipt of comments
Final Administrative Record (On CD/DVD)	Upon completion of the Record
Daily QC Report for Environmental Sampling	Daily during Environmental Sampling Activities
Analytical Data Submittal for QA Evaluation	30 days after completion of fieldwork
Electronic Laboratory Data Submittal	45 days after completion of fieldwork
Final GIS Files on CD	End of Project

4.8 Submittal Quantities
Provide the number of submittals shown in Table 4-2 to the addressees given in Section 4.6.

Table 4-2 Submittal Guidance

	Draft TPP/Plans /Reports/Documents	Draft Final/Final TPP /Plans /Reports/Documents	Others
USAESCH	*4*	4	TBD
CESAJ	*12*	12	TBD

4.9 Review Comments: Various reviewers will have the opportunity to review submittals made by the Contractor under this contract. The Contractor shall review all comments received through the Project Delivery Team/Contracting Officer and evaluate their appropriateness based upon their merit and the requirements of the PWS. The Contractor shall issue to the Project Manager a formal, annotated response to each. The Contractor shall not non-concur with a comment without discussing with the PM and/or comment maker. Where comments refer to a specific paragraph of a document and the paragraph number has changed since the comment was made, the Contractor shall note the new paragraph number in the annotated response to the comment.

4.10 Schedule: A final schedule shall be submitted a minimum of 30 days before commencing field work in a format compatible with Microsoft Project. A PDF version shall also be submitted. This is an electronic submittal only. The Contractor shall update the schedule in accordance with DID MR-085 Project Status Report.

4.11 Telephone Conversations/Correspondence Records/Meeting Minutes: The Contractor shall keep a record of each phone conversation, written correspondence concerning this Task Order and meeting minutes in accordance with DID MR-055 and DID MR-045. A copy of these records shall be attached to the Project Status Report.

4.12 Project Status Reports: The Contractor shall prepare and submit Project Status Reports in accordance with DID MR-085 and include any other items required in the PWS.

4.13 Period of Performance: The Completion Date for this Task Order is December 30, 2011.

4.14 Milestone Payments for firm fixed price tasks: Milestones will be considered met or completed when the required QC documentation has been submitted, QA completed and the submittal and/or product is accepted. Any payment vouchers submitted that do not coincide with the final accepted milestones or do not have the appropriate QC documentation will be rejected. All payments will be made utilizing an agreed upon Payment Milestone Schedule.

5.0 REFERENCES:

5.1 Refer to "Basic Contract."

5.2 Data Item Descriptions: are available at the following: http://www.hnd.usace.army.mil/oew/didsindex.aspx. DIDs MR-005-05, MR-005-05A, MR-005-07 and MR-005-10 have been revised. The new DIDs are MR-005-05.01, MR-005-07.01 and MR-005-10.01. MR-005-05A is no longer used.

6.0 PERFORMANCE METRICS:

6.1 Performance Metrics for Performance Assessment Record (PAR)

	Exceptional	Very Good	Satisfactory	Marginal	Unsatisfactory

	Exceptional	Very Good	Satisfactory	Marginal	Unsatisfactory
PAR Category: Quality of Product or Service					
Performance indicator: Document reviews					
Draft Plans, Reports, and documents [Plans, documents and reports are considered draft until accepted as final by the Government]	All contract-milestone documents accepted as submitted	No substantive comments (i.e. limited to grammar, spelling, terminology) to any of the documents or subplans, but a few exceptions were noted and corrected by change pages	One or more documents or subplans required revisions to be resubmitted for approval prior to proceeding. However, no document or subplan required more than one backcheck, all original comments were resolved satisfactorily.	One or more documents or subplans required revisions to be resubmitted for approval prior to proceeding. Two backchecks were required on one or more documents or subplans before original comments were resolved satisfactorily.	One or more documents or subplans did not comply with contract requirements, or one or more documents or subplans required more than two backchecks before original comments were resolved satisfactorily, or one or more documents or subplans were rejected.
Performance indicator: Project Execution					
Process Compliance	Zero Corrective Action Requests (CAR)	1-5 CARs for non-critical violations to WP requirements	6-8 CARS for non-critical violations and/or 1 CAR for critical violation	8-10 CARS for non-critical violations and/or 2-4 CARS for critical violations	>10 CARS for non-critical violations and/or >4 CARS for critical violations, or any unresolved CARS
Project Execution	Zero letters of reprimand, grievances, or formal complaints AND one or more unsolicited letters of commendation		Zero letters of reprimand, grievances, or formal complaints	One letter of reprimand, grievance or formal complaint that was resolved through negotiation	More than one letter of reprimand, grievance or formal complaint that were resolved through negotiation
Task Completion			All final data and QC documentation submitted and accepted		Final data and QC documentation submitted but not accepted
PAR Category: Schedule					
Performance indicator: Timely completion of tasks					
Final Plans and Reports, project milestones, T.O. invoices	All document submittals and task order milestones and invoices complete and accepted by	Project closed out/final invoice accepted ahead of schedule	Project closed out/final invoice accepted on T.O. date	Project closed out/final invoice accepted within 30 calendar days after T.O. date.	Project closed out/final invoice accepted more than 30 calendar days after T.O. date.

	Exceptional	Very Good	Satisfactory	Marginal	Unsatisfactory
	T.O date, project closed out/final invoice approved ahead of schedule				
Project status reports accurate			Yes		No
Performance indicator: Impacts to schedule					
Impacts caused by Contractor or other causes identified, in writing to HNC CO/ PM, in a timely manner to apply acceptable corrective actions.			Yes		No
PAR Category: Cost Control (Not Applicable for Firm Fixed Price)					
Performance indicator: No unauthorized cost overruns					
Unauthorized cost overruns			No		Yes
Total Project Costs	Total contract invoices less than 98% of T.O. authorized amount	Total contract invoices greater than 98% but less than 99.99%of T.O. authorized amount	Total contract invoices between 99.99% and 100% of T.O. authorized amount	Total contract invoices greater than 100% but less than 105% of T.O. authorized amount	Total contract invoices greater than or equal to 105% of T.O. authorized amount
Performance indicator: Monthly cost report					
Monthly cost reports accurate			Yes		No
Performance indicator: Impacts to cost					
Impacts caused by Contractor or other causes identified, in writing to HNC CO/PM, in a timely manner to apply acceptable corrective actions.			Yes		No
PAR Category: Business Relations					
Performance indicator: Met contractual obligations					
Corrective Actions taken were timely and effective (Refer to CARs issued to Contractor)			Yes		No
Performance indicator: Professional and Ethical Conduct					
Meetings and correspondences with Public, project delivery	Zero letters of reprimand, grievances, or formal		Zero letters of reprimand, grievances, or formal	One letter of reprimand, grievance or formal complaint	More than one letter of reprimand, grievance or

	Exceptional	Very Good	Satisfactory	Marginal	Unsatisfactory
team and other stakeholders	complaints AND one or more unsolicited letters of commendation		complaints	that was resolved through negotiation	formal complaint that were resolved through negotiation OR removal of one or more project personnel as a results of a letter of reprimand, grievance or formal complaint.
Performance indicator: Customer has overall satisfaction with work performed					
Customer survey results for rating period	4.0-5.0	3.0-3.9	2.0-2.9	1.0-1.9	<1.0
Performance indicator: Personnel responsive and cooperative					
Key personnel responsive, and cooperative	Always		Most Times		Almost Never
PAR Category: Management of Key Personnel and Resources					
Performance indicator: Personnel knowledgeable and effective in their areas of responsibility					
Personnel assigned to tasks	All personnel proposed by Contractor were assigned to project, some personnel were substituted by higher qualified individuals.		All personnel proposed by Contractor were assigned to project, some personnel were substituted by equally qualified individuals.	All personnel proposed by Contractor were assigned to project, some personnel were substituted by equally qualified individuals, Letter of reprimand received for personnel conduct from HNC.	All personnel proposed by Contractor were assigned to project, some personnel were substituted by lesser qualified individuals or HNC requested, in writing, removal of assigned personnel for poor performance.
Performance indicator: Personnel able to manage resources efficiently					
Instances when resource management had negative impact on project execution	0	1-2	3-4	5-6	>6
PAR Category: Safety					
Performance indicator: Accidents and Violations					
*No Class A Accidents, Contractor at fault	0 No class A accidents IAW AR 385-40	No class A accidents IAW AR 385-40	<1 non-explosive related Class D, accidents, or <2 non-explosive Class C accidents IAW	<2 non-explosive related Class C accidents, or 1 non-explosive Class B accident, IAW AR 385-40	1 Any Class A accident IAW AR-385-40, or Any explosive related accident.

	Exceptional	Very Good	Satisfactory	Marginal	Unsatisfactory
			AR 385-40.		
*Major safety violations	0 accidents/injuries No safety violations	0 accidents/injuries No safety violations	0 accidents/injuries 1 non-explosive related safety violation.	2 non-explosive safety violations.	>1 any violation of procedures for handling, storage, transportation, or use of explosives IAW the WP, and all Federal, State and local laws/ordinances.
*Minor safety violations	No safety violations	1 safety violation	2 safety violations.	3 safety violations	>3 safety violations

Classes of Accidents:

- **Class A:** Fatality or permanent total disability (Government Civilian, Military Personnel, and/or Contractor), or >$1,000,000 property damage.

- **Class B:** Permanent partial disability or impatient hospitalization of 3 or more persons (Government Civilian, Military Personnel, and/or Contractor), $200,000< $1,000,000 property damage.

- **Class C:** Lost Workday (Contractor) or Lost Time (Government Civilians), $20,000< $200,000 property damage.

- **Class D:** $2000 < $20,000 property damage.

* From Section C of Solicitation Number W912DY-04-R-0003, Amendment 0001 (may be included but are not limited to these).

The following guidelines are provided for issuing ratings that are subjective in nature; these ratings will be supported by the weight of evidence documented during the government's surveillance efforts:

<u>Exceptional:</u> Performance *meets* contractual requirements and *exceeds many* to the Government's benefit. The contractual performance of the element or sub-element being assessed was accomplished with *few minor problems* for which corrective actions taken by the Contractor were *highly effective*.

<u>Very Good:</u> Performance *meets* contractual requirements and *exceeds some* to the Government's benefit. The contractual performance of the element or sub-element being assessed was accomplished with *some minor problems* for which corrective actions taken by the Contractor were *effective*.

<u>Satisfactory:</u> Performance *meets* contractual requirements. The contractual performance of the element or sub-element contains *some minor problems* for which corrective actions taken by the Contractor *appear or were satisfactory*.

<u>Marginal:</u> Performance *does not meet all* contractual requirements. The contractual performance of the element or sub-element being assessed reflects a *serious problem* for which the Contractor has *not yet identified corrective actions*. The Contractor's proposed actions appear only *marginally effective or were not fully implemented*.

<u>Unsatisfactory:</u> Performance *does not meet most* contractual requirements and *recovery is not likely* in a timely manner. The contractual performance of the element or sub-element contains *serious problems* for which the Contractor's corrective actions *appear or were ineffective*

7.0 CONTRACTOR MINIMUM PERFORMANCE AND QC REQUIREMENTS: Underwater investigation QC shall be recommended by the Contractor in the QCP. Government QA is expected to be limited to visual observation of the Contractors work and QC operation. The government recognizes that submerged metallic items can move due to the local current and surf conditions and that prolonged seeding of test items (more than 1 day) is not feasible for the Culebra RI/FS. The government requests that the Contractor submit a modified Performance Requirement table for the underwater and beach portions of the project to meet the needs of the project and still insure acceptable data quality to meet the project objectives.

The following tables will be used for the land survey**.** The Contractor shall include in their QC plan specific tests that are itemized below. The values listed in the various requirements listed in Tables 7-1 and 7-2 below may be adjusted upon request, provided the Contractor supplies supporting documentation and rationales for Government concurrence. All reported QC results from these tests will be reviewed as part of government QA. In the event a requirement is not met and the contractor submits the data to the Government, the contractor shall provide rationales for accepting them. All such rationales will be reviewed as part of government QA. If the rationales are either insufficient or technically unfeasible, or are attempts to justify non-conformances that should be corrected to meet project needs, the Government will issue a Corrective Action Request to the contractor and the submittal(s) will be rejected. Some performance standards are default values and may be changed by the PDT to suit project needs. These requirements are marked with an asterisk (*). These QC requirements supersede the required QC entries in the DID MR-005-05.01 Access Database. The database template shall be used; however, the required fields will change based on these tables.

Table 7-1 Performance Requirements for RI/FS using DGM Methods [1]

Requirement	Applicability (Specific to Collection Method/Use)	Performance Standard	Frequency	Consequence of Failure[2]
Static Repeatability (instrument functionality)[3]	All	Response (mean static spike minus mean static background) +-10% of GPO/original value on all channels	Min 1 daily	Day's data fails unless seed item is mapped that day with repeatable anomaly characteristics (see Dynamic Detection Repeatability)
Along Line Measurement Spacing	All	98% <=25cm along line[4]	By dataset	Dataset submittal fails
Speed	Transects without seeds[5]	95% within max project design speed or demonstrated speed	By dataset	Dataset submittal fails unless new max speed successfully demonstrated at GPO.
Coverage(*)	Grids	>90% coverage at project design line spacing.[6]	By dataset or grid[7]	Submittal fails unless gaps filled, additional data collected, or government refund for missing acreage.
Dynamic Detection Repeatability	Grids	Test item anomaly characteristics (peak response and size) repeatable with allowable variation +/-25%.[8]	1 test item per grid or dataset. [7]	Submittal fails
	Transects	(a) #anomalies on repeat segment w/in +-20% or +-8 of original or within range of adjacent sections (b) Test item (in test strip or on transect) anomaly characteristics (peak response and size) repeatable with allowable variation +/-25%. Or Fit coefficient[10] over test strip is acceptable.	(a) repeat 2% per lot[9] or (b) repeat test strip once per system per lot or daily; or 2 test items per system per lot	(a) Lot submittal fails or (b) Lot (or day's data) fails
Dynamic Positioning Repeatability	Grid coverage	Position offset of Test item target <=35cm + 1/2 line spacing[11] (<=50cm + 1/2 line spacing for fiducially positioned data).	1 test item per grid or dataset [7] (same item as Dynamic Detection Repeatability)	submittal fails
	Transects with reacquisition/digging	(a) Demonstrate reacquisition by reproducing randomly chosen anomaly signals (reac amplitude >= original & offset <= 1m) [12] or (b) Test item anomaly characteristics (peak response and	(a) 2 targets per system per lot or (b) 2 test items per system per lot (can be same as detection repeatability test items)	Lot submittal fails

Requirement	Applicability (Specific to Collection Method/Use)	Performance Standard	Frequency	Consequence of Failure[2]
		size) repeatable with allowable variation +/-25% and position offset <=1m.		
Target Selection	All	All dig list targets are selected according to project design	By grid or dataset[7]	submittal fails
Anomaly Resolution(*)[13]	Verification checking by DGM re-mapping[14] Or Verification checking with original instrument of anomaly footprint after excavation [15]	If MEC[16]: 70% confidence <10% unresolved anomalies[17] If no MEC: 90% confidence <5% unresolved anomalies Accept on zero.	Rate varies depending on lot size. [18] See Acceptance Sampling Table.	Lot submittal fails
Geodetic Equipment Functionality(*)	All	Position offset of known/temporary control point within expected range as described in the approved work plan. [19]	Daily	Redo affected work or re-process affected data
Geodetic Internal Consistency	Grids with line/fiducial positioning	Grid corners are internally consistent within 30cm on any leg or diagonal.	Per Grid	Redo affected work (corner placement & data collection, or data processing)
Geodetic Accuracy	Points used for RTK or RTS base stations	Project network must be tied to HARN, CORS, OPUS or other recognized network[20]. Project control points that are used more than once must be repeatable to within 5cm	For points used more than once, repeat occupation[21] of each point used, either monthly (for frequently used points) or before re-use (if used infrequently[22]).	Re-set points not located at original locations or resurvey point following approved work plan.
Geodetic Repeatability(*)	Grid centroids or corners/transect points without anomaly reacquisition	Measured locations are reoccupied within 10m. [23]	1 per lot	Lot submittal fails

[1] These are the critical requirements for RI DGM methods. Contractors shall use additional methods/frequencies that they deem beneficial and as required in their SOPs.
[2] All failures also require a Root Cause Analysis.
[3] Item should be placed on a jig that ensures consistent geometry between the sensor and item to ensure repeatability, response not to exceed 500 units, or optionally use the Geonics calibration coil. Duration of data collection needed TBD by the contractor. Must compare to original to ensure instrument is consistent throughout the

project. .It is recognized that this QC requirement may be redundant and could contradict results from seeding QC, however, in the event of seed failure, information from this test may aid in determining cause of failure, i.e. instrument or processing.

[4] 25cm based on institutional knowledge and common instrument physical dimensions. Assumes speed used achieves detection. This requirement can be relaxed if supporting documentation is provided to the Government for concurrence.

[5] Needed because increase in speed can reduce SNR and increase # false hits (alternatively this test can be supplanted by repeatable anomaly characteristics of seed items within the dataset).

[6] Recommended default line spacing is 0.6m for items of interest the size of 40mm grenades and smaller, else 0.8m

[7] The terms ―grid" and ―dataset" refer here to logical groupings of data or data collection event. Logical groupings of data are contiguous areas mapped by the same instrument and in the same relative time-frame. These can be grids, acres, or some other unit of area. A data collection event is similar to logical groupings of data but refers to data collected over a contiguous time frame, such as ―morning", ―afternoon", ―battery life", or some other measure of contiguous time. It is recognized that physical marking of corners on the ground is not always beneficial to the government. Additionally, size and shape of the grid is not specified.

[8] A standard test item shall be placed within the survey area (i.e. a small pipe or flat plate with a small area response. Item can be placed flush with the surface or buried at a standard depth and standard orientation). This test does not demonstrate the detection capabilities of the MEC of interest. The standard response to this test item must be defined prior to the start of production field activities. Response repeatability to this standard test item in the mapping data will indicate data quality is consistent and sufficient for detection of the MEC items of interest.

[9] Fit Coefficient means how well the repeated data matches the original data. Method of calculation and acceptance criteria can be proposed by the Contractor, and could be based on the UX-Process repeatability gx value.

[10] Contractor shall propose the lot size and criteria for designation (i.e. woods vs. open)

[11] For 0.8m line spacing, this would be a 0.75m allowable error radius (or 0.9 for fiducial).

[12] Does not necessarily mean the peak response or actual item location (i.e. for transect data the response could still be ramping up off-line). This could also be demonstrated through blind seed items.

[13] Resolved is defined as 1) there is no geophysical signal remaining at the flagged/selected location, or 2) a signal remains but it is too low or too small to be associated with UXO/DMM, or 3) a signal remains but is associated with surface material which when moved results in low, or no signal at the interpreted location, or 4) a signal remains and a complete rationale for its presence exists.

[14] Mapping shall cover the required number of anomaly locations. This is used in-lieu of checking individual anomalies for those instances where it is quicker to re-map sections of land rather than return to individual anomalies. Only the data at the anomaly locations is reviewed for resolution.

[15] This may require leaving flags at excavated locations until QC is complete. It is up to the contractor to indicate which holes knowingly have metal left in them where the PDT has agreed such is acceptable. It is the contractor‗s responsibility to not put hot material back in the hole before QC is complete. As part of this requirement location accuracy must also be demonstrated (i.e. cleared location is within dynamic positioning error radius as described above). Contractor SOPs that incorporate post-excavation inspections using digital geophysical instruments can be used to meet the excavation verification need of this requirement provided appropriate QC protocols are in place to monitor and document the SOPs are followed. Acceptance sampling or alternative QC protocols to monitor and document the reacquisition SOP would be required to demonstrate the correct locations are excavated.

[16] If MEC (or intact or partial training or practice rounds) are not detected in a lot then the information from that lot may be used to support certain decisions where the confidence in the results must be greater than that for grids where MEC are detected.

[17] This is a statistical test number. It does not imply there are 10% bad units. It tests there are fewer than 10% bad units, including zero bad units. Values for confidence levels will be determined by the PDT and are dependent on the information needed. Stopping rules will take precedence over this standard (i.e. for high MEC density, decision could be made to stop because the team has enough data for characterization)

[18] For example, if lot size is 500 anomalies, to achieve a 90% confidence that there are less than 5% unresolved anomalies, 43 anomalies must be re-checked. If any one of the 43 is unresolved, then the confidence level has not been met, the lot submittal fails and all anomalies in that lot must be re-checked (i.e. accept on zero). The contractor shall propose the lot size for government concurrence (i.e. The contractor determines the amount of risk they are willing to take. The larger the lot, the less sampling needs to be done, but the larger the risk of increased costs/rework if failure occurs.) For anomaly resolution, in order to use statistics/confidence levels, it is based on number of anomalies, not grids.

[19] Most high-accuracy systems should demonstrate repeatability between 5cm and 10cm. Typical accuracies achievable for some high-accuracy systems are: 2cm to sub-centimeter for RTK DGPS and RTS units depending on manufacturer and site conditions. Less accurate systems should demonstrate repeatability within manufacturer published ranges. Typical accuracies for less accurate systems are 5m to sub-meter for WAAS or satellite correction service DGPS units depending on manufacturer, correction service and site conditions, and 30m to 1m for USCG beacon corrected units depending on manufacturer.
[20] The plan for tying the project network to a common reference network must be described in the approved work plan. If monumentation is part of the plan, specific monumentation procedures and data quality objectives will also need to be specified and installation of monumentation or network control points shall follow all guidance and accuracies specified in EC 1110-1-73 – ―Standards and Specifications for Surveys, Maps, Engineering Drawings, and Related Spatial Data Products".
[21] Repeat occupation means demonstrate the control points being used can be recovered and reoccupied and that they have not moved more than the requirement specification. This can be accomplished using the same methodology used to initially tie the local network to a HARN, CORS, OPUS, or other recognized network, or it can be accomplished by other means that achieve this requirement.
[22] An example of frequently used control points would be points used as RTK DGPS base stations. Infrequently used points could be those used during RTS operations where the control point was used during mapping and then again at some later time for reacquisition and QC statistical sampling. Infrequently used points could also include grid corners they are used for line and fiducial positioning and then subsequently re-used for reacquisition or QC statistical sampling.
[23] The exact location of a single transect/grid is not critical when the information is used only for characterization by interpolating over large areas (e.g. transect spacings are larger than geodetic accuracies). The acceptable accuracy may be tightened by the PDT if more exact positioning is needed (e.g. trying to characterize extents of small MRS's). If specific anomalies/locations must be recovered this metric must be revised to meet project needs and will likely have the same accuracy needs as the Geodetic Accuracy requirement.

Table 7-2 QC Requirements for RI/FS using Analog Methods[1]

Requirement	Limited Applicability (Specific to Collection Method/Use)	Performance Standard	Frequency	Consequence of Failure[2]
Repeatability (instrument functionality)	All	All items in test strip detected (trains ear daily to items of interest)[3]	Min 1 daily[4]	Remedial training and additional remedial measures as described in the approved work plan if due to operator error, or replacement of faulty equipment.[5]
Dynamic Repeatability	Transects used only for density estimates	Repeat a segment of transect & show #Counts repeated w/in the greater of +-20% or +-8, or w/in range of adjacent segments.	2nd party repeat of 2% per lot	Redo lot
	Transects with digging	Repeat a segment of transect & show extra flags/digs not greater than the greater of 20% or 8 flags/digs, or w/in range of adjacent segments.	2nd party repeat of 2% per lot	Redo lot
Coverage(*)	Grids	Blind coverage seeds and blind detection seeds recovered[6]: 75% if MEC 90% if no MEC[7]	Variable rate at 2, 3 or 4 times # operators, per lot.	Redo lot.
Detection & Recovery (*)	No DGM QC remapping	Blind detection seeds recovered: 80% if MEC 100% if no MEC	Per operator per lot: variable 1-2 large/deep and 1-3 small/ shallow[8]	Redo lot
	With DGM QC remapping	If MEC[9]: 70% confidence <10% unresolved anomalies[10] If no MEC: 90% confidence <5% unresolved anomalies Accept on zero. [11]	Rate varies depending on lot size. [Table showing acreage rates per lot size for varying confidence levels will be provided][12]	Redo lot
Anomaly Resolution(*)[13]	Verification checking of excavated locations (analog or digital instrument)	2nd party checks open holes to determine: If MEC: 70% confidence <10% anomalies unresolved[14] If no MEC: 90% confidence <5% anomalies unresolved	Rate varies depending on lot size. See Acceptance Sampling Table.[15]	Redo lot

Requirement	Limited Applicability (Specific to Collection Method/Use)	Performance Standard	Frequency	Consequence of Failure[2]
	Verification checking by DGM remapping[16]	Same as Detection & Recovery	Rate varies depending on lot size. See Acceptance Sampling Table.	Redo lot
Geodetic Equipment Functionality (*)	All	Position offset of known/temporary control point within expected range as described in the approved work plan.[17]	Daily	Redo affected work
Geodetic Accuracy	Points used for RTK or RTS base stations	Project network must be tied to HARN, CORS, OPUS or other recognized network[18]. Project control points that are used more than once must be repeatable to within 5cm	For points used more than once, repeat occupation[19] of each point used, either monthly (for frequently used points) or before re-use (if used infrequently[20]).	Re-set points not located at original locations or resurvey point following approved work plan.
Geodetic Repeatability (*)	Grid corners/transect points without anomaly reacquisition	Measured locations are reoccupied within 10m.[21]	1 per lot	Redo affected work

[1] These are the critical requirements for RI analog methods. Contractors shall use additional methods/frequencies that they deem beneficial and as required in their SOPs.
[2] All failures also require a Root Cause Analysis.
[3] The requirement is that each operator demonstrates positive detection on a daily basis of the smallest and largest expected MEC of interest when it is placed at both its best and worst orientations and buried between 95% and 100% of their respective maximum consistent detection depth. Maximum consistent detection depth is defined as producing any above background response on a minimum of the first three time gates of the EM61MK2 optimized for site conditions and having a $0.9m^2$ size or more as calculated using the Geosoft Oasis Montaj UCEAnalyseTarget.gx or equivalent routine.
[4] Random blind reconfiguration of test strip is also required (i.e. moving/adding items) at a frequency determined by the contractor and approved in the work plan, to address the potential for simply memorizing seed locations.
[5] Some examples of additional remedial measures are: removal of operator from mapping for one day, retesting on new blind strip meeting the same requirements for seed items (could move location of items in same area), 100% QC re-inspection of initial lanes by that operator, etc.
[6] Coverage seeds are small pieces of metal that will produce relatively large amplitude anomalies over small areas, such as small nails or ball bearings. Known location accuracy of placement is not critical. See endnote #8 for description of blind detection seeds.
[7] If MEC (or intact or partial training or practice rounds) are not detected in a grid/lot then the information from that grid/lot may be used to support certain decisions where the confidence in the results must be greater than that for grids where MEC are detected.
[8] Detection and recovery must be consistently demonstrated for the hard to detect items; therefore, the largest expected MEC and the smallest expected MEC shall be placed between 95% and 100% of their respective maximum consistent detection depth
[9] If MEC (or intact or partial training or practice rounds) are not detected in a lot then the information from that lot may be used to support certain decisions where the confidence in the results must be greater than that for grids where MEC are detected.

[10] This is a statistical test number. It does not imply there are 10% bad units. It tests there are fewer than 10% bad units, including zero bad units. Values for confidence levels will be determined by the PDT and are dependent on the information needed. Stopping rules will take precedence over this standard (i.e. for high MEC density, decision could be made to stop because the team has enough data for characterization)

[11] Unresolved anomaly for ‗Detection & Recovery Testing' means a significant signal remains without a complete rationale for its presence. Default values for such a ‗significant signal' are peak amplitude on sum channel >=30mv & anomaly width >=1.2m or anomaly size >=0.9m^2. This value may change but must be agreed upon by the PDT up front.

[12] The statistical calculations for this test are in progress. This is different from sampling of excavated holes, in that a portion of the acreage is re-mapped, and the amount re-mapped must be statistically valid to show, to some confidence level, that anomalies did not go undetected.

[13] This requires leaving flags at excavated locations until QC is complete. If shovel called to a flag during QC then the failure has already occurred—it is not important that something large or small comes out of the hole. Assumption here is ―mapping coverage" is addressed through other means. It is up to the contractor to indicate which holes knowingly have metal left in them where the PDT has agreed such is acceptable. It is the contractor's responsibility to not put hot material back in the hole before QC is complete.

[14] Resolved is defined as 1) there is no geophysical signal remaining at the flagged/selected location, or 2) a signal remains but it is too low or too small to be associated with UXO/DMM, or 3) a signal remains but is associated with surface material which when moved results in low, or no signal at the interpreted location, or 4) a signal remains and a complete rationale for its presence exists.

[15] For example, if lot size is 500, to achieve a 90% confidence that there are less than 5% unresolved anomalies, 43 anomalies must be re-checked. If any one of the 43 is unresolved, then the confidence level has not been met , the lot submittal fails and all anomalies in that lot must be re-checked (i.e. accept on zero). The contractor shall propose the lot size for government concurrence (i.e. The contractor determines the amount of risk they are willing to take. The larger the lot, the less sampling needs to be done, but the larger the risk of increased costs/rework if failure occurs.) For anomaly resolution, in order to use statistics/confidence levels, it is based on number of anomalies, not grids.

[16] Mapping shall cover the required number of anomaly locations. This is used in-lieu of checking individual anomalies for those instances where it is quicker to re-map sections of land rather than return to individual anomalies. Only the data at the anomaly locations is reviewed for resolution.

[17] Most high-accuracy systems should demonstrate repeatability between 5cm and 10cm. Typical accuracies achievable for some high-accuracy systems are: 2cm to sub-centimeter for RTK DGPS and RTS units depending on manufacturer and site conditions. Less accurate systems should demonstrate repeatability within manufacturer published ranges. Typical accuracies for less accurate systems are 5m to sub-meter for WAAS or satellite correction service DGPS units depending on manufacturer, correction service and site conditions, and 30m to 1m for USCG beacon corrected units depending on manufacturer.

[18] The plan for tying the project network to a common reference network must be described in the approved work plan. If monumentation is part of the plan, specific monumentation procedures and data quality objectives will also need to be specified and installation of monumentation or network control points shall follow all guidance and accuracies specified in EC 1110-1-73 – ―Standards and Specifications for Surveys, Maps, Engineering Drawings, and Related Spatial Data Products".

[19] Repeat occupation means demonstrate the control points being used can be recovered and reoccupied and that they have not moved more than the requirement specification. This can be accomplished using the same methodology used to initially tie the local network to a HARN, CORS, OPUS, or other recognized network, or it can be accomplished by other means that achieve this requirement.

[20] An example of frequently used control points would be points used as RTK DGPS base stations. Infrequently used points could be those used during RTS operations where the control point was used during mapping and then again at some later time for reacquisition and QC statistical sampling. Infrequently used points could also include grid corners they are used for line and fiducial positioning and then subsequently re-used for reacquisition or QC statistical sampling.

[21] The exact location of a single transect/grid is not critical when the information is used only for characterization by interpolating over large areas (e.g. transect spacings are larger than geodetic accuracies). The acceptable accuracy may be tightened by the PDT if more exact positioning is needed (e.g. trying to characterize extents of small MRS's). If specific locations must be recovered this metric must be revised to meet project needs and will likely have the same accuracy needs as the Geodetic Accuracy requirement, which is 30cm.

Table 7-3 Acceptance Sampling Table for Anomaly Resolution

	Lot size = **50** anomalies	**100**	**200**	**500**	**1000**	**2000**	**5000**	**10,000**
70% confidence <**10%** unresolved[1]	11	11	12	12	12	12	12	12
80% confidence <**10%** unresolved	14	15	15	16	16	16	16	16
90% confidence <**10%** unresolved	18	20	21	22	22	22	22	22
95% confidence <**10%** unresolved	22	25	27	28	29	29	29	29
70% confidence <**5%** unresolved	17	21	23	23	24	24	24	24
80% confidence <**5%** unresolved	21	27	30	31	31	32	32	32
85% confidence <**5%** unresolved	23	31	34	36	37	37	37	37
90% confidence <**5%** unresolved[2]	27	37	41	43	44	45	45	45
95% confidence <**5%** unresolved	31	45	51	56	57	58	59	59
80% confidence <**1%** unresolved	40	80	111	138	144	154	158	159
85% confidence <**1%** unresolved	43	85	123	158	172	181	186	187
90% confidence <**1%** unresolved[3]	45	90	137	184	205	217	224	227
95% confidence <**1%** unresolved	48	95	155	225	258	277	290	294

* Gray boxes show number of dug locations to check post-excavation. All must be shown to be resolved to meet confidence values (accept on zero)

[1] Default for RIFS where MEC has been recovered.

[2] Default for RIFS where no MEC has been recovered.

[3] Default for Removal Action.

8.0 GENERAL CONDITIONS:

8.1 The Contractor acknowledges that it has taken steps reasonably necessary to ascertain the nature and location of the work, and that it has assessed and satisfied itself as to the general and local conditions, which can affect the work or its price, including but not limited to:

- conditions bearing upon transportation, disposal, handling, and storage of materials, explosives, or scrap;

- the availability of labor, facilities, water, electric power, communications, and roads;

- uncertainties of weather, river stages, tides, or similar physical conditions at the site;

- the conformation and conditions of the ground, soil, geology, and vegetation (type, height, density), the distribution of each, and the seasonal effects on each;

- the character of equipment and facilities needed preliminary to and during work performance;

- Personal Protective Equipment (PPE) requirements including all effects on price or production due to the requirement to use PPE;

- exclusion zone requirements including all effects and prices of implementing and enforcing exclusion zones. The Contractor is responsible for evaluating, identifying the requirements of, and implementing/complying with all exclusion zones;

- responsibility for understanding and implementing the required safety and access control requirements and factoring them into its approach and price;

- the availability or price of qualified labor, material, and/or equipment;

- the availability or price of lodging for on-site personnel;

- the availability or location of explosives storage.

8.2 The Government has provided the Contractor with access to the site, which allowed the Contractor to become confident in its independent understanding of the site conditions. The Government strongly encourages prospective Contractors to use this time to perform the requisite site assessments necessary to ascertain the site conditions to a reasonable degree of accuracy The Contractor attests that the quantity and distribution of hot rocks, vegetation, terrain, soil condition, weather and other similar price drivers are reasonably ascertainable from the Contractor's research and assessment of the site in conjunction with the contractor verified data provided by the Government. Contractors are strongly encouraged to perform this site assessment and use their experienced judgment and reasoned interpolation and extrapolation of all the available site information to assess the general and local conditions, which can affect the work or its price. Contractors who do not perform a site assessment assume the risks associated with the decision to forgo this important source of information about the site. The Contractor is expected to apply due diligence in the research and development of its proposal and to know or reasonably estimate the conditions to be encountered that will affect the price, quality, or schedule of the work included in this task order. The Government expects the Contractor to assess the risk and factor this risk into its proposal. The act of signing this task order signifies that the Contractor has been given ample opportunity to assess the conditions under which the work will be performed and the Contractor fully understands those conditions. The Contractor accepts full and sole responsibility for identifying and considering all factors that may affect the price to execute the work. The Contractor attests that it has been provided the opportunity to make an independent assessment of the site, has gathered the information necessary to fully understand the conditions it will encounter during execution of this task order, and has used any data provided by the Government at the its own risk.

8.3 Government acceptance of the proposed technical approach and/or price does not relieve the Contractor from full responsibility for the viability, productivity, and efficiency of the approach used to perform the work and for meeting the performance requirements of the PWS at the price proposed.

8.4 Use of the data provided as the basis of estimate for an accurate price proposal requires an experienced understanding of how the data of this type is collected, analyzed, interpreted, and presented. The Contractor is responsible for interpreting the data provided in the context of the conditions under which the data was collected and analyzed. The Contractor is responsible for recognizing the limitations of the data provided for assessments of this type. The Contractor is strongly encouraged to use the pre-proposal site visit to field verify its interpretation of the data and assumptions made during preparation of the proposal. The Government expects that Contractors will promptly notify the Contracting Officer (KO) if they have not been given adequate opportunity to assess the site conditions.

8.5 The Contractor attests that it has had sufficient opportunity to assess the conditions of the work and has used its experienced judgment and reasoned interpolation and extrapolation of all the available site information to assess the general and local conditions, which can affect the work or its price. The Contractor attests that any exceptions to any of the conditions of this PWS were clearly marked in the proposal in bold type as ―Exception to the RFP”. The Contractor certifies that its proposal is not qualified or contingent upon the site conditions.

Appendix A
Price Spreadsheet

Culebra						
				If priced per unit		
Task	Task Name	Task Pricing	Unit Price	Units	Number of Units	Total Price
1	Technical Project Planning	FFP		LS		
	Additional meeting	Unit Price		per meeting		
1a	Planning Site Visit (optional)	FFP		LS		
2	RI/FS Work Plan	FFP		LS		
2a	Explosive Safety Submission Amendment	FFP		LS		
3	GIS	FFP		LS		
3a	Landowner database and ROE	FFP		LS		
4	RI/FS Field Activities					
4a	MRS 13 Cayo Luis Pena Impact Areas	FFP		LS		
4b	MRS 10 Defensive Firing Area No. 1 (Optional)	FFP		LS		
4c	MRS 11 Defensive Firing Area No. 2 (Optional)	FFP		LS		
4d	MRS 06 Artillery Firing Area (Optional)	FFP		LS		
4e	MRS 09 Soldado Point Mortar and Bombing Area (Optional)	FFP		LS		
4f	MRS 08 Cayo Norte Impact Area (Optional)	FFP		LS		
	Civil Survey	Unit Price		per acre		
	Vegetation Removal - Light	Unit Price		per acre		
	Vegetation Removal - Medium	Unit Price		per acre		
	Vegetation Removal - Heavy	Unit Price		per acre		
	MEC Reconnaissance - Light Brush	Unit Price		per acre		
	MEC Reconnaissance - Medium Brush	Unit Price		per acre		
	MEC Reconnaissance - Heavy Brush	Unit Price		per acre		
	Transect geophysics	Unit Price		per acre		
	DGM Grids geophysics	Unit Price		per acre		
	Mag & Flag Grids geophysics	Unit Price		per acre		
	Underwater DGM Grids geophysics	Unit Price		per acre		
	Underwater Mag & Flag Grids geophysics	Unit Price		per acre		
	Underwater Transect geophysics	Unit Price		per acre		
	Sonar	Unit Price		per acre		
	Mob/Demob Geophysical Team	Unit Price		per mob/demob		
	Mob/Demob MEC Investigation Team	Unit Price		per mob/demob		
	Mob/Demob Sonar Team	Not Used		per mob/demob		
	Mob/Demob Underwater Geo Team	Unit Price		per mob/demob		

Culebra						
				If priced per unit		
Task	Task Name	Task Pricing	Unit Price	Units	Number of Units	Total Price
	Mob/Demob Underwater MEC Investigation Team	Unit Price		per mob/demob		
	Underwater Intrusive Investigation	Unit Price		per 10 anomalies		
	Demolition Shot	Unit Price		per Demo Shot		
	Underwater Demolition Shot	Unit Price		per Demo Shot		
	Intrusive Investigation	Unit Price		per 50 anomalies		
	Stand-by Events (Installation Delays due to training etc.)	Not Used				
5	Remedial Investigation Report	FFP		LS		
6	Feasibility Study Report	FFP		LS		
7	Proposed Plan	FFP		LS		
8	Decision Document	FFP		LS		
9	Community Relations Support	FFP		LS		
	Additional Meeting	Unit Price		per meeting		
	Maintain Website	Unit Price		per month		
10	Public Involvement Plan	FFP		LS		
11	Administrative Record	FFP		LS		
12	Environmental Sampling & Analysis	FFP		LS		
	Sampling and analysis - Soil	Unit Price		per 10 Samples		
	Sampling and analysis - Water	Unit Price		per 10 Samples		
	Sampling and analysis – Sediment	Unit Price		Per 10 Samples		
	Pre & Post Detonation	Unit Price		per Sample set		
	Groundwater sampling	Unit Price		per Sample		
	Installation of monitoring well – Base Price	Unit Price		per well		
	Installation of monitoring well – Price per additional foot	Unit Price		per Foot		
	Subsurface Sampling, boring 0’ - 10’	Unit Price		per boring		
	Subsurface Sampling, boring 10’ - 15’	Unit Price		per boring		
	Subsurface Sampling, Hand Auger	Unit Price		per sample		
13	Beach Monitoring	FUP		Each		
	Project Biologist	Unit Price		Per Week		
	Project Biologist	Unit Price		Per Month		
	Project Biologist: Mobilization/Demobilization	Unit Price		Each		
					TOTAL	

Appendix B

1. REQUIREMENTS AND PROCEDURES:

a. General requirements for the development and review of FUDS MMRP decision documents and action memoranda are documented in references 3a and 3b. This interim guidance provides specific requirements for MMRP.

b. Format and content of ALL MMRP decision documents and action memoranda, regardless of signature authority shall be in accordance with Section 2. Each document will contain:

(1) A title page,

(2) A table of contents,

(3) Page numbers on each page indicating page number and total number of pages in the document, e.g., ―1 of 25”.

(4) Header in the upper right-hand corner of each page including; document type (―Decision Document”, ―Time Critical Removal Actions (TCRA) Action Memorandum”, or ―Non-time Critical Removal Action (TCRA) Action Memorandum”), project name (―Sitka Naval Operating Base”), project location (―Sitka, Alaska”), and project number to include MRS number.

c. All decision documents or action memoranda, regardless of level of signature authority, will be accompanied by an Executive Summary that Headquarters (HQ), USACE will forward to ACSIM-ISE and DASA (ESOH). The Executive Summary shall be kept to a single page, whenever possible, and will include:

(1) Title, including project name and project number, date DD (or AM) was signed and by whom,

(2) Brief description of the Munitions Response Sites (MRS), covered by the decision,

(3) Brief description of selected response action and its relationship to other cleanup actions,

(4) Degree of risk reduction,

(5) Present worth cost of selected response action, and the contribution to the cost-to-complete of all remedies for the FUDS Property,

(6) Amounts and fiscal year(s) that funds are required for remedial/removal action design and construction,

(7) Duration of any remedial action-operation (RA-O), removal action construction (RmA-C) and/or Long Term Monitoring (LTM) actions,

(8) Land use controls (LUC) required and means of maintaining them,

(9) Other potential response actions considered, and

(10) Expected result of the action.

2.0 CONTENT

Remedial Action Decision Document
Table of Contents

Remedial Action Decision Document Outline

PART 1: THE DECLARATION

The Declaration functions as the abstract and formal authorizing signature page for the DD.

1. PROJECT NAME AND LOCATION.
2. STATEMENT OF BASIS AND PURPOSE.
   Certify the factual and legal basis for the Selected Remedy.

3. ASSESSMENT OF PROJECT MRS.
   Certify that the MRS poses a threat to public health, welfare, or the environment.

4. DESCRIPTION OF SELECTED REMEDY.
   a. Describe the major components of the Selected Remedy in a bullet fashion.

   b. Describe the scope and role of this MRS.

   c. Describe how this remedial action addresses principal threats and other contamination at the MRS (i.e., what is being treated, what is being contained, and what is the rationale for each).

5. STATUTORY DETERMINATIONS.
   a. Describe how the Selected Remedy satisfies the statutory requirements of CERCLA §121 and discuss the applicability of the 5-year review requirements.

6. DATA CERTIFICATION CHECKLIST.
   The Declaration should certify that the following information is included in the DD (or provide a brief explanation for why this information is not included):

   a. Munitions and Explosives of Concern (MEC) and munitions constituents (MC) and their respective concentrations.

   b. Baseline risk represented by the MEC/MCs.

   c. Cleanup levels established for MEC/MCs and the basis for these levels.

   d. How MEC and MC will be addressed.

   e. Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and DD.

   f. Potential land and groundwater use that will be available at the MRS as a result of the Selected Remedy.

   g. Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected.

   h. Key factor(s) that led to selecting the remedy (i.e., describe how the Selected Remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision).

7. AUTHORIZING SIGNATURE.

The following general paragraph and signature block. (*Note: Signature block may not appear alone on a page – it must be on the same page with the preceding paragraph*):

"This Decision Document presents the selected response action at [place]. The U.S. Army Corps of Engineers is the lead agency under the Defense Environmental Restoration Program (DERP) at the [FUDS property name] Formerly Used Defense Site, and has developed this Decision Document consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision document will be incorporated into the larger Administrative Record file for [FUDS property name], which is available for public view at [address]. This document, presenting a selected remedy with a present worth cost estimate of [$$], is approved by the undersigned, pursuant to Memorandum, DAIM-ZA, September 9, 2003, subject: Policies for Staffing and Approving Decision Documents (DDs), and to Engineer Regulation 200-3-1, Formerly Used Defense Sites (FUDS) Program Policy."

APPROVED:

(insert individual's signature block here) Date_________________________

For present worth cost estimate of $2M or less:
District Commander" Signature Block

For present worth cost estimate of more than $2M and less than or equal to $10M:
HQUSACE signature block for:
Chief, Department of Defense
Support Team
Directorate of Military Programs

For present worth cost estimate of more than $10M:
Signature block for ACSIM or DASA(ESOH) or both

PART 2: THE DECISION SUMMARY

The Decision Summary identifies the Selected Remedy, explains how the remedy fulfills statutory and regulatory requirements, and provides a substantive summary of the Administrative Record file that supports the remedy selection decision.

1. PROJECT NAME, LOCATION, AND BRIEF DESCRIPTION.

   a. Name and location.

   b. FUDS Project Number.

   c. Lead and support agencies (e.g., DoD, State, Tribes).

   d. Source of cleanup monies (e.g., ER-FUDS, ER-Army, ER-BRAC).

   e. Brief MRS description.

2. PROJECT HISTORY AND ENFORCEMENT ACTIVITIES.

   a. History of MRS activities that led to the current problems.

   b. History of federal, state, and local MRS investigations and removal and remedial actions conducted under CERCLA or other authorities.

c. History of CERCLA enforcement activities at the MRS (e.g., results of PRP searches, issuances of special notices to PRPs).

3. COMMUNITY PARTICIPATION.

a. Describe how the public participation requirements in CERCLA and the NCP were met in the remedy selection process (e.g., community relations plans, fact sheets, public notices, public meetings, public Restoration Advisory Board).

b. Describe other community outreach and involvement efforts.

c. Describe efforts to solicit views on the reasonably anticipated future land uses and potential future land uses.

4. SCOPE AND ROLE OF RESPONSE ACTION.

a. The planned sequence of actions.

b. The scope of problems those actions will address.

c. The authorities under which each action will be/has been implemented (e.g., removal, remedial).

5. PROJECT MRS CHARACTERISTICS: (Include maps, a site plan, or other graphical presentations, as appropriate.)

a. Describe the conceptual site model (CSM) on which the risk assessment and response action are based.

b. Provide an overview of the MRS, including the following:

(1) Size of MRS (e.g., acres).

(2) Geographical and topographical information (e.g., surface waters, flood plains, wetlands).

(3) Surface and subsurface features (e.g., number and volume of tanks, lagoons, structures, and drums on-site).

(4) Areas of archaeological or historical importance.

c. Describe the sampling strategy (e.g., which media were investigated, what sampling approach was used, over what area, when was the sampling performed).

d. Describe known or suspected sources of contamination.

e. Describe types of contamination and the affected media, including the following:

(1) Types and characteristics of MEC/MCs (e.g., toxic, mobile, carcinogenic, non-carcinogenic).

(2) Quantity/volume of MEC/MC that needs to be addressed.

(3) Concentrations of MEC/MCs in each medium.

(4) RCRA hazardous wastes and affected media.

f. Describe location of contamination and known or potential routes of migration, including the following:

(1) Lateral and vertical extent of contamination.

(2) Current and potential future surface and subsurface routes of human or environmental exposure.

(3) Likelihood for migration of MEC/MCs from current location or to other media.

(4) Human and ecological populations that could be affected.

g. For MRSs with groundwater contamination, describe the following:

(1) Aquifer(s) affected or threatened by site contamination, types of geologic materials, approximate depths, whether aquifer is confined or unconfined.

(2) Groundwater flow directions within each aquifer and between aquifers and groundwater discharge locations (e.g., surface waters, wetlands, other aquifers).

(3) Interconnection between surface contamination (e.g., soils, sediments/surface water) and groundwater contamination.

(4) Confirmed or suspected presence and location of non-aqueous phase liquids.

(5) If groundwater models were used to define the fate and transport of MEC/MC, identify the model used and major model assumptions.

h. Note other site-specific factors that may affect response actions at the MRS.

6. CURRENT AND POTENTIAL FUTURE LAND AND WATER USES.

a. Land Uses.

(1) Current on-site land uses.

(2) Current adjacent/surrounding land uses.

(3) Reasonably Anticipated Future Land Uses and Basis for Future Use Assumptions (e.g., zoning maps, nearby development, 20-year development plans, dialogue with local land use planning officials and citizens, reuse assessment).

b. Groundwater and Surface Water Uses.

(1) Current groundwater and surface water uses.

(2) Potential beneficial groundwater and surface water uses (e.g. potential drinking water, irrigation) and basis for future use assumptions (e.g., Comprehensive State Groundwater Protection Plan, promulgated state classification guidelines).

(3) If beneficial use is potential drinking water source, identify the approximate time frame of projected future drinking water use (e.g., groundwater aquifer not currently used as a drinking water source but expected to be utilized in 30 to 50 years).

(4) Location of anticipated use in relation to location and anticipated migration of contamination.

7. <u>SUMMARY OF PROJECT MRS RISKS.</u>

a. Human Health Risks.

(1) Identify the concentrations of MEC/MC in each medium.

(2) Summarize the results of the exposure assessment.

(3) Summarize the results of the toxicity assessment for the MEC/MC.

(4) Summarize the risk characterization for both current and potential future land use scenarios and identify major assumptions and sources of uncertainty.

b. Ecological Risks.

(1) Identify the concentrations of MEC/MC in each medium.

(2) Summarize the results of the exposure assessment.

(3) Summarize the results of the ecological effects assessment.

(4) Summarize the results of the ecological risk characterization and identify major assumptions and sources of uncertainty.

c. Basis for Response Action.

(1) Clearly Present the Basis for Taking the Response Action at the Conclusion of this Section.

8. REMEDIAL ACTION OBJECTIVES.

a. Present a clear statement of the specific RAOs for the MRS (e.g., treatment of contaminated soils above health-based action levels, restoration of groundwater plume to drinking water levels, and containment of DNAPL source areas) and reference a list or table of the individual performance standards.

b. Discuss the basis and rationale for RAOs (e.g., current and reasonably anticipated future land use and potential beneficial groundwater use).

c. Explain how the RAOs address risks identified in the risk assessment (e.g., how will the risks driving the need for action be addressed by the response action?).

9. DESCRIPTION OF ALTERNATIVES: The objective of this section is to provide a brief understanding of the remedial alternatives developed for the MRS.

a. Remedy Components. Provide a bulleted list of the major components of each alternative, including but not limited to:

(1) Treatment technologies and the materials they will be used to address (e.g., principal threats).

(2) Containment components of remedy (e.g., engineering controls, cap, hydraulic barriers) and the materials they will be used to address (e.g., low concentration source materials, treatment residuals).

(3) Land use controls (and entity responsible for implementing and maintaining them).

(4) Operations and maintenance (O&M) activities required to maintain the integrity of the remedy (e.g., cap maintenance).

(5) Monitoring requirements.

b. Common Elements and Distinguishing Features of Each Alternative. Describe common elements and distinguishing features unique to each response option. Examples of these elements include:

(1) Key ARARs (or ARAR waivers) associated with each alternative (e.g., action- and/or location-specific groundwater treatment units, manifesting of hazardous waste, and regulating solid waste landfills).

(2) Long-term reliability of remedy (potential for remedy failure/replacement costs).

(3) Quantity of untreated MEC/MC to be disposed off-site or managed on-site in a containment system and degree of residual contamination remaining in such waste.

(4) Estimated time required for design and construction (i.e., implementation time frame).

(5) Estimated time to reach cleanup levels (i.e., time of operation, period of performance).

(6) Estimated capital, annual O&M, and total present worth costs, discount rate, and the number of years over which the remedy cost estimate is projected.

(7) Describe uses of presumptive remedies and/or innovative technologies.

c. Expected Outcomes of Each Alternative.

(1) Available land uses upon achieving performance standards. Note time frame to achieve performance standards (e.g., commercial or light industrial use available in 3 years when cleanup levels are achieved).

(2) Available groundwater uses upon achieving performance standards. Note time frame to achieve performance standards (e.g., restricted use for industrial purposes in technical impracticability [TI] waiver zone, drinking water use in non-TI zone upon achieving cleanup levels in 50 to 70 years).

(3) Other impacts or benefits associated with each alternative.

10. <u>COMPARATIVE ANALYSIS OF ALTERNATIVES.</u> Compare the relative performance of each alternative against the others with respect to the nine evaluation criteria (summarize in a table if appropriate).

11. <u>PRINICIPAL MEC/MC ISSUES</u>. Identify the MEC/MC issues at the MRS and discuss how the alternatives will address them.

Note: The *Statutory Determinations* section of the DD should explain whether or not the Selected Remedy satisfies the statutory preference for remedies employing treatment that reduces toxicity, mobility, or volume as a principal element. By indicating whether the principal threats will be addressed by the alternatives, this section of the *Decision Summary* should provide the basis for that statutory determination.

12. <u>SELECTED REMEDY</u>.

a. Summary of the Rationale for the Selected Remedy.

(1) Provide a concise discussion of the key factors for remedy selection.

b. Detailed Description of the Selected Remedy.

(1) Expand on the Description of the Selected Remedy from that which was provided in the Description of Alternatives section and provide a brief overview of the RAOs and performance standards.

c. Cost Estimate for the Selected Remedy.

(1) Present a detailed, activity-based breakdown of the estimated costs associated with implementing and maintaining the remedy (include estimated capital, annual O&M, and total present worth costs discount rate and the number of years over which the remedy cost estimate is projected).

d. Estimated Outcomes of Selected Remedy.

(1) Available land use(s) upon achieving cleanup levels. Note time frame to achieve available use (e.g., commercial or light industrial use available in 3 years when cleanup levels are achieved).

(2) Available groundwater use(s) upon achieving cleanup levels. Note time frame to achieve available use (e.g., restricted use for industrial purposes in TI waiver zone, drinking water use in non-TI zone upon achieving cleanup levels in 50 to 70 years).

(3) Final cleanup levels for each medium (i.e., contaminant-specific cleanup levels), basis for cleanup levels, and risk at cleanup levels (if appropriate).

(4) Anticipated socioeconomic and community revitalization impacts (e.g., increased property values, reduced water supply costs, jobs created, increased tax revenues due to redevelopment, environmental justice concerns addressed, enhanced human uses of ecological resources).

(5) Anticipated environmental and ecological benefits (e.g., restoration of sensitive ecosystems, protection of endangered species, protection of wildlife populations, wetlands restoration).

13. STATUTORY DETERMINATIONS.

a. Explain how the remedy satisfies the requirements of §121 of CERCLA to:

(1) Protect human health and the environment.

(2) Comply with ARARs, or justify a waiver.

(3) Be cost-effective.

(4) Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable (i.e., explain why the Selected Remedy represents the best option).

(5) Satisfy the preference for treatment as a principal element, or justify the selection of an alternative remedy.

b. Explain 5-year review requirements for the Selected Remedy.

14. DOCUMENTATION OF SIGNIFICANT CHANGES FROM PREFERRED ALTERNATIVE OF PROPOSED PLAN. If there are significant changes in the Selected Remedy from the Preferred Alternative:

a. Discuss the Preferred Alternative originally presented in the Proposed Plan.

b. Describe the significant changes in the Selected Remedy.

c. Explain the rationale for the changes and how they could have been reasonably anticipated based on information presented in the Proposed Plan or the Administrative Record file.

PART 3: THE RESPONSIVENESS SUMMARY

The Responsiveness Summary serves the dual purposes of: (1) presenting stakeholder concerns about the MRS and preferences regarding the remedial alternatives; and (2) explaining how those concerns were addressed and the preferences were factored into the remedy selection process. This discussion should cross-reference sections of the Decision Summary that demonstrate how issues raised by the community have been addressed.

1. STAKEHOLDER ISSUES AND LEAD AGENCY RESPONSES: Summarize and respond concisely to issues raised by stakeholders.

2. TECHNICAL AND LEGAL ISSUES: Expand on technical and legal issues, if necessary

APPENDIX B. SITE MAPS

This appendix contains the following maps related to the RI/FS effort at the Culebra Island Site:

- Figure B-1: Location Map
- Figure B-2: MRS Site Map
- Figure B-3: MRS 13 – Cayo Luis Pena Impact Areas
- Figure B-4: MRS 10 – Defensive Firing Area #1
- Figure B-5: MRS 11 – Defensive Firing Area #2
- Figure B-6: MRS 6 – Artillery Firing Area
- Figure B-7: MRS 9 – Solodado Point Mortar and Bombing Area
- Figure B-8: MRS 8 – Cayo Norte Impact Area
- Figure B-9: MRS 13 – Cayo Luis Pena Impact Areas – Overall Transect Map
- Figure B-10: MRS 13 – Cayo Luis Pena Impact Areas North – Land and Beach Transects
- Figure B-11: MRS 13 – Cayo Luis Pena Impact Areas South – Land and Beach Transects
- Figure B-12: MRS 9 – Solodado Point Mortar and Bombing Area – Land and Beach Transects
- Figure B-13: MRS 10 – Defensive Firing Area #1 – Land and Beach Transects
- Figure B-14: MRS 11 – Defensive Firing Area #2 – Land and Beach Transects
- Figure B-15: MRS 8 – Cayo Norte Impact Area Land and Beach Transects
- Figure B-16: MRS 6 – Artillery Firing Area Land and Beach Transects

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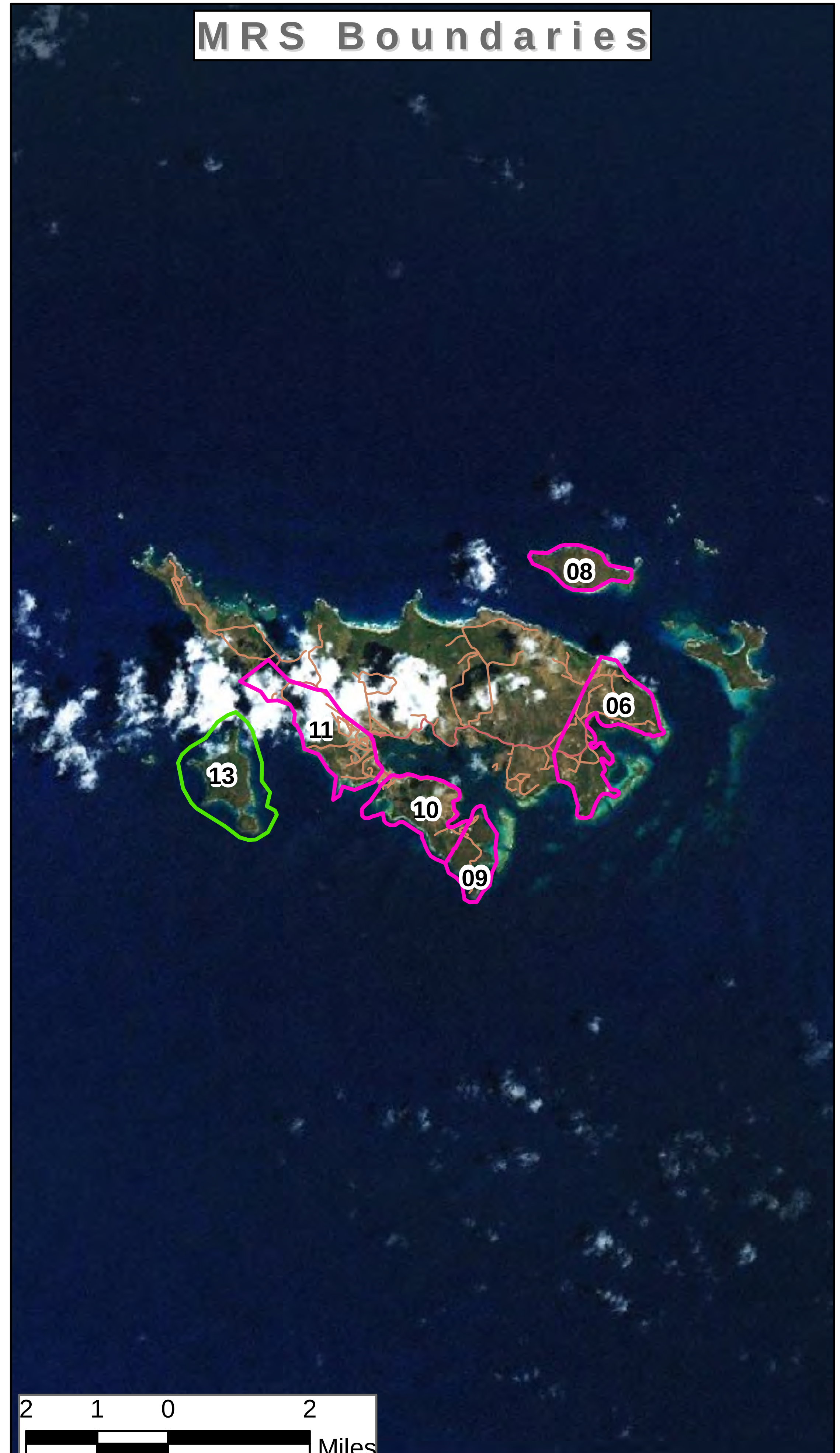

N

Scale Varies

Data is projected to the UTM Coordinate System: Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-1

Location Map

Culebra Island Site, Puerto Rico

Legend

MRS Boundaries

- Optional Areas
- Funded Areas

USA Environmental, Inc.

US Army Engineering And Support Center Huntsville, Alabama

Drawn By:	JAL	Scale:	Varies	Rev:	
Checked By:	DM	Date Drawn:	9-29-2009		
Submitted By:	DR	Revision Date:			

Path:
s:\culebra\RIFS 2009\Work Plan location map.mxd

N

900 450 0 900

Meters

Data is projected to the UTM Coordinate System:
Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-2

MRS Site Map

Culebra Island Site, Puerto Rico

Legend

MRS Boundaries

- Optional Areas
- Funded Areas
- Critical Habitat

MRS ID	Description
06	Artillery Firing Area
08	Cayo Norte Impact Area
09	Soldado Pt. Mortar and Bombing Areas
10	Defensive Firing Area #1
11	Defensive Firing Area #2
13	Cayo Luis Pena Impact Area

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama	
Drawn By: JAL	Scale: 1 inch = 900 meters	Rev:
Checked By: DM	Date Drawn: 8-10-2009	
Submitted By: DR	Revision Date:	
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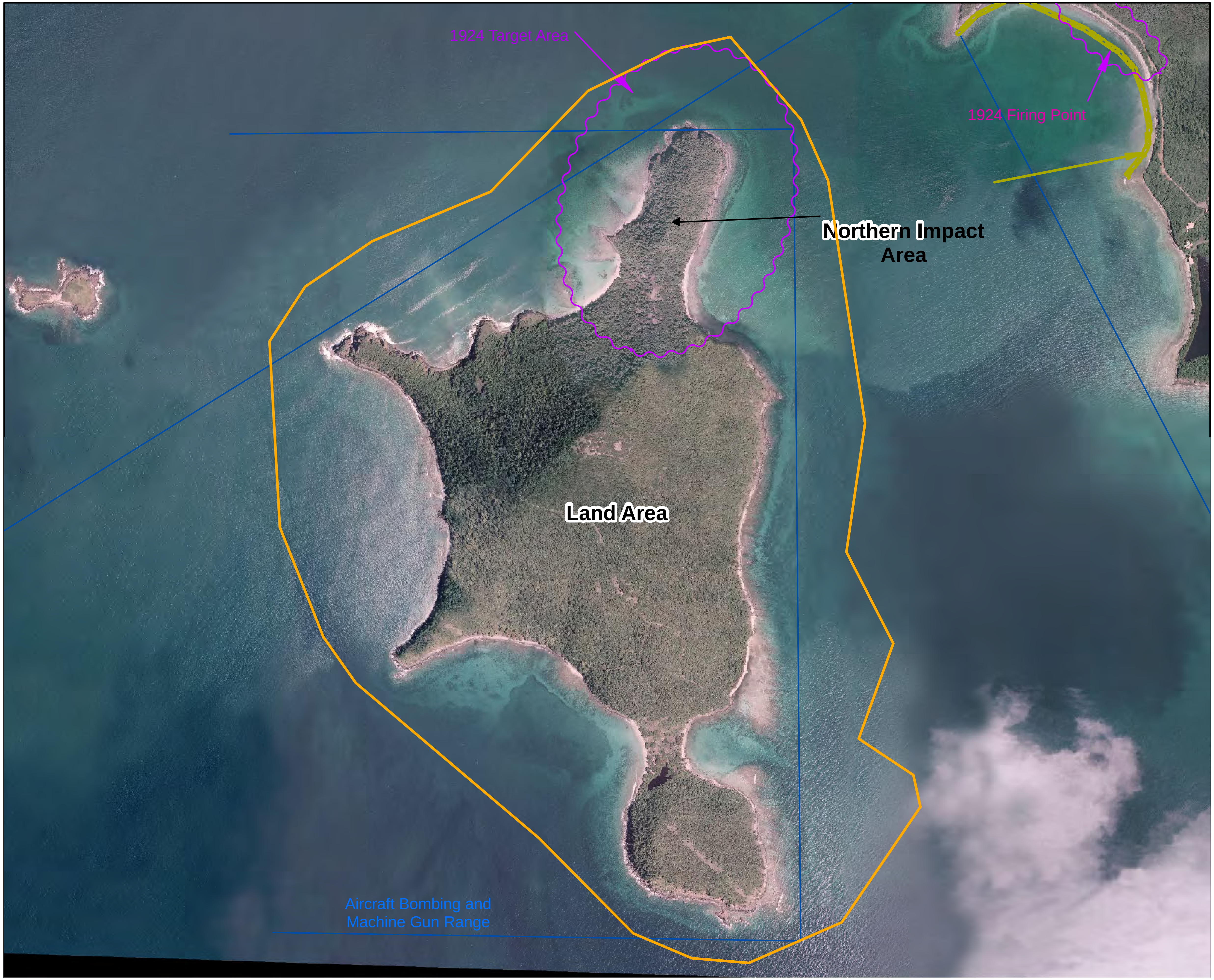

N

280 140 0 280

Meters

Data is projected to the UTM Coordinate System: Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-3

MRS 13- Cayo Luis Pena Impact Areas

Site Map

Culebra Island Site, Puerto Rico

Legend

- military_range_area

ASR Features

- 1924 Military Area
- 1938 Military Areas
- 1939 Military Exercises
- Feature Taken From 1936-1049 Oblique Photos
- Features Taken From 1937 Map Titled "U.S. Feet Landing Exercise #4"
- 1902-1903 Gun Positions

USA Environmental, Inc.

US Army Engineering And Support Center Huntsville, Alabama

Drawn By:	JAL	Scale:	1 inch = 280 meters	Rev:	1
Checked By:	DM	Date Drawn:	9-29-2009		
Submitted By:	DR	Revision Date:	10-27-2010		

Path:
S:\Culebra\RIFS 2009\Work Plan
B-03 MRS 13 Site Map.mxd

N

220 110 0 220

Meters

Data is projected to the UTM Coordinate System:
Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-4

MRS 10- Defensive Firing Area #1

Site Map

Culebra Island Site, Puerto Rico

Legend

- 1924 Outpost And Ammunition Storage Locations
- Standing Barrages Previously Registered 1935
- Areas For Direct Fire And Infantry And Tanks (Possibly 1935)
- Water Areas For Direct Fire At Boats 1935
- Features Taken From 1937 Map Titled "U.S. Fleet Landing Exercise *4."
- RIFS Investigation Boundary
- Features Taken From 1937 Map Titled "U.S. Feet Landing Exercise #4"
- 1902-1903 Gun Positions

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama

Drawn By: JAL	Scale: 1 inch = 220 meters	Rev: 1	
Checked By: DM	Date Drawn: 9-29-2009		
Submitted By: DR	Revision Date: 10-27-2010		

Path:
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B-04 MRS 10 Site Map.mxd

N

330 165 0 330

Meters

Data is projected to the UTM Coordinate System: Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-5

MRS 11- Defensive Firing Area #2

Site Map

Culebra Island Site, Puerto Rico

Legend

ASR Features

- 1924 Military Area
- 1924 Outpost And Ammunition Storage Locations
- Standing Barrages Previously Registered 1935
- Areas For Direct Fire And Infantry And Tanks (Possibly 1935)
- Water Areas For Direct Fire At Boats 1935
- 1938 Military Areas
- 1939 Military Exercises
- Features Taken From 1937 Map Titled "U.S. Fleet Landing Exercise #4."
- 1936 Artillery Areas And Aerial Target
- RIFS Investigation Boundaries
- Feature Taken From 1936-1049 Oblique Photos
- Features Taken From 1937 Map Titled "U.S. Feet Landing Exercise #4"
- 1902-1903 Gun Positions

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama		
Drawn By: JAL	Scale: 1 inch = 330 meters	Rev: 1	
Checked By: DM	Date Drawn: 9-29-2009		
Submitted By: DR	Revision Date: 10-27-2010		

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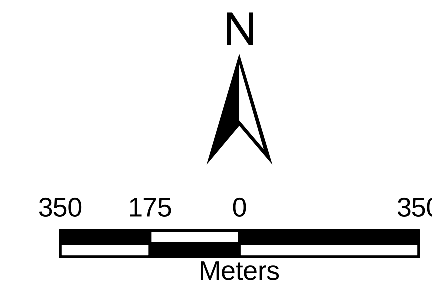
B-05 MRS 11 Site Map.mxd



Data is projected to the UTM Coordinate System: Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-6

MRS 6- Artillery Firing Area

Site Map

Culebra Island Site, Puerto Rico

Legend

RIFS Investigation Boundaries

ASR Features

- 1924 Military Area
- Standing Barrages Previously Registered 1935
- Areas For Direct Fire And Infantry And Tanks (Possibly 1935)
- Water Areas For Direct Fire At Boats 1935
- 1924 Outpost And Ammunition Storage Locations
- 1939 Military Exercises
- Features Taken From 1937 Map Titled "U.S. Fleet Landing Exercise *4."
- 1939_Military Excercises
- 1936 Artillery Areas
- 1936 Artillery Areas And Aerial Target
- Features Taken From 1937 Map Titled "U.S. Feet Landing Exercise #4"
- 1902-1903 Gun Positions

USA Environmental, Inc.

US Army Engineering And Support Center Huntsville, Alabama

Drawn By:	JAL	Scale:	1 inch = 375 meters	Rev:	1
Checked By:	DM	Date Drawn:	9-29-2009		
Submitted By:	DR	Revision Date:	10-27-2010		

Path:
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B-06 MRS 6 Site Map.mxd

N

220 110 0 220
Meters

Data is projected to the UTM Coordinate System: Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-7

MRS 9- Solodado Point Mortar and Bombing Area

Site Map

Culebra Island Site, Puerto Rico

Legend

- RIFS Investigation Boundaries
- Standing Barrages Previously Registered 1935
- Areas For Direct Fire And Infantry And Tanks (Possibly 1935)
- Water Areas For Direct Fire At Boats 1935
- 1938 Military Areas
- 1939 Military Exercises
- 1936 Artillery Areas And Aerial Target
- Feature Taken From 1936-1049 Oblique Photos
- 1902-1903 Gun Positions

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama		
Drawn By: JAL	Scale: 1 inch = 220 meters	Rev: 1	
Checked By: DM	Date Drawn: 9-29-2009		
Submitted By: DR	Revision Date: 10-27-2010		

Path:
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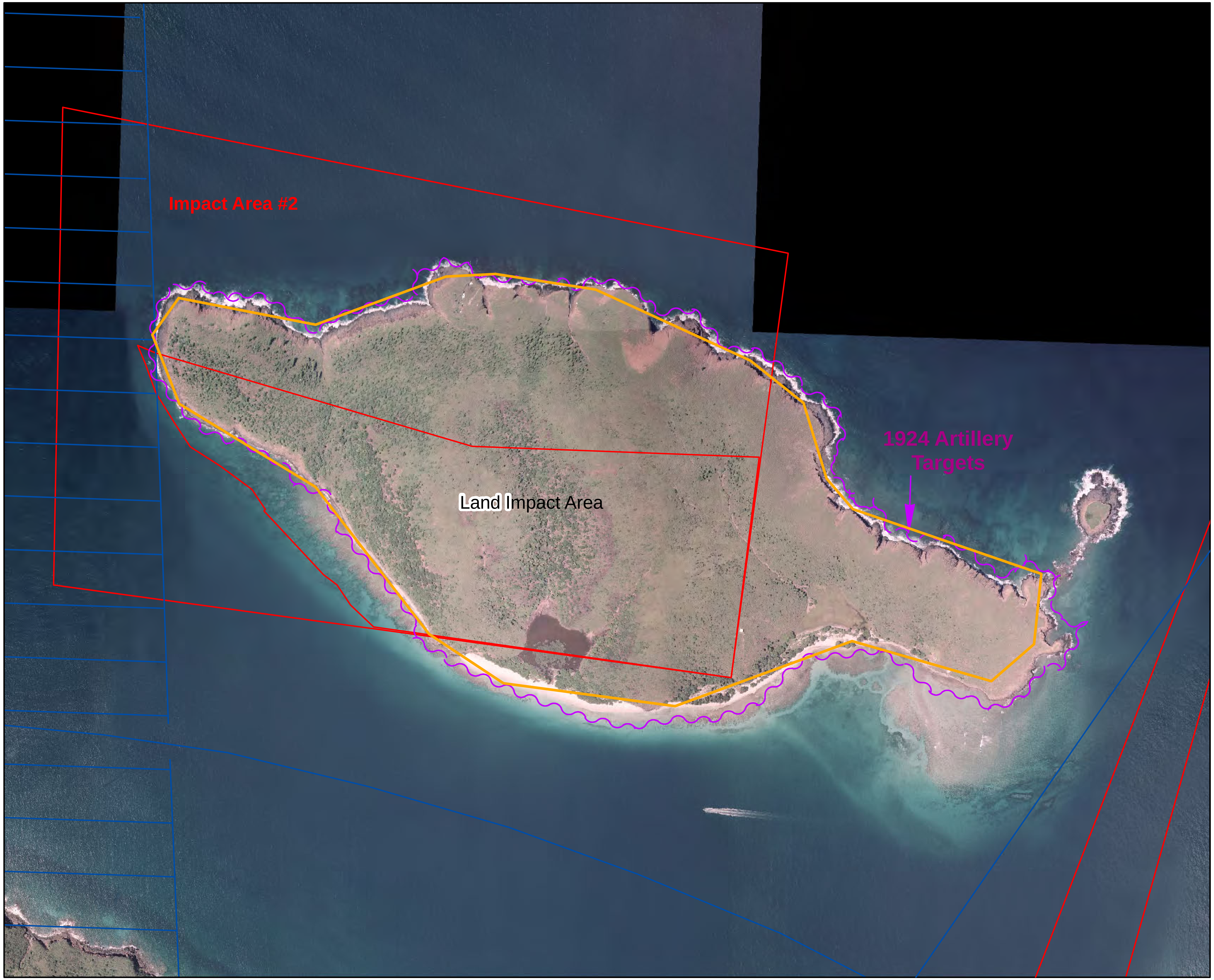
B-07 MRS 8 Site Map.mxd



Remedial Action/ Feasibility Study

Figure B-8

MRS 8- Cayo Norte Impact Area

Site Map

Culebra Island Site, Puerto Rico

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama		
Drawn By: JAL	Scale: 1 inch = 225 meters	Rev: 1	
Checked By: DM	Date Drawn: 9-29-2009		
Submitted By: DR	Revision Date: 10-27-2010		
Path: S:\Culebra\RIFS 2009\Work Plan B-08 MRS 8 Site Map.mxd			

N

280 140 0 280

Meters

Data is projected to the UTM Coordinate System: Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-9

MRS 13- Cayo Luis Pena Impact Areas

Overall Transect Map

Culebra Island Site, Puerto Rico

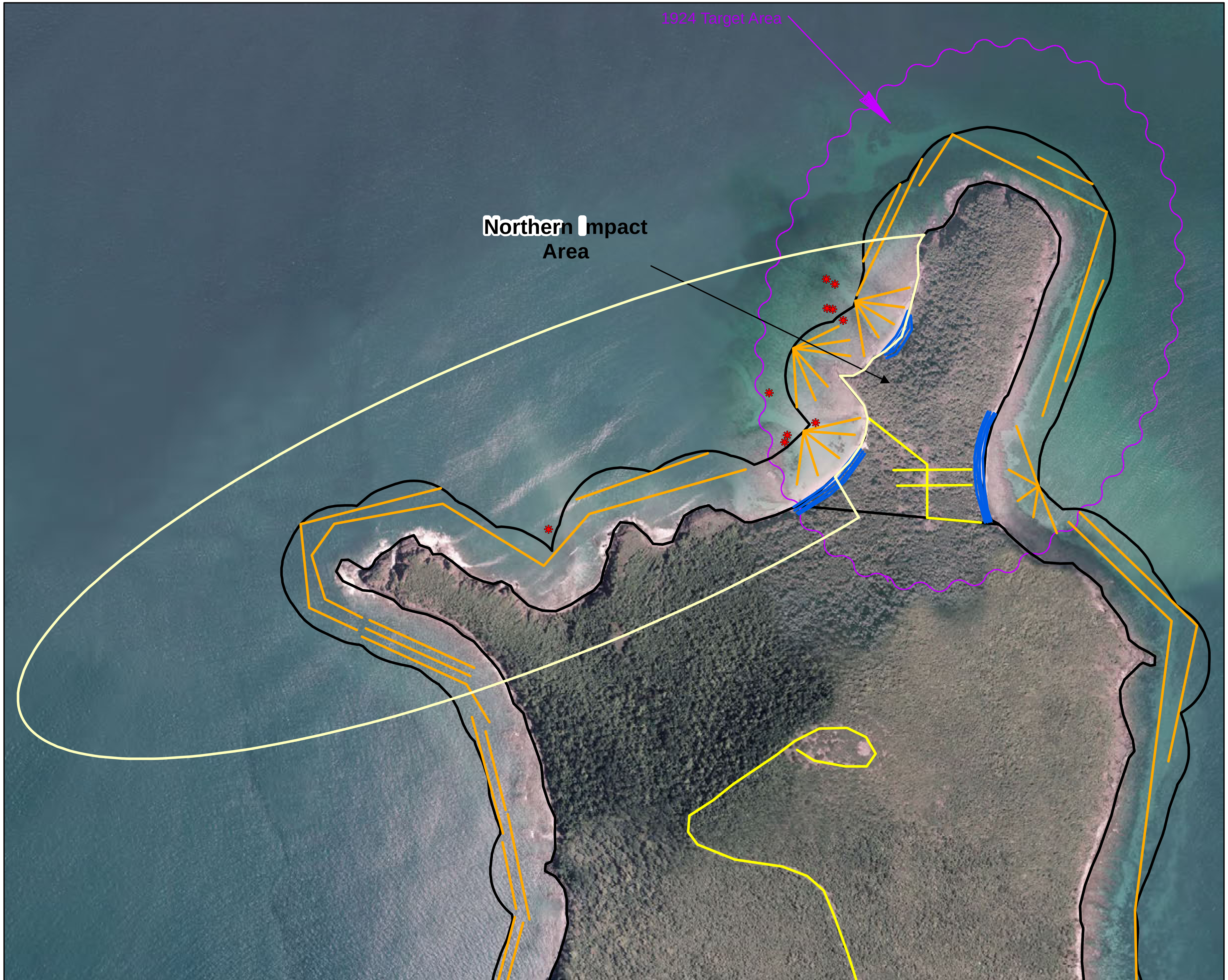
Legend

Previously Collected Data

- MEC Locations
- Ground Reconnaissance Transect- 1.80 miles
- Mag And Dig Beach Transect- 1.84 miles
- Underwater Video Transect- 7.62 miles
- RIFS Investigation Boundaries

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama		
Drawn By: JAL/SPC	Scale: 1 inch = 280 meters	Rev: 3	
Checked By: MT	Date Drawn: 9-29-2009		
Submitted By: DR	Revision Date: 3-17-2011		

Path:
S:\Culebra\RIFS 2009\Work Plan
B-09 MRS 13 Transect Map.mxd



N

160 80 0 160

Meters

Data is projected to the UTM Coordinate System:
Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-10

MRS 13- Cayo Luis Pena Impact Areas

North

Land and Beach Transects

Culebra Island Site, Puerto Rico

Legend

- Reported MEC Locations
- Ground Reconnaissance Transect- 1.80 miles
- Mag And Dig Beach Transect- 1.84 miles
- Underwater Video Transect- 7.62 miles
- Potential Overshoot Areas
- RIFS Investigation Boundaries

ASR Features

- 1924 Military Area

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama		
Drawn By: JAL/SPC	Scale: 1 inch = 160 meters	Rev: 3	
Checked By: MT	Date Drawn: 9-29-2009		
Submitted By: DR	Revision Date: 3-17-2011		

Path:
S:\Culebra\RIFS 2009\Work Plan
B-10 MRS 13 Transect Map North.mxd

N

160 80 0 160

Meters

Data is projected to the UTM Coordinate System: Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-11

MRS 13- Cayo Luis Pena Impact Areas

South

Land and Beach Transects

Culebra Island Site, Puerto Rico

Legend

- Ground Reconnaissance Transect- 1.46 miles
- Mag And Dig Beach Transect- 1.84 miles
- Underwater Video Transect- 7.62 miles
- RIFS Investigation Boundaries

ASR Features

- 1924 Military Area

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama

Drawn By:	JAL	Scale:	1 inch = 160 meters	Rev:	2
Checked By:	DM	Date Drawn:	9-29-2009		
Submitted By:	DR	Revision Date:	2-9-2011		

Path: S:\Culebra\RIFS 2009\Work Plan B-11 MRS 13 Transect Map South.mxd

N

220 110 0 220

Meters

Data is projected to the UTM Coordinate System: Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-12

MRS 9- Solodado Point Mortar and Bombing Area

Land and Beach Transects

Culebra Island Site, Puerto Rico

Legend

DGM and Analog Transects

- DGM Land Transects- 2.71 miles
- Mag And Dig Beach Transect- 0.25 miles
- Underwater Video Transect- 2.56 miles
- Geophysical Grids
- RIFS Investigation Boundaries

ASR Features

- Standing Barrages Previously Registered 1935
- Areas For Direct Fire And Infantry And Tanks (Possibly 1935)
- Water Areas For Direct Fire At Boats 1935
- 1939 Military Exercises
- 1936 Artillery Areas And Aerial Target
- 1938 Military Areas
- Feature Taken From 1936-1049 Oblique Photos
- 1902-1903 Gun Positions

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama		
Drawn By: JAL	Scale: 1 inch = 220 meters	Rev: 2	
Checked By: MT	Date Drawn: 9-29-2009		
Submitted By: DR	Revision Date: 2-9-2011		

Path:
S:\Culebra\RIFS 2009\Work Plan
B-12 MRS 9 Transect Map.mxd

N

220 110 0 220

Meters

Data is projected to the UTM Coordinate System:
Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-13

MRS 10- Defensive Firing Area #1

Land and Beach Transects

Culebra Island Site, Puerto Rico

Legend

- Geophysical Grids

DGM_Grids_TransectsRevised_2_2011

DGM and Analog Transects

- DGM Land Transects-10.51 miles
- Mag And Dig Beach Transect- 0.47 miles
- Underwater Video Transect- 2.75 miles
- RIFS Investigation Boundaries

ASR Features

- Standing Barrages Previously Registered 1935
- Areas For Direct Fire And Infantry And Tanks (Possibly 1935)
- Water Areas For Direct Fire At Boats 1935
- 1924 Outpost And Ammunition Storage Locations
- Features Taken From 1937 Map Titled "U.S. Fleet Landing Exercise *4."
- Features Taken From 1937 Map Titled "U.S. Feet Landing Exercise #4"
- 1902-1903 Gun Positions

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama		
Drawn By: JAL	Scale: 1 inch = 220 meters	Rev: 2	
Checked By: DM	Date Drawn: 9-29-2009		
Submitted By: DR	Revision Date: 2-9-2011		

Path:
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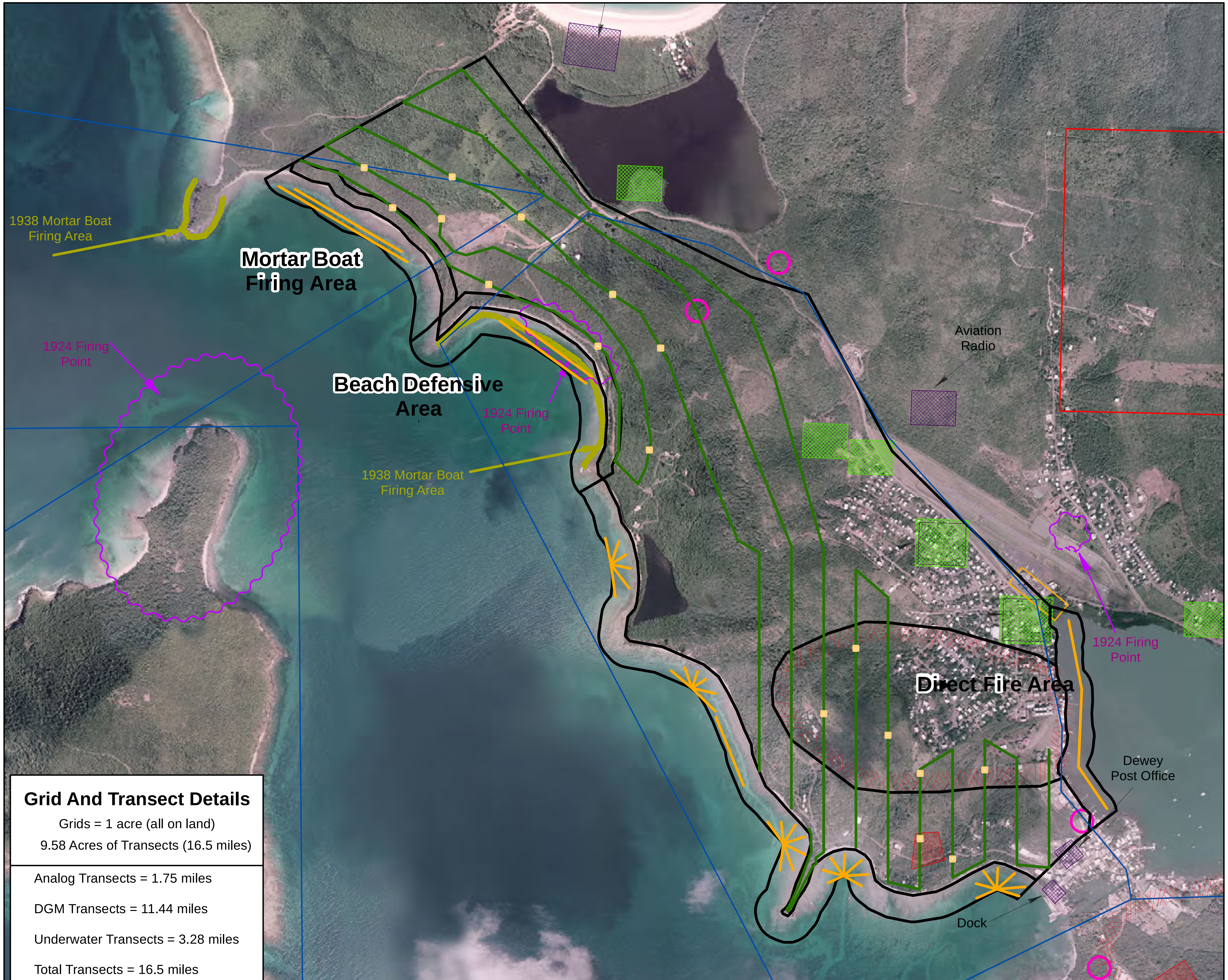
B-13 MRS 10 Transect Map.mxd



Grid And Transect Details

Grids = 1 acre (all on land)

9.58 Acres of Transects (16.5 miles)

Analog Transects = 1.75 miles

DGM Transects = 11.44 miles

Underwater Transects = 3.28 miles

Total Transects = 16.5 miles

N

330 165 0 330

Meters

Data is projected to the UTM Coordinate System: Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-14

MRS 11- Defensive Firing Area #2

Land and Beach Transects

Culebra Island Site, Puerto Rico

Legend

Geophysical Grids

DGM and Analog Transects

- DGM Land Transects- 11.44 miles
- Mag And Dig Beach Transect- 1.75 miles
- Underwater Video Transect- 3.28 miles
- RIFS Investigation Boundaries

ASR Features

- Standing Barrages Previously Registered 1935
- Areas For Direct Fire And Infantry And Tanks (Possibly 1935)
- Water Areas For Direct Fire At Boats 1935
- 1924 Military Area
- 1924 Outpost And Ammunition Storage Locations
- 1938 Military Areas
- 1939 Military Exercises
- Features Taken From 1937 Map Titled "U.S. Fleet Landing Exercise *4."
- 1936 Artillery Areas And Aerial Target
- Feature Taken From 1936-1049 Oblique Photos
- Features Taken From 1937 Map Titled "U.S. Feet Landing Exercise #4"
- 1902-1903 Gun Positions

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama	
Drawn By: JAL	Scale: 1 inch = 330 meters	Rev: 2
Checked By: DM	Date Drawn: 9-29-2009	
Submitted By: DR	Revision Date: 2-9-2011	

Path:
S:\Culebra\RIFS 2009\Work Plan
B-14 MRS 11 Transect Map.mxd

N

200 100 0 200

Meters

Data is projected to the UTM Coordinate System: Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-15

MRS 8 - Cayo Norte Impact Area

Land and Beach Transects

Culebra Island Site, Puerto Rico

Legend

DGM and Analog Transects

- DGM Land Transect- 3.63 miles
- Mag And Dig Beach Transect- 0.60 miles
- Underwater Video Transect- 1.67 miles
- Geophysical Grids
- RIFS Investigation Boundaries

USA Environmental, Inc.

US Army Engineering And Support Center Huntsville, Alabama

Drawn By:	SPC	Scale:	1 inch = 200 meters	Rev:	2
Checked By:	AC	Date Drawn:	9-15-2010		
Submitted By:	DR	Revision Date:	2-9-2011		

Path:
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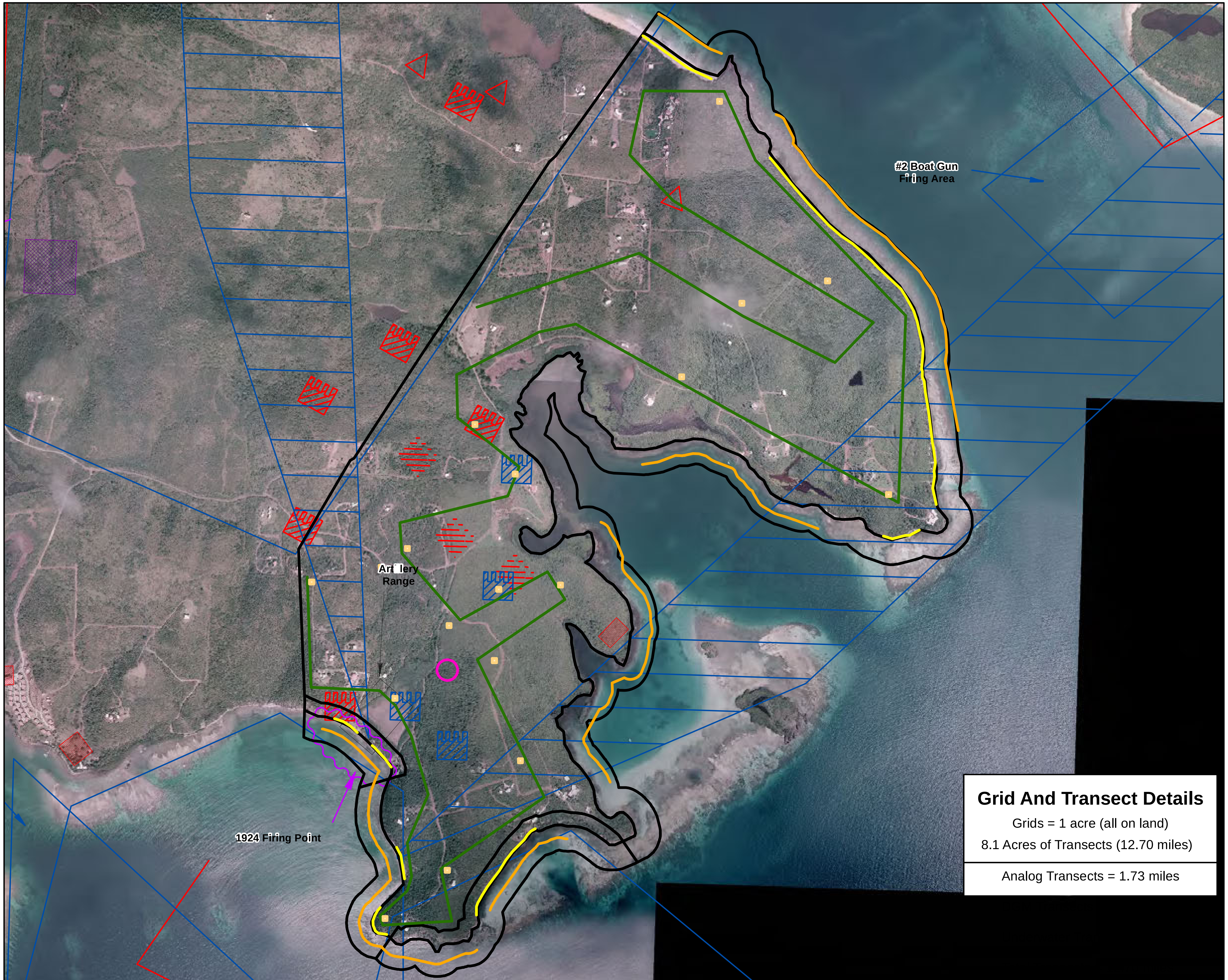
B-12 MRS 9 Transect Map.mxd



Grid And Transect Details

Grids = 1 acre (all on land)

8.1 Acres of Transects (12.70 miles)

Analog Transects = 1.73 miles

N

350 175 0 350

Meters

Data is projected to the UTM Coordinate System: Zone 20 North, NAD83, Units in Meters.

Remedial Action/ Feasibility Study

Figure B-16

MRS 6 - Artillery Firing Area

Land and Beach Transects

Culebra Island Site, Puerto Rico

Legend

DGM and Analog Transects

- DGM Land Transects-7.61 miles
- Mag And Dig Beach Transect- 1.73 miles
- Underwater Video Transect- 3.36 miles
- Geophysical Grids
- RIFS Investigation Boundaries

ASR Features

- 1924 Military Area
- 1924 Outpost And Ammunition Storage Locations
- 1939 Military Exercises
- Features Taken From 1937 Map Titled "U.S. Fleet Landing Exercise "4."
- 1939_Military Excercises
- 1936 Artillery Areas And Aerial Target
- 1936 Artillery Areas And Aerial Target
- Features Taken From 1937 Map Titled "U.S. Feet Landing Exercise #4"
- 1902-1903 Gun Positions

USA Environmental, Inc.	US Army Engineering And Support Center Huntsville, Alabama		
Drawn By: SPC	Scale: 1 inch = 350 meters	Rev: 2	
Checked By: AC	Date Drawn: 9-15-2010		
Submitted By: DR	Revision Date: 2-9-2011		

Path:
S:\Culebra\RIFS 2009\Work Plan
B-16 MRS 6 Transect Map.mxd

APPENDIX C. LOCAL POINTS OF CONTACT

This space is intentionally left blank.

POC	Position	Organization	Address/Email	Telephone
US Army Engineering and Support Center, Huntsville (CEHNC)				
Spencer O'Neal	Project Manager	CEHNC-DC-MM	4820 University Square Huntsville, AL 35816-1822 Spencer.D.Oneal@usace.army.mil	256-895-1574
Kelly Enriquez	Geophysicist	CEHNC-ED-CS-G	4820 University Square Huntsville, AL 35816-1822	256-895-1343
Teresa Carpenter	Technical Manager	CEHNC-ED-CS-P	4820 University Square Huntsville, AL 35816-1822 Teresa.M.Carpenter@usace.army.mil	256-895-1659
William Veith	Facilitator	CEHNC-CX-MM	4820 University Square Huntsville, AL 35816-1822 William.D.Veith@usace.army.mil	256-895-1592
USACE Jacksonville District				
Daphne Ross	Program Manager	CESAJ-DP-S	US Army Corps of Engineers Jacksonville District 701 San Marco Blvd Jacksonville, FL 32207 Daphne.Ross@saj02.usace.army.mil	
Jose Mendez	Project Manager	CESAJ-DP	US Army Corps of Engineers Jacksonville District 701 San Marco Blvd Jacksonville, FL 32207 Jose.Mendez@usace.army.mil	787-729-6893, 6895, Ext 3099
Elsa Jimenez	Public Affairs	CESAJ-DP	U.S. Army Corps of Engineers Antilles Office 400 Fernadez Juncos, San Juan, Puerto Rico 00901-3299	787-729-6876

POC	Position	Organization	Address/Email	Telephone
USA Environmental, Inc. (USA)				
George Spencer	Director of MEC Operations	USA	720 Brooker Creek Boulevard Suite 204 Oldsmar, FL 34677 gspencer@usatampa.com	813- 343-6358
Doug Ralston	Program Manager	USA	720 Brooker Creek Boulevard Suite 204 Oldsmar, FL 34677 dralston@usatampa.com	813-343-6368 813-500-1099 (cell)
Brian Skubin	Project Manager	USA	720 Brooker Creek Boulevard Suite 204 Oldsmar, FL 34677 bskubin@usatampa.com	813-343-6406 813-846-9138 (cell)
Al Crandall	Project Geophysicist	USA	720 Brooker Creek Boulevard Suite 204 Oldsmar, FL 34677 acrandall@usatampa.com	813-343-6362 813-927-2975 (cell)
Tess Rottero	Project Engineer	USA	720 Brooker Creek Boulevard Suite 204 Oldsmar, FL 34677 trottero@usatampa.com	813-343-6426
Robert Crownover	Safety/QC Manager	USA	720 Brooker Creek Boulevard Suite 204 Oldsmar, FL 34677 rcrownover@usatampa.com	813-343-6364
Joseph Blue	Contract Manager	USA	720 Brooker Creek Boulevard Suite 204 Oldsmar, FL 34677 jblue@usatampa.com	813-343-6400
Jeffery Lewis	GIS Manager	USA	720 Brooker Creek Boulevard Suite 204 Oldsmar, FL 34677 jlewis@usatampa.com	813-343-6376

POC	Position	Organization	Address/Email	Telephone
Department of Public Safety, Clinic, USCG, FWS, EPA				
Mr. Abraham Pena Nieves	Mayor	Culebra	PO Box 7 Culebra, PR 00775-0189	787-742-3577 787-742-0487 787-742-0616 Fax
		Fire Department	Calle Escudero 317 Culebra, PR 00775	787-742-3530
Mr. Felix Lopez	Contamination Specialist	U.S. Fish and Wildlife Service	PO Box 491 Boqueron, PR 00910 Felix_Lopez@fws.gov	787-510-5202
Susan Silander	Project Leader Caribbean Islands NWR Complex	U.S. Fish and Wildlife Service	susan_silander@fws.gov	787- 851-7258, Ext 238
Ana M. Roman	Refuge Manager Culebra Nnational Wildlife Refuge	U.S. Fish and Wildlife Service	P.O. Box 190 Culebra, PR 00775 Ana.roman@fws.gov	787- 742-0115 787- 306-1389 (cell)
Richard Henry	National Technical Liaison ERT	US FWS	2890 Woodbridge Ave. Edison, NJ 08837 Richard_Henry@fws.gov	732-906-6987 973- 204-5825 (cell)
Ms. Rosarito Morales	Biologist	Contractor FWS Biologist		787-458-2425
Dr. Lisamarie Carrubba, Ph.D.	Ecologist	National Marine Fisheries Service (USFWS) National Wildlife Refuge	301 km 5.1 P.O. Box 1310 Boqueron, PR 00622 Lisamarie.Carrubba@noaa.gov	787-857-3700 787-455-0007 (cell)
Diane Wehner	Regional Resource Coordinator	NOAA	85 Central Ave. New Providence, NJ 07974 diane.wehner@noaa.gov	240-338-3411
Daniel Rodriguez	Regional Project Manager	US EPA Vieques Field Office	Carr 200 km 0.4 Vieques, PR 00765 Rodriquez.Daniel@epamail.epa.gov	787-741-5201 787-741-5017 (cell)

POC	Position	Organization	Address/Email	Telephone
Mr. Gilberto Iglesias Mr. Felipe Fraticelli	FAA Coordination Facility	FAA	www.nes.notams.faa.gov	787-253-8663 787-253-8664 FAA Coordination Fac
Ms. Veronica Melendez Mr. Benjamin Maldonado		Puerto Rico State Police Department	General Delivery Culebra, PR 00775	787-742-3501
Wilmarie Rivera	Federal Facilities Coordinator Puerto Rico Environmental Quality Board	Puerto Rico Environmental Quality Board (PREQB)	P.O. Box 11488 San Juan, PR 00910 wilmarierivera@jca.gobierno.pr	787-767-8181 Ext 6141 787-365-5873 (cell)
Mr. Rolando Soler Mr. Hector Orta	Contracetee PR DNER	PR DNER	c/o USFWS and PR DNER PO Box 190 Culebra, PR 00775 horta@coqui@net	787-220-1185
Jim Pastorick	President, UXO Pro	UXO Pro	811 Duke St. Alexandria, VA 22314 Jim@uxopro.com www.uxopro.com	703- 548-5300
Robert Matos	DNER- National Reserves Div.	Puerto Rico Department National Environmental Resources (DNER)	P.O. Box 11488, PR 00910 Matos_resevas@yahoo.com	787- 983-7222
Mr. John Reyes	Marine Information Specialist	Prevention Department SECTOR	San Juan, Puerto Rico John.Reyes@uscg.mil 24 hours notification requirement for Broadcast Notice to Mariners (BNM)	(787) 475-6755 Cell (787) 729-5381 Office (787) 729-6704 Fax

<table>
<tr><th>POC</th><th>Position</th><th>Organization</th><th>Address/Email</th><th>Telephone</th></tr>
<tr><td colspan="5">Culebra</td></tr>
<tr><td></td><td>Culebra Health Clinic</td><td>Clinic</td><td></td><td>(787) 742-3511</td></tr>
<tr><td></td><td></td><td>Department of Tourism</td><td></td><td>(787) 742-3116</td></tr>
<tr><td></td><td>Culebra Conservation and Development Authority</td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Explosive Supplier Control Demolition Austin Blasting Services Corp</td></tr>
<tr><td>Paola Criado
Jose Criado</td><td>Sales Representative</td><td>CDR Corp.</td><td>Rd #2 KM 24,
3 Espinosaward Borado
Puerto Rico, 00646
orionjfc@aol.com
prcriado@hotmail.com</td><td>(787) 883-3695
(787) 781-2055
(787) 883-7136 Fax</td></tr>
<tr><td colspan="5">Information Repository</td></tr>
<tr><td colspan="3">Municipality of Culebra Office
PO Box 189
Culebra, PR 00775-0189
Telephone (787) 742-3291
Sonia Arocho
Administradora Isla Municipio de Culebra
Hours: Monday through Friday 8 a.m. – 4:30 p.m.</td><td colspan="2">Culebra Library – Biblioteca
Omayra L. Albino
PO Box 848
Culebra, PR 00775
Telephone (787) 742-3583
Fax (787) 742-0011
Library hours 9 a.m. – 3 p.m.</td></tr>
</table>

<table>
<tr><th>POC</th><th>Position</th><th>Organization</th><th>Address/Email</th><th>Telephone</th></tr>
<tr><th colspan="5">Meeting</th></tr>
<tr><td colspan="3">Municipality of Culebra Building
Sonia Arocho
Administradora Isla Municipio de Culebra
PO Box 189
Culebra, PR 00775-0189
Telephone (787) 742-3521 x423
Fax: (787) 742-0111
Direct (787) 742-1025
Reservations: Mayor Abraham Peña Nieves
Fees: None for public service meetings
Room capacity: 200</td><td colspan="2">Meetings for more than 200 could be accommodated in the baseball field behind El Batey Restaurant on the road to Culebra Airport. For weather cautions, be advised only a portion of the ball field is covered and protected.</td></tr>
<tr><th colspan="5">Public Meeting Notification</th></tr>
<tr><td colspan="3">Culebra Calendar
PO Box 761
Culebra, PR 00775-0761</td><td colspan="2">www.Culebra-island.com
To post a page on the Web site, contact Blue Horizon Realty, (787) 742-3298, or e-mail websmaster@Culebra-Island.com

Post meeting notification flyers at:
—Culebra Municipal Building
—Culebra post office bulletin board
—Culebra Island dive shops</td></tr>
</table>

APPENDIX D. ACCIDENT PREVENTION PLAN

ACCIDENT PREVENTION PLAN ACKNOWLEDGEMENT

Accident Prevention Plan Acknowledgement

I have read, understand, and agree to abide by the provisions as detailed in this Accident Prevention Plan and Site Safety and Health Plan prepared by USA Environmental, Inc. Failure to comply with these provisions may lead to disciplinary action and/or my dismissal from the work site.

Printed Name	Company	Signature	Date

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ATTACHMENTS

ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AHA	Activity Hazard Analysis
APP	Accident Prevention Plan
°C	Degrees Celsius
CDCP	Center for Disease Control and Prevention
CFR	Code of Federal Regulations
CP	Competent Person
CSHM	Corporate Safety and Health Manager
CSP	Certified Safety Professional
DGM	Digital Geophysical Mapping
EM	Engineer Manual
ERPCP	Emergency Response Plan and Contingency Procedures
EZ	Exclusion Zone
°F	Degrees Fahrenheit
FWS	U.S. Fish and Wildlife Service
HAZWOPER	Hazardous Waste Operations and Emergency Response
IDLH	Immediately Dangerous to Life or Health
MEC	Munitions and Explosives of Concern
MSDS	Material Safety Data Sheet
OSHA	Occupational Safety and Health Administration
OT	Oral Temperature
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
PR	Pulse Rate
PWS	Performance Work Statement
SSHP	Site Safety and Health Plan
SUXOS	Senior Unexploded Ordnance Supervisor
TLV	Threshold Limit Value
USA	USA Environmental, Inc.
USACE	Unites States Army Corps of Engineers
UXO	Unexploded Ordnance
UXOSO	Unexploded Ordnance Safety Officer
WBGT	Wet Bulb, Dry Globe Temperature
WNV	West Nile Virus

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D.1 SIGNATURE SHEET

ACCIDENT PREVENTION PLAN
Remedial Investigation/Feasibility study
Culebra Island Site, Puerto Rico

Plan Approval: Jonathan Chionchio Date: 10 Feb 11

Jonathan Chionchio
President
USA Environmental, Inc.
(813) 343-6350

Plan Prepared By: Cheryl M. Riordan Date: 10 Feb 11

Cheryl Riordan
Certified Safety Professional
USA Environmental, Inc.
(813) 343-6412

Plan Concurrence By: Robert D. Crownover Date: 10 Feb 11

Robert D. Crownover
Corporate Safety and Health Manager
USA Environmental, Inc.
(813) 343-6364

D.2 BACKGROUND INFORMATION

This Accident Prevention Plan (APP) has been prepared by USA Environmental Inc. (USA) for the Remedial Investigation/Feasibility Study at the Culebra Site in the Municipality of Culebra, Puerto Rico. The purpose of the project is to perform a Remedial Investigation to characterize the nature and extent of MEC contamination at the specified sites, and a Feasibility Study to develop and evaluate effective remedial alternatives.

Culebra came under Navy control in 1901, and the Navy built a small base that same year and an airfield about 20 years later. The Navy used the area for fleet exercises from 1902 until 1975. The Navy began surface and aerial bombing of the Flamenco Peninsula in 1935, and expanded the range to include eastern and western cays (small islands surrounding Culebra) in the early 1960s. Ordnance firing ended in September 1975.

Culebra Island National Wildlife consists of Culebra Island and about 20 cays surrounding Culebra Island which are owned by the Fish and Wildlife Service (FWS). Total land area is about 7300 acres, and the FWS owns approximately 1500 of these acres. The rest (approximately 1200 acres) is owned by the Commonwealth of Puerto Rico (about 1200 acres), primarily the Department of Natural and Environment Resources.

Two endangered species of turtles, the Hawksbill and the Leather Back, are found at Culebra. In addition, there are two species that have been proposed for threatened status: the Loggerhead and the Green sea turtles. All four of these species use the Culebra area and most of the beaches for nesting sites.

D.2.1 PURPOSE

The purpose of this APP is to establish site-specific safety and health procedures, practices, and equipment to be implemented and used to protect affected personnel from the potential hazards associated with the field activities to be performed at the project sites. The APP assigns responsibilities, establishes standard operating procedures, and provides for contingencies that may arise while operations are being conducted during the Remedial Investigation process. The APP will interface with the USA Corporate Safety and Health Program.

D.2.2 PROJECT DETAILS

Contractor:

USA Environmental, Inc.
720 Brooker Creek Boulevard, Suite 204
Oldsmar, FL 34677

Contract Number: W912DY-04-D-0006

Task Order Number: 0022

Project Name: Remedial Investigation/Feasibility Study, Culebra Island Site, Puerto Rico.

D.3 PROJECT DESCRIPTION

MRS 13 Cayo Luis Pena Impact Areas: The Cayo de Luis Pena Impact area consists of 342 land acres and 864 total MRS acres. The MRS is approximately one-quarter mile off the western coast of Culebra. USA will perform 4 acres of DGM transects and 2 acres of grids. USA will investigate 350 anomalies and perform 3 demolition shots. USA will investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

MRS 10 Defensive Firing Area No. 1 (Optional): This area consists of 547 acres on the southwest peninsula of Culebra, south of the town of Dewey and north of MRS 09. USA will perform 5 acres of DGM transects and 1 acre of grids. USA will investigate 350 anomalies and perform 3 demolition shots. USA will investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

MRS 11 Defensive Firing Area No. 2 (Optional): The Defensive Firing Area No. 2 is located on the west side of Culebra between Northwest Peninsula and the town of Dewey. The MRS consists of 719 acres. USA will perform 6 acres of DGM transects and 1 acre of grids. USA will investigate 400 anomalies and perform 3 demolition shots. USA will investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

MRS 06 Artillery Firing Area (Optional): The Artillery Firing Area (MRS 06) consists of 826 acres and is located on the eastern end of Culebra extending from a point at the most northern tip of Mosquito Bay, northeast to a point just west of Duck Point, and east to the end of the island. USA will perform 6 acres of DGM transects and 2 acre of grids. USA will investigate 450 anomalies and perform 4 demolition shots. USA will investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

MRS 09 Soldado Point Mortar and Bombing Area (Optional): This area consists of 328 acres on the southern tip of the southwestern peninsula of Culebra. USA will perform 2 acres of DGM transects and 1 acre of grids. USA will investigate 200 anomalies and perform 2 demolition shots. USA will investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

MRS 08 Cayo Norte Impact Area (Optional): The Cayo Norte Impact Area includes only Cayo Norte and covers approximately 306 acres. USA will perform 3 acres of DGM transects, and one acre of grids. USA will investigate 250 anomalies and perform 3 demolition shots. USA will investigate up to 100 yards seaward of mean high tide; depth shall not exceed recreational diving depth.

USA will be responsible for the on-site destruction of all MEC encountered during the remedial investigation. USA will backfill excavations and detonation holes in order to restore the land to its original condition. All MPPEH will be inspected and disposed of on site, and MD will be collected and sent to a qualified recycler for disposition.

Table D-1: Site Description

Site Location	Approximate Size (Acres)
Various former range areas on and around Culebra, Puerto Rico	Entire site is 3,068 acres, investigation area is 34 acres.
Topography	**Present Usage**
☐ Forested ☐ Tillage ☐ River/Creeks ☐ Grassland ☒ Flat land ☒ Open Terrain ☐ Wetland ☐ Arid ☒ Other: Beaches	☐ Rural ☐ Commercial ☐ Urban ☒ Government ☐ Industrial ☐ Farming ☐ Ranching ☐ Residential ☒ Recreational ☐ Military ☒ Other – Various potential uses

D.4 DESCRIPTION OF WORK

Work required under this Performance Work Statement (PWS) falls under the Formerly Used Defense Sites (FUDS), Military Munitions Response Program (MMRP). USA will perform a Remedial Investigation of the designated sites in a manner consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104 and the National Contingency Plan (NCP), Sections 300.120(d) and 300.400(e). All MEC encountered during this munitions response shall be destroyed on-site in coordination with the Unites States Coast Guard (USCG) and local environmental agencies.

D.5 CONTRACTOR ACCIDENT EXPERIENCE

USA's Experience Modification Rate for the last 5 years is shown in Table D-2. A copy of the latest Occupational Safety and Health Administration (OSHA) Form 300 and OSHA Form 300A is provided in Attachment 1 of this APP.

Table D-2: Experience Modification Rate

Year	Interstate	Intrastate
2009	0.72	N/A
2008	0.70	N/A
2007	0.80	N/A
2006	0.78	N/A
2005	0.69	N/A

D.6 PHASES OF WORK REQUIRING ACTIVITY HAZARD ANALYSIS

The following phases of work on this project require an Activity Hazard Analysis (AHA):

- Boat Operations
- Boat Transportation
- Geophysical Prove-Out Test Strip
- Location, Survey and Mapping
- MEC Disposal
- MEC Investigation
- MPPEH Inspection
- Quality Control
- Vegetation Clearance
- Vehicle Operations.

The AHA forms are located in Attachment 2 of this APP. Table D-3 lists the hazards and action levels that may be associated with this project.

Table D-3: Hazards Table

HAZARDS*	ACTION LEVELS**
Safety: include falling (sand, rocks, inclines, slippery surfaces); climbing (uneven terrain); walking (uneven terrain, surface indentations); hand and power tool operations (hammers, machetes, chainsaws, weed eaters) eye hazards; heavy equipment; boat operations and MEC.	None/Awareness/Avoidance
Chemical: lubricants and fuels for equipment.	Per Material Safety Data Sheets (MSDSs)
Physical: include heat injuries and noise.	Per Monitoring Requirements
Radiological: none anticipated.	Not Applicable
Biological Hazards: may be present; include biting and stinging insects, hazardous plants and wildlife.	None/Awareness/Avoidance
MEC: may be present on site; use approved measures.	Observe Safety Procedures

Notes to Hazards Table

*HAZARDS

Safety:

Falling: (e.g., Open pits, wells, shafts, rocks, crevices, steep inclines, slippery surfaces, etc.)

Climbing: (e.g., Falls from structures > 4 ft high; deteriorated ladders or missing rungs, etc.)

Walking or Debris: (e.g., Uneven terrain, animal burrows, surface indentations, exposed nails, broken timbers, sharp protruding objects, broken glass, metal fragments, etc.)

Confined Space (e.g., Excavations > 4 ft deep, surface/underground utility vaults, open surface tanks/cisterns/septic tank, underground/above ground storage tanks, etc.) (DO NOT ENTER.)

Water: (e.g., Moving waterways (Flash Floods), drowning/near drowning conditions or environments, etc.)

Eye Hazards: (e.g., Airborne dust/windy conditions, liquid splashes, etc.)

MEC/Other: (e.g., Explosives, combustible or flammable materials, etc.)

Chemical: Evaluate the chemical hazards that may be encountered during site activities for each task. For activities utilizing this plan, encounters with chemicals above the permissible exposure limit (PEL), or threshold limit value (TLV) are not expected. THIS PLAN SHALL NOT BE USED IF OVEREXPOSURES OR IMMEDIATELY DANGEROUS TO LIFE OR HEALTH (IDLH) CONDITIONS ARE EXPECTED. [(List the chemical TLV/PEL/recommended exposure level (REL), Occupational Safety and Health Administration (OSHA)/National Institutes for Occupational Safety and Health IDLH, odor threshold/warning levels, warning signs/symptoms of overexposure, concentrations expected on site.]

Physical: Evaluate the potential for injury from physical agents such as noise, electricity, moving parts/machinery, and heat and cold stress that may be present (e.g., loud machinery, overhead or underground power lines, personal protective clothing, etc.).

Radiological: Evaluate the risk to human health caused by radioactive materials in the area where work is to be performed.

Biological: Evaluate the potential for illness or injury from biological agents (e.g., poisonous plants, animals, insects, microorganisms, etc.)

MEC: Evaluate exposure; minimize people, time, and amount of hazardous material. Age or condition of UXO DOES NOT decrease hazard. UXO exposed to fire is EXTREMELY hazardous: EVACUATE IMMEDIATELY.

**ACTION LEVELS: Action Levels shall typically be defined as requiring site evacuation only, if significant hazards are encountered. Note: The activities for which this SSHP is designed will not typically encounter chemical contaminant or radioactive exposures above background. In the event that chemical or radioactive exposures, which are judged to be significant, are encountered (reasonable potential to exceed PELs or encounter IDLH conditions), this plan requires work stoppage of the site, reevaluation, and development of procedures designed by Safety Management that will address the potential exposure. Chemical exposures (releases) requiring evacuation shall always be in an upwind direction to a safe distance. Personal protective equipment (PPE) per hazard assessment will be worn.

D.7 STATEMENT OF SAFETY AND HEALTH POLICY

In recognition of the responsibilities of USA and the need for management to establish a policy with regard to the prevention of on-the-job injuries, this APP has been developed. Through application of these safety policies and procedures, it is USA's primary goal to reduce to a minimum the human suffering by employees resulting from occupational injuries. Not only can injuries have a serious physical and emotional impact on the employees themselves, but they can also have a negative effect on family members and co-workers.

In addition, we must recognize the deterrent and eroding effect injuries have on the potential profit. Insurance costs, combined with the indirect costs of injuries, are a matter of serious concern and it is USA's intention that they be reduced. This desired reduction could take place, over a long term, if the frequency of injuries is kept to a minimum. As it affects USA, the elimination of on-the-job injuries is an important responsibility of management. This responsibility must be assumed and treated in the same manner as our business philosophies relating to services rendered.

For USA's Corporate Safety and Health Program to become effective, it will be necessary for each employee to take a serious interest in the prevention of injuries. Management fully intends to provide, in administration of the program, the leadership and direction to which supervisory personnel and employees will respond. It is USA's earnest request that all concerned devote their serious attention toward making this Safety and Health Program an integral part of the day to day business operations. Always remember that no job is so important and no service is so urgent that we cannot take the time to perform our work safely.

All site operations will be performed in accordance with applicable Federal, state, and local regulations and procedures, OSHA requirements, client requirements, and USA's Corporate Safety and Health Program and this APP. Compliance with the 2008 edition of EM 385-1-1 is required by USA and any subcontractors working on this site. All USA employees and subcontractors will comply with the requirements of this plan.

D.8 RESPONSIBILITIES AND LINES OF AUTHORITY

All personnel are responsible for continuous adherence to this APP and safety and health procedures during the performance of their work.

D.8.1 PERSONNEL RESPONSIBILITIES

No person may work in a manner that conflicts with the intent of, or the inherent safety and environmental precautions expressed in these procedures. After due warnings, USA will dismiss from the site any person who violates safety procedures. USA employees are subject to progressive discipline and may be terminated for continued violations. All on-site personnel will be trained in accordance with this document.

D.8.1.1 USA Project Manager – Matt Tucker

Responsibilities include:

- Ensures conformance with USA corporate and US Army Corps of Engineers (USACE) policies and procedures
- Coordinates project with the Corps of Engineers personnel
- Ensures the project has the necessary resources to operate safely
- Ensures that the project personnel satisfy USA and USACE Safety & Health requirements
- Ensures that the project personnel implement the project APP
- Ensures that the project personnel have the appropriate regard for safe job performance.

D.8.1.2 USA Corporate Safety and Health Manager – Robert Crownover

Responsibilities for the Corporate Safety and Health Manager (CSHM) include:

- Oversees development and coordination of the APP, as required
- Makes changes to the APP if warranted by changed conditions
- Administers and enforces General Health and Safety Program
- Determines the level of personal protection required
- Investigates significant accidents and illnesses and implements corrective action plans
- Establishes air-monitoring parameters based on expected contaminants
- Establishes employee exposure monitoring notification programs
- Develops site-specific employee/community emergency response plans based on expected hazards
- Stops any operation that threatens the health or safety of the team or surrounding population
- Upgrades or downgrades levels of protection based on site observations or monitoring results.

D.8.1.3 USA Certified Safety Professional – Cheryl Riordan, CSP

Responsibilities for the Certified Safety Professional (CSP) include:

- Develops and coordinates the APP, as required
- Recommends changes to the APP if warranted by changed conditions
- Administers General Safety and Health Program
- Determines the level of personal protection required
- Confirms each USA team member's suitability for work based on physician's recommendation
- Conducts field safety and health audits to ensure APP and SSHP conformance and USA policy compliance
- Investigates significant accidents and illnesses and implements corrective action plans
- Certifies that all workers have proper training in accordance with (IAW) 29 CFR 1910.120(e)
- Updates equipment or procedures based on information obtained during site operations
- Investigates significant accidents and illnesses and implements corrective action plans
- Establishes air monitoring parameters based on expected contaminants
- Establishes employee exposure monitoring notification programs

- Develops site-specific employee/community emergency response plans based on expected hazards
- Stops any operation that threatens the health or safety of the team or surrounding population
- Upgrades or downgrades levels of protection based on site observations or monitoring results.

D.8.1.4 Senior UXO Supervisor – TBD

All site activities will be conducted under the supervision of the USA SUXOS. The SUXOS will oversee normal and emergency work and will perform any emergency notification. His/her responsibilities also include:

- Supervises all USA site activities
- Implements the field APP
- Coordinates with the Unexploded Ordnance (UXO) Safety Officer (UXOSO) on safety-related matters
- Determines evacuation routes
- Presents daily safety meetings
- Maintains logs and records in the field
- Implements changes to APP as directed by the CSHM, the CSP, or UXOSO.

D.8.1.5 UXO Safety Officer- (TBD)

Site activities will be conducted under the supervision of the USA UXOSO for safety on an as-needed basis. The UXOSO will act as safety oversight for normal and emergency work and will perform any emergency notification as the On-Scene-Incident-Commander. He/she also has the following responsibilities:

- Implements the field APP
- Enforces all provisions of the APP
- Determines evacuation routes
- Presents daily safety meetings
- Presents training requirements for site personnel and visitors
- Maintains safety logs and records in the field
- Implements changes to APP as directed by the Corporate Safety and Health Manager or CSP
- Administers and enforces General Health and Safety Program
- Enforces the level of personal protection required
- Investigates work-related accidents and illnesses and implements corrective action plans
- Establishes air monitoring parameters based on expected contaminants
- Establishes employee exposure monitoring notification programs
- Stops any operation that threatens the health or safety of the team or surrounding population
- Upgrades levels of protection based on site observations or monitoring results.

D.8.2 LINES OF AUTHORITY

Table D-4 lists contact information for project personnel and Figure D-1 contain the project personnel, their involvement on the project, the organization these individuals represent, and several ways to contact these individuals.

Table D-4: Project Contacts

Name	Organization	Telephone	Mobile Number	E-mail
Spencer O'Neal	USACE Project Manager	256-895-1574		Spencer.oneal@usace.army.mil
Doug Ralston	USA Program Manager	813-343-6368	813-500-1099	dralston@usatampa.com
Matt Tucker	USA Project Manager	813-343-6370	813-426-2426	mtucker@usatampa.com
Cheryl Nichols	USA Project Engineer	813-343-6433		cnichols@usatampa.com
Robert Crownover	Corporate Safety and Health Manager	813-343-6364	813-748-1642	rcrownover@usatampa.com
Cheryl Riordan	Certified Safety Professional	757-486-8567	813-426-2112	criordan@usatampa.com
TBD	SUXOS	813-343-6336		
TBD	UXO Safety Officer	813-343-6336		

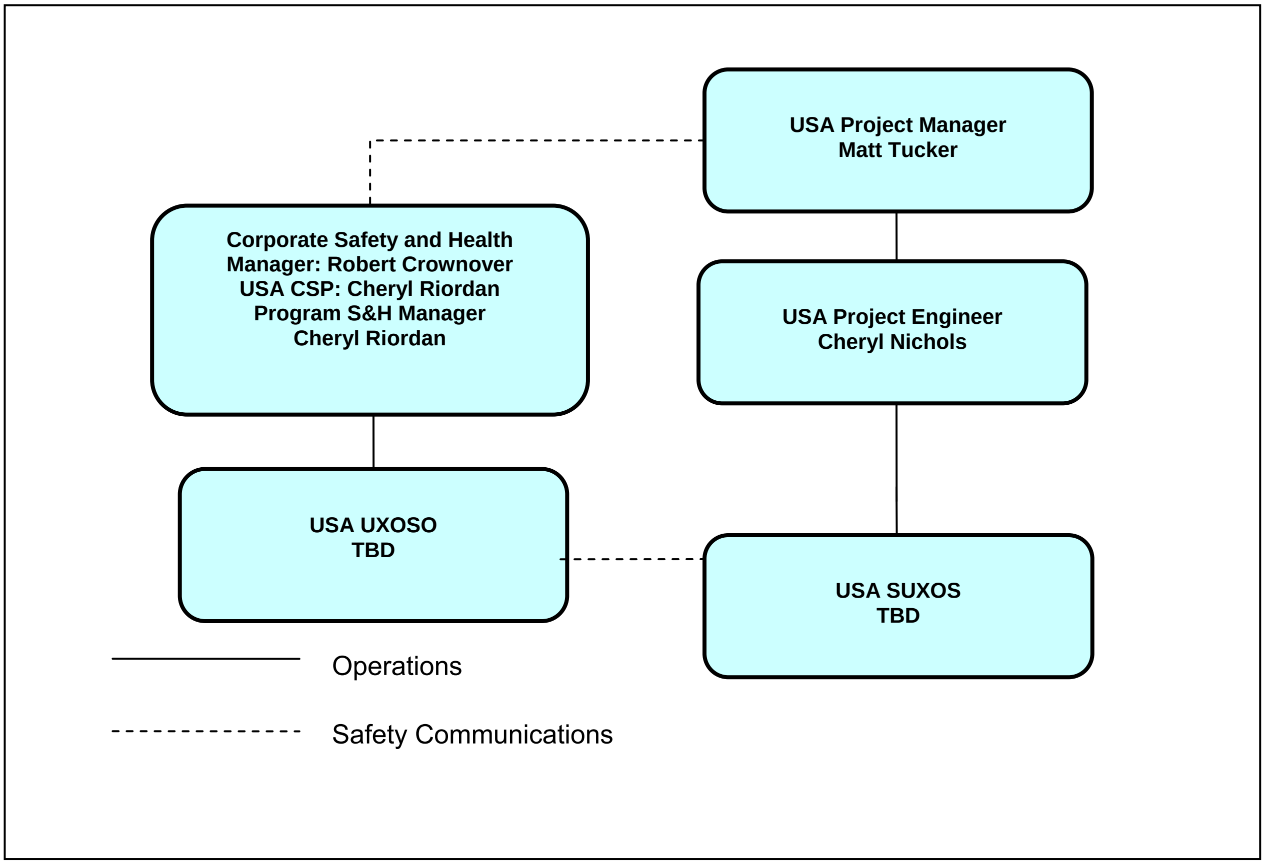


Figure D-1: Lines of Authority for USA Corporate and Site Activities

D.9 SUBCONTRACTORS AND SUPPLIERS

The USA subcontractor to be used on this project is Sea Ventures, who will provide transportation via boats to support the offshore operations.

D.9.1 MEASURES FOR CONTROLLING AND COORDINATING SUBCONTRACTORS

Before work is performed by the subcontractor, USA will negotiate and prepare an agreement that will detail all necessary and appropriate terms and conditions, including the Scope of Work. Once the subcontract is executed, USA will perform periodic reviews to ensure that requirements are met. These reviews will cover technical requirements, and cost and schedule status. The personnel at Sea Ventures will be responsible for providing boat transportation to and from the offshore sites and personal flotation devices for all personnel.

D.9.2 SAFETY RESPONSIBILITIES OF SUBCONTRACTORS

All service supplier personnel will receive training on ordnance recognition and UXO safety precautions prior to commencing activities on the project site. All personnel will be given a daily safety briefing and will be escorted by a UXO Technician at all times on site. All personnel will acknowledge that they have read, understood, and will abide by the Accident Prevention Plan and Site Specific Safety and Health Plan for this project, by signing the acknowledgement page. In addition, personnel must abide by the guidance given by the Senior UXO Supervisor (SUXOS) and UXO escort accompanying them at all times.

Any deviations from the site plans could be used as the basis for termination of the subcontract agreement.

D.10 TRAINING

Prior to commencement of site activities, the Corporate Safety and Health Manager and the UXOSO will ensure that all USA employees engaged in hazardous waste operations are informed of the nature and degree of exposure to chemical and physical hazards that are likely to result from participation in site operations. USA will accomplish this by ensuring that all personnel entering the site have received the appropriate OSHA and site-specific training, prior to participation in site activities. OSHA-required training will be conducted prior to site mobilization. Site-specific training will be held at the time of site mobilization and will be reinforced during the daily safety briefings, which all site workers will be required to attend.

D.10.1 SUBJECTS TO BE DISCUSSED WITH EMPLOYEES DURING SAFETY INDOCTRINATION

The UXOSO will conduct the site specific training. This training will include classroom type instruction covering the topics specified for site-specific training, and on-site participation in the following:

- Scope of Work
- Details of the Site Specific Safety and Health Plan
- Employee rights and responsibilities
- Sequence of work events
- Identification of safety issues for the site
- Identification of Safety staff and lines of authority
- Safe work practices
- Proper lifting techniques
- Recognition of potential MEC and hazards associated with MEC
- Nature and extent of anticipated chemical, physical, and biological hazards
- Measures and procedures for controlling site hazards
- Emergency Response and Contingency Plan
- Location of medical services
- Site communication
- Evacuation routes
- Rules and regulations for vehicle use
- Safe use of field equipment
- Boat operations
- Handling, storage, and transportation of hazardous materials
- Use, care, and limitations of PPE
- Hazard communication per OSHA 29 CFR 1910.1200.

D.10.2 MANDATORY TRAINING AND CERTIFICATIONS THAT ARE APPLICABLE TO THIS PROJECT

D.10.2.1 General Training

All USA employees who are involved in hazardous waste site activities receive 40 hours of OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) training in accordance with 29 CFR 1910.120 and 29 CFR 1926.65. If it has been more than a year since any worker has received the

40 Hour OSHA HAZWOPER training, he or she must also have a current HAZWOPER 8-Hour Refresher Training in accordance with 29 CFR 1910.120 and 29 CFR 1926.65 prior to working on the site. Any visitor entering the exclusion zone (EZ) during hazardous waste operations will also be required to have current HAZWOPER training. The EZ, during hazardous waste activities, would include the project footprint and an area around the footprint equivalent to the fragmentation distance of the largest MEC item expected to be encountered on the site.

All current certifications and training tables for USA personnel will be maintained on site for the duration of the project. Individuals without proper training records will not be permitted to work on site.

D.10.2.2 Supervisory Training

On-site managers and supervisors who are responsible for directing others will receive the same training as the general site workers for whom they are responsible. They will also receive an additional 8 hours of OSHA-required supervisory training in accordance with 29 CFR 1910.120 and 29 CFR 1926.65 to enhance their ability to provide guidance and make informed decisions. This additional training includes the following topics:

- Review of the USA Corporate Safety and Health Program
- Regulatory requirements
- Management of hazardous waste site cleanup operations
- Management of site work zones
- How to communicate with the media and the public
- PPE selection and limitations
- Spill containment
- Monitoring site hazards.

The UXOSO, with specific responsibilities for safety and health guidance on site, will receive the training provided to general site workers and their supervisors. He also will receive advanced training in safety and health issues, policies and techniques. The UXOSO will also receive the 10-hour OSHA Construction Safety class in accordance with Engineer Manual (EM) 385-1-1, 01.A.17.

D.10.2.3 Requirements for Emergency Response Training

Prior to commencement of the project, all USA site personnel will review and discuss the posted emergency telephone numbers, location of spill kit materials as applicable, directions to the hospital, the location of all site fire extinguishers, proper use of fire extinguishers, identification and location of first aid kits and blood-borne pathogen kits, and identification and location of the First Aid/CPR trained First Responders.

D.10.2.4 Fire Prevention

Smoking and lighters are prohibited in the EZ or work zone. A cigarette butt receptacle will be provided in the support zone. No cigarette butts are to be discarded on the ground. No smoking is allowed except in an approved designated location with fire extinguisher. Procedures will be reviewed with all site personnel.

D.10.2.5 MEC Training

All USA employees performing work involving the handling and destruction of MEC must be graduates of the U.S. Naval Explosive Ordnance Disposal School (at a minimum Phase I, chemical; and Phase II, surface) or equivalent recognized training. A copy of their certificate of graduation will be kept on file at corporate headquarters. UXO qualified personnel shall have knowledge and experience in military ordnance, ordnance components, and explosives location, identification, render safe, recovery/removal, transportation, and disposal safety precautions. UXO personnel shall have the knowledge and experience to effect safe handling and transportation of ordnance items found. Copies of certificates of this training will be kept on the project site for the duration of site operations.

D.10.2.6 Hazard Communication

All USA employees who will be performing work involving the handling of hazardous materials will receive Hazard Communication training detailing the hazards of the product, appropriate protective measures to prevent exposure to the product, procedures for safe storage and handling of the product, and response to emergencies. Personnel may request an MSDS for any hazardous material on the site at any time. USA personnel will be informed that the location of the MSDSs for this site will be in an MSDS binder in the UXOSO site vehicle. This training will occur as part of the initial mobilization training at the site.

D.10.3 REQUIREMENTS FOR SUPERVISORY AND EMPLOYEE SAFETY MEETINGS

D.10.3.1 Tailgate Safety Briefing

Tailgate Safety Briefings consist of providing short training sessions in various subjects that give the site worker knowledge and confidence in performing duties in a potentially hazardous environment. The Tailgate Safety Briefing will be given prior to commencing work each day and will include such items as:

- Expected weather conditions
- General site hazards
- Biological hazards on site
- MEC hazards
- PPE required at each site
- Emergency evacuation procedures
- Heat stress precautions
- Buddy system procedures
- A review of any safety violations from the previous day
- Any other significant events involving safety.

Additional briefings will be provided as needed concerning the use of safety equipment, emergency medical procedures, emergency assistance notification procedures, accident prevention, the work plan, and site orientation to ensure that accomplishment of the project can be carried out in a safe and effective manner. All site workers are required to attend the Tailgate Safety Briefing daily.

D.10.3.2 Daily Debriefing

At the conclusion of each work day, a debriefing for all employees may be held, as appropriate, and the day's work will be discussed to determine if changes are warranted before commencing activities the following day.

D.10.3.3 Periodic Site Training

On the first work day of each work week/period, when new employees arrive on site, or more frequently if needed, a pertinent topic will be selected and elaborated upon by the UXOSO during the Tailgate Safety Briefing. These safety meetings will help ensure the safety and health of site personnel in the performance of regular work activities and in emergency situations. Safety meetings will be documented in the appropriate log and the Documentation of Training Form will be completed. Potential topics for discussion are as follows:

- Names and titles of key personnel responsible for site safety and health, and other hazards present at the site
- Components of the Site Safety and Health Program
- General site safety
- Hazards and symptoms of contaminant exposure (chemical), as applicable
- Routes of exposure from on-site contaminants (as applicable)
- Physical hazards (fall protection, noise, heat stress, etc.)
- Biological hazards
- Location and availability of written hazard communication program
- Site and activity PPE (including purpose, donning, doffing, and proper use)
- Work practices by which employees can minimize risks for hazards
- Safe use of engineering controls and equipment use
- Site control measures
- MEC suspected on site
- MEC/UXO hazards and precautions
- Reporting requirements for UXO, spills, and emergencies
- Personnel decontamination procedures (as applicable)
- Contingency plans (communications, phone numbers, emergency exits, assembly points, etc.)
- Worker Right to Know/ Hazard Communication
- Emergency equipment locations and use (fire extinguishers, spill kits, first aid kits, etc.)
- Equipment safety.

D.10.3.4 Visitors

Essential Personnel are defined as USACE and USA project personnel necessary for the safe and efficient completion of field operations conducted in an EZ. This is limited to the USA work team members including the UXOSO, UXOQCS, SUXOS, and a USACE OESS.

All visitors (persons other than Essential Personnel) to the site, even if escorted, must receive, as a minimum, a briefing of on-site conditions, hazards, and emergency response procedures. The UXOSO will generally be the one providing the visitor briefing. All visitors to the EZ will be escorted at all times. When visitors enter the EZ, all MEC operations will cease, and will resume again after the visitor has left the area. Visitors will not be permitted in the restricted work areas unless they have the appropriate level of OSHA training and are medically approved as part of a company-sponsored medical surveillance program. Visitors not complying with the above requirements will not enter the restricted work areas; however, they may observe site conditions from a safe distance in the support zone. All visitors will sign the Visitor's Log prior to entering the site.

D.10.4 TRAINING DOCUMENTATION

A training record will be kept in each employee's individual file to confirm that adequate training for assigned tasks is provided and that training is current. In addition, Documentation of Training Forms will be completed and kept on file at the work site for the duration of site activities, and made available for inspection upon request.

D.11 SAFETY AND HEALTH INSPECTIONS

General safety and health inspections are described throughout this APP. USA site personnel will conduct safety inspections on a daily basis, or more frequently if conditions warrant. The UXOSO will be responsible for daily safety inspections of the project. During periods when the UXOSO is not present, the Senior UXO Technician who is present will ensure that site personnel follow safety requirements and policy. The Safety Inspection Form will be used to record, track and provide follow-up to ensure that safety deficiencies are corrected after they have been identified. A record of the safety inspection checklist will be maintained in the project file. Deficiencies will be identified, posted, and dated when the deficiencies are rectified.

D.11.1 EXTERNAL INSPECTIONS

External inspections are expected for this project. The USACE Project Manager assigns an on-site Safety Representative who is responsible for conducting external inspections.

D.11.2 DAILY SITE INSPECTIONS

The UXOSO will be responsible for daily inspections of the project when present. The Corporate Safety and Health Manager or the CSP may make random inspections, as warranted.

D.12 SAFETY AND HEALTH EXPECTATIONS, INCENTIVE PROGRAM, AND COMPLIANCE

D.12.1 GOALS AND OBJECTIVES

The goal for USA on this project is zero accidents. All managers and supervisors are responsible for implementing the provisions of this APP and attached SSHP and for answering team member questions about accident prevention. Management is responsible for ensuring that all safety and health policies and procedures are clearly communicated and understood by all team members. Managers and supervisors are expected to enforce the rules fairly and uniformly. This will be accomplished by:

- Informing team members of the provisions of the Safety and Health Program
- Evaluating the safety performance of all team members
- Recognizing team members who perform safe and healthful work practices
- Providing training to team members whose safety performance is deficient
- Disciplining team members for failure to comply with safe and healthful work practices.

All team members are responsible for using safe work practices, for following all directives, policies and procedures, and for assisting in maintaining a safe work environment. USA recognizes that open, two-way communication between management and all team members on health and safety issues is essential to an injury-free, productive workplace. To facilitate a continuous flow of safety and health information among all team members, the following will be accomplished:

- Training all new team members, during the site-specific training, on the site safety and health policies and procedures, which will include this APP and attached SSHP
- Training all new team members on the hazards associated with the job site
- Conducting daily Tailgate Safety Briefings for all team members
- Conducting quarterly refresher type training
- Posting and, if applicable, distributing safety information
- Encouraging open communications.

D.12.2 USA'S CORPORATE SAFETY PROGRAM

USA's corporate safety program is designed to provide the safety training and tools required to ensure that USA is providing the safest work environment for its employees, other project personnel, and the general population in areas adjacent to our project sites.

The USA Corporate Safety and Health Manager and CSP have reviewed the scope of the project and, based on this review, have developed this APP designed to protect health and safety during the project.

As part of the job requirements, employees are required to:

- Read and follow the APP and attached SSHP
- Attend health and safety meetings, courses, and seminars, when available, to make them more informed and aware of potential hazards that exist at the site.

D.12.3 USA'S SAFETY INCENTIVE PROGRAM

USA builds an information database for each project it undertakes, which includes the rate/occurrence of accidents and injuries. Safety data, including injury and accident occurrence, are noted and incentives such as monetary bonuses and additional training courses are provided as rewards for superior employee performance for compliance with the project APP, SSHP, and corporate safety and health policies.

D.12.4 SAFETY PROGRAM NONCOMPLIANCE POLICIES AND PROCEDURES

USA management takes seriously employee noncompliance with safety requirements. Personnel not following procedures are warned and counseled in the proper safety procedures, and if the problem persists, are again counseled with notations made in their individual file. Continued noncompliance will lead to termination. On USA job sites, visitors are briefed about site safety requirements and are provided with the appropriate level of PPE. If visitors refuse to follow these procedures, they will be escorted from the site.

D.12.5 USA'S WRITTEN PROCEDURES FOR HOLDING MANAGERS AND SUPERVISORS ACCOUNTABLE FOR SAFETY

USA's commitment to safety and health is documented and required from the time an offer is made to a job applicant. Managers and supervisors are made responsible for enforcing safety and health as part of their job descriptions. They are ultimately responsible for protecting the welfare of the employees as well as minimizing the potential liability associated with on-the-job accidents.

D.13 ACCIDENT REPORTING

This section provides the requirements for implementing the accident reporting provisions of EM 385-1-1. This APP requirement applies to all work performed by USA for each project site.

The USA Project Manager and the USA Corporate Safety and Health Manager will be notified immediately by telephone of any accidents, and will follow up with USA's Accident Report Form (see Appendix E). USA's Site Manager will notify the USACE Contracting Officer and Project Manager immediately and initiate ENG Form 3394 for submittal to the USACE Safety Office or a designated representative for review, within 24 hours of the event. USA will thoroughly investigate all accidents.

Person(s) who become ill or injured during work activities must immediately inform the SUXOS or UXOSO, regardless of the severity of the illness or injury. The victim(s) will be decontaminated if the injury occurred in contaminated areas. In the event that the medical emergency is severe enough, the SUXOS or UXOSO will order a cessation of work and notify off-site emergency personnel. All personnel at the work site will use the buddy system, staying within sight of their partner. If a partner becomes incapacitated or severely ill, an ambulance will be called. In the event that a cessation of work is ordered, all personnel should:

- Assist the UXOSO, if required, in decontaminating the victim and/or administering first aid
- Leave the contaminated area and undergo decontamination prior to entering the worker rest area
- Assist emergency response personnel when requested.

In the event of an accident that results in a lost work day or $2,000 or more in property damage, an accident report (ENG Form 3394) will be completed and submitted within 5 work days, and a copy will be provided to the client contact.

All workers receiving medical treatment, other than first aid, by a medical professional will obtain a medical release on the date of treatment stating one of the following: (1) the employee is not fit for duty; (2) the employee is fit for restricted duty; or (3) the employee is fit for duty. A copy of the release will be attached to the accident report and submitted to the client Project Manager.

D.13.1 EXPOSURE DATA

All work-related incidents occurring to USA employees should be reported for statistical purposes. All recordable incidents count against USA's recordable incident experience when they occur, to either an employee or a subcontractor working under the direct supervision of USA's Site Manager. Personnel man-hours will be defined as hours worked by all persons assigned to the project, including subcontractor employees under direct supervision of USA's Site Manager. These man-hours will be annotated on the Daily Operations Summary and/or the Weekly Operations Summary forms (see Appendix C of this Work Plan for forms) and transmitted to the Project Manager. The USA UXOSO will document and review with the Corporate Safety and Health Manager, the potential exposure data versus the man-hours worked per day to evaluate the association to site accidents or injury. The most current OSHA 300 form will be posted on site and is presented in Attachment 1 of this APP.

D.13.2 ACCIDENT INVESTIGATIONS, REPORTS, AND LOGS

Investigation and documentation of emergency responses shall be initiated by the UXOSO. This is important in all cases, but especially so when the incident has resulted in personal injury, property damage, or environmental impact. The documentation will be a written report and will include the following:

- Accurate, concise, and objectively recorded information
- Authentic Information: Each person making an entry must sign and date that entry. Nothing is to be removed or erased. If details are changed or revised, the person making the change should strike out the old material with a single line and initial and date the change.
- Titles and names of personnel involved
- Actions taken, decisions made, orders given, to whom, by whom, when, what, where, and how, as appropriate
- Summary of data available
- Possible exposure of personnel
- Copies of the Employer's Report of Occupational Injury or Illness (OSHA 300) or the USA Accident Report (ENG Form 3394), as appropriate, will be completed and forwarded to the Corporate Safety and Health Manager.

All accidents will be investigated and immediate steps will be taken to prevent recurrence. The client will be notified of any accidents occurring on this project site. Should an accident occur on the site, all reports and records will be documented. Copies will be maintained on site for the duration of site activities. A permanent copy will be maintained at the USA Corporate Office.

D.13.3 IMMEDIATE NOTIFICATION OF MAJOR ACCIDENTS

Should an accident occur resulting in a fatality, $100,000 or more in property damage, three or more persons being hospitalized, or possible adverse publicity to the Corps of Engineers, immediate notification will be made to the USACE Project Manager and/or Contracting Officer in person, telephonically, or by email. The reporting requirement of submitting an incident report still applies. The Corporate Safety and Health Manager will report the incident to OSHA, as required.

D.14 MEDICAL SUPPORT

A minimum of two USA personnel have been trained in cardiopulmonary resuscitation (CPR) and First Aid and have current American Red Cross certification cards. These individuals will be on site throughout the project, and they will act as First Responders to site emergencies.

The USA Occupational Physician will be available to provide patient specific information in case medical treatment is needed. Dr. James Vawter of Tierney-Vawter Medical Group can be reached at telephone number (831) 647-8700.

A first aid kit, emergency eyewash kit, and bloodborne pathogens kit will be kept in each site vehicle and in the site office. Personnel who have any type of injury (including first aid injuries) will report to the UXOSO so that he can replace used supplies in the first aid kit and he can investigate to determine the root cause(s) of the accident in order to prevent recurrences. The UXOSO will also be responsible for making the determination as to whether professional medical assistance will be required. The UXOSO will summon an ambulance, as required, and will direct emergency personnel to the victim and provide any assistance required by the emergency personnel. The ambulance will transport the victim to the designated hospital for treatment. Maps displaying the route to the hospital will be maintained in each site vehicle.

D.15 PERSONAL PROTECTIVE EQUIPMENT

When feasible, engineering controls and work practices, or a combination thereof, shall be used to protect site workers from safety and health hazards and to maintain personal exposures to hazardous substances below established exposure limits. The exposure limits used by USA will be the lower of the OSHA PEL found in 29 CFR 1910 Subpart G, and 29 CFR 1910.1000, or the American Conference of Governmental Industrial Hygienists (ACGIH) TLVs. Other recognized published exposure levels, such as those found on MSDSs, will be used if the substance is not listed by OSHA or the ACGIH. USA will not use a system of employee rotation as a means of complying with the PPE, PEL, TLV, or other published limits.

D.15.1 TYPES OF PPE

Requirements for task- and activity-specific levels of protective clothing are presented on the Activity Hazard Analyses located in this APP. Personnel performing site tasks shall use the appropriate level and type of PPE specified in this plan for each individual task. This APP makes provisions for use of the following levels of PPE, in accordance with the hazards and contamination level anticipated for each task or operation: Level A, Level B, Level C, and Level D. The following sections describe the PPE requirements for activities and locations on the site.

D.15.1.1 Level A Protection

Level A protection is not required.

D.15.1.2 Level B Protection

Level B protection is not required.

D.15.1.3 Level C Protection

Level C protection is not required.

D.15.1.4 Level D Protection

The minimal level of protection that will be required of USA personnel and visitors at the site will be Level D. The UXOSO may increase the level of protection as a result of changing requirements but may not decrease the level of protection without approval of corporate safety management. The following equipment will be used for Level D protection:

- Hard hat (around heavy equipment operations, vegetation clearance operations, or other operations that present a head hazard)
- Face shield (around vegetation clearance operations)
- Leather gloves
- Safety glasses with side shields or safety goggles
- Hearing protection, where required by high noise levels (in the vicinity of vegetation clearance operations or heavy equipment operations)
- Leather work boots with ankle support and non-slip soles; no steel toe shoes in the vicinity of magnetometer operations
- Cotton work clothes or coveralls
- Back supports (optional)
- Leg chaps (when working around vegetation clearance operations)
- Chemical-resistant work gloves (when performing equipment fueling operations or any other types of operations presenting a potential for chemical exposure)
- Life preservers, during boat operations.

D.15.1.4.1 Eye Protection

All personnel shall use appropriate eye protection when exposed to eye hazards from flying particles, liquid chemicals, or other eye hazards. All personnel shall use eye protection that provides side protection when there is a hazard from flying objects. Detachable side protectors (e.g., clip-on or slide-on side shields) meeting the pertinent requirements of this section are acceptable.

- All personnel who wear prescription lenses while engaged in operations that involve eye hazards shall wear eye protection that incorporates the prescription in its design, or wear eye protection that can be worn over the prescription lenses without disturbing the proper position of the prescription lenses or the protective lenses.
- Eye protection shall be distinctly marked to facilitate identification of the manufacturer.

Protective eye equipment, shall comply with American National Standards Institute Z87.1-89, “American National Standard Practice for Occupational and Educational Eye and Face Protection,” which is incorporated by reference as specified in Section 1910.6.

D.15.1.4.2 Head Protection

When personnel are working in the vicinity of vegetation clearance equipment, heavy equipment operations, or when the possibility of overhead hazards exist hard hats will be worn.

D.15.1.4.3 Body Protection

Special body protection is not expected to be required. Personnel will wear shirts and long pants or coveralls made of cotton to reduce the generation of static electricity.

D.15.1.4.4 Foot Protection

Because of uneven working surfaces and potential for tripping hazards common to an outdoor environment, all USA personnel shall wear sturdy leather work boots with ankle support and non-slip soles. Personnel using magnetometers for the detection of buried MEC will not wear steel-toed safety shoes, as they will affect the readings of the equipment. Safety toe boots will be required in the vicinity of heavy equipment operations and vegetation clearance operations.

D.15.1.4.5 Hand Protection

USA selects and requires employees to use appropriate hand protection when employees' hands are exposed to hazards such as those from skin absorption of harmful substances, severe cuts or lacerations, severe abrasions, punctures, thermal burns, and harmful temperature extremes. For most operations on this project, leather gloves will provide adequate protection against minor cuts, which are a hazard in most site operations. Chemical gloves will be required in fueling operations or any other operations with a potential for chemical exposure.

D.15.1.4.6 Hearing Protection

USA shall make hearing protectors available to all employees exposed to an 8-hour time-weighted average (TWA) of 85 dB or greater. Hearing protectors shall be replaced as necessary. Hearing protection will be required for all personnel working in and around any operations likely to produce high noise levels, such as during the use of chain saws and weed-eaters during vegetation clearance operations and heavy equipment operations.

D.15.2 PROPER PPE SELECTION

Each task outlined in the PWS has been assessed to determine the risk of personnel exposure to safety and health hazards, which may be encountered during its conduct. The hazard assessment is based on available information pertaining to the historical use of the site, site contaminant characterization data, and the anticipated operational hazards. This information has been provided by the client, or collected by USA site personnel. The PPE assigned as a result of the hazard assessment represents the minimum PPE to be used during initial site activities. Since hazard/risk assessment is a continuing process, changes in the initial types and levels of PPE will be made in accordance with information obtained from the actual implementation of site operations and data derived from the site monitoring. As a general rule, the levels of PPE will need to be reassessed if any of the following occur:

- Commencement of a new work phase, such as the start of drum sampling or work that begins on a different portion of the site
- Change in job tasks during a work phase
- Change of season/weather

- When temperature extremes or individual medical considerations limit the effectiveness of PPE
- Contaminants other than those previously identified are encountered
- Change in ambient levels of contaminants
- Change in work scope, which affects the degree of contact with contaminants.

During the selection of PPE, the Corporate Safety and Health Manager and UXOSO will also take into consideration the following factors:

- Limitations of the equipment
- Duration of the work mission
- Temperature extremes
- Material flexibility
- Durability/integrity of the equipment.

D.15.3 UPGRADING/DOWNGRADING PPE

If work tasks are added or amended after completion and approval of the APP/SSHP, the UXOSO will conduct the task hazard assessment and consult with the Corporate Safety and Health Manager and/or the CSP. The level and type of PPE to be used will be identified. The UXOSO can increase the level of PPE when the situation warrants, as a result of an increase in hazardous exposure. Any decreases in the level of PPE must be approved by the Corporate Safety and Health Manager and/or CSP, only after review of documentation demonstrating that the conditions and/or potential for hazardous exposure are reduced enough to justify the downgrade. Normally a week of data demonstrating a reduced hazard will be required to justify a downgrade in PPE.

D.15.4 GENERAL REQUIREMENTS

All PPE shall be provided, used, and maintained in a sanitary and reliable condition where it is necessary. PPE is required because of hazards of processes or environment, chemical hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation, or physical contact. All PPE will be used in the manner for which it was designed. The assignment of PPE will be based upon hazard analysis, and the equipment will be selected based on its protection factor against site hazards.

D.15.5 INSPECTIONS

Each piece of PPE will be inspected daily prior to use. Defective or damaged PPE shall not be used. It shall be removed from service and turned in for repair, or removed from the site for disposal and replaced with new PPE. During the work task, buddy teams should periodically inspect each other's PPE for evidence of chemical attack, such as discoloration, swelling, stiffening, or softening.

D.15.6 CLEANING AND DECONTAMINATION

The UXOSO will be responsible for ensuring that PPE is in good, clean, working order prior to issuing the PPE the first time. Once issued, site personnel will ensure that reusable articles of PPE are maintained in a clean and sanitary fashion. For items used inside an EZ, site personnel will follow the requirements of the Site Specific Decontamination Plan and ensure that the PPE is properly decontaminated before removing the item from the EZ or Contamination Reduction Zone.

D.15.7 MAINTENANCE

Maintenance of PPE can vary greatly, based upon the complexity of the PPE and the intricacy of the repair involved. The UXOSO will become familiar with the manufacturer's recommended maintenance and, when possible, repair defective PPE. If unable or unauthorized to conduct the repair, the UXOSO will return the item to the manufacturer for repair, or procure a replacement.

D.15.8 STORAGE

PPE will be stored in a location that is protected from the harmful effects of sunlight, damaging chemicals, moisture, extreme temperatures, impact, or crushing. If needed, the UXOSO will designate a specified area for the storage of PPE.

D.15.9 PPE PROGRAM EFFECTIVENESS

Based on the inhalation hazard and potential chemical exposures anticipated on these sites, Level D PPE is considered adequate for the work that is to be accomplished at the sites. If work tasks are added to the PWS after approval of this APP and its SSHP, the SUXOS and/or UXOSO (as applicable) shall identify and assess the task hazards and relay that information to the Corporate Safety and Health Manager. The Corporate Safety and Health Manager or his staff will prepare an amendment to the SSHP and submit the amendment for approval from the Corps of Engineers. The amendment will be added to the SSHP upon Corps of Engineers approval.

The UXOSO will ensure PPE use complies with all applicable OSHA, USACE, and USA requirements. It is the responsibility of each employee to report to work wearing proper attire and to assemble the necessary PPE prior to initiating donning procedures.

D.15.10 TRAINING

USA shall provide training to each employee who is required by this section to use PPE. Each affected employee shall demonstrate an understanding of the training, and the ability to use PPE properly, before being allowed to perform work requiring the use of PPE. Each such employee shall be trained to know at least the following:

- The decisions and justifications used to select each piece of PPE
- The nature of the hazards and the consequences of not using PPE
- What PPE will be required for the conduct of each task
- When PPE will be required during the performance of each task
- How to properly don, doff, adjust, and wear each piece of PPE
- The proper inspection, cleaning, decontaminating, maintenance, and storage of each PPE item used
- The limitations of the PPE.

All personnel receiving PPE training will be required to demonstrate an understanding of the training topics and the ability to correctly use the PPE. This will be accomplished through the UXOSO supervising and visually inspecting each individual's ability to properly don and use the PPE during initial use of the PPE.

When the UXOSO has reason to believe that any affected employee who has already been trained does not have the understanding and skill required, he/she should retrain each such employee. Circumstances where retraining is required include, but are not limited to, situations where:

- Changes in the workplace render previous training obsolete

- Changes in the types of PPE to be used render previous training obsolete
- Inadequacies in an affected employee's knowledge or use of assigned PPE indicate that the employee has not retained the requisite understanding or skill.

Upon completion of the training and after each employee has successfully demonstrated the requisite understanding, the UXOSO will complete the Training form (see Table D-5). This identifies: the employees who attended the training course and successfully demonstrated the required knowledge; the date(s) of the training and demonstration session(s); and the PPE covered by the training session.

Table D-5: USA Certification of PPE Training

SITE INFORMATION	
Site Name:	
Location:	Instructor(s):
Date of Classroom Instruction:	Date of Demonstration:

PPE TRAINING COURSE ATTENDANTS

The following personnel have attended the site PPE training course, and demonstrated, through use, an understanding of the donning/doffing procedures, inspection, cleaning, maintenance, storage, limitations, and proper disposal of the PPE listed on this certificate. These personnel are now qualified to use the site- and task-specific PPE, as required by the APP/SSHP.

Name	Organization	Name	Organization

TYPES AND LEVELS OF PPE ADDRESSED DURING TRAINING

Trainer's Initials	Personal Protective Equipment Reviewed	Trainer's Initials	Personal Protective Equipment Reviewed

CERTIFICATION

I the undersigned do hereby certify that the above-listed personnel have received the requisite training and successfully demonstrated their ability to use the PPE listed above, in accordance with the USA Personal Protective Equipment Program.

Name (printed):	Signature:	Date:

D.16 PLANS, PROGRAMS, AND PROCEDURES

The following subsections describe the plans, programs, and procedures that will be used during site operations.

D.16.1 LAYOUT PLANS

Layout plans are not applicable for this project, as temporary structures will not be constructed.

D.16.2 EMERGENCY RESPONSE PLAN AND CONTINGENCY PROCEDURES

The UXOSO will perform pre-emergency planning before starting field activities and during the mobilization and site-specific training phase of the project, and will coordinate emergency response with police/fire/emergency rescue personnel and the hospital. Pre-emergency planning meetings shall be used to inform local authorities of the nature of site activities that will be performed under the PWS and the potential hazards that activities may pose to site workers, the environment, and the public.

D.16.2.1 Procedures and Tests

An agreement will be established between USA and emergency response personnel and the hospital regarding responsibilities of each party in responding to a project site emergency. The UXOSO will verify all on-site emergency services information, to include procedures for requesting services. It shall be the UXOSO's responsibility to post these procedures and contact information in accordance with the requirements of this APP/SSHP. Pre-emergency planning tasks include:

- Post emergency instructions and telephone numbers in the site office and in each site vehicle
- Inspect all emergency equipment and supplies to ensure they are in proper working order
- Provide a site map marked with planned evacuation routes, assembly points, and emergency equipment and supplies
- Provide a map with the route to the medical clinic marked and highlighted, with copies of this map posted in the emergency evacuation vehicle and all other site vehicles
- Conduct an emergency response drill to test the effectiveness of the Emergency Response Plan and Contingency Procedures (ERCP)
- Review and revise the ERCP in the event of a failure of the plan in an actual or staged emergency, or when changes in site conditions or scope of work affect the ERCP
- Before normal activities are resumed, on-site personnel must be prepared and equipped to handle another emergency. These follow-up activities should be completed prior to actual work commencing
- The Corporate Safety and Health Manager will notify appropriate Government agencies as required (Reminder: OSHA must be notified if there have been any fatalities or three or more hospitalizations)
- Restock, service, and inspect all equipment and supplies
- Review and revise all aspects of the SSHP as necessary to address and prevent future emergencies of this type.

As part of mobilization training, prior to start of project work, all personnel will review the points of contact list and where it is posted, and the location of the nearest medical treatment facility. A meeting place off site will be identified in case of emergency evacuation and the responsibilities of all persons on site will be reviewed.

- All personnel will review the locations of fire extinguishers and be competent to use one properly

- All emergency telephone numbers will be posted next to the directions to the hospital map on site.

D.16.2.2 Potential Site Emergencies

There are several emergencies, which could reasonably be anticipated during project activities, including:

- Thermal stress
- Worker injuries; slips, trips, or falls; and/or illness
- Fires and explosions.

D.16.2.3 Personnel and Lines of Authority

In the event of an emergency, the UXOSO will be designated as the On-Scene Incident Commander and will have the overall responsibility for implementation of the ERCP and coordination with responding off-site emergency services. In the event of a medical emergency, the UXOSO will summon the USA first responders to assist the victim. The UXOSO will make the determination as to whether professional medical assistance is required and will summon the ambulance, if required. The UXOSO may also direct USA personnel to assist the emergency rescue personnel.

Specific responsibilities of the UXOSO include, but are not limited to, the following:

- Notifying local police, fire department, and other off-site emergency units, as required
- Notifying the SUXOS and providing updates as conditions change (The SUXOS will notify the Project Manager, who will be responsible for informing the Corps of Engineers Contracting Officer and Project Manager.)
- Directing off-site emergency response personnel to the scene and providing assistance
- Site control
- Completing any follow-up reports
- Rescuing personnel
- Accounting for all site personnel and visitors
- Providing emergency first aid
- Preventing further injury of personnel
- Providing current status of the incident to the USA Corporate Safety and Health Manager
- Ensuring that on-site emergency response personnel don the proper PPE, if needed
- Assisting on-site emergency response personnel with treatment and transport of sick/injured
- Providing medical background information of the sick/injured and applicable site health and safety information to the off-site emergency medical responders
- Accompanying sick/injured personnel to the hospital.

If the emergency involves employee injury, UXOSO will complete the USA Accident Report. The Corporate Safety and Health Manager will be responsible for notifying applicable Federal, state, and local authorities/agencies. Once the emergency has been resolved, the UXOSO, Project Manager, and Corporate Safety and Health Manager will conduct a follow-up investigation and critique. Actions will be taken to prevent recurrence.

All USA personnel and visitors will be responsible for:

- Reporting any site emergencies to the SUXOS or UXOSO
- Knowing the exit location and evacuation route within the EZ

- Knowing the pre-planned evacuation assembly point and going there in the event of an emergency
- Assisting emergency response personnel, as requested.

D.16.2.4 Emergency Recognition and Prevention

An emergency is an unplanned event that threatens the safety of any personnel. Compliance with this APP can assist in the prevention of anticipated site emergencies. These emergency situations can easily be recognized by visual observations, worker complaints, or monitoring instruments.

Prevention of emergencies will be aided by the effective implementation of this APP and its accompanying Site Safety and Health Plan, personnel awareness, contingency planning, and on-site safety meetings. Anticipated emergencies may include physical injury, illness, fire, explosion, chemical spill or release, inclement weather, and natural disasters. The UXOSO will use the site-specific briefing and/or the Tailgate Safety Briefings to inform site workers of the recognition, prevention, and response procedures for each anticipated emergency.

In the event of an emergency, site personnel will be notified by either an alarm or verbal communication. Personnel will be notified to:

- Stop work activities
- Evacuate to the designated assembly point in the support zone
- Begin emergency procedures
- Notify off-site emergency response organizations.

After evacuation, the UXOSO will account for all personnel, ascertain information about the emergency, and advise responding on-site personnel. The UXOSO will contact, advise, and coordinate with responding off-site emergency personnel if deemed necessary by the situation.

In all situations that require evacuation, personnel shall not re-enter the work area until:

- The conditions causing the emergency have been corrected
- The hazard has been reassessed
- The SSHP has been revised and reviewed with on-site personnel, if needed
- Instructions have been given for authorized re-entry by the UXOSO.

D.16.2.5 Safe Distances and Places of Refuge

The UXOSO will determine safe distances and places of refuge. Prior to the start of each work day, the UXOSO or SUXOS (as applicable) will hold a safety meeting with all personnel and discuss the following:

- Times when the gate to ranges may be locked
- Who has the gate key or combination on site
- Evacuation routes from work areas
- The assembly point to be used in the event of an emergency
- Locations of the nearest fire extinguishers and spill containment equipment
- Discussion of specific health and safety concerns of personnel.

D.16.3 EVACUATION PROCEDURES

The UXOSO will establish evacuation routes. Evacuation notification will be one long blast on an air horn, vehicle horn, or direct verbal communication. If evacuation is necessary, all personnel are to:

- Gather equipment to the extent safely possible
- Evacuate to the vehicle(s) location and prepare to move out.

D.16.4 MEDICAL EMERGENCY PROCEDURES

Any person(s) who become ill or injured during work activities must immediately inform the UXOSO regardless of the severity of the illness or injury. The victim(s) will be assisted by the First Responders at the direction of the UXOSO. The UXOSO will make the determination if professional medical assistance will be required, and he will summon the ambulance if necessary. All personnel at the work site will use the buddy system. All personnel using the buddy system will stay within sight of their partner. If a partner becomes incapacitated or severely ill, the UXOSO will be called. In the event that a cessation of work is ordered, all personnel should:

- Assist the First Responders, if required, in administering first aid
- Leave the area if the hazard warrants such action.

If the medical emergency is not severe, the victim will be treated on site by the First Responders with additional treatment at the medical treatment facility, if required. If the medical emergency is serious, the victim is brought to the medical treatment facility for treatment via ambulance (air or ground).

It is not anticipated that hazardous waste decontamination shall be required during any activities under the PWS. This determination has been made based upon available knowledge of past activities conducted at the site and the type of work taking place. Basic cleaning and disinfection is all that will be required prior to most types of treatment. If a worker is accidentally injured using chemicals brought onto the site, the first aid procedures described in the MSDS are followed by the First Responders to clean as much of the chemical off as possible before treatment. The MSDS is taken with the victim to the medical treatment facility for treatment.

D.16.5 BLOODBORNE PATHOGENS PROGRAM

The strategy of "Universal Precautions" was developed by the Centers for Disease Control to address concerns regarding transmission of Human Immunodeficiency Virus (HIV). This concept stresses that all sources should be assumed to be infectious for HIV, hepatitis B virus, and other bloodborne pathogens. The philosophy of universal precautions shall be applied whenever USA employees render first aid involving potential contact with blood, body fluids, or other potentially infectious materials. All blood and body fluids will be treated as if they are infectious. PPE and cleanup procedures will be implemented accordingly.

D.16.5.1 Engineering Controls

Engineering controls will be used whenever possible to eliminate or reduce the potential for employee exposure, and will be periodically examined, maintained or replaced to ensure their effectiveness. USA employees shall observe "universal precautions," and treat all body fluids as potentially infectious materials. USA shall provide hand-washing facilities readily accessible to employees. Where the installation of hand-washing facilities is not feasible, appropriate antiseptic cleanser and clean paper or cloth towels shall be provided. USA employees shall wash their hands and any other potentially exposed skin with soap and running water as soon as possible:

- After removing gloves or other PPE
- After contact with potentially infectious materials
- Even after washing with antiseptic as described
- USA employees shall flush eyes or other mucous membranes with copious amounts of water as soon as possible after contact of these areas with potentially infectious materials.

For emergency first aid situations involving multiple victims, equipment shall not be used on different victims unless it has been properly decontaminated or if the victim's medical condition would be seriously affected by a delay in treatment.

D.16.5.2 Safe Work Practices

Safe work practices will be implemented whenever possible to eliminate or reduce the potential for employee exposure. Employees shall wash their hands immediately or as soon as feasible after removal of gloves or other PPE. Employees shall wash hands and any other skin with soap and water, or flush mucous membranes with water immediately following contact with blood or potentially infectious materials.

If potentially contaminated sharps are encountered, the item shall immediately be disposed of in an appropriate puncture-resistant container or decontaminated.

Eating, drinking, smoking, applying cosmetics or lip balm, handling of contact lenses, any hand-to-face activities, or storage/handling of food is prohibited in all areas where potentially infectious materials are present.

Equipment that has become contaminated will be decontaminated prior to servicing or storage, unless decontamination is not feasible, in which case the equipment will be disposed of properly in appropriately labeled and color-coded containers.

D.16.5.3 Personal Protective Equipment

When occupational exposures remain after the implementation of engineering and work practice controls, appropriate PPE will be utilized to control employee exposures.

USA shall provide appropriate PPE including gloves, face masks, eye protection, mouthpieces, etc., for protection against potentially infectious materials.

PPE shall not allow potentially infectious materials to pass through or reach an employee's clothes, skin, eyes, mouth, or other mucous membranes during normal use for the expected duration of time for which the PPE will be used.

Employees shall use the appropriate PPE unless, in unusual circumstances, the employee believes that using the protective equipment will prevent the administering of first aid or would pose an increased risk. Any incident where the use of protective equipment is declined shall be investigated and documented by the UXOSO and be approved by the Corporate Safety and Health Manager.

Single-use protective equipment, such as surgical gloves, shall be disposed of after each use, or as soon as possible after the equipment has become damaged.

Multi-use protective equipment, such as coveralls or utility gloves, shall be cleaned and decontaminated after each use or when they become contaminated in order to maintain its effectiveness.

Multi-use protective equipment shall be removed, and then disposed of or repaired as soon as possible after becoming damaged.

When PPE is removed, it will be placed in an appropriately designated area or container for storage, washing, decontamination or disposal. PPE shall be removed and disposed or decontaminated before leaving the area.

Gloves will be worn when it can be reasonably anticipated that the employee may have hand contact with potentially infectious materials.

Disposable (single-use) gloves will not be washed for reuse and will be disposed of after each use or if their ability to function as a barrier is compromised.

Utility gloves may be decontaminated for re-use if the integrity of the gloves is not compromised. However, they must be discarded if they exhibit signs of deterioration or when their ability to function as a barrier is compromised.

Masks, in combination with eye protection devices such as safety glasses, goggles, or face shields, will be worn whenever blood or other potentially infectious materials may be generated and eye, nose, or mouth contamination can be reasonably anticipated.

D.16.5.4 Decontamination Procedures

All equipment, working surfaces and non-working surfaces shall be decontaminated after contact with potentially infectious materials. A solution of ten parts water to one part bleach or equally effective material shall be used to clean contaminated areas.

Contaminated sharp objects shall be cleaned up using mechanical means, such as a brush and dustpan. Sharp objects shall not be picked up directly with the hands.

Two pairs of gloves, inner surgical gloves and outer utility gloves shall be worn for cleaning contaminated surfaces. A smock or apron and eye protection shall also be worn.

Only those employees directly involved with the decontamination efforts shall be allowed in the work area while cleaning is taking place.

All cleaning equipment shall be disinfected or disposed of in accordance with this program.

For minor injuries where the employee is able to return to work, the injured employee shall clean up his/her own blood or other potentially infectious materials.

D.16.5.5 Housekeeping and Waste Disposal

The work site will be maintained in a clean and sanitary condition to prevent the spread of contamination to other areas of the facility. All equipment and working surfaces will be cleaned and decontaminated after contact with blood or other potentially infectious materials. Contaminated work surfaces and equipment shall be decontaminated with an appropriate disinfectant immediately after they become contaminated in accordance with the decontamination section of this program. Regulated waste, other than contaminated sharps, shall be placed in containers which are: closable, constructed to contain all contents and prevent leakage, properly labeled or color-coded, and closed prior to removal or replacement. Labels or color-coding shall be fluorescent orange or orange-red, and display the biohazard symbol in a contrasting color.

Regulated waste containing contaminated sharps will be placed in containers that are: closable, puncture resistant and leak proof on sides and bottom, properly labeled or color-coded, and closed prior to removal or replacement. Contaminated clothing, equipment, and other materials shall be handled as little as possible and with minimum agitation. Bags containing contaminated materials shall not be carried or handled from the bottom. All regulated waste will be disposed of in accordance with applicable Federal, state, and local regulations.

D.16.5.6 Emergency Medical Facilities

For most anticipated types of on-site injuries, site personnel will report to the UXOSO, who will have the First Responders examine the injury and provide first aid treatment. In cases of more serious injuries or illnesses, the victim will still report to the UXOSO (or the UXOSO will come to the victim) and will examine the victim and determine if further medical treatment is indicated. If required, the UXOSO will summon an ambulance to transport the victim to the nearest hospital.

The nearest medical treatment facility is the Culebra Health Clinic at (787) 742-3511. See Attachment 3 for directions to the medical treatment facility from the various work locations.

D.16.5.7 Material Safety Data Sheets

As part of the USA Hazard Communication Program, an MSDS binder will be maintained on site, which includes copies of MSDSs for all hazardous materials brought onto the site by USA. It will be kept in the UXOSO site vehicle during operations. This MSDS binder will be available on request to all site personnel during all working hours of the site. If site workers have further questions about any of the hazardous materials they come into contact with, the USA UXOSO or the Corporate Safety and Health Manager will locate the required information and pass it on to the employee. If an employee is injured as a result of exposure to a chemical on site, that MSDS will be retrieved and given to the medical providers. MSDSs for chemicals expected to be used on this site are included in Attachment 6; however, if additional materials are purchased for use on the site, these MSDSs will be added to the site MSDS binder.

Chemical Inventory sheets will be prepared by the UXOSO after mobilization to the site and will be maintained on site for the duration of project activities. As chemicals are brought to the site, or are used, the inventory will be updated accordingly.

D.16.5.8 Training

Training in emergency procedures will be accomplished by performing drills. After any drill or real emergency scenario, the Project Manager, Corporate Safety and Health Manager, and UXOSO will evaluate the situation and determine any potential areas for improvement in the procedures. Procedures will be updated accordingly.

D.16.6 SPILL PLANS

USA will conduct cleanup operations in the event of a spill of hazardous material (e.g., fuel or oil from UXO field operations). The UXOSO will manage the collection of the spilled material with absorbent pads and containerize the pads or materials within Department of Transportation-approved drums for disposal as potential contaminated hazardous waste. A complete spill kit will be maintained on site when spills are a potential hazard.

In the event of a spill or leak of any potentially harmful material (regardless of quantity), on-site personnel will:

- Notify the UXOSO immediately
- The UXOSO shall notify the Project Manager of the spill/leak with relevant information (location, time, chemical identity, quantity, hazards listed on the MSDS), and any corrective actions/measures taken
- Locate the source and stop the leak/spill if it can be done safely (as dictated by the UXOSO)
- Begin containment and recovery of spilled material (as directed by the UXOSO), using appropriate PPE and spill cleanup equipment and materials
- Once notified, the USA Project Manager will in turn notify the USACE Project Manager and the Contracting Officer. The USACE Project Manager will advise USA if any additional actions are necessary.

D.16.7 FIREFIGHTING PLANS

In the event of a fire or explosion, the UXOSO will notify the police, fire department, and ambulance, as required. The UXOSO will also contact the Corps of Engineers site Safety Representative and Project Manager, and escort the response personnel to the location of the fire or explosion. The UXOSO will determine the extent of the fire, coordinate and manage the fire suppression effort until the fire department arrives, use available on-site fire extinguishers on incipient stage fires only, and provide emergency first aid as needed. Site personnel will not fight fires containing explosives. The responding fire department personnel will be informed of the nature of the fire and, if explosives are present, the fragmentation distance from which to fight or contain the fire.

The decision on whether or not to try to extinguish a fire using available site personnel and equipment will be made by the UXOSO and based on whether the fire is small, large, or involves explosives.

D.16.7.1 Small Fires

A small fire is defined as a fire that can most likely be extinguished by site personnel using portable extinguishers. A small fire must also be free and clear of explosive materials, especially MEC. If a small fire occurs, the UXOSO will direct site personnel to perform the following, if safe to do so:

- Evacuate unnecessary personnel to an upwind position
- Attempt to extinguish the fire using portable fire extinguishers or by smothering
- Remove any essential or flammable items from the path of the fire
- Notify emergency response services (fire, police, ambulance, hospital, etc.), as needed.

If a fire extinguisher is used, this must be immediately reported to the UXOSO. The fire extinguisher must be immediately removed from service until it can be recharged. Another fire extinguisher must be made available to the operating area. The area around where the fire occurred must be watched for a minimum of 30 minutes after the fire has been extinguished to assure re-ignition does not occur. If personnel are not working in the area, the UXOSO should check the area of the fire periodically to assure re-ignition does not occur.

D.16.7.2 Large Fires

A large fire is defined as a fire that cannot be extinguished or that, because of its size, cannot be extinguished using portable fire extinguishers. In the event that a large fire occurs and the fire does not involve explosive materials, the UXOSO will direct personnel to conduct the following, if safe to do so:

- Evacuate all non-essential personnel from the site to an upwind location
- Notify the fire department and other emergency response services (police, ambulance, hospital, etc.), as needed
- Order the appropriate level of protective equipment to be worn by personnel responding to the fire
- Attempt to control the fire to the extent possible
- Remove any essential or flammable items from the path of the fire.

D.16.7.3 Fires Involving Explosive Materials

If a fire occurs that involves explosive materials such as chemicals, fuels, or MEC, the UXOSO will order the immediate evacuation of all site personnel to an upwind assembly point at least fragmentation distance from the fire site. The UXOSO will then notify the fire department and any other emergency services (police, ambulance, hospital, etc.), as needed. At no time will USA personnel fight a fire involving explosive materials, nor will they allow outside emergency personnel to do so. The fire department personnel may not enter any closer than fragmentation distance from the fire and they may spray water to surrounding buildings or structures in order to prevent the spread of fire.

After the fire has burned itself out, the site must be barricaded and entry prohibited until adequate cooling time has passed (at least 24 hours for a large fire). Explosive materials that may not have discharged during the fire may still be liable to function in the presence of extreme heat. After the site has cooled down, the UXOSO will inspect the site and the condition of any MEC involved in the fire, and make a determination as to whether or not the site is safe for others to enter.

If MEC is still intact, the UXOSO will determine whether or not it is considered to be hazardous. If it is non-hazardous, it will be moved to a secured collection point, and will be sold to a qualified recycler at the end of the project. If it is considered hazardous, a UXO team will destroy it in place. All MEC must be either removed or destroyed in place before non-UXO qualified personnel are permitted to enter the area.

If non-UXO-qualified personnel must enter the site for purposes of fire investigation, they must receive a briefing on the potential hazards of MEC on the site. They must be accompanied at all times by a UXO-qualified employee of USA. NO OUTSIDE PERSONNEL WILL BE PERMITTED ONTO THE SITE WHILE THERE IS A KNOWN MEC HAZARD PRESENT. If during the course of the investigation MEC is observed, the site will be evacuated of all non-UXO-qualified personnel until the site can be rendered safe for re-entry.

D.16.7.4 Explosions

In the event of an explosion, the UXOSO will order the evacuation of all site personnel to a safe, upwind assembly point at least fragmentation distance away. The UXOSO will then notify all necessary emergency response services. After an explosion has occurred, the site will remain barricaded for a minimum of 30 minutes before entry is permitted. The UXOSO will enter the site with a team member and inspect for the presence and condition of MEC. If MEC is non-hazardous, it will be removed to a secured collection point for later sale to a qualified recycler. If MEC is hazardous, a USA UXO Team will be notified and the MEC will be destroyed by the UXO team. Non-UXO-qualified personnel may not enter the area until all known MEC has been removed or destroyed. If visitors need to enter the site, they must first be briefed on the potential hazards of the site. They must be accompanied at all times by UXO-qualified personnel (escort). If MEC is discovered during the course of their visit, they must immediately leave the site until it can be rendered safe for re-entry.

D.16.7.5 Safe Distances and Places of Refuge

The EZ of this project is the actual project footprint and an additional distance around it of the hazardous fragment distance of the most hazardous MEC expected to be encountered on the site. Outside of that distance is the support zone. Normally, during an evacuation, personnel would evacuate to the support zone, where the UXOSO would take roll and account for all site personnel. An exception to this rule would be in the case of encountering a CWM item, in which case personnel would evacuate at least 450 ft upwind of the item. This location would change with the shifting winds, so it cannot be specifically identified.

D.16.7.6 Posting of Emergency Telephone Numbers

Emergency resources are listed in Table D-6.

Table D-6: Emergency Contact Numbers

Contact	Phone Number
Fire	787-742-3530
Police	787-742-3501
Hospital: Culebra Medical Clinic	787-742-3511
AERO Med Medical Evacuation Flight	787-756-3480
Emergency Management Office - Culebra	787-742-3849
Poison Control Hotline	1-800-222-1222

Contact	Phone Number
USEPA National Response Center	1-800-424-8802
CHEMTREC	1-800-424-9300
Federal OSHA Emergency Hotline	1-800-321-OSHA (6742)
TEU (duty hours)	410-671-3601
TEU (after duty hours)	410-671-2773
USA Project Manager, Doug Ralston	813-343-6368
USA Corporate Safety and Health Manager, Robert Crownover	813-343-6364

D.16.8 WILD LAND FIRE PREVENTION PLAN

In order to prevent grass fires from starting in the area, USA will control employee smoking. Smoking will be permitted only in designated areas. These areas will be equipped with a fire extinguisher, as well as a can containing sand, where cigarette butts can be safety discarded without concern for the spread of fire. All lighters and matches will remain in the designated smoking area and will not be permitted into the site. All flammable liquids brought to the site for the purpose of fueling equipment will be stored in an approved flammable liquid container in a designated flammable liquid storage area. No smoking will be permitted within 50 ft of the storage or use of flammable materials.

In the event that a grass fire does start in the area, all personnel will be trained in the use of fire extinguishers, and fire extinguishers will be available to all site operations. Fire extinguishers are designed for the incipient stages of a fire, which is when they are most effective. If a large fire starts, employees will be instructed to evacuate the area to at least the hazardous fragment distance from the site and to contact the fire department. The fire department will remain at least fragmentation distance from the fire and implement applicable procedures to prevent the fire from spreading outside of the fragmentation distance.

D.16.9 MAN OVERBOARD/ABANDON SHIP PLAN

USA is contracting with Sea Ventures to provide transportation back and forth from Culebra to the offshore operations sites. All personnel on the boat will be required to wear a personal flotation device for the duration of the boat ride. The buddy system will be in effect for the ride back and forth to the site. USA employees will watch out for each other. In the event that somebody falls overboard, co-workers will immediately alert the boat's captain, who will immediately turn the boat around and go back to retrieve the missing individual. The boat is equipped with rescue equipment to assist in getting the individual back on board.

Visitors to the site will also be required to wear a personal flotation device during transportation by boat to and from the remote island sites. Visitors will receive a safety briefing by the UXOSO. A qualified UXO Technician will be responsible for escorting visitors for the duration of the visit. Should a visitor fall overboard, the same rescue procedures will apply.

D.16.10 HAZARD COMMUNICATION PROGRAM

The program establishes procedures for USA employees who handle and store chemical products at USA sites. It ensures that hazards of all chemicals purchased are evaluated and the information concerning their hazards is transmitted to employees. The delivery of information is to be accomplished by employee training, container labeling, and other forms of warning and MSDSs. All MSDSs are requested from the suppliers at the time of order. If not available, then a recent MSDS will be downloaded from the Internet.

As part of the USA Hazard Communication Program, an MSDS binder will be maintained on site, which includes copies of MSDSs for all hazardous materials brought onto the site by USA. It will be kept in the UXOSO site vehicle during operations, and all USA personnel will be made aware of that fact. This MSDS binder will be available on request to all site personnel during all working hours of the site. If site workers have further questions about any of the hazardous materials they come into contact with, the USA Corporate Safety and Health Manager or his staff will locate the required information and pass it on to the employee.

All USA employees who will be performing work involving the handling of hazardous materials will receive Hazard Communication training detailing the hazards of the product, appropriate protective measures to prevent exposure to the product, as well as safe procedures for storage and handling of the product, and response to emergencies. Personnel may request an MSDS for any hazardous material on the site at any time. This training will occur as part of the initial mobilization training at the site and will be documented on the USA Documentation of Training Form.

The UXOSO must ensure that project personnel can immediately obtain the required information about chemicals of concern during an emergency.

D.16.11 RESPIRATORY PROTECTION PLAN

Because of the type of work taking place, respirators are not expected to be required on these sites. Should unforeseen hazards develop, which would require a respirator, the USA Respiratory Protection Program would be followed per the USA Corporate Safety and Health Program.

D.16.12 HEALTH HAZARD CONTROL PROGRAM

Because of the type of work that will be taking place on this project site, toxic environments are not anticipated; therefore, the Health Hazard Control Program is not required. However, if toxic material or chemical agents are encountered, an Activity Hazard Analysis will be conducted and a Health Hazard Control Program will be implemented.

D.16.13 LEAD ABATEMENT PLAN

As this work is a remedial investigation as opposed to a remediation project, the site will be characterized. Lead abatement will not be required.

D.16.14 ASBESTOS ABATEMENT PLAN

As asbestos is not expected to be encountered on these outdoor sites, an Asbestos Abatement Plan is not required.

D.16.15 ABRASIVE BLASTING

Abrasive blasting is not required on this project.

D.16.16 CONFINED SPACE/EXCAVATION PLAN

Excavation work will be taking place as part of the remedial investigation, however, the excavations are not expected to exceed 4 feet in depth. Should an excavation exceed 4 ft in depth, then the excavation would be considered a confined space and the USA Confined Space Program and the USA Excavation Safety Program would be implemented.

D.16.17 HAZARDOUS ENERGY CONTROL PLAN

The work on these project sites should not require the use of equipment that would require a Hazardous Energy Control Plan. Should a particular site require it, the USA Lock Out/Tag Out program would be implemented per the Corporate Safety and Health Program and put into the SSHP.

D.16.18 CRITICAL LIFT PROCEDURES

Because USA will not be performing any crane operations on this project, critical lift procedures will not be required.

D.16.19 CONTINGENCY PLAN FOR SEVERE WEATHER

Rain and severe wind conditions can constitute a safety hazard to field operations at any site. The UXOSO will monitor the weather closely. If the area becomes wet, muddy, slippery, or windy such that an unacceptable level of risk exists for personnel who are working in proximity to MEC items, then MEC operations will cease until the UXOSO determines it to be safe to continue.

No MEC operations will take place if an electrical storm is within 10 miles of the site. The UXOSO and/or SUXOS will use an electrical storm monitor to determine if an electrical storm is approaching. MEC operations will cease when an electrical storm is within 10 miles of the site, and will not resume again until the UXOSO determines that the electrical storm is at least 10 miles past the site.

Daily weather conditions will be a part of the daily briefing. Many people incur injuries or are killed as a result of misinformation and inappropriate behavior during severe weather. During severe weather, project personnel will seek shelter in an appropriate location (e.g., building or vehicle).

The individual is ultimately responsible for his/her personal safety and has the right to take appropriate action when threatened by severe weather.

D.16.19.1 Safe Locations during Severe Weather and Locations to Avoid

No place is absolutely safe from severe weather; however, some places are safer than others.

- Large enclosed structures (substantially constructed buildings) tend to be much safer than smaller or open structures
- The risk for lightning injury depends on whether the structure incorporates lightning protection, the construction materials used, and the size of the structure
- In general, fully enclosed metal vehicles such as cars, trucks, buses, or vans with the windows rolled up provide good shelter from many weather conditions.

AVOID being in or near high places and open fields, light poles, metal fences, water (lakes, streams, rivers, or wet surfaces).

When inside a building, AVOID use of the telephone, washing your hands, or any contact with conductive surfaces with exposure to the outside such as metal door or window frames, electrical wiring, telephone wiring, cable TV wiring, or plumbing, if lightning is a factor.

D.16.19.2 Safety Guidelines for Individuals

Generally speaking, identify and seek shelter that is appropriate for the type of severe weather you are encountering. Proper shelter will always include a sound structure and removes you from the elements.

When available, pay attention to weather warning devices such as a National Oceanic and Atmospheric Administration (NOAA) weather radio and/or credible weather detection systems. However, do not let this information override good common sense.

D.16.19.3 Hurricane Evacuation Plan

Hurricanes are a potential threat to the area during hurricane season, which runs from May to November. Due to advanced hurricane tracking systems, there will normally be warning of an impending hurricane several days in advance of the event. During the hurricane season, it will be a duty of the UXOSO to closely monitor the weather forecasts. If a hurricane is forecast to hit Puerto Rico on a specific day, the crew should cancel operations for that day and remain on Culebra and seek shelter until the storm passes. In advance of a hurricane the waters could become treacherous and diving operations would be considerably more hazardous.

Personnel should seek shelter in a substantial building. The UXOSO will determine in advance the location of the established emergency hurricane shelter on Culebra. This shelter is in the high school gymnasium. The high school is on Route 251 between the airport and the city of Dewey. (The UXOSO can obtain additional emergency information from the Culebra Emergency Management Office at (787) 742-3849.)

The crew will report to the shelter as the storm approaches and remain there until the storm passes. If the police call for an evacuation of the island in advance of a hurricane, the crew will follow their directions and evacuate to the main island via available ferry and/or air transportation. Evacuations of this type normally occur a day or more in advance of the storm. Once on the main island, the crew will locate the established emergency hurricane shelter. Personnel will report to the established hurricane shelter and report to the UXOSO, who will assure all USA Environmental personnel have been accounted for. Personnel will remain in the hurricane shelter until the storm has passed and the evacuation order has been lifted.

D.16.20 ACCESS AND HAUL ROAD PLAN

Because there are no plans to create access and haul roads for these project sites, the Access and Haul Road Plan is not required. The access roads to the site will be controlled by USA for the duration of site operations as a means of site control. This is further detailed in the Site Control Plans.

D.16.21 DEMOLITION PLAN (ENGINEERING AND ASBESTOS SURVEYS)

As work on this plan does not involve demolition of buildings containing asbestos material, the Demolition Plan is not required.

D.16.22 EMERGENCY RESCUE (TUNNELING) PLAN

As work on this project does not involve tunneling operations, this Emergency Rescue Plan is not required.

D.16.23 UNDERGROUND CONSTRUCTION FIRE PREVENTION AND PROTECTION PLAN

As underground construction is not required on this project, the Underground Construction Fire Prevention and Protection Plan is not required.

D.16.24 COMPRESSED AIR PLAN

As there are no plans to use compressed air on this project, a Compressed Air Plan is not required.

D.16.25 FORMWORK AND SHORING ERECTION AND REMOVAL PLANS

As this project will not involve formwork and shoring erection and removal, this plan will not be required.

D.16.26 JACKING PLAN (LIFT) SLAB PLANS

As there will be no Lift Slab work on this project, this plan will not be required.

D.16.27 BLASTING PLAN

As all MEC disposal work on this project site will be handled by the USA UXO Team, explosive materials will be brought onto the site and used for disposal operations. Explosive operations on this project site are spelled out in the Work Plan in “Demolition, Explosive Storage, and MPPEH Disposal,” “MEC Disposal,” and “Explosive Management Plan.”

D.16.28 DIVING PLAN

Diving operations are not expected to occur on this site, so a Diving Plan will not be required.

D.16.29 PLAN FOR PREVENTION OF ALCOHOL AND DRUG ABUSE

The USA program is included as Attachment 5. All project personnel will be asked to read and abide by this plan. The policy will be posted at the job site.

D.16.30 FALL PROTECTION PLAN

Most of the work on these sites will be at ground level. However, there will be some excavation work involved in the Remedial Investigation. Excavations are not expected to reach 4 feet in depth, so sloping and/or shoring would not be required. However, personnel working in the vicinity of excavation operations will be made aware of the slip/trip/fall hazards in the area and advised to watch their step around the excavations. USA personnel on site will ensure that no unauthorized personnel enter the EZ of the site, and the excavations will be backfilled as soon as possible after work within them has been completed.

D.16.31 STEEL ERECTION PLAN

As no steel erection will be taking place on this project, this plan is not required.

D.16.32 NIGHT OPERATIONS LIGHTING PLAN

As there are no plans to operate during hours of darkness, there is no requirement for a Night Operations Lighting Plan.

D.16.33 SITE SANITATION PLAN

Adequate sanitation facilities will be provided at each work site to ensure proper personal hygiene. Site sanitation will be established and maintained in accordance with OSHA 29 CFR 1910.120(n).

An adequate supply of potable (drinkable) water shall be provided on site at all times, and will be supplied in accordance with the following provisions:

- Containers used for potable water shall be capable of being tightly closed, equipped with a tap, and maintained in a clean and sanitary condition.
- A container used for distribution of drinking water shall be clearly labeled as to its contents and not used for any other purpose.
- Water shall not be dipped from the container and use of a common cup will not be allowed.
- Where single-service cups are provided, separate sanitary containers will be provided for the storage of the unused cups and for the disposal of the used cups.
- Water coolers of drinking water will be placed in the support zone.
- Personnel will be instructed to wash their face and hands prior to drinking.
- Outlets and storage containers for non-potable water, such as water for fire fighting or decontamination, will be clearly labeled using the following wording to indicate that the water is not suitable for drinking: "CAUTION – WATER UNSAFE FOR DRINKING, WASHING, OR COOKING." There shall at no time be a cross connection or open potential between a system furnishing potable water and a system furnishing non-potable water.
- Chemical toilets will be available at the work site. The toilet will be equipped with toilet paper, toilet paper holder, light, washing facilities, locking door, and adequate ventilation.
- Hand and face washing facilities will be set up in the support zone of the work area. These will be utilized by all personnel exiting the EZ prior to eating, drinking, tobacco use or other hand-to-face activities. Washing facilities will consist of potable running water, soap, and drying towels. A portable eyewash will be available in site vehicles.
- Waste Disposal: A trash receptacle will be present in the support zone for the disposal of hand drying materials, any disposable PPE, paper towels used to dry hands, and other generated site debris.

D.16.34 FIRE PREVENTION PLAN

In order to prevent fire from occurring, every step will be taken to keep the site neat and clean. All equipment and materials not in use will be put away in designated locations. Trash cans with lids will be at the site, and will be emptied on a daily basis to keep trash from accumulating. All flammable liquids will be stored in approved flammable liquid cans in order to prevent spillage and ignition of the material. Bonding and grounding procedures will be in place when transferring flammable liquids from their designated containers and into equipment. Equipment will never be fueled in the back of a pick-up truck containing a bed liner. Personnel handling explosive and/or flammable materials will wear cotton under and outer garments to prevent build-up and transfer of static electricity.

D.16.34.1 Fire Protection

Portable fire extinguishers are rated and classified with NUMERAL and LETTER designations, based on fire tests conducted by the Underwriters Laboratories, Inc., or other nationally recognized testing laboratories. The numeral rating indicates the relative extinguishing effectiveness of extinguishers classified for Class A and B fires only. The letter classification coincides with the class of fire. Extinguishers found to be effective on more than one class of fire have multiple letter classifications (Example: B:C).

The rating of hand-portable fire extinguishers is based on the following categories.

- A Class A fire extinguisher is used for ordinary combustible materials.
- A Class B fire extinguisher is used for flammable liquids.
- A Class C fire extinguisher is used for electrical fires.
- A Class D fire extinguisher is used for combustible metal fires.

Many fires are small at origin and may be extinguished by the use of proper hand-portable fire extinguishers. It is strongly recommended that the fire department be notified as soon as a fire is discovered. This alarm should not be delayed awaiting result of application of portable fire extinguishers.

Fire extinguishers can represent an important segment of any overall fire protection program. However, their successful functioning depends upon meeting the following conditions.

- The extinguisher is properly located and in working order.
- The extinguisher is of proper type for a fire that may occur.
- The fire is discovered while it is still small enough for the extinguisher to be effective.
- The fire is discovered by a person ready, willing, and able to use the extinguisher.

Class A fires can be readily extinguished by quenching/cooling with water or a water-mixture agent. Class B fires are more effectively extinguished by an agent that blankets or smothers the fire through exclusion of oxygen surrounding the fire area. Those extinguishers containing bromochlorodifluoromethane, monobromotrifluoromethane, carbon dioxide, or dry chemical are generally best suited for extinguishing Class B fires.

For Class C fires, the primary consideration in extinguishing this type of fire is the selection of nonconductive extinguishing agent to prevent dangerous electrical shock and possible death to users. Water or water-mixture type extinguishing agent must not be used under any circumstances on energized electrical equipment (Class C) fires. When possible, electrical equipment and circuits should be de-energized before attacking a Class C fire. Due to its corrosive nature, dry chemical is not recommended for use on computerized, electronic, or other equipment with extensive circuitry.

D.17 CONTRACTOR INFORMATION

USA is the prime contractor on this project. This APP and attached SSHP are based on USA procedures. Sea Ventures will be a subcontractor on this project to provide boat transportation to and from the offshore operations sites and to provide support to the offshore operations. This subcontractor will be required to comply with all site requirements and will attend the initial mobilization training, which will describe the work to be performed, and all safety and health requirements regarding that work. They will also be required to attend the daily Tailgate Safety Briefings, which will go over the operations expected to take place that day. Any subcontractor personnel working on this project will also be required to attend any special safety meetings that are taking place for the duration of their operations on the site.

D.18 SITE-SPECIFIC HAZARDS AND CONTROLS

Site-specific hazards and controls are detailed in the Activity Hazard Analyses for each activity of the operation. These can be found in Attachment 2. The specific activities on this site are as follows:

- Geophysical Prove-Out Test Strip
- Location Surveying and Mapping
- MEC Investigation
- MEC Disposal Operations
- MPPEH Inspection
- Quality Control
- Vegetation Removal
- Vehicle Operations
- Boat Transportation
- Boat Operations

D.18.1 SAFETY HAZARDS

Because of the nature of planned site operations, the potential risk for exposure to safety hazards is high. Anticipated safety hazards that may be encountered during site activities, and precautions to be followed, are listed below and in individual Activity Hazard Analyses found in Attachment 2.

D.18.1.1 Slip, Trip, and Fall Hazards

As this project covers a variety of sites, sites will be sandy, with rocky areas as well. As with any outdoor site, there is generally an uneven walking/working surface, which makes for the possibility of slip, trip, and fall hazards. Site personnel shall be instructed to make themselves aware of foot placement at all times to avoid slips, trips, and falls. The use of sturdy leather work boots with ankle support and non-slip soles will reduce the risk of slips, trips, and falls.

D.18.1.2 Cuts/Laceration Hazards

MEC scrap surfaces and buried debris can be expected to have sharp and rusted surfaces. Project personnel should expect a high likelihood of cuts/lacerations if proper care is not taken. During all activities involving the handling of MEC, MEC scrap, and site materials and tools, personnel shall wear leather work gloves to prevent injury to hands.

D.18.1.3 Pinched/Crushed Fingers and Toes

The weight of MEC scrap expected to be recovered and handled during MEC inspection activities is expected to pose only a light to moderate hazard to fingers and toes. The mishandling of even light materials can cause injuries to site personnel. All site personnel are required to wear leather work boots and gloves while activities are being conducted. Personnel shall utilize proper lifting techniques and when appropriate, shall use additional personnel or material handling equipment for heavy objects.

D.18.1.4 Hand Tool Operation

Use of improper or defective tools can contribute significantly to the occurrence of accidents on site. Therefore, the following safe work practices shall be observed when using hand tools:

- Hand tools will be inspected for defects prior to each use
- Defective hand tools will be removed from service and repaired or discarded
- Tools will be selected and used in the manner for which they were designed
- Be sure of footing and grip before using any tool
- Do not use tools that have split handles, mushroom heads, worn jaws, or other defects
- Gloves will be worn whenever they increase gripping ability or if cut, laceration, or puncture hazards may exist during the use of hand tools
- Safety glasses with side shields, goggles, or a face shield will be used if tool use presents an eye/face hazard
- Do not use makeshift tools or other improper tools
- Use non-sparking tools where there are explosive vapors, gases, or residue.

D.18.1.5 Material Lifting

Many types of objects are handled in normal day-to-day operations. Care shall be taken in lifting and handling heavy or bulky items because they are the cause of many joint and back injuries. The following fundamentals address the proper lifting of materials to avoid joint and back injuries:

- The size, shape, and weight of the object to be lifted must be considered. Site personnel will not lift more than they can handle comfortably.
- A firm grip on the object is essential; therefore, the hands and object shall be free of oil, grease, and water, which might prevent a firm grip.
- The hands and especially the fingers shall be kept away from any points that cause them to be pinched or crushed, especially when setting the object down.
- The item shall be inspected for metal slivers, jagged edges, burrs, rough or slippery surfaces, and pinch points, and gloves shall be used, if necessary, to protect the hands.
- The feet shall be placed far enough apart for good balance and stability.
- Personnel will ensure that solid footing is available prior to lifting the object.
- When lifting, get as close to the load as possible, bend the legs at the knees, making sure that the back is kept as straight as possible.
- To lift the object, the legs are straightened from their bending position.
- Never carry a load that cannot be seen over or around.
- When placing an object down, the stance and position are identical to that for lifting, with the back kept straight, the legs bent at the knees, and the object lowered.
- If the item to be lifted is too large, bulky, or heavy for one person to safely lift, ask a co-worker for assistance. If a piece of material handling equipment is available that can do the job, use the equipment instead of trying to lift it yourself.
- When two or more people are required to handle an object, coordination is essential to ensure that the load is lifted uniformly and that the weight is equally divided between the individuals carrying the load. When carrying the object, each person, if possible, shall face the direction in which the object is being carried.

D.18.1.6 Munitions and Explosives of Concern

MEC may be present and located during site activities. UXO-qualified personnel will follow the requirements of the USA Safety Program, and the Basic Safety Concepts and Considerations for Ordnance and Explosives Operations, which outline the safety and health precautions to be taken if MEC are encountered and/or destroyed. All non-UXO qualified personnel will follow the safe work practices listed below:

- Non-UXO-qualified personnel will receive site-specific MEC recognition training prior to participation in site activities.
- No soil penetrating activities will be allowed without the area first being cleared by UXO-qualified personnel.
- Non-UXO-qualified personnel will be escorted on site by UXO-qualified personnel, until such time as the area is cleared.
- Once an area has been cleared and flagged, non-UXO-qualified personnel may perform duties in the area unescorted, but shall not leave the cleared area unescorted.
- Non-UXO-qualified personnel will not touch or disturb any object which could potentially be MEC related, and will immediately notify the nearest UXO-qualified person of the presence of the object.
- In order to protect other personnel and the general public, an EZ will be set up at a determined hazardous fragment distance all around the project footprint area of the work area, based on the most significant MEC item expected to be encountered on the site. A safe separation distance of at least K40 distance will be maintained between UXO teams working on the site. However, if MEC with a larger fragmentation distance is encountered on the site, the EZ will be extended to the hazardous fragment distance of the larger item. USA will have control of the entrance to the project area until the area has been cleared. Should personnel not associated with the project operations need to enter the EZ, it will be coordinated with the SUXOS. All MEC operations will halt for the duration of time the person is within the EZ. Once they have departed the area, MEC operations may resume.
- Hazardous MEC disposal operations will be performed by USA UXO teams. MDAS that is non-hazardous will be inspected and certified as non-hazardous, and will be collected in a secured location until the conclusion of the project work. After the project work has been completed, the non-hazardous MDAS will be sold to a qualified recycler.

D.18.2 CHEMICAL HAZARDS

The only anticipated chemical hazards that would be expected during site activities are those fuels and oils brought on site for equipment use and maintenance. All site personnel will follow the procedures and precautions outlined in the appropriate MSDS. The MSDS binder will be kept in the UXOSO site vehicle and will be available to all employees on request. Chemical Warfare Materiel (CWM) is not expected to be found on these sites.

D.18.3 PHYSICAL HAZARDS

For the planned site activities to be conducted, the potential for exposure to physical hazards is high for this project. The physical hazards that may be encountered during site operations and precautions to be taken are described in the following paragraphs.

D.18.3.1 Flammable/Explosive Hazards from Fueling Equipment and Site Vehicles

The chance of fire and/or explosion during vehicle and equipment refueling and maintenance is high when improper procedures are used. All site vehicles will be equipped with a portable fire extinguisher readily available to fight a fire. Equipment will never be refueled in the back of a pick-up truck with a bed liner. Cellular phones will not be used around flammable liquids in accordance with Ordnance and Explosives Safety Group Safety Advisory 03-2003. Grounding and bonding procedures will be used during all fueling operations. No smoking will be permitted in the vicinity of fueling operations, and flammable and combustible materials will be removed from the vicinity of fueling operations.

D.18.3.2 Noise Hazards

Protection against the effects of noise exposure shall be provided when the sound levels exceed those shown in Table D-7, as measured on the A scale of a standard sound level meter at slow response. When employees are subjected to sound exceeding those listed in Table D-7, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound to a safe level, PPE shall be provided and used to reduce sound exceeding protective levels. If the variations in noise level involve maximal intervals of 1 second or less, it is to be considered continuous.

Table D-7: Permissible Noise Exposures

Duration per Day (Hours)	Sound level dBA (Slow Response)
8.00	90
6.00	92
4.00	95
3.00	97
2.00	100
1.50	102
1.00	105
0.50	110
0.25	115
Note: When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: C1./T1. + C2./T2. C(n)/T(n) exceeds unity, then, the mixed exposure should be considered to exceed the limit value. C(n) indicates the total time of exposure at a specified noise level, and T(n) indicates the total time of exposure permitted at that level. Exposure to impulsive or impact noise should not exceed 140-dB peak sound pressure level.	

USA shall make hearing protection available to all employees exposed to an 8-hour time-weighted average of 85 dB or greater. Hearing protection shall be replaced as necessary. Hearing protection will be required for all personnel working in and around any operations likely to produce high noise levels, such as during the use of chain saws and weed-eaters used for vegetation clearance operations and around heavy equipment operations.

USA provides baseline hearing testing and annual follow-up screening as part of the annual HAZWOPER physicals performed on all field employees. All employees receive training in the hearing protection program and the use of hearing protection as part of their mobilization training when they arrive on site.

D.18.3.3 Heat Stress

Heat stress is one of the most common (and potentially serious) illnesses that affect hazardous waste site workers. When site personnel are engaged in operations involving hot environments and/or the use of semi-permeable or impermeable clothing, a number of physiological responses can occur that may seriously affect the health and safety of the workers. These effects can be eliminated or controlled through the use of a comprehensive heat stress prevention and monitoring program. Therefore, it is the objective of this program to outline the methods and procedures by USA personnel for the prevention, control, and/or treatment of heat-related illnesses.

D.18.3.3.1 Causes of Heat Stress

The most common cause of heat stress during site activities is the effect that PPE has on the body's natural cooling mechanism. Impermeable PPE interferes with the evaporation of perspiration and causes the body to retain metabolic and environmentally induced heat. Individuals will vary in their susceptibility and degree of response to the stress induced by increased body heat. Heat stress can result in health effects ranging from transient heat fatigue to serious illness or death. Heat stress is caused by a number of interacting factors, including environmental conditions, clothing, workload, and the individual characteristics of the worker. Because heat stress is probably one of the most common (and potentially serious) illnesses at hazardous waste sites, regular monitoring and other preventive precautions are vital.

Factors which may predispose a worker to heat stress include:

- Lack of physical fitness
- Lack of acclimatization to hot environments
- Degree of hydration
- Level of obesity
- Current health status (e.g., having an infection, chronic disease, diarrhea, etc.)
- Alcohol or drug use
- The worker's age and sex
- Sunburn.

Reduced work tolerance and the increased risk of excessive heat stress are directly influenced by the amount and type of PPE worn. PPE adds weight and bulk, severely reduces the body's access to normal heat exchange mechanisms (evaporation, convection, and radiation), and increases energy expenditure. Therefore, when selecting PPE, each item's benefit should be carefully evaluated in relation to its potential for increasing the risk of heat stress. Once PPE is selected, the safe duration of work/rest periods should be determined based on the following factors:

- Anticipated work rate
- Ambient temperature and other environmental factors
- Type of protective ensemble
- Individual worker characteristics and fitness.

Prior to initiating site activities each day, and periodically throughout the day, the UXOSO will inspect the site personnel for evidence of the previously mentioned factors to determine those personnel who are at increased risk for heat stress-related disorders. Evidence of extreme dehydration, illness, or drug or alcohol use may require the UXOSO to restrict the worker's activities until such time as the worker is fit for duty. Personnel identified as being at high risk for heat stress who are allowed to participate in site operations will be monitored frequently by the UXOSO throughout the day.

D.18.3.3.2 Heat Stress Disorders

This section outlines the major heat-related illnesses that may result from exposure to high heat environments and/or the use of semi-permeable or impermeable clothing. For the purpose of this program, reference to "liquids" will indicate the use of water or an electrolyte replacement solution, and not tea or coffee (unless it is decaffeinated) or carbonated soft drinks.

- Heat Rash

Heat rash is caused by continuous exposure to heat and humid air and is aggravated by wet, chafing clothes. This condition can decrease a worker's ability to tolerate hot environments.

Symptoms: Mild red rash, especially in areas of the body that sweat heavily.

Treatment: Decrease amount of time in protective gear and provide powder such as corn starch or baby powder to help absorb moisture and decrease chafing. Maintain good personal hygiene standards and change into dry clothes if needed.

- Heat Cramps

Heat cramps are caused by a profuse rate of perspiration that is not balanced by adequate fluid and electrolyte intake. The occurrence of heat-related cramps is often an indication that excessive water and electrolyte loss has occurred, which can further develop into heat exhaustion or heat stroke.

Symptoms: Acute, painful spasms of voluntary muscles such as the back, abdomen and extremities.

Treatment: Remove victim to a cool area and loosen restrictive clothing. Stretch and massage affected muscles to increase blood flow to the area. Have patient drink one to two cups of liquids immediately, and every 20 minutes thereafter. Consult with physician if condition does not improve. If available, an electrolyte replacement solution should be taken along with liquids.

- Heat Exhaustion

Heat exhaustion is a state of very definite weakness or exhaustion caused by increased stress on various organs to meet increased demands to cool the body as a result of excessive loss of fluids from the body. This condition leads to inadequate blood supply and cardiac insufficiency. Heat exhaustion is less dangerous than heat stroke, but nonetheless must be treated. If allowed to go untreated, heat exhaustion can quickly develop into heat stroke.

Symptoms: Pale or flushed, clammy, moist skin, profuse perspiration, and extreme weakness. Body temperature is basically normal or slightly elevated, the pulse is weak and rapid, and breathing is shallow. The individual may have a headache, or be dizzy or nauseated.

Treatment: Use passive and active cooling. Orally administer cool water and/or electrolyte replacement liquids immediately, to hydrate the victim, starting with small sips and continuing with larger amounts as the victim is able to hold it down. Total liquid consumption should be about 1 to 2 gallons per day. Transfer to a medical facility if symptoms do not subside, or become more severe.

- Heat Stroke

Heat stroke is an acute and dangerous reaction to heat stress caused by a failure of the heat-regulating mechanisms of the body. The failure of the individual's temperature control system causes the perspiration system to stop working correctly. When this occurs, the body core temperature rises very rapidly to a point (105 degrees Fahrenheit [°F] or higher) where brain damage and death will result if the person is not cooled quickly.

Symptoms: The victim's skin is hot and may or may not be red and dry (because the individual may still be wet from having sweat while wearing protective clothing earlier). Other symptoms include nausea; dizziness; confusion; extremely high body temperatures; rapid respiratory and pulse rate; delirium; convulsions; and unconsciousness or coma.

Treatment: Cool the victim immediately. If the body temperature is not brought down quickly, permanent brain damage or death may result. The victim should be moved to a shady area; lie down and keep the head elevated. Passive and active cooling should be used. If conscious, orally administer cool water and/or electrolyte replacement liquids immediately to hydrate the victim, starting with small sips and increasing amounts as the victim is able to hold it down. Rapidly transfer the victim to an emergency medical facility for immersion in cool water. Do not give the victim caffeinated or alcoholic beverages. Heat stroke is considered a medical emergency.

D.18.3.3.3 Preventive Measures

Required Preventive Measures – Proper training and preventive measures will help avert serious illness and loss of work productivity. Preventing heat stress is particularly important because once someone suffers from heat exhaustion, that person may become predisposed to additional heat injuries. In order to avoid heat-related illnesses, proper preventive measures will be implemented whenever environmental conditions dictate the need. These preventive measures represent the minimal steps to be taken and will include the following procedures.

The UXOSO should examine each site worker prior to start of daily operations to determine the individuals susceptible to heat-induced stress. Workers exhibiting factors that make them susceptible to heat stress will be closely monitored by the UXOSO.

Site workers will be trained to recognize and treat heat-related illnesses. This training will include the signs, symptoms, and treatment of heat stress disorders as outlined in this program.

In order to maintain workers' body fluids at normal levels, workers will be encouraged to drink, as a minimum, approximately sixteen ounces of liquids prior to start of work in the morning, after lunch and prior to leaving the site at the conclusion of the day's activities. Disposable four (4) to twelve (12) ounce cups and liquids will be provided on site. Acceptable liquids will include water and an electrolyte replacement solution. It is recommended that the water to balanced electrolyte liquids be taken at a 2:1 ration with the intake of water being twice the intake of the balanced electrolyte liquids. Liquids containing caffeine are to be avoided.

When ambient conditions and site workload requirements dictate, as determined by the UXOSO, workers will be required to drink a minimum of 16 to 32 ounces of liquids during each rest cycle. The normal thirst mechanism is not sensitive enough to ensure that enough water will be ingested to replace lost sweat. When heavy sweating occurs, workers should be encouraged to drink even though they may not be thirsty. The following strategies may be useful in encouraging fluid intake.

- Maintain water temperature at 50 ºF to 60 °F (10 ºC to 15.6 °C).
- Provide small disposable cups that hold about 4 ounces (0.1 liter).
- Have workers drink 16 ounces (0.5) liters) of fluids (preferably water or dilute drinks) before beginning work.
- Urge workers to drink a cup or two every 15 to 20 minutes, or at each monitoring break. A total of 1 to 1.6 gallons (4 to 6 liters) of fluid per day are recommended, but more may be necessary to maintain body weight.
- A shelter or shaded area will be provided where workers may be protected from direct sunlight during rest periods.

Monitoring of ambient or physiological heat stress indices will be conducted to allow prevention and/or early detection of heat induced stress. Monitoring will be conducted in accordance with applicable paragraphs of this program.

Site workers will be given time to acclimatize to site work conditions, temperature, protective clothing, and workload. Acclimatization usually takes about a week to 10 days of continued work in hot environments, and allows the worker's body to become adjusted to this level and type of work. This process involves a gradual increase in the workload over the required period, the length of which depends upon the nature of the work performed, the ambient temperatures, the level of PPE required for the job and the individual's susceptibility to heat stress.

Work schedules will be adjusted as follows:

- Modify work/rest schedules according to monitoring requirements
- Mandate work slowdowns as needed
- Rotate personnel: alternate job functions to minimize overstress or overexertion at one task

- Add additional personnel to work teams
- Perform work during cooler hours of the day if possible or at night if adequate lighting can be provided.

Supplemental Preventive Measures – When possible and/or feasible, the following measures will also be implemented to aid in prevention or reduction of the effects of heat-induced stress.

- Designated rest areas should be air-conditioned and the temperature maintained between 72 °F and 76 °F.
- Cooling devices will be provided to aid in body heat exchange. Cooling devices may include cooling jackets, vests, or suits and field showers or hose-down areas. Depending on the severity of the heat exposure, some form of artificial cooling may be required to ensure protection of the workers.
- Workers will be encouraged to achieve and maintain an optimum level of physical fitness. Increased physical fitness will allow workers to better tolerate and respond to hot environments and heavy workloads. In comparison to an unfit person, a fit person will have less physiological strain, a lower heart rate and body temperature, and a more efficient sweating mechanism.

D.18.3.3.4 Heat Stress Monitoring

Because the incidence of heat stress depends on a variety of factors, all workers, even those not wearing protective equipment, should be monitored. Initially, the frequency of physiological monitoring depends on the air temperature adjusted for solar radiation and the level of physical work (see Table D-8). The length of the work cycle will be governed by the frequency of the required physiological monitoring.

For workers wearing permeable clothing (e.g., standard cotton or synthetic work clothes), follow recommendations for monitoring requirements and suggested work/rest schedules in the current ACGIH Threshold Limit Values for Heat Stress. If the actual clothing worn differs from the ACGIH standard ensemble in insulation value and/or wind and vapor permeability, change the monitoring requirements and work/rest schedules accordingly.

When site personnel are engaged in site activities involving the use of Level D PPE with cotton clothing, in ambient temperatures greater than 75 °F, physiological monitoring will be conducted. If semi-permeable or impermeable clothing is used, monitoring will start at 70 °F. The goal of all heat stress monitoring is to ensure that the worker's body temperature does not exceed 100.4 °F. The physiological monitoring methods listed below are to be implemented based upon the severity of the heat and workload. As a minimum, the UXOSO will use the WBGT readings to monitor temperature and humidity and establish work/rest cycles. Depending on the conditions at the site, the UXOSO may also monitor the worker's heart rate as an indication of potential heat stress. However, if monitoring with the heart rate method indicates the need for closer, more direct monitoring, the oral temperature method will be implemented. The need for monitoring body water loss will be determined by the UXOSO, and will be based upon observation of the sweat loss experienced by site personnel during their work cycle. The frequency of physiological monitoring will be determined using the information presented in Table D-8.

For monitoring the body's recuperative ability toward excess heat, both of the following techniques should be used as a screening mechanism unless the UXOSO modifies the procedures and documents the log. Monitoring of personnel wearing impermeable clothing should commence when the ambient temperature is 70 °F or above, and for personnel wearing Level D PPE with cotton clothing the monitoring will commence when the ambient temperature reaches 75 °F. Frequency of monitoring should increase as the ambient temperature increases or as slow recovery rates to baseline (pre-work) levels are indicated.

Table D-8: Suggested Frequency of Physiological Monitoring for Fit and Acclimatized Workers[a]

Adjusted Temperature[b]	Normal Work Ensemble[c]	Impermeable Ensemble
90 °F (32.2 °C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5 - 90 °F (30.8 - 32.2 °C)	After each 60 minutes of work	After each 30 minutes of work
82.5 - 87.5 °F (28.1 - 30.8 °C)	After each 90 minutes of work	After each 60 minutes of work
77.5 - 82.5 °F (25.3 - 28.1 °C)	After each 120 minutes of work	After each 90 minutes of work
72.5 - 77.5 °F (22.5 - 25.3 °C)	After each 150 minutes of work	After each 120 minutes of work

[a] For work levels of 250 kilocalories/hour.

[b] Calculate the adjusted air temperature (at adj) by using this equation: at adj °F = ta °F + (13 x % sunshine). Measure air temperature (at) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow. (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows.)

[c] A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.

- **Wet Bulb, Dry Globe Temperature (WBGT) Monitoring**

For site conditions where personnel are working in Level D PPE, and the ambient temperature is greater than 75 °F, the UXOSO will conduct WBGT monitoring to assist in controlling the potential for site workers experiencing heat-related adverse health effects. The UXOSO will use a real-time direct reading WBGT monitor and, after estimating the work load, use the values expressed in Table D-9 to determine the work/rest schedule to be implemented. The values outlined in this table are designed such that nearly all acclimatized, fully clothed workers with adequate salt and water intake will be able to function without the body temperature exceeding 100.4 °F. If conditions and/or workloads warrant, the UXOSO may also implement the heart rate, OT and water weight loss monitoring.

Table D-9: Permissible WBGT Heat Exposure Threshold Limit Values

Work – Rest Regimen	WORK LOAD		
	Light*	Moderate	Heavy
Continuous work	86 (30.0)	80 (26.7)	77 (25.0)
75% Work - 25% Rest, each hour	87 (30.6)	82 (28.0)	78 (25.9)
50% Work - 50% Rest, each hour	89 (31.4)	85 (29.4)	82 (27.9)
25% Work - 75% Rest, each hour	90 (32.2)	88 (31.1)	86 (30.0)

* Consult the ACGIH TLV booklet for definitions of Light, Moderate, and Heavy workloads.

Values are given in °F and (°C) WBGT, and are intended for workers wearing single layer summer type clothing. Use of semi-permeable or totally impermeable clothing requires monitoring IAW the USA Heat Stress Prevention Program. As workload increases, the heat stress impact on an unacclimatized worker is exacerbated. For unacclimatized workers performing a moderate level of work, the permissible heat exposure TLV should be reduced by approximately 2.5 °C.

Acclimatization is the adaptive process that results in a decrease of the physiological response produced by the application of a constant environmental stress. On initial exposure to a hot environment, there is an impaired ability to work and evidence of physiological strain. If the exposure is repeated on several successive days, there is a gradual return of the ability to work and a decrease in physiological strain. Within 4 to 7 days following initiation of the acclimatization process, a dramatic improvement in the ability to perform work is noticed: subjective discomfort practically disappears; body temperature and heart rate are lower; there is a more stable blood pressure; and the sweat is more profuse and dilute.

Alcohol should not be consumed in a hot environment because the loss of body fluids increases the risk of heat stress.

- **Heart Rate Monitoring**

The worker's baseline heart rate should be recorded prior to initiation of site activities by measuring the radial pulse rate for 30 seconds. After each work cycle, the heart rate should be measured by taking the pulse rate (PR) for 30 seconds as early as possible into the resting period. Taking the radial (wrist) pulse rate is the preferred method; however, the carotid (neck) pulse rate may be taken if a worker has difficulty finding the radial pulse. The PR at the beginning of the rest period should not exceed 110 beats per minute (bpm). If the PR is higher than 110 bpm, the next work period should be shortened by 33 percent, while the length of the rest period stays the same. If the PR exceeds 110 bpm at the beginning of the next rest period, the work cycle should be further shortened by 33 percent. This procedure will be continued until the worker's PR at the beginning of the rest cycle is maintained below 110 bpm.

- **Oral Temperature Monitoring**

If deemed necessary by the UXOSO, and the conditions warrant, oral temperature (OT) monitoring will be conducted. The worker's OT will be taken and recorded prior to initiation of site activities using a clinical thermometer placed under the tongue. The OT must be taken prior to consumption of cool liquids and will be done at the end of each work period or at a frequency determined by Table D-9. Whenever the OT exceeds 99.6 °F, the work cycle must be shortened by one third, without changing the length of the rest period. If a worker's OT has exceeded 99.6 °F, test the OT again at the end of the rest cycle, and do not allow the worker to return to work until the OT drops below 99.6 °F. If a worker's OT exceeds 100.4 °F, the worker will not be allowed to work in impermeable or semi-permeable PPE for the remainder of that workday.

- **Body Weight Loss**

If expected site conditions and work requirements have the potential for causing excessive fluid loss, the UXOSO will monitor the workers' fluid loss by weighing each worker prior to and again at the conclusion of each day's site activities. This measurement will be needed to ensure that proper hydration is being maintained and that the total amount of water weight loss throughout the day does not exceed 1.5% of the employee's body weight. Body weights will be taken with the workers wearing undergarments only. If, as determined by the UXOSO, site conditions and work requirements cause an extreme amount of fluid loss, body weights will also be taken prior to the lunch break. Calculation of the water weight loss, and assessing the effectiveness of hydration, shall be conducted as follows:

Once the ending weight is obtained subtract it (W_{end}) from the daily starting weight (W_{start}) to obtain the weight lost (W_{lost}) during a given work period, i.e.,: (W_{start}) - (W_{end}) = (W_{lost}).

Multiply the starting weight by 1.5% to obtain permissible weight loss (W_{perm}), i.e.,

(W_{start}) x 0.015 = (W_{perm}).

Compare (W_{lost}) to the (W_{perm}); if (W_{lost}) is less than or equal to (W_{perm}), then hydration during the measured period has been adequate, but if (W_{lost}) is greater than (W_{perm}), then hydration should be increased during the next work period.

D.18.3.3.5 Heat Stress Documentation

The UXOSO will be responsible for recording all heat stress-related information. This will include training sessions and monitoring data. Training sessions will be documented using the Documentation of Training form. Pulse rate monitoring data will be recorded on the Heat Stress Monitoring Log, with the WBGT, OT, and/or water loss calculations being recorded in the Site Safety Log, and/or Site Monitoring Log.

D.18.4 IONIZING RADIATION HAZARDS

Ionizing radiation is not expected to be an issue on these project sites.

D.18.5 BIOLOGICAL HAZARDS

Biological hazards that are usually found on site include hazardous plants, bees, spiders, mosquitoes, ticks, snakes, and rodents. Employee awareness and the safe work practices outlined in the following paragraphs should reduce the risk associated with these hazards.

D.18.5.1 Bees, Hornets, and Wasps

Contact with stinging insects like bees, hornets, and wasps may result in site personnel experiencing adverse health effects that range from being mildly uncomfortable to being life threatening. Therefore, stinging insects present a serious hazard to site personnel, and extreme caution must be exercised whenever site and weather conditions increase the risk of encountering stinging insects. Some of the factors related to stinging insects that increase the degree of risk associated with accidental contact are as follows.

- The nests for these insects are frequently found in remote wooded or grassy areas.
- The nests can be situated in trees, rocks, and bushes or in the ground, and are usually difficult to see.
- Accidental contact with these insects is highly probable, especially during warm weather conditions when the insects are most active.
- If a site worker accidentally disturbs a nest, the worker may be inflicted with multiple stings, causing extreme pain and swelling which can leave the worker incapacitated and in need of medical attention.
- Some people are hypersensitive to the toxins injected by a sting, and when stung, experience a violent and immediate allergic reaction resulting in a life-threatening condition known as anaphylactic shock.
- Anaphylactic shock manifests itself very rapidly and is characterized by extreme swelling of the body, eyes, face, mouth and respiratory passages.
- The hypersensitivity needed to cause anaphylactic shock can, in some people, accumulate over time and exposure; therefore, even if someone has been stung previously, and has not experienced an allergic reaction, there is no guarantee that they will not have an allergic reaction if they are stung again.
- With these things in mind, and with the high probability of contact with stinging insects, all site personnel will comply with the following safe work practices:
- If a worker knows that he is hypersensitive to bee, wasp, or hornet stings, he must inform the UXOSO of this condition prior to participation in site activities.
- All site personnel will be watchful for the presence of stinging insects and their nests, and will advise the UXOSO if a stinging insect nest is located or suspected in the area.

- Any nests located on site will be flagged off and site personnel will be notified of its presence.
- If stung, site personnel will immediately report to the UXOSO to obtain first aid treatment and to allow the UXOSO to observe them for signs of allergic reaction. If a breathing emergency (anaphylactic shock) occurs as a result of the sting, immediately call 911.
- Site personnel with a known hypersensitivity to stinging insects will keep required emergency medication on or near their person at all times, and will let the UXOSO and co-workers know where it is kept.

D.18.5.2 Spiders

A large variety of spiders may be encountered during site activities. While most spider bites merely cause localized pain, swelling, reddening, and, in some cases, tissue damage, there are a few spiders that, due to the severity of the physiological effects caused by their venom, are dangerous. These species include the black widow and the brown or violin spiders, as shown in Figure D-2.

Figure D-2: Examples of Dangerous Spiders

Brown/Violin Spider	Black Widow Spider
	

The black widow is a coal-black bulbous spider about ¾-inch in length, with a bright red hourglass on the underside of the abdomen. The black widow is usually found in dark, moist locations, especially under rocks and rotting logs, and may even be found in outdoor toilets where they inhabit the underside of the seat. Victims of a black widow bite may exhibit the following signs or symptoms:

- Sensation of pinprick or minor burning at the time of the bite.
- Appearance of small punctures (but sometimes none are visible).
- After 15 to 60 minutes, intense pain is felt at the site of the bite which spreads quickly, and is followed by profuse sweating, rigid abdominal muscles, muscle spasms, breathing difficulty, slurred speech, poor coordination, dilated pupils, and generalized swelling of face and extremities.

The brown or violin spider is brownish to tan in color, rather flat, about 5/8-in. long with a dark brown "violin" shape on the top. Of the brown spider, there are three varieties found in the United States, which present a problem to site personnel. These are the brown recluse, the desert violin, and the Arizona violin. These spiders may be found in a variety of locations including trees, rocks, or in dark locations. Victims of a brown or violin spider bite may exhibit the following signs or symptoms:

- Blistering at the site of the bite, followed by a local burning at the site 30 to 60 minutes after the bite.
- Formation of a large, red, swollen, postulating lesion with a bull's-eye appearance.
- Systemic effects may include a generalized rash, joint pain, chills, fever, nausea, and vomiting.
- Pain may become severe after 8 hours, with the onset of tissue necrosis.

There is no effective first aid treatment for either of these bites. Except for very young, very old, or weak victims, these spider bites are not considered to be life threatening; however, medical treatment must be sought to reduce the extent of damage caused by the injected toxins. If either of these spiders are suspected or known to be on site, the UXOSO will brief site personnel as to the identification and avoidance of the spiders. As with stinging insects, site personnel shall report to the UXOSO if they locate either of these spiders on site or notice any type of bite while involved in site activities.

D.18.5.3 Hazardous Plants

During the conduct of site activities, a number and variety of hazardous plants may be encountered. The ailments associated with these plants range from mild hay fever to varying forms of contact dermatitis. However, the plants that present the greatest degree of risk to site personnel (i.e., potential for contact vs. effect produced) are those that produce skin and tissue injury.

D.18.5.3.1 Plants Causing Skin and Tissue Injury

Contact with splinters, thorns, and sharp leaf edges is of special concern to site personnel, as is the contact with the pointed surfaces found on branches, limbs, and small trunks left by site clearing and grubbing crews. This concern stems from the fact that punctures, cuts, and even minor scrapes caused by accidental contact may result in non-infectious skin lesions, and the introduction of fungi or bacteria through the skin or eye. This is especially important in light of the fact that the warm moist environment created inside impermeable protective clothing is ideal for the propagation of fungal and bacterial infection. Personnel receiving any of the injuries listed above, even minor scrapes, will report immediately to the UXOSO for initial and continued observation and care of the injury.

D.18.5.3.2 Plants Causing Skin Reactions

The poisonous plant of greatest concern is poison ivy, called "pica pica" locally. Poison ivy thrives in all types of light and usually grows in the form of a trailing vine; however, it can also grow as a bush and can attain heights of 10 feet or more. As illustrated in Figure D-3, Poison ivy has shiny, pointed leaves that grow in clusters of three.

Figure D-3: Examples of Hazardous Plants

Poison Ivy	**Leaves and Fruit of Manchineel Tree**
	

The skin reaction associated with contacting this plant is caused by the body's allergic reaction to toxins contained in oils produced by the plant. Becoming contaminated with the oils does not require contact with just the leaves. Contamination can be achieved through contact with other parts of the plant such as the branches, stems or berries, or contact with contaminated items such as tools and clothing. Being downwind from areas where these plants are burning can also produce reactions. The allergic reaction associated with exposure to these plants will generally cause the following signs and symptoms:

- Blistering at the site of contact, usually occurring within 12 to 48 hours after contact
- Reddening, swelling, itching and burning at the site of contact
- Pain, if the reaction is severe
- Conjunctivitis, asthma, and other allergic reactions if the person is extremely sensitive to the poisonous plant toxin
- If the rash is scratched, secondary infections can occur. The rash usually disappears in 1 to 2 weeks in cases of mild exposure and up to 3 weeks when exposure is severe. Preventive measures, which can prove effective for most site personnel, are:
- Avoid contact with any poisonous plants on site, and keep a steady watch to identify, report, and mark poisonous plants found on site
- Wash hands, face or other exposed areas at the beginning of each break period and at the end of each workday
- Avoid contact with, and wash on a daily basis, contaminated tools, equipment, and clothing
- Barrier creams, detoxification/wash solutions and orally administered desensitization may prove effective and should be tried to find the best preventive solution
- Keeping the skin covered as much as possible (i.e., long pants and long sleeved shirts) in areas where these plants are known to exist will limit much of the potential exposure

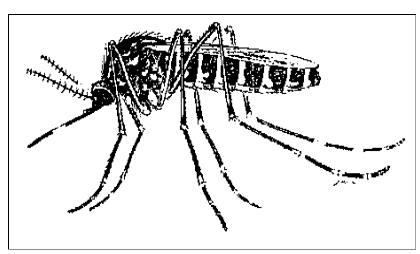
D.18.5.3.3 Poisonous Tree

The poisonous Manchineel Tree grows in the Caribbean region. The tree is also referred to as Manzanilla de la muerte “Little Apple of Death,” as it is one of the most poisonous trees in existence. It resembles an apple tree. It has grayish bark and grows up to 45+ feet in height. It has shiny green leaves and spikes of small, greenish flowers. Its fruits, which look similar to an apple are green to greenish-yellow in color. They are normally found on or near coastal beaches and their roots stabilize the sand from erosion.

The tree and its parts contain strong toxins. It will secrete a white, milky substance during rainfall. Standing beneath the tree during rainfall is said to cause blistering of the skin due to contact with this substance. Burning the tree can cause blindness if smoke reaches the eyes. The fruit can be fatal if eaten. Do not stand under the tree, and do not touch the bark, branches, leaves or fruit of this tree, as it will result in contact dermatitis. Skin contact can cause blistering, burns, erythema, swelling and inflammation. If ingested it will cause burning and swelling of the mucosa, esophageal ulcerations, edema, and cervical lymphadenopathy, making it impossible to swallow, difficult to talk and hard to breathe. The fruit is poisonous and should not be ingested, as it can be fatal.

Treatment of exposure includes cleaning the skin with soap and water to remove the plant latex, being careful to avoid further exposure, and using antihistamines to minimize the immune response and the edema. If an exposure to this tree is suspected, report it immediately to the UXOSO, and he will arrange for transport to the hospital emergency room for treatment.

D.18.5.4 Mosquitoes



The Centers for Disease Control and Prevention (CDCP) has noted the increase of West Nile Virus (WNV), which is transmitted by bites from an infected mosquito. Mosquitoes live in nearly all environments, including urban, wooded, grassy, brushy, arid, or other areas that contain standing pools of water (seeps, drainage, watering holes, etc.).

WNV disease has been documented in at least 42 states. WNV was first detected in the western hemisphere in 1999. The virus is transmitted by certain types of mosquitoes to birds and some mammals, including humans. WNV is not spread from person to person. In areas where the virus exists, usually less than one percent of the mosquito population is likely to be infected with the virus.

Most people who become infected with the WNV do not show symptoms or may show only mild ones. The symptoms of WNV include: fever, headache, body aches, occasional skin rash, and swollen lymph nodes. At its most serious, it can cause encephalitis or meningitis. Less than one percent of people who are bitten by an infected mosquito will develop severe illness. These symptoms include a rapid onset of: severe headache, high fever, stiff neck, confusion, loss of consciousness (coma), or muscle weakness, and may be fatal.

Treatment for WNV includes supportive measures such as rest, observation, intravenous fluids, and respiratory support, as needed.

If you believe you are showing any of the symptoms noted above, contact the UXOSO, who will authorize you to visit a physician for an examination and possible treatment.

D.18.5.4.1 Protective Measures

Standard field gear (work boots, hats, socks, trousers, and work shirts) provides good protection against mosquito bites; exposed skin is particularly susceptible to bites. However, even when wearing field gear, the following precautions shall be taken when working in areas that might be infested with mosquitoes.

- Spray outer clothing, **BUT NOT YOUR SKIN**, with an insect repellant that contains permethrin or permanone.
- When working in infested areas, apply an insect repellant containing 33 percent Deet to exposed skin and avoid standing water areas as much as possible.
- Also look for the symptoms of the onset of WNV, which occur within 3 to 15 days after being bitten by an infected mosquito.

D.18.5.5 Ticks

The CDC has noted the increase of Lyme Disease and Rocky Mountain Spotted Fever, both of which are caused by bites from infected ticks that live in and near wooded areas, grass, and brush. Ticks are small, ranging from the size of a comma up to about one-quarter inch. They are sometimes difficult to see. When embedded in the skin, they may look like a freckle. The tick season usually extends from spring through summer.

D.18.5.5.1 Protective Measures

Standard field gear (work boots, socks and light-colored coveralls) provide good protection against tick bites, particularly if the joints are taped. However, even when wearing field gear, the following precautions shall be taken when working in areas that might be infested with ticks:

- When in the field, check yourself often for ticks, particularly on your lower legs and areas covered with hair
- Spray outer clothing, particularly your pant legs and socks, **BUT NOT YOUR SKIN**, with an insect repellant that contains permethrin or permanone
- When walking in wooded areas, wear a hat, and avoid contact with bushes, tall grass, or brush as much as possible
- If you find a tick, remove it by pulling on it gently with tweezers

- If the tick resists, cover the tick with salad oil for about 15 minutes to asphyxiate it, then remove it with tweezers
- **DO NOT** use matches, a lit cigarette, nail polish or any other type of chemical to "coax" the tick out
- Be sure to remove all parts of the tick's body, and disinfect the area with alcohol or a similar antiseptic after removal
- For several days to several weeks after removal of the tick, look for the signs of the onset of Lyme disease, such as a rash that looks like a bulls-eye or an expanding red circle surrounding a light area, frequently seen with a small welt in the center
- Also look for the signs of the onset of RMSF, such as an inflammation which is visible in the form of a rash comprising many red spots under the skin, which appears 3 to 10 days after the tick bite

D.18.5.6 Snakes

Puerto Rico has no identified poisonous snakes. However, even non-poisonous snakes will strike in defense of themselves. When site activities are conducted in warm weather on sites that are located in wooded, grassy, or rocky environments, the potential for contact with snakes becomes a possibility. Normally, if a person is approaching a snake, the noise created by the person is usually sufficient to frighten the snake off. However, during the warm months, caution must be exercised when conducting site operations around areas where snakes might be found (e.g., rocks, bushes, logs, or in holes, crevices, and abandoned pipes). Proper care is to be taken by site personnel during activities which may bring them in contact with local wildlife.

D.18.5.7 Centipedes

Centipedes are commonly found in Puerto Rico. They are larger than those seen on the mainland of the United States and can grow up to 15 inches in length. They are venomous and a bite from a centipede will feel similar to a bee sting. Although the bite can be painful, the venom is rarely fatal to humans unless they experience an allergic reaction. If a worker is bitten by a centipede, report the incident immediately to the UXOSO who will see that first aid is provided to the victim. The victim will also be monitored for at least 30 minutes to assure there is no allergic reaction. If an allergic reaction occurs, (like anaphylactic shock that is experienced from a bee sting) the victim will be transported to the hospital for medical treatment.

D.19 LOGS, RECORDKEEPING, AND REPORTS

USA will perform and document safety inspections, as well as maintain a site visitor log. Personnel records will be kept on site, which document medical surveillance and appropriate training certifications. In addition, accident reports and site monitoring reports will also be maintained on site. All site logs, documents, and records will be included in the final report.

D.19.1 SAFETY INSPECTION LOGS

The UXOSO will perform and document daily and weekly safety inspections of all site operations on a scheduled and non-scheduled basis. The UXOSO will conduct non-scheduled safety and health inspections as deemed appropriate, based upon the ongoing site activities. Scheduled safety and health inspections will be conducted as outlined in Table D-10. When discrepancies are observed, follow-up will be documented in the UXOSO log until the corrective actions required have been completed.

Table D-10: Inspection Type and Frequency

Area	Frequency
Sanitation	Daily
Medical and First Aid	Daily
Temporary Facilities	Weekly
Personal Protective and Safety Equipment	Daily
Hazardous Substances, Agents, and Environments	Weekly
Lighting	Monthly
Accident Prevention Signs, Tags, Labels, and Signals and Piping System Identification	Monthly
Fire Prevention and Protection	Weekly
Hand and Power Tools	Daily, if applicable
Material Handling, Storage and Disposal	Weekly
Machinery and Mechanized Equipment	Daily, if applicable
Motor Vehicles	Daily
Safe Access and Fall Protection	Weekly, if applicable
HTRW	Daily, if applicable

D.19.2 VISITOR LOG

The Visitor's Log will be maintained by the UXOSO and will document the visitor's name, company name, date, time, and reason for visit. There will also be documentation that the visitor was given a safety briefing prior to being permitted to enter the EZ of the site. Visitors will be escorted by UXO personnel at all times within the EZ. MEC operations will cease while visitors are within the EZ.

D.19.3 RECORD KEEPING

Each person on the site will have an individual file folder, which contains a copy of the following items:

- 40-hr HAZWOPER Certificate
- Current 8-hr HAZWOPER Annual Refresher Certificate
- 8-hr HAZWOPER Supervisor Certificate, if applicable
- EOD Training Certificate
- Any other applicable training certificates.

Personnel folders will be maintained by the UXOSO on site for the duration of site activities. A Training/Tailgate Safety Briefing record will be completed for all on-site daily training. The UXOSO will maintain the file, which will be made available for the client as requested.

D.19.3.1 Medical Surveillance Records and Certifications

A copy of the Physician Statement from a licensed physician who is certified in Occupational Medicine by the American Board of Preventive Medicine, regarding the current annual HAZWOPER physical examination, will be maintained in the individual folder with the HAZWOPER certificates. The Physician

Statements will remain in the individual's file on the project site for the duration of site operations. The files will then be transferred to the Corporate Office in Oldsmar, Florida, at the end of site operations.

D.19.3.2 Accident Reporting Records

Should an accident occur on the site, all reports and records will be documented. Copies will be maintained on site for the duration of site activities. A permanent copy will be maintained in the Oldsmar, Florida, office.

D.19.3.3 Site Monitoring Results

All site monitoring results will be documented. These results will be kept in a file at the project site for reference, and will become a part of the permanent site record at the conclusion of site activities.

D.19.4 FINAL REPORT

USA will develop, retain, and submit as part of the final report, all visitor registration logs, training logs, and daily safety inspection logs as part of the daily quality control reports.

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APPENDIX D, ATTACHMENT 1.
OSHA FORM 300

OSHA's Form 300 (Rev. 01/2004)
Log of Work-Related Injuries and Illnesses

Attention: This form contains information relating to employee health and must be used in a manner that protects the confidentiality of employees to the extent possible while the information is being used for occupational safety and health purposes.

Year ______

U.S. Department of Labor
Occupational Safety and Health Administration

You must record information about every work-related injury or illness that involves loss of consciousness, restricted work activity or job transfer, days away from work, or medical treatment beyond first aid. You must also record significant work-related injuries and illnesses that are diagnosed by a physician or licensed health care professional. You must also record work-related injuries and illnesses that meet any of the specific recording criteria listed in 29 CFR 1904.8 through 1904.12. Feel free to use two lines for a single case if you need to. You must complete an injury and illness incident report (OSHA Form 301) or equivalent form for each injury or illness recorded on this form. If you're not sure whether a case is recordable, call your local OSHA office for help.

Form approved OMB no. 1218-0176

Establishment name USA Environmental, Inc.

City ______ State ______

Identify the person			Describe the case			Classify the case											
						CHECK ONLY ONE box for each case based on the most serious outcome for that case:				Enter the number of days the injured or ill worker was:		Check the "injury" column or choose one type of illness:					
(A) Case No.	(B) Employee's Name	(C) Job Title (e.g., Welder)	(D) Date of injury or onset of illness (mo./day)	(E) Where the event occurred (e.g. Loading dock north end)	(F) Describe injury or illness, parts of body affected, and object/substance that directly injured or made person ill (e.g. Second degree burns on right forearm from acetylene torch)	Death (G)	Days away from work (H)	Remained at work: Job transfer or restriction (I)	Remained at work: Other record-able cases (J)	Away From Work (days) (K)	On job transfer or restriction (days)	(M) Injury (1)	Skin Disorder (2)	Respiratory Condition (3)	Poisoning (4)	Hearing Loss (5)	All other illnesses (6)
					Page totals	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
												Injury (1)	Skin Disorder (2)	Respiratory Condition (3)	Poisoning (4)	Hearing Loss (5)	All other illnesses (6)

Be sure to transfer these totals to the Summary page (Form 300A) before you post it.

Public reporting burden for this collection of information is estimated to average 14 minutes per response, including time to review the instruction, search and gather the data needed, and complete and review the collection ofi nformation. Persons are not required to respond to the collection of information unless it displays a currently valid OMB control number. If you have any comments about these estimates or any aspects of this data collection, contact: US Department of Labor, OSHA Office of Statistics, Room N-3644, 200 Constitution Ave, NW, Washington, DC 20210. Do not send the completed forms to this office.

APPENDIX D, ATTACHMENT 2.
ACTIVITY HAZARD ANALYSES

This attachment contains the following Activity Hazard Analyses related to the RI/FS effort:

- Boat Operations
- Boat Transportation
- Geophysical Prove-out Test Strip
- Location, Survey and Mapping
- MEC Disposal
- MEC Investigation
- MPPEH Inspection
- Quality Control
- Vegetation Clearance
- Vehicle Operations.

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ACTIVITY HAZARDS ANALYSIS

Overall Risk Assessment Code (RAC)

Date: 3 February 2011

Project: RI/FS

Activity: Boat Operations

Activity Location: Culebra Island, Puerto Rico

Prepared By: Cheryl M. Riordan, CSP

Risk Assessment Code Matrix

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Severity	Frequent	Likely			
Catastrophic	E	E			
Critical	E	H			
Marginal	H	M			
Negligible	M	L			

Add Identified Hazards

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	
X	• Locate MEC under water using geophysical equipment as well as visual survey of video taken with equipment in order to characterize the site.	• Under water MEC hazards • Uneven and/or moving working surfaces of the boat – slip, trip, fall hazards • Muscle strain carrying instruments • Heat Stress • Biological hazards – bees, wasps, mosquitoes, spiders. • Noise • Sunburn	• On-site MEC Training. • Personnel will wear rubber soled shoes to prevent slipping while on boat, and will avoid stepping in wet areas that could be slippery. • Follow appropriate lifting/ carrying procedures • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks. • Training in biological hazards avoidance • PPE for noise and cuts/lacerations. • Use barrier creams/insect repellants as necessary • Wear cotton shirts and long pants • Use sunscreen and wear cap • Fire extinguishers will be readily available. • First aid kits will be readily available. • ROV will be characterizing levels of underwater MEC contamination through video taping of underwater conditions. items is not intended or anticipated. • Personnel will remain seated while boat is in motion. • All personnel will wear personal flotation devices while on boat. • Good housekeeping standards will be enforced. properly staged on the boat to prevent tripping hazards. • Emergency equipment will be available for a man overboard situation and personnel will be trained in its use. • Communication equipment will be functional and readily available. • Local weather will be monitored and boat operations will be terminated should a storm be approaching, or should sea conditions make it unsafe to continue.	

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	
X	• A scan sonar/magnetometer and an ROV will both be used under water in order to detect MEC under water at various depths • This equipment will present video of the items located and identify the latitude/longitude coordinates of MEC items identified. • This is an MEC avoidance operation that will be performed remotely from boats on the surface of the water. • At no time will physical contact be made with MEC.	• Under water MEC hazards • Uneven and/or moving working surfaces of the boat – slip, trip, fall hazards • Muscle strain carrying instruments • Heat Stress • Biological hazards – bees, wasps, mosquitoes, spiders. • Noise • Sunburn	• On-site MEC Training. • Personnel will wear rubber soled shoes to prevent slipping while on boat, and will avoid stepping in wet areas that could be slippery. • Follow appropriate lifting/ carrying procedures • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks. • Training in biological hazards avoidance • PPE for noise and cuts/lacerations. • Use barrier creams/insect repellants as necessary • Wear cotton shirts and long pants • Use sunscreen and wear cap • Fire extinguishers will be readily available. • First aid kits will be readily available. • ROV will be characterizing levels of underwater MEC contamination through video taping of underwater conditions. items is not intended or anticipated. • Personnel will remain seated while boat is in motion. • All personnel will wear personal flotation devices while on boat. • Good housekeeping standards will be enforced. properly staged on the boat to prevent tripping hazards. • Emergency equipment will be available for a man overboard situation and personnel will be trained in its use. • Communication equipment will be functional and readily available. • Local weather will be monitored and boat operations will be terminated should a storm be approaching, or should sea conditions make it unsafe to continue..	
X				
X				

Add Items

	EQUIPMENT	TRAINING	INSPECTION
X	• Footwear with rubber soles to prevent slipping • Back braces (optional) • Appropriate clothing and PPE (to include personal flotation device, canvas or leather gloves, cotton work clothing, safety glasses or goggles and cap). Hearing protection will be required if noise from boat engine or generator reaches hazardous levels.	• Site-specific training, slip/fall hazards • Site-specific training/lifting techniques • Training in lifting and carrying techniques • PPE Training	• PPE inspected daily prior to use

ACTIVITY HAZARDS ANALYSIS

	EQUIPMENT	TRAINING	INSPECTION
X	• Scan sonar/magnetometer • ROV • Generator	• UXO personnel will meet training and experience requirements outlined in DDESB TP 18 • Site specific MEC training will be presented to all site personnel • Equipment familiarity training • All site personnel will have current HAZWOPER training	Field Team Leader/UXOSO will assure that all controls are being followed; all equipment is being utilized and that all personnel have received appropriate training. • Equipment inspected daily prior to use • Daily serviceability check of magnetometers
X	• Communications equipment • First aid kit. • Fire extinguishers • Man overboard rescue equipment (hook, rope, life ring) • WBGT monitor	• Emergency response procedures • Heat Stress symptoms/first aid • Site-specific biological hazards to include first aid • Equipment familiarity training	• Communications equipment checked daily prior to use • First aid kits checked daily and inspected weekly • Fire extinguishers checked daily and inspected weekly • Equipment inspected daily prior to use

Involved Personnel:

Acceptance Authority (digital signature): CSHM

	PRINT	SIGNATURE		
SUXOS Name:	______	______		______
UXOSO Name:	______	______		______
Employee Name(s):	______	______	Date/Time:	______
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ACTIVITY HAZARDS ANALYSIS

Overall Risk Assessment Code (RAC)

Date: 2 February 2011

Project: RI/FS

Activity: Boat Transportation

Activity Location: Culebra Island, Puerto Rico

Prepared By: Cheryl M. Riordan, CSP

Risk Assessment Code Matrix

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Severity	Frequent	Likely			
Catastrophic	E	E			
Critical	E	H			
Marginal	H	M			
Negligible	M	L			

Add Identified Hazards

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	
X	• Identify the hazards associated with boat operations • UXOSO will inspect boat for physical condition and condition and presence of required safety and rescue equipment • UXOSO will assure all personnel are wearing required personal flotation device • Ship Captain will give safety briefing prior to transport of personnel	• Potential for malfunction of boat engine or equipment • Fire hazards • Slip, trip and fall hazards • Heat Stress • Weather hazards • Sunburn	• Sea Ventures will assure that boat is well maintained and in good condition prior to taking on passengers • Sea Ventures will assure that Captain and vessel are licensed in accordance with local requirements • Sea Ventures will be in communication with Captain and aware of destination, when boat leaves wharf and docks on each trip • Emergency radios will be in operating condition prior to leaving the wharf. There will be a primary and alternate means of communication, and extra batteries will be available. • Directions for contacting the Coast Guard and hospital will be posted with each radio and cell phone • Personnel will attend daily safety briefing by Captain prior to transport by boat, and will obey all directions from the Captain during transport • All passengers will wear personal flotation device at all times while on boat • Boat will be equipped with rescue equipment to handle a man-overboard situation (such as rescue hook, life preserver with rope, or similar equipment) • Block, brace, and secure cargo from movement during transportation • Fire extinguishers and first aid kit must be readily available • Personnel will wear shoes with non-slip soles and will avoid walking in wet areas of the boat that may be slippery • Adequate supply of drinking water will be available • Personnel will wear long or short-sleeve shirts and long pants • Personnel will wear caps and use sunscreen	

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS
X	• Captain will operate boat to transport personnel to desired destination	• Potential for boat accidents during transport • Potential for malfunction of boat engine or equipment • Fire hazards • Drowning hazards • Slip, trip and fall hazards • Heat Stress • Weather hazards • Sunburn	• Sea Ventures will be in communication with Captain and aware of destination, when boat leaves wharf and docks on each trip • Emergency radios will be in operating condition prior to leaving the wharf. There will be a primary and alternate means of communication, and extra batteries will be available. • Directions for contacting the Coast Guard and hospital will be posted with each radio and cell phone • Personnel will attend daily safety briefing by Captain prior to transport by boat, and will obey all directions from the Captain during transport • All passengers will wear personal flotation device at all times while on boat • Boat will be equipped with rescue equipment to handle a man-overboard situation (such as rescue hook, life preserver with rope, or similar equipment) • Block, brace, and secure cargo from movement during transportation • Fire extinguishers and first aid kit must be readily available • Personnel will wear shoes with non-slip soles and will avoid walking in wet areas of the boat that may be slippery • Adequate supply of drinking water will be available • Personnel will not ride in boat during electrical storm, or if electrical storm is approaching • Personnel will wear long or short-sleeve shirts and long pants • Personnel will wear caps and use sunscreen
X			
X			

Add Items

	EQUIPMENT	TRAINING	INSPECTION
X	• Boat • Storm monitor • Drinking water	• Licensed boat Captain • Training in boat safety procedures • All personnel will have current HAZWOPER training	SUXOS/UXOSO will assure that all controls are being followed; all equipment is being utilized and that all personnel have received appropriate training. • Assure that Sea Ventures is providing daily inspection of their boats
X	• First Aid Kit • Fire Extinguishers • Communication equipment (radios, cell phones and extra batteries • Rescue equipment	• Emergency procedures training • Fire extinguisher training • Heat stress training and first aid	• Communications equipment checked daily prior to use • First aid kits checked daily and inspected weekly • Fire extinguishers checked daily and inspected weekly • Rescue equipment will be inspected daily prior to boat leaving dock
X	• PPE to include personal flotation device, safety sunglasses and cap	• PPE training	• PPE inspected daily prior to use.

ACTIVITY HAZARDS ANALYSIS

Involved Personnel:

Acceptance Authority (digital signature): ________________________________

PRINT SIGNATURE

SUXOS Name: ____________ ____________ ____________

UXOSO Name: ____________ ____________ ____________

Employee Name(s): ____________ ____________ Date/Time: ____________

Date/Time:

Date/Time:

Date/Time: ____________

Date/Time: ____________

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ACTIVITY HAZARDS ANALYSIS

Overall Risk Assessment Code (RAC):

Date: 2 February 2011

Project: RI/FS

Activity: Geophysical Prove-out Test Strip

Activity Location: Culebra Island, Puerto Rico

Prepared By: Cheryl M. Riordan, CSP

Risk Assessment Code Matrix

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Severity	Frequent	Likely			
Catastrophic	E	E			
Critical	E	H			
Marginal	H	M			
Negligible	M	L			

Add Identified Hazards

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	
X	• Using geophysical equipment, the UXOQCS will locate a plot of land where a GPO Test Strip can be prepared and assure there are no buried anomalies in the area.	• MEC hazards • Uneven working surfaces – slip, trip, fall hazards • Muscle strain carrying instruments • Heat stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn	• On-site MEC training • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles (No steel toes around magnetometer operations) • Follow appropriate lifting/ carrying procedures • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Training in biological hazards avoidance • Use barrier creams/insect repellants as necessary • PPE – leather work gloves • Wear cotton shirts and long pants • Use sunscreen and wear cap	
X	• Using inert ordnance or other items that would give off a similar signature, the UXOQCS will bury these items at differing depths and directions throughout the GPO Test Strip. • The UXOQCS will prepare a map of the GPO Test Strip showing all of the buried items.	• Uneven working surfaces – slip, trip, fall hazards • Muscle strain using shovels • Heat stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Cuts and abrasions from handling rocks or buried debris during burial of inert ordnance • Sunburn	• Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles (No steel toes around magnetometer operations) • Follow appropriate lifting/ carrying procedures • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Training in biological hazards avoidance • Use barrier creams/insect repellants as necessary • PPE – leather work gloves • Wear cotton shirts and long pants • Use sunscreen and wear cap	

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	RAC
X	• Each day, prior to use of geophysical equipment, each person will test the equipment on the GPO Test Strip. • If the geophysical equipment is able to locate all buried items in the GPO Test Strip, it will be used for work that day. • If the geophysical equipment is unable to locate all buried items in the GPO Test Strip, it will be removed from service until repairs can be made. Another piece of equipment will be tried until one is found that can detect all buried items	• Uneven working surfaces – slip, trip, fall hazards • Muscle strain carrying instruments • Heat stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn	• Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles (No steel toes around magnetometer operations) • Follow appropriate lifting/ carrying procedures • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Training in biological hazards avoidance • Use barrier creams/insect repellants as necessary • PPE – leather work gloves • Wear cotton shirts and long pants • Use sunscreen and wear cap	L
X				

Add Items

	EQUIPMENT	TRAINING	INSPECTION
X	• Footwear with ankle support and non-slip soles (no steel toes around magnetometers) • Back braces (optional) • Appropriate clothing and PPE (to include leather gloves, cotton work clothing, safety glasses or goggles and cap)	• Site-specific training, slip/fall hazards • Training in lifting and carrying techniques • PPE Training	• PPE inspected daily prior to use
X	• Appropriate geophysical equipment. • Hand tools	• UXO personnel will meet training and experience requirements outlined in DDESB TP 18 • Instrument familiarity training • All site personnel will have current HAZWOPER training	SUXOS/UXOSO will assure that all controls are being followed; all equipment is being utilized and that all personnel have received appropriate training. • Equipment inspected daily prior to use • Daily serviceability check of magnetometers
X	• Communications equipment. • First aid kit. • Fire extinguishers • WBGT monitor	• Equipment familiarity training • Heat Stress symptoms/first aid • Site-specific flora/fauna to include first aid • Emergency response procedures	• Equipment inspected daily prior to use • Communications equipment checked daily prior to use • First aid kits checked daily and inspected weekly • Fire extinguishers checked daily and inspected weekly

Involved Personnel:

Acceptance Authority (digital signature): CSHM

NWW Form 385-1 (Revised) April 2008

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SUXOS Name:	______	______	______
UXOSO Name:	______	______	______
Employee Name(s):	______	______ Date/Time:	______
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ACTIVITY HAZARDS ANALYSIS

Overall Risk Assessment Code (RAC)

Date: 2 February 2011

Project: RI/FS

Activity: Location Survey and Mapping

Activity Location: Culebra Island, Puerto Rico

Prepared By: Cheryl M. Riordan, CSP

Risk Assessment Code Matrix

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Severity	Frequent	Likely			
Catastrophic	E	E			
Critical	E	H			
Marginal	H	M			
Negligible	M	L			

Add Identified Hazards

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	
X	• The UXO team will enter the site ahead of the survey crew to clear a path of entry to the site for the purpose of establishing grids throughout the site.	• MEC hazards • Uneven working surfaces – slip, trip, fall hazards • Muscle strain carrying instruments • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn	• On-site MEC training • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles (No steel toes around magnetometer operations) • Follow appropriate lifting/ carrying procedures • Heat stress monitoring, drinking water, work-rest schedule and cool shelter for breaks • Training in biological hazards avoidance • Use barrier creams/insect repellants as necessary • Wear cotton shirts and long pants • Use appropriate PPE for job being performed • Use sunscreen and wear cap	
X	• If live MEC is encountered, the area will be marked and the disposal operation will be performed later by a UXO team.	• MEC hazards • Uneven working surfaces – slip, trip, fall hazards • Muscle strain carrying instruments • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn	• On-site MEC training • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles (No steel toes around magnetometer operations) • Follow appropriate lifting/ carrying procedures • Heat stress monitoring, drinking water, work-rest schedule and cool shelter for breaks • Training in biological hazards avoidance • Use barrier creams/insect repellants as necessary • Wear cotton shirts and long pants • Use appropriate PPE for job being performed • Use sunscreen and wear cap	

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS
X	• If inert MEC is encountered, it will be inspected and certified as inert and secured at a collection point until the end of the project when it will be sold to a qualified recycler.	• In accordance with MPPEH Inspection AHA	• In accordance with MPPEH Inspection AHA
X	• Where intrusive operations, such as driving stakes, are required UXO personnel, using geophysical equipment, will determine if there are potential MEC beneath the ground surface. • If potential MEC is located below the ground surface, the area for the intrusive operations will be moved. • When clear area is located, the stakes will be driven. • Location data will be prepared and submitted at completion of work.	• MEC hazards • Uneven working surfaces – slip, trip, fall hazards • Muscle strain carrying instruments • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn	• On-site MEC training • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles (No steel toes around magnetometer operations) • Follow appropriate lifting/ carrying procedures • Heat stress monitoring, drinking water, work-rest schedule and cool shelter for breaks • Training in biological hazards avoidance • Use barrier creams/insect repellants as necessary • Wear cotton shirts and long pants • Use appropriate PPE for job being performed • Use sunscreen and wear cap

Add Items

EQUIPMENT	TRAINING	INSPECTION
• Footwear with ankle support and non-slip soles (no steel toes around magnetometers). • Back braces (optional). • Appropriate cotton clothing and PPE to include leather gloves, safety glasses or goggles and cap.	• Site-specific training, slip/fall hazards • Site-specific training/lifting techniques • PPE training	• PPE inspected daily prior to use
• Appropriate geophysical equipment. • Flagging material	• UXO personnel will meet training and experience requirements outlined in DDESB TP 18 • Site-specific MEC training will be presented to all site personnel. • Equipment familiarity training • Current HAZWOPER Training	SUXOS/UXOSO will assure that all controls are being followed; all equipment is being utilized and that all personnel have received appropriate training. • Equipment inspected daily prior to use • Daily serviceability check of magnetometers
• Communications equipment. • First aid kit. • Fire extinguishers • WBGT monitor.	• Emergency response procedures • Equipment familiarity training • Heat Stress symptoms/first aid • Site-specific flora/fauna to include first aid.	• Communications equipment checked daily prior to use • First aid kits checked daily and inspected weekly • Fire extinguishers checked daily and inspected weekly • Equipment inspected daily prior to use

Involved Personnel:

ACTIVITY HAZARDS ANALYSIS

Acceptance Authority (digital signature): , CSHM

PRINT **SIGNATURE**

SUXOS Name: ____________ ____________ ____________

UXOSO Name: ____________ ____________ ____________

Employee Name(s): ____________ ____________ **Date/Time:** ____________

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ACTIVITY HAZARDS ANALYSIS

Overall Risk Assessment Code (RAC)

Date: 2 February 2011

Project: RI/FS

Activity: MEC Disposal

Activity Location: Culebra Island, Puerto Rico

Prepared By: Cheryl M. Riordan, CSP

Risk Assessment Code Matrix

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Severity		Frequent	Likely			
	Catastrophic	E	E			
	Critical	E	H			
	Marginal	H	M			
	Negligible	M	L			

Add Identified Hazards

JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS
X	• Any rounds of MEC that are encountered will involve a blow in place disposal operation, using sandbags to mitigate the blast and fragment hazards.	• MEC hazards • Unintentional detonations • Unauthorized personnel in area • Uneven working surfaces – slip, trip, fall hazards • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn • Noise • Fire hazards	• On-site MEC Training • Be alert. Cease operations if unsafe conditions arise • Controlled use of radios and cell phones • Establish EZ and secure according to type of shot • Maintain positive site control; cease operations if unauthorized entry is made • Observe all MEC/UXO safety precautions, such as movement, heat, shock, and friction • Do not handle MEC/UXO items unnecessarily • Only UXO qualified personnel will perform demolition operations • Use engineering controls to reduce or eliminate fragmentation/ overpressure hazards • Observe safe work practices, operating precautions, and instructions for the equipment in use • Do not allow smoking or flame producing devices in the vicinity of explosives • Keep personnel to a minimum during operations • Use and enforce the buddy system • Wear the appropriate PPE for the task being performed • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles • Training in biological hazards avoidance • Wear cotton shirts and long pants • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Use barrier creams/insect repellants as necessary • Use sunscreen and cap • First aid kits and fire extinguishers will be readily available
X	• Evacuate area around disposal operation for required fragmentation distance except for personnel involved in disposal operation. • Place guard on access road at least fragmentation distance to assure no further entry into site.	• Unauthorized personnel in area • Uneven working surfaces – slip, trip, fall hazards • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn	• Be alert. Cease operations if unsafe conditions arise • Controlled use of radios and cell phones • Establish EZ and secure according to type of shot • Maintain positive site control; cease operations if unauthorized entry is made • Do not allow smoking or flame producing devices in the vicinity of explosives • Keep personnel to a minimum during operations • Use and enforce the buddy system • Wear the appropriate PPE for the task being performed • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles • Training in biological hazards avoidance • Wear cotton shirts and long pants • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Use barrier creams/insect repellants as necessary • Use sunscreen and cap

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	
X	• Identify item. • Prepare shot. • Make notifications of impending shot. • Personnel performing disposal evacuate to fragmentation distance or to shielded area. • Observe area for potential unauthorized entrants. If any are observed, halt operation until they are removed.	• MEC hazards • Unintentional detonations • Unauthorized personnel in area • Uneven working surfaces – slip, trip, fall hazards • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn • Noise • Fire hazards	• On-site MEC Training • Be alert. Cease operations if unsafe conditions arise • Controlled use of radios and cell phones • Establish EZ and secure according to type of shot • Maintain positive site control; cease operations if unauthorized entry is made • Observe all MEC/UXO safety precautions, such as movement, heat, shock, and friction • Do not handle MEC/UXO items unnecessarily • Only UXO qualified personnel will perform demolitions operations • Use engineering controls to reduce or eliminate fragmentation/overpressure hazards • Observe safe work practices, operating precautions, and instructions for the equipment in use • Do not allow smoking or flame producing devices in the vicinity of explosives • Keep personnel to a minimum during operations • Use and enforce the buddy system • Wear the appropriate PPE for the task being performed • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles • Training in biological hazards avoidance • Wear cotton shirts and long pants • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Use barrier creams/insect repellants as necessary • Use sunscreen and cap • First aid kits and fire extinguishers will be readily available	

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS
X	• Sound signal for impending shot. • Perform disposal operation. • Check to see that disposal operation was successful. • If not successful, repeat disposal operation. • Give signal that operation is complete.	• MEC hazards • Unintentional detonations • Unauthorized personnel in area • Uneven working surfaces – slip, trip, fall hazards • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn • Noise • Fire hazards	• On-site MEC Training • Be alert. Cease operations if unsafe conditions arise • Controlled use of radios and cell phones • Establish EZ and secure according to type of shot • Maintain positive site control; cease operations if unauthorized entry is made • Observe all MEC/UXO safety precautions, such as movement, heat, shock, and friction • Do not handle MEC/UXO items unnecessarily • Only UXO qualified personnel will perform demolitions operations • Use engineering controls to reduce or eliminate fragmentation/ overpressure hazards • Observe safe work practices, operating precautions, and instructions for the equipment in use • Do not allow smoking or flame producing devices in the vicinity of explosives • Keep personnel to a minimum during operations • Use and enforce the buddy system • Wear the appropriate PPE for the task being performed • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles • Training in biological hazards avoidance • Wear cotton shirts and long pants • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Use barrier creams/insect repellants as necessary • Use sunscreen and cap • First aid kits and fire extinguishers will be readily available

Add Items

EQUIPMENT	TRAINING	INSPECTION
• Footwear with ankle support and non-slip soles • Appropriate clothing and PPE to include safety glasses, leather gloves, hearing protection, cotton work clothing and cap)	• Site-specific training on slip, trip and fall hazards • PPE Training	• PPE inspected daily prior to use
• Demolitions Equipment	• UXO personnel will meet training and experience requirements outlined in DDESB TP 18 • Site-specific MEC training will be presented to all site personnel • Training in disposal operations for items expected to be encountered • All site personnel will have current HAZWOPER training	SUXOS/UXOSO will assure that all controls are being followed; all equipment is being utilized and that all personnel have received appropriate training. • Equipment inspected daily prior to use

ACTIVITY HAZARDS ANALYSIS

	EQUIPMENT	TRAINING	INSPECTION
X	• Communications equipment • First aid kit. • Fire extinguishers • WBGT monitor	• Equipment familiarity training • Emergency response procedures • Heat Stress symptoms/first aid • Site-specific flora/fauna to include first aid	• Equipment inspected daily prior to use • Communications equipment checked daily prior to use • First aid kits checked daily and inspected weekly • Fire extinguishers checked daily and inspected weekly

Involved Personnel:

Acceptance Authority (digital signature): CSHM

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UXOSO Name:	____________	____________		____________
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ACTIVITY HAZARDS ANALYSIS

Overall Risk Assessment Code (RAC)

Date: 2 February 2011

Project: RI/FS

Activity: MEC Investigation

Activity Location: Culebra Island, Puerto Rico

Prepared By: Cheryl M. Riordan, CSP

Risk Assessment Code Matrix

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Severity	Frequent	Likely			
Catastrophic	E	E			
Critical	E	H			
Marginal	H	M			
Negligible	M	L			

Add Identified Hazards

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	
X	• Locate anomalies using geophysical equipment. • Mark anomaly locations with pin flags	• MEC hazards • Uneven working surfaces – slip, trip, fall hazards • Muscle strain carrying instruments • Heat Stress • Unauthorized personnel entering site during operations • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn	• On-site MEC Training • Establish exclusion zone around project site • Establish separation distance between teams • Site control measures will be implemented (fencing, barricades, signage) • Only UXO trained personnel will locate anomalies. • Cease operations if unsafe conditions arise • Cease operations if unauthorized entry is made • Wear the appropriate PPE for the task being performed • Keep personnel to a minimum during operations • Use and enforce the buddy system • Ensure First Aid Kits and Fire Extinguishers are in place • No smoking, except in designated areas • Be observant while walking. Use sturdy leather work boots with ankle support, composite safety toe, and non-slip soles (no steel toe around magnetometer operations) • Follow appropriate lifting/ carrying procedures • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Training in biological hazards avoidance • Wear cotton shirts and long pants • Use insect repellants and barrier creams/ointments as necessary • Use sunscreen	

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	
X	• Anomalies will be carefully excavated using hands and hand tools, so that MEC identification can be made. • Carefully dig around the item, so that MEC can be identified and examined for condition. • Heavy equipment can be used to within one foot of buried MEC.	• MEC hazards • Uneven working surfaces – slip, trip, fall hazards • Muscle strain carrying instruments and using hand tools • Heat Stress • Unauthorized personnel entering site during operations • Unplanned Detonations • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn • Heavy equipment hazards • Noise • Cuts and abrasions from handling rocks or buried debris	• On-site MEC Training • Establish exclusion zone around project site • Establish separation distance between teams • Site control measures will be implemented (fencing, barricades, signage) • Observe all MEC safety precautions, such as movement, heat, shock, and friction • Only UXO trained personnel will locate anomalies. • Do not handle MEC items unnecessarily • Identification of MEC items will be made by 2 UXO qualified personnel • Cease operations if unsafe conditions arise • Cease operations if unauthorized entry is made • Wear the appropriate PPE for the task being performed • Keep personnel to a minimum during operations • Use and enforce the buddy system • Maintain clearance around heavy equipment. • Do not place any part of the body under load. • Use ground guides for heavy equipment operations. • Ensure First Aid Kits and Fire Extinguishers are in place • No smoking, except in designated areas • Be observant while walking. Use sturdy leather work boots with ankle support, composite safety toe, and non-slip soles (no steel toe around magnetometer operations) • Follow appropriate lifting/ carrying procedures • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Training in biological hazards avoidance • Wear cotton shirts and long pants • Use insect repellants and barrier creams/ointments as necessary • Use sunscreen	
X	• UXO team will dispose of live MEC.	In accordance with MEC Disposal AHA	In accordance with MEC Disposal AHA	

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS
X	• Inert MEC will be inspected and certified as inert, and secured at a collection point until the end of the project when it will be sold to a qualified recycler.	• Uneven working surfaces – slip, trip, fall hazards • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn • Cuts and abrasions from handling MPPEH/MD	• On-site MEC Training • Establish exclusion zone around project site • Establish separation distance between teams • Site control measures will be implemented (fencing, barricades, signage) • Certification of MEC items will be made by 2 UXO qualified personnel • Cease operations if unsafe conditions arise • Cease operations if unauthorized entry is made • Wear the appropriate PPE for the task being performed • Use and enforce the buddy system • Ensure First Aid Kits and Fire Extinguishers are in place • No smoking, except in designated areas • Be observant while walking. Use sturdy leather work boots with ankle support, composite safety toe, and non-slip soles (no steel toe around magnetometer operations) • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Training in biological hazards avoidance • Wear cotton shirts and long pants • Use insect repellants and barrier creams/ointments as necessary • Use sunscreen

Add Items

EQUIPMENT	TRAINING	INSPECTION
• Footwear with ankle support, composite safety toe and non-slip soles (no steel toes around magnetometers) • Back braces (optional) • Appropriate clothing and PPE to include safety glasses, leather gloves, cotton work clothes,(hearing protection and hard hats around heavy equipment)	• Site-specific training on slip, trip and fall hazards • Site-specific training/lifting techniques • PPE Training	• PPE inspected daily prior to use
• Appropriate geophysical equipment • Hand tools • Heavy equipment • Pin flags • Barricades and signage	• UXO personnel will meet training and experience requirements outlined in DDESB TP 18 • Site-specific MEC training will be presented to all site personnel • Instrument familiarity as required • Heavy equipment operators trained and certified on each piece of equipment operated • Heavy Equipment familiarity as required for ground crew in vicinity of heavy equipment operation • All UXO personnel will receive refresher training in excavating of anomalies • All site personnel will have current HAZWOPER training • Excavation safety training	SUXOS/UXOSO will assure that all controls are being followed; all equipment is being utilized and that all personnel have received appropriate training. • Equipment inspected daily prior to use • Daily serviceability check of instrument

ACTIVITY HAZARDS ANALYSIS

	EQUIPMENT	TRAINING	INSPECTION
X	• Communications equipment • First aid kit • Fire extinguishers • WBGT monitor	• Heat Stress symptoms/first aid • Site-specific flora/fauna to include first aid • Emergency response procedures	• Equipment inspected daily prior to use • Communications equipment checked daily prior to use • First aid kits checked daily and inspected weekly • Fire extinguishers checked daily and inspected weekly

Involved Personnel:

Acceptance Authority (digital signature): ______, CIH

	PRINT	SIGNATURE	
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UXOSO Name:	______________________	______________________________	____________________________________
Employee Name(s):	______________________	______________________________	Date/Time: ____________________________________
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ACTIVITY HAZARDS ANALYSIS

Overall Risk Assessment Code (RAC)

Date: 2 February 2011

Project: RI/FS

Activity: MPPEH Inspection

Activity Location: Culebra Island, Puerto Rico

Prepared By: Cheryl M. Riordan, CSP

Risk Assessment Code Matrix

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Severity		Frequent	Likely			
	Catastrophic	E	E			
	Critical	E	H			
	Marginal	H	M			
	Negligible	M	L			

Add Identified Hazards

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS
X	• When MEC scrap is encountered, two UXO Technicians will verify that it is inert. • After a disposal operation, disposal team will check area of the shot for MEC scrap and two UXO technicians will verify that it is inert.	• MEC hazards • Unauthorized personnel entering site during operations • Uneven working surfaces – slip, trip, fall hazards • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn • Cuts and abrasions from handling MPPEH/MD	• On-site MEC training • Site control measures will be implemented (fencing, barricades, signage) and exclusion zone established • Observe all MEC safety precautions, such as movement, heat, shock, and friction • Only UXO trained personnel will inspect/certify and handle MEC scrap. • Maintain positive site control; cease operations if unauthorized entry is made • Keep personnel to a minimum during operations • Use and enforce the buddy system • Cease operations if unsafe conditions arise • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles • Training in biological hazards avoidance • Wear cotton shirts and long pants • Wear the appropriate PPE for the task being performed • Use insect repellants and barrier creams/ointments as necessary • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Ensure First Aid Kits and Fire Extinguishers are in place • Communications equipment in place • No smoking, except in designated areas • Use sunscreen and wear cap

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS
X	• Inert scrap will be placed in a secured bin on the site until the completion of site operations. • The bin will remain secured to prevent intermingling of inert scrap items and live items. • QC Specialist will inspect bin periodically to assure procedures are followed and no live MEC is intermingled.	• Uneven working surfaces – slip, trip, fall hazards • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn • Cuts and abrasions from handling MPPEH/MD	• Only UXO trained personnel will inspect/certify and handle MEC scrap. • Maintain positive site control; cease operations if unauthorized entry is made • Use and enforce the buddy system • Cease operations if unsafe conditions arise • Properly close and seal each container after inspection • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles • Training in biological hazards avoidance • Wear cotton shirts and long pants • Wear the appropriate PPE for the task being performed • Use insect repellants and barrier creams/ointments as necessary • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Ensure First Aid Kits and Fire Extinguishers are in place • Communications equipment in place • No smoking, except in designated areas • Use sunscreen and wear cap
X	• At conclusion of site operations, the MEC scrap will be certified and transferred to an approved recycler for demilitarization and recycling of the metal scrap.	• Uneven working surfaces – slip, trip, fall hazards • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Sunburn	• Maintain positive site control; cease operations if unauthorized entry is made • Use and enforce the buddy system • Cease operations if unsafe conditions arise • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles • Training in biological hazards avoidance • Wear cotton shirts and long pants • Wear the appropriate PPE for the task being performed • Use insect repellants and barrier creams/ointments as necessary • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Ensure First Aid Kits and Fire Extinguishers are in place • Communications equipment in place • No smoking, except in designated areas • Use sunscreen and wear cap
X			

Add Items

	EQUIPMENT	TRAINING	INSPECTION
X	• Footwear with ankle support and non-slip soles • Appropriate clothing and PPE to include safety glasses, leather gloves, cotton clothing	• Site-specific training on slip, trip and fall hazards • PPE Training	• PPE inspected daily prior to use

ACTIVITY HAZARDS ANALYSIS

	EQUIPMENT	TRAINING	INSPECTION
X	• MEC scrap bin, secured • Hand tools	• UXO personnel will meet training and experience requirements outlined in DDESB TP 18 • Site-specific MEC training will be presented to all site personnel • All site personnel will have current HAZWOPER training • Requirements under DoD 4160.21-M • Required documents for inspection, certification, and verification of MPPEH related scrap	SUXOS/UXOSO will assure that all controls are being followed; all equipment is being utilized and that all personnel have received appropriate training. • Equipment inspected daily prior to use • Serviceability of containers • Daily check for security of scrap to prevent intermingling with inspected scrap
X	• Communications equipment • First aid kit • Fire extinguishers • WBGT monitor	• Emergency response procedures • Site-specific flora/fauna to include first aid • Heat Stress symptoms/first aid • Equipment familiarity training	• Communications equipment checked daily prior to use • First aid kits checked daily and inspected weekly • Fire extinguishers checked daily and inspected weekly • Equipment inspected daily prior to use

Involved Personnel:

Acceptance Authority (digital signature): CSNM

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ACTIVITY HAZARDS ANALYSIS

Overall Risk Assessment Code (RAC)

Date: 2 February 2011

Project: RI/FS

Activity: Quality Control

Activity Location: Culebra Island, Puerto Rico

Prepared By: Cheryl M. Riordan, CSP

Risk Assessment Code Matrix

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

		Frequent	Likely			
Severity	Catastrophic	E	E			
	Critical	E	H			
	Marginal	H	M			
	Negligible	M	L			

Add Identified Hazards

JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	

NWW Form 385-1 (Revised) April 2008

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	
X	• Inspection of Project Documentation, Site Conditions, Work Performance and Operations.	• MEC hazards • Unauthorized personnel entering site during operations • Unplanned Detonations • Uneven working surfaces – slip, trip, fall hazards • Muscle strain carrying instruments • Cuts/lacerations hazards • Heavy equipment • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Heat Stress • Noise • Sunburn	• On-site MEC Training • Site control measures will be implemented (fencing, barricades, signage) and exclusion zone established • Establish Exclusion Zones based on the known hazards • Keep personnel to a minimum during operations • Only UXO trained personnel will perform UXO operations • Only UXO qualified personnel will escort non-UXO personnel • Inspection of MEC will be made by UXO qualified personnel • Follow safe work practices • Use and enforce the buddy system • Observe all MEC safety precautions, such as movement, heat, shock, and friction • Be alert. Cease operations if unsafe conditions arise • Maintain positive site control; cease operations if unauthorized entry is made • Maintain clearance around heavy equipment operations • Do not place any part of body under raised load • Ground guides used during heavy equipment operations • Wear the appropriate PPE for the task being performed • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles (no steel toes around magnetometer operations) • Wear cotton shirts and long pants • Use insect repellants and barrier creams/ointments as necessary • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Training in biological hazards avoidance • Follow appropriate lifting/ carrying procedures • Ensure 1st. Aid Kits and Fire Extinguishers are in place • No smoking, except in designated areas • Hearing protection program • Use sunscreen and wear cap • Ensure required site documentation is on hand	

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	
X	• Inspection of Material and Packaging of Containers	• Uneven working surfaces – slip, trip, fall hazards • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Heat Stress • Sunburn	• Use and enforce the buddy system • Be alert. Cease operations if unsafe conditions arise • Maintain positive site control; cease operations if unauthorized entry is made • Wear the appropriate PPE for the task being performed • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles (no steel toes around magnetometer operations) • Wear cotton shirts and long pants • Use insect repellants and barrier creams/ointments as necessary • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Training in biological hazards avoidance • Ensure 1st. Aid Kits and Fire Extinguishers are in place • No smoking, except in designated areas • Use sunscreen and wear cap	
X	• Inspection of Completed Project Documentation	• Uneven working surfaces – slip, trip, fall hazards • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Heat Stress • Sunburn	• Use and enforce the buddy system • Be alert. Cease operations if unsafe conditions arise • Maintain positive site control; cease operations if unauthorized entry is made • Wear the appropriate PPE for the task being performed • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles (no steel toes around magnetometer operations) • Wear cotton shirts and long pants • Use insect repellants and barrier creams/ointments as necessary • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Training in biological hazards avoidance • Ensure 1st. Aid Kits and Fire Extinguishers are in place • No smoking, except in designated areas • Use sunscreen and wear cap • Ensure required site documentation is on hand • Ensure logs, briefings, reports and forms are completed in a timely and accurate manner • Review or inspect all site generated documents for accuracy and deliverability • Review DD Form 1348-1A for required information • Ensure concerned parties receive copies of documents pertaining to their activities • Ensure contract deliverables have been met	
X				

ACTIVITY HAZARDS ANALYSIS

EQUIPMENT	TRAINING	INSPECTION
Add Items		

	EQUIPMENT	TRAINING	INSPECTION
X	• Footwear with ankle support and non-slip soles (no steel toes around magnetometers) • Back braces (optional) • Appropriate clothing and PPE to include safety glasses, leather gloves, cotton clothing, (hard hat and hearing protection around heavy equipment and vegetation clearance operations)	• Site-specific training on slip, trip and fall hazards • Site-specific training/lifting techniques • PPE training • Training in hearing protection program	• PPE inspected daily prior to use
X	• Appropriate geophysical equipment • Hand tools • Barricades and signage	• UXO personnel will meet training and experience requirements outlined in DDESB TP 18 • Site-specific MEC training will be presented to all site personnel • Heavy equipment operators trained and certified on each piece of equipment operated • Heavy Equipment familiarity as required for ground crew in vicinity of heavy equipment operations • All site personnel will have current HAZWOPER training • Requirements under DoD 4160.21-M • Required documents for inspection, certification, and verification of MEC/UXO/MPPEH related scrap	The SUXOS/UXOSO will assure that all controls are being followed; all equipment is being utilized and that all personnel have received appropriate training. • Equipment inspected daily prior to use • Daily serviceability check of magnetometers • Serviceability of containers
X	• Communications equipment • First aid kit • Fire extinguishers • WBGT monitor	• Emergency response procedures • Heat Stress symptoms/first aid • Site-specific flora/fauna to include first aid • Equipment familiarity training	• Communications equipment checked daily prior to use • First aid kits checked daily and inspected weekly • Fire extinguishers checked daily and inspected weekly • Equipment inspected daily prior to use

Involved Personnel:

Acceptance Authority (digital signature): ____________________ CSNM

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UXOSO Name:	______________________	______________________________		____________________________________
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ACTIVITY HAZARDS ANALYSIS

Overall Risk Assessment Code (RAC)

Date: 2 February 2011

Project: RI/FS

Activity: Vegetation Clearance

Activity Location: Culebra Island, Puerto Rico

Prepared By: Cheryl M. Riordan, CSP

Risk Assessment Code Matrix

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Severity		Frequent	Likely			
	Catastrophic	E	E			
	Critical	E	H			
	Marginal	H	M			
	Negligible	M	L			

Add Identified Hazards

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS
X	• Lanes will be established throughout the footprint of the site. UXO personnel will walk down each lane while performing geophysical survey. • If there are areas where dense vegetation prevents a good reading on potential MEC contamination in the area, vegetation removal will be conducted as needed. • UXO personnel will perform a magnetometer survey in areas of dense vegetation in order to determine if MEC is present prior to vegetation removal operations.	• MEC hazards • Uneven working surfaces – slip, trip, fall hazards • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Muscle strain carrying instruments • Sunburn	• On-site MEC training • Observe all MEC safety precautions, such as movement, heat, shock, and friction • Be Alert. Mark and report any MEC encountered • Establish Exclusion Zones based on the known hazards • Maintain positive site control; cease operations if unauthorized entry is made • Keep personnel to a minimum during operations • Know and observe the safe work practices and operating instructions of the equipment • Use and enforce the buddy system • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles (no steel toes around magnetometer operations) • Training in biological hazards avoidance. • Follow appropriate lifting/ carrying procedures • Use appropriate PPE for the task performed. • Wear cotton shirts and long pants • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Use barrier creams/insect repellants as necessary • Use sunscreen • Ensure 1st. Aid Kits and Fire Extinguishers are in place • No smoking, except in designated areas

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS
X	• Vegetation clearing will be required using gasoline-powered weed eaters, chain saws, etc.	• MEC hazards • Uneven working surfaces – slip, trip, fall hazards • Heat Stress • Biological hazards – hazardous plants, trees, bees, wasps, centipedes, ticks, mosquitoes, spiders, and rodents. • Muscle strain carrying instruments/equipment • Lacerations and cuts from vegetation clearing equipment • Eye/face injuries due to use of vegetation clearing equipment • Gas Powered Equipment • Non-powered cutting tools • Noise • Sunburn	• On-site MEC training • Practice MEC avoidance • Be Alert. Mark and report any MEC encountered • Establish Exclusion Zones based on the known hazards • Maintain positive site control; cease operations if unauthorized entry is made • Keep personnel to a minimum during operations • Know and observe the safe work practices and operating instructions of the equipment • Guard against splashes and spills of fuel and oil • Guard against burns from hot equipment • Allow equipment to cool down before fueling, sharpening, adjusting or replacing items • Don't fuel equipment in back of pick-up truck with bed-liner • Use and enforce the buddy system • Be observant while walking. Use sturdy leather work boots with ankle support and non-slip soles (no steel toes around magnetometer operations) • Training in biological hazards avoidance. • Follow appropriate lifting/ carrying procedures • Use appropriate PPE for the task performed. • Wear long sleeved shirts and long pants • Heat stress monitoring, drinking water, work-rest schedule, and cool shelter for breaks • Use barrier creams/insect repellants as necessary • Use sunscreen • Ensure 1st. Aid Kits and Fire Extinguishers are in place • No smoking, except in designated areas
X	• If live MEC is encountered, vegetation clearance operators will avoid that area until after the disposal of the MEC is performed	In accordance with MEC Disposal AHA	In accordance with MEC Disposal AHA
X			

Add Items

	EQUIPMENT	TRAINING	INSPECTION
X	• Footwear with ankle support and non-slip soles (No steel toes around magnetometers) • Back braces, optional • Appropriate clothing and PPE to include hard hat, face shield, safety glasses, leather gloves, hearing protection, and leg chaps	• Site-specific training, slip/fall hazards • Training in proper lifting techniques • Noise prevention training • PPE training	• PPE inspected daily prior to use

ACTIVITY HAZARDS ANALYSIS

	EQUIPMENT	TRAINING	INSPECTION
X	• Geophysical equipment • Vegetation removal equipment: weed eaters, chain saws, etc. • Non-powered cutting tools • MEC flagging materia	• UXO personnel will meet training and experience requirements outlined in DDESB TP 18 • Site-specific MEC training will be presented to all site personnel • Equipment familiarity training • All site personnel will have current HAZWOPER training	SUXOS/UXOSO will assure that all controls are being followed; all equipment is being utilized and that all personnel have received appropriate training. • Equipment inspected daily prior to use
X	• Communications equipment • First aid kit • Fire extinguishers • WBGT monitor	• Emergency response procedures • Heat Stress symptoms/first aid • Site-specific flora/fauna to include first aid • Equipment familiarity training	• Communications equipment checked daily prior to use • First aid kits checked daily and inspected weekly • Fire extinguishers checked daily and inspected weekly • Equipment inspected daily prior to use

Involved Personnel:

Acceptance Authority (digital signature): ____________ CSHM

	PRINT	SIGNATURE		
SUXOS Name:	____________________	____________________		____________________
UXOSO Name:	____________________	____________________		____________________
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ACTIVITY HAZARDS ANALYSIS

Overall Risk Assessment Code (RAC)

Date: 2 February 2011

Project: RI/FS

Activity: Vehicle Operations

Activity Location: Culebra Island, Puerto Rico

Prepared By: Cheryl M. Riordan, CSP

Risk Assessment Code Matrix

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Severity		Frequent	Likely			
	Catastrophic	E	E			
	Critical	E	H			
	Marginal	H	M			
	Negligible	M	L			

Add Identified Hazards

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS	
X	• Identify the hazards associated with vehicle operations • Inspect vehicle	• Potential for vehicle accidents during field operations	• Daily vehicle inspections will be performed to ensure a safe operating vehicle • Must have a valid driver's license. If transporting explosives on public roads, must have CDL • Fire extinguisher and first aid kit must be with vehicle. explosives, two fire extinguishers are required	
X	• Assure placards are visible on all four sides of vehicle when transporting explosive materials • Assure explosives are properly packed and braced in the vehicle • Fill out DD Form 626 when transporting explosives	• MEC hazards • Fire hazards	• Observe all MEC safety precautions, such as movement, heat, shock, and friction • Only UXO trained personnel will transport explosives • Load and unload vehicles in designated areas only • Assure vehicle is chocked while loading/unloading cargo • Block, brace, and secure cargo from movement during transportation • Transport explosives using approved containers and methods • Use only authorized explosive routes when transporting explosives • When transporting explosive materials over public roads, assure vehicle is properly placarded • Must have a valid driver's license. If transporting explosives on public roads, must have CDL • Fire extinguisher and first aid kit must be with vehicle. explosives, two fire extinguishers are required • Never fuel a vehicle loaded with explosive carg0	

ACTIVITY HAZARDS ANALYSIS

	JOB STEPS	HAZARDS	ACTIONS TO ELIMINATE OR MINIMIZE HAZARDS
X	• Drive to destination	• Potential for vehicle accidents during field operations • MEC hazards • Fire hazards • Be aware of animals in the road way	• Always wear a seat belt • Use a ground guide when reversing and/or as needed • Obey the speed limit • Obey all traffic signs • Use established roads • Use the parking brake if parked on inclines and/or as necessary • Never leave the vehicle running unattended • Observe all MEC safety precautions, such as movement, heat, shock, and friction • Only UXO trained personnel will transport explosives • Assure vehicle is chocked while loading/unloading cargo • Transport explosives using approved containers and methods • Use only authorized explosive routes when transporting explosives • When transporting explosive materials over public roads, assure vehicle is properly placarded • Must have a valid driver's license. If transporting explosives on public roads, must have CDL • Fire extinguisher and first aid kit must be with vehicle. explosives, two fire extinguishers are required • Never fuel a vehicle loaded with explosive cargo • No passengers will be transported in back of a pick-up truck. passengers will be in a seat with a seat-belt in use during vehicle operation. • No smoking is permitted in vehicles
X			

Add Items

EQUIPMENT	TRAINING	INSPECTION
• Vehicles • Placards • Chocks • Blocking and bracing equipment	• UXO personnel will meet training and experience requirements outlined in DDESB TP 18 • Fire extinguisher training • All site personnel will have current HAZWOPER training • Valid Driver's license (CDL for transporting explosives) • Vehicle familiarity	SUXOS/UXOSO will assure that all controls are being followed; all equipment is being utilized and that all personnel have received appropriate training. • Vehicle inspected daily prior to use • Equipment inspected daily prior to use
• First Aid Kit • Fire Extinguisher • Communication equipment	• Emergency procedures training • Fire extinguisher training	• Communications equipment checked daily prior to use • First aid kits checked daily and inspected weekly • Fire extinguishers checked daily and inspected weekly

ACTIVITY HAZARDS ANALYSIS

Involved Personnel:

Acceptance Authority (digital signature): ______, CSHM

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APPENDIX D, ATTACHMENT 3.
HOSPITAL INFORMATION

HOSPITAL INFORMATION

All site personnel will be briefed on this information prior to the commencement of operations.

The following are the identification and location of the Medical Treatment Facility for this project.

Figure 1: Medical Facilities Location

- **Criteria for Alerting the Local Community Responders**

In the event of an on-site emergency, the individual team leader or first person aware of the emergency will contact the UXOSO by cell phone, field radio, or in person, as circumstances allow. The UXOSO will normally be responsible for summoning emergency medical services. If the order is given to evacuate the site of all personnel, each on-site team leader will assemble, account for, and evacuate all team personnel to the pre-designated staging area in the support zone. The First Responders shall render emergency first aid treatment and the UXOSO will authorize site personnel to assist, where required. The UXOSO will determine the need for professional medical attention and summon an ambulance or AEROMED flight if necessary, to transport injured personnel for further medical treatment at the medical treatment facility.

- **Directions to Medical Treatment Facility:**

Directions to the medical treatment facility from Flamenco Beach in Culebra: Drive Southeast on Highway 251 road from Flamenco Beach or the unnamed resort, to the City of Dewey. Pass the Airport on your left. Continue along the bay until you approach the first major intersection. Turn right at the first intersection on Highway 250. Travel towards the Ferry Dock. (Follow the signs for the hospital.) Turn right on the road to Melonea. The hospital will be on the right side of the road.

Directions to the medical treatment facility from Culebrita: For any accident or medical emergency while on the Isle of Culebrita, Sea Ventures (the commercial water transport company) will return to Culebra. The vessel will dock at the public docks near the Plaza in the City of Dewey. Drive from the parking area near the public dock and turn on the unnamed major road in the city going toward the bay. (Follow the signs for the hospital.) Turn left on the road to Melonea. The road to the hospital will be on the right side of the road.

Table 1: Emergency Phone Numbers

Culebra Health Clinic	787-742-3511
AEROMED Medical Evac.	787-756-3480 (Evac to Medical Facilities)
Fire Department	787-742-3530
Police Department	787-742-3501
Poison Control Center	800-552-6337
USA Occupational Physician (California)	831-647-8700

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APPENDIX D, ATTACHMENT 4.
SITE SAFETY AND HEALTH PLAN

SITE SAFETY AND HEALTH PLAN

Plan approval:

Cheryl M. Riordan ______________________________ Date: 10 Feb 11

Cheryl M. Riordan
Certified Safety Professional
USA Environmental, Inc.
(813) 343-6412

Plan concurrence:

James Walden ______________________________ Date: 10 Feb 11

James Walden
UXO Safety Manager
USA Environmental, Inc.
(813) 343-6374

TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

This Site Safety and Health Plan (SSHP) establishes the responsibilities, requirements, and procedures for protecting the project personnel and the surrounding community from the hazards associated with the Remedial Investigation/Feasibility Study of Culebra, Puerto Rico. Project work will include characterizing the sites for MEC contamination and analyzing potential options for remediation. USA Environmental, Inc. (USA) will dispose of all MEC that is encountered during the project efforts.

1.1 SITE DESCRIPTION

The sites involve former range areas on land, beaches, and in the waters around Culebra Island. See Section D.3 of the Accident Prevention Plan for specifics on the work to be performed at each site.

1.2 CONTAMINANT CHARACTERISTICS

The areas of concern and acreages are listed in Table 1-1.

Table 1-1: Areas of Concern

Site	Description	Acreage
MRS 13	Cayo Luis Pena Impact Areas	864 total MRS acres, with 342 land acres. 6 acres of DGM transects will be investigated.
MRS 10	Defensive Firing Area No. 1	547 total MRS acres. 5 acres of DGM transects and 1 acre of grids will be investigated.
MRS 11	Defensive Firing Area No. 2	719 total MRS acres. 6 acres of DGM Transects and 1 acre of grids will be investigated.
MRS 06	Artillery Firing Area	826 total MRS acres. 6 acres of DGM transects and 2 acres of grids will be investigated.
MRS 09	Soldado Point Mortar and Bombing Area	328 total MRS acres. 2 acres of DGM transects and 1 acre of grids will be investigated.
MRS 08	Cayo Norte Impact Area	306 total MRS acres. 3 acres of DGM transects and 1 acre of grids will be investigated.

Table 1-2: Munitions of Concern

Site	MEC
MRS 13	75mm MKI and HE projectiles; 37mm projectiles; 5-inch HVAR MKI; 5-inch MK41
MRS 10	Infantry and tank rounds; 81mm M43 HE; 3-inch Common MK3 Mod7
MRS 11	75mm projectiles; small arms ammunition; 81mm mortars; 4.2-inch M3A1 HE; 81mm M43 HE; 3-inch Common MK3 Mod 7
MRS 06	Small arms ammunition; 37mm MKII; 81mm M43 HE
MRS 09	5-inch battery rounds; 30-lb bombs; 100 pound AN-M30A1 HE bombs; 81mm mortars; 3-inch Common MK3 Mod 7; 37mm MKII; small arms ammunition
MRS 08	.75mm MK1 and HE; 5-inch HVAR MKI

2.0 HEALTH AND SAFETY HAZARD ASSESSMENT

An Activity Hazard Analysis (AHA) has been conducted and documented for each activity warranted by the hazards associated with the activity (see Attachment 2 for the site-specific AHAs). The following AHAs have been prepared for all anticipated field operations:

- Boat Operations
- Boat Transportation
- Geophysical Prove-Out Test Strip
- Location, Surveying and Mapping
- MEC Disposal
- MEC Investigation
- MPPEH Inspection
- Quality Control
- Vegetation Clearance
- Vehicle Operations.

Table 2-1: Minimum Separation Distances

		MSD (ft)					
		For Unintentional Detonations			For Intentional Detonations		
Area	MGFD	Team Separation Distance (K40)	Exclusion Zone Hazardous Fragment Distance (HFD)	To Sides and Rear using OFB	Without Engineering Controls	Using Sandbag Mitigation	Using Water Mitigation Carboys/Pool
MRS 06							
Land Impact Area	37mm MK II	16	90	90	980	200	200/200
Beach Defensive Area #1 & #2	81mm M43 HE	49	230	230	1,395	200	264/200
Underwater Impact Area	37mm MK II	16	90	N/A	980	N/A	N/A
MRS 08							
Land	75mm MKI & HE	50	238	238	1,702	200	200
Water	5" HVAR MK 1	87	398	N/A	2,100	N/A	N/A
MRS 09							
Mortar Boat Firing Area	4.2" M3A1 HE	86	311	N/A	1,617	200	275
Aircraft Bombing Target	100lb AN-M30A1 HE	172	483	N/A	1,831	N/A	N/A
Direct Fire Area	3" Common MK 3 Mod 7	28	126	126	1,702	200	200
Water Target	37mm MK II	16	90	90	980	200	200/200
MRS 10							
Beach Defensive Area	81mm M43 HE	49	230	230	1,395	200	264/200
Direct Fire Area	3" Common MK 3 Mod 7	28	126	126	1,702	200	200

		MSD (ft)					
		For Unintentional Detonations			For Intentional Detonations		
Area	MGFD	Team Separation Distance (K40)	Exclusion Zone Hazardous Fragment Distance (HFD)	To Sides and Rear using OFB	Without Engineering Controls	Using Sandbag Mitigation	Using Water Mitigation Carboys/Pool
Underwater	81mm M43 HE	49	230	N/A	1,395	N/A	N/A
MRS 11							
Mortar Boat Firing Area	4.2" M3A1 HE	86	311	N/A	1,617	200	275
Beach Defensive Area	81mm M43 HE	49	230	230	1,395	200	264/200
Direct Fire Area	3" Common MK 3 Mod 7	28	126	126	1,702	200	200
Underwater	81mm M43 HE	49	230	N/A	1,395	N/A	N/A
MRS 13							
Northern Impact Area	75mm MKI & HE	50	238	238	1,702	200	200
Underwater	5" HVAR MK 1	87	398	N/A	2,100	N/A	N/A
Land	5" MK 41	79	358	358	2,370	220	275

Notes:

1. See Appendix B for calculation sheets and documentation of MSD.

2. Denotes MGFD during intrusive operations within the area indicated.

See Appendix A for Maps of the MSD for each MRS.

Should conditions, equipment, or types of operations change during the course of the project work, the Corporate Safety and Health Manager will update an existing AHA for continuing work, or prepare a new AHA for new operations. The site exclusion zone (EZ) will be based on the fragmentation distance of the munitions with the greatest fragmentation distance (MGFD). In addition, a minimum separation distance (MSD) of the K40 distance or greater will be established between unexploded ordnance (UXO) teams to protect individual operating units in the event of an accidental detonation while intrusive operations are underway. If an MEC item with a larger fragmentation distance than the MGFD is encountered during site operations, the MGFD and MDS will be re-evaluated and re-established. Fragmentation zones would be extended in accordance with the requirements of the Department of Defense (DoD) 6055.9 Standard. The EZ will be based on the largest and most hazardous item encountered at the site.

Risk management is and will continue to be integrated into the planning, preparation, and execution of all operations at each site. Risk management is a dynamic process, and is continuously improved upon as personnel become more familiar with the site operations, equipment, and environment. Site personnel are trained to continuously identify hazards and assess accident risks. Once identified, these hazards will be brought to the attention of the Team Leader or UXO Safety Officer (UXOSO). Control measures will be developed and coordinated by USA safety personnel. All site personnel are responsible for continuous assessment of variable hazards and the implementation of risk controls.

2.1 HAZARD MITIGATION

The hazards listed above will be addressed through a combination of training, engineering controls, and personal protective equipment (PPE).

2.1.1 IMPLEMENTATION OF ENGINEERING CONTROLS AND WORK PRACTICES

Training in site procedures and the use of site equipment can prevent accidents from occurring. Training in recognition of MEC or MEC pieces that could be hazardous will be given to all site workers. When MEC or pieces of MEC are encountered, site personnel will contact a UXO-qualified person to handle the situation. Other controls include the MSD the K40 distance or greater, which will provide protection of individual teams from nearby site operations, and the EZ, which will be used to keep unauthorized personnel out of the site operations area.

2.1.2 UPGRADES/DOWNGRADES IN LEVELS OF PERSONAL PROTECTIVE EQUIPMENT

Because of the types of hazards at this site, Level D PPE will be required. This type of PPE is used for levels of contamination that may present a nuisance, but not an identifiable hazard. Level D PPE consists of a hard hat, safety glasses, face shield, hearing protection, leather work gloves, leg chaps, and leather work boots. The hard hat and hearing protection will be worn only in specific hazard areas, such as in the vicinity of the heavy equipment operations and during vegetation clearance operations. The face shield and leg chaps would be required only for vegetation clearance operations. Leather work boots will have ankle support and non-slip soles. Boots with steel safety toes will not be worn in the vicinity of magnetometer operations as they impact the readings of the equipment. If site hazards are encountered that require additional PPE, the PPE level can be increased by the Corporate Safety and Health Manager, who would base the decision on documented evidence of the hazards. If the site is not as hazardous as originally anticipated, the level of PPE can be downgraded by the Corporate Safety and Health Manager. This decision would also be based on definitive data that confirms the PPE can be lessened. Normally, downgrading of PPE would require at least a week’s worth of data demonstrating that the site is not as hazardous as originally suspected.

2.1.3 WORK STOPPAGE

All personnel are trained to be constantly aware of their work environment. Anyone has the ability to stop operations for safety reasons. No worker is expected to perform any operation for which he has not been properly trained, or to perform any operation that is considered to be unsafe. After operations are stopped for safety reasons, the UXOSO will be notified and will evaluate the situation. The UXOSO will, in consultation with the Corporate Safety and Health Manager, determine what steps need to be taken to make the situation safe for operations to continue.

2.1.4 EMERGENCY EVACUATION

In the event of an emergency that requires evacuation of the site, verbal instruction or one blast of a horn will be given by the UXOSO to evacuate the area. Personnel will exit the area to the pre-designated assembly point. After evacuation, the UXOSO will account for all personnel, ascertain information about the emergency, and advise responding on-site personnel. The UXOSO will contact, advise, and coordinate with responding off-site emergency personnel if deemed necessary by the situation.

In all situations that require evacuation, personnel shall not re-enter the work area until the following conditions have been met.

- The conditions causing the emergency have been corrected

- The hazard has been reassessed
- The SSHP has been revised and reviewed with on-site personnel, if needed
- Instructions have been given for authorized re-entry by the UXOSO.

2.1.5 PREVENTION AND/OR MINIMIZATION OF PUBLIC EXPOSURE TO HAZARDS CREATED BY SITE ACTIVITIES

The creation of an EZ for fragmentation distances between the site footprint and the general public acts as a safety buffer to protect the public from site hazards. Controlling access to the site, closing roads, and installing signs and barricades are all means of keeping the general public from accidentally wandering into the site during operations. In addition, the training of all site workers in the hazards and recognition of MEC will reduce the potential for public exposure to hazards. Any worker observing MEC or pieces of MEC will not touch or handle it in any way and will immediately inform a UXO-qualified USA worker, who will then handle the situation. If unauthorized personnel are observed in the EZ, all MEC operations will cease until the area is cleared of unauthorized personnel.

3.0 SAFETY STAFF

See Section D.8 of the Accident Prevention Plan.

4.0 HEALTH AND SAFETY STAFF ORGANIZATION AND RESPONSIBILITIES

See Section D.8 of the Accident Prevention Plan

5.0 SITE-SPECIFIC TRAINING

See Section D.10 of the Accident Prevention Plan.

6.0 SITE-SPECIFIC MEDICAL SURVEILLANCE

Medical surveillance of USA employees will be conducted in accordance with the requirements of the Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910.120(f), 29 CFR 1910.134(b)(10) and other established guidelines. Personnel to be included in the Medical Surveillance Program will be those who perform hazardous waste operations that may potentially expose the worker to hazardous substances or other significant safety and health threats. All USA personnel on the project site will participate in the USA Medical Surveillance Program. Visitors desiring entry into the EZ must participate in their employer’s Medical Surveillance Program and must have a current physician’s statement prior to entry.

6.1 BASELINE HEALTH ASSESSMENT PHYSICAL OR ANNUAL PHYSICAL

A baseline health assessment physical or annual physical will be conducted prior to participating in site operations, to determine the worker’s ability to perform hazardous waste operations in a safe and healthful manner. The Project Manager, in conjunction with the Corporate Safety and Health Manager, will ensure that all health assessments address the site-specific health hazards to which workers may be exposed.

Physicals will be scheduled through the Corporate Health and Safety Manager, who will contract the services of a board certified occupational medicine physician in the vicinity of the employee’s home or job site. The designated physician will perform the medical assessments and review medical examination results to determine each worker’s ability to perform his assigned hazardous waste duties. The physician will also be responsible for determining if supplemental or follow-up examinations are required, and for maintaining medical and exposure records in accordance with OSHA 29 CFR 1910.120(d).

The purpose of the Medical Surveillance Program is to:

- Assess the individual's health status prior to participation in hazardous waste operations
- Determine the individual's ability to perform work assignments that require the use of PPE
- Establish baseline data for comparison to future medical data in order to provide a means of monitoring a worker's health status
- Establish facilities and procedures for emergency and non-emergency medical treatment
- Establish procedures for maintenance and storage of medical and exposure records.

The following information is provided to the examining physician:

- Description of the employee's duties
- Anticipated hazardous exposures and levels
- Description of the PPE commonly used
- Information from previous medical exams.

The medical surveillance provided to the employees includes a judgment by the medical examiner of the ability of the employee to use either positive or negative pressure respiratory equipment in accordance with 29 CFR 1910.134. Any employee found to have a medical condition that could directly or indirectly be aggravated by exposure to chemical substances or by the use of respiratory equipment will not be employed for the project requiring clearance under the Respiratory Protection Program. A copy of the medical examination is provided at the employee's request.

The employee will be informed of any medical conditions that would result in work restriction or that would prevent him or her from working at hazardous waste sites.

Contractors will certify that all their employees have successfully completed a physical examination by a qualified occupational health physician and will supply certification of medical clearance for each on-site employee.

6.2 PHYSICIAN'S STATEMENT

The results of this examination will be made available to the employee and a written physician's statement will be sent to USA. A copy of the physician's statement will be kept in each employee's file at the project site for the duration of site operations. The physician's statement will include the following information:

- The physician's opinion regarding any conditions that would place the employee at an increased risk from working in hazardous waste operations
- The physician's recommended limitations upon the employee's assigned work, if any
- A statement that the employee has been informed by the physician of the results of the examination, and any conditions that may require further examination or treatment.

6.3 SUPPLEMENTAL EXAMINATION

Any site worker who has: been injured; received health impairment; developed signs or symptoms from possible over-exposure; or received a documented over-exposure without the use of respiratory protection, will undergo a supplemental examination. The contents of this examination will be based upon the type of injury, illness, signs or symptoms of exposure involved and will be determined by the physician. Prior to reassignment to site activities, the physician will certify that the employee is fit to return to work. If necessary, the physician will specify in writing any activity restrictions or additional tests that may be required.

6.4 FOLLOW-UP HEALTH ASSESSMENTS

If, during any pre-assignment, annual or supplemental examination, a condition is detected that requires follow-up tests, the physician will notify USA and the employee as to the nature of the follow-up health assessment. The physician will determine the schedule and content of the follow-up health assessment. A statement outlining the employee's fitness for work will be provided to USA and the employee upon conclusion of the follow-up health assessment.

6.5 EMERGENCY AND NON-EMERGENCY MEDICAL TREATMENT

USA will have a least two personnel on site who are certified in First Aid/Cardiopulmonary Resuscitation (CPR). They will act as First Responders to any accidental injury or illness. The UXOSO will be contacted whenever an incident occurs. He will summon the First Responders, who will handle any first aid cases, or will stabilize the victim until professional medical assistance arrives. If professional medical assistance is required, the UXOSO will summon the ambulance to take the victim to the nearest hospital for treatment, which is the Culebra Health Clinic.

The nearest hospital and a map with directions from the sites to the hospital are included in the APP at Attachment C. The map and directions, as well as the emergency telephone numbers, will be kept in each site vehicle. Emergency equipment will also be kept in each site vehicle, to include: a first aid kit, a blood-borne pathogens kit, and emergency eyewash kit.

6.6 MEDICAL RESTRICTION

Should an occupational injury or illness occur that restricts an employee's ability to function at full capacity, USA maintains a policy of providing these employees with restricted duty assignments whenever possible to allow them to continue to be productive.

6.7 RECORDKEEPING

USA will retain and maintain copies of all physician statements, exposure records, and associated information for USA employees involved in hazardous waste operations, in accordance with the requirements of 29 CFR 1910.120(f). These records will be kept at the project site for the duration of site operations. When the site work is complete, the records will be retained by USA at the Corporate Office located in Oldsmar, Florida. Examining physicians will be responsible for maintaining records related to laboratory analyses and other tests for each USA employee examined. All records, whether maintained by USA or by the examining physician, will be kept on file for a period of 30 years beyond an employee's termination.

7.0 PERSONAL PROTECTIVE EQUIPMENT

The Personal Protective Equipment Program for USA is described in the Personal Protective Equipment section of the Accident Prevention Plan (APP). Because of the expected hazards at these sites during most operations, Level D PPE will be required. Level D PPE is a work uniform affording minimal protection, used for nuisance contamination only. The following Level D equipment will be required on this site:

- Hard hat (as required around vegetation clearance operations, heavy equipment operations, and any other head hazard operations)
- Leather gloves
- Safety glasses with side shields or safety goggles
- Hearing protection (as required by high noise levels, in the vicinity of vegetation clearance operations and heavy equipment operations)
- Leather work boots with ankle support and non-slip soles (Steel safety toes may not be worn around geophysical equipment.)
- Cotton work clothes
- Chemical-resistant gloves (as required when working around equipment fueling operations or while handling other types of chemicals)
- Personal flotation devices, while on boat
- Back supports (optional).

8.0 MONITORING AND SAMPLING PLANS

Chemical monitoring is not expected to be required, as no significant exposure to hazardous chemicals at these sites is expected. Soil and water sampling will be conducted and Chain of Custody requirements will be implemented. Personnel performing vegetation removal operations and MEC disposal operations, as well as those working in the vicinity of heavy equipment, will be provided with hearing protection. However, noise in excess of the action level is not expected to occur outside of the EZ of this site. Workers on this site will normally be in Level D PPE; however, heat stress monitoring is likely if work occurs during times when the temperature reaches 75 ºF or higher.

8.1 HEAT STRESS MONITORING

Heat stress monitoring will be conducted using Wet Bulb Globe Temperature (WBGT) readings and/or additional methods (pulse method, oral temperature method, or water weight loss method) as required as soon as the temperature reaches 75 ºF or higher. Work/rest cycles will be implemented based on the requirements of the APP. Monitoring will be performed by the UXOSO and the results will be documented. Plenty of drinking water will be made available on the site to maintain hydration of site personnel. Balanced electrolyte drinks may also be provided to help replace the chemicals the body loses through sweating. If balanced electrolyte drinks are provided on site, it is recommended that workers drink water to the balanced electrolyte drink at a ratio of 2:1 (two drinks of cold water to each drink of balanced electrolyte drink).

8.2 METEOROLOGICAL MONITORING

Rain can constitute a safety hazard to field operations at this site. The UXOSO will be responsible for monitoring the weather closely. If the area becomes wet, muddy, or slippery such that an unacceptable level of risk exists for personnel who are working in proximity to MEC items, then site operations will cease until the UXOSO determines the area as safe to continue.

No site operations will take place if an electrical storm is within 10 miles of the site. An electrical storm monitor will be used to determine if an electrical storm is approaching. Site operations will cease when an electrical storm is within 10 miles of the site, and will not resume again until the UXOSO determines that the electrical storm is at least 10 miles away from the site. Personnel will evacuate the site to the pre-designated evacuation point and will await the determination by the UXOSO that it is safe to resume operations.

8.3 PERIMETER MONITORING

No perimeter monitoring of USA operations will be required on this site.

9.0 HEALTH AND SAFETY WORK PRECAUTIONS AND PROCEDURES

Using common sense and following safe practices can reduce hazards. Personnel must keep the prudent guidelines listed below in mind when conducting field activities.

- Hazard assessment is a continuous process. Personnel must be aware of their surroundings and constantly be aware of MEC, chemical, and physical hazards that are or may be present.
- The number of personnel in the EZ will be the minimum number necessary to perform work tasks in a safe and efficient manner.
- Team members will be familiar with the physical characteristics of each site, including wind direction, site access, and the location of communication devices and safety/emergency equipment.
- Detection or appearance of unusual or unknown liquids, odors or discolored soil could indicate the presence of contaminants and should be reported to the UXOSO immediately.
- Site personnel are to report any other unusual or potentially hazardous condition to the UXOSO for investigation and/or corrective action.

9.1 SITE RULES/PROHIBITIONS

All personnel on site will be required to follow the safe work practices contained in this Plan, as they relate to the hazards encountered during site activities. All site personnel will be required to read, understand, and comply with the provisions of this SSHP. If new tasks or hazards are identified during site operations, which pose additional hazards, the SSHP will be amended by the Corporate Safety and Health Manager to include additional safe work practices and other control methods, as needed.

9.1.1 SAFE PRACTICES

Safe practices can reduce hazards associated with normal site activities. Personnel must keep the prudent guidelines listed below in mind when conducting field activities. General personnel requirements include the following:

- Horseplay or fighting is prohibited.
- Eating, drinking, smoking, chewing gum, tobacco, or any other hand-to-face activities are prohibited on site, except in designated areas after both face and hands have been washed.
- Wearing contact lenses is prohibited in the EZ.
- When required to sit or kneel on the ground, avoid contaminated surfaces.
- Placing equipment on contaminated surfaces should be avoided.
- Climbing on or over obstacles is prohibited. Stacks of materials can be unstable and could cause injury.
- Open flames of any type are prohibited on site.
- Bringing defective or unsafe equipment on site is prohibited.

Only authorized employees may enter the work site. Visitors must check in with the UXOSO, receive an appropriate safety briefing, and be escorted by UXO-qualified personnel at all times while on site.

9.1.2 BUDDY SYSTEM

The buddy system is a safety practice in which each individual is concerned with the health and well being of co-workers. The buddy system will be implemented during all on-site activities and will be incorporated when workers may be isolated or as determined by the UXOSO. The UXOSO will assign "buddies" to ensure accounting of all site personnel. The following additional procedures will be implemented.

- A minimum of two personnel, with one being a UXO-qualified person, will be present during all MEC operations to ensure that one person will always act as a safety observer. During all MEC operations, only the minimum number of personnel required to safely perform the task will be allowed on site. All other personnel will evacuate to a pre-designated assembly point.
- At no time will an individual desert his "buddy" unless his "buddy" goes down, and it is considered too hazardous to render assistance. "Buddies" will enter and exit the EZ together and frequently monitor one another for signs of fatigue, heat stress, cold stress, and any other problems. In such cases, the worker in danger may not be aware he/she is having a problem. The "buddy" must always be alert to changes in the behavior of his "buddy" so that he can remove him/her from the situation immediately.
- "Buddies" should frequently inspect each other's equipment, including PPE, to ensure that it is adequate and in proper working order.

9.2 WORK PERMIT REQUIREMENTS

At this time, USA does not anticipate work permits for the work associated with this project. Under the Statement of Work (SOW) and activities anticipated for this project, there are no requirements for hot work, (welding). Excavations will be under four feet in depths, so confined space permitting will not be required.

9.3 MATERIAL HANDLING PROCEDURES

Many types of objects are handled in normal day-to-day operations. Care will be taken and training will be provided to all personnel for lifting and handling heavy or bulky items, as this is the cause of many joint and back injuries. The following fundamentals address the proper lifting of materials to avoid joint and back injuries.

- The size, shape, and weight of the object to be lifted must be considered. Site personnel will not lift more than they can handle comfortably.
- A firm grip on the object is essential; therefore, the hands and object will be free of oil, grease, and water, which might prevent a firm grip.
- The hands, and especially the fingers, will be kept away from any points that may cause them to be pinched or crushed, especially when setting the object down.
- The item will be inspected for metal slivers, jagged edges, burrs, rough or slippery surfaces, and pinch points, and gloves will be used, if necessary, to protect the hands.
- The feet will be placed far enough apart for good balance and stability.
- Personnel will ensure that solid footing is available prior to lifting the object.
- When lifting, get as close to the load as possible, bend the legs at the knees, making sure that the back is kept as straight as possible.
- To lift the object, the legs are straightened from their bending position.
- Never carry a load that cannot be seen over or around.
- When placing an object down, the stance and position are identical to that for lifting, with the back kept straight, the legs bent at the knees, and the object lowered.

- If the item to be lifted is too large, bulky, or heavy (over 50lb) for one person to safely lift, ask a co-worker for assistance. If a piece of material handling equipment is available that can do the job, the employee should use the equipment instead of trying to lift the object himself/herself.
- When two or more people are required to handle an object, coordination is essential to ensure that the load is lifted uniformly and that the weight is equally divided between the individuals carrying the load. When carrying the object, each person, if possible, will face the direction in which the object is being carried.

9.4 SPILL CONTAINMENT

Major spills are not expected on this site. Hazardous materials, where necessary, are being brought to the site in small quantity containers. This will minimize the amount of material involved, should a spill occur, as well as reduce the amount of hazardous material on hand to the minimum amount consistent with efficient operations. If a small amount of liquid hazardous material is spilled, it will be cleaned up with absorbent material by site personnel wearing appropriate chemical-resistant gloves. It will then be containerized, labeled, and sent for disposal at an approved facility.

9.5 DRUM, CONTAINER, AND TANK HANDLING

USA could potentially be using drums or other containers for the storage of MD after it has been inspected and is considered to be MDAS. USA personnel will not be lifting or carrying these containers. The recycling company that will come to the site to pick up this material will have the required equipment to lift these containers to load them into their trucks to be taken for recycling.

9.6 COMPREHENSIVE ACTIVITY HAZARD ANALYSIS OF TREATMENT TECHNOLOGIES

Treatment technologies are not expected to be used on this project. When hazardous MEC is found on site, it will be blown in place in accordance with established procedures.

9.7 MATERIAL SAFETY DATA SHEETS

The Material Safety Data Sheets are located in Attachment 6.

9.8 SUBCONTRACTOR CONTROL

See the “Subcontractors and Suppliers” section of the Accident Prevention Plan.

9.9 BOATING SAFETY

Sea Ventures is the USA subcontractor for boat transportation for this project work. This company and it’s boats are registered in Puerto Rico. They have experienced Captains, familiar with the waters throughout Puerto Rico. Sea Ventures will be taking the USA Project Team to remote island sites and off-shore sites for the performance of this RI/FS.

All boats are inspected by Sea Ventures daily, prior to being used for operations to assure they are in optimal mechanical condition. The boats are equipped with personal flotation devices for all passengers. They also maintain readily available rescue equipment in the event of a passenger falling overboard, so that they can quickly be brought back onto the boat. Communications equipment is well maintained and checked daily prior to launching of the boat to assure that they can seek assistance should an emergency occur on the water. There will be a primary means of communication (radio), as well as a back-up, and extra batteries will be available. Directions on how to contact the Coast Guard and the Hospital will be available with each radio and cell phone.

Fire extinguishers are also readily available for use in the event of a fire situation on the boat. Sea Ventures personnel as well as USA personnel are all trained in the use of fire extinguishers to put out fires in the incipient stages. The boat is also equipped with a First Aid kit. USA will also have a First Aid kit available during operations.

The Captain provides a daily safety briefing to all personnel prior to launching the boat from the dock. All passengers are required to obey any directions given by the Captain and they will also wear personal flotation devices for the duration of time on the boat. Personnel will wear shoes with non-slip soles while on the boat and will avoid stepping in wet areas that may be slippery, as much as possible.

9.9.1 OPERATIONS CONDUCTED WHILE ABOARD BOAT

In addition to transportation to offshore sites, operations to take place on board the boat will also include the operation of the Video-Ray Miniature Remote Operating Vehicle (ROV) for performing underwater surveillance, as well as the generator and computers required to provide power and to record data generated by the ROV.

9.9.2 HAZARDS DURING BOAT OPERATIONS

Potential hazards that could be encountered during boat operations include heat stress; fire, underwater MEC; falling overboard; biological hazards (insects); sunburn; slips, trips and falls, and weather emergencies. Safety during boat operations will be addressed in the AHA for Boat Operations.

In order to control these hazards, the following will be required:

- Adequate supply of cool drinking water will be available to all personnel working on the boat.
- Heat stress program will be implemented.
- Decrease intake of coffee or caffeinated drinks.
- Monitor workers for signs of heat stress.
- Use sunscreen and cap,
- Fire extinguishers will be readily available.
- First aid kits will be readily available.
- ROV will be characterizing levels of underwater MEC contamination through video taping of underwater conditions. Contact with MEC items is not intended or anticipated.
- Personnel will remain seated while boat is in motion.
- All personnel will wear personal flotation devices while on boat.
- Good housekeeping standards will be enforced. Cargo will be properly staged on the boat to prevent tripping hazards.
- Personnel will wear rubber soled shoes to prevent slipping while on boat, and will avoid stepping in wet areas that could be slippery.
- Emergency equipment will be available for a man overboard situation and personnel will be trained in its use.
- Communication equipment will be functional and readily available.
- Local weather will be monitored and boat operations will be terminated should a storm be approaching, or should sea conditions make it unsafe to continue.

10.0 SITE CONTROL MEASURES

Site control measures are used to prevent or minimize the potential for site hazards. The site control measures, as well as all requirements of this SSHP, are mandatory for all personnel entering the EZ of this project site. Authorized Government personnel will undergo the mobilization training, along with all USA personnel and any subcontractors who may be required to work on this site, which includes a briefing in all of the requirements of this SSHP. All personnel receiving this training must sign a statement that they were trained and fully understand the requirements of this SSHP.

10.1 SITE MAP

A site map will be utilized by the UXOSO during the Tailgate Safety Briefing to inform the workers of the location of hazardous areas on the site, the assembly areas to be used in the event of site evacuation, and any other information relevant to the day's activities. The site map of each particular site will be provided in an Addendum to this SSHP. The site map will include the following information:

- Site topography
- Site work zones
- Location of unusual/hazardous areas
- Prevailing winds
- Ingress and egress corridors
- Evacuation routes and assembly points
- Location of emergency supplies.

10.2 WORK ZONE DELINEATION AND ACCESS POINTS

Site work zones will be established by the UXOSO prior to initiating operations to control site access. Establishment of site work zones is based upon site conditions, activities, and exposure potentials. A site EZ will be set up, which includes the footprint of the area where work will take place and a fragmentation distance around that to protect areas outside the site from potential fragmentation. The fragmentation distance will be based on the MGFD for each site. Within the EZ, operating teams will maintain a Minimum Separation Distance (MSD) of at least the K40 distance of the MGFD to protect the teams from each other's operations. Site work zones will be marked using barricades and signage closing roads into the area to unauthorized vehicular traffic. Barricades and signs will remain in place for the duration of site operations.

10.3 SITE ACCESS CONTROL

The UXOSO will control access to each work zone and will ensure that all site workers and visitors have received the proper training and medical surveillance required to enter a specific zone. Access will be denied to any potential entrant not meeting these requirements. The following work zones will be established at this site:

- Exclusion Zone (EZ) – Area where a significant hazard does or could occur and includes all areas where PPE is required to control worker exposure to chemical or physical hazards. All personnel entering the EZ will be logged in/out by the UXOSO. The EZ of these sites will be designated as the footprint area of actual project operations and the required fragmentation distance surrounding the area. This distance is based on the fragmentation distance of the MGFD for each site. These distances can be found at Table 2-1, Minimum Separation Distances. Should more hazardous MEC be encountered on this site, the EZ will be changed to the fragmentation distance of the most dangerous MEC item encountered, per DoD 6055.9. Entry into the project area will be under the control of USA. USA will control use of the roads inside the project area. Essential Personnel are defined as USACE and USA project personnel necessary for the safe and efficient completion of field operations conducted within the EZ. This is limited to the USA work team members including the UXOSO, UXOQCS, SUXOS and a USACE OESS. All visitors (persons other than Essential Personnel) to the EZ must be escorted by a UXO-qualified USA employee and all UXO operations will cease until all visitors are outside of the EZ.

- Support Zone (SZ) – Area outside the EZ where site support activities are conducted. This zone includes break areas and sanitation facilities. Visitors desiring entry into the EZ must first meet with the UXOSO and receive the appropriate safety and emergency procedures briefing in the SZ before gaining admittance to the EZ. In addition, visitors will be escorted at all times by a UXO-qualified employee while in the EZ.

Site access control will be implemented by USA and will be accomplished through a program that limits movement and activities of people and equipment at the project site. This control will be based on site-specific characteristics, to include:

- Potential chemical, biological, physical or explosive hazards
- Terrain
- Expected weather conditions
- Planned site activities
- Site proximity to populated areas.

The degree of site access control will include the following.

- Controlled site ingress/egress points – Work area will be clearly visible to anyone approaching the site and vice versa. The access road leading into the area will be closed and barricaded. Signs will be posted to warn unauthorized personnel against entry into the area. Anyone entering the work area must clear access through USA. Only authorized personnel will be permitted within the EZ during MEC operations. All others will remain in the SZ.
- Worker/visitor registration – All personnel working on the site sign in daily at the time of their daily safety briefing in the morning. All visitors to the site must sign the visitor log when they report to the site for their visitor briefing.
- Escort of visitors – All visitors to the site will be escorted by a UXO-qualified USA employee. Visitors will be briefed on site hazards, PPE requirements, and emergency procedures. Visitors who are not UXO qualified will not be permitted within the EZ during MEC operations. If visitors need to access the EZ, all MEC operations will cease while they are in the area, and the visitors will be escorted at all times.
- PPE requirements – PPE requirements have been established based on the site hazards. Personnel working in areas requiring PPE will wear required PPE for the duration of the operation. Visitors to the area will be required to have the required PPE for the area they will be visiting.

10.4 ON- AND OFF-SITE COMMUNICATION SYSTEM

On-site communication will be conducted by voice, hand signals and/or radio. If off-site communication is required, it will be established through the use of Puerto Rican cellular telephones.

11.0 PERSONNEL HYGIENE AND DECONTAMINATION FACILITIES AND PROCEDURES

Sanitation facilities will be provided in the SZ area so that employees can wash prior to eating, drinking, smoking, or engaging in any other hand-to-face activities. Chemical toilets will be available in the SZ of the work area. As chemical contamination is not expected to be an issue at this site, basic washing of equipment and standard hygiene practices are the minimum requirements. Site sanitation will be established and maintained in accordance with OSHA 29 CFR 1910.120(n) and USACE EM 385-1-1, Section 2. In particular:

- Temporary toilet facilities will be provided in the work areas of the site. Chemical toilets will be used in these locations and will be serviced every week. Each temporary toilet will be naturally lighted, have a toilet seat with a seat cover, have a urinal, have ventilation with vents screened, and be lockable from the inside. There will be at least one toilet for every 15 workers at the work site, as required.
- Hand and face washing facilities will be set up at the USA work site and will be utilized by all personnel exiting the EZ prior to eating, drinking, tobacco use, or other hand-to-face activities. Paper towels will be provided for drying. A trash receptacle will be provided for discarded paper towels. An eyewash kit will be located in each site vehicle.

General work practices include the following:

- Safe work practices will be implemented when possible to eliminate or reduce the potential for employee exposure.
- Employees will wash their hands immediately or as soon as feasible after removal of gloves or other PPE.
- Employees will wash hands and any other skin with soap and water, or flush mucous membranes with water immediately following contact with blood or potentially infectious materials.
- If potentially contaminated sharps are encountered, the item will immediately be disposed of in an appropriate puncture-resistant container or decontaminated.
- Eating, drinking, smoking, applying cosmetics or lip balm, handling of contact lenses, or storage/handling of food are prohibited in all areas where potentially infectious materials are present.
- Equipment that has become contaminated will be decontaminated prior to servicing or storage, unless decontamination is not feasible, in which case the equipment will be disposed of properly.

12.0 EQUIPMENT DECONTAMINATION FACILITIES AND PROCEDURES

Because chemical contamination is not anticipated at this site, basic washing of equipment is all that will be required.

13.0 ON-SITE FIRST AID AND EMERGENCY PROCEDURES AND EQUIPMENT

Emergency equipment will be maintained on site for the duration of site operations. An approved emergency first aid kit, blood-borne pathogen kit, and eyewash kit, will be kept in each site vehicle. First aid kits are assigned by the Safety Office and approved by the Occupational Health Physician. The UXOSO will be charged with providing regular inspections of the emergency supplies, replacing any items that are used, and maintaining readiness.

A 5-lb ABC fire extinguisher will be kept in each site vehicle for emergency use on site. This equipment will be inspected on a weekly basis to ensure it is maintained and ready to use. Any used items will be replaced immediately.

Fire extinguishers will be stored where they are well marked and readily accessible. Fire extinguishers shall be protected from the damaging effects of environmental elements. The UXOSO is responsible for ensuring that all fire extinguishers are visually inspected weekly and that these inspections are documented. All site personnel will be familiar with the locations of fire extinguishers and will be trained in their use.

14.0 EMERGENCY RESPONSE PLAN AND CONTINGENCY PROCEDURES

The Emergency Response Plan and contingency procedures address emergencies that could occur during site operations, and outline the appropriate response actions. This information can be found in “Emergency Response Plan and Contingency Procedures” under the “Plans, Programs and Procedures” section of the APP.

15.0 EVACUATION PLAN

In the event of an emergency requiring evacuation, the evacuation signal will be given as an alarm or through verbal instructions or a single blow of a horn. Personnel will evacuate to a pre-determined evacuation point in the SZ. The UXOSO will account for all personnel and will summon emergency response personnel, if required. If the fire department is summoned, the UXOSO will meet them upon their entrance to the site and will inform them of the presence of MEC, and provide the appropriate fragmentation distance from the fire for the purpose of fighting or preventing the spread of fire from the site.

Potentially hazardous weather conditions will be closely monitored by the UXOSO. The UXOSO will determine if high wind or heavy rain conditions pose a hazard to site operations, in which case, personnel will evacuate to the pre-determined evacuation point and will wait for conditions to clear or for further instructions from the UXOSO.

After the emergency situation has been controlled and eliminated, or has passed the Project Manager, UXOSO, and Corporate Safety and Health Manager will review the way the emergency was handled and change procedures if necessary.

After allowing the appropriate wait time (24 hours in the case of a fire), the SUXOS and the UXOSO will enter the site together and determine if the site is safe for re-entry. If MEC is encountered that may have been subjected to extreme temperatures in a fire, that MEC will be blown in place prior to allowing re-entry into the site.

16.0 LOGS, REPORTS, AND RECORDKEEPING

See the “Logs, Reports, and Recordkeeping” section of the APP.

17.0 ON-SITE WORK PLANS

The approved Work Plans will be maintained on site by the SUXOS, UXOSO, and UXOQCS, which include the APP/SSHP, the Explosives Safety Submission, Dive Plan and the Quality Control Plan. These plans will be fully implemented for the duration of site operations. If new hazards are encountered that are not fully addressed within these documents, the documents will be amended in accordance to the requirements of DoD 6055.9 and will be sent for approval through the same appropriate channels that approved the original plans.

18.0 COMMUNICATION PROCEDURES

On-site communication will generally be verbal. The sites are expected to be small enough that where there is a need for groups to communicate with each other, they will be able to hear each other. There may also be an alarm signal used for the purposes of site evacuation.

Off-site communication will be by Puerto Rican cellular telephone. Cellular telephones from the U.S. mainland will not work here.

19.0 SPILL CONTAINMENT PROCEDURES

Small-quantity containers of chemicals will be used at the work sites, which will minimize the amount of hazardous materials that could potentially become part of a spill should an accident occur. The majority of chemicals used will include oils and lubricants for use in vegetation clearance equipment. Spill cleanup kits will be available for use to clean up these chemicals and the impacted soils in the event a spill occurs. Chemical-resistant gloves will be used during all cleanup activities. The spilled chemical and the contaminated soil will be cleaned up, placed in labeled plastic bags, and stored in drums or other secured location until such time as they can be sent to a certified disposal facility.

20.0 CONFINED SPACE PROCEDURES

Because of the nature of this SOW, confined spaces are not expected to be an issue on these sites. None of the excavations on these sites are expected to exceed 4 feet in depth.

21.0 FIRE PROTECTION REQUIREMENTS

Through appropriate use and storage of flammable products, USA intends to prevent fires as much as feasible during operations on this site. Should a fire occur, all site teams will have at least one ABC fire extinguisher with them during the course of operations. Fire extinguishers are the first line of defense should a fire start. USA personnel will be trained in the use of fire extinguishers and they will be instructed to try to fight a fire only in the incipient stages. If the fire is too large to fight, personnel will evacuate the site and the UXOSO will call in the fire department, who will stand no closer than fragmentation distance from the fire to fight or prevent spreading of the fire. If it is possible to do so safely, USA will remove any flammable and/or combustible materials from the path of the fire.

After the fire has been extinguished, the area will be closely monitored by the UXOSO for a period of at least 1 hour for a small fire, to ensure that re-ignition does not occur. For larger fires or explosions, a wait time of 24 hours will be given after the fire has been extinguished before anyone would be permitted to gain access to the site. At that point, the SUXOS and the UXOSO would enter the site together. If MEC is observed, it will be considered to be unstable as a result of exposure to extreme heat. The MEC will be blown in place. After all visible MEC has been disposed of, it is considered safe for other personnel to enter the site for the purposes of site investigations. All personnel entering the site who are not UXO qualified will be escorted by a UXO-qualified person for the duration of the site visit. If MEC is encountered while non-UXO-qualified personnel are visiting the site, they will be removed from the site until the MEC can be blown in place and the site can be made safe for re-entry.

22.0 INCIDENT REPORTING REQUIREMENTS

Should an accident or mishap occur on the site, regardless of the severity, it will be fully investigated by USA and all reports and records will be documented on the USA Accident Report Form. Copies will be maintained on site for the duration of site activities. A permanent copy will be maintained in the USA-Oldsmar Office. Accidents/incidents shall be reported in accordance with EM 385-1-1. All accident/incident reports will be reviewed by the Corporate Safety and Health Manager to ensure all root causes of the accident/incident have been adequately addressed in order to prevent future recurrences on this or any other project sites.

The Site Manager will notify the USACE technical representative immediately and fill out and submit the ENG Form 3394 form to the Contracting Officer or designated representative for review within one working day after the event.

Any accident involving a fatality or three or more hospitalizations from the same incident will be reported telephonically to the nearest OSHA Area office within 24 hours by the Corporate Safety and Health Manager. If all information is not known at that time, an initial report will be made and a follow-up report will be submitted after all of the facts are documented.

APPENDIX D, ATTACHMENT 5.
USA'S DRUG FREE WORK PLACE PROGRAM

DRUG FREE WORK PLACE PROGRAM

January 01, 2010

The USA ENVIRONMENTAL, INC. program is an extension of our work safety and employee health programs. The program requires refraining from substance abuse both on and *off* the job as a condition of continued employment.

WHAT IS SUBSTANCE ABUSE?

Federal Acquisition Regulation Clause 23.500 defines substance abuse as the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance in the workplace. USA ENVIRONMENTAL INC.'s program further expands that definition as follows: Substance abuse includes but is not limited to the consumption, by any means, of any legal or illegal substance that alters an individual's normal behavior and results in intoxication and/or renders the employee incapable of safe/efficient job performance. Substance abuse also includes over use or abuse of legally prescribed drugs. Also prohibited are the use of, selling, trading, giving away, possession or offering for sale illegal drugs, prescription drugs, or alcohol whether on company property, while operating a company vehicle or company-leased vehicle (on or off company property and during working or non-working hours), or operating a personal vehicle while on company business.

USA ENVIRONMENTAL SUBSTANCE ABUSE TESTING PROGRAM

The substance abuse program includes substance abuse testing under the following situations:

1. Pre-employment testing.
2. Testing for reasonable suspicion of substance abuse.
3. Testing following on-the-job accidents.
4. Testing as part of all "fitness for duty" medical examinations.
5. Quarterly testing for a period of 2 years after program completion for all employees participating in a substance abuse rehabilitation program.
6. Random testing of employees to promote abstinence.
7. Testing following a 30-day or greater layoff or return to work following a leave of absence or termination.

A urine, saliva or blood specimen will be analyzed for the presence of any of the following substances:

1. Marijuana - Cannabinoids, THC
2. Cocaine
3. Methadone - Dolophine, Methadose
4. Barbiturates - Nembutal, Tuinal, Seconal, etc.
5. Amphetamines - Desoxyn, Biphetamine, Dexedrine, etc.
6. Methaqualone - Qualudes
7. Opiates - Codeine, Percodan, Paregoric, Morphine, etc
8. Propoxyphene - Darvon, Dolene, etc.
9. Phencyclidine - (PCP)
10. Benzodiazepines - Librium, Valium, Xanax, Serax, Halcion, etc.

(Alcohol as required through breathalyzer or other testing means – Ethyl Alcohol as a beverage or as part of a medication)

A list of the most common drugs or medication by brand name, common name, as well as chemical name, which may alter or affect a drug test will be provided to all job applicants and employees at the time of testing.

A form is provided for employees or job applicants to report, voluntarily and confidentially, the use of prescription or non-prescription medications both before and after being tested.

Specific confirmation testing will be performed for all positive screening test results. Employees testing positive for prescription drugs that are commonly abused must produce evidence from their attending physician to justify the treatment necessity for use of the drug(s).

USA ENVIRONMENTAL, INC. is responsible for testing costs, except for test costs incurred by the employee or job applicant challenging test results.

RANDOM TESTING
Unless prohibited by law, USA ENVIRONMENTAL, INC. reserves the right to randomly test its employees for substance abuse. The number of personnel tested and the frequency of tests will be solely at the discretion of USA ENVIRONMENTAL, INC. or as contractually specified by USA ENVIRONMENTAL INC.'s clients.

REASONABLE SUSPICION TESTING .
Employees reporting to work or a USA ENVIRONMENTAL, INC. job site who demonstrate impaired conduct will be interviewed by two (2) supervisors or managers to determine the cause of the irregular behavior.

If both supervisors conclude that the irregular behavior is unsafe the employee will not be allowed to continue working and will be transported home or to a medical facility. The employee will not be allowed to drive any motor vehicle. If a medical problem is not the cause, the employee may be tested for substance abuse. The employee may also be tested for substance abuse regardless of the cause of irregular behavior.

Reasonable suspicion testing shall also be conducted when there is:

1. An independently corroborated report of observed substance abuse.
2. Evidence that an individual tampered with a drug test during his or her employment with USA ENVIRONMENTAL, INC.
3. Information that an employee caused or contributed to an accident while at work.
4. Evidence that an employee has used, possessed, sold, solicited, or transferred drugs while working on USA ENVRIONMENTAL, INC. premises or while operating vehicles, machinery or equipment belonging to USA ENVIRONMENTAL, INC.

Supervisors will complete an incident report for observed irregular conduct, documenting their observations and the results of the employee interview. Final disposition of the incident will be documented with signatures and the dates listed by both supervisors.

A copy of the supervisor's report will be provided to the employee with appropriate employee's signature of receipt.

This confidential Incident Report will be retained by USA ENVIRONMENTAL, INC. for a period of at least one (1) year.

CONSEQUENCES OF POSITIVE TEST OR TEST REFUSAL

Refusal or failure to submit to testing or positive test results following an on-the-job injury disqualifies an employee from Workers' Compensation benefits.

Testing positive for abused substances will eliminate applicants from employment consideration.

Any employee may be terminated from employment for a positive test result. Refusal or failure to submit to testing following an on-the-job accident or random test will result in termination of employment.

Any employee who is given a "second chance" must seek treatment. Time away from work for treatment will be in a leave without pay status. The USA ENVIRONMENTAL, INC. Employee Assistance Program (EAP) will coordinate the employee's treatment plan. If the employee is enrolled in the employee health benefit plan or another medical plan, it may provide benefits to help pay for this treatment.

A second positive test for abused substances will result in termination.

OTHER GROUNDS FOR TERMINATION

An employee bringing onto the USA ENVIRONMENTAL, INC. premises or job sites; having possession of; being under the influence of; possessing in the employee's body, blood or urine (at levels exceeding or equal to established cut-off levels, 38F-9.007 (4)); or using, consuming, transporting, selling, attempting to sell, or giving away any illegal drugs (including prescription drugs illegally obtained or prescribed for the individual only), or alcohol, at any time, is guilty of misconduct and is subject to discipline to include discharge, suspension without pay or other actions even for a first offense. USA ENVIRONMENTAL, INC. reserves the right to inspect the property and person of individuals suspected of illegal drug or alcohol possession while on company property or at company job sites (see Right to Inspect).

CHALLENGING TEST RESULTS

An employee may challenge a confirmed positive test by submitting an explanation in writing to the Human Resources Department concerning personal circumstances that might have affected test results. This challenge must be submitted within 5 working days following the employee's notification of a confirmed positive test result. The donor of a tested specimen will be responsible for providing all necessary documentation, i.e., a doctor's report, signed prescription or current prescription container with relevant information and other related supporting documents.

USA ENVIRONMENTAL, INC. will, within 15 days of receipt of the employee's written explanation or challenge of positive test results, provide a written explanation to the employee as to whether, and if so, why, the employee's explanation is unsatisfactory, along with a copy of the positive test results.

The employee or job applicant desiring to challenge a test result will be responsible for notifying the original testing laboratory of an alternate HRS licensed laboratory, for the purpose of transferring, under Chain of Custody, a portion of the employee's or job applicant's specimen for re-testing. The employee may have a portion of their original specimen re-tested during a period of 180 days following written notice of a positive test result. When an employee undertakes a challenge to the result of a test, it shall be the employee's responsibility to notify the laboratory and the sample shall be retained by the laboratory until the matter is settled. Retesting will be at the employee's expense.

In the case of a denial of a workers' compensation claim, an employee may undertake an administrative challenge by filing a claim for benefits with a judge of compensation claims, concerning workplace injury. Other challenges not involving workplace injuries must challenge a test result in a court of competent jurisdiction.

Employees or job applicants may call the testing laboratory for technical information regarding prescription or non-prescription medications that may affect test results.

Employees and job applicants may report, in confidence, to their manager or Human Resources Director, the use of prescription or non-prescription medications that may affect job performance or testing results, either before or after testing.

Job applicants or employees whose drug test results are confirmed positive shall not by virtue of the result alone, be defined as having a "disability" under the Americans with Disabilities Act.

GETTING HELP

Employees who require a treatment program will be referred to USA ENVIRONMENTAL, INC.'s Employee Assistance Program (EAP).

Employees may inspect this program file and/or receive more information on the program on a confidential basis, in the USA ENVIRONMENTAL, INC. Human Resources Office, during normal hours of operation.

REQUIREMENT TO NOTIFY USA OF A CONVICTION

Any employee convicted of a criminal drug statute violation must notify USA ENVIRONMENTAL, INC., Attention: Human Resources Department, within 5 calendar days of the conviction. This notification must be in writing.

CONFIDENTIALITY OF INFORMATION

All drug test information, reasonable suspicion reports, or other related information concerning an employee or applicant will remain confidential and will not be disclosed except under conditions required by law.

Release of such information under any circumstances, other than those required by law, will be solely pursuant to a written consent voluntarily signed by the person tested. The consent duration and precise information to be disclosed will be stated.

GOVERNMENTAL COMPLIANCE

The Drug Free Work Place Program is implemented pursuant to the requirements of Florida Statute 440.102 and Administrative Rules 38F-9-001 through 38F-9.014 of the Florida Department of Labor and Employment Security, Division of Workers' Compensation, and 48 CFR 23.500 (Federal Acquisition Regulation 23.500). Laws may be amended at project sites in other states due to those states' requirements.

Robin Miller

Robin Miller
Human Resources Director

APPENDIX D, ATTACHMENT 6.
MATERIAL SAFETY DATA SHEETS

This attachment contains the following MSDSs applicable to this site:

- Anti-Freeze
- Cast Boosters PETN
- Deep Woods OFF
- Detonating Cord
- Diesel Fuel #2
- Electric / Non-Electric Detonators
- Fire Extinguishers
- Hydraulic Fluid
- Insect Repellent
- Shaped Charge
- Unleaded Gas.

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MSDS
ANTI-FREEZE

*** IDENTIFICATION ***
MSDS RECORD NUMBER: 897945
PRODUCT NAME(S): ETH. GLYCOL(MEG) OFFSPEC
PRODUCT IDENTIFICATION: PRODUCT CODE R00000024044
DATE OF MSDS: 1994-10-21
EMERGENCY TELEPHONE NO. : 800-964-8861 (SUN COMPANY, AFTER NORMAL BUSINESS HOURS) 800-424-9300 (CHEMTREC, AFTER NORMAL BUSINESS HOURS)
*** MATERIAL SAFETY DATA ***
1. CHEMICAL PRODUCT AND COMPANY INFORMATION
REVISION DATE: 10/21/1994
UN NUMBER- N/A
PRIMARY APPLICATION- ANTIFREEZE, SOLVENT.
SYNONYMS: MONOETHYLENE GLYCOL; ETHYLENE ALCOHOL
CAS REGISTRY NO: 107-21-1
CAS NAME...... : 1,2-ETHANEDIOL
CHEMICAL FAMILY: GLYCOL
EMERGENCY PHONE NUMBERS (AFTER NORMAL BUSINESS HOURS)
SUN CO.. 1-800-964-8861
CHEMTREC. 1-800-424-9300
2. COMPOSITION / INFORMATION ON INGREDIENTS
EXPOSURE GUIDELINES
OSHA ACGIH SUN/MFR
COMPONENT/CAS NO. LO% HI% TWA STEL TWA STEL TWA STEL UNIT
LIMITS FOR THE PRODUCT:
CEILING LIMIT - 50 PPM
ETHYLENE GLYCOL 107-21-1 99.00 100.0
CEILING LIMIT - 50 PPM
ADDITIONAL EXPOSURE LIMITS GOVERNMENT REGULATION
OTHER LIMIT- OSHA/ACGIH CEILING: 50PPM; 125MG/M3.
3. HAZARDS IDENTIFICATION
EMERGENCY OVERVIEW
WARNING] HARMFUL IF INHALED. MAY CAUSE RESPIRATORY TRACT IRRITATION. <u>INHALATION</u> CAUSES EYE IRRITATION. HARMFUL OR FATAL IF SWALLOWED. CAN CAUSE SEVERE CHRONIC TOXICITY.
APPEARANCE-- COLORLESS LIQUID
ODOR-- SLIGHTLY SWEET
POTENTIAL HEALTH EFFECTS
PRIMARY ROUTES OF ENTRY- INHALATION(X) SKIN(X) EYE(X) INGESTION(X)
<u>INHALATION</u>
EXCESSIVE EXPOSURES MAY CAUSE IRRITATION TO EYES, NOSE, THROAT AND LUNGS. IRRITATION TO RESPIRATORY TRACT; CENTRAL NERVOUS SYSTEM (BRAIN) <u>EFFECTS</u>; DISCOMFORT, DISAGREEABLE ODOR, NAUSEA. REPEATED EXCESSIVE EXPOSURES MAY CAUSE LIVER EFFECTS OR DAMAGE. KIDNEY EFFECTS OR DAMAGE.
CHRONIC, ADVERSE SYSTEMIC EFFECTS.
<u>SKIN</u>
SKIN ABSORPTION OF MATERIAL MAY PRODUCE SYSTEMIC TOXICITY. CONTAINS A MATERIAL WHICH MAY CAUSE IRRITATION WITH PROLONGED OR REPEATED CONTACT.
<u>EYE</u>
CONTACT WITH THE EYE MAY CAUSE IRRITATION.
<u>INGESTION</u>
HARMFUL OR FATAL IF SWALLOWED. INGESTION OF THIS MATERIAL MAY CAUSE ABDOMINAL PAIN; CENTRAL NERVOUS SYSTEM (BRAIN) EFFECTS; DIFFICULTY IN BREATHING; RESPIRATORY FAILURE; AND DEATH. INGESTION OF THIS MATERIAL MAY CAUSE DAMAGE TO KIDNEYS;
CARCINOGEN LISTED BY-IARC(NO) NTP(NO) OSHA(NO) ACGIH(NO) OTHER(NO)
<u>PRE-EXISTING MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE</u>-
DISORDERS OR DISEASES OF THE SKIN, EYE, KIDNEY, LIVER.
4. FIRST AID MEASURES

MOVE PERSON TO FRESH AIR. IF NOT

BREATHING, GIVE ARTIFICIAL RESPIRATION,
OBTAIN MEDICAL ASSISTANCE.

SKIN

WASH WITH SOAP AND WATER UNTIL NO ODOR REMAINS. IF REDNESS OR SWELLING DEVELOPS, OBTAIN MEDICAL FLUSH WITH WATER FOR AT LEAST 15 MINUTES. IF IRRITATION PERSISTS, OBTAIN MEDICAL ASSISTANCE.

INGESTION

GIVE LIQUIDS AND INDUCE VOMITING UNLESS VICTIM IS UNCONSCIOUS. OBTAIN EMERGENCY MEDICAL ATTENTION. SMALL AMOUNTS WHICH ACCIDENTALLY ENTER MOUTH SHOULD BE RINSED OUT UNTIL TASTE OF IT IS GONE.

5. FIRE FIGHTING MEASURES

FLASH POINT: 245 CLOSED CUP (DEG. F); 111 CLOSED CUP (DEG. C)
AUTOIGNITION TEMP.: 748 (DEG. F); 398 (DEG. C)

---FLAMMABLE LIMITS IN AIR---

LOWER EXPLOSIVE LIMIT (LEL): 3.2 % VOLUME
UPPER EXPLOSIVE LIMIT (UEL): ESTIMATED @ 15.3 % VOLUME

FIRE AND EXPLOSION HAZARDS

CAN BE MADE TO BURN (FLASH POINT GREATER THAN 200F).

EXTINGUISHING-MEDIA

WATER SPRAY. ALCOHOL RESISTANT FOAM. DRY CHEMICAL. CARBON DIOXIDE.

SPECIAL FIRE FIGHTING INSTRUCTIONS

USE WATER SPRAY. COOL TANK/ CONTAINER. WEAR SELF-CONTAINED BREATHINGAPPARATUS. WEAR STRUCTURAL FIREFIGHTERS PROTECTIVE CLOTHING.

NFPA/HMIS CLASSIFICATION
HAZARD RATING

HEALTH - 1 / 1	0=LEAST	1=SLIGHT
FIRE - 1 / 1	2=MODERATE	3=HIGH
REACTIVITY - 0 / 0	4=EXTREME	

PERSONAL PROTECTION INDEX - X
SPECIFIC HAZARD: NONE LISTED.

6. ACCIDENTAL RELEASE MEASURES

CONTAIN SPILL. FOR LARGE SPILL, LEAK OR RELEASE. USE PERSONAL PROTECTIVE EQUIPMENT STATED IN SECTION 8. ASSISTANCE. OBTAIN MEDICAL ATTENTION.
IMMEDIATELY REMOVE SOAKED CLOTHING. WASH CLOTHING BEFORE REUSE.

EYE

ADVISE EPA; STATE AGENCY IF REQUIRED. ABSORB ON INERT MATERIAL. SHOVEL, SWEEP OR VACUUM SPILL. FLUSH WITH WATER AND REMOVE CONTAMINATED ARTICLES.

7. HANDLING AND STORAGE

KEEP IN COOL, DRY PLACE. KEEP IN WELL VENTILATED SPACE. STORAGE HAS TEMPERATURE LIMITS--SEE STABILITY. NFPA CLASS IIIB STORAGE. CONSULT NFPA AND OSHA CODES. AVOID PROLONGED BREATHING OF MIST OR VAPOR. AVOID PROLONGED OR REPEATED CONTACT WITH SKIN. WASH THOROUGHLY AFTER HANDLING.

8. EXPOSURE CONTROL / PERSONAL PROTECTION

CONSULT WITH A HEALTH/SAFETY PROFESSIONAL FOR SPECIFIC SELECTION.

VENTILATION

VENTILATE AS NEEDED TO COMPLY WITH EXPOSURE LIMIT. LOCAL EXHAUST VENTILATION RECOMMENDED. MECHANICAL VENTILATION RECOMMENDED.

PERSONAL PROTECTIVE EQUIPMENT

EYE

SPLASH PROOF CHEMICAL GOGGLES RECOMMENDED TO PROTECT AGAINST SPLASH OF PRODUCT.

GLOVES

PROTECTIVE GLOVES RECOMMENDED WHEN PROLONGED SKIN CONTACT CANNOT BE AVOIDED. POLYETHYLENE; NEOPRENE; NITRILE; POLYVINYL ALCOHOL; NATURAL RUBBER; BUTYL RUBBER;

RESPIRATOR

CONCENTRATION-IN-AIR DETERMINES PROTECTION NEEDED. USE ONLY NIOSH CERTIFIED RESPIRATORY PROTECTION. RESPIRATORY PROTECTION USUALLY NOT NEEDED UNLESS PRODUCT IS

HEATED OR MISTED. HALF-MASK AIR PURIFYING RESPIRATOR WITH ORGANIC VAPOR CARTRIDGES IS ACCEPTABLE TO 10 TIMES THE EXPOSURE LIMIT. FULL-FACE AIR PURIFYING RESPIRATOR WITH ORGANIC VAPOR CARTRIDGES IS ACCEPTABLE TO 50 TIMES THE EXPOSURE LIMIT NOT TO EXCEED THE CARTRIDGE LIMIT OF 1000 PPM. PROTECTION BY AIR PURIFYING RESPIRATORS IS LIMITED. USE A POSITIVE PRESSURE-DEMAND FULL-FACE SUPPLIED AIR RESPIRATOR OR SCBA FOR EXPOSURES ABOVE 50X THE EXPOSURE LIMIT. IF EXPOSURE IS ABOVE POLYETHYLENE; POLYVINYL ALCOHOL(PVA); NEOPRENE; NITRILE; NATURAL RUBBER; LAUNDER SOILED CLOTHES. FOR NON-FIRE EMERGENCIES RESPIRATORY PROTECTION MAY BE NECESSARY AND WEAR APPROPRIATE PROTECTIVE CLOTHING TO AVOID CONTACT.

9. PHYSICAL AND CHEMICAL PROPERTIES

BOILING POINT...... : 388 (DEG. F) _____ 198 (DEG. C)
MELTING POINT...... : 9 (DEG. F) _____ MINUS 13.3 (DEG. C)
SPECIFIC GRAVITY... : 1.1 (WATER=1)
PACKING DENSITY.... : N/A (KG/M3)
VAPOR PRESSURE..... : 0.08 (MM HG @ 20 DEG C)
VAPOR DENSITY...... : 2.1 (AIR=1)
SOLUBILITY IN WATER.: COMPLETE (% BY VOLUME)
PH INFORMATION..... : N/A AT CONC. N/A G/L H2O
% VOLATILES BY VOL..: N.D.
EVAPORATION RATE... : 1000X SLOWER (ETHYL ETHER=1)
OCTANOL/WATER COEFF.: N.D.
APPEARANCE......... : COLORLESS LIQUID
ODOR............... : SLIGHTLY SWEET
ODOR THRESHOLD..... : N.D. (PPM)
VISCOSITY.......... : N.D. SUS @ N.D DEG F ... N.D. CST @ N.D DEG C
MOLECULAR WEIGHT... : N.D. (G/MOLE)

10. STABILITY AND REACTIVITY

STABILITY
STABLE.

IDLH(IMMEDIATELY DANGEROUS TO LIFE & HEALTH) OR THERE IS THE POSSIBILITY OF AN UNCONTROLLED RELEASE OR EXPOSURE LEVELS ARE UNKNOWN THEN USE A POSITIVE PRESSURE-DEMAND FULL-FACE SUPPLIED AIR RESPIRATOR WITH ESCAPE BOTTLE OR SCBA. IMPORTANT SUPPLEMENTAL INSTRUCTION OR INFORMATION FOR PROPER RESPIRATORY PROTECTION IS CONTAINED IN SECTION 16.

<u>OTHER</u>

IF CONTACT IS UNAVOIDABLE, WEAR CHEMICAL RESISTANT CLOTHING.

CONDITIONS TO AVOID-
EXTREME HEAT WILL IGNITE IN AIR AT 748F. DO NOT STORE AT TEMPERATURES ABOVE 120F (60C).

INCOMPATIBLE MATERIALS
STRONG OXIDIZING CHEMICALS. REACTS VIOLENTLY WITH CHLOROSULFONIC ACIDOLEUM, SULFURIC ACID, STRONG BASES.

HAZARDOUS DECOMPOSITION
CARBON MONOXIDE AND ASPHYXIANTS ARE PRODUCED BY BURNING.
POLYMERIZATION WILL NOT OCCUR.

11. TOXICOLOGICAL INFORMATION

FOR THE PRODUCT
INHALATION: OVEREXPOSURE TO MIST OR VAPORS MAY CAUSE EYE, NOSE, THROAT AND RESPIRATORY TRACT IRRITATION, CNS (BRAIN) EFFECTS, DIZZINESS, DRUNKENESS, INCOORDINATION, COMA, RESPIRATORY FAILURE, OR DEATH.
EXCESSIVE EXPOSURES MAY CAUSE BRAIN, LIVER, AND/OR KIDNEY EFFECTS AND DAMAGE.
SKIN & EYE: LARGE ACUTE EXPOSURE MAY CAUSE SYSTEMIC EFFECTS. IRRITANT ON CONTACT.
INGESTION: TOXIC] HARMFUL OR FATAL IF SWALLOWED. ACUTE POISONING (AS LITTLE AS 100 ML IN HUMANS) CHARACTERIZED BY GI PAIN, NAUSEA, VOMITING, MUSCLE TENDERNESS, CNS DEPRESSION, POSSIBLE RESPIRATORY AND RENAL FAILURE, DEATH. IN LAB ANIMALS BY ORAL AND INHALATION

EXPOSURE EMBRYOTOXICITY & TERATOGENICITY WERE REPORTED.
ETHYLENE GLYCOL (COMPONENT)
INHALATION: OVEREXPOSURE TO MIST OR VAPORS GENERATED BY HEATING MAY CAUSE EYE, NOSE, THROAT, & RESPIRATORY IRRITATION, CNS (BRAIN) EFFECTS & DIZZINESS. EXCESSIVE PROLONGED EXPOSURES MAY CAUSE KIDNEY, LIVER, BLOOD, BRAIN EFFECTS OR DAMAGE. SKIN & EYE: LARGE ACUTE EXPOSURE MAY CAUSE SYSTEMIC TOXICITY. IRRITANT ON CONTACT. ORAL: TOXIC] HARMFUL OR FATAL IF SWALLOWED. ACUTE POISONING (AS LITTLE AS 100 ML IN HUMANS) CHARACTERIZED BY GI PAIN, NAUSEA, VOMITING, MUSCLE SPASMS, CONVULSIONS & CNS DEPRESSION, POSSIBLE RENAL AND RESPIRATORY FAILURE, DEATH. IN LAB ANIMALS BY ORAL & INHALATION EXPOSURE FETAL TOXICITY AND BIRTH DEFECTS WERE REPORTED.

12. ECOLOGICAL INFORMATION
AQUATIC TOXICITY
TLM96 (CONCENTRATION IN WATER THAT KILLS 50% OF EXPOSED ORGANISMS)IS IN THE RANGE OF 100 TO 1000 PPM. LC50 (24 HRS.) TO GOLDFISH: >5,000 MG/L THE TOXICITY THRESHOLD FOR SCENDESMUS QUADRICAUDA (GREEN ALGAE) TO ETHYLENE GLYCOL IS >10,000 MG/L.

13. DISPOSAL CONSIDERATIONS
FOLLOW FEDERAL, STATE AND LOCAL REGULATIONS. NOT A RCRA HAZARDOUS WASTE IF UNCONTAMINATED. DO NOT FLUSH TO DRAIN/ STORM SEWER. CONTRACT TO AUTHORIZED DISPOSAL SERVICE.

14. TRANSPORTATION INFORMATION
DOT- PROPER SHIPPING NAME- ETHYLENE GLYCOL (ANTIFREEZE)
HAZARD CLASS- NOT REGULATED
IDENTIFICATION NUMBER- NOT REGULATED
LABEL REQUIRED- NOT REGULATED
IMDG- PROPER SHIPPING NAME- NOT AVAILABLE
IATA- PROPER SHIPPING NAME- NOT AVAILABLE

15. REGULATORY INFORMATION
SARA 302 THRESHOLD PLANNING QUANTITY. N/A
SARA 304 REPORTABLE QUANTITY .... N/A
SARA 311 CATEGORIES- IMMEDIATE (ACUTE) HEALTH EFFECTS.. Y
DELAYED (CHRONIC) HEALTH EFFECTS.. Y
FIRE HAZARD .... N
SUDDEN RELEASE OF PRESSURE HAZARD. N
REACTIVITY HAZARD .... N
WHEN A PRODUCT AND/OR COMPONENT IS LISTED BELOW, THE REGULATORY LIST ON WHICH IT APPEARS IS INDICATED.
FOR THE PRODUCT - MA NJ PA RI 01
ETHYLENE GLYCOL - CA FL MA MN NJ PA RI 01

01=SARA 313 02=SARA 302/304 03=IARC CARCINOGEN 04=OSHA CARCINOGEN 05=ACGIH CARCINOGEN 06=NTP CARCINOGEN 07=CERCLA 302.4 08=WHMIS CONTROLLED PROD. 10=OTHER CARCINOGEN PA=PENNSYLVANIA RTK NJ=NEW JERSEY RTK CA=CALIFORNIA PROP 65 MA=MASSACHUSETTS RTK MI=MICHIGAN 406 MN=MINNESOTA RTK FL=FLORIDA RI=RHODE ISLAND IL=ILLINOIS NY=NEW YORK WV=WEST VIRGINIA CT=CONNECTICUT LA=LOUISIANA ME=MAINE OH=OHIO
THIS PRODUCT OR ALL COMPONENTS OF THIS PRODUCT ARE LISTED ON THE U.S. TSCA INVENTORY.

16. OTHER INFORMATION
ETHYLENE GLYCOL IS TOXIC BY INGESTION AND DETAILS ON BODILY EFFECTS AND FIRST AID TREATMENT CAN BE FOUND IN "CLINICAL TOXICOLOGY OF COMMERCIAL PRODUCTS" BY GOSSELIN, HODGE, SMITH AND GLEASON. WILLIAMS < WILKINS PUB.
WARNING] HARMFUL OR FATAL IF SWALLOWED. DO NOT DRINK ETHYLENE GLYCOL OR SOLUTION. IF SWALLOWED

AND IF CONSCIOUS, INDUCE VOMITING. CALL FOR MEDICAL HELP IMMEDIATELY. NON-FATAL DOSES CAN PRODUCE KIDNEY, LIVER, AND OTHER SYSTEMIC DAMAGE. HAS PRODUCED BIRTH DEFECTS IN LABORATORY ANIMAL STUDIES. MINIMIZE EXPOSURE TO MISTS, VAPORS AND FUMES. IN CASE OF EYE CONTACT, FLUSH WITH WATER FOR AT LEAST 15 MINUTES. WASH THOROUGHLY AFTER HANDLING. DO NOT STORE IN OPEN OR UNLABELED CONTAINERS. KEEP OUT OF REACH OF CHILDREN AND ANIMALS.SHELF LIFE LIMITATIONS: 6 MONTHS IN DRUMS OR 12 MONTHS IN BULK.

RESPIRATOR: IF GENERATED AS MIST AT <250 MG/CUBIC METER THEN USEDUST/ MIST FILTER OVER CARTRIDGES STATED IN SECTION 8.

MATERIAL SAFETY DATA SHEET

CAST BOOSTERS

SECTION I **Issued by the Safety and Compliance Dept.**

AUSTIN POWDER COMPANY 25800 SCIENCE PARK DRIVE CLEVELAND, OHIO 44122 EMERGENCY PHONE DAY 216-464-2400 NIGHT 216-464-2407	TRADE NAME AND SYNONYMS ACP Boosters: Orange Cap, Red Cap, Black Cap, Brown Cap Green Cap, Purple Cap, White Cap, Gray Cap, etc. NDS Boosters, ADP Boosters, Gold Nugget, Silver Nugget, Diamond Nugget, DES SERIES, DES Pentolite Charges, Rock Crushers, 90 Gram,150 Gram, DES Shaped Charges, Prime Gel*, Renforcatuers, HDP 150, HDP 400, HDP 400LP, HDP 450, Doubledet and Ringprime

SECTION II HAZARDOUS INGREDIENTS

Formulated with TNT and an explosive sensitizer such as PETN, RDX and/or HMX.

TNT, Trinitrotoluene, $C_7H_5N_3O_6$,	CAS No. 118-96-7	30% to 80% TNT
PETN, Pentaerythritol tetranitrate, $C_5H_8N_4O_{12}$,	CAS No. 78-11-5	20% to 70% PETN, RDX, and/or HMX.
HMX, Cyclotetramethylene tetranitramine, Octogen, $C_4H_8N_8O_8$,	CAS No. 261-41-0	
RDX, Cyclotrimethylene trinitramine, Cyclonite, $C_3H_6N_6O_6$,	CAS No. 121-82-4	
Aluminum, AL	CAS No. 7429-90-5	0% to 20% Aluminum
Pentolite is a 50/50 mixture of PETN and TNT.	CAS No. 8066-33-9	

SECTION III PHYSICAL DATA

BOILING POINT	Decomposes	VAPOR PRESSURE (mm Hg)	Negligible at 20°C
SPECIFIC GRAVITY (H_2O = 1)	1.65	VAPOR DENSITY (Air = 1)	N/A
PERCENT VOLATILE BY VOL. (%)	N/A	EVAPORATION RATE:	N/A
SOLUBILITY IN WATER:	0.15%		

APPEARANCE AND ODOR: Solid yellow-buff cast crystalline material. No odor.

SECTION IV FIRE AND EXPLOSION DATA

FLASH POINT:	N/A
FLAMMABLE LIMITS:	N/A
EXTINGUISHING MEDIA:	See below
SPECIAL FIRE FIGHTING PROCEDURES:	Do not fight fires. Withdraw personnel immediately . Allow fire to burn itself out. Avoid toxic fumes from fire.
UNUSUAL FIRE AND EXPLOSION HAZARDS:	May explode when subjected to fire or shock.

SECTION V HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE: ACGIH: TNT-Skin, 0.1 MG/M^3 PETN-None RDX-Skin, 1.5 MG/M^3 AL-10MG/M^3
OSHA : TNT-Skin, 1.5 MG/M^3 PETN-None RDX-None AL-15MG/M^3

EFFECTS OF OVEREXPOSURE: TNT ingestion may cause headache, weakness, anemia, or liver damage. Excessive skin contact may cause dermatitis and sensitization. PETN is a vasodilator. Ingestion of RDX may cause nervous system disorders or epiliptiform seizures.

EMERGENCY AND FIRST AID PROCEDURES:

FUMES: Remove to fresh air.
IF INGESTED: Obtain medical attention immediately.

CAST BOOSTERS

SECTION VI REACTIVITY DATA

Issued by the Safety and Compliance Dept.

STABILITY: Stable under normal conditions. May explode when subjected to fire shock or friction.

INCOMPATIBILITY (MATERIALS TO AVOID): Avoid contact with strong acids or alkalies. Do not exceed 150°F (66°C).

HAZARDOUS DECOMPOSITION PRODUCTS: Gaseous Nitrogen Oxides and Carbon Oxides

SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Sweep up and dispose of all spilled material immediately. Do not permit smoking or open flames near spill site.

WASTE DISPOSAL METHOD: Dispose of under direct supervision of a qualified person according to local, state and federal regulations. Call Austin Powder for recommendations and assistance. This material may become a hazardous waste under certain conditions and must be collected, labeled and disposed of per state and federal hazardous waste regulations.

TRANSPORTATION EMERGENCIES involving spills, leaks, fires or exposures in the United States: **CALL CHEMTREC:** 1-800-424-9300. For emergency calls originating outside the U. S. dial the U. S. access number followed by: 1-703-527-3887. All calls are recorded.

SECTION VIII SPECIAL PROTECTION INFORMATION:

RESPIRATORY PROTECTION:	Avoid breathing fumes from detonation.
VENTILATION:	Not required under normal conditions.
PROTECTIVE GLOVES:	Not required for normal handling of boosters.
EYE PROTECTION:	Not required under normal conditions.

SECTION IX SPECIAL PRECAUTIONS

COMPLY WITH "ALWAYS AND NEVER" AS ADOPTED BY THE INSTITUTE OF MAKERS OF EXPLOSIVES. TRANSPORTATION, STORAGE AND USE MUST COMPLY WITH OSHA SAFETY AND HEALTH STANDARDS 29CFR1910.109, APPLICABLE MSHA REGULATIONS, THE DOT AND HAZARDOUS MATERIALS REGULATIONS BATF REQUIREMENTS AND STATE AND LOCAL TRANSPORTATION, STORAGE AND USE REGULATIONS AND ORDINANCES.

DOT or IMDG proper shipping description: Boosters, Without Detonator, 1.1D, UN 0042, PG II

None of the components are listed in the 1987 IARC Monographs, Group 1, 2A, or 2B as a known, probable or possible carcinogen, nor are they listed in the NTP annual report on carcinogens.

*Prime Gel contains both a Cast Booster and Hydromite.
Also see the Hydromite MSDS.

MSDS
DEEP WOODS OFF

*** IDENTIFICATION ***

MSDS RECORD NUMBER : 668986
PRODUCT NAME(S): DEEP WOODS OFF PUMP SPRAY

MATERIAL SAFETY DATA SHEET

WHMIS Serial No: 8 Issued: 1993-04-26 Supersedes: 1993-01-27

PRODUCT IDENTIFICATION

PRODUCT NAME: DEEP WOODS OFF! PUMP SPRAY

PRODUCT USE: HOUSEHOLD INSECT REPELLANT

HMIS RATING
HEALTH: 2
FLAMMABILITY: 3
REACTIVITY: 0
SPECIAL WARNING:

INGREDIENT INFORMATION

WEIGHT %	CAS	INGREDIENT
25	134-62-3	DIETHYLTOLUAMIDE LD50: 1,950 MG/KG (ORAL - RAT) EXP. LIMITS: NOT ESTABLISHED
15 - 40	64-17-5	ETHANOL LD50: 7,060 MG/KG (ORAL - RAT) EXP. LIMITS: 1000 PPM (TLV-TWA ACGIH)

PHYSICAL DATA
PHYSICAL STATE: LIQUID
ODOUR/APPEARANCE: CLEAR, COLOURLESS LIQUID WITH CHARACTERISTIC FLORAL ODOUR
ODOUR THRESHOLD: NOT AVAILABLE
SPECIFIC GRAVITY: 0.923 (WATER = 1.0)
VAPOUR PRESSURE (MM HG): NOT AVAILABLE
VAPOUR DENSITY (AIR=1.0): NOT AVAILABLE
CARCINOGENICITY : NONE KNOWN
WATER SOLUBILITY: DISPERSIBLE
EVAPORATION RATE: NOT AVAILABLE (BUTYL ACETATE = 1.0)
BOILING POINT (DEG C): 75
FREEZING POINT (DEG C): NOT AVAILABLE PH: 7.5
COEF. WATER/OIL: NOT AVAIL.

FIRE AND EXPLOSION INFORMATION
FLASH POINT (DEG C): 25 (TCC)
FLAMMABLE LIMITS: NOT AVAILABLE
AUTO-IGNITION TEMP (DEG C): NOT APPLICABLE
FLAMMABILITY CLASSIFICATION : FLAMMABLE LIQUID
EXTINGUISHING MEDIA : CARBON DIOXIDE, FOAM, DRY CHEMICAL, "ALCOHOL" FOAM.
SPECIAL FIREFIGHTING PROCEDURES :
NORMAL FIRE FIGHTING PROCEDURE MAY BE USED. COOL AND USE CAUTION WHEN APPROACHING CONTAINERS.
FIRE FIGHTERS SHOULD WEAR SCBA AND PROTECTIVE CLOTHING.
EXPLOSION DATA : RISK OF EXPLOSION BY FIRE OR OTHER SOURCES OF IGNITION.

TOXICOLOGICAL AND FIRST AID DATA
LD50 : 5,400 MG/KG (ORAL-MALE RAT), 2,510 MG/KG (ORAL-FEMALE RAT)
SOURCE: RALTECH SCIENTIFIC SERVICES REPORT 795400 LC50 : NOT AVAILABLE
PRIMARY ROUTE OF ENTRY :
EYE CONTACT, INHALATION, INGESTION.
EFFECTS OF ACUTE EXPOSURE :
MAY CAUSE EYE IRRITATION.
MAY DRY OR DEFAT SKIN ON PROLONGED CONTACT.
INHALATION MAY CAUSE DIZZINESS AND DROWSINESS.
EFFECTS OF CHRONIC EXPOSURE :
NOT AVAILABLE
IRRITANCY OF PRODUCT : MODERATELY IRRITATING TO EYES.
MILDLY IRRITATING TO SKIN ON PROLONGED CONTACT.
SENSITIZATION : NONE KNOWN

REPRODUCTIVE TOXICITY : NONE KNOWN

TERATOGENICITY : NONE KNOWN
MUTAGENICITY :NONE KNOWN

FIRST AID PROCEDURES

EYE CONTACT : FLUSH IMMEDIATELY WITH WATER FOR 15 MINUTES.
IF IRRITATION OCCURS, GET MEDICAL ATTENTION.
SKIN CONTACT : NO SPECIAL REQUIREMENT FOR NORMAL USE.
IF IRRITATION OCCURS, GET MEDICAL ATTENTION.
INHALATION : REMOVE TO FRESH AIR.
ADMINISTER ARTIFICIALRESPIRATION, IF NEEDED.
INGESTION : DILUTE WITH 1 - 2 GLASSES OF MILK. SEEK MEDICAL AID.

REACTIVITY DATA

STABILITY : STABLE
CONDITIONS TO AVOID : EXCESSIVE HEAT.
INCOMPATIBILITY : AVOID PLASTIC, RUBBER AND OXIDIZERS.
HAZARDOUS DECOMPOSITION PRODUCTS : WHEN EXPOSED TO FIRE, PRODUCES NORMAL COMBUSTION PRODUCTS.
HAZARDOUS POLYMERIZATION : WILL NOT OCCUR.

CONDITIONS TO AVOID :NOT APPLICABLE

PREVENTIVE MEASURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED :
ELIMINATE ALL SOURCES OF IGNITION.
ABSORB WITH OIL-DRI. SWEEP/SCRAPE UP. CONTAINERIZE IN STEEL DRUMS.
WASTE DISPOSAL INFORMATION :
KEEP STORAGE CONTAINERS WELL SEALED. OBSERVE ALL FEDERAL, STATE AND MUNICIPAL REGULATIONS FOR IGNITABLE WASTE.

SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION : NOT REQUIRED FOR NORMAL USE.
VENTILATION : ROOM VENTILATION SHOULD BE SUFFICIENT.
PROTECTIVE GLOVES : NOT REQUIRED FOR NORMAL USE. GROSS CONTACT POSSIBLE (E.G. SPILLS): NEOPRENE GLOVE.
EYE PROTECTION : SAFETY GLASSES.
OTHER PROTECTIVE MEASURES :

SPECIAL PRECAUTIONS

PRECAUTIONARY LABELING : KEEP AWAY FROM SOURCES OF IGNITION.
KEEP AWAY FROM HEAT.
OTHER HANDLING AND STORAGE CONDITIONS : BOND AND GROUND DURING MATERIAL TRANSFER.
DO NOT TRANSFER WITH AIR PRESSURE.
KEEP CONTAINER WELL CLOSED WHEN NOT IN USE.

ADDITIONAL INFORMATION

SHIPPING NAME: ETHANOL SOLUTION
TDG CLASSIFICATION: 3.3
PIN/NIP: 1170
PACKING GROUP:
PLACARD: FLAMMABLE LIQUID
EXEMPTION NAME: CONSUMER COMMODITY
HMIS CLASSIFICATION : REGULATED UNDER P.C.P. ACT NO. 22258

MATERIAL SAFETY DATA SHEET

DETONATING CORD

DATE SEPTEMBER 1998 MSDS NO. C-1 PAGE 1 of 2

SECTION I — **Issued by the Safety and Compliance Dept.**

AUSTIN POWDER COMPANY 25800 SCIENCE PARK DRIVE CLEVELAND, OHIO 44122 EMERGENCY PHONE DAY 216-464-2400 NIGHT 216-464-2407	TRADE NAME AND SYNONYMS Lite Line, Scotch Cord, A-Cord, Tuff-Kote, No. 40, No. 50 No. 60, etc. Seismic Detonating Cord, Slide Line Series, Heavy Duty Series, Cordeau Detonant Fuse, Cord, Detonating, Flexible, Fine Line, Trim Line, Special 18, Special 25 and Special 50.

SECTION II HAZARDOUS INGREDIENTS

PETN, Pentaerythritol tetranitrate, $C_5H_8N_4O_{12}$, CAS No. 78-11-5

SECTION III PHYSICAL DATA

BOILING POINT	N/A	VAPOR PRESSURE (mm Hg)	Negligible at 20 °C
SPECIFIC GRAVITY (H_2O = 1)	1.76	VAPOR DENSITY (Air = 1)	N/A
PERCENT VOLATILE BY VOL. (%)	N/A	EVAPORATION RATE:	N/A
SOLUBILITY IN WATER:	Negligible		

APPEARANCE AND ODOR: Flexible cord with an explosive core of PETN protected within a textile casing covered by a seamless polyethylene and/or ethylene-co-vinyl acetate jacket and an optional outer layer of yarn and wax. PETN is a white crystalline solid. No odor.

SECTION IV FIRE AND EXPLOSION DATA

FLASH POINT:	N/A
FLAMMABLE LIMITS:	N/A
EXTINGUISHING MEDIA:	See below
SPECIAL FIREFIGHTING PROCEDURES:	Do not fight fire. Withdraw personnel immediately . Allow fire to burn itself out.
UNUSUAL FIRE AND EXPLOSION HAZARDS:	May explode when subjected to fire or shock. Avoid toxic fumes from fire.

SECTION V HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE: ACGIH: PETN-None
OSHA : PETN-None

EFFECTS OF OVEREXPOSURE: Ingestion of PETN may cause headache and nausea. PETN is a vasodilator and produces dilation of blood vessels.

EMERGENCY AND FIRST AID PROCEDURES:
FUMES: Remove to fresh air.
IF INGESTED: Obtain medical attention immediately.

DETONATING CORD

DATE SEPTEMBER 1998 MSDS NO. C-1 PAGE 2 OF 2

SECTION VI REACTIVITY DATA

Issued by the Safety and Compliance Dept.

STABILITY: Stable under normal conditions. May explode when subjected to fire or shock.
INCOMPATIBILITY (MATERIALS TO AVOID): Avoid contact with strong acids or alkalies.
HAZARDOUS DECOMPOSITION PRODUCTS: Gaseous Nitrogen Oxides and Carbon Oxides.

HAZARDOUS POLYMERIZATON WILL NOT OCCUR.

SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Sweep up and dispose of all spilled material immediately. Do not permit smoking or open flames near spill site.

WASTE DISPOSAL METHOD: Dispose of under direct supervision of a qualified person according to local, state and federal regulations. Call Austin Powder for recommendations and assistance. This material may become a hazardous waste under certain conditions and must be collected, labeled and disposed of per state and federal hazardous waste regulations.

TRANSPORTATION EMERGENCIES involving spills, leaks, fires or exposures in the United States: **CALL CHEMTREC:** 1-800-424-9300. For emergency calls originating outside the U. S. dial the U. S. access number followed by: 1-703-527-3887. All calls are recorded.

SECTION VIII SPECIAL PROTECTION INFORMATION:

RESPIRATORY PROTECTION:	Not required under normal conditions.
VENTILATION:	Not required under normal conditions.
PROTECTIVE GLOVES:	Not required except to prevent abrasive injuries.
EYE PROTECTION:	Not required under normal conditions.

SECTION IX SPECIAL PRECAUTIONS

COMPLY WITH "ALWAYS AND NEVER" AS ADOPTED BY THE INSTITUTE OF MAKERS OF EXPLOSIVES. TRANSPORTATION, STORAGE AND USE MUST COMPLY WITH OSHA SAFETY AND HEALTH STANDARDS 29CFR1910.109, APPLICABLE MSHA REGULATIONS, THE DOT AND HAZARDOUS MATERIALS REGULATIONS BATF REQUIREMENTS AND STATE AND LOCAL TRANSPORTATION, STORAGE AND USE REGULATIONS AND ORDINANCES.

DOT or IMDG proper shipping description: Cord, Detonating, Flexible, 1.1D, UN0065, PG II

May be offered for transportation domestically and transported as Cord, Detonating (UN 0289), Division 1.4 compatibility group D (1.4D) Explosives, if the explosive content does not exceed 100 grains per linear foot and the gross weight of all packages of detonating cord does not exceed (45 KG) 99 pounds per vehicle. See 49 CFR 173.63

The maximum recommended temperature for detonating cord is 160°F (71°C).

None of the components are listed in the 1987 IARC Monographs, Group 1, 2A or 2B as known, probable, or possible carcinogens, nor are they listed in the NTP annual report on carcinogens.

The Valvoline Company Date Prepared: 05/12/03

MSDS No: 999.0013902-009.001I

DIESEL FUEL #2

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1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Material Identity
Product Name: DIESEL FUEL #2
General or Generic ID: HYDROCARBON

Company	Telephone Numbers	
The Valvoline Company	Emergency:	1-800-274-5263
P.O. Box 14000		
Lexington, KY 40512	Information:	1-859-357-7206

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2. COMPOSITION/INFORMATION ON INGREDIENTS

Ingredient(s)	CAS Number	% (by weight)
ALIPHATIC & AROMATIC HYDROCARBONS	68476-34-6	100.0

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3. HAZARDS IDENTIFICATION

Potential Health Effects

Eye

May cause mild eye irritation.

Skin

May cause mild skin irritation. Prolonged or repeated contact may dry and crack the skin. Passage of this material into the body through the skin is possible, but it is unlikely that this would result in harmful effects during safe handling and use.

Swallowing

Swallowing small amounts of this material during normal handling is not likely to cause harmful effects. This material can get into the lungs during swallowing or vomiting. This results in lung inflammation and other lung injury.

Inhalation

It is possible to breathe this material under certain conditions of handling and use (for example, during heating, spraying, or stirring). Breathing small amounts of this material during normal handling is not likely to cause harmful effects. Breathing large amounts may be harmful.

Symptoms of Exposure

Signs and symptoms of exposure to this material through breathing, swallowing, and/or passage of the material through the skin may include: stomach or intestinal upset (nausea, vomiting, diarrhea) irritation (nose, throat, airways), central nervous system depression (dizziness, drowsiness, weakness, fatigue, nausea, headache, unconsciousness), loss of coordination, liver damage.

Target Organ Effects

Exposure to this material (or a component) has been found to cause kidney damage in male rats. The mechanism by which this toxicity occurs is specific to the male rat and the kidney effects are not expected to occur in humans. Overexposure to this material (or its components) has been suggested as a cause of the following effects in laboratory animals, and may aggravate preexisting disorders of these organs in humans: anemia, lung damage.

Developmental Information

Based on the available information, risk to the fetus from maternal exposure to this material cannot be assessed.

Cancer Information

Diesel engine exhaust is listed as carcinogenic by the International Agency for Research on Cancer (IARC). Excess lung and bladder cancers have been reported in workers exposed to these emissions. In addition, exposure to diesel exhaust particulates is listed as carcinogenic by the National Toxicology Program. This product (or a component) is a petroleum-derived material. Similar materials and certain compounds occurring naturally in petroleum oils have been shown to cause skin cancer in laboratory animals following repeated exposure without washing or removal.

Other Health Effects

No data

Primary Route(s) of Entry

Inhalation, Skin absorption, Skin contact, Eye contact, Ingestion.

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4. FIRST AID MEASURES

Eyes

If symptoms develop, move individual away from exposure and into fresh air. Flush eyes gently with water while holding eyelids apart. If symptoms persist or there is any visual difficulty, seek medical attention.

Skin

Remove contaminated clothing. Wash exposed area with soap and water. If symptoms persist, seek medical attention. Launder clothing before reuse.

Swallowing

Seek medical attention. If individual is drowsy or unconscious, do not give anything by mouth; place individual on the left side with the head down. Contact a physician, medical facility, or poison control center for advice about whether to induce vomiting. If possible, do not leave individual unattended.

Inhalation

If symptoms develop, move individual away from exposure and into fresh air. If symptoms persist, seek medical attention. If breathing is difficult, administer oxygen. Keep person warm and quiet; seek immediate medical attention.

Note to Physicians

This material is an aspiration hazard. Potential danger from aspiration must be weighed against possible oral toxicity (See Section 3 - Swallowing) when deciding whether to induce vomiting. Preexisting disorders of the following organs (or organ systems) may be aggravated by exposure to this material: skin, lung (for example, asthma-like conditions), liver, Exposure to this material may aggravate any pre-existing condition sensitive to a decrease in available oxygen, such as chronic lung disease, coronary artery disease or anemias.

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5. FIRE FIGHTING MEASURES

Flash Point
> 135.0 F (57.2 C)

Explosive Limit
No data

Autoignition Temperature
No data

Hazardous Products of Combustion
May form: carbon dioxide and carbon monoxide, various hydrocarbons.

Fire and Explosion Hazards
Vapors are heavier than air and may travel along the ground or be moved by ventilation and ignited by heat, pilot lights, other flames and ignition sources at locations distant from material handling point. Never use welding or cutting torch on or near drum (even empty) because product (even just residue) can ignite explosively.

Extinguishing Media
regular foam, carbon dioxide, dry chemical.

Fire Fighting Instructions
Water or foam may cause frothing which can be violent and possibly endanger the life of the firefighter. Wear a self-contained breathing apparatus with a full facepiece operated in the positive pressure demand mode with appropriate turn-out gear and chemical resistant personal protective equipment. Refer to the personal protective equipment section of this MSDS.

NFPA Rating
Health - 1, Flammability - 2, Reactivity - 0

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6. ACCIDENTAL RELEASE MEASURES

Small Spill
Eliminate all sources of ignition such as flares, flames (including pilot lights), and electrical sparks. Absorb liquid on vermiculite, floor absorbent or other absorbent material.

Large Spill
Eliminate all ignition sources(flares, flames, including pilot lights, electrical sparks). Persons not wearing protectivve equipment should be excluded from the area of the spill until clean-up has been completed. Contain spill to the smallest area possible. Dike area to prevent spreading. Prevent from entering drains, sewers, streams or other bodies of water. Recover as much of the product as possible by methods such as vacuuming and use of absorbant. Transfer contaminated absorbent, soil and other materials in proper containers for ultimate disposal.

7. HANDLING AND STORAGE

Handling

Containers of this material may be hazardous when emptied. Since emptied containers retain product residues (vapor, liquid, and/or solid), all hazard precautions given in the data sheet must be observed. All five gallon pails and larger metal containers including tank cars and tank trucks should be grounded and/or bonded when material is transferred.

Storage

Not applicable

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Eye Protection

Chemical splash goggles in compliance with OSHA regulations are advised; however, OSHA regulations also permit other type safety glasses. Consult your safety representative.

Skin Protection

Wear resistant gloves such as: neoprene, nitrile rubber, To prevent repeated or prolonged skin contact, wear impervious clothing and boots.

Respiratory Protections

If workplace exposure limit(s) of product or any component is exceeded (See Exposure Guidelines), a NIOSH/MSHA approved air supplied respirator is advised in absence of proper environmental control. OSHA regulations also permit other NIOSH/MSHA respirators (negative pressure type) under specified conditions (consult your industrial hygienist). Engineering or administrative controls should be implemented to reduce exposure.

Engineering Controls

Provide sufficient mechanical (general and/or local exhaust) ventilation to maintain exposure below TLV(s).

Exposure Guidelines

Component

ALIPHATIC & AROMATIC HYDROCARBONS (68476-34-6)

No exposure limits established

9. PHYSICAL AND CHEMICAL PROPERTIES

Boiling Point

(for product) 320.0 - 400.0 F (160.0 - 204.4 C) @ 760.00 mmHg

Vapor Pressure

(for product) < 1.000 mmHg @ 68.00 F

Specific Vapor Density

> 5.000 @ AIR=1

Specific Gravity
.876 @ 60.00 F

Liquid Density
7.296 lbs/gal @ 60.00 F
.876 kg/l @ 15.60 C

Percent Volatiles (Including Water)
No data

Evaporation Rate
SLOWER THAN ETHYL ETHER

Appearance
No data

State
LIQUID

Physical Form
HOMOGENEOUS SOLUTION

Color
RED, DYED LIQUID

Odor
No data

pH
Not applicable

---

10. STABILITY AND REACTIVITY

Hazardous Polymerization
Product will not undergo hazardous polymerization.

Hazardous Decomposition
May form: carbon dioxide and carbon monoxide, various hydrocarbons.

Chemical Stability
Stable.

Incompatibility
Avoid contact with: strong oxidizing agents.

---

11. TOXICOLOGICAL INFORMATION

Mutagenicity
This material (or a component) caused mutations in cells in culture and in laboratory animals. The relevance of this finding to human health is uncertain.

---

12. ECOLOGICAL INFORMATION

No data

---

13. DISPOSAL CONSIDERATION

Waste Management Information

Dispose of in accordance with all applicable local, state and federal regulations.

---

14. TRANSPORT INFORMATION

DOT Information - 49 CFR 172.101

DOT Description:

Not Regulated

Container/Mode:

No data

NOS Component:

None

RQ (Reportable Quantity) - 49 CFR 172.101

Not applicable

---

15. REGULATORY INFORMATION

US Federal Regulations

TSCA (Toxic Substances Control Act) Status

TSCA (UNITED STATES) The intentional ingredients of this product are listed.

CERCLA RQ - 40 CFR 302.4

None

SARA 302 Components - 40 CFR 355 Appendix A

None

Section 311/312 Hazard Class - 40 CFR 370.2

Immediate(X) Delayed(X) Fire(X) Reactive( ) Sudden Release of Pressure( )

SARA 313 Components - 40 CFR 372.65

None

International Regulations

Inventory Status

AICS (AUSTRALIA) The intentional ingredients of this product are listed.

DSL (CANADA) The intentional ingredients of this product are listed.

ECL (SOUTH KOREA) The intentional ingredients of this product are listed.

EINECS (EUROPE) The intentional ingredients of this product are listed.

ENCS (JAPAN) The intentional ingredients of this product are listed.

State and Local Regulations

California Proposition 65

None

16. OTHER INFORMATION

The information accumulated herein is believed to be accurate but is not warranted to be whether originating with the company or not. Recipients are advised to confirm in advance of need that the information is current, applicable, and suitable to their circumstances.

Last page

MATERIAL SAFETY DATA SHEET

ELECTRIC DETONATORS
NON ELECTRIC DETONATORS

DATE SEPTEMBER 1998 MSDS NO. ED-1

SECTION I	Issued by the Safety and Compliance Dept.
AUSTIN POWDER COMPANY 25800 SCIENCE PARK DRIVE CLEVELAND, OHIO 44122 EMERGENCY PHONE DAY 216-464-2400 NIGHT 216-464-2407	TRADE NAME AND SYNONYMS **Coal* Star, Rock* Star, Time* Star, Coal Mine Delays, Seismic* Star, Twin* Star Detonators, 3-D Star, Seismic Detonators and Shock*Star; In-Hole Delays, Surface Delay Connectors, Quick-Relay Connectors, Dual Delays, Shorty STD (Shock Tube with Detonators) and MS Connector.** Electric Blasting Caps

SECTION II HAZARDOUS INGREDIENTS

Explosive components are PETN (possibly TNT) and lead compounds sealed in a metal shell.

PETN, Pentaerythritol Tetranitrate,	CAS No. 78-11-5
Lead Azide, Pb $(N_3)_2$,	CAS No. 13424-46-9
Lead Styphnate, Lead Trinitroresorcinate, $C_6H_3N_3O_9Pb$	CAS No. 15245-44-0
TNT, Trinitrotoluene, $C_7H_5N_3O_6$	CAS No. 118-96-7 (May be included in some detonators)

SECTION III PHYSICAL DATA

BOILING POINT	N/A	VAPOR PRESSURE (mm Hg)	N/A
SPECIFIC GRAVITY (H_2O = 1)	N/A	VAPOR DENSITY (Air = 1)	N/A
PERCENT VOLATILE BY VOL. (%)	N/A	EVAPORATION RATE:	N/A
SOLUBILITY IN WATER:	Insoluble		

APPEARANCE AND ODOR: Aluminum or copper shells with attached PVC or polyethyene coated copper or iron leg wires. No odor.

SECTION IV FIRE AND EXPLOSION DATA

FLASH POINT:	N/A
FLAMMABLE LIMITS:	N/A
EXTINGUISHING MEDIA:	See below
SPECIAL FIREFIGHTING PROCEDURES:	Do not fight fire. Withdraw personnel immediately . Allow fire to burn itself out.
UNUSUAL FIRE AND EXPLOSION HAZARDS:	May explode when subjected to flame, heat, impact, friction, electric current, electrostatic or radio frequency energy. Do not exceed 150°F (66°C). Avoid toxic fumes from fire.

SECTION V HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE: ACGIH: 0.05 mg/M^3 TWA, lead, elemental, and inorganic compounds, as Pb.
OSHA : 50 µg/M^3 PEL as Pb. For additional information, see 29 CFR 1910.1025

EFFECTS OF OVEREXPOSURE: None likely when safe blasting practices are employed.

EMERGENCY AND FIRST AID PROCEDURES: Improper handling or misuse may cause detonation resulting in injuries from shrapnel. Lead and lead compounds are listed in the 1987 IARC Monographs as possible human carcinogens (Group 2B). Lead is not listed in the NTP annual report on carcinogens.

MATERIAL SAFETY DATA SHEET

ELECTRIC DETONATORS
NON ELECTRIC DETONATORS

SECTION VI REACTIVITY DATA

Issued by the Safety and Compliance Dept.

STABILITY: May explode when subjected to flame, heat, impact, friction, electric currents, electrostatic or radio frequency energy. Avoid static charge build up. Keep lead wires shunted until wiring into circuit.

INCOMPATIBILITY (MATERIALS TO AVOID): Avoid contact with acids or alkalies.

HAZARDOUS DECOMPOSITION PRODUCTS: Gaseous Nitrogen Oxides, Carbon Oxides, and lead fumes.

HAZARDOUS POLYMERIZATION WILL NOT OCCUR.

SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Pick up containers or units by hand. Avoid conditions affecting stability. DO NOT use damaged detonators.

WASTE DISPOSAL METHOD: Dispose of under direct supervision of a qualified person according to local, state and federal regulations. Call Austin Powder for recommendations and assistance. This material may become a hazardous waste under certain conditions and must be collected, labeled and disposed of per state and federal hazardous waste regulations.

TRANSPORTATION EMERGENCIES involving spills, leaks, fires or exposures in the United States: **CALL CHEMTREC:** 1-800-424-9300. For emergency calls originating outside the U. S. dial the U. S. access number followed by: 1-703-527-3887. All calls are recorded.

SECTION VIII SPECIAL PROTECTION INFORMATION:

RESPIRATORY PROTECTION:	Avoid breathing fumes from detonation.
VENTILATION:	Not required.
PROTECTIVE GLOVES:	Not required.
EYE PROTECTION:	Not required.

SECTION IX SPECIAL PRECAUTIONS

COMPLY WITH "ALWAYS AND NEVER" AS ADOPTED BY THE INSTITUTE OF MAKERS OF EXPLOSIVES.
TRANSPORTATION, STORAGE AND USE MUST COMPLY WITH OSHA SAFETY AND HEALTH STANDARDS 29CFR1910.109, APPLICABLE MSHA REGULATIONS, THE DOT AND HAZARDOUS MATERIALS REGULATIONS BATF REQUIREMENTS AND STATE AND LOCAL TRANSPORTATION, STORAGE AND USE REGULATIONS AND ORDINANCES.
THESE DETONATORS MAY BE SHIPPED UNDER ONE OF THE FOLLOWING DOT CLASSIFICATIONS:
DOT or IMDG proper shipping description:

- Detonators, Electric, 1.4B, UN0255, PGII
- Detonators, Electric, 1.1B, UN0030, PGII
- Detonator Assemblies, Non-Electric, 1.1B, UN0360, PGII
- Detonator Assemblies, Non-Electric, 1.4B, UN0361, PGII
- Articles, explosive, n.o.s. 1.4S, UN0349, PGII

Consult IME Safety Library Publication No. 20, SAFETY GUIDE FOR THE PREVENTION OF RADIO FREQUENCY RADIATION HAZARDS IN THE USE OF ELECTRIC BLASTING CAPS, and Publication No. 22, RECOMMENDATIONS FOR THE SAFE TRANSPORTATION OF DETONATORS IN A VEHICLE WITH CERTAIN OTHER EXPLOSIVE MATERIALS.

MSDS
Fire Extinguishers

*** IDENTIFICATION ***

MSDS RECORD NUMBER : 503384
PRODUCT NAME(S): General Triplex Dry Chemical

*** MATERIAL SAFETY DATA ***

Material Safety Data SheetU.S. Department of Labor May be used to comply with Occupational Safety and Health OSHA's Hazard Communication Administration Standard, 29 CFR 1910.1200.
(Non-Mandatory Form)
Standard must be consulted for Form Approved specific requirements.
OMB No. 1218-0072

Section II - Hazardous Ingredients/Identity Information

Hazardous Components OSHA PEL ACGIH TLV Other Limits (Specific Chemical Identity; Recommended % (optional)
Common Name(s))

Not Applicable - Dry Chemical Fire Extinguishing Agent - Monoammonium Phosphate Base Contains No Hazardous Ingredients

Section III - Physical/Chemical Characteristics

Boiling Point NA
Specific Gravity (H2O = 1) 1.8
Vapor Pressure (mm Hg.) NA
Melting Point NA
Vapor Density (AIR = 1) NA
Evaporation Rate NA
(Butyl Acetate = 1)
Solubility in Water
Water repellant. 94% soluble.
Appearance and Odor Fine yellow Powder

Section IV - Fire and Explosion Hazard Data
Flash Point (Method Used) NA

Flammable Limits NA
LEL NA
UEL NA
Extinguishing Media NA - Fire Extinguishing agent
Special Fire Fighting Procedures
Unusual Fire and Explosion Hazards

Section V - Reactivity Data
Stability Unstable [ ] Conditions to Avoid
Stable [X]

Incompatibility (Materials to Avoid)
Do not mix with bicarbonate base fire extinguishing agents.

Hazardous Decomposition or Byproducts
Decomposes to ammonia and phosphoric acid at high temperature.

Hazardous Conditions to Avoid
May Occur [ ]
Polymerization Will Not Occur [X]

Section VI - Health Hazard Data

Route(s) of Entry: NA

Inhalation?	Skin?	Ingestion?
NA	NA	NA

Health Hazards (Acute and Chronic) NA

Carcinogenicity: NA NTP? IARC Monographs? OSHA Regulated?

Signs and Symptoms of Exposure NA

Medical Conditions Generally Aggravated by Exposure NA

Emergency and First Aid Procedures
Wash from eyes with warm water.

Section VII - Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled
Clean up in normal manner. Use vacuum to avoid causing dust.

Waste Disposal Method
Dispose of in normal manner. Use closed container to prevent dust.

Precautions to Be Taken in Handling and Storing
Protect from moisture

Other Precautions

Section VIII - Control Measures

Respiratory Protection (Specify Type)
Use particle mask, 3M 8500 Non-Toxic, when handling
Ventilation
Local Exhaust Special
Use to remove dust
Mechanical (General) Other

Protective Gloves Not needed Eye Protection Not needed

Other Protective Clothing or Equipment
Not needed.

Work/Hygienic Practices
After handling, wash exposed skin with warm water and soap.

*** ***
*** M S D S ***
*** ***
*** Canadian Centre for Occupational Health and Safety ***
*** * * * * * * * * * * * * Issue : 94-4 (November, 1994) ***

***** IDENTIFICATION *****

MSDS RECORD NUMBER : 503383
PRODUCT NAME(S) : General "Quick-Aid" Dry Chemical
DATE OF MSDS : 1986-05-06

***** MANUFACTURER INFORMATION *****

MANUFACTURER : General Fire Extinguisher Corporation
ADDRESS : 1685 Shermer Road
Northbrook Illinois
U.S.A. 60062
Telephone: 312-272-7500 (Information)
EMERGENCY TELEPHONE NO. : 312-729-8800

***** MATERIAL SAFETY DATA *****

Material Safety Data Sheet U.S. Department of Labor
May be used to comply with Occupational Safety and Health
OSHA's Hazard Communication Administration
Standard, 29 CFR 1910.1200. (Non-Mandatory Form)
Standard must be consulted for Form Approved
specific requirements. OMB No. 1218-0072

IDENTITY (As Used on Label and List)
Note: Blank spaces are not permitted.
General "Quick-Aid" Dry Chemical If any item is not applicable, or no information is available, the space must be marked to indicate that.

Section I

Date Prepared May 6, 1986
Signature of Preparer (optional) William R. Warnock

Section II - Hazardous Ingredients/Identity Information

Hazardous Components OSHA PEL ACGIH TLV Other Limits
(Specific Chemical Identity; Recommended % (optional)
Common Name(s))

Not Applicable - Dry Chemical Fire Extinguishing Agent - Sodium Bicarbonate Base.
Contains no hazardous ingredients.

Section III - Physical/Chemical Characteristics

Boiling Point NA Specific Gravity (H2O = 1) 2.16
Vapor Pressure (mm Hg.) NA Melting Point NA

Vapor Density (AIR = 1) NA
Evaporation Rate NA
(Butyl Acetate = 1)
Solubility in Water Water repellant. 98% soluble
Appearance and Odor Fine white powder

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used) NA
Flammable Limits LEL UEL
NA NA
NA
Extinguishing Media NA - Fire Extinguishing agent
Special Fire Fighting Procedures NA
Unusual Fire and Explosion Hazards NA

Section V - Reactivity Data

Stability Unstable [ ] Conditions to Avoid
Stable [X]

Incompatibility (Materials to Avoid)
Do not mix with ammonium phosphate base fire extinguishing agents.

Hazardous Decomposition or Byproducts
Decomposes to sodium carbonate, carbon dioxide and water at high temperatures.

Hazardous May Occur [ ] Conditions to Avoid
Polymerization Will Not Occur [X]

Section VI - Health Hazard Data

Route(s) of Entry: Inhalation? Skin? Ingestion?
NA NA NA NA

Health Hazards (Acute and Chronic) NA

Carcinogenicity: NA NTP? IARC Monographs? OSHA Regulated?

Signs and Symptoms of Exposure NA

Medical Conditions Generally Aggravated by Exposure NA

Emergency and First Aid Procedures
Wash from eyes with warm water.

Section VII - Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled
Clean up in normal manner. Use vacuum to avoid causing dust.

Waste Disposal Method
Dispose of in normal manner. Use closed container to prevent dust.

Precautions to Be Taken in Handling and Storing
Protect from moisture.

Other Precautions

Section VIII - Control Measures

Respiratory Protection (Specify Type)

Use particle mask, 3M 8500 Non-Toxic, when handling

Ventilation **Local Exhaust** **Special**

Use to remove dust

Mechanical (General) **Other**

Not needed.

Work/Hygienic Practices

After handling, wash exposed skin with warm water and soap.

Protective Gloves **Not needed** **Eye Protection** **Not needed**

Other Protective Clothing or Equipment

*** ***
*** M S D S ***
*** ***
*** Canadian Centre for Occupational Health and Safety ***
*** * * * * * * * * * * * * Issue : 94-4 (November, 1994) ***

***** IDENTIFICATION *****

MSDS RECORD NUMBER : 503382
PRODUCT NAME(S) : General Purple K Dry Chemical
DATE OF MSDS : 1986-05-06

***** MANUFACTURER INFORMATION *****

MANUFACTURER : General Fire Extinguisher Corporation
ADDRESS : 1685 Shermer Road
Northbrook Illinois
U.S.A. 60062
Telephone: 312-272-7500 (Information)
EMERGENCY TELEPHONE NO. : 312-729-8800

***** MATERIAL SAFETY DATA *****

Material Safety Data Sheet U.S. Department of Labor
May be used to comply with Occupational Safety and Health
OSHA's Hazard Communication Administration
Standard, 29 CFR 1910.1200. (Non-Mandatory Form)
Standard must be consulted for Form Approved
specific requirements. OMB No. 1218-0072

IDENTITY (As Used on Label and List)
Note: Blank spaces are not permitted.
General Purple K Dry Chemical If any item is not applicable, or no
information is available, the space
must be marked to indicate that.

Section I

Date Prepared May 6, 1986
Signature of Preparer (optional) William R. Warnock

Section II - Hazardous Ingredients/Identity Information

Hazardous Components OSHA PEL ACGIH TLV Other Limits
(Specific Chemical Identity; Recommended % (optional)
Common Name(s))

Not Applicable - Dry Chemical Fire Extinguishing Agent - Potassium Bicarbonate Base
Contains no hazardous ingredients.

Section III - Physical/Chemical Characteristics

Boiling Point NA Specific Gravity (H2O = 1) 2.17
Vapor Pressure (mm Hg.) NA Melting Point NA

Vapor Density (AIR = 1) NA
Evaporation Rate NA
(Butyl Acetate = 1)
Solubility in Water Water repellant. 94% soluble
Appearance and Odor Fine purple powder

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used) NA
Flammable Limits LEL UEL
NA NA
NA
Extinguishing Media NA - Fire extinguishing agent
Special Fire Fighting Procedures NA
Unusual Fire and Explosion Hazards NA

Section V - Reactivity Data

Stability Unstable [ ] Conditions to Avoid
Stable [X]

Incompatibility (Materials to Avoid)
Do not mix with ammonium phosphate base fire extinguishing agents.

Hazardous Decomposition or Byproducts
Decomposes to potassium carbonate, carbon dioxide and water at high temperatures.

Hazardous May Occur [ ] Conditions to Avoid
Polymerization Will Not Occur [X]

Section VI - Health Hazard Data

Route(s) of Entry: Inhalation? Skin? Ingestion?
NA NA NA NA

Health Hazards (Acute and Chronic) NA

Carcinogenicity: NA NTP? IARC Monographs? OSHA Regulated?

Signs and Symptoms of Exposure NA

Medical Conditions Generally Aggravated by Exposure NA

Emergency and First Aid Procedures
Wash from eyes with warm water.

Section VII - Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled
Clean up in normal manner. Use vacuum to avoid causing dust.

Waste Disposal Method
Dispose of in normal manner. Use closed container to prevent dust.

Precautions to Be Taken in Handling and Storing
Protect from moisture.

Other Precautions

Section VIII - Control Measures

Respiratory Protection (Specify Type)
Use particle mask 3M 8506 Non-Toxic, when handling.
Ventilation Local Exhaust Special
Use to remove dust.
Mechanical (General) Other

Protective Gloves Not needed Eye Protection Not needed

Other Protective Clothing or Equipment
Not needed.

Work/Hygienic Practices
After handling, wash exposed skin with warm water and soap.

* *
* M S D S *
* *
* Canadian Centre for Occupational Health and Safety *
* * * * * * * * * * * * * Issue : 94-4 (November, 1994) *

*** IDENTIFICATION ***

MSDS RECORD NUMBER : 500586
PRODUCT NAME(S) : General LS-61 Anti Freeze Charge
DATE OF MSDS : 1990-09

*** MANUFACTURER INFORMATION ***

MANUFACTURER : General Fire Extinguisher Corporation
ADDRESS : 1685 Shermer Road
Northbrook Illinois
U.S.A. 60062
Telephone: 312-272-7500 (Information)
EMERGENCY TELEPHONE NO. : 312-729-8800

*** MATERIAL SAFETY DATA ***

Material Safety Data Sheet U.S. Department of Labor
May be used to comply with Occupational Safety and Health
OSHA's Hazard Communication Standard, Administration
29 CFR 1910.1200. Standard must be (Non-Mandatory Form)
consulted for specific reuqirements. Form Approved
OMB No. 1218-0072

IDENTITY (As Used on Label and List)
General LS-61 Anti Freeze Charge

Note: Blank spaces are not permitted. If any item is not applicable or no
information is available, the space must be marked to indicate that.

Section I

Date Prepared May 6, 1986 Septembre 1990
Signature of Preparer (optional) William R. Warnock

Section II - Hazardous Ingredients/Identity Information

Hazardous Components
(Specific Chemical
Identity; Common Name(s)) OSHA PEL ACGIH TLV % (optional)

Anti-Freeze Charge for Pressurized Water
Anti-gel charge d'eau pressurize

Fire Extinguishers Extincteurs d'incendie

Potassium Carbonate Carbone potasse Not Specified Non specifie >50%
Other Limits Recommended:

Potassium Acetate Acetate potasse Not Established Non etabli <50%
Other Limits Recommended:

Section III - Physical/Chemical Characteristics

MSDS
Fire Extinguishers

Boiling Point Point d'ebullition NA
Vapor Pressure (mm Hg) pressure vapeur NA
Vapor Density (AIR = 1) densite vapeur NA
Specific Gravity (H20 = 1) 2.0
Gravite specifique
Melting Point point de fonte NA
Evaporation Rate taux d'evaporation NA
(Butyl Acetate = 1)
Solubility in Water 100%
solubilite d'eau
Appearance and Odor Off-White granular powder
apparence & odeur poudre granule blanc casse

Section IV - Fire and Explosion Hazard Data
schema feu & explosion hazard

Flash Point (Method Used) NA
point d'etincelles NA

Flammable Limits limite flammable LEL UEL
NA NA NA

Extinguishing Media NA- Fire extinguisher charge
point d'extinction charge d'extincteur d'incendie

Special Fire Fighting Procedures
Procedure speciale pour combattre l'incendie

Unusual Fire and Explosion Hazards
Hazard feu & explosion peu commun

Section V- Reactivity Data

Stability Unstable [ ] Conditions to Avoid
Stabilite instable Conditions a eviter

Stable [X]
Stable

Incompatibility (Materials to Avoid) NA
Incompatibilite materiel a eviter

Hazardous Decomposition or Byproducts NA
Decomposition hazardeuse sous-produit

Hazardous Polymerization May Occur [ ] Conditions to Avoid
polymerization a survenir Conditions a eviter
Will Not Occur [X]
ne surviendra pas.

Section VI - Health Hazard Data Schema hazard sante

Route(s) of Entry Inhalation? Skin? Ingestion?
NA NA NA NA

Health Hazards (Acute and Chronic)
May cause irritation of the skin and eyes.
Peut causer irritation de la peau et des yeux.

Carcinogenicity: NA NTP? IARC Monographs? OSHA Regulated?
cancerigene N/A

Signs and Symptoms of Exposure NA
Signes et symptomes a l'exposition

Medical Conditions Generally Aggravated by Exposure NA
Conditions medical aggrave par exposition

Emergency and First Aid Procedures
Alkaline, Wash from eyes with large volume of warm water.
Laver les yeux avec une large quantite d'eau tiede
Consult doctor. Wash from skin with warm water.
Consulter un medecin. Laver la peau avec eau tiede

Section VII - Precautions for Safe Handling and Use
Precaution pour utilisation secure

Steps to Be Taken in Case Material is Released or Spilled
Sweep up and dispose in normal manner. Flush spill area with water
balayer de maniere normale. Laver la piece avec de l'eau

Waste Disposal Method Methode pour dechets
Dispose in normal manner. Disposer de maniere normale

Precautions to Be Taken in Handling and Storing Protect from moisture.
precaution a prendre pour utilisation proteger de la moissisure

Other Precautions Autres precautions

Section VIII - Control Measures Mesures controle

Respiratory Protection (Specify Type)
Not required. Protection respiratoire non requise

Ventilation Local Exhaust Special
Ventilation Mechanical (General) Other

Protective Gloves
Wear rubber gloves when preparing solution.

Eye Protection
Wear goggles or glass with side shields when preparing solution.

Other Protective Clothing or Equipment
Wear long sleeves when preparing solution.

Work/Hygienic Practices
After handling, wash exposed skin thoroughly with warm water.

MSDS
HYDRAULIC FLUID

*** IDENTIFICATION ***

MSDS RECORD NUMBER : 480541
PRODUCT NAME(S): HYDRAULIC FLUID
DATE OF MSDS : 1991-07-15
EMERGENCY TELEPHONE NO.:
303-623-5716 800-424-9300 (CHEMTREC)

*** MATERIAL SAFETY DATA ***

MATERIAL SAFETY DATA SHEET
307-766 REV. C
Issued: 8-30-91 Supersedes Rev., Dated: 6-18-86

SECTION I - PRODUCT IDENTIFICATION AND USE

PRODUCT IDENTIFIER HYDRAULIC FLUID

PRODUCT IDENTIFICATION NUMBER (PIN) UN

PRODUCT USE Hydraulic fluid used in hydraulic motors and hydraulic power supplies.

CHEMICAL NAME AND SYNONYMS
Industrial oils
CHEMICAL FAMILY Petroleum hydrocarbons

SECTION II - HAZARDOUS INGREDIENTS

HAZARDOUS INGREDIENTS & CAS #
% BY WEIGHT EXPOSURE LIMITS

Petroleum hydrocarbon industrial mixture
100 NE
oil (CAS# Unavailable)
LD50 (SPECIES & ROUTE): NE
LC50 (SPECIES): NE
Oil mist, if generated (mineral)
5 mg/m3 (1, 2)
(CAS# 64742-65-0)
10 mg/m3 (3)
LD50 (SPECIES & ROUTE): NE
LC50 (SPECIES): NE

Sara (40 CFR 372), Title III, Section 313
Reportable Chemicals: None
Product does not meet classification criteria of WHMIS and is not a controlled product.
NOTES: (1) ACGIH TLV (TWA); (2) OSHA PEL (TWA); (3) ACGIH STEL; (4) OSHA STEL; (5) MFR./SUPPLIER TLV; c=Ceiling value LD50 Values are via Oral Route unless otherwise indicated.

SECTION III - PHYSICAL DATA
PHYSICAL STATE Liquid
VAPOR PRESSURE (mm Hg) NE
VAPOR DENSITY (Air=1) >1
% VOLATILE AT ROOM TEMP. DEG C Negligible
EVAPORATION RATE (N-BUTYL ACETATE=1) <1
APPEARANCE Clear, yellow
SOLUBILITY IN WATER Negligible
SPECIFIC GRAVITY (WATER=1) 0.88 - 0.89
BOILING POINT DEG C 316
FREEZING POINT DEG C NA
ODOR Characteristic petroleum odor
ODOR THRESHOLD NE
pH NA
COEFFICIENT OF WATER/OIL DISTRIBUTION NE
OTHER NA

SECTION IV - FIRE AND EXPLOSION DATA

FLAMMABLE YES [ ] NO [X]
IF YES, UNDER WHAT CONDITIONS? This material will burn, but will not readily ignite.
FLASH POINT DEG C (METHOD) 210 (COC)
UPPER FLAMMABLE LIMIT (%) NE
LOWER FLAMMABLE LIMIT (%) NE
AUTOIGNITION TEMP. DEG C UN
METHOD OF EXTINCTION Dry chemical, CO2, water spray, foam, sand or earth.
Water and foam may cause frothing.
SPECIAL PROCEDURES Water spray may minimize vapors and cool containers exposed to heat and flame. Avoid spreading burning liquid with water used for cooling purposes.

EXPLOSION DATA Heat from fire may cause containers to explode.
HAZARDOUS COMBUSTION PROD. Oxides of carbon, nitrogen, sulfur

SECTION V - REACTIVITY DATA

CHEMICAL STABILITY YES [X] NO [ ]
AVOID Extended exposure to high temperatures
DECOMPOSITION PRODUCTS See Section IV.
INCOMPATIBILITY WITH OTHER SUBSTANCES Strong oxidizing agents
HAZARDOUS POLYMERIZATION Will not occur.

SECTION VI - TOXICOLOGICAL PROPERTIES

ROUTES OF ENTRY
SKIN CONTACT [Yes] SKIN ABSORPTION [NA] EYE CONTACT [Yes]
INHALATION [Yes] INGESTION [Yes]
EFFECTS OF ACUTE EXPOSURE TO PRODUCT
This material may cause eye and skin irritation. Direct eye contact may result in burning, tearing and redness. Exposure to mists, or prolonged or repeated exposure to fumes or vapors that may be generated if this material is heated, may cause irritation of nose and throat.
EFFECTS OF CHRONIC EXPOSURE TO PRODUCT
Prolonged or repeated skin contact may cause redness, burning anddermatitis.
IRRITANCY OF PRODUCT Eye, skin - slight
SENSITIZATION TO PRODUCT None anticipated
SYNERGISTIC MATERIALS None known
CARCINOGENICITY NA
SOURCE NA
REPRODUCTIVE TOXICITY NA
TERATOGENICITY NA
MUTAGENICITY NA

SECTION VII - PREVENTIVE MEASURES
PERSONAL PROTECTIVE EQUIPMENT (SPECIFY APPROPRIATE SELECTIONS FOR EACH CATEGORY)
GLOVES/CLOTHING Wear gloves impermeable to petroleum hydrocarbons to prevent skin contact and possible irritation.
EYE Chemical safety goggles.
RESPIRATORY If TLV is exceeded or for symptoms of overexposure wear a NIOSH-approved respirator.
OTHER An eyewash and safety shower is recommended to be available in the workplace.
ENGINEERING CONTROLS If current ventilation practices are not adequate in maintaining airborne concentrations below the established exposure limits, additional ventilation or exhaust systems may be required.
LEAK/SPILL PROCEDURES Collect leaking liquid in sealable containers. Absorb spilled liquid in sand or inert absorbant.
WASTE DISPOSAL Dispose of product in accordance with local, county, state, provincial, and federal regulations.
HANDLING PROCEDURES/EQUIPMENT AND STORAGE REQUIREMENTS Store in cool, dry location. Keep away from incompatible materials (Section V). Avoid generating oil mists while handling. Avoid prolonged or repeated skin contact. Wash thoroughly after handling. Do not wear oil-soaked clothing or shoes.
SPECIAL SHIPPING INFORMATION Product is not DOT or TDG regulated. The CHEMTREC emergency telephone number is to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure, or accident involving chemicals.

SECTION VIII - FIRST AID MEASURES

INHALATION If irritation of nose or throat develops, move away from source of exposure and into fresh air. Seek medical attention if irritation persists.
SKIN Wipe material from skin and remove contaminated clothing. Wash affected area(s) thoroughly using mild soap and water and, if necessary, a waterless skin cleanser. Seek medical attention if irritation develops or persists.

EYES If irritation or redness develops, move victim to fresh air. Flush eyes with clean water. Seek medical attention if irritation persists.
INGESTION Contact physician or local poison control center immediately.
GENERAL ADVICE/SPECIAL NOTES TO PHYSICIAN
Acute aspiration of large amounts of oil laden material may produce a serious aspiration pneumonia. Repeated aspiration of small quantities of mineral oil can produce chronic inflammation of the lung.

MSDS
INSECT REPELLENT

SECTION 1. CHEMICAL IDENTIFICATION

CHEMINFO RECORD NUMBER : 333
CCOHS CHEMICAL NAME : Permethrin
SYNONYMS : 3-(2,2-Dichloroethenyl)-2,2-dimethylcyclopropane carboxylic acid, (3-phenoxyphenyl)methyl ester 3-Phenoxybenzyl (1RS)-cis,trans-3-(2,2-dichlorovinyl)-2,2-dimethyl cyclopropanecarboxylate Permethrine
TRADE NAME(S) :
Ambush
Ectiban
Pounce

SECTION 2. DESCRIPTION

APPEARANCE AND ODOUR : Colourless crystals or pale yellow-brown viscous liquid, depending on purity. Partially crystalizes at ambient temperature.
ODOUR THRESHOLD : No information available.
WARNING PROPERTIES : No information available for evaluation.
COMPOSITION/PURITY : Permethrin is a pyrethroid, a man-made chemical which is similar to chemicals occurring naturally in plants (pyrethrins). Commercial permethrin is a mixture of 4 isomers (chemical forms). Most technical material is a mixture of approximately 50-60% trans- and 50-40% cis-isomers, but formulations with 75:25 trans:cis ratio are also available. Permethrin may be formulated as emulsifiable or ultra low volume concentrates, dusts, fogs or wettable powders. This material is often only a small percentage of pesticide formulations. The overall physical, chemical and toxicological characteristics of the product may depend on other ingredients such as solvents.

SECTION 3. HAZARDS IDENTIFICATION

POTENTIAL HEALTH EFFECTS

EFFECTS OF SHORT-TERM (ACUTE) disturbances such as nausea, vomiting, irritable

EXPOSURE : INHALATION : One study reported respiratory tract irritation in a large percentage of workers exposed to permethrin formulations (emulsion or wettable powder). Symptoms included increased nasal secretion, sneezing, coughing and difficulty breathing and varied with the formulation tested.(12) Other components of products may contribute to the irritation.

SKIN CONTACT : Animal tests show that permethrin is readily absorbed through the skin, but is rapidly broken down in the body and has a low toxicity by this route. There is extensive documentation of a unique skin sensory change caused by permethrin and some other pyrethroids. This is described as a stinging, tingling or burning sensation progressing to numbness in some cases. Usually there is a short delay between exposure and onset of symptoms (30 minutes to a few hours) with a peak in about 8 hours and complete clearance within 24 hours. Inflammation (redness, swelling, blistering) is not apparent. Permethrin tends to produce relatively mild effects.(12-16) Of a group of 4 pyrethroids tested (permethrin, cypermethrin, fenvalerate and flucythrinate), permethrin produced the least amount of skin sensation. Forestry workers exposed to permethrin reported symptoms that were mainly irritative, such as itching and burning of the skin. However, it could not be discerned whether this sensation was an irritative one or a sign of peripheral sensory nerve involvement.

EYE CONTACT : Among forestry workers exposed to permethrin, eye irritation was reported for 7% or 18% of planters, depending on formulation used.(12) There are no reports of eye damage from permethrin contact.

INGESTION : No human cases of ingestion have been reported. Animal data indicates relatively low acute oral toxicity for permethrin. Due to its low toxicity and rapid metabolism, toxic effects are not expected unless there is accidental ingestion of large amounts. In this case, nervous system behaviour, tremors and muscle weakness might occur.

CARCINOGENICITY : No information available
TERATOGENICITY AND EMBRYOTOXICITY : No human information available. No teratogenic or embryotoxic effects in mice.
REPRODUCTIVE TOXICITY : No information available.
MUTAGENICITY : No human information available. Permethrin was not mutagenic in a variety of short-term tests.
TOXICOLOGICALLY SYNERGISTIC MATERIALS : No information available.
POTENTIAL FOR ACCUMULATION : Animal studies indicate rapid breakdown and excretion of this pyrethroid. Thus, the potential for accumulation in humans is considered to be low.

SECTION 4. FIRST AID MEASURES

INHALATION : If symptoms are experienced, remove source of contamination or move victim to fresh air. Obtain medical advice immediately.
SKIN CONTACT : Symptoms of skin contact are delayed. Therefore, if contact occurs, remove contaminated clothing, shoes and leather goods (e.g. watchbands, belts).
Gently blot or brush away excess chemical quickly. Wash gently and thoroughly with water and non-abrasive soap. If symptoms occur, obtain medical attention immediately. Completely decontaminate clothing, shoes and leather goods before reuse, or discard.
EYE CONTACT : Gently blot or brush away excess chemical quickly. Immediately flush the contaminated eye(s) with lukewarm, gently flowing water for 20 minutes, by the clock, holding the eyelid(s) open. If irritation persists, obtain medical advice immediately.
INGESTION : Have victim rinse mouth thoroughly with water. DO NOT INDUCE VOMITING. Have victim drink 240 to 300 mL (8 to 10 oz.) of water. If vomiting occurs naturally, rinse mouth and repeat administration of water. Obtain medical attention immediately.
FIRST AID COMMENTS : Consult a physician and/or the nearest Poison Control Center for all exposures except minor instances of inhalation or skin contact. All first aid procedures should be periodically reviewed by a physician familiar with the material and its conditions of use in the workplace. NOTE: Other ingredients in permethrin formulations may cause toxic effects and require specific first aid measures.
NOTE TO PHYSICIANS : Studies with permethrin showed that topical Vitamin E acetate (dl-alpha tocopheryl acetate) reduced or eliminated the sensations from skin contact. Mephenesin (a muscle relaxant) has been proposed for use in treatment of pyrethroid poisoning. In tests with rats receiving lethal doses of the pyrethroids cismethrin and deltamethrin, all animals survived when treated with mephenesin.

SECTION 5. FIRE FIGHTING MEASURES

FLASH POINT : No information available. Probably can burn only if strongly heated.
LOWER FLAMMABLE (EXPLOSIVE) LIMIT (LFL/LEL) : Not available
UPPER FLAMMABLE (EXPLOSIVE) LIMIT (UFL/UEL) : Not available
AUTOIGNITION (IGNITION) TEMPERATURE : Not available
EXPLOSION DATA - SENSITIVITY TO MECHANICAL IMPACT : Probably not sensitive.
EXPLOSION DATA - SENSITIVITY TO STATIC CHARGE : Information not available
COMBUSTION AND THERMAL DECOMPOSITION PRODUCTS :Carbon monoxide, carbon dioxide, hydrogen chloride gas.
FIRE HAZARD COMMENTS : Permethrin may emit toxic hydrogen chloride gas at high temperatures.
EXTINGUISHING MEDIA : Carbon dioxide, dry chemical powder, alcohol foam, polymer foam, water fog.
FIRE FIGHTING INSTRUCTIONS :

No special procedures required for permethrin. Flash point data is not available, but it is probable the material can burn only if strongly heated. Cool fire-exposed containers. Pesticide formulations may contain combustible ingredients. Select extinguishing media and prepare fire fighting procedures appropriate for the product as a whole.

SECTION 6. ACCIDENTAL RELEASE MEASURES

PRECAUTIONS : Restrict access to area until completion of clean-up. Ensure clean-up is conducted by trained personnel only. Wear adequate personal protective equipment. Ventilate area. Notify occupational health and safety and environmental authorities.
CLEAN-UP :Prevent material from entering sewers or waterways. Do not touch spilled material. Stop or reduce leak if safe to do so. Contain spill with earth, sand or absorbent material which does not react with spilled material. Small spills (liquid): Soak up spill with absorbent material which does not react with spilled chemical. Put material in suitable, covered, labelled containers. Small spills (solid): Shovel into clean, dry, labelled containers and cover. Large spills: Contact fire and emergency services and supplier for advice.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

RESPIRATORY PROTECTION GUIDELINES :No specific guidelines are available. Contact manufacturer or supplier for advice.The NIOSH recommendations for PYRETHRUM may be applicable. See CHEMINFO record number 311 (Pyrethrins) for details.
EYE/FACE PROTECTION : No specific requirement, but it is good practice to wear chemical safety goggles. During pesticide application, a full-face shield may also be required to ensure adequate protection.

SKIN PROTECTION : No specific requirement, but it is good practice to prevent skin contact. During pesticide application, this will require the use of impervious gloves, overalls, boots and/or other resistant protective clothing.
STABILITY : Stable to heat (more than 2 years at 50 deg C).(2) Relatively stable in sunlight.(17) More stable in acid than alkaline media with optimum stability at about pH 4.(2)
HAZARDOUS POLYMERIZATION : Does not

RESISTANCE OF MATERIALS FOR PROTECTIVE CLOTHING : No specific information is available. Contact manufacturer/supplier for advice. Polyvinyl alcohol (PVA) provides good resistance to pyrethrins and related materials (higher monobasic carboxylic esters). Consider solvent base when selecting resistant materials for pyrethroid formulations. NOTE: Resistance of specific materials can vary from product to product. Evaluate resistance under conditions of use and maintain clothing carefully.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

MELTING POINT: 34-35 deg C (pure)
BOILING POINT: Very high (approximately 200 deg C at 0.008 mm Hg); probably decomposes on heating.
RELATIVE DENSITY (SPECIFIC GRAVITY) : 1.19-1.27 at 20 deg C (water = 1)
SOLUBILITY IN WATER : Practically insoluble (0.2 mg/L at 20 deg C)
SOLUBILITY IN OTHER LIQUIDS : Readily soluble in common organic solvents such as alcohols, acetone, ether, chloroform, methylene chloride, xylene; moderately soluble in ethylene glycol.
VAPOUR DENSITY: Not applicable
VAPOUR PRESSURE: Very low (3.4 x 10(-7) mm Hg at 25 deg C)
SATURATION VAPOUR CONCENTRATION : Not applicable
EVAPORATION RATE : Practically zero.
pH VALUE: Not available
CRITICAL TEMPERATURE: Not applicable
COEFFICIENT OF OIL/WATER DISTRIBUTION (PARTITION COEFFICIENT) : Log P(oct) = 6.5. Also reported as 3.48.

SECTION 10. STABILITY AND REACTIVITY

occur
HAZARDOUS DECOMPOSITION PRODUCTS : None known
INCOMPATIBILITY - MATERIALS TO AVOID : STRONG OXIDIZING AGENTS - May increase

the risk of fire. STRONG BASES - Cause decomposition of material. CALCIUM NITRATE
CORROSIVITY TO METALS : Not corrosive to aluminum.
STABILITY AND REACTIVITY COMMENTS :Permethrin is more stable to sunlight than natural pyrethrins, but some
degradation does occur.

SECTION 13. DISPOSAL CONSIDERATIONS
Pyrethroids are highly toxic to fish. Do not release to water. Disposal by controlled incineration or secure landfill may be acceptable. Treat with alkali (lime) before landfilling. Decontamination of waste material should only be done by specially-trained personnel using appropriate facilities and
protective equipment. Incineration must be carried out in approved facilities equipped with adequate emission control devices. Comply with applicable federal, state and local government regulations regarding disposal.

HALLIBURTON

HALLIBURTON ENERGY SERVICES

Explosive Products Center / 8432 South I-35 West / Alvarado, Texas 76009-9775 / Tel: 817-783-5111 / Fax: 817-783-5812

MATERIAL SAFETY DATA SHEET

PRODUCT IDENTIFICATION

PRODUCT NAME: SHAPED CHARGE PRODUCTS   Revision Date: 9/29/94
TRADE NAMES ANS SYNONYMS
Tubing Cutters, Drill Pipe Cutters, Casing Cutters, Big Hole Charges, Deep Penetrating Charges, Gravel Pack Charges, DYNA-Strip Charges, DYNA-Cap Charges, DYNA-Jet Charges, SSB Charges, Sidewinder Charges, GSC Charges, Junk Shot Charges, Linear Shaped Charges, (LSC) Flexible Linear Shaped Charges (FLSC)

MANUFACTURER: Halliburton Energy Services
Explosive Products Center
8432 South I-35 W
Alvarado, Texas 76009-9775

PRODUCT INFORMATION PHONE: (817) 783-5111
EMERGENCY PHONE: (817) 783-5111
TRANSPORTATION EMERGENCY PHONE: INFOTRAC: (800) 535-5053 U.S. & CANADA

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HAZARDOUS COMPONENTS

CHEMICAL	Exposure Limits TLV	Exposure Limits PEL
Cyclotrimethylenetrinitramine (RDX)	1.5mg/M³	1.5 mg/M³
Cyclotetramethylenetetranitramine (HMX)	NE	NE
Hexanitrostilbene (HNS)	NE	NE
2,6-bis (Picrylamino)-3,5-dinitropyridine (PYX)	NE	NE
Nonanitroterphenyl (NONA)	NE	NE
Desensitizing Wax	NE	NE
Iron	5 mg/M³	10 mg/M³
Copper	1 mg/M³	1 mg/M³
Tin	2 mg/M³	2 mg/M³
Aluminum	5 mg/M³	NE
Corrosion Resistant Steel	NE	NE
Lead	0.15 mg/M³	50 g/M³
Antimony	0.5 mg/M³	0.5 g/M³

NE = Not Established

****

PHYSICAL DATA

Packed powder charges (encased in metal casing).

****

HAZARDOUS REACTIVITY

INSTABILITY: May detonate with friction, impact, heat, and low level electrical current.
INCOMPATIBILITY: Acids and aklalis.
HAZARD DECOMPOSITION: Detonation may product shrapnel. Gases produced may contain carbon monoxide and nitrogen oxide. Lead fumes may also be produced.
POLYMERIZATION: Polymerization will not occur.

****

FIRE AND EXPLOSION DATA

FLASHPOINT: N/A

EXTINGUISHING MEDIA: None

SPECIAL FIRE FIGHTING PROCEDURES: DO NOT fight fire. Isolate area. Evacuate personnel to a safe area. Guard against intruders. Allow fire to burn itself out.

SPECIAL FIRE FIGHTING PROCEDURES: DO NOT fight fire. Isolate area. Evacuate personnel to a safe area. Guard against intruders. Allow fire to burn itself out.

UNUSUAL FIRE AND EXPLOSION HAZARDS: May detonate with impact or on heating. May explode and throw fragments 1 mile or more if fire reaches cargo. Evacuate all persons, including emergency responders from the area.

****

HEALTH HAZARDS

Shaped Charge Products do not present health hazards in normal handling and use. However, the proudcts are Class A or Class C Explosives and detonation may cause severe physical injury, including death. All explosives are dangerous and must be handled carefully and used folooing approved sagety procedures under the direction of competent, experienced peroens in accordance with all applicable Federal, State, and Local Laws, Regulations and Ordinances.

Inhalation of explosive powders may cause nervous system irregularities including headaches and dizziness. May be absorbed through the skin in toxic amounts.

Over exposure to lead may cause adverse effects to the blood forming, nervous, urinary, and reproductive systems inclduing weatkness, weight loss, insomnia, constipation, anemia, motor weakness, and encephalopathy. Lead may penetrate the placental barrier and has caused congenital abnomalties in animals. Several animal studies have indicated that hight doses of lead may be carcinogenic.

Nitrogen oxides generated during use are skin, eye and respiratory tract irritants.

CARCINOGENICITY

None of the components of these materials are listed as a carcinogen by NTP, IARC, or OSHA.

OTHER SYMPTOMS AFFECTED

A review of available data does not identify any conditions worsened by exposure to this product.

FIRST AID

INHALATION:

Not a likely route of exposure. If inhaled, remove to fresh air. If not breathing, give artificial respiration, preferably by mouth-to-mouth. If breathing is difficult, give oxygen. Seek Prompt Medical Attention.

EYE AND SKIN CONTACT:

Not a likely route of exposure.

INGESTION:

Not a likely route of exposure.

NOTE: Seek prompt medical attention if detonation caused physical injury.

****

SPILL OR LEAK PROCEDURES:

Use appropriate protective equipment. Isolate area and remove sources of friction, impact, heat, low level electrical current, electrostatic or RF energy. Only competent, experienced persons should be involved in clean up procedures. Sweep up with non-sparking tools and remove.

WASTE DISPOSAL

Disposal of in compliance with applicable Federal Regulations under the authority of the Resource Conservation and Recovery Act (40 CFR, parts 260-271).

****

SPECIAL PROTECTION INFORMATION

VENTILATION: Use only with adequate ventilation.

RESPIRATORY: NIOSH/MESA approved particle masks for dust and mist.

EYE: Safety glasses or goggles.

GLOVES: Normal work gloves.

****

SPECIAL PRECAUTIONS

Keep away from friction, impact and heat. Do Not consume food, drink or tobacco in areas where they may become contaminated with these materials.

STORAGE CONDITIONS

Refer to manufacturer's recommendations and warning for proper storage conditions.

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MSDS
UNLEADED GASOLINE

*** IDENTIFICATION ***

MSDS RECORD NUMBER : 802164
PRODUCT NAME(S) : CFR 40-86-96 RON UNLEADED GASOLINE + 15% MTBE
PRODUCT IDENTIFICATION : PRODUCT CODE R00000573200
DATE OF MSDS : 1994-09-13

*** MATERIAL SAFETY DATA ***

PRIMARY APPLICATION- MOTOR FUEL

SYNONYMS...... : UNLEADED PREMIUM GASOLINE
CAS REGISTRY NO: SEE SEC. 2
CAS NAME...... : NO CLASSIFICATION - MIXTURE
CHEMICAL FAMILY: MOTOR FUEL.

EMERGENCY PHONE NUMBERS (AFTER NORMAL BUSINESS HOURS)
CHEMTREC. 1-800-424-9300

2. COMPOSITION / INFORMATION ON INGREDIENTS

EXPOSURE GUIDELINES

			OSHA		ACGIH				
COMPONENT/CAS NO.	LO%	HI%	TWA	STEL	TWA	STEL	TWA	STEL	UNIT
LIMITS FOR THE PRODUCT:			300	500	300	500			PPM
XYLENE 1330-20-7	.00	25.00	100	150	100	150			PPM
TERT-BUTYL ALCOHOL 75-65-0	.00	10.00	100	150	100	150			PPM
MTBE 1634-04-4	15.00	20.00					100	150	PPM
TOLUENE 108-88-3	.00	30.00	100	150	50				PPM
BENZENE 71-43-2	.10	4.90	1	5	10				PPM
LIGHT PETROLEUM DISTILLATE 8006-61-9	.00	84.00	300	500	300	500			PPM
CUMENE 98-82-8	.00	1.00	50		50				PPM
ETHYL BENZENE 100-41-4	.00	5.00	100	125	100	125			PPM
N-HEXANE 110-54-3	.00	5.00	50		50				PPM
NAPHTHALENE 91-20-3	.00	5.00	10	15	10	15			PPM
CYCLOHEXANE 110-82-7	.00	9.00	300		300				PPM
1,2,4-TRIMETHYLBENZENE 95-63-6	.00	5.00	25		25				PPM

ADDITIONAL EXPOSURE LIMITS
OTHER LIMIT- LIMIT IS DEPENDENT ON BENZENE, SEE SECTION 10

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW
DANGER EXTREMELY FLAMMABLE LIQUID & VAPOR - VAPOR MAY CAUSE FLASH FIRE.

HARMFUL IF INHALED. HIGH VAPOR CONCENTRATIONS MAY CAUSE DIZZINESS. MAY CAUSE SKIN IRRITATION.

HARMFUL OR FATAL IF SWALLOWED. PULMONARY ASPIRATION HAZARD-CAN ENTER LUNGS AND CAUSE DAMAGE. CONTAINS MATERIAL
WHICH CAN CAUSE CANCER.

APPEARANCE-- COLORLESS LIQUID. ODOR-- GASOLINE ODOR

POTENTIAL HEALTH EFFECTS

PRIMARY ROUTES OF ENTRY- INHALATION(X) SKIN(X) EYE(X) INGESTION(X)

INHALATION: EXCESSIVE EXPOSURES MAY CAUSE IRRITATION TO EYES, NOSE, THROAT AND LUNGS. RESPIRATORY TRACT; CENTRAL NERVOUS SYSTEM (BRAIN) EFFECTS;
HEADACHES, NAUSEA; DIZZINESS, LOSS OF BALANCE AND COORDINATION;
UNCONSCIOUSNESS, COMA; RESPIRATORY FAILURE AND DEATH. REPEATED EXCESSIVE
EXPOSURES MAY CAUSE BLOOD DISORDERS SUCH AS ANEMIA & LEUKEMIA. CONTAINS A MATERIAL WHICH HAS BEEN RELATED TO CANCER IN HUMANS.

SKIN
SKIN ABSORPTION OF MATERIAL MAY PRODUCE SYSTEMIC TOXICITY. MAY CAUSE MODERATE IRRITATION WITH PROLONGED OR REPEATED CONTACT.

EYE
CONTACT WITH THE EYE MAY CAUSE DO NOT INDUCE VOMITING] DO NOT GIVE LIQUIDS] OBTAIN EMERGENCY MEDICAL MILD IRRITATION.

INGESTION
HARMFUL OR FATAL IF SWALLOWED. INGESTION OF THIS MATERIAL MAY CAUSE ABDOMINAL PAIN; PULMONARY ASPIRATION HAZARD IF SWALLOWED AND/OR VOMITING OCCURS - CAN ENTER LUNGS AND CAUSE DAMAGE. CONTAINS MATERIAL THAT HAS
BEEN RELATED TO CANCER IN HUMANS.

CARCINOGEN LISTED BY-IARC(YES) NTP(NO) OSHA(YES) ACGIH(NO) OTHER(NO)

PRE-EXISTING MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE-
DISORDERS AND DISEASES OF THE SKIN, EYE, BLOOD FORMING ORGANS,
NERVOUS SYSTEM AND OR PULMONARY SYSTEM, LUNG (E.G. ASTHMA-LIKE CONDITIONS).

4. FIRST AID MEASURES

INHALATION
MOVE PERSON TO FRESH AIR. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION, OBTAIN MEDICAL ASSISTANCE.

SKIN
WASH WITH SOAP AND WATER UNTIL NO ODOR REMAINS. IF REDNESS OR SWELLING DEVELOPS, OBTAIN MEDICAL ASSISTANCE. IMMEDIATELY REMOVE SOAKED CLOTHING.
WASH CLOTHING BEFORE REUSE.

EYE
FLUSH WITH WATER FOR AT LEAST 15 MINUTES. IF IRRITATION PERSISTS, OBTAIN MEDICAL ASSISTANCE.

INGESTION

ATTENTION. SMALL AMOUNTS WHICH ACCIDENTALLY ENTER MOUTH SHOULD

BE RINSED
OUT UNTIL TASTE OF IT IS GONE.

5. FIRE FIGHTING MEASURES

FLASH POINT: -40 CLOSED CUP (DEG. F); -40 CLOSED CUP (DEG. C)
AUTOIGNITION TEMP.: APPROX. 750 (DEG. F); APPROX. 400 (DEG. C)

---FLAMMABLE LIMITS IN AIR---
LOWER EXPLOSIVE LIMIT (LEL): 1.5 % VOLUME
UPPER EXPLOSIVE LIMIT (UEL): 7.6 % VOLUME

FIRE AND EXPLOSION HAZARDS
EXTREMELY FLAMMABLE LIQUID (FLASH POINT LESS THAN 20F)

EXTINGUISHING-MEDIA
WATER SPRAY. REGULAR FOAM. DRY CHEMICAL. CARBON DIOXIDE.

SPECIAL FIRE FIGHTING INSTRUCTIONS
COOL TANK/ CONTAINER. WEAR SELF-CONTAINED BREATHING APPARATUS. WEARSTRUCTURAL FIREFIGHTERS PROTECTIVE CLOTHING.

NFPA/HMIS CLASSIFICATION
HAZARD RATING
HEALTH - 1 / 1 FIRE - 3 / 3

0=LEAST 1=SLIGHT 2=MODERATE
3=HIGH 4=EXTREME

REACTIVITY - 0 / 0
PERSONAL PROTECTION INDEX - X

SPECIFIC HAZARD: FLAMMABLE

6. ACCIDENTAL RELEASE MEASURES
PREVENT IGNITION; STOP LEAK; PROTECTIVE GLOVES RECOMMENDED TO PROTECT AGAINST CONTACT WITH PRODUCT. THE FOLLOWING GLOVE MATERIALS ARE ACCEPTABLE: VENTILATE AREA. CONTAIN SPILL. USE WATER SPRAY TO DISPERSE VAPORS. KEEP UPWIND OF LEAK. FOR LARGE SPILL, LEAK OR RELEASE. USE PERSONAL PROTECTIVE EQUIPMENT STATED IN SECTION 8. ADVISE EPA; STATE AGENCY IF REQUIRED. ABSORB ON INERT MATERIAL. SHOVEL, SWEEP
OR VACUUM SPILL.

7. HANDLING AND STORAGE
KEEP AWAY FROM HEAT, SPARKS AND FLAME. KEEP CONTAINER TIGHTLY CLOSED. KEEP IN WELL VENTILATED SPACE. NFPA CLASS IA STORAGE. CONSULT NFPA AND OSHA CODES. TRANSFER OPERATIONS MUST BE ELECTRICALLY GROUNDED TO
DISSIPATE STATIC BUILDUP. AVOID PROLONGED BREATHING OF MIST OR VAPOR. AVOID PROLONGED OR REPEATED CONTACT WITH SKIN. AVOID CONTACT WITH EYES.
WASH THOROUGHLY AFTER HANDLING. NEVER SIPHON BY MOUTH.

8. EXPOSURE CONTROL / PERSONAL PROTECTION
CONSULT WITH A HEALTH/SAFETY PROFESSIONAL FOR SPECIFIC SELECTION.

VENTILATION
USE ONLY WITH ADEQUATE VENTILATION. EXPLOSION PROOF VENTILATION EQUIPMENT REQUIRED.

PERSONAL PROTECTIVE EQUIPMENT

EYE
SPLASH PROOF CHEMICAL GOGGLES OR FULL FACE SHIELD RECOMMENDED TO PROTECT AGAINST SPLASH OF PRODUCT.

GLOVES
POLYETHYLENE; NEOPRENE;
NITRILE; POLYVINYL ALCOHOL; VITON;

RESPIRATOR

CONCENTRATION-IN-AIR DETERMINES PROTECTION NEEDED. USE ONLY NIOSH CERTIFIED RESPIRATORY PROTECTION. HALF-MASK AIR PURIFYING RESPIRATOR WITH ORGANIC VAPOR CARTRIDGES IS ACCEPTABLE TO 10 TIMES THE EXPOSURE LIMIT. FULL-FACE AIR PURIFYING RESPIRATOR WITH ORGANIC VAPOR CARTRIDGES
IS ACCEPTABLE TO 50 TIMES THE EXPOSURE LIMIT NOT TO EXCEED THE CARTRIDGE LIMIT OF 1000 PPM. PROTECTION BY AIR PURIFYING RESPIRATORS IS LIMITED. USE A POSITIVE PRESSURE-DEMAND FULL-FACE SUPPLIED AIR RESPIRATOR OR SCBA FOR EXPOSURES ABOVE 50X THE EXPOSURE LIMIT. IF EXPOSURE IS ABOVE IDLH(IMMEDIATELY DANGEROUS TO LIFE & HEALTH) OR THERE IS THE POSSIBILITY OF AN UNCONTROLLED RELEASE OR EXPOSURE LEVELS ARE UNKNOWN THEN USE A POSITIVE PRESSURE-DEMAND FULL-FACE SUPPLIED AIR RESPIRATOR WITH ESCAPE BOTTLE OR SCBA.

<u>OTHER</u>
IF CONTACT IS UNAVOIDABLE, WEAR CHEMICAL RESISTANT CLOTHING. THE FOLLOWING MATERIALS ARE ACCEPTABLE AS PROTECTIVE CLOTHING MATERIALS:
POLYETHYLENE; POLYVINYL ALCOHOL(PVA); NEOPRENE; NITRILE; VITON; POLYURETHANE; SAFETY SHOWER AND EYE WASH AVAILABILITY RECOMMENDED.
LAUNDER SOILED CLOTHES. FOR NON-FIRE EMERGENCIES, POSITIVE PRESSURE SELF-CONTAINED BREATHING APPARATUS (SCBA) & STRUCTURAL FIREFIGHTERS'
PROTECTIVE CLOTHING WILL PROVIDE LIMITED PROTECTION.

<u>INHALATION</u>: OVEREXPOSURE MAY CAUSE EYE & RESPIRATORY TRACT IRRITATION, CNS (BRAIN) EFFECTS, DIZZINESS, LOSS OF BALANCE & COORDINATION, COMA,

<u>9. PHYSICAL AND CHEMICAL PROPERTIES</u>

BOILING POINT...... : <100 - 435 (DEG. F) <38 - 223 (DEG. C)
MELTING POINT...... : N/A
SPECIFIC GRAVITY... : 0.74 (WATER=1)
PACKING DENSITY.... : N/A (KG/M3)
VAPOR PRESSURE..... : 325 TO 525 (MM HG @ 20 DEG C)
VAPOR DENSITY...... : 4 (AIR=1)
SOLUBILITY IN WATER.: SLIGHT (% BY VOLUME)
PH INFORMATION..... : N/A AT CONC. N/A G/L H2O
% VOLATILES BY VOL..: 100
EVAPORATION RATE... : RAPID & VARIES (ETHYL ETHER=1)
OCTANOL/WATER COEFF.: N.D.
APPEARANCE......... : COLORLESS LIQUID.
ODOR............... : GASOLINE ODOR
ODOR THRESHOLD..... : 15(EST) (PPM)
VISCOSITY.......... : N.D. SUS @ N.D DEG F ... N.D. CST @ N.D DEG C
MOLECULAR WEIGHT... : N.D. (G/MOLE)

<u>10. STABILITY AND REACTIVITY</u>

<u>STABILITY</u>
STABLE. CONDITIONS TO AVOID-
SOURCES OF IGNITION.
INCOMPATIBLE MATERIALS
STRONG OXIDIZERS
HAZARDOUS DECOMPOSITION
CARBON MONOXIDE AND ASPHYXIANTS ARE PRODUCED BY FIRE IGNITION

<u>POLYMERIZATION</u>
WILL NOT OCCUR.

<u>11. TOXICOLOGICAL INFORMATION</u>

FOR THE PRODUCT

UNCONSCIOUSNESS, DEATH. CONTAINS

<u>BENZENE</u>: PROLONGED/REPEATED OVER-EXPOSURE TO BENZENE CAN CAUSE BLOOD DISORDERS RANGING FROM

ANEMIA TO LEUKEMIA. SKIN: PROLONGED/WIDESPREAD CONTACT MAY CAUSE ADVERSE EFFECT,
IRRITATION. EYE: MILD IRRITANT.

ORAL: HARMFUL/FATAL IF SWALLOWED. ASPIRATION HAZARD--CAN ENTER LUNGS & CAUSE DAMAGE. LIFETIME INHALATION CAUSED LIVER TUMORS (FEMALE MICE)--API STUDY ON AN UNLEADED GASOLINE.
GASOLINE ENGINE EXHAUST CLASSIFIED AS POSSIBLE (IARC 2B) CARCINOGEN (INADEQUATE EVIDENCE EXISTS IN ANIMALS & HUMANS).

XYLENE (COMPONENT) INHALATION: VAPOR HARMFUL] OVEREXPOSURE TO HIGH CONCENTRATIONS CAN CAUSE EYE, NOSE, THROAT, LUNG IRRITATION; CNS (BRAIN) EFFECTS,
DIZZINESS, DIFFICULTY IN BREATHING, UNCONSCIOUSNESS, COMA AND DEATH. REPORTS OF HEART IRREGULARITIES FROM MASSIVE EXPOSURES.
PROLONGED OVEREXPOSURES CAN CAUSE BRAIN, LIVER, KIDNEY EFFECTS/DAMAGE.

SKIN: CAN BE ABSORBED. REPEATED/PROLONGED CONTACT IS IRRITATING. EYES:
IRRITANT. ORAL: HARMFUL OR FATAL IF SWALLOWED. PULMONARY ASPIRATION HAZARD-CAN ENTER LUNGS AND CAUSE DAMAGE. IN RATS, PROLONGED BREATHING OF 500 PPM-FETAL EFFECTS BUT NO BIRTH DEFECTS; NO EFFECTS AT 400 PPM.
EYE CONTACT: IRRITATION. ORAL: MODERATE ACUTE TOXICITY. HARMFUL OR FATAL IF SWALLOWED AND/OR VOMITING OCCURS BECAUSE IT CAN ENTER LUNGS AND CAUSE DAMAGE--PULMONARY ASPIRATION HAZARD. LIFETIME OVEREXPOSURES
AT HIGH CONCENTRATIONS: 3000 PPM & HIGHER--RATS: DEATH, KIDNEY DAMAGE, AND KIDNEY TUMORS (MALES); AT 8000 HIGH ORAL DOSE WAS TOXIC TO PREGNANT MICE; CLEFT PALATE IN FETUSES.

TERT-BUTYL ALCOHOL (COMPONENT) INHALATION: VAPOR HARMFUL] OVEREXPOSURE TO HIGH CONCENTRATIONS MAY CAUSE EYE, NOSE, THROAT, LUNG IRRITATION; CNS (BRAIN) EFFECTS, HEADACHE, NAUSEA, DIZZINESS, DROWSINESS, VOMITING, FATIGUE, BLURRED VISION, LOSS OF BALANCE, UNCONSCIOUSNESS.

SKIN: SLIGHT IRRITANT.

EYES: SEVERE IRRITATION WITH CONTACT.

ORAL: MODERATELY TOXIC.
SYMPTOMS SIMILAR TO INHALATION. HARMFUL OR FATAL IF SWALLOWED.
PULMONARY ASPIRATION HAZARD IF SWALLOWED AND/OR VOMITING OCCURS - CAN ENTER LUNGS AND CAUSE DAMAGE. CAUSED TOXICITY/DAMAGE TO FETUS WHEN
REPEATEDLY FED AT VERY HIGH CONCENTRATIONS TO PREGNANT MICE.

MTBE (COMPONENT) INHALATION: MAY CAUSE EYE & RESPIRATORY TRACT IRRITATION, COUGHING,
SHORTNESS OF BREATH, CNS (BRAIN) EFFECTS, HEADACHE, NAUSEA, DIZZINESS, INCOORDINATION. SKIN: PROLONGED/REPEATED CONTACT MAY CAUSE IRRITATION.

PPM-- LIVER TUMORS IN FEMALE MICE.
MICE: MATERNAL TOXICITY & FETAL EFFECTS AT 4000 PPM. HUMAN EXPOSURES AT THESE HIGH CONCENTRATIONS ARE HIGHLY UNLIKELY.

TOLUENE (COMPONENT) INH: VAPOR HARMFUL] OVEREXPOSURE TO HIGH CONCENTRATIONS: EYE, NOSE, THROAT,

LUNG IRRITATION; CNS (BRAIN) EFFECTS, DIZZINESS, DIFFICULTY IN BREATHING, COMA, DEATH. REPORTS OF HEART BEAT IRREGULARITIES FROM MASSIVE EXPOSURE. PROLONGED OVEREXPOSURE CAN CAUSE BRAIN, LIVER, KIDNEY EFFECTS/DAMAGE. SKIN: CAN BE ABSORBED. PROLONGED CONTACT IS IRRITATING.

EYE: IRRITATION.

ORAL: HARMFUL OR FATAL IF SWALLOWED. PULMONARY ASPIRATION HAZARD-CAN ENTER LUNG & CAUSE DAMAGE. PREG: MAY
CAUSE MENTAL AND/OR GROWTH RETARDATION IN CHILDREN OF FEMALE SOLVENT ABUSERS (SNIFFERS); IN RATS PROLONGED BREATHING WAS TOXIC TO FETUSES &
MOTHERS - 1500 PPM; NO BIRTH DEFECTS - 5000 PPM. NO EFFECTS - 750 PPM.

BENZENE (COMPONENT) INHALATION: VAPOR HARMFUL] OVEREXPOSURE TO HIGH CONCENTRATIONS CAN
CAUSE CENTRAL NERVOUS SYSTEM (BRAIN) EFFECTS, HEADACHE, DIZZINESS, DIFFICULTY IN BREATHING, UNCONSCIOUSNESS, COMA, DEATH. THERE ARE REPORTS OF HEART IRREGULARITIES FROM MASSIVE EXPOSURES. IARC GROUP 1- HUMAN CANCER HAZARD. REPEATED PROLONGED INHALATION CAN CAUSE BLOOD DISORDERS-ANEMIA TO LEUKEMIA. CANCER-ANIMAL STUDIES. CHANGES IN INCOORDINATION, UNCONSCIOUSNESS, DEATH. SKIN: LOW ACUTE TOXICITY. CAN BE ABSORBED. MODERATE IRRITATION. EYE: MILD IRRITANT.

ORAL: MODERATE ACUTE TOXICITY. HARMFUL OR FATAL IF SWALLOWED. PULMONARY ASPIRATION HAZARD - CAN ENTER LUNGS AND CAUSE DAMAGE. OVEREXPOSURE BY INHALATION/INGESTION MAY CAUSE LIVER, KIDNEY, SPLEEN AND LUNG
CHROMOSOMES. FETAL EFFECTS IN ANIMAL STUDIES AT REPEATED/PROLONGED EXPOSURES.

SKIN: CAN BE ABSORBED; IRRITATING.

EYE: SEVERE IRRITATION POSSIBLE.

ORAL: POISON] HARMFUL OR FATAL IF SWALLOWED. PULMONARY ASPIRATION HAZARD- CAN ENTER LUNGS AND CAUSE DAMAGE.

LIGHT PETROLEUM DISTILLATE (COMPONENT) INHALATION: OVEREXPOSURE MAY CAUSE EYE, NOSE, THROAT, RESPIRATORY TRACT
IRRITATION; CNS (BRAIN) EFFECTS, NAUSEA, DIZZINESS, UNCONSCIOUSNESS, COMA, RESPIRATORY FAILURE, DEATH. SKIN: IRRITATION WITH PROLONGED AND REPEATED CONTACT.

EYE: MILD TO MODERATE IRRITATION. ORAL: HARMFUL OR FATAL IF SWALLOWED DUE TO A PULMONARY ASPIRATION HAZARD IF SWALLOWED
AND/OR VOMITING OCCURS - CAN ENTER LUNGS AND CAUSE DAMAGE.

CUMENE (COMPONENT) INHALATION: VAPOR HARMFUL] OVEREXPOSURE TO HIGH CONCENTRATIONS CAN CAUSE EYE, NOSE, THROAT, RESPIRATORY TRACT IRRITATION, CNS (BRAIN) EFFECTS, NAUSEA, HEADACHE, DIZZINESS, DIFFICULTY IN BREATHING,

EFFECTS/DAMAGE. EQUIVOCAL RESULTS IN ANIMAL STUDY REPORTING BIRTH
DEFECTS & EMBRYONAL MORTALITY. CONFLICTING RESULTS IN GENETIC TESTS.

ETHYL BENZENE (COMPONENT)

INHALATION: OVEREXPOSURE TO HIGH CONCENTRATIONS CAN CAUSE EYE, NOSE, THROAT & RESPIRATORY IRRITATION, CENTRAL NERVOUS SYSTEM

(BRAIN) EFFECTS, DIZZINESS, LOSS OF BALANCE & COORDINATION, UNCONSCIOUSNESS, RESPIRATORY FAILURE & DEATH. PROLONGED BREATHING CAN CAUSE LIVER AND KIDNEY EFFECTS.

SKIN: LOW ACUTE TOXICITY. ABSORBABLE THROUGH SKIN. MODERATE IRRITATION.

EYE: MODERATE IRRITANT.

ORAL: HARMFUL OR FATAL IF SWALLOWED. PULMONARY ASPIRATION HAZARD IF SWALLOWED AND/OR VOMITING OCCURS-CAN ENTER LUNGS AND CAUSE DAMAGE. PROLONGED OVEREXPOSURE OF 1000 PPM CAUSED MATERNAL AND FETAL TOXICITY.

N-HEXANE (COMPONENT)
INHALATION: OVEREXPOSURE TO HIGH CONCENTRATIONS CAN CAUSE EYE, NOSE, THROAT, RESPIRATORY TRACT IRRITATION; CNS (BRAIN) EFFECTS, DIZZINESS, CONFUSION, COMA.

SKIN: CAN BE ABSORBED. PROLONGED AND REPEATED CONTACT MAY CAUSE IRRITATION, BURNING SENSATION, ITCHING, BLISTERS.

EYE: IRRITATING; REPEATED EXPOSURE KIDNEY INJURY MAY ALSO OCCUR. MAY CAUSE GASTROINTESTINAL IRRITATION, VOMITING, AND DIARRHEA.

CYCLOHEXANE (COMPONENT)
INHALATION: OVEREXPOSURE TO HIGH CONCENTRATIONS CAN CAUSE EYE, NOSE, THROAT, RESPIRATORY IRRITATION; CNS (BRAIN) EFFECTS, HEADACHE, DIZZINESS, EXCITEMENT, DIFFICULTY BREATHING, FATIGUE, INCOORDINATION, ANESTHESIA, UNCONSCIOUSNESS, DEATH.

MAY CAUSE VISUAL DISTURBANCE.

INGESTION: ASPIRATION HAZARD IF SWALLOWED AND/OR VOMITING OCCURS - CAN ENTER LUNGS AND CAUSE DAMAGE. PROLONGED EXPOSURES CAUSE HARM TO THE CENTRAL NERVOUS SYSTEM PRODUCING A LACK OF FEELING IN EXTREMITIES (HANDS AND FEET) AND MORE SEVEE NERVE DAMAGE (PERIPHERAL NEUROPATHY).

NAPHTHALENE (COMPONENT)
INHALATION: VAPORS MAY CAUSE RESPIRATORY TRACT IRRITATION, HEADACHE, CONFUSION, EXCITEMENT, PROFUSE SWEATING, ABDOMINAL PAIN, VOMITING, DIARRHEA.

SKIN: MAY BE ABSORBED THROUGH THE SKIN. MAY CAUSE IRRITATION AND DERMATITIS. CAN CAUSE ALLERGIC SKIN REACTION.

EYE: VAPOR CAUSES IRRITATION AT 15 PPM. CONTACT MAY CAUSE IRRITATION, CONJUNCTIVITIS, CORNEAL OPACITY. REPORTED TO CAUSE CATARACTS.

ORAL: MODERATELY TOXIC IF SWALLOWED . BLOOD EFFECTS (HEMOLYSIS), LIVER &

SKIN: LOW ACUTE TOXICITY. MAY BE IRRITATING WITH PROLONGED AND REPEATED CONTACT.

EYE: MAY CAUSE MILD IRRITATION WITH CONTACT.

ORAL: MODERATE ACUTE TOXICITY. INGESTION OF LARGE QUANTITIES MAY CAUSE EFFECTS SIMILIAR TO INHALATION. HARMFUL OR FATAL IF SWALLOWED AND/OR VOMITING OCCURS BECAUSE IT CAN ENTER LUNGS AND CAUSE DAMAGE--PULMONARY

ASPIRATION HAZARD.

1,2,4-TRIMETHYLBENZENE (COMPONENT)
INHALATION: MODERATELY TOXIC. VAPOR OR MIST IRRITATES THE EYES, MUCOUS
MEMBRANES, RESPIRATORY TRACT. OVEREXPOSURE MAY CAUSE CENTRAL
NERVOUS SYTEM (BRAIN) EFFECTS, NARCOTIC EFFECTS, NAUSEA, HEADACHE, DIZZINESS, INCOORDINATION, UNCONSCIOUSNESS, COMA, DEATH.

SKIN: CAN BE ABSORBED. CONTACT MAY CAUSE IRRITATION AND DERMATITIS. EYE: IRRITATING

INGESTION: MODERATELY TOXIC. SYMPTOMS SIMILAR TO INHALATION. HARMFUL OR FATAL IF SWALLOWED. PULMONARY ASPIRATION HAZARD- HARMFUL OR FATAL BECAUSE IT CAN ENTER THE LUNGS AND CAUSE DAMAGE.

12. ECOLOGICAL INFORMATION

AQUATIC TOXICITY: GASOLINE SPILLS ARE TOXIC TO FISH AND AQUATIC FLORA.

13. DISPOSAL CONSIDERATIONS

FOLLOW FEDERAL, STATE AND LOCAL

WHEN A PRODUCT AND/OR COMPONENT IS LISTED BELOW, THE REGULATORY LIST ON WHICH IT APPEARS IS INDICATED.

FOR THE PRODUCT - FL MA MN NJ 03 04
XYLENE - FL IL MA ME MN NJ PA RI 01 07
TERT-BUTYL ALCOHOL - FL MA MN NJ PA 01
MTBE - MA NJ PA 01 07
TOLUENE - CA FL MA MN NJ PA 01 07
BENZENE - CA FL MA MN NJ PA 01 03 04 06 07 10
LIGHT PETROLEUM DISTILLATE - FL MA MN NJ
CUMENE - FL MA MN NJ PA 01 07
ETHYL BENZENE - FL MA MN NJ PA 01 07
N-HEXANE - FL MA MN NJ PA

REGULATIONS. RCRA HAZARDOUS WASTE. DO NOT FLUSH TO DRAIN/ STORM SEWER. CONTRACT TO AUTHORIZED DISPOSAL SERVICE.

14. TRANSPORTATION INFORMATION

DOT- PROPER SHIPPING NAME- GASOLINE
HAZARD CLASS- 3 (FLAMMABLE LIQUID)
IDENTIFICATION NUMBER- UN1203
LABEL REQUIRED- PG II, PLACARD; FLAMMABLE LIQUID
IMDG- PROPER SHIPPING NAME- GASOLINE
IATA- PROPER SHIPPING NAME- GASOLINE

15. REGULATORY INFORMATION

SARA 302 THRESHOLD PLANNING QUANTITY. N/A

SARA 304 REPORTABLE QUANTITY .... 204 POUNDS

SARA 311 CATEGORIES- IMMEDIATE (ACUTE) HEALTH EFFECTS.. Y
DELAYED (CHRONIC) HEALTH EFFECTS.. Y
FIRE HAZARD .... Y
SUDDEN RELEASE OF PRESSURE HAZARD. N
REACTIVITY HAZARD .... N

NAPHTHALENE - FL MA MN NJ PA 01 07
CYCLOHEXANE - FL MA MN NJ PA 01 07
1,2,4-TRIMETHYLBENZENE - MA NJ PA 01

01=SARA 313
02=SARA 302/304
03=IARC CARCINOGEN
04=OSHA CARCINOGEN
05=ACGIH CARCINOGEN
06=NTP CARCINOGEN
07=CERCLA 302.4
08=WHMIS CONTROLLED PROD.
10=OTHER CARCINOGEN

THIS PRODUCT OR ALL COMPONENTS OF THIS PRODUCT ARE LISTED ON THE U.S. TSCA INVENTORY.

16. OTHER INFORMATION

PRECAUTIONARY LABELING FOR PUMPS, PORTABLE CONTAINERS, AND DRUMS IS REQUIRED. A "HAZARDOUS WHEN EMPTY" PICTOGRAM AND D.O.T. FLAMMABLE LIQUID LABEL ARE ALSO REQUIRED FOR DRUMS. BECAUSE BENZENE IS PRESENT IN THIS PRODUCT ABOVE 0.1%, THE OSHA STANDARD
FOR BENZENE IS APPLICABLE TO WORK LOCATIONS UPSTREAM OF FINAL DISCHARGE FROM TERMINALS. CONSULT 29CFR1910.1028 FOR DETAILS. PROLONGED AND REPEATED EXCESSIVE EXPOSURES TO BENZENE CAN RESULT IN BLOOD DISORDERS
RANGING FROM ANEMIA TO LEUKEMIA. RECOMMEND THAT EXPOSURES TO BENZENE BE KEPT BELOW 1.0 PPM FOR 8-HOURS; 5.0 PPM FOR 15-MIN. NORMAL SERVICE STATION OPERATIONS ARE BELOW THESE VALUES. FOR USE AS A MOTOR
FUEL ONLY. DO NOT USE FOR ANY OTHER PURPOSE.

APPENDIX D, ATTACHMENT 7.
HAZARD CONTROL PLAN

APPENDIX D - ATTACHMENT 7: HAZARD CONTROL PLAN

HAZARD-BASED HAZARD CONTROL PLAN, OPERATION WORK PLAN (OWP)

D7.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY, CULEBRA ISLAND SITES, PUERTO RICO

D7.1 POINT OF CONTACT

Robert Crownover, Corporate Safety and Health Manager, (813) 343-6364

D7.2 DEFINITION OF WORK

USA shall provide the necessary personnel and equipment to perform the remedial investigation/feasibility study (RI/FS) and to safely destroy and/or remove and dispose of all explosive hazards encountered IAW the SOW. All MEC encountered will be accounted for to include identification, condition, depth, location, and disposition; all MEC scrap will be inspected and certified as explosive free, to be sent to a qualified recycler at the end of the project.

D7.3 IDENTIFICATION OF PRINCIPAL HAZARDS

- Munitions and Explosives of Concern
- Unexploded Ordnance Identification and Disposal
- Munitions Potentially Presenting an Explosive Hazard

D7.4 RISK EVALUATION

MEC is a safety hazard and may constitute an imminent and substantial endangerment to site personnel and the local populous. During this RI/FS, it is the Government's intent that USA destroy all MEC/UXO encountered on site and that USA work is to be performed in accordance with the Comprehensive Environment Response, Compensation, and Liability Act (CERCLA), Section 104 and the National Contingency Plan (NCP), Sections 300.120(d) and 300.400(e).

D7.4.1 BASIS OF EVALUATION

- Exposure to hazards associated with MEC/UXO. These items, if moved or handled improperly, could detonate, either killing or seriously injuring personnel at the work site.
- Exposure to explosive hazards associated with demolition operations.
- Transportation hazards inherent in the driving of vehicles and movement of MEC and/or demolition materials.
- Explosive hazards as a result of inerting/venting UXO material.
- Hazards associated with the collection, inspection, and movement of MPPEH**.**

Initial Risk without Controls (Check One) ☐ High ☐ Medium ☒ Low ☐ Minimal

Note: High or medium risks require risk analysis.

Residual Risk with Controls (Check One) ☐ High ☐ Medium ☐ Low ☒ Minimal

Reviewed by USA Environmental Safety and Health Point of Contact:

Robert Crownover, CSHM **on** ____________________
Name **Date**

Approved By: USA Environmental Certified Safety Professional

Cheryl Riordan, CSP **on** ____________________
Name **Date**

D7.5 AUTHORIZATION RESPONSIBILITY

Work Authorization			Worker Authorization	
	Initial Risk	**Residual Risk**		**Residual Risk**
Minimal	No Review	Supervisor Approval	**Minimal**	Supervisor
Low	S & H Consultation	Corporate Safety Approval	**Low**	Corporate Safety Approval
Medium	S & H Concurrence	CSP Approval	**Medium**	CSP Approval
High	S & H/Peer concurrence	Will Not Be Approved. Full Review Required.	**High**	Worker Will Not Be Approved

D7.6 HAZARD CONTROL

This portion of the Hazard Control Plan (HCP), when approved, defines the manner in which each hazard will be controlled to an acceptable level, thus certifying the adequacy of the controls. The hierarchy of controls [engineering, administrative, and personal protective equipment (PPE) as a last resort] has been utilized in identifying and employing control systems.

TABLE 7-1: MEC/UXO

Task	Hazard Scenario	Hazard Control
MEC/UXO Location	Improper handling or marking of MEC/UXO during investigation of project area.	Training and supervision of personnel. Only UXO-qualified personnel will handle MEC/UXO items. Marking of items will be done IAW the approved work plan. EZ distances will be enforced at all times.

TABLE 7-2: MEC/UXO IDENTIFICATION

Task	Hazard Scenario	Hazard Control
Identification of MEC/UXO	Mis-Identification and handling of MEC/UXO	Only UXO-qualified personnel will handle or identify MEC/UXO. Identification of UXO will be made by two UXO-qualified personnel. UXO will not be moved or handled unnecessarily, regardless of markings or apparent condition. Do not rely on color code for positive identification of ordnance item(s) or their contents. Always assume ordnance items contain a live charge until it can be ascertained otherwise. EZ distances will be enforced at all times.

TABLE 7-3: MEC/UXO DISPOSAL

Task	Hazard Scenario	Hazard Control
Disposal of MEC/UXO	Mis-Handling of Explosives, Unplanned detonation, Unauthorized personnel within the EZ	Only UXO-qualified personnel will perform disposal operations for MEC/UXO. UXO will not be moved or handled unnecessarily, regardless of markings or apparent condition. Engineering controls will be utilized. EZ distances will be enforced. PPE for the task performed will be worn.

TABLE 7-4: MPPEH IDENTIFICATION AND STORAGE

Task	Hazard Scenario	Hazard Control
Inspection of MPPEH	Mis-Identification of MPPEH, Improper Storage of Material	UXO-qualified personnel will inspect MPPEH. The Technician III, SUXOS, UXOSO, and UXOQCS will perform additional inspections of material. Proper documentation will be maintained for containerized material, to include labels and seals. Proper PPE will be worn at all times while handling material. Shipping documents will reflect accurate information. Bins of inspected materials will be secured against accidental co-mingling with other scrap or live items.

D7.7 PERFORMING THE WORK SAFELY

Fill out each section below. If a section is not applicable to your project, type in "NA."

D7.7.1 TRAINING REQUIREMENTS

Individual training records and certifications are maintained on the project site for review and inspection:

- 40-hour HAZWOPER training.
- 8-hour HAZWOPER refresher training, as required annually.
- 8-hour Supervisor's training (UXO Technicians III and above), as required annually.
- EOD/UXO training and certification for UXO personnel.
- MEC/UXO identification, hazards, and precautions.

- First Aid and CPR training for selected personnel (two, minimum) who remain on site during operations.
- Equipment specific training and certification.

D7.7.2 APPLICABLE INSTITUTIONAL REQUIREMENTS

N/A

D7.7.3 OPERATING PROCEDURES

See Standard Operating Procedures (SOPs) for the following:

- Receipt, Storage, and Issue of Explosives
- Explosives Transportation
- Explosives Disposal Operations
- Engineering Controls
- Investigation of MEC/UXO
- Avoidance Procedures of MEC/UXO
- MPPEH/Scrap Inspection.

D7.7.4 WASTE INFORMATION

Consult with the USA Project Manager for proper evaluation and/or disposal of waste if generated by USA personnel or operations.

D7.7.5 EMERGENCY PROCEDURES

In the event of an emergency (injury or illness), refer to the procedures and contacts listed in the APP/SSHP and Attachment 3 for the specific medical treatment facility for the project.

D7.7.6 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)/ESH IDENTIFICATION (ID)

Not required for this project.

D7.7.7 NEPA TRACKING NUMBER:

Not required for this project.

D7.7.8 ESH ID TRACKING NUMBER:

Not required for this project.

D7.7.9 SAMPLING RESULTS (DATA)

None required at this time.

D7.7.10 REQUIRED PERMITS

None required for this project. Personnel transporting explosives over the public highways must have a current commercial driver's license (CDL).

D7.7.11 STEPS FOR SAFE SHUTDOWN

None required for this project.

D7.8 REVIEW AND IMPROVEMENT

The review cycle for this HCP is one year. At the end of a year, the system will be evaluated for changes in the SOW, the potential hazards, or other conditions that might warrant revision of the HCP system. Any significant modifications that impact the safety envelope of the activity at any time require updating the HCP and reauthorization.

Change control of this document is accomplished by retaining the master HCP document at USA Environmental, Inc.

End of Document

APPENDIX E. SAMPLING AND ANALYSIS PLAN

E. MUNITIONS CONSTITUENTS SAMPLING AND ANALYSIS PLAN

Culebra Island Site, Puerto Rico

Contract No. W912DY-04-D-0006
Delivery Order No. 0022

Prepared for

U.S. Army Corps of Engineers
U.S. Army Engineering and Support Center
4820 University Square
Huntsville, Alabama 35816

U.S. Army Corps of Engineers
Jacksonville District
701 San Marco Boulevard
Jacksonville, Florida 32207

Under Regulatory Authority of the Comprehensive Environmental Restoration, Compensation, and Liability Act

Final

February 2011

COMMITMENT TO IMPLEMENT THE SAMPLING AND ANALYSIS PLAN

Matt Tucker	[signature]	10 Feb 11
USA Project Manager (Print)	Signature	Date
Robert Crownover	[signature]	11 Feb. 2011
USA QC Manager (Print)	Signature	Date
Charles O'Bryan		
RTI QC Manager (Print)	Signature	Date
Stella Cuenco		
LDC Data Validator (Print)	Signature	Date

DISTRIBUTION LIST

This list should include all recipients of the SAP, and any addendums or modifications thereto.

Spencer O'Neal Project Manager U.S. Army Engineering and Support Center 4820 University Square Huntsville, AL 35816-1822	Teresa Carpenter Technical Manager U.S. Army Engineering and Support Center 4820 University Square Huntsville, AL 35816-1822
Charles O'Bryan Quality Assurance Manager RTI Laboratories 31628 Glendale Ave. Livonia, MI 48150	Stella Cuenco Data Validator Laboratory Data Consultants 7750 El Camino Real, Suite 2L Carlsbad, CA 92009
Doug Ralston Program Manager USA Environmental, Inc. 720 Booker Creek Blvd, Suite 204 Oldsmar, FL 34677	Matthew Tucker Project Manager USA Environmental, Inc. 720 Booker Creek Blvd, Suite 204 Oldsmar, FL 34677
Cheryl Nichols, Project Engineer USA Environmental, Inc. 720 Booker Creek Blvd, Suite 204 Oldsmar, FL 34677	USEPA US EPA Vieques Field Office Carr 200 km 0.4 Vieques, PR 00765

PART I:

FIELD SAMPLING PLAN

Remedial Investigation/Feasibility Study

Culebra Island Site, Puerto Rico

Contract No. W912DY-04-D-0006
Delivery Order No. 0022

November 2010

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LIST OF FIGURES

Attachments

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ACRONYMS AND ABBREVIATIONS

>	Greater Than
<	Less Than
°C	Degrees Celsius
mg/kg	milligram per kilogram
µg/kg	microgram per kilogram
AOC	Area of Concern
GPL	GPL Laboratories LLLP
BGS	Below Ground Surface
CDA	Civil Defense Agency
COC	Chain of Custody
CWM	Chemical Warfare Materiel
DFW	Definable Feature of Work
DID	Data Item Description
DOD	Department of Defense
DQO	Data Quality Objective
EB	Equipment Blank
EDD	Electronic Data Deliverable
EM	Engineering Manual
ER	Engineering Regulation
FAA	Federal Aviation Administration
FD	Field Duplicate
FSP	Field Sampling Plan
GC/MS	Gas Chromatography/Mass Spectrometry
ICV	Initial Calibration Verification
IDW	Investigation-Derived Waste
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MB	Method Blanks
MC	Munitions Constituents
MEC	Munitions and Explosives of Concern
MD	Munitions Debris
MDL	Method Detection Limit
MMRP	Military Munitions Response Program
MS	Matrix Spike
MSD	Matrix Spike Duplicate

NIST	National Institute of Standards and Technology
PCB	Polychlorinated Biphenyl
C	Post-detonation Composite Soil
PE	Performance Evaluation
PPE	Personal Protective Equipment
PQL	Practical Quantitation Limit
QA	Quality Assurance;QA Split (sample abbreviation)
QC	Quality Control
QCR	Quality Control Reports
RI/FS	Remedial Investigation/Feasibility Study
RPD	Relative Percent Deviation
RSL	Regional Screening Levels
SAP	Sampling and Analysis Plan
SDL	Sample Detection Limit
SOW	Scope of Work
SD	Sediment
S	Surface Soil Sample
SS	Subsurface Soil
SW	Surface Water
USA	USA Environmental, Inc.
USACE	U.S. Army Corps of Engineers
USAESCH	U.S. Army Engineering and Support Center, Huntsville
USEPA	United States Environmental Protection Agency

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E.1. PART I: FIELD SAMPLING PLAN

E.1.1. PROJECT BACKGROUND

E.1.1.1. The U.S. Army Corps of Engineers (USACE) Jacksonville District and the U.S. Army Engineering and Support Center, Huntsville (USAESCH) have tasked USA Environmental, Incorporated (USA) to perform a Remedial Investigation (RI) and Feasibility Study (FS) at Culebra Island Site in Puerto Rico under Contract No. W912DY-04-D-0006, Delivery Order No. 0022.

E.1.1.2. Under Task 4 of the 27 March 2009 Performance Work Statement (PWS) (Appendix A to the Work Plan), USA will collect discrete surface soil, subsurface soil, sediment and surface water samples (including discrete background samples for each environmental medium) to determine the presence and nature and extent of munitions constituents (MC) and to support the human health and ecological risk assessment. USA will also collect pre- and post-detonation composite soil samples using the CRREL 7-sample wheel approach (as described in ERDC SR96-15) to verify that no MC are detected above the applicable regulatory criteria due to disposal operations. USA will coordinate sample collection, data quality control (QC), and laboratory analysis of collected samples for explosives and metals.

E.1.1.3. USA prepared this Munitions Constituents (MC) Sampling and Analysis Plan (SAP) to detail the methods and procedures for the sampling and analysis efforts which satisfy the project data quality objectives (DQOs) established in the project work plan. This SAP combines the Field Sampling Plan (FSP) and the Quality Assurance Project Plan (QAPP), and details sampling rationale and procedures, equipment, and methods for sample collection, preservation, shipment, and chemical analysis. This SAP also details QC methods and procedures and data reporting requirements. USA prepared the FSP in accordance with Data Item Description (DID) MR-005-10.01 – *Munitions Constituents Chemical Data Quality Deliverables* and Engineer Manual (EM) 200-1-3 – *Requirements for the Preparation of Sampling and Analysis Plans*. USA prepared the QAPP in accordance with the *Uniform Federal Policy for Quality Assurance Project Plans*.

E.1.1.4. Site History and Contaminants

E.1.1.4.1. The Navy used Culebra Island for fleet exercises from 1902 until 1975. The Navy began surface and aerial bombing of the Flamenco Peninsula in 1935, and expanded the range to include eastern and western cays (small islands surrounding Culebra) in the early 1960s. Ordnance firing ended in September 1975.

E.1.1.5. Summary of Existing Site Data

E.1.1.5.1. MRS 06 Artillery Firing Area

E.1.1.5.1.1. The Artillery Firing Area consists of 826 acres and is located on the eastern end of Culebra extending from a point at the most northern tip of Mosquito Bay, northeast to a point just west of Duck Point, and east to the end of the island. The SI (Parsons, 2007) included the collection of two soil samples and indicated that soil and surface water/sediment migration pathways are complete for human receptors, but unacceptable human health risks are not expected through exposure to soil or surface water/sediment. Groundwater and air migration pathways are not complete for human receptors at MRS 06.

E.1.1.5.1.2. Soil and surface water/sediment pathways are complete for ecological receptors and there is a potential for ecological risk due to chromium and copper in soil and possible MC migration from soil to surface water/sediment. Groundwater and air migration pathways are not complete for ecological receptors at MRS 06.

E.1.1.5.1.3. The SI recommended further MC investigation of surface water/sediment in Mosquito Bay to evaluate the potential for human health risk and further MC investigation of soil and surface water/sediment to evaluate the potential for ecological risk.

E.1.1.5.2. MRS 08 Cayo Norte Impact Area

E.1.1.5.2.1. The Cayo Norte Impact Area includes only Cayo Norte and covers approximately 306 acres. The SI included collection of two soil samples and one sediment sample and indicated that soil and surface water/sediment migration pathways are complete for human receptors, but unacceptable human health risks are not expected through exposure to soil or surface water/sediment. Groundwater and air migration pathways are not complete for human receptors at MRS 08.

E.1.1.5.2.2. Soil and surface water/sediment pathways are complete for ecological receptors and there is a potential for ecological risk due to zinc in soil. However, unacceptable ecological risk posed by zinc is unlikely due to low HQ and unacceptable ecological risk from MC is not expected through exposure to surface water/sediment. Groundwater and air migration pathways are not complete for ecological receptors at MRS 08.

E.1.1.5.2.3. The SI recommended further MC investigation of soil and surface water/sediment to evaluate the potential for ecological risk.

E.1.1.5.3. MRS 09 Soldado Point Mortar and Bombing Area

E.1.1.5.3.1. The Soldado Point Mortar and Bombing Area consists of 328 acres on the southern tip of the southwestern peninsula of Culebra. The SI included collection of two soil samples and indicated that soil and surface water/sediment migration pathways are complete for human receptors, but unacceptable human health risks are not expected through exposure to soil or surface water/sediment. Groundwater and air migration pathways are not complete for human receptors at MRS 09.

E.1.1.5.3.2. Soil and surface water/sediment migration pathways are complete for ecological receptors and there is potential for ecological risk due to chromium in soil and possible MC migration from soil into surface water/sediment. Groundwater and air migration pathways are not complete for ecological receptors at MRS 09.

E.1.1.5.3.3. The SI recommended further MC investigation of soil and surface water/sediment to evaluate the potential for ecological risk.

E.1.1.5.4. MRS 10 Defensive Firing Area No. 1

E.1.1.5.4.1. This Defensive Firing Area No. 1 consists of 547 acres on the southwest peninsula of Culebra, south of the town of Dewey and north of MRS 09. The SI included collection of two soil samples and indicated that soil migration pathways are complete for human receptors, but no human health risk from MC is expected through exposure to soil. Surface water/sediment, groundwater, and air migration pathways are not complete for human receptors in MRS 10.

E.1.1.5.4.2. Surface water/sediment and soil migration pathways are complete for ecological receptors and there is potential for ecological risk due to barium, chromium, copper, and zinc in soil and possible MC migration from soil into surface water/sediment. Groundwater and air migration pathways are not complete for ecological receptors at MRS 10.

E.1.1.5.4.3. The SI recommended further MC investigation of soil and surface water/sediment to evaluate the potential for ecological risk.

E.1.1.5.5. MRS 11 Defensive Firing Area No. 2

E.1.1.5.5.1. The Defensive Firing Area No. 2 is located on the west side of Culebra between Northwest Peninsula and the town of Dewey. The MRS consists of 719 acres. The SI included collection of four soil samples and indicated that soil, surface water/sediment, groundwater, and air migration pathways are not complete for human or ecological receptors at MRS 11.

E.1.1.5.5.2. The SI did not recommend further MC investigation at MRS 11.

E.1.1.5.6. MRS 13 Cayo Luis Pena Impact Areas

E.1.1.5.6.1. The Cayo de Luis Pena Impact area consists of 342 land acres and 864 total MRS acres. MRS 13 is approximately one-quarter mile off the western coast of Culebra. The SI indicates that the soil migration pathways are complete for human receptors, but unacceptable human health risk from MC is not expected through exposure to soil. Surface water/sediment, groundwater, and air migration pathways are not complete for human receptors at MRS 13.

E.1.1.5.6.2. Soil and surface water/sediment migration pathways are complete for ecological receptors and there is potential for ecological risk due to chromium in soil and possible MC migration from soil into surface water/sediment. Groundwater and air migration pathways are not complete for ecological receptors at MRS 13.

E.1.1.5.6.3. The SI recommended further MC investigation of soil and surface water/sediment to evaluate the potential for ecological risk.

E.1.1.5.6.4. Conceptual Site Models (CSMs) are located in Appendix Q of the Work Plan.

E.1.2. PROJECT ORGANIZATION AND RESPONSIBILITIES

E.1.2.1. The following sections provide a brief description of the project organization and responsibilities specific to MC sampling and analysis for this project. Organizations directly involved in MC sampling and analysis for this project include USAESCH, USA, the primary analytical laboratory RTI Laboratories, Livonia, Michigan (RTI), data validators, Laboratory Data Consultants (LDC), and the Quality Assurance (QA) laboratory, TestAmerica.

E.1.2.2. U.S. Army Engineering and Support Center, Huntsville

E.1.2.2.1. As the lead technical agency for this project, USAESCH is responsible for direction of the contractor, and for review and approval of this MC SAP. USAESCH will review electronic data deliverables and chemical data final reports submitted by USA and the QA Laboratory (TestAmerica). The USAESCH Technical Manager is Ms. Kim Meacham. The USAESCH Project Chemist is Ms. Teresa Carpenter.

E.1.2.3. USA Environmental, Incorporated

E.1.2.3.1. USA is the prime contractor to USAESCH for this project. USA will provide staff to perform all aspects of sample collection and provide oversight of field sampling activities. USA will assign project personnel based on management and technical experience and abilities. USA will contract TestAmerica for chemical analytical, APPL for QA analysis, and LDC for data validation. USA will prepare and submit data reports in accordance with (IAW) relevant USACE guidance. The USA Project Manager (PM) is Mr. Matt Tucker. The USA Quality Manager is Mr. Robert Crownover.

E.1.2.4. RTI Laboratories

E.1.2.4.1. RTI Laboratories (RTI) is the analytical laboratory subcontractor for this project. The RTI Customer Services Manager will coordinate with the USA QC Manager and PM on all issues concerning laboratory sample handling, analysis, analytical results, work scheduling, and laboratory QA/QC such that all environmental samples are analyzed according to appropriate methods and within specified holding times. The RTI QA Manager is responsible for oversight of data processing, data processing QC, and performance and system audits. The RTI QA Manager is Charles O'Bryan. RTI is a DoD ELAP Certified laboratory and is approved to perform USEPA Method 8330, USEPA Method 6010, and USEPA Methods 7470 and 7471.

E.1.2.5. Laboratory Data Consultants, Incorporated

E.1.2.5.1. LDC is the chemical data validation subcontractor for this project. LDC will validate the analytical data submitted IAW USACE EM 200-1-1. The LDC Data Validator is Stella Cuenco.

E.1.2.6. TestAmerica Laboratories, Incorporated

E.1.2.6.1. TestAmerica is the QA analytical laboratory subcontractor for this project. QA analytical data will be submitted directly to USAESCH. Per the website: TestAmerica is a DoD ELAP Certified laboratory and is approved to perform USEPA Method 8330, USEPA Method 6010, and USEPA Method 7471.

E.1.3. PROJECT SCOPE AND OBJECTIVES

E.1.3.1. The objective of the MC sampling and analysis effort is to determine the presence of, and the nature and extent of, the MCs that are detected above the applicable regulatory criteria and to perform a human health and ecological risk assessment IAW the EPA RAGS and USACE EM 200-1-4, Volumes I and II.

E.1.3.1.1. Rationale/Design

E.1.3.1.1.1. To determine the presence of and the nature and extent of MC and to support the human health and ecological risk assessment, USA will collect discrete surface soil, discrete subsurface soil, discrete surface water, discrete sediment, and associated background samples for laboratory analysis. Sample locations will be determined utilizing field equipment designed to indicate the presence of metals and explosive constituents. Specifically, the Innov X Systems tube-based alpha series x-ray to analyze soils for presence. The Innov-X Systems machine is approved for field use by the US Army. All field screening will be confirmed by laboratory analysis.

E.1.3.1.1.2. The sampling program for this project is a non-statistical, directed sampling approach that is intended to collect samples from locations that have the potential for MC contamination based on survey and intrusive investigation results, and information found utilizing field instrument information from the Innov-X results to determine constituent presence.

E.1.3.1.1.3. Survey and intrusive investigation data will determine the locations that project analytes may exist in soil, sediment, or surface water.

E.1.3.1.1.4. The project team will determine where the environmental investigation will occur. Once locations are determined, the field sampling team will mobilize to perform field screening and collect laboratory analytical samples. Field screening and laboratory analytical sampling will be performed in accordance with the step-out procedure presented in Figure E-1.

E.1.3.1.1.4.1. Per the step-our procedure presented in the flow chart, the location of the MEC item will first be identified. If the item is located in surface water, one surface water sample will be collected in the vicinity of the MEC item for laboratory analysis, followed by one sediment sample immediately adjacent to the MEC item at a down gradient position. This sample will also be submitted for laboratory analysis. Upon receipt of the laboratory data, it will be determined if no further analysis is required or if additional down gradient sampling is required. If the latter is determined, the project team will determine further sampling locations.

E.1.3.1.1.4.2. If the MEC item is located in sediment, one sediment sample will be collected immediately adjacent to the MEC item at a down gradient position. This sample will be submitted for laboratory analysis. Upon receipt of the laboratory data, it will be determined if no further analysis is required or if additional down gradient sampling is required. If the latter is determined, the project team will determine further sampling locations.

E.1.3.1.1.4.3. If the MEC item is located in soil, one surface soil and one subsurface soil sample will be collected immediately adjacent to the MEC item, from a down gradient position for laboratory analysis. The soil will also be screened with the Innov-X metals detector. If presence of metals is detected by the Innov-X machine, additional delineation will be performed.

E.1.3.1.1.4.3.1. The first step-out will be to collect six surface and subsurface samples from a distance of five feet from the MEC item, in a circular pattern (12 total samples). These samples will be submitted for laboratory analysis. These positions will also be screened with the Innov-X metals detector. If presence of metals is detected by the Innov-X machine, additional delineation will be performed.

E.1.3.1.1.4.3.2. From the second delineation point, the second step will proceed. The sampler will move an additional five feet out from the sample position (10 feet from the MEC item) and collect one surface and one subsurface sample for laboratory analysis. The soil will also be screened with the Innov-X metals detector. If presence of metals is detected by the Innov-X machine, additional delineation will be performed.

E.1.3.1.1.4.3.3. This delineation process will continue until the Innov-X metals detector no longer indicates the presence of metals. At the first location no presence is detected, one surface soil and one subsurface soil sample will be collected to confirm the lack of presence of metals constituents.

E.1.3.1.1.4.3.4. If laboratory data indicate that the Innov-X metals detector is not accurately determining the presence of metals, it will not be used to delineate soil in remaining sample locations.

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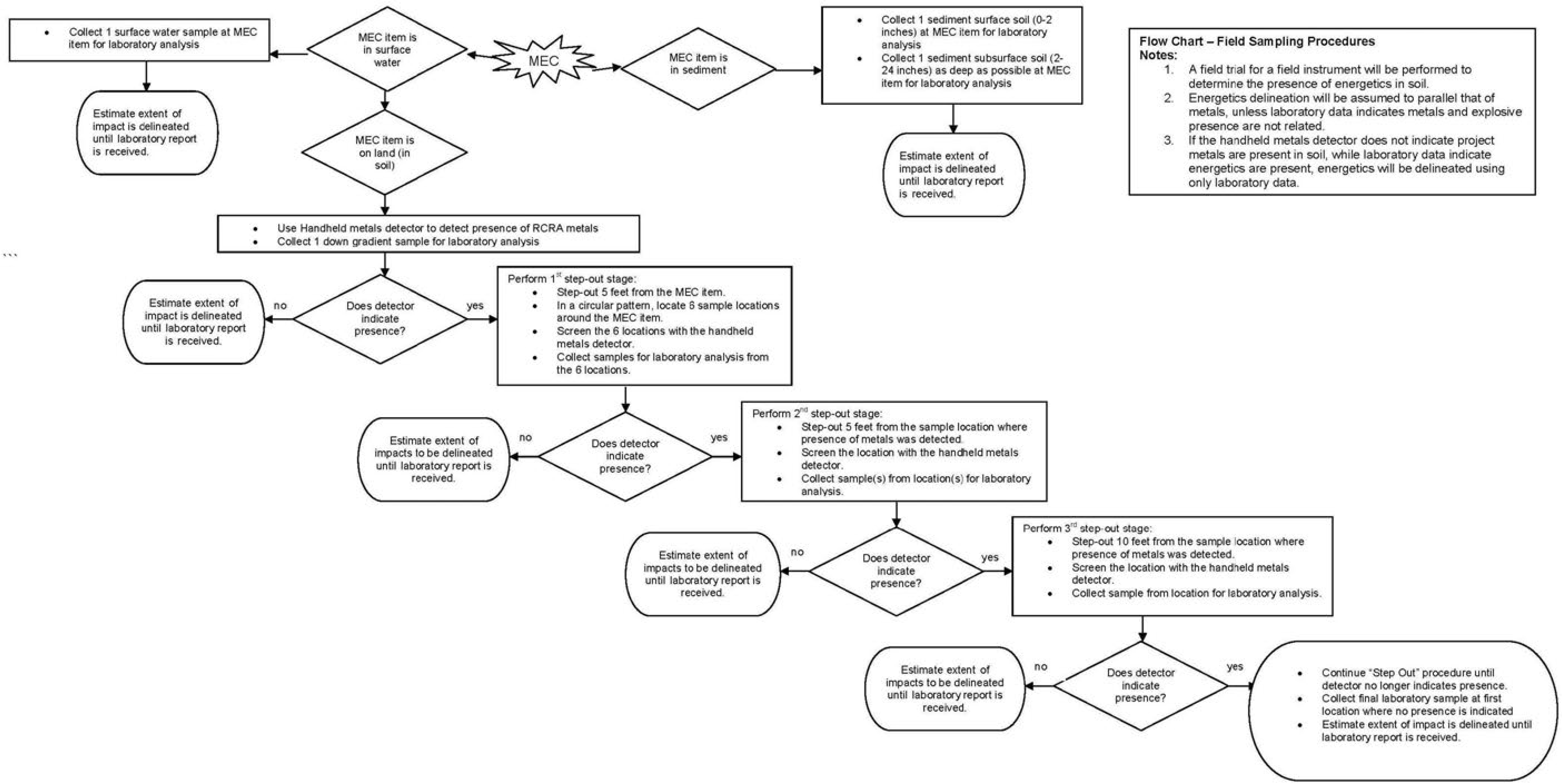

Figure E-1: Sampling Flow Chart

E.1.3.2. Task Description

E.1.3.2.1. The total number of samples will be determined by the project team based on the results of the survey and intrusive investigations. Each laboratory sample will be analyzed for energetics utilizing United States Environmental Protection Agency (USEPA) Method SW-846 Method 8330B and project metals in accordance with QAPP Worksheet 15 utilizing SW-846 Method 6010B (except mercury) and SW7470A/SW7471A (for mercury).

E.1.3.2.2. For each blow-in-place (BIP) disposal operation, the USA SUXOS and UXOQCS will collect one pre-detonation and one post-detonation composite soil sample using the CRREL 7-sample wheel approach as described in ERDC SR96-15. The total number of samples will depend on the total number of BIP events. Each soil sample will be analyzed for energetic utilizing USEPA Method SW-846 Method 8330B and metals utilizing SW-846 Method 6010B (except mercury) and SW7471A (for mercury).

E.1.3.2.3. Sample Locations

E.1.3.2.3.1. Sample locations for soil, surface water, and sediment will be established based on MEC locations discovered during the geophysical/intrusive investigation. Discrete soil samples will be collected at the immediate MEC locations. Surface water and sediment samples will be collected from the depositional areas that are downstream from MEC/MD locations. Discrete sampling procedures are provided in Section E.1.5.

E.1.3.2.3.2. Composite soils samples will be taken at the location of all pre- and post-detonation BIP events. Composite soil sampling procedures are provided in Section E.1.5.

E.1.3.2.4. Background Sample Locations

E.1.3.2.4.1. Background sampling locations will be paired to the respective soil map units as shown on the USDA soils map for Culebra (Puerto Rico, Humacao Area, Puerto Rico Eastern Part - PR689, Version 3, August 19, 2008) located in Attachment 1 of this FSP. Background samples will be taken from representative soil units in locations within the MRS (as shown in Attachment 1). Specific background locations will be recorded IAW Section E.1.6.

E.1.3.2.5. Quality Assurance (QA)/Quality Control (QC) Samples and Frequency

E.1.3.2.5.1. QA/QC samples are used to assess the representativeness of the sampling activities. They are designed to determine what effects activities such as sample container cleaning, sample collection, field decontamination, bottling and shipping have on sample integrity and to ensure that samples sent to the laboratory are representative of site conditions. Table E-1 lists the required QA/QC and blank samples for this project, along with their associated sample collection frequency.

Table E-1. QA/QC Samples and Frequency

Sample Type	Sample Collection Frequency
Field Duplicates	1 for every 10 samples
QA Split	1 for every 10 samples
MS/MSD	1 for every 20 samples
Equipment Blank	1 per sampling technique per location, when using non-disposable equipment
Temperature Blanks	1 per cooler

E.1.3.3. Cleanup Criteria

E.1.3.3.1. USA will compare MC detection to the USEPA Regional and Puerto Rico Screening Levels (RSLs) for human health risk and the USEPA Region 4 ecological screening values (ESVs) for ecological risks. Should regulatory departments find that more stringent limits be should be applied to account for the synergistic effect of non-carcinogenic compounds, USA will utilize agreed-upon limits.

E.1.3.4. Project Schedule

E.1.3.4.1. Appendix J of the RI Work Plan provides the anticipated schedule for this project.

E.1.4. NONMEASUREMENT DATA ACQUISITION

E.1.4.1. This section of the FSP is not applicable to this project. Acquisition of non-measurement data is not within the scope of this project.

E.1.5. FIELD ACTIVITIES

E.1.5.1. This section details the field sampling procedures for this project. These procedures will ensure that representative samples are collected to define the concentrations of metals and explosives in site soils, sediment, and surface water.

E.1.5.2. At each sampling location, the sampler dons a new pair of disposable latex or nitrile gloves and uses only clean, decontaminated sampling equipment for sample collection.

E.1.5.3. At each soil sampling location, the sampler removes all vegetation and debris from the sampling point prior to sampling and backfills any borings with the soil removed from the hole following sample collection.

E.1.5.4. Discrete Surface Soil Sampling Procedures

E.1.5.4.1. The discrete surface soil sample (including discrete background soil samples) will be collected from 0 to 2 inches below ground surface (bgs) using a sampling spoon. Each discrete sample will be placed into a stainless steel or Pyrex bowl and quartered. Each quarter will be mixed, and then the quarters will be mixed together to form the single discrete sample. Portions of the sample will be allocated to the sample jar until the jar is full.

E.1.5.5. Discrete Subsurface Soil Sampling Procedures

E.1.5.5.1. The discrete subsurface soil sample will be collected from 2 to 24 inches using a hand auger. Samples will be removed from the auger using a sampling spoon. Each discrete sample will be placed into a stainless steel or Pyrex bowl and quartered. Each quarter will be mixed, and then the quarters will be mixed together to form the single discrete sample. Portions of the sample will be allocated to the sample jar until the jar is full.

E.1.5.6. Composite Soil Sampling Procedures

E.1.5.6.1. Composite soil samples will be collected before and after each BIP operation using the Cold Regions Research & Engineering Laboratory (CRREL) 7-sample wheel approach described in Engineer Research and Development Center (ERDC) Special Report 96-15, titled *Assessment of Sampling Error Associated with Collection and Analysis of Soil Samples at Explosives-Contaminated Sites.* This technique will be performed as follows.

- A round, 1.2-meter in diameter sheet of plastic will be placed on the ground, centered over the desired sampling location.
- Six equally spaced surface soil samples (0 to 6 inches bgs) will be collected from around the circle and one sample will be collected from the center of the circle (Figure E-2).
- The seven samples collected will be composited by thoroughly mixing in a stainless steel or Pyrex bowl.
- Any clumps in the soil should be reduced by hand crushing with a stainless steel spoon.
- It is very important that the soil samples be mixed as thoroughly as possible to ensure that the sample is representative of all seven samples collected from the site.
- Once the soil has been thoroughly composited, the material should be coned and divided into quarters. A representative sample will then be obtained from each quarter.
- Collect suitable aliquots with a sampling spoon or equivalent and transfer into an appropriate sample bottle.

  Repeat this process as necessary until the amount of soil needed to completely fill the sample containers is obtained.
- Secure the bottle caps tightly.
- Place filled sample containers on ice immediately.
- Complete all Chain-of-Custody (COC) documents and record information in the field logbook.
- Dispose of all sampling equipment after each use in an appropriate container and label the container with the location where the sample was collected.

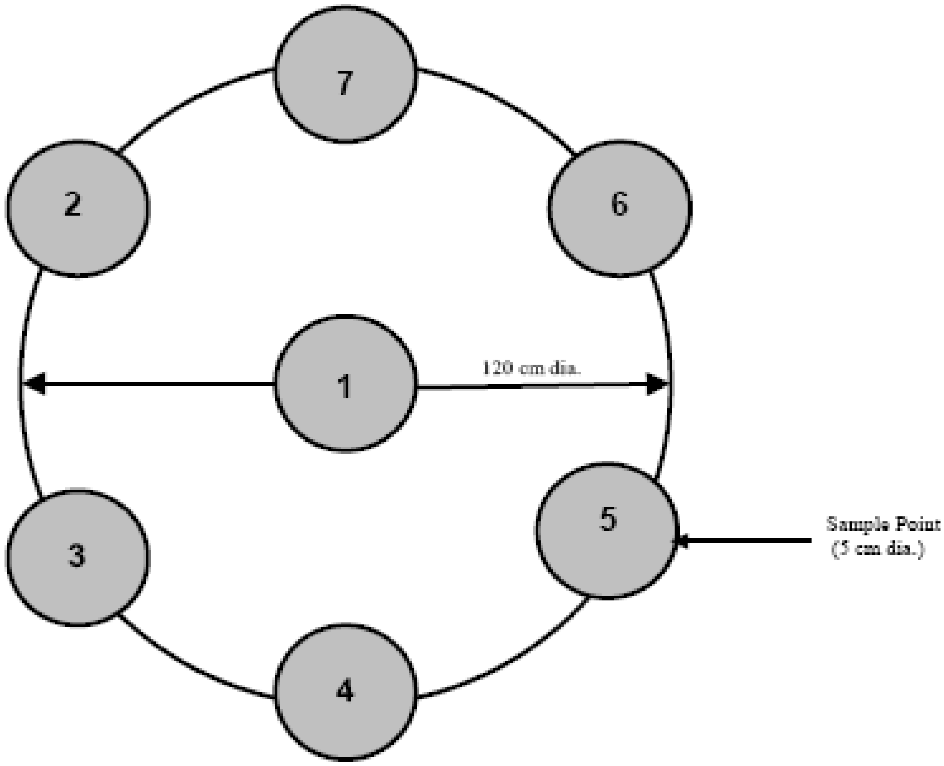

Figure E-2: CRREL 7-Wheel Diagram

E.1.5.7. Surface Water Sampling Procedures

E.1.5.7.1. The surface water sample collection location should be deep enough so the sample bottles can be completely submerged, in an area with minimal flow or surface disturbance and free of suspended material. Downstream samples will be collected first and disturbances during wading should be avoided. The direction of sample collection shall begin at the furthest downstream location and proceed to the farthest upstream location. At locations where both surface water and sediments will be collected, the surface water samples should be collected before sediment samples. The process for collecting surface water samples is as follows:

1. Facing upstream, submerge pre-labeled sample bottles in the upright position to prevent the loss of preservative into the water. Sediment should not be disturbed during the collection of surface water samples.
2. Allow sample bottle to fill and use bottle cap if necessary to fill the bottle completely.
3. After the sample bottle is filled, the cap will be placed on the bottle and the bottle will be packaged for shipment.

E.1.5.8. Sediment Sampling Procedures

E.1.5.8.1. The sediment samples should be collected furthest from the source locations first, to minimize the possibility of cross-contamination. Thereafter, the most downstream sediment samples will be collected followed by the next upstream samples, if required. If surface water samples are to be taken at the same location, they should be collected before the sediment samples. The addition of organic matter into the sediment samples should be avoided. The process for collecting sediment samples is as follows.

1. In shallow streams and ditches that allow wading, sediment samples will be collected by advancing a piece of decontaminated PVC several inches into the surface bed. A hand auger will be advanced into the center of the PVC to allow collection of the soil without influence of the water body. In areas where wading is not possible, a bucket auger or sampler outfitted with a butterfly valve will be utilized to minimize soil sample washing by the water body.
2. While facing upstream, collect the sample by scooping along the bottom of the surface water body. Remove excess water and place the sediment sample into a decontaminated stainless steel bowl.
3. After a sufficient sample volume has been collected into the stainless steel bowl, the sample will be homogenized using the quartering method and then placed into the appropriate sample bottle.
4. After the sample bottle is filled, the cap will be placed on the bottle and the bottle will be packaged for shipment.

E.1.5.9. Sample Bottles and Preservation Requirements

E.1.5.9.1. Pre-cleaned, and preserved sample bottles will be provided by the laboratory for use in collecting samples. Table E-2 lists the bottles and preservatives for this project.

Table E-2. Sample Bottles and Preservation Requirements

Analyte	Matrix	Bottle Required	Preservative
Metals	Solid	16oz glass or polyethylene container	Storage at 4°C
Mercury	Solid	16oz glass or polyethylene container	Storage at 4°C
Explosives	Solid	8oz glass wide- mouth container w/ Teflon lined lid	Storage at 4°C
Metals	Water	1L glass or polyethylene container	HNO3, Storage at 4°C
Mercury	Water	1L glass or polyethylene container	HNO3, Storage at 4°C
Explosives	Water	1L amber glass container w/ Teflon lined lid	Storage at 4°C

NOTES (to Table E-2):
1. Sample containers and coolers will be provided to USA by the analytical laboratory.
2. Samples for analysis maintained in coolers packed with ice at 4 °C ± 2 °C from the time of collection until arrival at the laboratory. Upon arrival at analytical laboratory, samples are refrigerated at 4 °C until preparation and analysis.

E.1.5.10. Field QC Sampling Procedures

E.1.5.10.1. Field Duplicates - Field duplicates will be collected during the field effort. Duplicate samples are samples collected simultaneously from the same media source under identical conditions, homogenized and split into separate containers. One field duplicate will be collected for every 10 field samples collected and submitted for laboratory analysis.

E.1.5.10.2. QA Split – QA split samples will be collected during the field effort. QA split samples are samples collected simultaneously from the same media source under identical conditions, homogenized and split into separate containers. One QA split sample will be collected for every 10 field samples collected and submitted to the QA laboratory for analysis.

E.1.5.10.3. Equipment Blanks - To the extent practicable, USA will use pre-cleaned, pre-packaged, and dedicated sampling equipment for each sample location to eliminate the generation of rinsate and decontamination water. However, if non-disposable/non-designated sampling equipment is used, USA will collect equipment blanks from each type of sampling tool used to collect environmental samples. Equipment blank samples are samples of clean analyte-free water passed through and over the sampling equipment. These blanks permit evaluation of equipment decontamination procedures and potential cross-contamination of environmental samples between sampling locations. The number of equipment blanks for each project will vary from site to site and be determined by the project team.

E.1.5.10.4. Temperature Blank - A temperature blank is a container (e.g., 40 mL) of water packaged along with field samples in the shipping cooler that will represent the temperature of the incoming cooler upon receipt at the laboratory. Use of these samples within a shipping container enables the receiving laboratory to assess the temperature of the shipment without disturbing any project field samples. All coolers will contain a minimum of one temperature blank.

E.1.5.11. Decontamination Procedures

E.1.5.11.1. Sample collection devices will be decontaminated prior to each use. Decontamination methods will be modified if necessary. The decontamination methods to be used for sampling equipment (e.g., stainless steel scoops/spoons, bowls, hand auger) are as follows:

1. Wash with tap/potable water and laboratory-grade detergent (Alconox or Liquinox). Use a scrub brush to remove dirt and surface film.
2. Rinse thoroughly with tap/potable water.
3. Rinse with deionized, organic-free, reagent grade water
4. Remove excess water.
5. Wrap in aluminum foil, shiny side out.

E.1.6. FIELD OPERATIONS DOCUMENTATION

E.1.6.1. Daily Quality Control Reports

E.1.6.1.1. During the sampling activities, daily Quality Control Reports (QCRs) will be dated and signed by the SUXOS. The QCR will be included with the SUXOS Daily Report. These will be sent to USAESCH PM daily. The QCR will include weather information at the time of sampling, field instrument measurements, calibrations, identification of all field and control samples taken, the status of each sample, departures from the SAP that were necessary, any problems encountered, and instructions from Government personnel. Any deviations that may affect DQOs will be conveyed to the USACE PM immediately.

E.1.6.2. Field Logbook and/or Sample Field Sheets

E.1.6.2.1. A logbook will be maintained during each sampling event. Its primary purpose is to provide documentation of the activities which have occurred in the field on any given day, including the conditions or activities that affected the fieldwork. The logbook will be bound and paginated, and all information will be recorded in indelible black or blue ink. Entries in the logbook will be signed and dated. The following is a partial list of the types of information that will be recorded in the logbook:

- Name and title of author; date and time of entry; and physical/environmental (weather included) conditions during the daily field activities

- Names of field personnel
- Names and titles of all site visitors
- Sampling activity purpose and plan
- Type of sampled media (e.g., surface soil)
- Name of soil map unit (reference to soil map in Attachment 1)
- Sample collection method (e.g., grab into sample container)
- Number, type, and volume of samples taken
- Sample ID number of each sampling point
- GPS location and elevation of the sampling point
- Sample description
- Analysis, number of containers, and preservation required
- Date and time sample was collected
- Instrument operational check records
- Description of sample collection activities
- Overnight shipper airbill number for each shipment and associated Chain of Custody (COC) number(s)
- Documentation of investigation-derived wastes, including contents and volume of waste generated, storage, and disposal methods.

E.1.6.2.2. Any corrections made in the logbook will be marked through with a single line and then dated and initialed.

E.1.6.3. Photographic Records

E.1.6.3.1. USA will collect digital photographs of the sampling location to depict the soil and surrounding terrain/vegetation during the surface soil sampling activities.

E.1.6.4. Sample Documentation

E.1.6.4.1. Sample Numbering System

E.1.6.4.1.1. A sample numbering system will be used to identify each sample collected during the field investigation. The numbering system will provide a tracking procedure to allow retrieval of information about a particular location and to monitor that each sample is uniquely numbered. The samples will be identified by the following sample designation scheme (refer to Table E-3). Each sample number will include an abbreviated sample location identifier. The sample designation will include the following information:

Table E-3. Sample Numbering System Example

State Code	4-Digit Date Code	Sample Type	4-Digit Sequential Sample Number
PR	1004	SS	0001

E.1.6.4.1.2. For this project, the State Code, PR, indicates that the sample was collected in Puerto Rico. The 4-Digit Date Code, 1004, indicates that the sample was collected April 2010. The sample type, SS, indicates that the collected sample media is surface soil. The 4-Digit Sequential Sample Number, 0001, indicates that the sample is sequentially the first sample collected with prefix PR-1004-SS.

E.1.6.4.1.3. Sample Type Abbreviations specific to the Culebra Island Site Sampling Program include:

- S – Surface Soil Sample
- SS – Subsurface Soil Sample
- CPRE- Pre- detonation Composite Soil Sample
- CPST – Post-detonation Composite Soil Sample
- SD – Sediment Sample
- SW – Surface Water Sample
- FD – Field Duplicate
- QA – QA Split
- EB – Equipment Blank.

E.1.6.4.2. Sample Labels and/or Tags

E.1.6.4.2.1. Prior to soil sample collection, USA will enter applicable information onto sample labels and affix the labels onto the appropriate soil sample bottle. Labels of surface water samples will be affixed following sample collection to protect the integrity of the label. All information will be clearly recorded with an indelible ink. Field sampling personnel will cover sample labels with clear tape to protect the sample information. Each sample label will contain the following information:

- Site name
- Site location
- Sample number designation
- Date and time of sample collection
- Analysis required
- Preservation

Sampler**USA Environmental, Inc.** **720 Brooker Creek Blvd., Suite 204** **Oldsmar, FL 34677**			
Project:	______________	**Contract No.**	______
Sample ID:	______ - ______ -	______ -	______
	State Date	Sample Type	Sample No.
Sample Date:	______________	**Sample Time:**	______
Site Name:	______________		
Analysis:	______________		
Sampler:	______________	**Preservation:**	______

Figure E-3: Sample Label

E.1.6.4.3. Chain-of-Custody Records

E.1.6.4.3.1. USA will follow COC procedures to protect the technical validity and legal defensibility of laboratory data. COC procedures provide legal documentation of sample collection, transfer of sample custody between personnel, sample shipping, and receipt by the laboratory that will analyze the sample. Sampling personnel will initiate the COC record during sample collection for all samples sent to RTI. At all times, samples and COC records will remain in the custody of USA personnel responsible for the samples. A sample is considered to be under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession.
- The sample is in the sampler's view after being in possession.
- The sample was in the sampler's possession and then was locked up to prevent tampering.
- The sample is in a designated secure area.

E.1.6.4.3.2. All sample shipments will be accompanied by a COC Form, presented as Attachment 3. COC forms will be signed and dated by the person receiving or relinquishing custody of the samples. If common couriers are used for sample shipment, the COC form will be documented with the carrier's name and airbill number. The airbill will be used to document the date and time of receipt and delivery.

E.1.6.4.3.3. To minimize unauthorized tampering of samples for analysis by RTI, sample coolers will be sealed with signed and dated custody seals. Only sealed coolers will be left in storage until transport to the laboratory. Samples will not be accepted as legitimate if the custody seal is compromised in any way.

E.1.6.4.3.4. The person or courier receiving the samples for transport to the laboratory will submit copies of the COC forms to the USA PM upon signature and receipt. This copy will be maintained in the USA's project files.

E.1.6.4.3.5. RTI will submit copies of signed and completed COC forms to the USA PM along with the laboratory data package. This package will become part of the final project deliverable submitted to USAESCH.

E.1.6.4.3.6. Any loss of COC forms or samples at any point during the above process will be reported to the USAESCH Project Officer.

E.1.6.5. Field Analytical Records

E.1.6.5.1. This section is not applicable to this project. USA will not perform field analyses during the soil sampling activities.

E.1.6.6. Documentation Procedures/Data Management and Retention

E.1.6.6.1. Following all site activities, field documentation will be filed in the permanent project files. All project files will be maintained for 5 years.

E.1.7. SAMPLE PACKAGING AND SHIPPING REQUIREMENTS

E.1.7.1. Sample Handling

E.1.7.1.1. Immediately after each sample has been collected, the following procedures will be used to initially prepare the sample bottles for shipment to the laboratory:

- Seal the container by wrapping tape around the lid of the container. Use PVC tape on bottles containing samples for inorganic constituent analysis.
- Place containers in bubble pack.
- Place all glass containers in a Ziplock-type bag and seal.
- Use a permanent marker to write the sample ID on the outside of the Ziplock-type bag.
- Line insulated shipping cooler with a large trash bag and place samples into the lined, insulated cooler, and then cool (to 4 ± 2 °C) using wet ice.
- Place all samples in designated cooler. Make sure all samples in the cooler are listed on the COC. Samples will be placed on ice as soon as possible following collection.

E.1.7.2. Sample Packing

E.1.7.2.1. Once all of the samples for the day are collected, the following procedures will be used to complete the sample packaging procedures for shipment to the laboratory:

- Seal completed COC form in a sealable plastic bag and tape to the inside of the cooler lid.
- Pour out water from melted ice and replace with double bagged fresh ice.
- Place sample bottles in upright position in such a way they do not touch.
- Close trash bag and seal with tape.
- Fill empty spaces in cooler with ice or packaging material.
- Tape shut cooler drain plug.
- Securely seal shipping container/cooler with packing tape and custody seals (provided by laboratory).
- Place “This side up” labels on all four sides of the cooler and “Fragile” labels on two sides of the cooler.
- Ship container/ cooler to the appropriate laboratory via overnight express.

E.1.7.3. Sample Shipping

E.1.7.3.1. Field samples collected from the project site will be sent to:

RTI Laboratories
ATTN: Charles O’Bryan
31628 Glendale Ave.
Livonia, MI 48150
Ph: (734) 422-8000

E.1.7.3.2. Upon receipt, the laboratory will use a Cooler Receipt Form consistent with Figure 3-3 in EM 200-1-3 to note the condition of each cooler and the samples contained therein. Once the cooler has been examined and logged-in, the laboratory will contact the USA PM and discuss the status of the sample shipment.

E.1.8. INVESTIGATION-DERIVED WASTES

E.1.8.1. To the extent practicable, the field sampling team will use disposable sampling equipment to minimize generation of investigation-derived waste (IDW). All disposable sampling equipment used will be wiped dry and disposed of in a municipal waste container. If only disposable sampling equipment is used, no rinsate or decontamination water will be generated.

E.1.8.2. If equipment decontamination is required, all IDW generated during the field sampling activities will be segregated by type and placed in sealed drum containers. For this project, IDW may include decontamination water, sampling and decontamination equipment, and personal protective equipment (PPE). At the completion of the field activities, each drum of IDW will be relocated to a location specified by the USAESCH PM.

E.1.8.3. Each container of IDW will be sampled to determine the final disposition of the waste.

E.1.8.4. Following receipt of analytical result, the IDW will be disposed of at an appropriate disposal facility. All waste manifests will be reviewed by USAESCH as documentation of the disposal activities.

E.1.9. FIELD ASSESSMENT/THREE-PHASE INSPECTION PROCEDURES

E.1.9.1. USA will ensure chemical data quality throughout sampling and analytical activities using the three-phase Contractor Quality Control (CQC) process, as detailed in Engineer Regulation 1180-1-6 and Corps of Engineers Guide Specifications 01450 and 01451.

E.1.9.2. Contractor Quality Control

E.1.9.2.1. As part of the USA quality control program, the USA QA Officer will review project activities at three distinct phases (preparatory, initial, and follow-up) in the CQC process. The USA QA Officer will perform these duties whether or not a Government representative is present. The USA QA Officer will summarize CQC activities in the contractor daily quality control reports.

E.1.9.2.2. The frequency of implementation is specified by each definable feature of work (DFW) (a task that is separate and distinct from other tasks and has separate control requirements). For this project, the definable features are soil sample collection and sample custody transfer/ shipment. In addition, the USA QA Officer will ensure that data reporting meets the project requirements.

E.1.9.2.3. Preparatory Phase

E.1.9.2.3.1. The USA QA Officer, in conjunction with the field sampling team, will conduct the preparatory phase inspection prior to the beginning of soil sample collection. The USA field sampling team will review the SAP prior to this inspection, and will participate in a discussion of pertinent sections of this plan during the preparatory meeting. This inspection includes a review of work requirements, a physical examination of required materials and equipment, and a demonstration of field activities, including:

- Soil sample collection using the intended sample containers, sampling equipment, and sample handling procedures.
- Sample numbering, sample labeling, and sample shipment documentation using a full set of sample custody forms, proper shipping addresses and phone numbers,

proper analytical test methods, and proper sample preservation requirements.

E.1.9.2.4. Initial Phase

E.1.9.2.4.1. The USA QA Officer will perform the initial phase inspection when soil sampling is first initiated. The USA QA Officer will oversee sampling activities and review the work for compliance with contract requirements, including:

- Inspection of field logbooks to confirm that pertinent data are recorded IAW the contract requirements,
- Inspection of sample labels and COC forms for accuracy, completeness, and consistency,
- Inspection of the packaging and shipping of the samples, and
- Inspection of the sample summary table (Table E-4) to confirm that the sampling team leader has matched up primary and QA samples at the conclusion of each day of sampling and attached a copy of the daily quality control reports.

E.1.9.2.5. Follow-up Phase

E.1.9.2.5.1. The USA QC Officer will perform follow-up inspections on an as-needed basis to confirm that samples are properly collected, stored, packaged, shipped, and analyzed. The USA QC Officer will periodically check general procedures and documentation to ensure they are complete, accurate, and consistently executed for the duration of the project. These follow-up Inspections will also include a review of field data.

Table E-4. Sample Summary Table

Sample	**Sample Depth (bgs*) in inches**	**Primary Sample Number PR-XXXX-**	**Field Duplicate Sample Number PR-XXXX-**	**QA Split Sample Number PR-XXXX-**	**EPA Method 8330**	**EPA Method 6010B/7471A**
1	0 - 2	S-0001	FD-0001	QA-0001	X	X
2	0 - 2	S-0002	-	-	X	X
3	0 - 2	S-0003	-	-	X	X
4	0 - 2	S-0004	-	-	X	X
5	0 - 2	S-0005	-	-	X	X
6	0 - 2	S-0006	-	-	X	X
7	0 - 2	S-0007	-	-	X	X
8	0 - 2	S-0008	-	-	X	X
9	0 - 2	S-0009	-	-	X	X
10	0 - 2	S-0010	-	-	X	X
*** bgs =below ground surface**						

E.1.9.3. Sampling Apparatus and Field Instrumentation Checklist

E.1.9.3.1. The following is a checklist of required on-site materials, which will be verified during the preparatory phase inspection.

E.1.9.3.1.1. Project plans, and contractual documentation

- Contract plans and specifications
- Project plans: Work Plan, SAP, APP, Standard Operating Procedures (SOPs)
- Summary of QA Elements and associated Measurement Quality Objectives
- Area maps for site identification and documenting sampling locations.

E.1.9.3.1.2. Project logbooks, forms, logs, and tables

- Field logbooks/indelible ink pens
- Sample summary table
- CQC reports
- Shipping container checklist
- COC forms
- Laboratory notification checklist
- Sample shipping documents (e.g., airbills)
- Communication and phone logs
- Copy of ENG Form 4025.

E.1.9.3.1.3. Sample collection and handling equipment

- SOPs available for each sampling and sample handling protocol planned
- Direct sampling equipment that comes in direct contact with the sample
- PPE (e.g., gloves, safety glasses, duct tape)
- Sample containers for each test or chemical analysis
- Labels for sample containers.

E.1.9.3.1.4. Sample packaging and shipment materials

- Shipping container checklist
- Sample shipping coolers
- Chain-of-custody forms, analysis request forms, laboratory notification checklist, cooler receipt forms
- Sample packing materials, including plastic bags and bubble wrap/packing peanuts
- Ice/ice packs to cool sample cooler
- Temperature blanks
- Strapping tape
- COC seals

- Address labels, airbill, or shipping papers, including a completed example of the sample shipping documents used
- Laboratory information: name, address, phone number, point of contact, turnaround time for the analyses
- Communication log between field and laboratory personnel. Documentation that all laboratories have been notified that the samples will be shipped and confirmation that the laboratory will accept the samples.

E.1.10. NONCONFORMANCE/CORRECTIVE ACTIONS

E.1.10.1. In the event a nonconformance/discrepancy is discovered by field personnel or during a desk or field audit (e.g., improper sampling procedures, improper instrument use, incomplete or improper sample preservation, and problems with samples upon receipt at the laboratory), USA will determine the cause of the discrepancy, take corrective actions to preclude repetition, and document and report the discrepancy, cause, and proposed corrective actions to the USA PM, the USA QA Officer, and the USAESCH PM. Implementation of corrective actions will be verified by documented follow-up action. All project personnel have the daily responsibility to promptly identify and report any condition adverse to quality.

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SAP ATTACHMENT 1

SOIL MAP

SOIL SURVEY OF

Humacao Area of Eastern Puerto Rico

United States Department of Agriculture
Soil Conservation Service

In cooperation with
University of Puerto Rico
College of Agricultural Sciences

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1962–68. Soil names and descriptions were approved in 1969. Unless otherwise indicated, statements in the publication refer to conditions in the area in 1969. This survey was made cooperatively by the Soil Conservation Service and the University of Puerto Rico, College of Agricultural Sciences, Mayaguez Campus. It is part of the technical assistance furnished to the Noreste, Este, and Sudeste Soil Conservation Districts.

Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, woodlands, and wildlife areas; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of the Humacao Area are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the area in alphabetic order by map symbol and gives the capability classification and the woodland suitability group of each. It also shows the page where each soil is described.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the descriptions of the capability units and the woodland suitability groups.

Foresters and others can refer to the section "Use of the Soils for Woodland," where the soils of the county are grouped according to their suitability for trees.

Community planners and others can read about soil properties that affect the choice of sites for recreation areas in the section "Use of the Soils for Recreation Facilities."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers to the Humacao Area may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given on page 1.

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Issued January 1977

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Summary of Tables

SOIL SURVEY OF THE HUMACAO AREA OF EASTERN PUERTO RICO

BY RAFAEL A. BOCCHECIAMP, SOIL CONSERVATION SERVICE

FIELDWORK BY RAFAEL A. BOCCHECIAMP, WILLIAM FRANCIA RIVERA, JULIO E. TRIGO, JUAN E. BRUNET, ENRIQUE ORTIZ TORRES, WILLIAM E. McKINZIE, AND LUIS H. RIVERA, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE UNIVERSITY OF PUERTO RICO, COLLEGE OF AGRICULTURAL SCIENCES

THE HUMACAO AREA OF EASTERN PUERTO RICO is about 470,202 acres in size. It includes 16 municipalities and two offshore islands of Vieques and Culebra (fig. 1). Important cities are Humacao, the

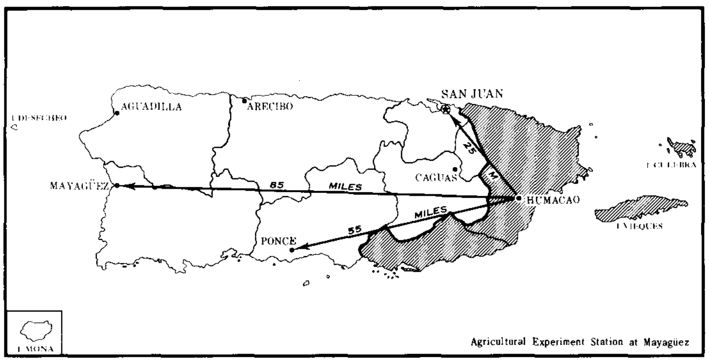

Figure 1.—Location of the Humacao Area in Puerto Rico.

more centrally located city in the area, Carolina, Fajardo, and Guayama. The area has three well-defined climatic regions. The southern part is semiarid, the northern and eastern parts are humid, and in the north central part there is a tropical rain forest where the annual precipitation is very high. Within these climatic regions are well-defined physiographic areas, such as the coastal plains and lowlands, inner valleys, nearly level river flood plains, and sloping to very steep uplands. Sugarcane is grown in the nearly level to sloping areas, and pasture and a variety of food crops are grown in the steeper uplands.

In 1970, 444,369 persons lived in the Humacao Area; in 1960, only 346,930 lived there. Much of the increase has been in the suburbs of the larger cities, especially Carolina, which is the closest township to San Juan. Land use is changing rapidly near San Juan.

The Guayanés River Watershed Project has been approved for this survey area. Two large petrochemical complexes and numerous light industries are established in the area. Public and private transportation link towns and the rural areas on an excellent network of state and municipal roads.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in the Humacao Area, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in areas nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Humacao and Fajardo, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Bajura clay, frequently flooded, is one of several phases within the Bajura series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Three such kinds of mapping units are shown on the soil map of the Humacao Area: soil complexes, soil associations, and undifferentiated soil groups.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Descalabrado-Rock land complex, 40 to 60 percent slopes, is an example.

A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but are shown as one unit because the time and effort of delineating them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils may differ greatly one from another. The name of an association consists of the names of the dominant soils, joined by a hyphen. Guayabota-Ciales-Picacho association, very steep, is an example.

An undifferentiated soil group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Descalabrado and Guayama soils, 20 to 60 percent slopes, eroded, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Rock land is a land type in the Humacao Area.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kind of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants and as building material, foundation, or covering for structures. They relate this behavior to properties of the soils. For example, if they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, they relate this to the slow permeability of the soil or its high water table. If they see that streets, road pavements, and foundations for houses are cracked on a named kind of soil, they relate that failure to the high shrink-swell potential of the soil. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consulting farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the Humacao Area. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association can occur in another but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in an area, who want to compare different parts of an area, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area or in planning engineering works, recreation facilities, and community developments. It is not a suitable map for planning the management of a farm or field or for selecting a site for a road or building or other structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in this survey have been grouped into two general kinds of landscapes for broad interpretative purposes. Each of the broad groups and their included soil associations are described in the following pages.

Soils of the Humid Areas

Nearly level to hilly soils that receive sufficient moisture for growing the common plants. Eight soil associations are in this group.

1. Swamps-Marshes association

Deep, very poorly drained soils on the coastal plains

This association is in level or nearly level, narrow strips adjacent to the ocean. The areas are slightly above sea level but are wet and, when the tide is high, are covered or affected by salt water or brackish water. The high concentration of salt inhibits the growth of all vegetation except mangrove trees and, in small scattered patches, other salt-tolerant plants.

The association occupies about 4 percent of the survey area. Tidal swamps make up 85 percent of the association and Tidal flats and Salt water marshes make up 15 percent.

The soils are sandy or clayey and contain organic material from decaying mangrove trees. They are underlain by coral, shells, and marl at varying depths.

This association is not extensive and has no value for farming, but it serves as a feeding and breeding place for birds and crabs.

2. *Pandura-Rock land-Patillas association*

Shallow to deep, well-drained, steep and very steep soils on plutonic uplands

This association consists of brown-colored soils that formed in residual material that weathered from plutonic rocks, mainly quartz diorite and granodiorite. It occupies about 17 percent of the survey area.

Pandura soils make up about 49 percent of the association; Rock land, 19 percent; and Patillas soils, 12 percent. The rest is minor soils.

The Pandura soils are moderately deep and well drained and are underlain by granitic rocks. Rock land consists of areas where granitic boulders cover 50 to 70 percent of the land surface. The Patillas soils are moderately deep to saprolite, are well drained, and are underlain by partly weathered granitic rocks.

The minor soils are of the Vieques and Teja series. These soils are on side slopes.

The soils of this association are used mainly for food crops and native grasses. Steep slopes and shallow depth to bedrock are limitations for farming and for recreation and urban uses.

3. *Coloso-Toa-Bajura association*

Deep, moderately well drained to poorly drained, nearly level soils on flood plains

This association consists of nearly level soils that formed in fine textured and moderately fine textured sediment of mixed origin on flood plains. It occupies about 12 percent of the survey area.

Coloso soils make up about 18 percent of the association; Toa soils, 13 percent; Bajura soils, 10 percent; Maunabo soils, 8 percent; and Reilly soils, 7 percent. The remaining 44 percent consists of minor soils.

The Coloso soils are deep and somewhat poorly drained. The Toa soils are deep and moderately well drained. The Bajura soils and the Maunabo soils are deep and poorly drained. The Reilly soils are shallow to sand and gravel and are excessively drained; they lie adjacent to streams.

The minor soils are Talante, Vivi, Fortuna, Vega Alta, and Vega Baja soils. The Fortuna, Talante, Vivi, and Vega Baja soils are on flood plains, but the Vega Alta soils occupy slightly higher positions on terraces.

Soils of this association are the best soils for farming in the humid part of the survey area, though they are occasionally flooded. They are suited to many kinds of plants. Some of the soils have impeded drainage that can be corrected by a suitable drainage system. The soils have severe limitations for industrial and recreation uses because they are subject to flooding.

4. *Los Guineos-Humatas-Lirios association*

Deep, well drained and moderately well drained, gently sloping to very steep, acid soils on volcanic uplands

This association consists of soils that formed in medium-textured and fine-textured residual material derived from highly weathered intrusive and extrusive rocks. It occupies about 10 percent of the survey area.

Los Guineos soils make up about 40 percent of the association; Humatas soils, 30 percent; and Lirios soils, 14 percent. The remaining 16 percent consists of minor soils.

The Los Guineos soils are deep, moderately well drained, and moderately steep to very steep. They are on side slopes of strongly dissected uplands. The Humatas soils are deep, well drained, and steep to very steep. The Lirios soils are deep, well drained, and gently sloping to steep.

The minor soils are Limones, Ingenio, Jagueyes, and Aceitunas soils. The Limones, Ingenio, and Jagueyes soils are on side slopes and narrow ridgetops, and the Aceitunas soils are on foot slopes and terraces.

Soils of this association are used mainly as woodland and for crops. Food crops, such as plantains, tanniers, and yams, are the most important. Because the soils are gently sloping to very steep and subject to erosion, they have limitations for urban, farm, and recreation uses.

5. *Mabi-Rio Arriba-Cayagua association*

Deep, somewhat poorly drained and moderately well drained, nearly level to moderately steep soils on foot slopes, side slopes, terraces, and alluvial fans

This association consists of soils that formed in moderately coarse-textured to fine-textured sediment derived from intrusive and extrusive rocks. It occupies about 7 percent of the survey area.

Mabi soils make up about 29 percent of the association; Rio Arriba soils, 23 percent; and Cayagua soils, 15 percent. The remaining 33 percent consists of minor soils.

Mabi soils are deep, somewhat poorly drained, and nearly level to moderately steep. They lie on terraces and alluvial fans above the river flood plains. Rio Arriba soils also are on terraces and alluvial fans. They are deep, moderately well drained, and gently sloping to strongly sloping. Cayagua soils are deep, somewhat poorly drained, and gently sloping to moderately steep. They occupy side slopes and foot slopes.

The minor soils are Junquitos, Candelero, Via, Humacao, Fajardo, and Parcelas soils. The Junquitos soils are on foot slopes, and the Candelero, Via, Humacao, Fajardo, and Parcelas soils are on terraces.

The soils of this association are used for crops. Unfavorable drainage is the main limitation for farming. The shrink-swell potential limits recreation and urban uses of the soils.

6. Caguabo-Mucara-Naranjito association

Shallow and moderately deep, well-drained, sloping to very steep soils on volcanic uplands

This association consists of soils that formed in residual material that weathered from volcanic rocks. It occupies 19 percent of the survey area.

Caguabo soils make up about 42 percent of the association; Mucara soils, 19 percent; and Naranjito soils, 13 percent. The remaining 26 percent consists of minor soils.

The Caguabo soils are shallow, well drained, and moderately steep to very steep. They occupy side slopes of strongly dissected volcanic uplands. The Mucara soils are moderately deep, well drained, and strongly sloping to very steep. They also occupy side slopes of strongly dissected volcanic uplands. Naranjito soils are moderately deep, well drained, and steep to very steep. They are on dissected volcanic uplands.

The minor soils are Sabana, Daguao, and Yunes soils. The Sabana and Yunes soils are on side slopes, and the Daguao soils are on foot slopes and side slopes.

The soils of this association are used for pasture and food crops, such as tanniers, yams, plantains, bananas, and pigeonpeas. Steep slopes, the hazard of erosion, and depth to bedrock are the main limitations for farming and for recreation and urban uses.

7. Los Guineos-Guayabota-Rock land association

Shallow to deep, well-drained to poorly drained, strongly sloping to very steep soils on volcanic uplands of the tropical rain forest

This association consists of soils that formed in fine-textured residual material that weathered from intrusive and extrusive rocks. It occupies about 6 percent of the survey area.

Los Guineos and Yunque soils and Stony rock land together make up about 56 percent of the association; Guayabota, Ciales, and Picacho soils together, 27 percent; and Rock land, the remaining 17 percent.

The Los Guineos soils are deep, moderately well drained, and moderately steep to very steep. They are on side slopes of dissected uplands. The Yunque soils also are deep and moderately well drained. They lie on ridgetops and upper side slopes of strongly dissected uplands. Stony rock land is on the lower part of side slopes and along drainageways, where 90 to 100 percent of the surface is made up of grayish and bluish volcanic rocks.

The Guayabota soils are shallow, poorly drained soils on ridgetops and upper side slopes. The Ciales soils are deep and poorly drained. They occupy strongly dissected, moderately steep ridgetops and steep upper side slopes. The Picacho soils are deep, moderately well drained soils that are on upper side slopes. Rough stony land consists of the high, jagged mountain peaks and long, very steep side slopes. Rocks make up about 75 to 100 percent of the surface.

Rock land consists of areas where rock outcrops occupy 50 to 70 percent of the surface.

The soils of this association are used mainly as woodland, and some areas of virgin timber still remain. These soils have severe limitations for farm and urban uses because of very steep slopes, stoniness and rockiness, and high rainfall. They are suitable for recreation uses because of their high esthetic value.

8. Catano-Aguadilla association

Deep, excessively drained, nearly level to gently sloping soils on coastal plains

This association consists of soils that formed in a mixture of sand-sized fragments of shells and volcanic material and grains of quartz sand. It occupies about 2 percent of the survey area.

Catano soils make up about 53 percent of the association, and Aguadilla soils, 30 percent. The remaining 17 percent is minor soils.

The Catano soils are deep and excessively drained and lie close to sea level. The Aguadilla soils are deep, excessively drained, acid, and nearly level.

The minor soils are Meros soils and the land type Coastal beaches. These are along the coast, slightly above sea level.

Soils of this association are mainly in pasture and coconut trees. The available water capacity, organic-matter content, and fertility all are low, and these are the main limitations for farming. The soils have slight limitations for recreation uses.

Soils of the Dry Areas

Nearly level to hilly soils that receive limited rainfall and are deficient in moisture for growing the common plants. Three soil associations are in this group.

9. Coamo-Guamani-Vives association

Deep, well-drained, nearly level to strongly sloping soils on terraces and alluvial fans

This association consists of soils that formed in sediment derived from limestone and volcanic rocks. It occupies about 6 percent of the survey area.

Coamo soils make up 30 percent of the association; Guamani soils, 18 percent; and Vives soils, 17 percent. The remaining 35 percent consists of minor soils.

The Coamo soils are deep, well drained, and nearly level to strongly sloping. They are on terraces. The Guamani soils are shallow to sand and gravel, well drained, and nearly level. They occur on flood plains. The Vives soils are deep, well drained, and nearly level to strongly sloping. They are on flood plains, alluvial fans, and terraces.

The minor soils are Machete, Arenales, Pozo Blanco, and Vayas soils. The Vayas and Arenales soils are on river flood plains, the Pozo Blanco soils are on foot slopes, and the Machete soils are on alluvial fans and terraces.

Soils of this association are some of the best soils for farming in the semiarid part of the survey area, and they are used mainly for pasture and sugarcane. Low rainfall is a limitation, but if the soils are properly irrigated, many kinds of cultivated crops can be grown. Some of the soils in the association are suitable for urban and industrial uses, but others have severe limitations.

10. Descalabrado-Guayama association

Shallow, well-drained, strongly sloping to very steep soils on volcanic uplands

This association consists of soils that formed in moderately fine textured to fine textured residual material derived from basic volcanic rocks. It occupies about 12 percent of the survey area.

Descalabrado soils make up about 41 percent of the association, and Guayama soils, 32 percent. The rest is small areas of Rock land and minor soils.

The Descalabrado and Guayama soils are shallow, well drained, and strongly sloping to very steep.

The soils of this association are used for pasture or are in brush. They have severe limitations for farming and for recreation and urban uses because they are shallow to bedrock, lack sufficient moisture, are steep, and are susceptible to erosion.

11. *Jacana-Amelia-Fraternidad association*

Moderately deep and deep, well drained and moderately well drained, nearly level to strongly sloping soils on terraces, alluvial fans, and foot slopes

This association consists of soils that formed in fine-textured sediment and gravelly sediment derived from limestone and volcanic rocks. It occupies about 5 percent of the survey area.

Jacana soils make up about 24 percent of the association; Amelia soils, 23 percent; and Fraternidad soils, 15 percent. The rest is minor soils.

The Jacana soils are moderately deep, well drained, and gently sloping to strongly sloping. They are on foot slopes. The Amelia soils are deep, well-drained, gently sloping to strongly sloping soils on foot slopes. The Fraternidad soils are deep, moderately well drained, and nearly level to strongly sloping. They are on terraces and alluvial fans.

The minor soils are Cartagena, Paso Seco, and Poncena soils on alluvial fans and terraces.

Soils of this association are used mainly for sugarcane and pasture. They have limitations for farm, recreation, and urban uses because of moderate slope, susceptibility to erosion, low rainfall, and high shrink-swell potential.

Descriptions of the Soils

This section describes each soil series in detail and then, briefly, each mapping unit in that series. Unless stated otherwise, what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface down to rock or other underlying material. Each series contains two descriptions of the profile. The first is brief and in terms familiar to a layman. The second is more detailed and is included for those who need to make thorough and precise studies of soils. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit. Color terms are for moist soil unless otherwise stated.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Coastal beaches, for example, does not belong to a soil series, but nevertheless, it is listed in alphabetic order along with the soil series.

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and woodland suitability group in which the mapping unit has been placed. The capability unit and woodland suitability group of each mapping unit is also listed in the "Guide to Mapping Units" at the end of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*5*).[1]

Aceitunas Series

The Aceitunas series consists of deep soils that are well drained and moderately permeable. These soils formed in moderately fine textured and fine textured sediment. They are on foot slopes and terraces. Slopes are 5 to 12 percent. The climate is humid tropical. The average annual rainfall is 66 inches, and the average annual temperature is 77° F.

In a representative profile, the surface layer is dark reddish-brown, extremely acid silty clay loam about 10 inches thick. Below this layer, yellowish-red clay extends to a depth of 35 inches. It is underlain by yellowish-red, friable silty clay, which extends to a depth of more than 60 inches.

These soils have moderate available water capacity and shrink-swell potential and medium fertility. Runoff is medium. Most of the acreage is used for sugarcane, improved pasture, and food crops, but there are small areas in native pasture and brush.

Representative profile of Aceitunas silty clay loam, 5 to 12 percent slopes, 200 meters south and 8 meters west of kilometer marker 13.1 on Highway No. 31, Naguabo to Juncos:

Ap—0 to 10 inches, dark reddish-brown (5YR 3/3) silty clay loam; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; clay films along root channels; few, fine, black concretions; few pebbles 1 to 4 millimeters in diameter; few krotovinas; common root channels; extremely acid; abrupt, wavy boundary.

B21t—10 to 19 inches, yellowish-red (5YR 5/6) clay; moderate, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; common fine roots; thin patchy clay films on root channels and ped surfaces; few krotovinas; few fine pebbles; few dark minerals; extremely acid; gradual, wavy boundary.

B22t—19 to 25 inches, yellowish-red (5YR 4/8) clay; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; thin patchy clay films; few fine pebbles; very strongly acid; clear, smooth boundary.

B23t—25 to 35 inches, yellowish-red (5YR 4/6) clay; weak, fine, subangular blocky structure; firm, slightly sticky and slightly plastic; common fine pores; few

[1] Italic numbers in parentheses refer to Literature Cited, p. 99

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Mapping unit	Area	Extent
	Acres	*Percent*
Aceitunas silty clay loam, 5 to 12 percent slopes	2,920	0.6
Aguadilla loamy sand	2,100	.4
Aguadilla sandy loam, moderately wet	743	.2
Amelia gravelly clay loam, 2 to 5 percent slopes	1,961	.4
Amelia gravelly clay loam, 5 to 12 percent slopes, eroded	2,971	.6
Arenales sandy loam	407	.1
Arenales sandy loam, gravelly substratum	345	.1
Bajura silty clay, saline	253	([1])
Bajura clay, frequently flooded	5,170	1.1
Caguabo clay loam, 12 to 20 percent slopes, eroded	163	.1
Caguabo clay loam, 20 to 60 percent slopes, eroded	40,337	8.6
Candelero loam, 2 to 5 percent slopes	1,193	.2
Candelero loam, 5 to 12 percent slopes, eroded	3,149	.7
Cartagena clay	1,704	.4
Catano loamy sand	4,957	1.1
Cayagua sandy loam, 5 to 12 percent slopes, eroded	3,170	.7
Cayagua sandy loam, 12 to 20 percent slopes, eroded	1,393	.3
Coamo clay loam, 2 to 5 percent slopes	5,659	1.2
Coamo clay loam, 5 to 12 percent slopes	1,805	.4
Coastal beaches	1,094	.2
Cobbly alluvial land	3,824	.8
Coloso silty clay loam, occasionally flooded	7,892	1.7
Coloso silty clay	2,139	.4
Corcega sandy loam	1,210	.3
Daguao silty clay loam, deep variant, 2 to 12 percent slopes	237	([1])
Daguao clay, 20 to 40 percent slopes, eroded	826	.2
Descalabrado clay loam, 5 to 12 percent slopes, eroded	1,125	.2
Descalabrado clay loam, 20 to 40 percent slopes, eroded	12,741	2.7
Descalabrado and Guayama soils, 20 to 60 percent slopes, eroded	19,810	4.2
Descalabrado-Rock land complex, 40 to 60 percent slopes	12,462	2.6
Fajardo clay, 2 to 10 percent slopes	274	.1
Fajardo clay, 2 to 10 percent slopes, eroded	423	.1
Fortuna clay	2,044	.4
Fraternidad clay, 0 to 2 percent slopes	2,288	.5
Fraternidad clay, 2 to 5 percent slopes	777	.2
Guamani silty clay loam	4,849	1.1
Guayabota silty clay loam, 20 to 40 percent slopes, eroded	584	.1
Guayabota-Ciales-Picacho association, very steep	6,863	1.5
Guayama clay loam, moderately deep variant, 2 to 12 percent slopes, eroded	810	.2
Humacao loam, 2 to 5 percent slopes	885	.2
Humatas clay, 20 to 40 percent slopes, eroded	5,002	1.1
Humatas clay, 40 to 60 percent slopes, eroded	5,240	1.1
Humatas-Stony land complex, 40 to 60 percent slopes	1,786	.4
Ingenio silty clay loam, 20 to 40 percent slopes, eroded	1,210	.3
Jacana clay, 2 to 5 percent slopes	975	.2
Jacana clay, 5 to 12 percent slopes, eroded	4,167	.9
Jagueyes loam, 20 to 40 percent slopes, eroded	828	.2
Junquitos gravelly clay loam, 5 to 12 percent slopes	1,370	.3
Leveled clayey land	987	.2
Limones silty clay, 20 to 40 percent slopes, eroded	1,754	.4
Lirios clay loam, 3 to 10 percent slopes, eroded	509	0.1
Lirios silty clay loam, 20 to 40 percent slopes, eroded	5,132	1.1
Los Guineos silty clay loam, 12 to 20 percent slopes	354	.1
Los Guineos silty clay loam, 20 to 40 percent slopes, eroded	3,868	.8
Los Guineos silty clay loam, 40 to 60 percent slopes, eroded	14,233	3.1
Los Guineos-Yunque-Stony rock land association, steep	15,766	3.3
Mabi clay, 0 to 5 percent slopes	4,653	1.0
Mabi clay, 5 to 12 percent slopes, eroded	2,669	.6
Mabi clay, 12 to 20 percent slopes, eroded	541	.1
Machete loam, 0 to 2 percent slopes	1,049	.2
Machete loam, 2 to 5 percent slopes	1,333	.3
Made land	3,167	.7
Maunabo clay	4,215	.9
Mayo loam, 3 to 10 percent slopes	578	.1
Meros sand, 1 to 6 percent slopes	725	.1
Mucara silty clay loam, 12 to 20 percent slopes, eroded	1,891	.4
Mucara silty clay loam, 20 to 40 percent slopes, eroded	17,166	3.6
Naranjito silty clay loam, 20 to 40 percent slopes, eroded	5,979	1.3
Naranjito silty clay loam, 40 to 60 percent slopes, eroded	6,001	1.3
Pandura loam, 12 to 40 percent slopes, eroded	2,177	.5
Pandura loam, 40 to 60 percent slopes, eroded	23,353	5.0
Pandura-Very stony land complex, 40 to 60 percent slopes	14,845	3.2
Parcelas clay, 5 to 12 percent slopes, eroded	1,125	.2
Paso Seco clay, 0 to 5 percent slopes	1,157	.2
Patillas clay loam, 12 to 20 percent slopes, eroded	462	.1
Patillas clay loam, 20 to 40 percent slopes, eroded	3,272	.7
Pinones silty clay	1,215	.3
Poncena clay	3,233	.7
Pozo Blanco clay loam, 5 to 12 percent slopes, eroded	725	.1
Reilly soils	3,885	.8
Reparada clay	222	.1
Rio Arriba clay, 2 to 5 percent slopes	2,799	.6
Rio Arriba clay, 5 to 12 percent slopes, eroded	3,989	.8
Rock land	21,913	4.7
Rough stony land	3,964	.8
Sabana silty clay loam, 20 to 40 percent slopes, eroded	5,756	1.2
Sabana silty clay loam, 40 to 60 percent slopes, eroded	6,247	1.3
Salt water marsh	1,174	.2
Talante soils	3,332	.7
Teja gravelly sandy loam, 12 to 40 percent slopes	6,768	1.4
Tidal flats	1,513	.3
Tidal swamp	15,364	3.3
Toa silty clay loam	5,417	1.1
Utuado-Picacho-Stony rock land association, very steep	3,476	.7
Vayas silty clay loam, occasionally flooded	442	.1
Vayas silty clay, frequently flooded	1,398	.3
Vega Alta silty clay loam, 2 to 5 percent slopes	765	.2
Vega Alta silty clay loam, 5 to 12 percent slopes	739	.2

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

Mapping unit	Area	Extent
	Acres	*Percent*
Vega Baja silty clay loam, 0 to 3 percent slopes	435	0.1
Via silty clay loam, 3 to 10 percent slopes	1,470	.3
Vieques loam, 5 to 12 percent slopes	1,114	.2
Vieques loam, 12 to 40 percent slopes, eroded	7,566	1.6
Vives silty clay loam, high bottom	3,147	.7
Vives clay, 0 to 2 percent slopes	1,646	.3
Vives clay, 2 to 7 percent slopes	2,490	.5
Vivi loam	1,421	0.3
Wet alluvial land	3,722	.8
Yunes silty clay loam, 20 to 60 percent slopes, eroded	2,943	.6
Urban, built-up, water areas, miscellaneous, etc.	26,816	5.7
Total	470,202	100.0

[1] Less than 0.1 percent.

patchy clay films; few pebbles; very strongly acid; clear, wavy boundary.

B3—35 to 60 inches, yellowish-red (5YR 4/8) silty clay; weak, fine, subangular blocky structure; friable, nonsticky and slightly plastic; few fine pores; very strongly acid.

The solum is more than 60 inches thick. The A horizon has a chroma of 3 to 4. The B2t horizon is 25 inches or more thick. It has weak or moderate, subangular blocky structure, and has value of 4 or 5 and chroma of 6 to 8.

The Aceitunas soils are on the same landscape as the Mabi and Rio Arriba soils. They are less plastic and have a lower shrink-swell potential than the Mabi and Rio Arriba soils.

AcC—Aceitunas silty clay loam, 5 to 12 percent slopes. This soil is on foot slopes and terraces. Included with it in mapping were small areas of Rio Arriba, Mabi, and Junquitos soils.

This soil has moderate limitations for farming because of slope and the hazard of erosion. Special conservation practices are required if the soil is clean cultivated. This soil is used for sugarcane, food crops, and pasture. If the soil is properly limed and fertilized, it is suited to most crops grown in the area. Capability unit IIIe–1.

Aguadilla Series

The Aguadilla series consists of deep soils that are excessively drained and rapidly permeable. These soils formed in sands of mixed origin. They are near sea level, and slopes are 0 to 2 percent. The climate is humid tropical. The average annual precipitation is 80 inches, and the average annual temperature is 77° F.

In a representative profile, the surface layer is dark-brown, very strongly acid loamy sand about 8 inches thick. The underlying material is brown, dark yellowish-brown, and grayish-brown, loose sand that extends to a depth of more than 50 inches.

These soils are low in available water capacity, shrink-swell potential, and natural fertility. Most of the acreage is used for coconut trees and pangolagrass, but a few areas are in native grasses and shrubs.

Representative profile of Aguadilla loamy sand, 4.8 kilometers east of town of Yabucoa, on the Riog farm, 30 meters north from farm road and 90 meters south from east end of sugar plantation:

Ap—0 to 8 inches, dark-brown (10YR 3/3) loamy sand; single grained; loose; many fine roots; very strongly acid; clear, smooth boundary.

C1—8 to 20 inches, brown (10YR 4/3) sand; single grained; loose; few fine roots; very strongly acid; clear, smooth boundary.

C2—20 to 40 inches, dark yellowish-brown (10YR 4/4) sand; single grained; loose; very strongly acid; gradual, smooth boundary.

C3—40 to 58 inches, grayish-brown (10YR 5/2) sand; single grained; loose; strongly acid.

The Ap horizon is 6 to 12 inches thick. The A horizon is sand, sandy loam, or loamy sand and has value of 3 to 4. The C horizon has value of 4 or 5 and chroma of 2, 3, or 4.

The Aguadilla soils are on the same landscape as Catano soils and Coastal beaches. Unlike the Catano soils, the Aguadilla soils are acid. Coastal beaches, a land type, have no horizon differentiation.

Ad—Aguadilla loamy sand. This nearly level soil is along the coast. It has the profile described as representative of the Aguadilla series. Included with this soil in mapping were small areas of Catano soils.

This soil has limitations for farming because of its available water capacity, low organic-matter content, and low fertility. It is not suited to cultivated crops, but it can be used for coconut trees and pasture. Capability unit VIs–3.

Ag—Aguadilla sandy loam, moderately wet. This nearly level soil is along the coast. The seasonal water table is close to the surface. Included with this soil in mapping were small areas of Catano loamy sand.

Low organic-matter content, low fertility, low available water capacity, and wetness are severe limitations for cultivated crops. The soil is better suited to pasture than to most other uses. Capability unit VIs–3.

Amelia Series

The Amelia series consists of deep soils that are well drained and moderately permeable. These soils formed in gravelly sediment derived from volcanic rocks. They are on alluvial fans and foot slopes. Slopes are 2 to 12 percent. The climate is semiarid tropical. The average annual precipitation is 30 to 40 inches, and the average temperature is 79° F.

In a representative profile, the surface layer is dark yellowish-brown, medium acid gravelly clay loam about 6 inches thick. Below this layer is brown, friable gravelly clay loam 7 inches thick. Dark-brown, friable gravelly clay is between depths of 13 and 22 inches. The underlying material is strong-brown gravelly clay loam that extends to a depth of 46 inches.

These soils are low in available water capacity and fertility. Their shrink-swell potential is moderate. The soils are difficult to work, and most of their acreage is used for pasture and sugarcane. Some areas are in native pasture and brush.

Representative profile of Amelia gravelly clay loam, 5 to 12 percent slopes, eroded, in a cultivated field on Lot No. 505, 5 meters southwest of an Almacigo tree on this lot, Parcelas Las Ochenta, Salinas:

Ap—0 to 6 inches, dark yellowish-brown (10YR 3/4) gravelly clay loam, brown (7.5YR 5/4) when dry; massive parting to weak, fine, granular structure; very hard, friable, slightly sticky and slightly plastic; common fine roots; many gravel fragments 1/8 to 2 inches in diameter; medium acid; clear, wavy boundary.

B1—6 to 13 inches, brown (7.5YR 4/6) gravelly clay loam, dark yellowish brown (10YR 4/4) when dry; weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine roots; many angular rock fragments 1/4 to 2 inches in diameter and few rock fragments 4 to 16 inches in diameter; medium acid; clear, wavy boundary.

B2t—13 to 22 inches, dark-brown (7.5YR 4/4) gravelly clay, brown (7.5YR 5/4) when dry; moderate, medium, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; few fine roots; many angular rock fragments 1/4 to 3 inches in diameter; medium acid; clear, wavy boundary.

C—22 to 46 inches, strong-brown (7.5YR 5/6) gravelly clay loam; massive; hard, friable, slightly sticky; many angular rock fragments 1 to 3 inches in diameter; medium acid.

The solum ranges from 16 to 44 inches in thickness. The A horizon has hue of 10YR, 7.5YR, or 5YR, value of 3 or 4, and chroma of 2 to 4. The B horizon has hue of 10YR, 7.5YR, or 5YR, value of 3 or 4, and chroma of 4 to 6. It has weak or moderate, medium, subangular blocky structure and ranges from medium acid to neutral in reaction. The C horizon ranges from medium acid to mildly alkaline. The content of volcanic rock fragments averages 40 to 75 percent, by volume, throughout the soil profile.

The Amelia soils are on the same landscape as the Guayama, Descalabrado, and Jacana soils. The Amelia soils are deeper to bedrock than all those soils.

AmB—Amelia gravelly clay loam, 2 to 5 percent slopes. This soil is on foot slopes and alluvial fans in the semiarid part of the survey area. It has a thicker surface layer and is less affected by erosion than the soil described as representative of the Amelia series. Included with this soil in mapping were small areas of Jacana soils.

Low rainfall in the area and the soil's low available water capacity and low fertility are severe limitations for farming. This soil has been in native pasture and sugarcane. If the soil is irrigated, it is better suited to sugarcane than to most other uses. Capability units IVc–3 nonirrigated and IIIs–1 irrigated.

AmC2—Amelia gravelly clay loam, 5 to 12 percent slopes, eroded. This soil is on foot slopes in the semiarid part of the survey area. It has the profile described as representative of the Amelia series. Included with this soil in mapping were small areas of Guayama, Descalabrado, and Jacana soils.

This soil has severe limitations for farming because it has a low available water capacity, low fertility, and gravelly texture and because the climate is semiarid. Because of slope and the hazard of erosion, the soil requires special conservation practices. This soil has been in pasture and sugarcane. If it is irrigated, it is better suited to sugarcane than to most other uses. Capability unit IVe–8.

Arenales Series

The Arenales series consists of deep soils that are excessively drained and rapidly permeable. These soils formed in stratified, coarse-textured sediment derived from volcanic and limestone rocks. They are on flood plains and alluvial fans. Slopes are 0 to 2 percent. The climate is semiarid tropical. The average annual precipitation is 35 to 50 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is very dark grayish-brown, mildly alkaline sandy loam about 8 inches thick. Below that is dark grayish-brown, very dark gray, and very dark grayish-brown, loose sand 34 inches thick. Gravel mixed with coarse sand is at a depth of 42 inches.

These soils are low in available water capacity and natural fertility. Runoff is slow. The soils are easily worked, and most of the acreage is used for sugarcane, but there are small areas in native pasture and brush.

Representative profile of Arenales sandy loam, near mango tree along farm road, 0.8 kilometers south and 15 meters west of kilometer marker 92.1 on Highway No. 1, near town of Salinas:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, fine, granular structure; very friable, nonsticky and nonplastic; many fine roots; common, fine, subrounded volcanic fragments; mildly alkaline; clear, wavy boundary.

C1—8 to 24 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) loamy sand; single grained; loose, nonsticky and nonplastic; few fine roots; moderately alkaline; abrupt, smooth boundary.

IIC2—24 to 31 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) coarse sand; single grained; loose, nonsticky and nonplastic; moderately alkaline; abrupt, smooth boundary.

IIC3—31 to 42 inches, very dark grayish-brown (10YR 3/2) sand; single grained; loose, nonsticky and nonplastic; mildly alkaline; clear, smooth boundary.

IIIC4—42 to 50 inches, gravel mixed with coarse sand.

The Ap horizon ranges from 6 to 10 inches in thickness. It has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 or 3. The A horizon is neutral to mildly alkaline. The C horizon has hue of 10YR or 7.5YR, value of 3 to 5, and chroma of 1 to 4.

The Arenales soils are on the same landscape as the Guamani soils. They have a coarser textured A horizon than the Guamani soils.

An—Arenales sandy loam. This nearly level soil is on flood plains and alluvial fans in the semiarid part of the survey area. It has the profile described as representative of the Arenales series. Included with this soil in mapping were small areas of Vives silty clay loam, high bottom; Arenales sandy loam, gravelly substratum; and Guamani soils.

This soil has severe limitations for farming because of its low available water capacity and rapid permeability. Also, rainfall in the area is low. If the soil is properly irrigated and fertilized, it is suited to sugarcane and pasture. Capability units VIc–1 nonirrigated and IVs–1 irrigated.

Ar—Arenales sandy loam, gravelly substratum. This nearly level soil lies on river flood plains and alluvial fans. Its profile is similar to the one described as representative of the series, but gravel is at a depth of only 20 to 36 inches. Included with this soil in mapping were small areas of Guamani soils.

The rapid permeability and low available water capacity of the soil and the low rainfall in the area are severe limitations for farming. This soil has been used for sugarcane and pasture. If it is properly irrigated, it is suited to sugarcane. Capability units VIc–1 nonirrigated and IVs–1 irrigated.

Bajura Series

The Bajura series consists of deep soils that are poorly drained and slowly permeable. These soils formed in fine-textured sediment of mixed origin. They are on alluvial flood plains. Slopes are 0 to 2 percent. The climate is humid tropical. The average annual precipitation is 84 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is very dark grayish-brown, mottled, slightly acid clay about 5 inches thick. Below this layer is very dark grayish-brown, dark-gray, very dark gray, black, and yellowish-brown, mottled, firm clay that extends to a depth of 60 inches.

These soils have a high available water capacity, high shrink-swell potential, and high natural fertility. Runoff is slow. These soils have been in sugarcane and pasture for many years.

Representative profile of Bajura clay, frequently flooded, 1.1 kilometers north of Land Authority office and 10 meters west of telephone pole along road, Colonia San Luis, Carolina:

Ap—0 to 5 inches, very dark grayish-brown (10YR 3/2) clay; few, fine, dark-gray (10YR 4/1) mottles; weak, fine, subangular blocky structure; very firm, slightly sticky and slightly plastic; common fine roots; few worm casts; slightly acid; clear, smooth boundary.

B1g—5 to 12 inches, very dark grayish-brown (10YR 3/2) clay; common, medium, distinct, dark-gray (5Y 4/1) and dark-brown (7.5YR 4/4) mottles; weak, coarse, subangular blocky structure; very firm, sticky and plastic; few fine roots; few pressure faces; slightly acid; clear, smooth boundary.

B2g—12 to 19 inches, dark-gray (10YR 4/1) clay; many, coarse, prominent, dark-brown mottles; weak, coarse, subangular blocky structure; firm, slightly sticky and plastic; few pressure faces; few worm casts; few krotovinas; slightly acid; clear, smooth boundary.

C1g—19 to 25 inches, very dark gray (10YR 3/1) clay; many, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; firm, slightly sticky and plastic; few pressure faces; slightly acid; clear, smooth boundary.

C2g—25 to 44 inches, black (10YR 2/1) clay; many, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; firm, slightly sticky and plastic; slightly acid; clear, smooth boundary.

C3g—44 to 66 inches, yellowish-brown (10YR 5/6) clay; many, medium, prominent, dark-gray (2.5Y 4/0) mottles and few, fine prominent dark-gray (7.5YR 4/0) mottles; massive; firm, slightly sticky and plastic; slightly acid.

The solum is 16 to 24 inches thick. The Ap horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 2 or lower. It is silty clay or clay. The B horizon has hue of 10YR or 2.5Y, value of 3 to 6, and chroma of 2 or lower. It has weak, moderate or coarse, subangular blocky structure.

The Bajura soils occupy the same landscape as the Coloso, Corcega, and Fortuna soils. Unlike the Coloso and Corcega soils, the Bajura soils are poorly drained. The Bajura soils are not so acid as the Fortuna soils, and unlike Fortuna soils, they have pressure faces.

Ba—Bajura silty clay, saline. This nearly level soil is on alluvial flood plains close to seaboard mangrove swamps. Its profile is similar to the one described as representative of the series, but it is occasionally affected by salinity caused by high tides. Included with this soil in mapping were small areas of Tidal flats and Salt water marsh.

Because this soil is poorly drained, is not easily worked, has a high shrink-swell potential, and is affected by salt water. Its use for farming is limited. Frequent flooding and a seasonal high water table also limit the use of the soil for cultivated crops. Most of the acreage is in salt-tolerant plants. This soil is suited to pasture and wildlife habitat. Capability unit VIIw–1.

Bc—Bajura clay, frequently flooded. This nearly level soil is on alluvial flood plains. It occupies the farther areas from the river. It has the profile described as representative of the series. Included with this soil in mapping were some areas of Coloso silty clay.

Because this soil has slow permeability and a seasonal high water table, is subject to frequent flooding, and is difficult to work, it has severe limitations for farming (fig. 2). If the soil is drained and properly managed, it is suited to sugarcane, food crops, and pasture. Capability unit IIIw–1.

Caguabo Series

The Caguabo series consists of shallow soils that are well drained and moderately permeable. These soils formed in moderately fine textured residuum from partly weathered volcanic rocks. They are on side slopes. Slopes are 12 to 60 percent. The climate is humid tropical. The average annual precipitation is 80 inches, and the average annual temperature is 76° F.

In a representative profile, the surface layer is grayish-brown, slightly acid clay loam about 4 inches thick. The next layer, 5 inches thick, is dark-gray gravelly clay loam and 60 percent rock fragments. Below that is olive-gray gravelly clay loam that extends to a depth of 17 inches and is underlain by hard rock.

These soils have a moderate available water capacity, moderate shrink-swell potential, and medium natural fertility. Runoff is medium to rapid. The soils are susceptible to erosion, and they have been in pasture and brush for many years.

Representative profile of Caguabo clay loam, 20 to 60 percent slopes, eroded, 2.4 kilometers south of kilometer marker 17.4 on Highway No. 31, Juncos to Naguabo:

A1—0 to 4 inches, grayish-brown (10YR 5/2) clay loam; weak, fine, subangular blocky structure parting to granular; very hard, very firm, slightly sticky and slightly plastic; common fine roots; many fine volcanic rock fragments; few worm casts; slightly acid; abrupt, smooth boundary.

B—4 to 9 inches, dark-gray (10YR 4/1) gravelly clay loam; weak, medium, subangular blocky structure; very hard, very firm, slightly sticky and slightly plastic;

Figure 2.—A field of sugarcane that is flooded on Bajura clay, frequently flooded.

few fine roots; few fine pores; rock fragments make up 60 percent, by volume, of soil mass; slightly acid; clear, wavy boundary.

C—9 to 17 inches, olive-gray (5Y 5/2) gravelly clay loam; common, medium, distinct, very dark grayish-brown (10YR 3/2) mottles and few, fine, distinct, reddish-yellow (7.5YR 7/8) mottles; massive; very hard, firm, slightly sticky and slightly plastic; few fine roots; many rock fragments; common, dark, weathered minerals; most of this horizon is saprolite; medium acid; gradual, wavy boundary.

R—17 inches, hard consolidated volcanic rock.

The solum is 6 to 11 inches thick. Some profiles have an Ap horizon that has value of 3 or 4 and chroma of 2 or 3. The amount of rock fragments in the B and C horizons ranges from 35 to 70 percent. Depth to consolidated volcanic rock ranges from 12 to 20 inches.

The Caguabo soils are on the same landscape as the Mucara and Sabana soils. They are shallower and coarser textured than the Mucara soils. The Caguabo soils are less acid than the Sabana soils, and unlike Sabana soils, they are gravelly.

CbD2—Caguabo clay loam, 12 to 20 percent slopes, eroded. This soil is on side slopes. Its profile is similar to the one described as representative of the Caguabo series, but the surface layer is slightly thicker. Included with this soil in mapping were small areas of Mucara and Sabana soils.

Shallowness to hard rock and medium runoff are severe limitations for cultivated crops. Conservation practices are needed to slow surface runoff. This soil has been used for food crops and pasture. It is suited to pasture and woodland. Capability unit VIs-2; woodland suitability group 3d5.

CbF2—Caguabo clay loam, 20 to 60 percent slopes, eroded. This soil is on ridgetops and side slopes in the volcanic uplands. It has the profile described as representative of the series. Included with this soil in mapping were small areas of Mucara and Sabana soils and Rock land.

Rapid to very rapid runoff, shallowness to hard rock, and steep slopes are severe limitations for farming. Conservation practices are needed to slow surface runoff. This soil has been used for native pasture. It is not suited to cultivated crops, but it is suited to pasture and woodland. Capability unit VIIs-1; woodland suitability groups 3d5 and 4d5.

Candelero Series

The Candelero series consists of deep soils that are somewhat poorly drained and slowly permeable. These soils formed in moderately fine textured sediment derived from granitic rocks. They are on alluvial fans, terraces, and foot slopes. Slopes are 2 to 12 percent. The climate is humid tropical. The average annual precipitation is 87 inches, and the average annual temperature is 77° F.

In a representative profile, the surface layer is dark grayish-brown, extremely acid loam about 7 inches thick. The next layer is gray and yellowish-brown, mottled, very firm sandy clay loam 8 inches thick. Below that is greenish-gray and light greenish-gray, very firm sandy clay loam 19 inches thick. Underlying the material is friable sandy clay loam that is mottled with yellowish-brown and greenish-gray and extends to a depth of more than 60 inches.

These soils have a moderate available water capacity and shrink-swell potential. Runoff is medium. The soils are subject to occasional flooding. They have been in sugarcane, native pasture, and brush.

Representative profile of Candelero loam, 5 to 12 percent slopes, eroded, 87 meters southwest from kilometer marker 1.9 on Highway No. 905 and 10 meters northwest from farm road:

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) loam; weak, fine, granular structure; very friable, slightly sticky and slightly plastic; few fine roots; few, fine, black mineral grains; few concretions 2 to 3 millimeters in diameter; extremely acid; clear, smooth boundary.

B1—7 to 11 inches, gray (10YR 6/1) and yellowish-brown (10YR 5/8) sandy clay loam; fine purplish mottles; weak, coarse, subangular blocky structure; very firm, slightly sticky and plastic; few roots; thin, discontinuous, gray (10YR 6/1) films on ped surfaces; black coatings on root channels; common fine quartz grains; extremely acid; clear, smooth boundary.

B21t—11 to 15 inches, gray (10YR 6/1) and yellowish-brown (10YR 5/6) sandy clay loam; weak, medium, subangular blocky structure; very firm, slightly sticky and plastic; few roots; thin, discontinuous, gray (10YR 6/1) films on ped surfaces; dark films on root channels; common fine quartz grains; few, fine, black mineral grains; many weathered feldspar and hornblende crystals; very strongly acid; gradual, smooth boundary.

B22tg—15 to 24 inches, greenish-gray (5GY 6/1) sandy clay loam; common, medium, distinct, brownish-yellow (10YR 6/6) mottles and few, fine, distinct, reddish-brown mottles; weak, coarse, subangular blocky structure; very firm, slightly sticky and plastic; few roots; thin, discontinuous, greenish-gray (5GY 6/1) films on ped surfaces; dark films on root channels; many fine quartz grains; many weathered feldspar and hornblende crystals; strongly acid; gradual, smooth boundary.

B23tg—24 to 34 inches, light greenish-gray (5GY 7/1) sandy clay loam; common, fine, distinct, greenish-gray mottles and common, medium, distinct, yellowish-brown (10YR 5/8) and grayish-brown (10YR 5/2) mottles; weak, coarse, prismatic structure; very firm, slightly sticky and slightly plastic; thin, discontinuous, light greenish-gray (5GY 7/1) films on ped surfaces, gray tends to run in vertical tongues; many fine quartz grains; few, fine, black mineral grains; many weathered feldspar and hornblende crystals; slightly acid; clear, smooth boundary.

C—34 to 64 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles and common, fine distinct, greenish-gray mottles; massive; friable, slightly sticky; many fine quartz grains; many weathered feldspar crystals; common, fine, black mineral grains; slightly acid.

The solum is 25 to 42 inches thick. The Ap horizon has value of 3 to 4 and is very strongly acid or extremely acid. The upper part of the B horizon has value of 5 or 6. Few to many quartz grains are mixed throughout the profile.

The Candelero soils are on the same landscape as the Humacao, Parcelas, and Mayo soils. Unlike the Humacao and Parcelas soils, they have dominant low-chroma colors and a B2t horizon. The Candelero soils are less permeable than the Mayo soils, and they are somewhat poorly drained.

CdB—Candelero loam, 2 to 5 percent slopes. This soil is on terraces and alluvial fans. Its profile is similar to the one described as representative of the series, but the surface layer is 2 to 4 inches thicker. Included with this soil in mapping were some areas of Humacao and Mayo soils.

This soil has severe limitations for farming because it is slowly permeable, somewhat poorly drained, susceptible to flooding, and has a seasonal water table. Complex soil conservation practices and proper management are required to overcome these limitations. If the soil is properly drained, limed, and fertilized, it is suited to sugarcane and pasture. Capability unit IIIw-2.

CdC2—Candelero loam, 5 to 12 percent slopes, eroded. This soil is on alluvial fans and foot slopes. It has the profile described as representative of the Candelero series. Included with this soil in mapping were small areas of Mayo and Parcelas soils.

This soil has severe limitations for farming because it is somewhat poorly drained. If the soil is clean cultivated, it requires special conservation practices because it is susceptible to erosion. It has been used for sugarcane, native pasture, and brush. If the soil is properly limed, drained, and fertilized, it is suited to sugarcane and pasture. Capability unit IVe-1.

Cartagena Series

The Cartagena series consists of deep soils that are somewhat poorly drained, mildly alkaline, and slowly permeable. These soils formed in fine-textured sediment derived from volcanic rocks and limestone. They are on alluvial fans. Slopes are 0 to 5 percent. The climate is semiarid tropical. The average annual precipitation is 30 to 45 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is dark-brown, mildly alkaline or neutral, mottled clay about 19 inches thick. Below that layer is dark yellowish-brown, firm, mottled silty clay that extends to a depth of 45 inches.

These soils have a high available water capacity and shrink-swell potential. Runoff is slow. The soils are difficult to work, and they have been in sugarcane, pasture, and brush for many years.

Representative profile of Cartagena clay, 46 meters north and 1.3 kilometers west of gasoline station on Highway No. 705, from kilometer marker 151.3 on Highway No. 3 to Central Aguirre, Salinas:

Ap—0 to 10 inches, dark-brown (10YR 3/3) clay; common, fine faint, dark-brown (7.5YR 4/4) and dark-gray (10YR 4/1) mottles; weak, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; common roots; few, fine, dark concretions; few limestone fragments; common pressure faces; mildly alkaline; clear, smooth boundary.

AC—10 to 19 inches, dark-brown (10YR 4/3) clay; common, fine, faint, dark-gray (10YR 4/1) mottles; massive; few roots; firm, slightly sticky and slightly plastic; common, fine, dark concretions; few pressure faces; few slickensides; neutral; clear, smooth boundary.

C1ca—19 to 31 inches, dark yellowish-brown (10YR 4/4) silty clay; common, fine, distinct, gray (5Y 5/1) mottles and few, fine, distinct, dark redddish-brown (5YR 3/4) mottles; massive; few roots; firm, slightly sticky and slightly plastic; common, fine, dark concretions; few limestone fragments; few pressure faces and slickensides; moderately alkaline; gradual, wavy boundary.

C2—31 to 45 inches, dark yellowish-brown (10YR 4/4) silty clay; common, fine, distinct, yellowish-brown (10YR 5/8) mottles; massive; firm, slightly sticky and slightly plastic; many or common very dark brown (10YR 2/2) stains; few seashell fragments; moderately alkaline.

The Ap horizon is 4 to 12 inches thick. It has value of 3 or 4 and chroma of 2 or 3.

The Cartagena soils are on the same landscape as the Fraternidad and Paso Seco soils. Unlike the Fraternidad soils, they are somewhat poorly drained. The Cartagena soils lack the gravelly horizons of the Paso Seco soils.

Ce—Cartagena clay. This nearly level to gently sloping soil is on alluvial fans. Included with it in mapping were small areas of Fraternidad soils.

This soil has severe limitations for farming because it is somewhat poorly drained, slowly permeable, and difficult to work. It has been in sugarcane. If the soil is properly drained and managed, it is suited to sugarcane and grasses. Capability units IIIc-1 nonirrigated and IIs-1 irrigated.

Catano Series

The Catano series consists of deep soils that are excessively drained and rapidly permeable. These soils formed in miscellaneous sands and sand-sized rock fragments. They are along the sea. Slopes are 0 to 2 percent. The climate is humid tropical. The average annual precipitation is 75 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is dark-brown, moderately alkaline loamy sand about 8 inches thick. Below that layer is dark-brown, brown, and grayish-brown, loose sand that extends to a depth of 64 inches.

These soils have a low available water capacity, shrink-swell potential, and natural fertility. They have been in coconut trees, native pasture, and brush, but a few areas are in food crops.

Representative profile of Catano loamy sand, 30 meters east of Guayanes River delta and about 120 meters west of the coast, Yabucoa:

A1—0 to 8 inches, dark-brown (10YR 3/3) loamy sand; single grained; loose, nonsticky and nonplastic; moderately alkaline; clear, smooth boundary.

C1—8 to 18 inches, dark-brown (10YR 4/3) sand; single grained; loose, nonsticky and nonplastic; moderately alkaline; clear, smooth boundary.

C2—18 to 59 inches, brown (10YR 5/3) sand; single grained; loose, nonsticky and nonplastic; moderately alkaline; clear, smooth boundary.

C3—59 to 64 inches, grayish-brown (10YR 5/2) sand; loose, nonsticky and nonplastic; moderately alkaline.

The A horizon is 6 to 12 inches thick. It has value and chroma of 2 or 3. The C horizon has value of 4 or 5 and chroma of 2 or 3.

The Catano soils are on the same landscape as the Aguadilla soils and the land type Coastal beaches. The Catano soils, unlike the Aguadilla soils, are moderately alkaline. Coastal beaches are wave-reworked sands that are saturated with sea water or lack horizon differentiation.

Cf—Catano loamy sand. This nearly level soil is along the coast. Included with it in mapping were small areas of Aguadilla soils and Coastal beaches.

This soil is not suited to cultivated crops because of its low available water capacity, rapid permeability, and low fertility. It is used for coconut trees, cassava, pangolagrass, and Guineagrass. It is suitable for coconut trees, pasture, wildlife food and cover, and recreation. Capability unit VIs-1.

Cayagua Series

The Cayagua series consists of deep soils that are somewhat poorly drained and slowly permeable. These soils formed in residuum derived from coarse-textured plutonic rocks. They are on foot slopes. Slopes are 5 to 20 percent. The climate is humid tropical. The average precipitation is 80 to 90 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is dark grayish-brown, strongly acid sandy loam about 4 inches thick. Below that layer is light brownish gray, mottled clay 16 inches thick. The next layer is yellowish-red sandy loam and light-gray clay 7 inches thick. The underlying material is yellowish-red sandy loam and light-gray clay to a depth of 36 inches. Yellowish-red and reddish-yellow, very friable sandy loam extends to a depth of 100 inches.

These soils have medium natural fertility. Runoff is slow. The soils have been in sugarcane and native pasture. A few areas are in pineapples.

Representative profile of Cayagua sandy loam, 5 to 12 percent slopes, eroded, 4.8 kilometers northwest of the town of Humacao, 135 meters west of kilometer marker 0.7 on Highway No. 935, 22 meters west of fence:

Ap—0 to 4 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, fine, granular structure; very friable, nonsticky and nonplastic; many fine roots; few medium iron concretions in lower part; strongly acid; abrupt, smooth boundary.

B21t—4 to 10 inches, light brownish-gray (10YR 6/2) clay; many, coarse, distinct, strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; very firm, slightly sticky and plastic; common fine roots; patchy clay films on ped surfaces and root channels; very strongly acid; clear, wavy boundary.

B22t—10 to 20 inches, light brownish-gray (10YR 6/2) clay; many, coarse, distinct, strong-brown (7.5YR 5/6) mottles and few, fine, distinct, red (2.5YR 5/6) mottles; weak, coarse, angular blocky structure; firm, slightly sticky and plastic; few fine roots; thin patchy clay films on ped surfaces and root channels; very strongly acid; clear, wavy boundary.

B3—20 to 27 inches, sixty percent yellowish-red (5YR 5/6) sandy loam; massive; friable, nonsticky and nonplastic; 40 percent light-gray (10YR 7/1) clay; massive; friable, nonsticky and plastic; few fine roots; very strongly acid; gradual, wavy boundary.

C1—27 to 36 inches, sixty percent yellowish-red (5YR 4/6) sandy loam; massive; friable, nonsticky and nonplastic; 40 percent light-gray (10YR 7/1) clay; massive; friable, nonsticky and plastic; quartz seams in the clayey sections; very strongly acid; gradual, wavy boundary.

C2—36 to 100 inches, yellowish-red (5YR 4/6) and reddish-yellow (7.5YR 6/6) sandy loam; massive; very friable, nonsticky and nonplastic; slightly acid.

The solum is 18 to 36 inches thick. The Ap horizon has value of 3 or 4 and chroma of 2 or 3. The B2t horizon is 12 to 20 inches thick and has value of 4 to 6. Mottles range from few to many and from fine to coarse; they are in shades of strong brown, light gray, and red. The B3 horizon has hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6.

The Cayagua soils are on the same landscape as the Candelero, Mayo, and Pandura soils. They occupy higher positions and are finer textured in the B2t horizon than the Candelero soils. The Cayagua soils occupy higher positions than the Mayo soils, and unlike Mayo soils, they are somewhat poorly drained. They occupy lower positions and are deeper than the Pandura soils.

CgC2—Cayagua sandy loam, 5 to 12 percent slopes, eroded. This soil is on foot slopes. It has the profile described as representative of the Cayagua series. Small areas of Candelero and Mayo soils were included with this soil in mapping.

This soil has moderate limitations for farming because it is somewhat poorly drained and is slowly permeable. It requires soil conservation practices and proper management. It has been planted to pineapples for many years. If the soil is properly limed and drained, it is suited to cultivated crops. If it is properly drained and cultivated, it is suited to sugarcane and pasture. Capability unit IIIe–2.

CgD2—Cayagua sandy loam, 12 to 20 percent slopes, eroded. This soil is on foot slopes. Its profile is similar to the one described as representative of the Cayagua series, but the surface layer is 2 or 3 inches thinner and this soil is more susceptible to erosion if it is clean cultivated. Included in mapping were small areas of Mayo and Pandura soils.

This soil has severe limitations for farming because it is moderately steep and somewhat poorly drained. If the soil is clean cultivated, it requires special conservation practices because it is susceptible to erosion. If the soil is properly drained, it is suited to cultivated crops. This soil is suited to sugarcane, pineapples, and pasture. Capability unit IVe–2.

Ciales Series

The Ciales series consists of deep soils that are poorly drained and slowly permeable in the upper part and well drained and moderately permeable in the lower part. These soils formed in fine-textured, highly weathered residuum of igneous rocks. They are on ridgetops and upper side slopes in the humid uplands. Slopes are 12 to 45 percent. The average annual precipitation is 185 inches, and the average annual temperature is 72° F.

In a representative profile, the surface layer is dark-brown, very strongly acid silty clay loam about 7 inches thick. The upper part of the subsoil, to a depth of 26 inches, is gray, very strongly acid clay that is mottled and friable. The lower part of the subsoil is reddish-yellow, very strongly acid, friable clay 7 inches thick. The underlying material is friable silty clay loam and silt loam of variegated colors of red, yellow, and brown that extends to a depth of 60 inches or more.

These soils have a moderate available water capacity and medium fertility. Runoff is medium to rapid. The soils have been in hardwood trees and tree ferns for many years.

In the Humacao Area of Eastern Puerto Rico, the Ciales soils are mapped only in an association with Guayabota and Picacho soils.

Representative profile of Ciales silty clay loam, 12 to 20 percent slopes, in an area of the Guayabota-Ciales-Picacho association, very steep, 17 meters west of kilometer marker 15.7 on Highway No. 191:

O1—1 to 0 inches, undecomposed and partially decomposed leaves and twigs.

A1—0 to 7 inches, dark-brown (10YR 3/3) silty clay loam; weak, fine, subangular blocky structure breaking to moderate, medium, granular; friable, slightly sticky and slightly plastic; many fine and medium roots; many fine quartz grains; very strongly acid; clear, smooth boundary.

B21tg—7 to 15 inches, gray (10YR 5/1) clay; common, fine, distinct, light yellowish-brown mottles and common, medium, distinct, yellowish-brown (10YR 5/8) mottles; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; common fine and medium roots; thin patchy clay films on ped surfaces and along root channels; many fine quartz grains; very strongly acid; clear, smooth boundary.

B22tg—15 to 26 inches, gray (5Y 5/1) clay; common, medium, distinct, light yellowish-brown (2.5YR 6/4) mottles, few, medium, distinct, strong-brown (7.5YR 5/6) mottles, and common, medium, faint, gray (N 5/0) mottles; weak, coarse, subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; patchy clay films on ped surfaces and along root channels; common worm casts; many fine quartz grains; very strongly acid; clear, smooth boundary.

B3—26 to 33 inches, reddish-yellow (7.5YR 6/8) clay; common, fine, distinct, gray and light yellowish-brown mottles; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; common fine quartz grains; very strongly acid; clear, smooth boundary.

C1—33 to 41 inches, reddish-yellow (5YR 6/6) silty clay loam; common, medium, faint, strong-brown (7.5YR 5/8) mottles; massive; friable, slightly sticky and slightly plastic; common fine quartz grains; very strongly acid; clear, smooth boundary.

C2—41 to 48 inches, yellowish-red (5YR 5/6) silt loam; common, medium, distinct, strong-brown (7.5YR 5/6) mottles; massive; very friable, nonsticky and slightly plastic; many fine quartz grains; very strongly acid; clear, smooth boundary. About 40 percent of the soil mass of this horizon is saprolite.

C3—48 to 60 inches +, variegated colors of the saprolite; yellowish-red (5YR 5/6), strong-brown (7.5YR 5/8), yellowish-brown (10YR 5/8), and dark-red (7.5R 3/6) silty clay loam; massive; very friable, nonsticky and slightly plastic; common, fine, shiny flakes and quartz grains; very strongly acid.

The solum is 25 to 41 inches thick. The A horizon has hue of 10YR to 2.5 YR, value of 3 or less, and chroma of 1 to 3. It is dominantly silty clay loam. The B2t horizon has hue of 10YR, 2.5Y, or 5Y, value of 4 to 6, and chroma of 2 or less. It is clay or silty clay and has weak, coarse or weak, medium, subangular blocky structure. Clay films range from thin patchy to thin continuous. The C horizon has dominant hue of 7.5YR or 5YR, value of 4 to 6, and chroma of 4 to 8. Reaction ranges from strongly acid to extremely acid throughout.

The Ciales soils occupy the same landscape as the Yunque, Picacho, Utuado, Guayabota, and Los Guineos soils. The Ciales soils, unlike the Yunque soils, have low chroma mottles in the B2t horizon. In contrast to the Picacho soils, they have dominant colors with chromas of 2 or less in the B2t horizon. They have a B2t horizon that the Utuado and Guayabota soils lack; they are finer textured than the Utuado soils and deeper than the Guayabota soils. Unlike the Los Guineos soils, Ciales soils have low-chroma colors in the B2t horizon.

Coamo Series

The Coamo series consists of well-drained, moderately permeable soils that are moderately deep to stratified, coarse-textured materials. These soils formed in sediment derived from volcanic and limestone rocks. They are on alluvial fans or terraces. Slopes are 2 to 12 percent. The climate is semiarid. The average annual rainfall is 30 to 40 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is very dark brown, slightly acid clay loam about 15 inches thick. Below that layer is dark-brown, firm clay and gravelly clay 23 inches thick. The underlying material is gravel and gravelly clay loam that extends to a depth of 48 inches.

These soils have a moderate available water capacity, moderate shrink-swell potential, and high natural fertility. Runoff is medium. The soils have been in food crops, sorghum, sugarcane, native pasture, and brush. If the soils are irrigated, they can be used for many kinds of food crops.

Representative profile of Coamo clay loam, 2 to 5 percent slopes, 2.7 kilometers south of kilometer marker 85.1 on Highway No. 1, Salinas to Cayey, Salinas:

A11—0 to 5 inches, very dark brown (10YR 2/2) clay loam, very dark grayish brown (10YR 3/2) when dry; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; few fine pebbles; slightly acid; diffuse, wavy boundary.

A12—5 to 15 inches, very dark brown (10YR 2/2) clay loam, very dark grayish brown (10YR 3/2) when dry; weak, coarse, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; few patchy clay films; few fine pebbles; slightly acid; clear, smooth boundary.

B2t—15 to 25 inches, dark-brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when dry; weak, medium, subangular blocky structure; very hard, firm, slightly sticky and slightly plastic; few fine lime splotches; common fine gravel; few discontinuous clay films along root channels and vertical cleavage plants; mildly alkaline; gradual, wavy boundary.

B3ca—25 to 38 inches, dark-brown (10YR 3/3) gravelly clay, dark brown (7.5YR 4/2) when dry; weak, medium, subangular blocky structure; very hard, firm, slightly sticky and slightly plastic; moderately alkaline; ped surfaces coated with secondary lime; clear, smooth boundary.

IICca—38 to 48 inches, stratified gravel and gravelly clay loam; gravel ranges from ½ inch to 2 inches in diameter; common, fine, dark minerals; common fine lime splotches.

The solum is 31 to 57 inches thick. The A horizon has value of 2 or 3, and is slightly acid or neutral. The B horizon has hue of 7.5YR or 10YR, value of 3 or 4, and chroma of 2 or 3. It is mildly alkaline or moderately alkaline. Depth to the ca horizon ranges from 21 to 37 inches. Depth to the gravelly horizon ranges from 31 to 57 inches.

The Coamo soils are on the same landscape as the Descalabrado, Jacana, and Amelia soils. The Coamo soils are deeper and occupy lower positions than the Descalabrado soils. They are deeper than the Jacana soils and lack the semiconsolidated volcanic rocks of those soils. In contrast to the Amelia soils, the Coamo soils lack gravelly sediment throughout the profile.

ClB—Coamo clay loam, 2 to 5 percent slopes. This soil is on alluvial fans and terraces in the semiarid part of the survey area. It has the profile described as representative of the series. Included with this soil in mapping were small areas of Vives silty clay loam, high bottom, and Paso Seco soils.

This soil has severe limitations for farming because rainfall is low. The soil is fertile, however, and if it is irrigated, it is suited to sugarcane, minor crops, sorghum, and pasture. Capability units IIIc–2 nonirrigated and IIe–1 irrigated.

ClC—Coamo clay loam, 5 to 12 percent slopes. This soil is on alluvial fans and terraces. Small areas of Jacana and Amelia soils were included with this soil in mapping.

Low rainfall and a high evaporation rate are severe limitations for cultivated crops. Conservation practices are needed to slow surface runoff. This soil has been used for sugarcane, pasture, and sorghum. If it is irrigated, it is suited to food crops, sugarcane, sorghum, and pasture. Capability unit IVe–3.

Coastal Beaches

Cm—Coastal beaches consists of narrow strips of light-colored beach sand along the coast. This wave-worked sand is saturated with seawater and contains many seashells and shell fragments throughout.

This land type has no value for farming. Most of it is devoid of vegetation, except for a few coconut palms and halophytic vegetation, such as uva playera (*Colobis ubifera*) and bejuco de playa (*Ipomoea prescaprae*). Capability unit VIIIs–1.

Cobbly Alluvial Land

Cn—Cobbly alluvial land is along the flood plains of streams and rivers. It consists of unconsolidated alluvium and about 70 percent, by volume, rock fragments that range from 3 to 10 inches in diameter.

This land type has severe limitations for farming because it has a low available water capacity and a high content of rock fragments. Some of the areas are used for grass. Capability unit Vs–1.

Coloso Series

The Coloso series consists of deep soils that are somewhat poorly drained and slowly permeable. These soils formed in moderately fine textured sediment of mixed origin. They are on river flood plains. Slopes are 0 to 2 percent. The climate is humid tropical. The average annual temperature is 78° F. Depth to the water table ranges from 24 to 48 inches.

In a representative profile, the surface layer is dark-brown, slightly acid silty clay loam about 9 inches thick. The next layer is dark grayish-brown, mottled silty clay loam 10 inches thick. The underlying layer is gray and yellowish-brown, mottled clay, silty clay, and silty clay loam that is firm and extends to a depth of 60 inches.

These soils have a high available water capacity, moderate shrink-swell potential, and high natural fertility. Runoff is slow. The soils have been in sugarcane for many years, and some areas are in native pasture and brush.

Representative profile of the Coloso series from an area of Coloso silty clay loam, occasionally flooded, 300 meters northeast, 515 meters northwest, and 6 meters northeast from kilometer marker 2.8 on Highway No. 925, Humacao:

Ap—0 to 9 inches, dark-brown (10YR 4/3) silty clay loam; common, medium, faint, dark grayish-brown mottles; weak, fine, subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common fine roots; common krotovinas; few, fine, dark concretions; common residue of burned sugarcane; slightly acid; abrupt, smooth boundary.

B—9 to 19 inches, dark grayish-brown (10YR 4/2) silty clay loam; common, fine, distinct, strong-brown (7.5YR 5/8) mottles and common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, fine, subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common worm casts; common, fine, dark minerals; worm channels coated with thin continuous clay films; few, fine, dead roots; slightly acid; clear, smooth boundary.

C1—19 to 27 inches, gray (10YR 5/1) silty clay loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles and few, fine, prominent, red (2.5YR 4/6) mottles; massive; hard, firm, slightly sticky and slightly plastic; few fine pores; common fine sand grains; few, fine, dead roots; few worm casts; slightly acid; clear, smooth boundary.

C2—27 to 32 inches, yellowish-brown (10YR 5/6) silty clay; common, medium, distinct, grayish-brown (10YR 5/2) mottles; massive; hard, firm, slightly sticky and slightly plastic; few fine pores; common worm casts with thin layer of clay films; few, fine, dead roots; slightly acid; clear, smooth boundary.

IIC3—32 to 43 inches, gray (10YR 5/1) clay; few, medium, distinct, dark-brown (10YR 4/3) mottles; weak, fine, subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common fine to medium pores; few dark minerals; few, fine, dead roots; roots and worm channels coated with thick clay films; slightly acid; gradual, wavy boundary.

IIIC4—43 to 60 inches, gray (10YR 5/1) clay; few, fine, faint, dark-brown (10YR 4/3) mottles; massive; hard, firm, slightly sticky and slightly plastic; few, fine, dead roots; few fine pores; slightly acid.

The solum is 14 to 22 inches thick. The A horizon has value and chroma of 3 or 4. The Ap horizon is silty clay or silty clay loam. The B horizon has chroma of 2 or 3 and has weak, fine or medium, subangular blocky structure. The C horizon has a matrix color of gray and has yellowish-brown and gley mottles. It ranges from silty clay loam to clay.

The Coloso soils occupy the same landscape as the Bajura, Toa, Fortuna, Reilly, Talante, and Maunabo soils. Unlike all those soils, the Coloso soils are somewhat poorly drained. They are finer textured in the lower horizons than the Toa soils. The Coloso soils are finer textured than the Reilly and Talante soils, and unlike the Reilly soils, they are not underlain by sand and gravel.

Co—Coloso silty clay loam, occasionally flooded. This nearly level soil is on flood plains. It has the profile described as representative of the series. Small areas of Toa, Bajura, and Fortuna soils were included with this soil in mapping.

Occasional flooding, slow permeability, and a seasonal high water table are moderate limitations for farming. This soil requires soil and water conservation practices for proper cultivation. It has been used for sugarcane. If the soil is properly drained, it is suited to sugarcane and pasture. Capability unit IIw–1.

Cr—Coloso silty clay. This nearly level soil is on flood plains. Its profile is similar to the one described as representative of the series, but it lies at a higher elevation and is less subject to flooding. Included with this soil in mapping were small areas of Toa, Bajura, and Fortuna soils.

Because this soil is somewhat poorly drained, it has limitations for farming. Occasional flooding, slow permeability, and a seasonal high water table are limitations for cultivated crops. Careful management and water control practices are required to overcome these limitations. Most of the acreage of this soil is in sugarcane. If the soil is properly drained, it is suited to sugarcane and pasture. Capability unit IIw–1.

Corcega Series

The Corcega series consists of deep soils that are somewhat poorly drained and moderately permeable. These soils formed in moderately fine textured sediment of mixed origin over sand. They are on river flood plains. Slopes are 0 to 2 percent. The climate is humid tropical. The average annual precipitation is 80 inches, and the average annual temperature is 77° F.

In a representative profile, the surface layer is dark-brown, slightly acid sandy loam about 8 inches thick. Below that layer is dark-brown and dark-gray, mottled, firm, silty clay loam or sandy clay loam that extends to a depth of 32 inches. The underlying material is dark-gray, loose sand 18 inches thick.

These soils have a moderate available water capacity and high natural fertility. They are easily worked. Surface runoff is slow. These soils have been in sugarcane and pasture, and a few areas are in coconut trees.

Representative profile of Corcega sandy loam, 1 kilometer east of kilometer marker 2.0 on Highway No. 115:

Ap—0 to 8 inches, dark-brown (10YR 4/3) sandy loam; weak, medium, granular structure; firm, slightly sticky and slightly plastic; many fine roots; slightly acid; clear, smooth boundary.

B2—8 to 14 inches, dark-brown (10YR 4/3) silty clay loam; common, fine, prominent, yellowish-red (5YR 4/6) mottles and few, fine, distinct, light-gray (10YR 7/2) mottles; weak, fine, subangular blocky structure; firm, slightly sticky and slightly plastic; common fine roots; common, fine, black concretions; slightly acid; clear, smooth boundary.

B3—14 to 32 inches, dark-gray (10YR 4/1) sandy clay loam; common, fine, distinct, reddish-brown (5YR 4/3) mottles and common, fine, distinct, gray (10YR 5/1) mottles; weak, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; common, fine, black concretions; few fine roots; slightly acid; clear, smooth boundary.

IIC—32 to 50 inches, dark-gray (10YR 4/1) sand; single grained; loose, nonsticky and nonplastic; slightly acid.

Thickness of the solum and depth to sandy horizons range from 24 to 40 inches. The Ap horizon has value of 3 or 4. The B2 horizon has chroma of 2 to 4. Few to common, yellowish-red, reddish-brown, light-gray, and gray mottles are in the B and C horizons. The C horizon has a hue of 10YR or 2.5Y and chroma of 1 or 2.

The Corcega soils are on the same landscape as the Coloso and Bajura soils and the land type Wet alluvial land. They are coarser textured throughout than the Coloso and Bajura soils. The Corcega soils occupy higher positions and are less affected by water during the year than Wet alluvial land.

Cs—Corcega sandy loam. This nearly level soil is on river flood plains. Included with it in mapping were small areas of Coloso and Bajura soils.

Frequent flooding and a seasonal water table are moderate limitations for farming. Soil and water conservation practices are needed for proper cultivation. This soil has been in sugarcane and pasture, and some small areas are in coconut trees. If the soil is properly drained, it is suited to cultivated crops, sugarcane, and pasture. Capability unit IIw–5.

Daguao Variant

The Daguao variant consists of deep soils that are well drained and moderately slowly permeable. These soils formed in moderately fine textured residuum derived from volcanic rocks. They occupy foot slopes. Slopes are 2 to 12 percent. The climate is humid tropical. The average annual rainfall is 80 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is dark-brown, medium acid silty clay loam about 11 inches thick. Below that layer is dark-brown and strong-brown, friable clay that extends to a depth of 35 inches. The underlying material is dark yellowish-brown, friable silty clay loam weathered saprolite that can be crushed between the fingers.

These soils have a high available water capacity, moderate shrink-swell potential, and medium natural fertility. They have been in food crops, sugarcane, pasture, and trees.

Representative profile of Daguao silty clay loam, deep variant, 2 to 12 percent slopes, 2 miles south of the town of Humacao, 900 feet south of Central Ejemplo, 990 feet along farm road, and 28 feet west of lone mahogany tree:

A1—0 to 11 inches, dark-brown (7.5YR 3/2) silty clay loam; weak, fine, subangular blocky structure; hard, friable, nonsticky and slightly plastic; many fine roots; few, fine, dark concretions; few, fine, angular rock fragments; medium acid; clear, wavy boundary.

B21t—11 to 23 inches, dark-brown (10YR 3/3) clay; weak, medium, subangular blocky structure; friable, slightly sticky and plastic; common fine roots; many, fine, dark concretions; few, thin, patchy clay films on ped surfaces; few, fine, weathered rock fragments; medium acid; clear, wavy boundary.

B22t—23 to 35 inches, strong-brown (7.5YR 5/8) clay; moderate, medium, subangular blocky structure; friable, sticky and plastic; few fine roots; many, fine, dark grains and concretions; thin patchy clay films on ped surfaces; few fine rock fragments; strongly acid; clear, smooth boundary.

C—35 to 45 inches, dark yellowish-brown (10YR 3/4) silty clay loam; massive; friable, nonsticky and slightly plastic; medium acid. (This horizon consists of highly weathered volcanic rock saprolite that can be crushed easily between the fingers.)

The solum is 28 to 44 inches thick. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 2 to 4. It ranges from clay loam to silty clay loam and from weak subangular blocky to moderate granular in structure. The B2 horizon has hue of 10YR or 7.5YR, value of 3 to 5, and chroma of 3 to 8. It is 20 to 28 inches thick and ranges from silty clay to clay in texture. Structure is weak or moderate subangular blocky, and clay films vary from thin patchy to thin continuous. The reaction is strongly acid or medium acid. Depth to consolidated rock is more than 40 inches.

The Daguao variant soils occupy the same landscape as the Daguao, Lirios, Naranjito, and Pandura soils. The Daguao variant soils have a thicker profile and are deeper to consolidated rock than the Daguao soils. They are browner and finer textured than the Lirios soils, and they lack the yellowish-red horizons of the Naranjito soils. The Daguao variant soils are finer textured and have a thicker solum than the Pandura soils.

DaC—Daguao silty clay loam, deep variant, 2 to 12 percent slopes. This soil is on foot slopes. Included with it in mapping were small areas of Naranjito and Lirios soils.

Moderately slow permeability and slope are moderate limitations for farming. If the soil is properly limed and fertilized, it is suited to food crops, sugarcane, and pasture. Capability unit IIIe–3; woodland suitability group 3d5.

Daguao Series

The Daguao series consists of moderately deep soils that are well drained and moderately slowly permeable. These soils formed in moderately fine textured to fine textured residuum derived from volcanic rocks. They are on foot slopes and mountain side slopes. Slopes are 2 to 60 percent. The climate is humid tropical. The average annual rainfall is 80 to 85 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is very dark gray, strongly acid clay about 8 inches thick. Below that layer is dark yellowish-brown and yellowish-brown, firm clay that extends to a depth of 21 inches. The underlying material is saprolite of varying colors. Consolidated volcanic rock is at a depth of 34 inches.

These soils have a moderate available water capacity, moderate shrink-swell potential, and medium natural fertility and have been in crops, pasture, and trees.

Representative profile of Daguao clay, 20 to 40 percent slopes, eroded, 45 meters north of kilometer marker 0.55 on Highway No. 31 near its intersection with Highway No. 3:

Ap—0 to 8 inches, very dark gray (10YR 3/1) clay; weak, fine, granular structure; very firm, slightly sticky and plastic; strongly acid; gradual, wavy boundary.

B1—8 to 13 inches, dark yellowish-brown (10YR 4/4) clay; weak, coarse, subangular blocky structure; firm, slightly sticky and slightly plastic; thin discontinuous clay films; strongly acid; gradual, wavy boundary.

B2t—13 to 21 inches, yellowish-brown (10YR 5/4) clay; moderate, coarse, subangular blocky structure; firm, slightly sticky and slightly plastic; clay films on vertical ped surfaces and few clay films on horizontal ped surfaces; few partly weathered hornblende crystals; few pressure faces and small slickensides; strongly acid; clear, wavy boundary.

C—21 to 34 inches, variegated, yellowish-brown (10YR 5/6), yellowish-red (5YR 4/6), and dark greenish-gray (5GY 4/1) saprolite; many hornblende crystals.

R—34 inches +, dark greenish, consolidated volcanic rock.

The solum is 14 to 26 inches thick. The Ap horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 1 or 2. It ranges from silty clay loam to clay. The B2t horizon has value of 4 or 5 and chroma of 4 to 6. It has weak or moderate, medium or coarse, subangular blocky structure. Few to many rock fragments are scattered throughout the profile. Depth to consolidated rock ranges from 20 to 40 inches.

The Daguao soils are on the same landscape as the Lirios, Naranjito, and Pandura soils. The Daguao soils are finer textured than the Lirios soils and lack the red B2t horizon of those soils. They lack the yellowish-red horizons of the Naranjito soils. The Daguao soils are finer textured and have a thicker solum than the Pandura soils.

DcE2—Daguao clay, 20 to 40 percent slopes, eroded. This soil is on mountain side slopes. Small areas of Pandura, Lirios, and Naranjito soils were included with this soil in mapping.

This soil has severe limitations for cultivated crops because it is steep. Conservation practices must be used to control surface runoff. This soil is better suited to pasture and woodland than to most other uses. Capability unit VIe–1; woodland suitability group 3d5.

Descalabrado Series

The Descalabrado series consists of well-drained, moderately permeable soils that are shallow to consolidated volcanic rock. These soils formed in moderately fine textured residuum derived from volcanic rocks. Slopes are 5 to 60 percent. The climate is semiarid. The average annual rainfall is 30 to 35 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is very dark grayish-brown, neutral clay loam about 6 inches thick. The next layer, 4 inches thick, is brown, friable clay loam with small volcanic rock fragments. Dark-brown, firm silty clay is between depths of 10 and 14 inches. The underlying material is olive-brown loam saprolite that extends to a depth of about 19 inches. It is underlain by weathered volcanic rock.

These soils have a moderate available water capacity, moderate shrink-swell potential, and medium natural fertility. Runoff is medium to rapid. The soils are susceptible to erosion, and they have been in pasture and brush for many years.

Representative profile of Descalabrado clay loam, 20 to 40 percent slopes, eroded, 1.4 kilometers north of kilometer marker 155.9 on Highway 3 and 45 meters northeast of a shack:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/3) clay loam; weak, fine, subangular blocky structure parting to moderate, medium, granular; friable, slightly sticky and slightly plastic; many fine roots; few small volcanic fragments; neutral; clear, smooth boundary.

B1—6 to 10 inches, brown (10YR 4/3) clay loam; moderate, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; many fine roots; few small volcanic fragments; neutral; clear, smooth boundary.

B2—10 to 14 inches, dark-brown (10YR 4/3) silty clay; moderate, fine and medium, subangular blocky structure; firm, nonsticky and slightly plastic; common fine roots; thin very dark grayish-brown (10YR 3/2) clay films; few small volcanic fragments; few dark worm casts; 10 to 15 percent saprolite; neutral; clear, smooth boundary.

C—14 to 19 inches, olive-brown (2.5Y 4/4) loam (saprolite); fracture planes of the original rock structure coated with dark-brown (10YR 3/3) clay or organic matter, or both.

R—19 inches, greenish-gray slightly weathered volcanic rock.

The solum is 7 to 15 inches thick. The A horizon has value and chroma of 2 and 3. The B2 horizon has value of 3 or 4 and chroma of 2 or 3. Depth to consolidated volcanic rock ranges from 10 to 20 inches.

The Descalabrado soils are on the same landscape as the Guayama and Jacana soils. Unlike the Guayama soils, the Descalabrado soils are neutral and lack red horizons. The Descalabrado soils are coarser textured and shallower than the Jacana soils.

DeC2—Descalabrado clay loam, 5 to 12 percent slopes, eroded. This soil is on mountain side slopes. It occupies lower positions and has a thicker surface layer than the soil having the profile described as representative of the Descalabrado series.

This soil has severe limitations for farming because it is shallow to rock and rainfall is low. It is suited to pasture. Capability unit IVs–2; woodland suitability group 3d5.

DeE2—Descalabrado clay loam, 20 to 40 percent slopes, eroded. This soil is on mountain side slopes and ridgetops in the semiarid volcanic uplands. It has the profile described as representative of the Descalabrado series. Included with this soil in mapping were small areas of Guayama soils and Rock land.

Steep slopes, shallowness to bedrock, rapid runoff, low rainfall, and the hazard of erosion are severe limitations for farming. This soil is limited to pasture grazing and wildlife food and cover. Stocking rates should be controlled to avoid overgrazing and control erosion. The soil has been in pasture and brush for many years. It is better suited to grazing than to most other uses. Capability unit VIIs–4; woodland suitability group 3d5.

DgF2—Descalabrado and Guayama soils, 20 to 60 percent slopes, eroded. This mapping unit is on the sides and tops of ridges in the volcanic uplands. It consists of Descalabrado and Guayama soils. The proportion of each soil varies from one mapped area to another, and some areas may be entirely Guayama soils.

The Guayama soils are not so steep as the Descalabrado soils. The Guayama soils have chert throughout the surface layer and subsoil in places.

Steep slopes, shallowness to bedrock, rapid runoff, low rainfall, and the hazard of erosion are severe limitations for farming. These soils have been in pasture and brush for many years. They are suitable for pasture and wildlife food and cover. Capability unit VIIs–4; woodland suitability group 4d5.

DrF—Descalabrado-Rock land complex, 40 to 60 percent slopes. This mapping unit is on mountain side slopes and ridgetops in the semiarid volcanic uplands. It consists of Descalabrado soils and Rock land in such intricate patterns that they cannot be shown separately at the scale used in mapping. The Descalabrado soils make up about 80 to 85 percent of the mapping unit, and Rock land makes up 15 to 20 percent.

The Descalabrado soils in this complex are similar to the soil having the profile described as representative of the Descalabrado series, but they are steeper.

Because the soils of this mapping unit are steep, shallow to rocks, and rocky, they have severe limitations for farming. They are suitable for pasture and wildlife food and cover. Capability unit VIIs–4; woodland suitability group 4d5.

Fajardo Series

The Fajardo series consists of deep soils that are somewhat poorly drained and slowly permeable. These soils formed in fine-textured sediment of mixed origin. They occupy alluvial fans and terraces. Slopes are 2 to 10 percent. The climate is humid tropical. The average yearly precipitation is 75 to 80 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is dark grayish-brown, medium acid, mottled clay about 9 inches thick. Below that layer is yellowish-brown, red, and light-gray, very firm, mottled clay 27 inches thick.

This is underlain by very firm, mottled clay that has variegated colors and extends to a depth of 60 inches.

These soils have a high available water capacity, high shrink-swell potential, and medium natural fertility. Runoff is slow. The soils are not easily worked, and they have been in sugarcane for many years.

Representative profile of Fajardo clay, 2 to 10 percent slopes, on the Land Authority Farm, 165 meters south and 13 meters west of entrance to Luquillo Public Beach on Highway 3:

Ap—0 to 9 inches, dark grayish-brown (10YR 4/2) clay, common, fine, faint, gray (10YR 5/1) mottles; weak, medium, subangular blocky structure to moderate, medium, granular; firm, slightly sticky and slightly plastic; many fine roots; few fine volcanic fragments; common, fine, black concretions; medium acid; abrupt, smooth boundary.

B21t—9 to 14 inches, yellowish-brown (10YR 5/6) clay; many, medium, distinct, greenish-gray (5GY 6/1) mottles and many, medium, prominent, red (2.5YR 4/6) mottles; moderate, medium, subangular blocky structure; very firm, sticky and plastic; common fine roots; thin continuous clay films on ped surfaces and root channels; common, fine, black concretions; slightly acid; gradual, smooth boundary.

B22t—14 to 25 inches, yellowish-brown (10YR 5/6) clay; many, medium, prominent, gray (5Y 6/1) and red (2.5YR 4/6) mottles; moderate, medium, subangular blocky structure; very firm, sticky and plastic; common fine roots; thin patchy clay films on ped surfaces and root channels; common slickensides and pressure faces; common, fine, black concretions; medium acid; gradual, smooth boundary.

B23t—25 to 36 inches, red (2.5YR 4/6) and light-gray (N 7/0) clay; common, medium, prominent, dark-red (2.5YR 3/6) and yellowish-brown (10YR 5/6) mottles; weak, medium, angular blocky structure; very firm, sticky and plastic; few fine roots; common slickensides and pressure faces; few, fine, dark concretions; medium acid; gradual, smooth boundary.

B24t—36 to 48 inches, variegated, yellowish-brown (10YR 5/6), gray (N 6/0), light bluish-gray (5B 7/1), and dark-red (2.5YR 3/6) clay; weak, fine, subangular blocky structure; very firm, sticky and plastic; medium acid; gradual, smooth boundary.

B25t—48 to 60 inches, gray (N 6/0) clay; many, medium, distinct dark-red (2.5YR 3/6), yellowish-brown (10YR 5/6), and light bluish-gray (5B 7/1) mottles; weak, fine, subangular blocky structure; very firm, sticky and plastic; medium acid.

The solum is more than 60 inches thick. The Ap horizon has chroma of 2 or 3. The B21t and B22t horizons have hue of 10YR or 7.5YR and value of 4 or 5. Structure is weak or moderate, subangular blocky. Clay films vary from thin patchy to thin continuous. The B22 horizon has variegated colors of gray, yellowish brown, and red in varying proportions. Mottles throughout the profile are common or many and are shades of gray, yellowish brown, red, and dark red. Slickensides range from few to common.

The Fajardo soils are on the same landscape as the Vega Baja and Vega Alta soils. In contrast to the Vega Baja soils, the Fajardo soils have pressure faces and slickensides in the B2t horizon. Unlike the Vega Alta soils, they are somewhat poorly drained.

FaC—Fajardo clay, 2 to 10 percent slopes. This soil occupies alluvial fans. It has the profile described as representative of the series. Small areas of Vega Baja and Vega Alta soils were included with this soil in mapping.

Frequent flooding, slow permeability, and a seasonal high water table are moderate limitations for farming. Careful management is required to improve the air and water relationship. This soil has been used for sugarcane. If the soil is drained and properly managed, it is suited to sugarcane and pasture. Capability unit IIw–2.

FaC2—Fajardo clay, 2 to 10 percent slopes, eroded. This soil is on alluvial fans. Its profile is similar to the one described as representative of the Fajardo series, but erosion has removed some of the dark grayish-brown clay surface layer and small rills have formed from rains. In some places plowing has mixed the surface layer with the subsoil. Included with this soil in mapping were small areas of Vega Alta soils.

Slow permeability, a seasonal high water table, and unfavorable workability are moderate limitations for farming. Soil conservation practices and proper management are needed to control erosion. This soil has been used for sugarcane for many years. If it is drained and properly managed, it is suited to sugarcane and pasture. Capability unit IIw–2.

Fortuna Series

The Fortuna series consists of deep soils that are poorly drained and slowly permeable. These soils formed in fine-textured sediment of mixed origin. They are on the flood plains. Slopes are 0 to 2 percent. The climate is humid tropical. The average annual precipitation is 80 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is olive-gray, strongly acid clay about 5 inches thick. Below that is dark greenish-gray and greenish-gray, very firm clay that extends to a depth of 60 inches or more.

These soils have a high available water capacity, shrink-swell potential, and natural fertility. Runoff is slow. The soils are difficult to work. They have been in sugarcane, but a few areas are in native pasture and brush.

Representative profile of Fortuna clay, 2.0 kilometers south of the town of Maunabo and 10 kilometers northeast of the town of Humacao; 2.1 kilometers north of bridge over Anton Ruiz River on Highway 3, near an abandoned railroad:

Ap—0 to 5 inches, olive-gray (5Y 4/2) clay; few, fine, faint, greenish-gray (5Y 6/1) mottles and few, fine, distinct, strong-brown (7.5YR 5/8) mottles; massive; very firm, slightly sticky and slightly plastic; common fine roots; strongly acid; abrupt, smooth boundary.

B21g—5 to 9 inches, dark greenish-gray (5GY 4/1) clay; common, medium, distinct, strong-brown (7.5YR 5/8) mottles; massive; very firm, slightly sticky and plastic; common fine roots; few fine rock fragments; strongly acid; abrupt, smooth boundary.

B22g—9 to 18 inches, greenish-gray (5GY 5/1) clay; many, medium, distinct, yellowish-brown (10YR 5/8) mottles; weak, coarse, subangular blocky structure; very firm, slightly sticky and plastic; common fine roots; few, fine, black nodules; strongly acid; gradual, smooth boundary.

B3g—18 to 30 inches, greenish-gray (5GY 5/1) clay; common, medium, distinct, yellowish-brown (10YR 5/8) mottles; weak, coarse, subangular blocky structure; very firm, slightly sticky and plastic; few fine roots; dark coatings in root channels; strongly acid; gradual, smooth boundary.

Cg—30 to 77 inches, greenish-gray (5GY 5/1) clay; many, coarse, distinct, yellowish-brown (10YR 5/8) mottles; massive; very firm, sticky and plastic; very strongly acid.

The solum is 22 to 45 inches thick. The Ap horizon has chroma of 2 or 3. The B horizon has value of 4 or 5 and chroma of 2 or less. Consistence is slightly sticky or sticky and generally is plastic.

The Fortuna soils are on the same landscape as the Maunabo, Bajura, and Toa soils. The Fortuna soils occupy lower positions than the Maunabo soils, and unlike those soils, they are fine textured in the lower horizons. They lack the pressure faces that are present in the Bajura soils and are more acid than those soils. In contrast to the Toa soils, the Fortuna soils are fine textured and poorly drained.

Fo—Fortuna clay. This nearly level soil is on river flood plains in the humid part of the survey area. Small areas of Maunabo and Bajura soils were included with this soil in mapping.

Slow permeability, poor workability, poor drainage, and a seasonal high water table are severe limitations for cultivated crops. Soil conservation practices and management are needed. This soil has been used for sugarcane. If the soil is properly drained, it is suited to sugarcane and pasture. Capability unit IIIw–4.

Fraternidad Series

The Fraternidad series consists of deep soils that are moderately well drained and slowly permeable. These soils formed in fine-textured sediment derived from limestone and volcanic rocks. They are on coastal plains. Slopes are 0 to 5 percent. The climate is semiarid. The average annual rainfall is 30 to 45 inches, and the average annual temperature is 79° F.

In a representative profile, the upper part of the surface layer is very dark grayish-brown, slightly acid clay, about 8 inches thick, and the lower part is brown clay 5 inches thick. Below that layer is dark yellowish-brown, firm clay that extends to a depth of about 50 inches.

These soils have a high available water capacity, high natural fertility, and very high shrink-swell potential. Surface runoff is slow. The soils are difficult to work, and they have been used for sugarcane and pasture for many years.

Representative profile of Fraternidad clay, 0 to 2 percent slopes, 3.2 kilometers north of kilometer marker 161.9 on Highway No. 3, and 42 meters north of an irrigation reservoir:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) clay; weak, medium, subangular blocky structure; hard, firm, slightly sticky and plastic; common roots; slightly acid; abrupt, smooth boundary.

A12—8 to 13 inches, brown (10YR 4/3) clay; pockets of very dark grayish-brown (10YR 3/2) clay; weak, medium subangular blocky structure; firm, slightly sticky and plastic; common pressure faces and slickensides; common small pores; common pebbles 1 to 3 millimeters in diameter; few dark minerals; slighly acid; clear, wavy boundary.

C1—13 to 18 inches, dark yellowish-brown (10YR 4/4) clay; weak, coarse, angular blocky structure; firm, slightly sticky and plastic; very few patchy clay films along vertical cleavage planes and root channels; common pressure faces and slickensides; neutral; clear, wavy boundary.

C2ca—18 to 31 inches, dark yellowish-brown (10YR 4/4) clay; massive; firm, slightly sticky and plastic; common fine pores; few dead roots; few pressure faces and slickensides; common lime splotches and limestone fragments; few pebbles; few dark minerals; few krotovinas; strongly alkaline; clear, wavy boundary.

C3—31 to 50 inches, dark yellowish-brown (10YR 4/4) clay; massive; firm, plastic; few fine pores; few pressure faces; few, soft, dark concretions; common dark stains; strongly alkaline.

The A horizon is 9 to 16 inches thick. It has value of 3 or 4 and chroma of 2 or 3. The C horizon has chroma of 3 or 4.

The Fraternidad soils are on the same landscape as the Paso Seco and Cartagena soils. Unlike the Paso Seco soils, the Fraternidad soils lack gravelly horizons at a depth of 20 to 37 inches. The Fraternidad soils are better drained than the Cartagena soils.

FrA—Fraternidad clay, 0 to 2 percent slopes. This soil is on alluvial fans and terraces in the semiarid coastal plains. It has the profile described as representative of the series. Included with this soil in mapping were small areas of Paso Seco and Cartagena soils.

Slow permeability, poor workability, and low rainfall are moderate limitations for farming. This soil has been used for food crops, sorghum, sugarcane, and pasture. Capability units IIIc–1 nonirrigated and IIs–1 irrigated.

FrB—Fraternidad clay, 2 to 5 percent slopes. This soil is on terraces in the coastal plains. Included with it in mapping were small areas of Paso Seco soils.

Slow permeability, poor workability, slope, and low rainfall are moderate limitations for farming. These limitations affect land leveling and irrigation. If the soil is properly irrigated, it is suited to sugarcane, sorghum, cut grasses, and pasture. Capability units IIIc–1 nonirrigated and IIs–1 irrigated.

Guamani Series

The Guamani series consists of deep soils that are well drained and rapidly permeable. These soils formed in moderately fine textured sediment over coarse sand, gravel, and cobbles derived from volcanic rock (fig. 3). They are on river flood plains. Slopes are 0 to 2 percent. The climate is semiarid. The average annual rainfall is 35 to 45 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is very dark grayish-brown, slightly acid silty clay loam about 6 inches thick. Below that layer is brown, friable silty clay loam 14 inches thick. That material is underlain by sand, gravel, and cobbles.

These soils have a low available water capacity, medium runoff, and low shrink-swell potential. They are high in natural fertility and are easy to work. Runoff is medium. The soils have been used for sugarcane and pasture.

Representative profile of Guamani silty clay loam, 30 meters west of kilometer marker 144.3 on Highway No. 3, between Guayama and Salinas:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) silty clay loam; weak, fine, subangular blocky structure parting to fine, granular; slightly hard, friable, slightly sticky and slightly plastic; many fine roots; fine pores; few, fine, subrounded rock fragments; slightly acid; gradual, smooth boundary.

B—6 to 20 inches, brown (10YR 4/3) silty clay loam; weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common roots; common fine pores; few rock fragments and gravel; slightly acid; abrupt, wavy boundary.

IIC—20 inches, sand, gravel, and cobbles that are 3 to 8 inches in diameter.

The solum is 15 to 20 inches thick. The Ap horizon has

Figure 3.—An area of Guamani silty clay loam showing the underlying sand, gravel, and cobbles.

value and chroma of 2 to 5. The B horizon has chroma of 2 or 3.

The Guamani soils occupy the same landscape as the Vives and Arenales soils. They have a thinner solum than the Vives soils, and they are rapidly permeable. Unlike the Arenales soils, the Guamani soils have a B horizon.

Gm—Guamani silty clay loam. This nearly level soil is on river flood plains. Included with it in mapping were small areas of Vives soils, high bottom, and Arenales soils.

This soil has severe limitations for crops because it is shallow and has a low available water capacity and because rainfall is low. Deep cuts cannot be made to level the soil; shallow gravelly strata limit the construction of irrigation channels and irrigation reservoirs. Controlled irrigation practices are needed for proper farm management. If the soil is irrigated, it is suited to sugarcane and pasture. Capability unit IVc-1 nonirrigated and IIIs-2 irrigated.

Guayabota Series

The Guayabota series consists of shallow soils that are poorly drained and slowly permeable. These soils formed in residuum of thin-bedded, dark bluish-gray siltstone. They are on side slopes in the volcanic uplands. Slopes are 20 to more than 60 percent. The climate is that of a tropical rain forest. The average annual rainfall is 185 inches, and the average annual temperature is 72° F.

In a representative profile, the surface layer is very dark gray, very strongly acid silty clay loam about 5 inches thick. Below that layer is mottled, dark olive-gray firm silty clay 9 inches thick. The underlying material is silty clay loam of varying colors that extends to a depth of 18 inches. It is underlain by hard siltstone.

These soils have a high available water capacity and moderate shrink-swell potential. Runoff is medium to rapid. The soils have been in native pasture and forest vegetation for many years, and most of the acreage is still in tropical forest.

Representative profile of Guayabota silty clay loam, 20 to 40 percent slopes, eroded, in the El Yunque National Forest, 90 meters northeast, and 30 meters south from kilometer marker 11.8 on Highway No. 191 to Glorieta Bohique:

A1—0 to 5 inches, very dark gray (5Y 3/1) silty clay loam; few, fine, reddish-brown mottles; weak, fine, subangular blocky structure; firm, slightly sticky and slightly plastic; many fine and medium roots; few fine and medium pores; very strongly acid; clear, smooth boundary.

B2—5 to 11 inches, dark olive-gray (5Y 3/2) silty clay; many, fine, distinct, dark reddish-brown mottles, common, medium, distinct, dark bluish-gray (5B 4/1) mottles, and few, medium, distinct, yellowish-brown (10YR 5/8) mottles; weak, coarse, subangular blocky structure parting to weak, medium, subangular blocky; firm, slightly sticky and slightly plastic; common fine and medium roots; few fine pores; very strongly acid; gradual, smooth boundary.

B3—11 to 14 inches, dark olive-gray (5Y 3/2) silty clay, common, coarse, distinct, yellowish-brown (10YR 5/8) mottles, few, medium, distinct, yellowish-red (5YR 5/8) mottles, and few, fine, distinct, dark-gray mottles; weak, medium, subangular blocky structure; firm, slightly sticky and plastic; few pieces of weathered siltstone; extremely acid; abrupt, smooth boundary.

C—14 to 18 inches, variegated, dark bluish-gray (5B 4/1), dark greenish-gray (5G 4/1), and yellowish-red (5YR 4/8) silty clay loam; massive; friable, slightly sticky and slightly plastic; few fine and medium roots; few fine pores; about 50 percent saprolite; extremely acid; abrupt, smooth boundary.

R—18 inches, hard, dark bluish-gray and greenish-gray siltstone.

The solum is 10 to 15 inches thick. The A horizon has value of 2 or 3 and chroma of 2 or less. The B horizon has chroma of 2 or less and has weak, medium or coarse, subangular blocky structure. Reaction is strongly acid to extremely acid throughout the profile. Depth to hard siltstone ranges from 13 to 20 inches.

The Guayabota soils are on the same landscape as the Ciales, Yunque, Picacho, Los Guineos, and Utuado soils. They are shallower to hard rock than all those soils. The Guayabota soils lack the B2t horizons of the Ciales, Yunque, Picacho, and Los Guineos soils, and they are finer textured than the Utuado soils.

GuE2—Guayabota silty clay loam, 20 to 40 percent slopes, eroded. This soil occupies mountains in the upland rain forest. Included with it in mapping were small areas of Ciales, Yunque, Picacho, Los Guineos, and Utuado soils.

Steep slopes, poor drainage, shallowness, and the hazard of erosion are severe limitations for farming. Conservation practices are needed to slow surface runoff. This soil is not suited to cultivated crops. It is better suited to pasture and woodland than to most other uses. Capability unit VIIs–6; woodland suitability group 4d3.

GvF—Guayabota-Ciales-Picacho association, very steep. This mapping unit is on mountains in the rain forest. It occupies narrow, winding ridgetops where slopes range from 5 to 45 percent and side slopes where slopes range from 40 to 90 percent.

The composition of this unit is more variable than that of most other units in the survey area, but mapping has been controlled well enough to interpret for the expected use of the soils.

About 50 percent of this unit is Guayabota soils, and 20 percent is Ciales soils. Picacho soils make up 15 percent, and Rock land makes up 10 percent. Included in this mapping unit were small areas of better drained, clayey soils and a few areas of soils that are similar to the Guayabota soils but are deeper to hard rock.

The soils in this unit occur in a uniform pattern. The steeper Picacho soils and the less sloping Ciales soils are on the ridgetops and the Guayabota soils and Rock land are on the side slopes.

All of this mapping unit is in hardwood rain forest. Because of the very steep slopes, its use is limited to forest, recreation, habitat for wildlife, and water catchment. The soils in this unit are wet because of high rainfall, slow permeability, and a perched water table. Road stabilization is difficult since the soils are wet and susceptible to slippage. The soils are desirable for recreation uses because of their highly esthetic environment, but they have severe limitations for paths, trails, and roads because they are continuously wet and unstable. Capability unit VIIe–3; woodland suitability group 4d3.

Guayama Series

The Guayama series consists of shallow soils that are well drained and moderately permeable. These soils formed in moderately fine textured and fine textured residuum of volcanic rocks. They occupy side slopes and narrow ridgetops. Slopes are 12 to 60 percent. The average annual precipitation is 35 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is dark reddish-brown, neutral clay loam about 5 inches thick. Below that layer is reddish-brown, friable gravelly clay 7 inches thick. The underlying layer is yellowish-red, firm gravelly clay loam. Volcanic rock is at a depth of 18 inches.

These soils have a moderate available water capacity, medium fertility, and moderate shrink-swell potential. Runoff is medium to rapid. The soils are somewhat difficult to work, and they have been in pasture for many years.

In this survey area, Guayama soils are mapped only in an undifferentiated group with Descalabrado soils.

Representative profile of Guayama clay loam, 20 to 40 percent slopes, in an area of Descalabrado and Guayama soils, 20 to 60 percent slopes, eroded, 17 meters north of kilometer marker 1.5 on Highway No. 303:

A1—0 to 5 inches, dark reddish-brown (5YR 3/4) clay loam; weak, fine, granular structure; soft, friable, slightly sticky and plastic; many fine roots; many, fine, subrounded volcanic rock fragments; neutral; clear, smooth boundary.

B2t—5 to 12 inches, reddish-brown (5YR 4/4) gravelly clay; moderate, fine, subangular blocky structure; soft, friable, sticky and plastic; common fine roots; thin patchy clay films on peds, and fragments coated with clay; many fine volcanic rock fragments; neutral; clear, smooth boundary.

C—12 to 18 inches, yellowish-red (5YR 4/6) gravelly clay loam; weak, fine, subangular blocky structure; soft, firm, slightly sticky and plastic; few fine roots; many fine volcanic rock fragments; neutral; gradual, irregular boundary.

R—18 to 20 inches, volcanic rock; secondary calcium carbonate is in rock cavities and fracture planes.

The solum is 6 to 15 inches thick. The A horizon has hue of 5YR or 7.5YR and value of 3 or 4. It is dominantly clay loam or gravelly clay loam. The B2t horizon has hue of 5YR or 2.5YR, value of 4 to 6, and chroma of 4 or higher. It is clay or gravelly clay and has weak or moderate, fine, subangular blocky structure. Clay films vary from thin patchy to thin discontinuous in the B2t horizon. The C horizon has a hue of 5YR or 7.5YR, value of 4 to 6, and chroma of 4 to 8. It ranges from clay loam to gravelly clay loam. Reaction in all horizons ranges from slightly acid to mildly alkaline. Depth to semiconsolidated volcanic rock is less than 20 inches.

The Guayama soils are on the same landscape as the Guayama variant soils and the Descalabrado, Amelia, and Jacana soils. The Guayama soils are shallower to semiconsolidated volcanic rock than the Guayama variant soils, and they are not so red in the B2t horizon as those soils. Unlike the Descalabrado soils, Guayama soils have a reddish B2t horizon. The Guayama soils are shallower than the Amelia soils. They are shallower to volcanic rock than the Jacana soils, and they lack pressure faces.

Guayama Variant

The Guayama variant consists of moderately deep soils that are well drained and moderately permeable. These soils formed in moderately fine textured and fine textured residuum of volcanic rocks. They are on lower side slopes and foot slopes. Slopes are 2 to 12 percent. The average annual precipitation is 35 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is dark yellowish-brown, strongly acid clay loam about 8 inches thick. Below that layer is red clay that extends to a depth of 26 inches. It is friable in the upper 8 inches and firm in the lower 10 inches. The underlying material is semiconsolidated volcanic rock.

These soils have a moderate available water capacity, medium fertility, and moderate shrink-swell potential. Runoff is medium. The soils are somewhat difficult to work, and they have been in pasture for many years.

Representative profile of Guayama clay loam, moderately deep variant, 2 to 12 percent slopes, eroded, 14.4 kilometers north of kilometer marker 132.8 on Highway No. 3:

Ap—0 to 8 inches, dark yellowish-brown (10YR 3/4) clay loam; weak, fine, granular structure; friable, nonsticky and slightly plastic; many fine roots; common, fine, subrounded rock fragments; strongly acid; clear, smooth boundary.

B21t—8 to 16 inches, red (2.5YR 4/6) clay; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; common fine roots; thin patchy clay films on ped surfaces and root channels; few, fine, subangular rock fragments; medium acid; clear, wavy boundary.

B22t—16 to 26 inches, red (2.5YR 5/6) clay; weak, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; few fine roots; thin discontinuous clay films on ped surfaces; common, fine, black concretions; many, fine, angular rock fragments; slightly acid; clear, smooth boundary.

R—26 to 30 inches, semiconsolidated volcanic rock; can be dug with difficulty with a spade when moist.

Thickness of the solum and depth to semiconsolidated volcanic rock range from 20 to 34 inches. Reaction is strongly acid in the A horizon, and the acidity decreases with increasing depth. The A horizon has hue of 10YR, 7.5YR, or 5YR, value of 2 or 3, and chroma of 3 or 4. The B2t horizon has hue of 2.5YR or 5YR, value of 4 to 6, and chroma of 6 to 8. Angular and subangular rock fragments range from few to many and clay films range from thin patchy to thin discontinuous in the B2t horizon.

The Guayama variant soils are on the same landscape as the Guayama, Descalabrado, and Amelia soils. The Guayama variant soils are deeper to volcanic rock and have a redder B horizon than the Guayama and Descalabrado soils. They have a redder B horizon than the Amelia soils, and they lack gravelly layers.

GyC2—Guayama clay loam, moderately deep variant, 2 to 12 percent slopes, eroded. This soil is on the lower side slopes and foot slopes in the semiarid part of the survey area. Erosion has removed some of the dark yellowish-brown, clay loam surface layer, and in some places plowing has mixed this layer with the subsoil. Included with this soil in mapping were some small areas of Amelia, Guayama, and Descalabrado soils.

This soil has severe limitations for crops because rainfall is low. Slope and medium surface runoff are moderate limitations, and conservation practices are needed to reduce soil loss. This soil is suited to sugarcane, pasture, and woodland. Capability units IVc-2 nonirrigated and IIIe-4 irrigated; woodland suitability group 3d5.

Humacao Series

The Humacao series consists of deep soils that are well drained and moderately permeable. These soils formed in medium-textured and moderately fine textured sediment derived from granitic rocks. They occupy terraces above river flood plains. Slopes are 2 to 5 percent. The climate is humid tropical. The average annual rainfall is 85 to 90 inches, and the annual temperature is 78° F.

In a representative profile, the surface layer is dark-brown, strongly acid loam about 14 inches thick. The next layer, to a depth of 18 inches, is dark-brown, friable sandy clay loam. Below that layer is yellowish-brown, firm clay loam 13 inches thick. The underlying material is brown, friable clay loam that extends to a depth of 55 inches.

These soils have a moderate available water capacity. Surface runoff is slow. The soils are easily worked, and they have been in food crops and native pasture.

Representative profile of Humacao loam, 2 to 5 percent slopes, 0.2 kilometer south of kilometer marker 1.2 on Highway No. 908 and 3 meters west of farm road:

Ap—0 to 14 inches, dark-brown (7.5YR 3/2) loam; few, medium, distinct, dark-brown (10YR 4/3) mottles; weak, fine and medium, granular structure; friable, nonsticky and slightly plastic; many fine roots; few, fine, subrounded rock fragments; many fine quartz crystals; few, fine, dark minerals; strongly acid; clear, smooth boundary.

B2—14 to 18 inches, dark-brown (10YR 4/3) sandy clay loam with tongues of dark brown (7.5YR 3/2); weak, fine, subangular blocky structure; friable, nonsticky and slightly plastic; few fine roots; many, fine, subrounded rock fragments; common fine quartz crystals; common, fine, dark minerals; strongly acid; clear, smooth boundary.

C1—18 to 31 inches, yellowish-brown (10YR 5/4) clay loam; common, medium, faint, dark yellowish-brown (10YR 4/4) mottles; massive; firm, slightly sticky and slightly plastic; few fine roots; common fine quartz crystals; many, fine, subrounded, partially weathered rock fragments; few, fine, dark concretions; strongly acid; clear, smooth boundary.

C2—31 to 55 inches, yellowish-brown (10YR 5/6) clay loam; many, medium, prominent, dark-brown (10YR 3/3) mottles and common, medium, distinct, yellowish-red (5YR 5/8) mottles; massive; friable, slightly sticky and slightly plastic; few fine quartz crystals; many, fine, partially weathered rock fragments; common, medium, dark concretions; medium acid.

The solum is 12 to 28 inches thick. The A horizon has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 or 3. The B horizon has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 or 3. It has weak, fine or medium, subangular blocky structure. The C horizon has chroma of 4 to 6.

The Humacao soils occupy the same landscape as the Candelero and Vivi soils. They are better drained than the Candelero soils and lack their B2t horizon. The Humacao soils are finer textured in the C horizon than the Vivi soils, and unlike those soils, they are moderately permeable.

HmB—Humacao loam, 2 to 5 percent slopes. This soil is on terraces above the flood plains. Included with it in mapping were small areas of Candelero soils.

Proper management is needed to prevent soil loss. This soil is suited to cultivated crops, sugarcane, and pasture. Capability unit IIe–2.

Humatas Series

The Humatas series consists of deep soils that are well drained and moderately permeable. These soils formed in fine-textured residuum derived from basic volcanic rocks. They are on mountain side slopes and narrow ridgetops. Slopes are 20 to 60 percent. The climate is humid tropical. The average annual precipitation is 86 inches, and the average annual temperature is 76° F.

In a representative profile, the surface layer is brown to dark-brown, very strongly acid clay about 5 inches thick. Below that layer is yellowish-red and red clay and silty clay that extends to a depth of 38 inches. The underlying material is yellowish-red saprolite that is mottled with dark grayish brown and red. It extends to a depth of 60 inches.

These soils have a high available water capacity, medium natural fertility, and moderate shrink-swell potential. Surface runoff is medium to rapid. The soils are somewhat difficult to work. They have been in food crops, coffee trees, and pasture for many years.

Representative profile of Humatas clay, 20 to 40 percent slopes, eroded, 5.2 kilometers southwest, along paved road, from kilometer marker 2.7 on Highway No. 957 and 45 meters south, Palma Sola Ward, Canovanas:

A1—0 to 5 inches, brown to dark-brown (7.5YR 4/4) clay; weak, fine, subangular blocky structure parting to granular; friable, nonsticky and slightly plastic; many fine roots; very strongly acid; gradual, smooth boundary.

B21—5 to 10 inches, yellowish-red (5YR 4/6) clay; common, medium, faint, brown to dark-brown (7.5YR 4/4) mottles; weak to moderate, medium, subangular blocky structure; firm, nonsticky and slightly plastic; common fine roots; few fine pebbles, 1 to 2 millimeters; patchy clay films on peds; very strongly acid; clear, smooth boundary.

B22t—10 to 16 inches, red (2.5YR 4/6) clay; moderate, medium, subangular blocky structure; friable, nonsticky and plastic; few roots; thin continuous clay films on peds; very strongly acid; clear, smooth boundary.

B23t—16 to 27 inches, red (2.5YR 4/6) clay; weak, fine, subangular blocky structure; friable, nonsticky and plastic; few roots; common clay films; very strongly acid; clear, smooth boundary.

B3—27 to 38 inches, red (2.5YR 4/6) silty clay; common, fine, distinct, red (2.5YR 4/8), very pale brown (10YR 7/4), and strong-brown (7.5YR 5/6) mottles; weak, fine, subangular blocky structure; friable, nonsticky and slightly plastic; about 10 to 15 percent saprolite; very strongly acid; gradual, smooth boundary.

C—38 to 60 inches, yellowish-red (5YR 4/6) silty clay loam; few, fine, distinct, dark grayish-brown (10YR 4/2) and red (2.5YR 5/8) mottles; massive; friable, nonsticky and slightly plastic; about 80 percent saprolite; very strongly acid.

The solum is 23 to 50 inches thick. The A horizon has hue of 7.5YR or 5YR, value of 3 or 4, and chroma of 4 to 6. The B horizon ranges from 20 to 42 inches in thickness, and the B2t horizon from 14 to 30 inches. The B horizon has hue of 5YR or 2.5YR, value of 4 or 5, and chroma of 6 or more. The C horizon ranges from silty clay loam to clay loam.

The Humatas soils are on the same landscape as the Caguabo and Mucara soils. The Humatas soils are deeper and redder than the Caguabo and Mucara soils, and they have a B2t horizon.

HtE2—Humatas clay, 20 to 40 percent slopes, eroded. This soil is on side slopes and ridgetops in the humid volcanic uplands. It has the profile described as representative of the series. In some places plowing has mixed the surface layer with the subsoil. Included with this soil in mapping were small areas of Mucara and Caguabo soils.

Steep slopes, medium runoff, and the hazard of erosion limit this soil to occasional clean cultivation. Conservation practices and proper management are required to slow erosion. This soil has been used for coffee trees and pasture. If it is properly limed and managed, it is suited to occasional cultivated crops and to coffee trees, pasture, and woodland. Capability unit IVe–5; woodland suitability group 2c5.

HtF2—Humatas clay, 40 to 60 percent slopes, eroded. This soil occupies strongly dissected side slopes and narrow ridgetops in the humid volcanic uplands. It has a thinner surface layer than the soil described as representative of the series. Included with this soil in mapping were small areas of Mucara and Caguabo soils.

Steep slopes, rapid runoff, and the hazard of erosion are severe limitations for cultivated crops. The use of this soil is limited to pasture, woodland, and wildlife food and cover. Conservation practices are needed to slow runoff if the soil is used for food crops and coffee trees. Capability unit VIe–2; woodland suitability group 3r5.

HuF—Humatas-Stony land complex, 40 to 60 percent slopes. This mapping unit is on mountain side slopes and ridgetops in the humid volcanic uplands. Humatas clay and Stony land each make up 50 percent of this mapping unit. They occur in such intricate patterns that it is not feasible to map them separately. The areas of Stony land are covered with stones and boulders that range from 1 to 15 feet or more in diameter.

Very steep slopes, the hazard of erosion, rapid runoff, and boulders are severe limitations for cultivated crops. The soils of this complex are suitable for pasture, woodland, and wildlife food and cover. Capability unit VIIs–2; woodland suitability group 3r5.

Ingenio Series

The Ingenio series consists of deep soils that are well drained and moderately permeable. These soils formed in medium-textured and fine-textured residuum derived from highly weathered granitic rocks. They are on mountain side slopes and narrow ridgetops. Slopes are 20 to 40 percent. The climate is humid tropical. The average annual precipitation is 75 to 85 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is yellowish-brown, very strongly acid silty clay loam about 7 inches thick. The next layer is red, friable clay and silty clay 33 inches thick. Below that, to a depth of 51 inches, is silty clay loam saprolite that has varying colors. Below this layer the saprolite is silt loam to a depth of 76 inches.

These soils have a moderate available water capacity and medium fertility. Runoff is medium to rapid. The soils have been used for pasture. Most of the acreage is in native pasture, shrubs, and minor crops; small areas are in food crops.

Representative profile of Ingenio silty clay loam, 20 to 40 percent slopes, eroded, 4.9 kilometers southwest of Humacao and 1 kilometer southwest from Surillo School, Tejas Ward:

Ap—0 to 7 inches, yellowish-brown (10YR 5/4) silty clay loam; many, medium, distinct, strong-brown (7.5YR 5/6) mottles; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; many fine roots; common fine quartz grains; few, fine, black grains; very strongly acid; clear, smooth boundary.

B21t—7 to 15 inches, red (2.5YR 5/6) silty clay; moderate, medium and coarse, prismatic structure; friable, slightly sticky and plastic; thin, continuous, yellowish-red (5YR 4/8) coatings on vertical ped surfaces and thin discontinuous coatings on horizontal ped surfaces; common fine roots; few fine pores; common fine quartz grains; few, fine, black grains; few krotovinas about 5 millimeters in diameter; very strongly acid; clear, smooth boundary.

B22t—15 to 31 inches, red (2.5YR 4/6) clay; moderate, medium and coarse, subangular blocky structure; friable, slightly sticky and slightly plastic; thin, continuous, reddish-brown (2.5YR 5/4) coatings on vertical ped surfaces and thin discontinuous coatings on horizontal ped surfaces; common fine roots; few fine pores; common fine quartz grains; few, fine, black grains; few krotovinas 2 to 5 millimeters in diameter; very strongly acid; gradual, smooth boundary.

B3—31 to 40 inches, red (2.5YR 4/6) silty clay; weak, medium and coarse, subangular blocky structure; very friable, nonsticky and slightly plastic; thin, discontinuous, reddish-brown (2.5YR 5/4) coatings on ped surfaces; common fine roots; common fine pores; common fine quartz grains; few, fine, black grains; few krotovinas 1 inch in diameter that have thick clay coatings; very strongly acid; clear, smooth boundary.

C1—40 to 51 inches, variegated, dusky red, yellow, and white silty clay loam, dark yellowish brown (10YR 4/4) crushed; massive; very friable, nonsticky and slightly plastic; common fine roots; few fine pores; common fine quartz grains; 50 percent saprolite; very strongly acid; gradual, smooth boundary.

C2—51 to 76 inches, variegated, dusky-red, yellow, yellowish-brown, and white silt loam saprolite; massive; very friable, nonsticky and slightly plastic; few dead roots with clay and organic coatings in root channels; very strongly acid.

The solum is 27 to 48 inches thick. The A horizon has hue of 10YR or 5YR, value of 4 or 5, and chroma of 3 or 4. The B2t horizon has hue of 5YR or 2.5YR, value of 4 or 5, and Chroma of 4 to 6. It is silty clay or clay. The C horizon has variegated colors of dusky red, yellow, brown, yellowish brown, and white.

The Ingenio soils are on the same landscape as the Lirios, Jagueyes, and Limones soils. The Ingenio soils have a thicker B2t horizon than the Lirios soils. They are redder and finer textured than the Jagueyes soils. The Ingenio soils are coarser textured throughout than the Limones soils.

InE2—Ingenio silty clay loam, 20 to 40 percent slopes, eroded. This soil is on mountain side slopes and ridgetops in the humid granitic uplands. Erosion has removed part of the original surface layer, and in most places the remaining part of that layer has been mixed with the subsoil. Included with this soil in mapping were small areas of Jagueyes and Limones soils.

Although this soil is used occasionally for cultivated crops, the steep slopes, rapid runoff, and the hazard of erosion are severe limitations. The soil is suited to pasture and woodland. Capability unit IVe–5; woodland suitability group 2o5.

Jacana Series

The Jacana series consists of moderately deep soils that are well drained and moderately slowly permeable. These soils formed in fine-textured sediment and residuum derived from basic volcanic rocks. They occupy foot slopes and low rolling hills. Slopes are 2 to 12 percent. The climate is semiarid. The average annual precipitation is 35 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is very dark grayish-brown and dark-brown, medium acid clay about 5 inches thick. The next layer is dark-brown and dark yellowish-brown clay that extends to a depth of 21 inches. Partly weathered volcanic material is between depths of 21 and 26 inches; it is underlain by semiconsolidated volcanic rock.

These soils have high natural fertility and high shrink-swell potential. Surface runoff is medium. The soils are difficult to work. They have been in pasture for many years, and most of the acreage is still in pasture. Small areas are in sugarcane.

Representative profile of Jacana clay, 2 to 5 percent slopes, following farm roads 0.8 kilometer west of kilometer marker 92.1 on Highway No. 1, 3.2 kilometers north to southwestern corner of irrigation reservoir, then 0.2 kilometer west and 0.3 kilometer north to an irrigation channel and 9 meters north of the channel:

Ap—0 to 5 inches, very dark grayish-brown and dark-brown (10YR 3/2, 3/3) clay; weak, fine, subangular blocky structure parting to granular; friable, slightly sticky and slightly plastic; common fine roots; common, fine, subangular pebbles; few, fine, dark minerals; medium acid; gradual, smooth boundary.

B1—5 to 13 inches, dark-brown (10YR 3/3) clay; weak, medium and fine, subangular blocky structure; friable, slightly sticky and slightly plastic; few very dark grayish-brown (10YR 3/2) stains on ped surfaces; common fine roots; common, fine, subrounded pebbles; few, fine, dark minerals; neutral; abrupt, smooth boundary.

B2—13 to 21 inches, dark yellowish-brown (10YR 4/4) clay; weak, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; few very dark grayish-brown (10YR 3/2) stains along root channels and ped surfaces; few patchy clay films; common pressure faces; common subrounded pebbles; few quartz grains; few, fine, dark minerals; neutral; abrupt, smooth boundary.

C—21 to 26 inches, partly weathered volcanic material.

R—26 inches +, semiconsolidated volcanic rock.

The solum is 16 to 28 inches thick. The Ap horizon has hue of 10YR or 7.5YR and value of 2 or 3. The B horizon has hue of 10YR or 7.5YR and value and chroma of 3 or 4. Pressure faces and slickensides range from few to many in the B2 horizon. Reaction ranges from medium acid to neutral. Depth to the partly weathered rock ranges from 20 to 36 inches.

The Jacana soils are on the same landscape as the Descalabrado, Coamo, and Amelia soils. The Jacana soils are thicker and finer textured than the Descalabrado soils. They are shallower than the Coamo soils and lack the stratified C horizon of those soils. The Jacana soils are finer textured and shallower than the Amelia soils, and they lack gravelly layers.

JaB—Jacana clay, 2 to 5 percent slopes. This soil is on foot slopes in the semiarid area. It has the profile described as representative of the Jacana series. Included with this soil in mapping were small areas of Coamo and Amelia soils.

Low rainfall is a severe limitation that restricts the use of this soil for farming. During years when rainfall is above average the soil is used for cultivated crops. If it is irrigated, the soil is suited to sugarcane, cut grasses, and pasture. Capability units IVc–2 nonirrigated and IIIs–3 irrigated; woodland suitability group 3d5.

JaC2—Jacana clay, 5 to 12 percent slopes, eroded. This soil occupies foot slopes and low rolling hills in the semiarid area. Its profile is similar to the one described as representative of the Jacana series, but some of the surface layer of dark grayish-brown clay has been removed by erosion, and in most places this layer has been mixed with the subsoil by plowing. Small areas of Descalabrado soils were included with this soil in mapping.

This soil has severe limitations for farming because of moderate slopes, the hazard of erosion, and poor workability. Also, rainfall is low in the area. Good management and conservation practices are required to slow surface runoff. This soil is suited to pasture, and it has been in pasture for many years. Capability unit IVe–4; woodland suitability group 3d5.

Jagueyes Series

The Jagueyes series consists of deep soils that are well drained and moderately permeable. These soils formed in residuum derived from highly weathered granitic rocks. They are on side slopes and narrow ridgetops. Slopes are 20 to 40 percent. The climate is humid tropical. The average annual rainfall is 75 to 85 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is dark grayish-brown, very strongly acid loam about 8 inches thick. Below that layer is yellowish-brown sandy clay loam 6 inches thick. The next layer is yellowish-brown, yellow, and red, firm clay loam that extends to a depth of 37 inches. Below that layer is red, friable loam and sandy clay loam that extends to a depth of about 71 inches. It is underlain by saprolite.

These soils have a moderate available water capacity, medium natural fertility, and low shrink-swell potential. Surface runoff is medium. The soils have been used for food crops and pasture.

Representative profile of Jagueyes loam, 20 to 40 percent slopes, eroded, 7.5 kilometers southwest from Humacao and 7.7 kilometers north from Yabucoa, 445 meters west from junction of Highway No. 921 and farm road, 210 meters south of house and 150 meters northeast of mango trees, Tejas Ward, Yabucoa:

Ap—0 to 8 inches, dark grayish-brown (2.5Y 4/2) loam; weak, fine, granular structure; soft, very friable, nonsticky and nonplastic; common fine roots; very strongly acid; clear, smooth boundary.

A3—8 to 14 inches, yellowish-brown (10YR 5/6) sandy clay loam; weak, medium, subangular blocky structure; soft, friable, slightly sticky and slightly plastic; common fine roots; few, medium, black concretions; common, fine, shiny grains; many fine quartz grains; very strongly acid; clear, smooth boundary.

B1—14 to 18 inches, yellowish-brown (10YR 5/8) sandy clay loam; weak, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; strong-brown (7.5YR 5/6) and yellowish-brown (10YR 5/4) coatings on ped surfaces; common fine roots; thin patchy clay films; few, medium, black concretions; common, fine, black grains; many fine quartz grains; very strongly acid; clear, smooth boundary.

B21t—18 to 26 inches, yellow (10YR 7/6) clay loam; many, fine, distinct, dark-red (2.5YR 3/6) mottles and many, medium, distinct, red (2.5YR 4/8) mottles; moderate, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; common fine roots; thin continuous clay films; few, medium, black concretions; few, fine, black grains; many fine quartz grains; many weathered feldspar grains; very strongly acid; clear, smooth boundary.

B22t—26 to 37 inches, yellow (10YR 7/6) and red (2.5YR 4/8) clay loam; few, fine, faint, brownish-yellow (10YR 6/8) mottles; weak, coarse, subangular blocky structure; firm, nonsticky and slightly plastic; few fine roots; thin discontinuous clay films; many fine quartz grains; few, fine, black grains; many weathered feldspar grains; very strongly acid; gradual, smooth boundary.

B3—37 to 52 inches, red (2.5YR 4/8) sandy clay loam; weak, medium, subangular blocky structure; friable, nonsticky and nonplastic; brownish-yellow (10YR 6/8) coatings; few fine roots; thin patchy clay films; many fine quartz grains; few, fine, black grains; very strongly acid; gradual, smooth boundary.

C1—52 to 71 inches, red (2.5YR 4/8) loam; massive; friable, nonsticky and slightly plastic; few, fine, black grains; many fine quartz grains; many, fine, weathered feldspar grains; 50 percent saprolite; very strongly acid; gradual, wavy boundary.

C2—71 to 95 inches, red (2.5YR 5/8) loam saprolite; massive; friable, nonsticky and slightly plastic; very strongly acid; gradual, smooth boundary.

C3—95 to 120 inches, red (2.5YR 5/6) sandy loam saprolite; massive; friable, nonsticky and slightly plastic; very strongly acid.

The solum is 39 to 66 inches thick. The A horizon has hue of 2.5Y or 10YR, value of 4 or 5, and chroma of 2 to 6. It is loam, sandy loam, or sandy clay loam. The B horizon has hue of 10YR or 2.5YR, value of 4 to 7, and chroma of 6 to 8. It is clay loam or sandy clay loam and has weak to moderate, medium to coarse, subangular blocky structure. The C horizon is sandy loam to loam.

The Jagueyes soils occupy the same landscape as the Lirios, Ingenio, and Limones soils. The Jagueyes soils have a thicker solum than the Lirios soils, and they are coarser textured than the Ingenio and Limones soils.

JgE2—Jagueyes loam, 20 to 40 percent slopes, eroded. This soil is on narrow mountain ridgetops and side slopes in the humid plutonic uplands. Erosion has removed some of the dark grayish-brown loam surface layer, and in many places most of the plow layer is a mixture of the surface layer and the subsoil. Included with this soil in mapping were areas of Limones, Lirios, and Ingenio soils.

This soil has severe limitations for farming because of slope and the hazard of erosion. Steep slopes, medium runoff, and the hazard of erosion are severe limitations for cultivated crops. Conservation practices and proper management are required to slow surface runoff. This soil is used occasionally for food crops. If it is properly managed, it is suited to food crops, pasture, and woodland. Capability unit IVe–11; woodland suitability group 2o5.

Junquitos Series

The Junquitos series consists of moderately deep soils that are moderately well drained and moderately slowly permeable. These soils formed in alluvial and colluvial sediment derived from extrusive volcanic rocks and, to a small degree, in residuum from similar rocks. They are on foot slopes. Slopes are 5 to 12 percent. The climate is humid tropical. The average annual rainfall is 87 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is brown to dark-brown, extremely acid gravelly clay loam about 7 inches thick. The next layer is yellowish-brown, mottled, firm clay 21 inches thick. The underlying material is brownish-yellow, mottled clay that extends to a depth of 35 inches. It is underlain by volcanic rock fragments.

These soils have a high available water capacity and moderate shrink-swell potential. Runoff is medium. The soils are difficult to work. They have been in pasture for many years, but some areas are in sugarcane.

Representative profile of Junquitos gravelly clay loam, 5 to 12 percent slopes, 1 kilometer north, 0.2 kilometer west, and 15 meters south of kilometer marker 81.3 on Highway No. 3, east of Humacao:

Ap—0 to 7 inches, brown to dark-brown (10YR 4/3) gravelly clay loam; massive; slightly hard, firm, nonsticky and slightly plastic; many fine roots; many, medium and coarse, angular and subrounded rock fragments; extremely acid; clear, smooth boundary.

B1—7 to 21 inches, yellowish-brown (10YR 5/8) clay; few, fine, distinct, red (2.5YR 5/8) mottles; weak, medium, subangular blocky structure; hard, firm, slightly sticky and plastic; few fine roots; few, fine, subrounded rock fragments; few, fine, dark concretions; strongly acid; clear, smooth boundary.

B2—21 to 28 inches, yellowish-brown (10YR 5/8) clay; few, fine, distinct, red (2.5YR 5/8) and light-gray (10YR 7/1) mottles; weak, fine, subangular blocky structure; hard, firm, slightly sticky and plastic; few, fine, patchy clay films; many, fine and medium, dark concretions; common, fine and medium, angular and subrounded rock fragments; slightly acid; clear, smooth boundary.

C1—28 to 35 inches, brownish-yellow (10YR 6/8) clay; many, coarse, prominent, red (2.5YR 5/8) mottles and common, medium, distinct, gray (10YR 5/1) mottles; massive; hard, firm, slightly sticky and plastic; many, fine, dark concretions; common, fine, subrounded, rock fragments; neutral; abrupt, smooth boundary.

IIC2—35 inches+, angular volcanic rock fragments.

The solum is 20 to 40 inches thick. The A horizon has value of 3 or 4 and chroma of 2 or 3. The content of volcanic rock fragments in the surface layer ranges from 30 to 40 percent. The B horizon has weak, fine or medium, subangular blocky structure. The C horizon has hue of 10YR or 7.5YR and value of 5 or 6. Mottles in the B and C horizons range from few to many and are shades of red and gray. Patchy clay films range from few to many, and dark concretions range from few to many and are fine or medium sized.

The Junquitos soils occupy the same landscape as the Rio Arriba, Mabi, Aceitunas, and Via soils. The Junquitos soils are shallower to rock fragments than the Rio Arriba soils. They are shallower and coarser textured than the Mabi soils, and their shrink-swell potential is not so high. The Junquitos soils are shallower than the Aceitunas soils and lack their reddish horizons. They are shallower and finer textured than the Via soils, and they are not so well drained as Via soils.

JuC—Junquitos gravelly clay loam, 5 to 12 percent slopes. This soil is on foot slopes in the humid volcanic uplands. Included with it in mapping were small areas of Rio Arriba, Mabi, and Via soils.

Slope and surface runoff are moderate limitations for farming. Proper management and conservation practices are needed to reduce erosion. If this soil is properly managed, it is suited to sugarcane and pasture. Capability unit IIIe–5.

Leveled Clayey Land

Leveled clayey land (Lc) consists of clayey soils that have different colors, plasticity, and mineralogy. These soils have been reworked by machinery during land leveling for construction. The original soils have been so disturbed that it is impossible to identify them. Generally, the soils in this mapping unit are deep to consolidated parent material.

This land type has severe limitations for farming because the soils have been disturbed. It is suitable for such nonfarm uses as foundations and sites for light industries.

Limones Series

The Limones series consists of deep soils that are moderately well drained and moderately permeable. These soils formed in fine-textured residuum of very highly weathered granitic rocks. They are on side slopes and narrow ridgetops. Slopes are 20 to 40 percent. The climate is humid tropical. The average annual rainfall varies from 75 to 85 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is dark yellowish-brown, very strongly acid silty clay about 5 inches thick. Below that is dark yellowish-brown, yellowish-brown, and yellowish-red clay 35 inches thick. The underlying material is clay loam, clay, and silty clay loam saprolite that extends to a depth of 120 inches.

These soils have a high available water capacity and moderate to rapid runoff and are susceptible to erosion. They have been in pasture for many years, and there are small areas in food crops.

Representative profile of Limones silty clay, 20 to 40 percent slopes, 3 kilometers west of the town of Yabucoa and 30 meters north of kilometer marker 14.2 on Highway No. 182:

Ap—0 to 5 inches, dark yellowish-brown (10YR 4/4) silty clay; few, fine, distinct, strong-brown (7.5YR 5/8) and olive-gray (5Y 5/2) mottles; weak, fine and medium, subangular blocky structure; friable, nonsticky and plastic; common fine roots; red coatings along root channels; few fine quartz grains; very strongly acid; clear, smooth boundary.

B1—5 to 9 inches, dark yellowish-brown (10YR 4/4) clay; few, fine, faint, strong-brown (7.5YR 5/8) mottles; weak, fine, subangular blocky structure; friable, nonsticky and plastic; common fine roots; few, thin, patchy clay films; few fine quartz grains; few, fine, black grains; very strongly acid; clear, smooth boundary.

B21t—9 to 16 inches, yellowish-brown (10YR 5/6) clay; many, medium, distinct, red (2.5YR 4/8) mottles; moderate, medium and coarse, subangular blocky structure; firm, slightly sticky and plastic; common fine roots; thin, continuous, yellowish-brown clay films on ped surfaces and root channels; common fine quartz grains; few, fine, black concretions; very strongly acid; clear, smooth boundary.

B22t—16 to 26 inches, yellowish-red (5YR 5/6) clay; moderate, medium and coarse, subangular blocky structure; firm, slightly sticky and plastic; common fine roots; thin, continuous, strong-brown clay films on ped surfaces, root, and worm channels; common fine quartz grains; few, fine, black grains; very strongly acid; gradual, smooth boundary.

B3—26 to 40 inches, yellowish-red (5YR 4/8) clay; weak, medium, subangular blocky structure; friable, slightly sticky and plastic; few fine roots; thin, patchy, strong-brown clay films on ped surfaces and root channels; few fine quartz grains; few, fine, black grains; about 20 percent saprolite; very strongly acid; gradual, smooth boundary.

C1—40 to 54 inches, red (2.5YR 4/8) clay loam saprolite; massive; friable, nonsticky and plastic; few fine roots; thin clay films along root channels; many weathered feldspar grains; many fine quartz grains; very strongly acid; gradual, smooth boundary.

C2—54 to 72 inches, variegated colors of the saprolite; red (2.5YR 4/8), rubbed, clay; massive; friable, nonsticky and plastic; few fine roots; many fine quartz grains; common, fine, soft, black grains; many weathered feldspar grains; very strongly acid; gradual, smooth boundary.

C3—72 to 96 inches, variegated colors of the saprolite; red (2.5YR 4/8), rubbed, silty clay loam; massive; friable, nonsticky and slightly plastic; many weathered feldspar grains; many fine quartz grains; very strongly acid.

C4—96 to 120 inches, variegated colors of the saprolite; red (2.5YR 4/8), rubbed, silty clay loam; massive friable, nonsticky and slightly plastic; many weathered feldspar grains; many fine quartz grains; very strongly acid.

The solum is 33 to 53 inches thick. The B2t horizon has hue of 10YR or 5YR, value of 4 or 5, and chroma of 4 to 8. Clay films vary from thin patchy to thin continuous. The C horizon ranges from clay loam to clay.

The Limones soils are on the same landscape as the Jagueyes and Ingenio soils. They are finer textured than the Jagueyes soils. Unlike the Ingenio soils, the Limones soils are moderately well drained and lack red colors in the solum.

LeE2—Limones silty clay, 20 to 40 percent slopes, eroded. This soil is on side slopes and narrow ridgetops in the humid plutonic uplands. Included with it in mapping were small areas of Ingenio and Jagueyes soils.

This soil is not suited to cultivated crops because of the hazard of erosion. Steep slopes, surface runoff, and the hazard of erosion are severe limitations for farming. If the soil is properly managed, it is suited to pasture and woodland. Capability unit IVe-5; woodland suitability group 2c5.

Lirios Series

The Lirios series consists of deep soils that are well drained and moderately permeable. These soils formed in fine-textured, very highly weathered residuum derived from granitic rocks. They are on foot slopes, side slopes, and hilltops. Slopes are 3 to 40 percent. The climate is humid tropical. The average annual rainfall is 80 to 90 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is dark-brown, very strongly acid silty clay loam about 4 inches thick. Below that is red, friable clay and silty clay that extends to a depth of 23 inches. The underlying material is silty clay loam saprolite.

These soils have a high available water capacity. Surface runoff is moderate to rapid. The soils are susceptible to erosion. They have been in pasture for many years; few areas are in food crops.

Representative profile of Lirios silty clay loam, 20 to 40 percent slopes, eroded, 90 meters south of kilometer marker 11.9 on Highway No. 181, Barrio Guayabota, Municipality of Yabucoa:

Ap—0 to 4 inches, dark-brown (10YR 4/3) silty clay loam; weak, fine, subangular blocky structure; friable, nonsticky and slightly plastic; many fine roots; many fine quartz crystals; common, fine dark concretions; very strongly acid; abrupt, smooth boundary.

B2t—4 to 14 inches, red (2.5YR 4/8) clay; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; common fine roots; thin patchy clay films on ped surfaces and root channels; common fine quartz crystals; few, fine, white flakes; very strongly acid; gradual, smooth boundary.

B3—14 to 23 inches, red (10R 4/6) silty clay; common, fine, distinct, reddish-yellow (5YR 6/6) mottles; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; thin patchy clay films on ped surfaces; common fine quartz crystals; many, fine, shiny, white flakes; very strongly acid; gradual, smooth boundary.

C—23 to 50 inches, variegated, red (10R 4/6), strong-brown (7.5YR 5/8), reddish-brown (5YR 4/3), and pink (5YR 7/3) silty clay loam saprolite; massive; friable, nonsticky and slightly plastic; many fine quartz crystals; many, fine, shiny flakes; very strongly acid.

The solum is 22 to 36 inches thick. The Ap horizon has hue of 10YR or 7.5YR and chroma of 3 or 4. It is silty clay loam to clay loam. The B horizon has hue of 5YR, 2.5YR, or 10R, value of 4 to 6, and chroma of 4 to 8. It is silty clay or clay and has weak or moderate, fine or medium, subangular blocky structure. Clay films vary from thin patchy to thin continuous. The C horizon has variegated colors of strong brown, reddish brown, pink, and red.

The Lirios soils are on the same landscape as the Jagueyes and Limones soils. They are finer textured than the Jagueyes soils and are better drained than the Limones soils.

LoC2—Lirios clay loam, 3 to 10 percent slopes, eroded. This soil is on hilltops and foot slopes in the humid uplands. It has a thicker surface layer than the soil described as representative of the series. Erosion has removed some of the original surface layer, and in some places plowing has mixed the remaining part of that layer with the subsoil. Included with this soil in mapping were some areas of Jagueyes and Limones soils.

This soil is suited to cultivated crops and pasture, but good management and conservation practices are required to control erosion. Capability unit IIIe-6; woodland suitability group 2c5.

LrE2—Lirios silty clay loam, 20 to 40 percent slopes, eroded. This soil is on mountain side slopes. It has the profile described as representative of the series. Erosion has removed some of the original surface layer, and in some places the saprolite is exposed.

Steep slopes, surface runoff, and the hazard of erosion are severe limitations for cultivated crops. Proper management and soil conservation practices are required to control erosion. If the soil is properly limed and fertilized, it is suited to pasture and woodland. Capability unit IVe–5; woodland suitability group 2c5.

Los Guineos Series

The Los Guineos series consists of deep soils that are moderately well drained and moderately permeable. These soils formed in fine-textured residuum derived from highly weathered volcanic rocks. They are on mountain side slopes and narrow ridgetops. Slopes are 12 to 60 percent. The climate is humid tropical. The average annual precipitation is 100 inches, and the average annual temperature is 75° F.

In a representative profile, the surface layer is dark-brown, extremely acid silty clay loam about 5 inches thick. Below that is yellowish-brown and reddish-yellow very firm and firm clay 19 inches thick. The next layer is red, strong-brown, and reddish-yellow, very firm and firm clay. Clay saprolite is at a depth of 48 inches.

These soils have a high available water capacity and medium natural fertility. Runoff is medium to rapid. The soils are susceptible to erosion and are difficult to work. They have been in pasture, brush, and woodland for many years. Some areas are in abandoned coffee trees.

Representative profile of Los Guineos silty clay loam, 20 to 40 percent slopes, eroded, 350 meters southeast of kilometer marker 14.1 on Highway No. 179, Ward Carite, Guayama:

Ap—0 to 5 inches, dark-brown (10YR 4/3) silty clay loam; common, fine, distinct, yellowish-brown (10YR 5/8) mottles; weak, fine, granular structure; friable, slightly sticky and slightly plastic; few fine roots; extremely acid; clear, smooth boundary.

B21t—5 to 15 inches, yellowish-brown (10YR 5/6) clay; few, fine, yellowish-red (5YR 5/8) mottles; moderate, coarse, subangular blocky structure; very firm, slightly sticky and plastic; common fine roots; patchy clay films on ped surfaces and in root channels; extremely acid; numerous worm casts; gradual, smooth boundary.

B22t—15 to 24 inches, reddish-yellow (7.5YR 6/8) clay; ped interiors have common, medium, distinct, red (2.5YR 4/6) mottles; moderate, coarse, subangular blocky structure; firm, slightly sticky and plastic; thin continuous clay films on ped surfaces and patchy films in root channels; very strongly acid; gradual, wavy boundary.

B31—24 to 34 inches, red (2.5YR 4/6) and strong-brown (7.5YR 5/8) clay; weak, fine and medium, subangular blocky structure; very firm, slightly sticky and plastic; few fine roots; patchy clay films on vertical cleavage planes and in root channels; 20 percent saprolite; very strongly acid; gradual, wavy boundary.

B32—34 to 48 inches, red (2.5YR 4/6) and reddish-yellow (7.5YR 6/6) clay; weak, fine and medium, subangular blocky structure; firm, slightly sticky and plastic; few patchy clay films on vertical ped surfaces and in root channels; 40 percent saprolite; extremely acid; gradual, wavy boundary.

C—48 to 60 inches, mixed colors of the saprolite; red (2.5YR 4/6), brownish-yellow (10YR 6/6), very pale brown (10YR 7/4), and very dark brown (10YR 2/2) clay; massive; friable, slightly sticky and plastic; very strongly acid.

The solum is 36 to 58 inches thick. The Ap horizon has hue of 7.5YR or 10YR and chroma of 3 or 4. The B2t horizon has hue of 10YR or 7.5YR, value of 4 to 6, and chroma of 6 or higher. It has moderate or strong, medium or coarse, subangular blocky structure. Reaction is strongly acid or extremely acid.

The Los Guineos soils are on the same landscape as the Ciales and Picacho soils. The Los Guineos soils are better drained than the Ciales soils. Unlike the Picacho soils, they lack low-chroma mottles in the B2t horizon.

LsD—Los Guineos silty clay loam, 12 to 20 percent slopes. This soil is on side slopes and ridgetops in the humid volcanic uplands. It has a thicker surface layer than the soil described as representative of the Los Guineos series. Small areas of Los Guineos soils, 20 to 40 percent slopes, eroded, Mucara soils, and Rock land were included with this soil in mapping.

Slopes, medium runoff, and the hazard of erosion are severe limitations for farming. These limitations restrict the choice of plants and require very careful management if the soil is clean cultivated. The high intensity of rainfall restricts the time of planting, tilling, and harvesting. Most of the acreage is in brush and tropical rain forest. This soil is suited to food crops, grass, and woodland. Capability unit IVe–5; woodland suitability group 2c3.

LsE2—Los Guineos silty clay loam, 20 to 40 percent slopes, eroded. This soil is on side slopes and ridgetops. It has the profile described as representative of the series. Included with it in mapping were small areas of moderately steep Los Guineos soils, Mucara soils, and Rock land.

Steep slopes, rapid runoff, and the hazard of erosion are severe limitations for clean cultivation. If the soil is occasionally clean cultivated, conservation practices and proper management are required to control erosion. If the soil is properly limed and managed, it is suited to coffee trees, pasture, and woodland. Capability unit VIe–2; woodland suitability group 2c3.

LsF2—Los Guineos silty clay loam, 40 to 60 percent slopes, eroded. This soil is on side slopes and ridgetops in the humid volcanic uplands. Included with it in mapping were small areas of Caguabo soils and Rock land.

Very steep slopes, rapid runoff, and the hazard of erosion are severe limitations for clean cultivation. This soil has been in abandoned coffee trees, pasture, and forest. It is suitable for pasture, woodland, and food and cover for wildlife. Capability unit VIIe–1; woodland suitability group 2r3.

LyF—Los Guineos-Yunque-Stony rock land association, steep. This mapping unit is on mountains in the rain forest. The soils occur in uniform patterns; the Los Guineos soils are on the mountain side slopes, and the Yunque soils are on the upper side slopes and ridgetops. Stony rock land is on the lower part of the side slopes and along drainageways. In these places, 90 to 100 percent of the surface is covered with grayish and bluish volcanic rocks. Slopes range from 25 to 65 percent on the side slopes, from 10 to 35 percent on the upper side slopes, and from 25 to 70 percent in areas of Stony rock land.

The composition of this mapping unit is more variable than that of most other mapping units in the survey area but has been controlled well enough to interpret for the expected use of the soils. About 50 percent is Los Guineos soils, 31 percent is Yunque soils, and 10 percent is Stony rock land. The rest consists of other soils, rocks, and boulders.

This mapping unit is in hardwood rain forest. Because of the very steep slopes, its use is limited to forest, recreation, habitat for wildlife, and water catchment. Road stabilization is difficult because the soils are continuously wet and susceptible to slippage. Thus, the limitations for paths, roads, and trails are severe. Capability unit VIIe-3; woodland suitability group 3r3.

Mabi Series

The Mabi series consists of deep soils that are somewhat poorly drained and slowly permeable. These soils formed in sediment derived from volcanic rocks. They are on stream terraces, long foot slopes, and alluvial fans. Slopes are 0 to 20 percent. The climate is humid tropical. The average annual precipitation is 70 to 80 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is dark-brown, very strongly acid clay about 6 inches thick. It is underlain by yellowish-brown, mottled, very firm clay that extends to a depth of 56 inches.

These soils have a high available water capacity, high natural fertility, and high shrink-swell potential. Runoff is medium to slow. The soils are difficult to work. They have been in pasture (fig. 4) and sugarcane. Some areas are in tobacco.

Representative profile of Mabi clay, 0 to 5 percent slopes, 9 meters south and 9 meters west of kilometer marker 14.7 on Highway No. 31, Naguabo to Juncos:

Ap—0 to 6 inches, dark-brown (10YR 4/3) clay; common, fine, faint, dark-red (2.5YR 3/6) mottles; weak, fine, subangular blocky structure; firm, slightly sticky and slightly plastic; common fine roots; common, medium and fine, black concretions; few krotovinas; clay films on root channels; very strongly acid; abrupt, wavy boundary.

AC—6 to 18 inches, yellowish-brown (10YR 5/6) clay; common, medium, distinct, light-gray (5Y 7/2) mottles; weak, coarse, angular blocky structure; very firm, sticky and plastic; common dead roots in root channels; few black concretions; slickensides and pressure faces; very strongly acid; gradual, wavy boundary.

C1—18 to 35 inches, yellowish-brown (10YR 5/8) clay; many, coarse, prominent, light greenish-gray (5GY 7/1) mottles; weak, coarse, angular blocky structure; very firm, sticky and plastic; common dead roots; common, fine and medium, black concretions; slickensides and pressure faces; strongly acid; clear, wavy boundary.

C2—35 to 56 inches, yellowish-brown (10YR 5/6) clay; many, coarse, prominent, light greenish-gray (5GY 7/1) mottles; weak, coarse, angular blocky structure; very firm, sticky and plastic; fine dead roots; many, medium, black concretions; common dark concretions; common dark streaks on ped surfaces; slightly acid.

The Ap horizon is 6 to 12 inches thick. It has value of 4 or less and chroma of 2 or more. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 4 or more. Low-chroma mottles are below the Ap horizon. Reaction ranges from very strongly acid in the surface horizon to slightly acid in the lower horizons.

The Mabi soils occupy the same landscape as the Mucara and Rio Arriba soils. They are at a lower elevation and are finer textured and deeper than the Mucara soils. Unlike the Rio Arriba soils, the Mabi soils lack a B2t horizon and are somewhat poorly drained.

MaB—Mabi clay, 0 to 5 percent slopes. This soil is on alluvial fans, foot slopes, and terraces below the vol-

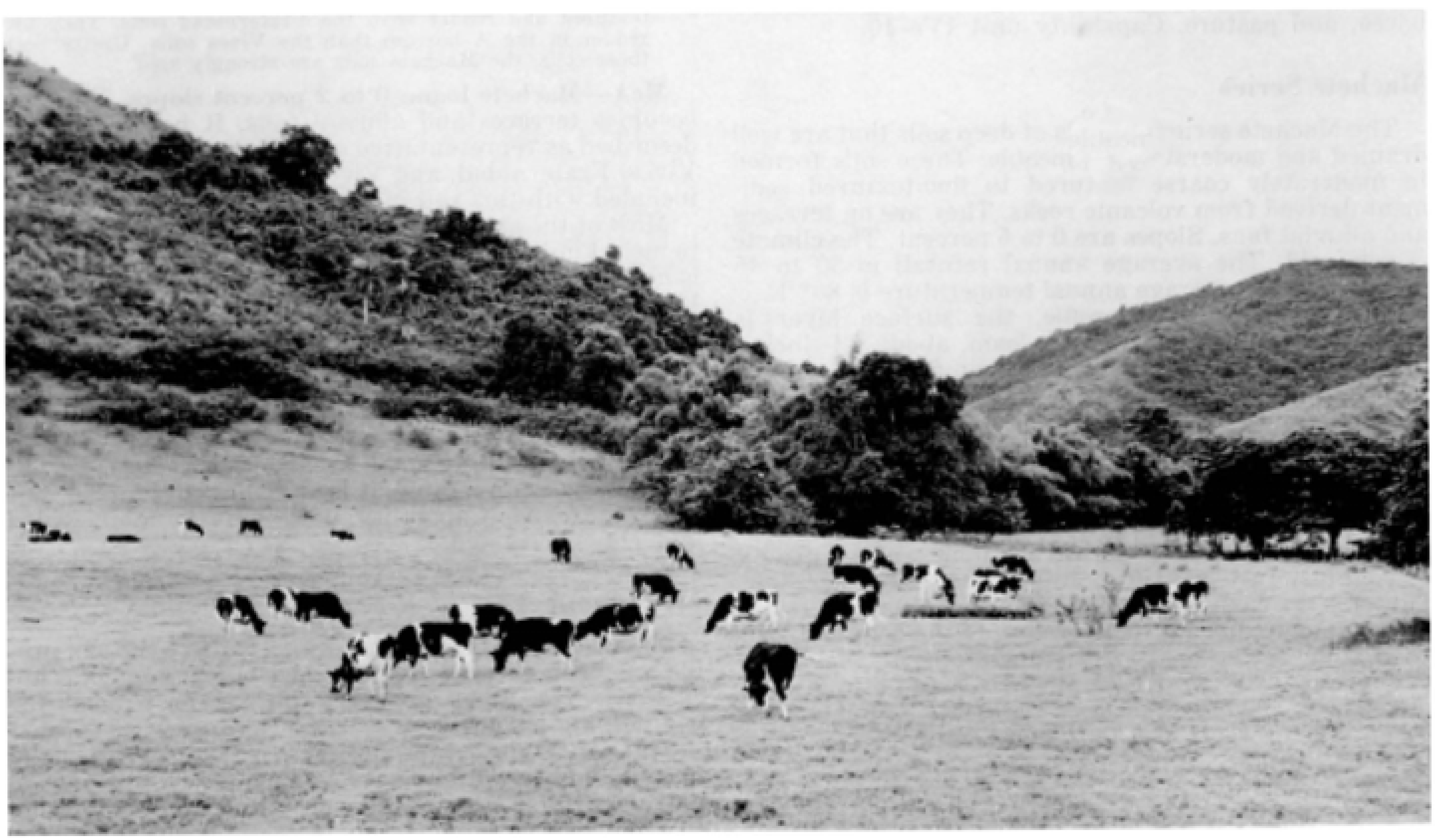

Figure 4.—**Pangolagrass pasture on Mabi soils. Steep Mucara soils are on the side slopes in the background.**

canic uplands. It has the profile described as representative of the series. Included with this soil in mapping were small areas of Rio Arriba soils.

This soil has moderate limitations for farming because of unfavorable workability and wetness. It is fertile and responds well to fertilizer but it needs careful management and drainage. The soil is suited to sugarcane, tobacco, and pasture. Capability unit IIw–3.

MaC2—Mabi clay, 5 to 12 percent slopes, eroded. This soil is on foot slopes and alluvial fans. Its profile is similar to the one described as representative of the Mabi series, but erosion has removed some of the dark-brown surface layer. In some places plowing has mixed the remaining part of the surface layer with some of the subsoil. Included with this soil in mapping were small areas of Rio Arriba soils.

This soil has moderate limitations for farming because it is somewhat poorly drained and difficult to cultivate. If it is properly managed and drained, the soil is suited to sugarcane, tobacco, and pasture. Capability unit IIIe–7.

MaD2—Mabi clay, 12 to 20 percent slopes, eroded. This soil is on foot slopes. It is steeper and better drained than the other Mabi soils. Erosion has removed some of the original dark-brown surface layer, and where the soil is plowed, the remaining part of that layer is mixed with some of the subsoil. In some places the yellowish-brown subsoil is exposed. Included with this soil in mapping were some areas of Mucara soils.

Slope, the hazard of erosion, and the difficulty of cultivation are severe limitations for farming. If the soil is properly managed, it is suited to sugarcane, tobacco, and pasture. Capability unit IVe–10.

Machete Series

The Machete series consists of deep soils that are well drained and moderately permeable. These soils formed in moderately coarse textured to fine-textured sediment derived from volcanic rocks. They are on terraces and alluvial fans. Slopes are 0 to 5 percent. The climate is semiarid. The average annual rainfall is 30 to 45 inches, and the average annual temperature is 80° F.

In a representative profile, the surface layer is reddish-brown, strongly acid loam about 14 inches thick. The next layer is reddish-brown friable clay loam to a depth of 20 inches. Below that layer is yellowish-red and reddish-brown clay and sandy clay loam 19 inches thick. Underlying that layer is reddish-brown and dark-brown, friable and very friable gravelly sandy clay loam and loamy sand that extends to a depth of 60 inches.

These soils have a moderate available water capacity and high natural fertility. Runoff is medium to slow. The soils are easily worked, and most of the acreage has been in sugarcane for many years. If the soils are irrigated, they are suited to cultivated crops.

Representative profile of Machete loam, 0 to 20 percent slopes, 800 meters east of Lafayette Sugar Central irrigation reservoir and 60 meters south of reservoir, 12 meters east of trail:

Ap—0 to 9 inches, reddish-brown (5YR 4/3) loam; weak, fine, granular structure; very friable, slightly sticky and slightly plastic; many fine roots; few, fine, black concretions; common fine sand grains; strongly acid; clear, smooth boundary.

A12—9 to 14 inches, reddish-brown (5YR 4/3) loam; weak, fine, granular structure; very friable, slightly sticky and slightly plastic; few fine roots; common medium and fine pores; common fine sand grains; strongly acid; clear, smooth boundary.

B1—14 to 20 inches, reddish-brown (5YR 4/4) clay loam; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; common medium and fine pores; thin patchy clay films; few, fine, black concretions; many fine sand grains; strongly acid; clear, smooth boundary.

B2t—20 to 32 inches, yellowish-red (5YR 4/6) clay; moderate, medium, subangular blocky structure; firm, slightly sticky and plastic; thin discontinuous clay films, more numerous on vertical ped surfaces and in root channels than on horizontal ped surfaces; few worm casts; few black concretions; many sand grains; strongly acid; clear, smooth boundary.

B3—32 to 39 inches, reddish-brown (5YR 4/4) sandy clay loam; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; few, thin, patchy clay films on peds and in root channels; few black concretions; many sand grains; few subrounded pebbles; strongly acid; abrupt, smooth boundary.

IIC1—39 to 45 inches, reddish-brown (5YR 4/3) gravelly sandy clay loam; massive; friable; strongly acid; abrupt, smooth boundary.

IIIC2—45 to 60 inches, dark-brown (7.5YR 4/4) loamy sand; massive; very friable; strongly acid.

The solum is 27 to 62 inches thick. The Ap horizon has hue of 5YR or 7.5YR and chroma of 3 or 4. The B horizon has hue of 7.5YR or 5YR and chroma of 4 to 6. The B2t horizon has weak or moderate, subangular blocky structure. The C horizon has reddish-brown and dark-brown colors. It ranges from gravelly sandy clay loam to loamy sand.

The Machete soils are on the same landscape as the Fraternidad and Vives soils. The Machete soils are coarser textured and redder than the Fraternidad soils. They are redder in the A horizon than the Vives soils. Unlike both those soils, the Machete soils are strongly acid.

McA—Machete loam, 0 to 2 percent slopes. This soil occupies terraces and alluvial fans. It has the profile described as representative of the series. Small areas of Vives, Fraternidad, and Vives, high bottom, soils were included with this soil in mapping.

Most of the acreage is in sugarcane. This soil is suited to most kinds of crops grown in the area, but irrigation is needed for successful crop production. Capability unit IIc–2 nonirrigated and I–1 irrigated.

McB—Machete loam, 2 to 5 percent slopes. This soil is on terraces and alluvial fans. It has a thinner surface layer than the soil described as representative of the Machete series. It occurs at a higher elevation than Machete loam, 0 to 2 percent slopes. Included with this soil in mapping were small areas of Vives soils.

If this soil is irrigated, it is suited to cultivated crops and sugarcane. Capability units IIIc–3 nonirrigated and IIe–3 irrigated.

Made Land

Made land (Md) consists of areas where the soil profile has been covered or destroyed by earthmoving operations. The areas generally have been graded for engineering purposes.

This land type is not suitable for agricultural uses. Because soil conditions are variable, it requires special management if lawns and trees are to be established. In some areas the hazards that affect engineering uses have been overcome, and the land type is used as sites for dwellings and light industries.

Maunabo Series

The Maunabo series consists of deep soils that are poorly drained and slowly permeable. These soils formed in fine-textured sediment derived from granitic rocks. They are on the river flood plains. Slopes are 0 to 2 percent. The climate is humid tropical. The average annual precipitation is 87 inches, and the average temperature is 79° F.

In a representative profile, the surface layer is light brownish-gray, mottled, strongly acid clay in the upper 4 inches and grayish-brown, mottled, very firm clay in the lower 6 inches. Below that is gray and greenish-gray, mottled clay and silty clay 29 inches thick. The underlying material is greenish-gray, very friable sandy loam that extends to a depth of 48 inches.

These soils are fertile and have a high available water capacity. Runoff is slow. The soils are difficult to work, and they have been in pasture and sugarcane for many years.

Representative profile of Maunabo clay 369 meters northeast of the intersection of Highway No. 905 and Highway No. 3:

Ap—0 to 4 inches, light brownish-gray (10YR 6/2) clay; few, fine, faint, strong-brown (7.5YR 5/6) mottles; massive; very firm, slightly sticky and plastic; common roots; few fine quartz grains; few, fine, black mineral grains; strongly acid; gradual, smooth boundary.

A12—4 to 10 inches, grayish-brown (10YR 5/2) clay; common, medium, distinct, strong-brown (7.5YR 5/6) mottles; massive; very firm, slightly sticky and plastic; common roots; few fine pores; dark-colored old roots; small charcoal fragments; few, fine, black mineral grains; strongly acid; gradual, smooth boundary.

B1g—10 to 15 inches, gray (5Y 5/1) clay; common, medium, distinct, yellowish-red (5YR 5/8) mottles; weak, medium, subangular blocky structure; very firm, slightly sticky and plastic; common fine roots; dark coatings along root channels; few fine quartz grains; few, fine, black mineral grains; strongly acid; gradual, smooth boundary.

B2g—15 to 22 inches, gray (5Y 6/1) clay; common, medium, yellowish-brown (10YR 5/8) mottles; weak, coarse, subangular blocky structure; very firm, slightly sticky and plastic; dark coatings along root channels; fine roots; common fine pores; few fine quartz grains; strongly acid; gradual, smooth boundary.

B3g—22 to 39 inches, greenish-gray (5G 6/1) silty clay; many, medium, distinct, strong-brown (7.5YR 5/6) and dark-red (2.5YR 3/6) mottles; massive; very firm, slightly sticky and plastic; few roots; common fine quartz grains; common, fine, dark mineral grains; strongly acid; gradual, smooth boundary.

IICg—39 to 48 inches, greenish-gray (5BG 5/1) sandy loam; massive; very friable; many silvery flakes; strongly acid.

Thickness of the solum and depth to coarser textured material range from 28 to 50 inches. The Ap horizon has value of 5 or 6. The B horizon has hue of 5Y, 5G, or 5GY and value of 5 or 6. It has weak, medium or coarse, subangular blocky structure or is massive.

The Maunabo soils are on the same landscape as the Coloso, Talante, and Vivi soils. They are finer textured than all those soils. The Maunabo soils are more poorly drained and occupy lower positions than the Coloso soils. They are poorly drained, whereas the Vivi soils are well drained.

Me—Maunabo clay. This nearly level soil is on flood plains of the Maunabo and Guayanés Rivers. Included with it in mapping were small areas of Coloso and Talante soils.

This soil has severe limitations for farming because of poor drainage conditions. It requires a complex drainage system. Frequent flooding, slow permeability, and seasonal high water table are severe limitations for clean cultivation. These limitations require careful management and water control practices. Most areas of this soil are in sugarcane. If the soil is properly drained, it is suited to cultivated crops, sugarcane, and pasture. Capability unit IIIw–4.

Mayo Series

The Mayo series consists of deep soils that are well drained and rapidly permeable. These soils formed in coarse-textured sediment derived from plutonic rocks. They are on alluvial fans and terraces. Slopes are 3 to 10 percent. The climate is humid tropical. The average annual precipitation is 75 to 85 inches, and the average annual temperature is 77° to 80° F.

In a representative profile, the surface layer is very dark brown, very strongly acid loam about 8 inches thick. Below that is dark-brown and pale-brown, very friable and loose sandy loam and loamy sand that extends to a depth of 44 inches. It is underlain by brown, very friable sandy loam.

These soils have a low available water capacity and low shrink-swell potential. Runoff is medium. The soils are easily worked. They have been in sugarcane and pasture for many years; small areas are in food crops.

Representative profile of Mayo loam, 3 to 10 percent slopes, 4.2 kilometers north of the town of Yabucoa and 3.2 kilometers northwest of intersection of Highway No. 3, Este Soil Conservation District:

Ap—0 to 8 inches, very dark brown (10YR 2/2) loam; moderate, medium, granular structure; soft, very friable, nonsticky and nonplastic; common fine roots; very strongly acid; clear, smooth boundary.

B—8 to 18 inches, dark-brown (10YR 3/3) sandy loam; weak, fine, subangular blocky structure; soft, very friable, nonsticky and nonplastic; few fine roots; common fine quartz grains; common, fine, partly weathered feldspar grains; common, fine, black concretions; very strongly acid; clear, smooth boundary.

C1—18 to 27 inches, dark-brown (10YR 4/3) sandy loam; massive; soft, very friable, nonsticky and nonplastic; few fine roots; many fine quartz grains; common, fine, partly weathered feldspar grains; few, fine, black concretions; very strongly acid; gradual, smooth boundary.

IIC2—27 to 34 inches, pale-brown (10YR 6/3) loamy sand; massive; loose, nonsticky and nonplastic; many fine quartz grains; few, fine, shiny flakes; many, fine, dark grains; very strongly acid; abrupt, smooth boundary.

IIIC3—34 to 44 inches, pale-brown (10YR 6/3) loamy sand; massive; loose, nonsticky and nonplastic; many fine quartz grains; few, fine, dark grains; common, fine, partly weathered feldspar grains; very strongly acid; abrupt, smooth boundary.

IIIC4—44 to 60 inches, brown (10YR 5/3) sandy loam; massive; very friable, nonsticky and nonplastic; many fine quartz grains; common, fine, black grains; common, fine, partly weathered feldspar grains; few, fine, black, shiny and flaky grains; strongly acid.

The solum is 14 to 26 inches thick. The A horizon has chroma of 2 or 3 and ranges from sandy loam to loam. The B horizon has chroma of 3 or 4. The C horizon has value of 4, 5, or 6 and chroma of 3 or 4. The B and C horizons range from sandy loam to loam. Reaction ranges from strongly acid to very strongly acid.

The Mayo soils occupy the same landscape as the Pandura, Teja, Candelero, and Maunabo soils. They are deeper than the Pandura and Teja soils. The Mayo soils are better drained and coarser textured than the Candelero and Maunabo soils, and they are at a higher elevation than the Maunabo soils.

MlC—Mayo loam, 3 to 10 percent slopes. This soil is on alluvial fans and terraces along the Guayanes Valley. Included with it in mapping were small areas of Candelero soils.

This soil has moderate limitations for farming. If the soil is clean cultivated, conservation practices are needed to control erosion. The soil is easily worked, has a low available water capacity, and responds well to lime and fertilizer. It is suited to food crops, sugarcane, and pasture. Capability unit IIIe–10.

Meros Series

The Meros series consists of deep soils that are excessively drained and rapidly permeable. These soils formed in fine sandy sediment derived from sand-sized volcanic rock fragments, seashells, and coral. They are on benches along the coast slightly above sea level. Slopes are 1 to 6 percent. The climate is semiarid tropical. The average annual precipitation is 35 to 40 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is very dark grayish-brown, neutral fine sand in the upper 8 inches and very dark brown fine sand in the lower 6 inches. The underlying material is very dark grayish-brown, dark yellowish-brown, black, and olive-brown, loose sand that extends to a depth of 60 inches.

These soils have a very low available water capacity and very low fertility. Runoff is slow. The soils have been in pasture and coconut trees for many years.

Representative profile of Meros sand, 1 to 6 percent slopes, 45 meters north of kilometer marker 93.8 on Highway No. 1:

A11—0 to 8 inches, very dark grayish-brown (10YR 3/2) fine sand; single grained; loose, nonsticky and nonplastic; many fine roots; common, fine, black minerals; neutral; clear, smooth boundary.

A12—8 to 14 inches, very dark brown (10YR 2/2) fine sand; single grained; loose, nonsticky and nonplastic; few fine roots; many, fine, black minerals; neutral; clear, smooth boundary.

C1—14 to 22 inches, very dark grayish-brown (2.5Y 3/2) fine sand; single grained; loose, nonsticky and nonplastic; few fine roots; neutral; clear, smooth boundary.

C2—22 to 40 inches, dark yellowish-brown (10YR 4/4) and black (10YR 2/1) sand; single grained; loose, nonsticky and nonplastic; mildly alkaline; clear, smooth boundary.

C3—40 to 50 inches, olive-brown (2.5Y 4/4) sand; single grained; loose, nonsticky and nonplastic; mildly alkaline; clear, smooth boundary.

C4—50 to 60 inches, very dark grayish-brown (2.5Y 3/2) sand; single grained; loose, nonsticky and nonplastic; moderately alkaline.

The A horizon is 12 to 20 inches thick. It has value and chroma of 2 or 3. The C horizon has hue of 10YR to 2.5Y, value of 3 or 4, and chroma of 2 to 4. Reaction ranges from neutral to moderately alkaline.

The Meros soils are on the same landscape as Coastal beaches and Tidal flats. Coastal beaches consist of miscellaneous sandy material that has been reworked by wave action. Tidal flats consist of miscellaneous materials that are covered by seawater of high tide.

MrB—Meros sand, 1 to 6 percent slopes. This soil is along the coast at an elevation in the semiarid area. Included with it in mapping were small areas of Coastal beaches and Tidal flats.

This soil is not suited to cultivated crops. Low available water capacity, very low fertility, and rapid permeability are severe limitations, and rainfall is low. The soil is suitable for pasture, coconut trees, and wildlife food and cover. Capability unit VIIs–7.

Mucara Series

The Mucara series consists of moderately deep soils that are well drained and moderately permeable. These soils formed in residuum derived from basic volcanic rocks. They are on side slopes and ridgetops of strongly dissected volcanic uplands. Slopes are 12 to 40 percent. The climate is humid tropical. The average annual precipitation is 75 to 80 inches, and the average annual temperature is 76° F.

In a representative profile, the surface layer is very dark grayish-brown, medium acid silty clay loam about 6 inches thick. Below that layer is very dark grayish-brown and yellowish-brown, firm silty clay 7 inches thick. The next layer is light olive-brown, firm silty clay loam that extends to a depth of 32 inches. It is underlain by semiconsolidated volcanic rock.

These soils are fertile and have high available water capacity and moderate shrink-swell potential. Runoff is medium to rapid. The soils are somewhat difficult to work. They have been used mainly for pasture, coffee trees, and food crops, but some areas are in sugarcane.

Representative profile of Mucara silty clay loam, 20 to 40 percent slopes, eroded, 45 meters southwest of kilometer marker 1.2 on Highway No. 449, Ward Paso Seco, Naguabo:

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) silty clay loam; weak, fine, subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common fine roots; few fine pores; common fine rock fragments; few worm casts; medium acid; abrupt, smooth boundary.

B2—6 to 9 inches, very dark grayish-brown (10YR 3/2) silty clay, inside color of peds is very dark grayish-brown (2.5Y 3/2); weak, medium, subangular blocky structure; hard, firm, slightly sticky and slightly plastic; few fine roots; few fine pores; few patchy clay films along cleavage planes; common, fine, angular rock fragments; few worm casts; medium acid; clear, smooth boundary.

B3—9 to 13 inches, yellowish-brown (10YR 5/4) silty clay; weak, medium, subangular blocky structure; hard, firm, slightly sticky and slightly plastic; few dead roots; common, fine, weathered rock fragments; few dark minerals; few patchy clay films along cleavage planes; root channels coated with dark brown (10YR 3/3); medium acid; clear, smooth boundary.

C1—13 to 18 inches, light olive-brown (2.5Y 5/4), crushed, sticky and slightly plastic; common dark minerals; common, fine, dead roots; few fine pores; many fine rock fragments weathered in place; medium acid; gradual, smooth boundary.

C2—18 to 32 inches, pale-yellow (2.5Y 7/4) clay loam; massive; hard, firm, slightly sticky and slightly plastic; most of this horizon is saprolite; common dark minerals; slightly acid; gradual, wavy boundary.

R—32 inches, semiconsolidated volcanic rock.

The solum is 10 to 20 inches thick. The A horizon has hue of 10YR or 2.5Y and chroma of 2 or 3. The B horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 4. It is silty clay or clay and has weak, medium or coarse, subangular blocky structure. Reaction is slightly acid or medium acid.

The Mucara soils occupy the same landscape as the Caguabo, Sabana, Naranjito, and Humatas soils. The Mucara soils are deeper to rock than the Caguabo and Sabana soils, and they have a thicker solum than the Caguabo soils. They lack red colors and are less acid than the Naranjito and Humatas soils, and they are shallower than the Humatas soils.

MuD2—Mucara silty clay loam, 12 to 20 percent slopes, eroded. This soil is on side slopes in the humid volcanic uplands. It has a thicker surface layer than the soil described as representative of the Mucara series. Erosion has removed some of the original surface layer of this soil, and in places that have been cultivated intensely, plowing has mixed the remaining part of that layer with some of the subsoil. Small rills and shallow gullies are common. Included with this soil in mapping were small areas of Caguabo, Naranjito, and Sabana soils and Rock land.

Slope, medium runoff, the hazard of erosion, and depth to rock are severe limitations for farming. This soil is somewhat difficult to work, and it requires very careful management if it is clean cultivated. It has been used for food crops, coffee trees, and native pasture. Capability unit IVe–6; woodland suitability group 3d5.

MuE2—Mucara silty clay loam, 20 to 40 percent slopes, eroded. This soil is on side slopes and ridgetops in the humid volcanic uplands. It has the profile described as representative of the series. As a result of past cultivation, erosion has removed part of the original surface layer, and in some places the yellowish-brown subsoil is exposed. Included with this soil in mapping were areas of Caguabo and Sabana soils and Rock land.

This soil is not suited to clean-cultivated crops. Slopes, rapid runoff, depth to volcanic rock, and the hazard of erosion are severe limitations for farming. This soil has been cultivated occasionally to pigeonpeas, tobacco, and food crops. It is better suited to pasture and woodland than to most other uses. Capability unit VIe–4; woodland suitability group 3d5.

Naranjito Series

The Naranjito series consists of moderately deep soils that are well drained and moderately permeable. These soils formed in moderately fine textured residuum weathered from volcanic rocks. They are in strongly dissected volcanic uplands. Slopes are 20 to 60 percent. The climate is humid tropical. The average annual precipitation is 75 to 100 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is dark-brown, extremely acid silty clay loam about 7 inches thick. Below that is yellowish-red, yellowish-brown, red, and light olive-brown clay and clay loam. Hard rock is at a depth of 38 inches.

These soils have a high available water capacity, moderate shrink-swell potential, and medium fertility. Runoff is rapid to very rapid, and the soils are susceptible to erosion. They have been in food crops and pasture for many years.

Representative profile of Naranjito silty clay loam, 20 to 40 percent slopes, eroded, 1.6 kilometers east from junction of Highway No. 924 and Highway No. 927 and 450 meters northwest from Highway No. 927, Ward Mambiche, Humacao:

Ap—0 to 7 inches, dark-brown (10YR 3/3) silty clay loam; weak, fine, subangular blocky structure; very hard, friable, slightly sticky and slightly plastic; common roots; thin clay films on root channels; few ¼- to 1-inch volcanic rock fragments; extremely acid; clear, smooth boundary.

B21t—7 to 20 inches, yellowish-red (5YR 4/6) clay; weak, fine, subangular blocky structure; very hard, firm, slightly sticky and slightly plastic; thin, patchy, dark-brown (10YR 3/3) clay films; few krotovinas; many, angular, ⅛- to 2-inch volcanic rock fragments; very strongly acid; gradual, smooth boundary.

B22t—20 to 30 inches, yellowish-red (5YR 4/6, 5YR 4/8) and yellowish-brown (10YR 5/4) clay; weak, fine, subangular blocky structure; very hard, firm, slightly sticky and plastic; thin dark-brown (10YR 3/3) clay films; few krotovinas; thin clay films along root channels and worm holes; many, angular, ⅛- to 2-inch volcanic rock fragments; about 40 percent, by volume, is saprolite; very strongly acid; gradual, smooth boundary.

C—30 to 38 inches, yellowish-red (5YR 4/6), red (2.5YR 4/6), and light olive-brown (2.5Y 5/4) clay loam; weak, fine, subangular blocky structure; hard, firm, slightly sticky and plastic; common, fine, dark concretions; many, angular, ⅛- to 3-inch rock fragments; about 40 percent is saprolite; very strongly acid; abrupt, smooth boundary.

R—38 inches, semiconsolidated volcanic rock.

The solum is 23 to 40 inches thick. The Ap horizon has chroma of 3 or 4. The B horizon has hue of 5YR or 2.5YR, value of 4 or 5, and chroma of 6 to 8. Rock fragments scattered throughout the profile range from few to many and from ⅛ inch to 3 inches in size. Reaction ranges from extremely acid to strongly acid.

The Naranjito soils are on the same landscape as the Caguabo, Sabana, Mucara, and Humatas soils. The Naranjito soils are deeper and more acid than the Caguabo soils. They are deeper to semiconsolidated rock than the Sabana soils and are more acid than the Mucara soils. The Naranjito soils are shallower to rock than the Humatas soils.

NaE2—Naranjito silty clay loam, 20 to 40 percent slopes, eroded. This soil is on side slopes in the humid uplands. It has the profile described as representative of the series. As a result of past cultivation, most of the original surface layer has been removed by erosion. Included with this soil in mapping were small areas of Mucara, Caguabo, and Humatas soils.

This soil is used occasionally for cultivated crops. Steep slopes, the hazard of erosion, and rapid runoff are severe limitations that make the soil unsuited to cultivated crops, however, and limit its use to pasture and woodland. Capability unit VIe–1; woodland suitability group 2c5.

NaF2—Naranjito silty clay loam, 40 to 60 percent slopes, eroded. This soil is on mountain side slopes and ridgetops in the humid volcanic uplands. It has a thinner surface layer than the soil described as representative of the series. Included with this soil in mapping were small areas of Mucara, Caguabo, and Humatas soils.

Very steep slopes, the hazard of erosion, and very rapid runoff are severe limitations for clean-cultivated crops. This soil is suitable for pasture, woodland, and wildlife food and cover. Capability unit VIIe–1; woodland suitability group 3r5.

Pandura Series

The Pandura series consists of moderately deep soils that are well drained and have moderately rapid permeability. These soils formed in residuum derived from partly weathered plutonic rocks, mainly quartz diorite and granodiorite. They are on side slopes of dissected uplands. Slopes range from 12 to 60 percent. The climate is humid tropical. The average annual precipitation is 75 to 85 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is dark-brown, strongly acid loam about 3 inches thick. The next layer is dark grayish-brown, friable loam 4 inches thick. Below that is light olive-brown, friable sandy loam that extends to a depth of 19 inches. It is underlain by partly weathered rock.

These soils have a low available water capacity. Runoff is medium to very rapid, and the soils are highly susceptible to erosion. Most of the acreage is in pasture and brush, but some areas are in food crops.

Representative profile of Pandura loam, 12 to 40 percent slopes, eroded, 45 meters northeast of kilometer marker 23.9 on Highway No. 181:

Ap—0 to 3 inches, dark-brown (10YR 3/3) loam; weak, fine, granular structure; friable, slightly sticky and slightly plastic; many fine roots; many fine quartz grains; many worm casts; strongly acid; clear, smooth boundary.

B2—3 to 7 inches, dark grayish-brown (10YR 4/2) loam; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; many fine roots; thin patchy clay films on ped surfaces; many fine quartz grains; many worm casts; many, fine, dark-colored, highly weathered minerals; strongly acid; gradual, smooth boundary.

C1—7 to 15 inches, light olive-brown (2.5Y 5/4) sandy loam; massive; friable, nonsticky and nonplastic; few fine roots; many fine quartz grains; medium acid; gradual, wavy boundary.

C2—15 to 19 inches, light olive-brown (2.5Y 5/4) sandy loam; massive; friable, nonsticky and nonplastic; very few fine roots; slightly acid; gradual, wavy boundary.

C3—19 to 35 inches, partly weathered rock.

The solum is 6 to 14 inches thick. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 2 or 3. The B horizon has hue of 10YR, value of 3 or 4, and chroma of 2 to 4. It ranges from loam to sandy loam and has weak subangular blocky to weak granular structure. The C horizon has hue of 2.5Y, value of 5 or 6, and chroma of 2 to 4. It ranges from strongly acid to slightly acid.

The Pandura soils are on the same landscape as the Teja, Mayo, Limones, Ingenio, Lirios, and Jagueyes soils. Pandura soils are finer textured and deeper to granitic rocks than Teja soils, and, unlike those soils, they have a B horizon. They are shallower and have a thinner solum than the Mayo soils. The Pandura soils are shallower and coarser textured than the Limones, Ingenio, Lirios, and Jagueyes soils; they have a thinner solum than all those soils and lack their red colors.

PaE2—Pandura loam, 12 to 40 percent slopes, eroded. This soil is on the sides and tops of ridges in the west-central part of the survey area. It has the profile described as representative of the Pandura series. Erosion has removed most of the original surface layer, and where the soil is clean cultivated, tillage has mixed the remaining part of that layer with some of the subsoil. In some areas the subsoil is exposed. Included with this soil in mapping were small areas of Teja, Lirios, Jagueyes, and Ingenio soils.

Slope, shallowness, and the hazard of erosion are severe limitations for cultivated crops. This soil is occasionally used for food crops, and it has been in pasture. It is better suited to pasture, woodland, and wildlife food and cover than to most other uses. Capability unit VIe–3; woodland suitability group 2o5.

PaF2—Pandura loam, 40 to 60 percent slopes, eroded. This soil is on side slopes and ridgetops in highly dissected, humid uplands. It has a thinner surface layer than the soil described as representative of the Pandura series. Most of the original surface layer has been removed by erosion, and in some areas the subsoil is exposed. Small areas of Teja and Lirios soils and Rock land were included with this soil in mapping.

This soil is not suited to clean-cultivated crops, and it has severe limitations for cultivated crops because it is steep, shallow, and susceptible to erosion. Proper management and conservation practices are required if this soil is cultivated. This soil has been in pasture and brush. It is better suited to pasture, woodland, and wildlife food and cover than to most other uses. Capability unit VIIe–2; woodland suitability group 3r5.

PdF—Pandura-Very stony land complex, 40 to 60 percent slopes. This mapping unit is on side slopes and ridgetops in the humid granitic uplands. It consists of Pandura soils and Very stony land in such intricate patterns that they cannot be shown separately at the scale used in mapping. The Pandura soils make up about 30 to 40 percent of the mapping unit, and Very stony land 40 to 50 percent. The remaining area consists of soils that are too variable to be classified.

The soils of this mapping unit are not suited to clean-cultivated crops, and because they are steep, rocky, and shallow, they have severe limitations for cultivated crops. They are suitable for pasture and wildlife food and cover. Capability unit VIIs–5; woodland suitability group 4d5.

Parcelas Series

The Parcelas series consists of deep, moderately well drained soils that have moderately slow permeability. These soils formed in fine-textured sediment derived from plutonic materials. They are on foot slopes, alluvial fans, and terraces. Slopes are 5 to 12 percent. The climate is humid tropical. The average annual precipitation is 80 to 90 inches, and the average annual temperature is 77° F.

In a representative profile, the surface layer is dark-brown, extremely acid clay about 7 inches thick. Below that is dark reddish-brown and dark-brown, firm clay 24 inches thick. The underlying material is yellowish-brown clay and clay loam that extends to a depth of 60 inches.

These soils have a high available water capacity and high shrink-swell potential. Runoff is medium. The soils are difficult to work and are susceptible to erosion. Most areas have been in sugarcane and pasture, but some areas are in food crops.

Representative profile of Parcelas clay, 5 to 12 percent slopes, eroded, 300 meters south of kilometer marker 3.6 on Highway No. 901, Barrio Nuevo, municipality of Yabucoa:

Ap—0 to 7 inches, dark-brown (7.5YR 3/2) clay; weak, fine, subangular blocky structure; firm, slightly sticky and plastic; many fine roots; extremely acid; clear, wavy boundary.

B1—7 to 17 inches, dark reddish-brown (5YR 3/3) clay; weak, medium, subangular blocky structure; firm, sticky and plastic; common fine roots; extremely acid; clear, smooth boundary.

B2—17 to 31 inches, dark-brown (7.5YR 4/4) clay; common, medium, distinct, yellowish-brown (10YR 5/8) mottles; weak, medium, subangular blocky structure; firm, sticky and plastic; few fine roots; few small slickensides and pressure faces; extremely acid; clear, smooth boundary.

C1—31 to 44 inches, yellowish-brown (10YR 5/6) clay; massive; firm, slightly sticky and plastic; very fine roots; few small slickensides and pressure faces; strongly acid; clear, smooth boundary.

C2—44 to 60 inches, yellowish-brown (10YR 5/8) clay loam; massive; friable, slightly sticky and plastic; strongly acid.

The solum is 22 to 37 inches thick. The Ap horizon has hue of 7.5YR or 10YR and value and chroma of 2 or 3. The B horizon has hue of 5YR or 7.5YR, value of 3 or 4, and chroma of 4 or higher. It has weak, medium or coarse subangular blocky structure. The C horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 4 to 8. Slickensides and pressure faces range from few to common. Reaction ranges from strongly acid to extremely acid.

The Parcelas soils occupy the same landscape as the Mayo, Pandura, Teja, and Candelero soils. The Parcelas soils are finer textured than the Mayo and Pandura soils, and unlike the Pandura soils, they have slickensides and pressure faces. They are on lower slopes and are deeper than the Teja soils. The Parcelas soils are better drained than the Candelero soils, and they have pressure faces and slickensides.

PeC2—Parcelas clay, 5 to 12 percent slopes, eroded. This soil is on foot slopes and terraces. Erosion has removed some of the original surface layer, and where the soil is cultivated, the plow layer is a mixture of the remaining dark-brown surface layer and the reddish-brown subsoil. Included with this soil in mapping were small areas of Candelero and Mayo soils.

This soil has moderate limitations for clean-cultivated crops because of slope, drainage, the hazard of erosion, and high clay content. If the soil is clean cultivated, careful management and conservation practices are required. If it is properly drained and limed, the soil is suited to sugarcane, pasture, cut grasses, and food crops. Capability unit IIIe–7.

Paso Seco Series

The Paso Seco series consists of deep soils that are moderately well drained and slowly permeable. These soils formed in fine-textured sediment of mixed origin that overlies gravelly, medium-textured sediment. They are on terraces and alluvial fans on the coastal plains. Slopes are 0 to 5 percent. The climate is semiarid tropical. The average annual precipitation is 30 to 40 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is dark-brown, neutral or mildly alkaline clay about 13 inches thick. The next layer is brown to dark-brown, firm clay 6 inches thick. It is underlain by brown to dark-brown gravelly clay and gravelly loam that extends to a depth of 50 inches.

These soils have a high available water capacity and high shrink-swell potential and are difficult to work. They have been mainly in sugarcane, pasture, and brush, but some areas are in cut grasses.

Representative profile of Paso Seco clay, 0 to 5 percent slopes, 9 meters north of farm road that borders the main irrigation canal, 0.2 kilometer west of Colonia house, and 0.9 kilometer south of Highway No. 3 at kilometer marker 185.2, Colonia Sabater, Aguirre:

Ap—0 to 5 inches, dark-brown (7.5YR 3/2) clay; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; few roots; common pebbles; few black minerals; neutral; gradual, smooth boundary.

A12—5 to 13 inches, dark-brown (7.5YR 3/2) clay; weak, medium, subangular blocky structure; firm, slightly sticky and plastic; few pores; few roots; common pressure faces; few black stains along root channels and ped surfaces; common pebbles; few, small, soft, black concretions; mildly alkaline; abrupt, wavy boundary.

C1—13 to 19 inches, brown to dark-brown (7.5YR 4/4) clay; weak, medium, angular blocky structure; firm, slightly sticky and plastic; very dark grayish-brown coatings along root channels and ped surfaces; common slickensides and pressure faces; mildly alkaline; clear, wavy boundary.

C2—19 to 38 inches, brown to dark-brown (7.5YR 4/4) gravelly clay; massive; firm, slightly sticky and plastic; mildly alkaline; clear, wavy boundary.

IIC3—38 to 50 inches, brown to dark-brown (10YR 4/3) gravelly loam; massive; friable, nonsticky and nonplastic; neutral.

The A horizon is 8 to 18 inches thick. It has hue of 10YR or 7.5YR and value and chroma of 2 or 3. The C horizon has hue of 10YR or 7.5YR and value and chroma of 3 or 4. Slickensides are common or many. Depth to gravelly horizons is 20 to 37 inches. Reaction is neutral to mildly alkaline.

The Paso Seco soils are on the same landscape as the Fraternidad, Jacana, Amelia, and Coamo soils. The Paso Seco soils are shallower to gravelly horizons than the Fraternidad soils. Unlike the Jacana soils, they lack a B horizon and are not underlain by volcanic rocks. The Paso Seco soils are neutral to mildly alkaline, whereas the Amelia soils are neutral to medium acid. Unlike the Coamo soils, the Paso Seco soils lack a B2t horizon and have pressure faces and slickensides.

PlB—Paso Seco clay, 0 to 5 percent slopes. This soil is on terraces and alluvial fans in the semiarid part of the survey area. Included with it in mapping were small areas of Fraternidad and Amelia soils.

The soil's high shrink-swell potential and poor workability are limitations for farming, and the climate in the area is adverse. This soil commonly has been used for pasture. If irrigated, the soil is suited to sugarcane, pasture, and cut grasses. Capability units IIIc–1 nonirrigated and IIs–1 irrigated.

Patillas Series

The Patillas series consists of deep soils that are well drained and moderately permeable. These soils formed in residuum that weathered from intrusive volcanic rocks. They are on side slopes in dissected uplands. Slopes are 12 to 40 percent. The climate is humid tropical. The average annual precipitation is 60 to 70 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is dark-brown, strongly acid clay loam about 8 inches thick. The next layer is reddish-brown, friable clay loam that extends to a depth of 19 inches. Below that is yellowish-red sandy loam saprolite.

These soils have a moderate available water capacity. Runoff is medium to rapid, and the soils are susceptible to erosion. They have been used for pasture and food crops for many years, and some areas are used for sugarcane.

Representative profile of Patillas clay loam, 20 to 40 percent slopes, eroded, 1.8 kilometers east from kilometer marker 162.2 on Highway No. 3 and 1.25 kilometers southeast from Highway 757, in the vicinity of Patillas:

A1—0 to 8 inches, dark-brown (10YR 3/3) clay loam; weak, fine, subangular blocky structure parting to moderate, medium, granular; friable, nonsticky and slightly plastic; common fine roots; few fine pores; few, fine, black minerals; few fine quartz crystals; common, fine, subrounded rock fragments; strongly acid; clear, smooth boundary.

B2t—8 to 19 inches, reddish-brown (5YR 4/4) clay loam; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; common fine pores; thin patchy clay films; few fine quartz grains; common, fine, subrounded rock fragments; few weathered feldspar fragments; strongly acid; clear, wavy boundary.

C—19 to 48 inches, yellowish-red (5YR 4/6) sandy loam; massive; friable, nonsticky and nonplastic; coatings of finer textured material from B2t horizon on fracture planes; very strongly acid; this horizon consists of weathered plutonic rock (saprolite).

The solum is 15 to 24 inches thick. The A horizon has hue of 10YR or 7.5YR and value and chroma of 3 or 4. The B2t horizon has hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6. It ranges from silty clay loam to clay loam and has weak, fine or medium, subangular blocky structure. The C horizon has hue of 7.5YR or 5YR and value and chroma of 4 to 6. It is sandy loam or loamy sand. Quartz crystals vary from few to common. Reaction is strongly acid or very strongly acid.

The Patillas soils are on the same landscape as the Limones, Pandura, and Lirios soils. The Patillas soils are coarser textured and have a thinner solum than the Limones soils. They are finer textured than the Pandura soils, and unlike those soils, they have a B2t horizon. They have a thinner solum than the Lirios soils.

PmD2—Patillas clay loam, 12 to 20 percent slopes, eroded. This soil is on side slopes in the humid plutonic uplands. It has a thicker surface layer than the soil described as representative of the Patillas series. Because this soil has been used intensively for food crops and tobacco, most of its surface layer has been eroded, and in some areas the reddish-brown subsoil is exposed. Included with this soil in mapping were small areas of Pandura, Limones, and Lirios soils.

Slope and the hazard of erosion are severe limitations for farming. This soil is used occasionally for cultivated crops and has been used for pasture and food crops for many years. Good management and conservation practices are needed if the soil is cultivated. If it is properly limed and managed, the soil is suited to sugarcane, food crops, pasture, and woodland. Capability unit IVe-7; woodland suitability group 2o5.

PmE2—Patillas clay loam, 20 to 40 percent slopes, eroded. This soil is on side slopes in the humid uplands. It has the profile described as representative of the series. Included with this soil in mapping were small areas of Pandura and Lirios soils and Rock land.

Slope and the hazard of erosion are severe limitations for clean cultivation. Conservation practices are needed if the soil is cultivated. This soil has been used for food crops, tobacco, and pasture for many years. It is better suited to pasture and woodland than to most other uses. Capability unit VIe-3; woodland suitability group 2o5.

Picacho Series

The Picacho series consists of deep, moderately well drained soils that have moderately slow permeability. These soils formed in fine textured and moderately fine textured residuum that weathered from igneous rocks. They are on upper side slopes and ridgetops in the humid uplands. Slopes range from 20 to 50 percent. The average annual precipitation is 185 inches, and the average annual temperature is 72° F.

In a representative profile, the surface layer is dark yellowish-brown, very strongly acid silty clay loam about 9 inches thick. Below that layer is yellowish-brown and strong-brown, mottled clay that is very strongly acid and firm and extends to a depth of 28 inches. The next layer is reddish-yellow, very strongly acid, firm clay 7 inches thick. The upper part of the underlying material is yellowish-red, very strongly acid, friable clay loam and silty clay loam that extends to a depth of 65 inches. The lower part is saprolite of variegated colors that extends to a depth of more than 72 inches.

These soils have a moderate available water capacity and medium fertility. Runoff is medium to rapid. The soils have been in hardwood trees and tree ferns for many years.

In this survey area, Picacho soils are mapped only in associations with Guayabota and Ciales soils and with Utuado soils and Stony rock land.

Representative profile of Picacho silty clay loam, 20 to 40 percent slopes, in an area of the Guayabota-Ciales-Picacho association, very steep, 42 meters south and 17 meters east of kilometer marker 15.7 on Highway No. 191:

A1—0 to 9 inches, dark yellowish-brown (10YR 4/4) silty clay loam; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; many fine to coarse roots; few fine pores; common, fine, silvery flakes; few, fine, dark minerals and quartz grains; very strongly acid; clear, smooth boundary.

B21t—9 to 19 inches, yellowish-brown (10YR 5/4) clay; common, fine, distinct, gray and yellowish-red mottles; weak, coarse and medium, subangular blocky structure; firm, slightly sticky and slightly plastic; few fine pores coated with brown; thin patchy clay films on ped surfaces and in root channels; few krotovinas, ⅜ inch in diameter; common fine quartz grains; few, fine, dark minerals and silvery flakes; very strongly acid; clear, wavy boundary.

B22t—19 to 28 inches, strong-brown (7.5YR 5/8) clay; common, fine, distinct, olive-gray mottles; weak, coarse and medium, subangular blocky structure; firm, slightly sticky and plastic; few fine and medium roots; few fine pores; thin patchy clay films on ped surfaces and in root channels; many coated quartz grains; common, fine, dark minerals; few, fine, silvery flakes; few krotovinas; very strongly acid; gradual, smooth boundary.

B3—28 to 35 inches, reddish-yellow (7.5YR 6/8) clay; weak, fine and medium, subangular blocky structure; firm, slightly sticky and plastic; few fine pores; thin patchy clay films on ped surfaces and in root channels; common fine quartz grains and silvery flakes; few krotovinas; very strongly acid; clear, smooth boundary.

C1—35 to 48 inches, yellowish-red (5YR 5/6) clay loam; weak, coarse and medium, subangular blocky structure; friable, nonsticky and slightly plastic; few fine roots; few fine pores coated with dark material; many silvery flakes and coated quartz grains; very strongly acid; clear, smooth boundary.

C2—48 to 65 inches, yellowish-red (5YR 4/6) silty clay loam; few, fine, faint, red mottles; weak, coarse, subangular blocky structure; friable, nonsticky and slightly plastic; few fine roots; few fine pores; many silvery flakes; many fine quartz grains; few, fine, dark minerals; very strongly acid; gradual, smooth boundary.

C3—65 to 72 inches +, mottled very pale brown (10YR 8/3), reddish-yellow (7.5YR 6/8, 5YR 6/8), and red (10YR 4/8) loam saprolite; massive; very friable, nonsticky and nonplastic; many silvery flakes and quartz grains; very strongly acid.

The solum is 26 to 46 inches thick. The A horizon has hue of 10YR or 7.5YR and value and chroma of 3 or 4. It is clay loam, silty clay loam, or clay. The B horizon has dominant hue of 10YR, 7.5YR, or 5YR, value of 4 to 6, and chroma of 4 to 8. It is clay or silty clay. Gray mottles are common in the upper part of the B horizon but decrease as depth increases. The B2t horizon has weak or moderate, medium or coarse, subangular blocky structure. The C horizon is loam, clay loam, or silty clay loam. The C1 and C2 horizons have hue of 5YR or 2.5YR, value of 4 to 6, and chroma of 4 to 8. The C3 horizon has variegated colors of the saprolite. Reaction is very strongly acid or extremely acid throughout the profile.

The Picacho soils are on the same landscape as the Los Guineos, Ciales, Guayabota, and Utuado soils. Unlike the Los Guineos soils, the Picacho soils have low-chroma mottles in the B2t horizon. Unlike the Ciales soils, they lack dominant gray colors in the B2t horizon. The Picacho soils are deeper than the Guayabota soils and finer textured than the Utuado soils, and they have a B2t horizon that those soils lack.

Pinones Series

The Pinones series consists of deep soils that are poorly drained and very slowly permeable. These soils formed in fine-textured sediment of mineral origin that overlies decomposed and partly decomposed organic layers. They are on coastal lowlands. Slopes are 0 to 2 percent. The climate is humid tropical. The average annual precipitation is 80 to 90 inches, and the average temperature is 78° F.

In a representative profile, the surface layer is very dark grayish-brown, very strongly acid silty clay about 4 inches thick. The next layer is dark-gray, mottled, firm silty clay 14 inches thick. The underlying material is dark reddish-brown organic materials that extend to a depth of 58 inches.

These soils have a high available water capacity, high natural fertility and high shrink-swell potential. They are difficult to work, and most of the acreage is in sugarcane, pasture, and cut grasses.

Representative profile of Pinones silty clay, 1 mile northeast of Central Pasto Viejo, 100 feet west of main farm road on unimproved secondary road, and 30 feet north of unimproved road:

AP—0 to 4 inches, very dark grayish-brown (10YR 3/2) silty clay; common, medium, distinct, yellowish-brown (10YR 5/8) mottles; weak, fine, subangular blocky structure; friable, slightly sticky and plastic; many fine roots; very strongly acid; abrupt, smooth boundary.

B21—4 to 13 inches, dark-gray (10YR 4/1) silty clay; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; firm, slightly sticky and plastic; common fine roots; very strongly acid; clear, smooth boundary.

B22—13 to 18 inches, dark-gray (10YR 4/1) silty clay; many, coarse, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; firm, slightly sticky and plastic; few fine roots; very strongly acid; clear, smooth boundary.

IIC—18 to 58 inches, dark reddish-brown (5YR 3/2), very strongly acid organic materials consisting of well-decomposed muck.

Thickness of the solum and depth to organic material range from 15 to 30 inches. The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 3 or less. The B horizon has hue of 10YR or 5Y, value of 4 to 6, and chroma of 1 or less. It is silty clay or clay and has weak, medium or coarse, subangular blocky structure. Yellowish-brown or strong-brown mottles are common or many. Reaction is strongly acid or very strongly acid.

The Pinones soils are on the same landscape as the Maunabo, Coloso, and Fortuna soils. Unlike all those soils, the Pinones soils have an organic layer. They are more poorly drained and more acid than the Coloso soils.

Pn—Pinones silty clay. This nearly level soil is on coastal lowlands. Included with it in mapping were areas of Tidal swamp.

Poor drainage, frequent flooding, and a seasonal high water table are severe limitations for farming. Careful management and drainage can help overcome these limitations. This soil has been used for sugarcane and pasture. If it is properly drained, it is suited to cultivated crops, sugarcane, pasture, and cut grasses. Capability unit IVw-1.

Poncena Series

The Poncena series consists of deep soils that are moderately well drained, calcareous, and slowly permeable. These soils formed in fine-textured sediment derived from volcanic rocks and limestone. They are on terraces and alluvial fans. Slopes are 0 to 2 percent. The climate is semiarid tropical. The average annual precipitation is 35 to 50 inches, and the average annual temperature is 79° F. Depth to the water table ranges from 30 to 60 inches.

In a representative profile, the surface layer is about 7 inches thick. In the upper part it is very dark clay, and in the lower part it is dark-gray, mottled clay. Below this layer is dark-gray and dark greenish-gray, firm, mottled clay that extends to a depth of 41 inches.

These soils have a high available water capacity and high shrink-swell potential. Runoff is medium. The soils are fertile but difficult to work. Most of the acreage is used for sugarcane and pasture.

Representative profile of Poncena clay, 0.5 kilometer south of kilometer marker 163.0 on Highway No. 3, near the town of Salinas:

Ap—0 to 2 inches, very dark gray (10YR 3/1) clay; weak, fine, granular structure; friable, slightly sticky and slightly plastic; many fine roots; few fine volcanic pebbles; few sea shells; calcareous; clear, smooth boundary.

AC—2 to 7 inches, dark-gray (5Y 4/1) clay; common, fine, distinct, brown to dark-brown (7.5YR 4/4) mottles; weak, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; common roots; few pressure faces; few fine volcanic pebbles; limestone fragments; few sea shells; calcareous; clear, smooth boundary.

C1—7 to 14 inches, dark-gray (5Y 4/1) clay; many, medium, distinct, brown to dark-brown (7.5YR 4/4) mottles and few, fine, distinct, gray (5Y 5/1) mottles; massive; firm, slightly sticky and plastic; few roots; many fine volcanic pebbles; calcareous; clear, smooth boundary.

C2g—14 to 25 inches, dark greenish-gray (5GY 4/1) clay; common, fine, distinct, brown to dark-brown (10YR 4/3) mottles; massive; firm, slightly sticky and plastic; few pressure faces and slickensides; common lime splotches; common sea shell fragments; calcareous; clear, smooth boundary.

C3g—25 to 41 inches, dark-gray (5Y 4/1) clay; common, medium, distinct, olive-brown (2.5Y 4/4) and greenish-gray (5G 5/1) mottles; massive; firm, slightly sticky and plastic; common seashell fragments; few volcanic pebbles; common lime splotches; calcareous.

The A horizon is 2 to 12 inches thick. The C horizon has hue of 10YR, 5Y, 5GY, or 2.5Y, value of 3 to 5, and chroma of 1 or 2. Mottles are few or common and fine or medium-sized and are in shades of brown, dark brown, olive brown, greenish gray, and gray. Reaction is neutral to strongly acid.

The Poncena soils occupy the same landscape as the Vayas and Cartagena soils. They are better drained than the Vayas soils, and unlike those soils, they have pressure faces and slickensides. The Poncena soils are better drained and have lower chroma than the Cartagena soils.

Po—Poncena clay. This nearly level soil is on coastal plains in the semiarid part of the survey area. Included with it in mapping were areas of Cartagena and Vayas soils.

Low rainfall in the area and the soil's slow permeability, high shrink-swell potential, and seasonal high water table are severe limitations for farming. This soil has been used for sugarcane. If drained, irrigated, and properly managed, it is suited to cultivated crops, sugarcane, and pasture. Capability units IIIc-1 nonirrigated and IIs-1 irrigated.

Pozo Blanco Series

The Pozo Blanco series consists of deep soils that are well drained and moderately permeable. These soils formed in medium-textured to moderately fine textured sediment derived from limestone or residuum weathered from volcanic rocks. They are on foot slopes and, to a minor extent, in the residual uplands. Slopes are 5 to 12 percent. The climate is semiarid. The average annual rainfall is 35 to 45 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is very dark grayish-brown, mildly alkaline clay loam about 7 inches thick. The next layer is brown clay loam 8 inches thick. Below that is pink, friable, very strongly alkaline silt loam 12 inches thick. That layer is underlain by very pale brown, friable, strongly alkaline silt loam and gravelly clay loam that extends to a depth of 58 inches.

These soils have a moderate available water capacity, medium natural fertility, and moderate shrink-swell potential. Most of the acreage is used for sugarcane and pasture.

Representative profile of Pozo Blanco clay loam, 5 to 12 percent slopes, eroded, 525 meters southwest from a gas station at north entrance of Central Aguirre, Salinas:

A1—0 to 7 inches, very dark grayish-brown (10YR 3/2) clay loam; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; common rock fragments 1 to 5 millimeters in diameter; mildly alkaline; abrupt, smooth boundary.

B—7 to 15 inches, brown (7.5YR 5/4) clay loam; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; common rock fragments 2 to 10 millimeters in diameter; moderately alkaline; clear, smooth boundary.

C1ca—15 to 27 inches, pink (7.5YR 8/4) silt loam; massive; friable, nonsticky and slightly plastic; few dead roots; common rock fragments 2 to 20 millimeters in diameter; very strongly alkaline; clear, smooth boundary.

C2—27 to 47 inches, very pale brown (10YR 7/3) silt loam; massive; very friable, nonsticky and slightly plastic; few dead roots; common pores; strongly alkaline; clear, smooth boundary.

C3—47 to 58 inches, very pale brown (10YR 7/4) gravelly clay loam; massive; friable, nonsticky and slightly plastic; many rock fragments; strongly alkaline.

The solum is 10 to 20 inches thick. The A horizon has value of 2 or 3. The B horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 3 or 4. It has weak, medium or fine, subangular blocky structure. The C horizon has hue of 7.5YR or 10YR, value of 7 or 8, and chroma of 3 or 4. Reaction ranges from neutral to very strongly alkaline.

The Pozo Blanco soils are on the same landscape as the Fraternidad soils. The Pozo Blanco soils are coarser textured than the Fraternidad soils, and unlike those soils, they have a B horizon and lack pressure faces and slickensides.

PrC2—Pozo Blanco clay loam, 5 to 12 percent slopes, eroded. This soil is on foot slopes in the semiarid part of the survey area. Included with it in mapping were areas of Fraternidad soils.

This soil has severe limitations for farming because of slope. It requires careful management and conservation practices if it is used for clean-cultivated crops. If the soil is properly managed, it is suited to sugarcane, pasture, cut grasses, and woodland. Capability unit IVe-3; woodland suitability group 2o2.

Reilly Series

The Reilly series consists of excessively drained, rapidly permeable soils that are shallow to sand and gravel. These soils formed in stratified material, dominantly gravel and sand but partly medium-textured and moderately coarse textured sediment. They are adjacent to the streams on river flood plains. Slopes are 0 to 2 percent. The climate is humid tropical. The average annual precipitation is 70 inches, and the average annual temperature is 77° F.

In a representative profile, the surface layer is dark-brown, medium acid sandy loam about 9 inches thick. Below that is dark-brown, very friable loamy sand and dark yellowish-brown, yellowish-brown, brown, and pale-brown, loose sand that extends to a depth of 62 inches.

These soils have a low available water capacity and low natural fertility and are easily worked. Most of the acreage is used for pasture, but small areas are in sugarcane.

Representative profile of Reilly sandy loam, 0 to 2 percent slopes, in an area of Reilly soils, 8 meters north and 90 meters west of kilometer marker 97.8 on Highway No. 3:

Ap—0 to 9 inches, dark-brown (10YR 3/3) sandy loam; massive; friable, nonsticky and nonplastic; medium acid; clear, smooth boundary.

C1—9 to 19 inches, dark-brown (7.5YR 4/4) loamy sand; massive; very friable, nonsticky and nonplastic; medium acid; clear, smooth boundary.

IIC2—19 to 35 inches, dark yellowish-brown (10YR 4/4) coarse sand; massive; loose; slightly acid; clear, smooth boundary.

IIIC3—35 to 50 inches, yellowish-brown (10YR 5/4) medium sand; massive; loose; slightly acid; clear, smooth boundary.

IVC4—50 to 58 inches, brown (10YR 5/3) coarse sand; massive; loose; slightly acid; clear, smooth boundary.

VC5—58 to 62 inches, pale-brown (10YR 6/3) coarse sand; massive; loose; slightly acid.

The A horizon is 7 to 16 inches thick. The A and C horizons have hue of 10YR or 7.5 YR, value of 3 to 6, and chroma of 2 to 4. The C1 horizon is loamy sand, sand, or gravelly sand. Below the C1 horizon, sand and gravel vary in proportion.

The Reilly soils are on the same landscape as the Toa, Coloso, Vivi, Maunabo, and Talante soils. The Reilly soils are coarser textured than all those soils, and unlike those soils, they are excessively drained.

Re—Reilly soils. These nearly level soils are adjacent to the streams on the flood plains in the humid part of the survey area. Included with them in mapping were small areas of Toa, Coloso, and Talante soils.

These soils have severe limitations for cultivated crops, because of the hazard of flooding, low available water capacity, and low fertility. They are suited to pasture. Capability unit IVs–3.

Reparada Series

The Reparada series consists of poorly drained soils that are underlain by organic material. Permeability is very slow. These soils formed in fine-textured sediment of mixed origin that overlies decomposed organic soil material. They are on coastal lowlands. Slopes are 0 to 2 percent. The climate is semiarid tropical. The average annual precipitation is 30 to 40 inches, and the average annual temperature is 79° F.

In a representative profile, the surface layer is very dark brown, mildly alkaline, mottled clay about 8 inches thick. Below that is very dark gray, firm, mottled clay about 8 inches thick. Below that is very dark gray, firm, mottled clay that extends to a depth of 18 inches. It is underlain by black organic material.

These soils have a high available water capacity, high natural fertility, and high shrink-swell potential. They are difficult to work and have been used for native pasture and sugarcane for many years.

Representative profile of Reparada clay 0.2 kilometer south and 0.2 kilometer east of kilometer marker 131.6 on Highway No. 3, 0.6 kilometer south on dirt road, 12 meters east of road, 75 meters north of coconut grove:

Ap—0 to 8 inches, very dark brown (10YR 2/2) clay; common, medium, distinct, dark-brown (7.5YR 4/4) mottles and few, medium, distinct, dark reddish-brown (2.5YR 2/4) mottles; weak, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; common fine roots; very dark gray coatings on ped surfaces; mildly alkaline; gradual, smooth boundary.

B2g—8 to 18 inches, very dark gray (N 3/0) clay; many, coarse, prominent, dark greenish-gray (5G 4/1) mottles; massive; firm, slightly sticky and slightly plastic; few fine roots; few partly decomposed plant residues; mildly alkaline; gradual, smooth boundary.

IIC—18 to 60 inches, black (10YR 2/1), decomposed, mildly alkaline organic material.

Thickness of the solum and depth to organic layers range from 12 to 22 inches. The A horizon has hue of 10YR to 2.5Y, value of 2 or 3, and chroma of 2 or less. Mottles range from few to common and are in shades of brown and red. The B horizon has hue of 2.5Y or N and has weak, subangular blocky structure or is massive. Reaction ranges from neutral to moderately alkaline.

The Reparada soils are on the same landscape as the Poncena soils. The Reparada soils have an organic layer whereas the Poncena soils do not.

Rp—Reparada clay. This nearly level soil is on coastal lowlands in the semiarid part of the survey area. Included with it in mapping were areas of Poncena soils.

This soil has severe limitations for cultivated crops because it has very slow permeability, poor drainage, and a seasonal water table and is difficult to work. If the soil is properly drained, it is suited to sugarcane and pasture. Capability unit IVw–2.

Rio Arriba Series

The Rio Arriba series consists of deep, moderately well drained soils. Permeability is moderately slow. These soils formed in fine-textured sediment of mixed origin. They are on alluvial fans and terraces above the river flood plains. Slopes are 2 to 12 percent. The climate is humid tropical. The average annual precipitation is 65 inches, and the average annual temperature is 77° F.

In a representative profile, the surface layer is brown to dark-brown, very strongly acid clay about 5 inches thick. The next layer is yellowish-brown and very pale brown, firm clay 21 inches thick. The layer below that is mottled, firm clay that has variegated colors and extends to a depth of 56 inches.

These soils have a high available water capacity and high shrink-swell potential. Runoff is slow to medium. The soils are somewhat difficult to work. They have been used for food crops, sugarcane, and pasture for many years.

Representative profile of Rio Arriba clay, 2 to 5 percent slopes, 0.5 kilometer south and 9 meters west of intersection of Highway No. 31 and Highway No. 924, Barrio Mambiche, Naguabo:

Ap—0 to 5 inches, brown (10YR 5/3) to dark-brown (10YR 4/3) clay; few, fine, faint, brown (10YR 5/3) mottles; weak, fine to medium, subangular blocky structure; firm, slightly sticky and slightly plastic; common fine roots; many, fine to medium, dark concretions; few worm casts; very strongly acid; abrupt, smooth boundary.

B21t—5 to 16 inches, yellowish-brown (10YR 5/8) clay; weak, medium, subangular blocky structure; firm, slightly sticky; slightly plastic; and few fine roots; few fine pores and krotovinas; many, thin, patchy clay films on vertical cleavage planes; common, fine to medium, dark concretions; very strongly acid; clear, wavy boundary.

B22t—16 to 26 inches, very pale brown (10YR 7/4) clay; weak, medium, subangular blocky structure; firm, sticky and plastic; few fine roots; peds coated with thin continuous clay films; few, fine to medium, dark concretions; some concretions coated with red (2.5YR 4/6); few worm casts; strongly acid; gradual, wavy boundary.

C1—26 to 39 inches, variegated light-gray (5Y 7/1), gray (5Y 6/1), brownish-yellow (10YR 6/6), and dark-red (10R 3/6) clay; massive; firm, sticky and plastic; few, fine, dead roots; few pores; common pressure faces and slickensides; few waterworn pebbles; few fine concretions; very strongly acid; clear, smooth boundary.

C2—39 to 56 inches, variegated brownish-yellow (10YR 6/6), light-gray (5Y 7/1), gray (5Y 6/1), and dark-red (10R 3/6) clay; massive; firm, sticky and plastic; few, fine, dead roots; common pressure faces and slickensides; few subrounded pebbles; very strongly acid.

The solum is 20 to 42 inches thick. The Ap horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 3 or 4. The B horizon has hue of 10YR or 7.5YR, value of 5 to 7, and chroma of 4 to 8. It has weak or moderate, subangular blocky structure.

The Rio Arriba soils are on the same landscape as the Mabi, Aceitunas, and Via soils. The Rio Arriba soils have a B2t horizon that the Mabi soils lack. They have a higher shrink-swell potential than the Aceitunas soils. The Rio Arriba soils are finer textured than the Via soils, and unlike those soils, they have pressure faces and slickensides.

RrB—Rio Arriba clay, 2 to 5 percent slopes. This soil is on alluvial fans and terraces. It has the profile described as representative of the series. Included with this soil in mapping were areas of Mabi and Aceitunas soils.

This soil has moderate limitations for farming because of slope, the hazard of erosion, and workability. Careful management and conservation practices can help overcome these limitations. The soil is suited to sugarcane, food crops, cut grasses, and pasture. Capability unit IIs–2.

RrC2—Rio Arriba clay, 5 to 12 percent slopes, eroded. This soil is on alluvial fans and terraces. Its profile is similar to the one described as representative of the series, but most of the original surface layer has been removed by erosion, and the plow layer is a mixture of the remaining part of that layer and the yellowish-brown subsoil. In some places the present surface layer is subsoil material. Included with this soil in mapping were areas of Mabi and Via soils.

This soil has moderate limitations for farming because of the hazard of erosion, slope, and workability. If it is properly limed and fertilized, it is suited to sugarcane and pasture. Capability unit IIIe–7.

Rock Land

Rock land (Rs) consists of areas where rock crops out on 50 to 70 percent of the surface. Loose stones also are common on the surface. Very shallow soil material lies between the outcrops and stones. This land type is in the mountainous part of the survey area. Slopes are 60 to 70 percent. The vegetation is brush.

Rock land has little value for farming or engineering uses. Its use is restricted mainly to wildlife habitat. Capability unit VIIIs–2.

Rough Stony Land

Rough stony land (Ru) consists of the high, jagged mountain peaks and long, very steep side slopes in the rain forest. Rocks and boulders cover 75 to 90 percent of the surface. The areas are inaccessible, so the soils have not been classified. Scattered observations indicate that the soils are clayey and poorly drained on the smoother slopes and somewhat poorly drained on the very steep side slopes. Nearly continuous rainfall is favorable for mosses and ferns.

Very steep slopes, stoniness, and rockiness are severe limitations for crops and pasture and for nonfarm uses such as highway location, foundations for low buildings, septic tank filter fields, and sewage lagoons. This land type has scenic value, but the very steep slopes, rockiness, and stoniness are severe limitations for paths, trails, intensive play areas, campsites, and picnic areas. The use of this land type is limited to forest, habitat for wildlife, and water catchment. Capability unit VIIIs–2.

Sabana Series

The Sabana series consists of shallow soils that are well drained and moderately permeable. These soils formed in fine-textured residuum derived from partly weathered volcanic rocks. They are on mountain side slopes and ridgetops. Slopes are 20 to 60 percent. The climate is humid tropical. The average annual precipitation is 80 to 90 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is very dark gray, strongly acid silty clay loam about 4 inches thick. The next layer is dark grayish-brown, mottled silty clay 8 inches thick. Below that layer is yellowish-red, mottled clay 6 inches thick. It is underlain by consolidated rock.

These soils have a moderate available water capacity and moderate shrink-swell potential. Runoff is rapid to very rapid. Most of the acreage is used for pasture and woodland, and some areas are in brush.

Representative profile of Sabana silty clay loam, 20 to 40 percent slopes, eroded, 2.4 kilometers north on Highway No. 925 from its junction with Highway No. 3, 45 meters north of Parcelas Junquitos:

Ap—0 to 4 inches, very dark gray (10YR 3/1) silty clay loam; moderate, medium, granular structure; firm, slightly sticky and slightly plastic; common fine roots; common fine volcanic fragments; strongly acid; clear wavy boundary.

B1—4 to 12 inches, dark grayish-brown (10YR 4/2) silty clay; common, medium, prominent, strong-brown (7.5YR 5/6) mottles; weak, fine, subangular blocky structure; firm, slightly sticky and slightly plastic; few fine roots; few fine pores; occasional thin clay films; few, fine, volcanic rock fragments; strongly acid; smooth boundary.

B2—12 to 18 inches, yellowish-red (5YR 5/6) clay; many, coarse, prominent, dark-brown (7.5YR 4/4) mottles; weak, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; few fine roots; few fine pores; few, thin, patchy clay films; common, fine, volcanic rock fragments; strongly acid; abrupt, smooth boundary.

R—18 inches, consolidated volcanic rock.

Thickness of the solum and depth to volcanic rock ranges from 10 to 20 inches. The Ap horizon has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 1 or 2. Coarse fragments are few or common. The B2 horizon has hue of 7.5YR or 5YR, value of 4 or 5, and chroma of 4 to 6. It has weak, fine or medium, subangular blocky structure.

The Sabana soils occupy the same landscape as the Caguabo, Mucara, and Naranjito soils. They are more acid than the Caguabo soils and lack their gravelly B horizon. The Sabana soils are shallower to hard rock than the Mucara and Naranjito soils, and they have a thinner solum than the Naranjito soils.

SaE2—Sabana silty clay loam, 20 to 40 percent slopes, eroded. This soil is on side slopes in the humid part of the survey area. It has the profile described as representative of the series. Erosion has removed some of the original surface layer, and in some places the subsoil is exposed. Included with this soil in mapping were areas of Caguabo, Mucara, and Naranjito soils.

This soil is not suited to clean-cultivated crops. Steep slopes, depth to volcanic rocks, rapid runoff, and the hazard of erosion are severe limitations for farming. The soil is suited to pasture and woodland. Capability unit VIIs-1; woodland suitability group 3d5.

SaF2—Sabana silty clay loam, 40 to 60 percent slopes, eroded. This soil is on side slopes and ridgetops in the humid volcanic uplands. Its profile is similar to the one described as representative of the Sabana series, but erosion has removed most of the surface layer. In some places the subsoil is exposed. Included with this soil in mapping were small areas of Caguabo soils.

This soil is not suited to clean-cultivated crops. It has severe limitations for farming because of steep slopes, the hazard of erosion, very rapid runoff, and shallowness to rock. It is suited to woodland and pasture. Capability unit VIIs-1; woodland suitability group 4d5.

Salt Water Marsh

Salt water marsh (Sm) consists of wet, periodically flooded areas that are covered mainly by grass, cattails, brush, or other herbaceous plants. It is occasionally flooded by salty water from adjacent mangrove swamps. During periods when rainfall is intense, rivers and streams drain into Salt water marsh and cause the water table to fluctuate. The soil material varies widely in texture.

This land type has severe limitations for farming because it is wet and salty. Expensive drainage systems are required to reclaim it. It is suitable for wildlife food and cover. Capability unit VIIIw-1.

Talante Series

The Talante series consists of deep soils that are poorly drained and moderately permeable. These soils formed in medium-textured to coarse-textured sediment that derived from granitic rocks. They are on flood plains. Slopes are 0 to 2 percent. The climate is humid tropical. The average annual precipitation is 87 inches, and the average annual temperature is 79° F. Depth to the water table ranges from 15 to 30 inches.

In a representative profile, the surface layer is about 10 inches thick. In the upper part it is dark-brown, very strongly acid, mottled clay loam, and in the lower part it is grayish-brown, mottled sandy clay loam. The next layer is brown, friable loam 8 inches thick. The layer below that is dark-brown and gray loamy sand and coarse sand that extends to a depth of 58 inches.

These soils have a moderate available water capacity and low shrink-swell potential. They are subject to flooding and difficult to work. Runoff is slow. The soils have been in pasture and sugarcane for many years.

Representative profile of Talante clay loam, 0 to 2 percent slopes, in an area of Talante soils, 1000 meters northeast of Central Roig and 180 meters north of Guayanes River:

Ap—0 to 4 inches, dark-brown (10YR 4/3) clay loam; many, medium, distinct, gray (10YR 5/1) and dark-brown (7.5YR 4/4) mottles; weak, fine, subangular blocky structure parting to granular; friable, slightly plastic; very strongly acid; clear, smooth boundary.

A1g—4 to 10 inches, grayish-brown (10YR 5/2) sandy clay loam; many, medium, prominent, dark-gray (5Y 4/1) and yellowish-red (5YR 4/8) mottles; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; many mica flakes; strongly acid; clear, smooth boundary.

B2g—10 to 18 inches, brown (10YR 5/3) loam; medium, prominent, gray (5Y 5/1) and dark-brown (7.5YR 4/4) mottles; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; strongly acid; clear, smooth boundary.

IIC1g—18 to 40 inches, mixed dark-brown (7.5YR 4/4) and gray (5Y 5/1) loamy sand; massive; very friable, nonsticky and nonplastic; strongly acid; clear, smooth boundary.

IIIC2g—40 to 58 inches, gray (2.5YR 5/1) coarse sand; many, medium, prominent, yellowish-brown (10YR 5/6) mottles; single grained; loose; strongly acid.

The solum is 14 to 38 inches thick. The A horizon has value of 3 or 4 and chroma of 2 or 3. Mottles are in shades of brown, yellowish red, and gray. The B horizon has value of 4 or 5 and chroma of 2 or 3. It ranges from loam to sandy loam and has gray, dark-brown, and brown mottles. Reaction is strongly acid or very strongly acid.

The Talante soils are on the same landscape as the Coloso, Maunabo, Reilly, and Vivi soils. The Talante soils are more poorly drained than the Coloso soils, and they are coarser textured than the Coloso and Maunabo soils. They are finer textured than the Reilly soils, and unlike these soils, they are poorly drained. Unlike the Vivi soils, the Talante soils are poorly drained and have low-chroma mottles.

Ta—Talante soils. These nearly level soils are on flood plains. Included with them in mapping were small areas of Maunabo, Coloso, and Reilly soils.

These soils have severe limitations for farming because of flooding, a seasonal water table, and poor drainage. If the soils are properly drained, they are suited to sugarcane, cut grasses, and pasture. Capability unit IIIw-3.

Teja Series

The Teja series consists of shallow soils that are well drained and rapidly permeable. These soils formed in gravelly residuum derived from granitic rocks. They are on mountain side slopes and ridgetops. Slopes are 12 to 40 percent. The climate is humid tropical. The average annual precipitation is 80 to 90 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is dark-brown, very strongly acid gravelly sandy loam about 6 inches thick. Below that layer is dark-brown and yellowish-brown, loose gravelly sandy loam 8 inches thick. This is underlain by hard rock.

These soils have a low available water capacity and are somewhat difficult to work. Runoff is medium to rapid. Most of the acreage is in pasture and woodland.

Representative profile of Teja gravelly sandy loam, 12 to 40 percent slopes, 8 meters south of kilometer marker 2.7 on Highway No. 906:

A1—0 to 6 inches, dark-brown (10YR 3/3) gravelly sandy loam; weak, fine, granular structure; very friable, nonsticky and nonplastic; common fine roots; many fine quartz grains; very strongly acid; clear, smooth boundary.

C—6 to 14 inches, dark-brown (10YR 4/3) and yellowish-brown (10YR 5/4) gravelly sandy loam; single grained; loose, nonsticky and nonplastic; few fine roots; about 40 percent, by volume, angular rock fragments; very strongly acid; abrupt, smooth boundary.

R—14 to 20 inches, hard, coarse-grained plutonic rock.

The A horizon is 4 to 10 inches thick. It has value and chroma of 2 or 3. The C horizon has value of 4 or 5 and chroma of 3 or 4. Depth to consolidated plutonic rock ranges from 10 to 20 inches. Reaction is strongly acid or very strongly acid.

The Teja soils are on the same landscape as the Pandura, Mayo, Daguao, and Candelero soils. The Teja soils are shallower and coarser textured than the Pandura soils. They are shallower than the Mayo soils and lack their B horizon. The Teja soils are shallower and coarser textured and have a thinner solum than the Daguao soils. They are shallower, coarser textured, and better drained than the Candelero soils.

TeE—Teja gravelly sandy loam, 12 to 40 percent slopes. This soil is on side slopes and ridgetops. Included with it in mapping were small areas of Pandura soils and Rock land.

This soil is not suited to cultivated crops, and it has severe limitations for farming because of slope, shallowness, and the hazard of erosion. It is suited to woodland and pasture. Capability unit VIIs–1; woodland suitability group 4d5.

Tidal Flats

Tidal flats (Tf) consists of low areas, slightly above sea level, that are affected by seawater during high tide. Because of the high concentration of salt, only salt-tolerant plants grow in these areas. Occasional barren spots that have visible salt accumulation are common. The soil material varies widely in texture.

This land type has severe limitations for farming because of salinity. It is suitable for wildlife food and cover. Capability unit VIIIw–1.

Tidal Swamp

Tidal swamp (Ts) consists of areas that are covered with a thick growth of mangrove trees and are under salty water most of the year. These areas are along the seacoast and inlets. The sandy or clayey soils are light colored and saline and contain organic material from decaying mangrove trees. They are underlain by coral, shells, and marl at varying depths.

This land type is not extensive and has no value for farming, but it serves as a feeding and breeding place for birds, oysters, and crabs. Some of the mangrove trees are used for making charcoal. The land type has very severe limitations for nonfarm uses, and reclamation is expensive. Capability unit VIIIw–1.

Toa Series

The Toa series consists of deep soils that are moderately well drained and moderately permeable. These soils formed from moderately fine textured and fine textured alluvial sediment of mixed origin. They are on river flood plains. Slopes are 0 to 2 percent. The climate is humid tropical. The average annual precipitation is 82 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is dark-brown, medium acid silty clay loam about 10 inches thick. The next layer is dark grayish-brown, mottled silty clay loam 6 inches thick. Below this layer is grayish-brown and dark-brown, friable, mottled clay loam that extends to a depth of 60 inches or more.

These soils have a moderate available water capacity and high fertility and are easily worked. They have been in sugarcane and pasture for many years, and some small areas are in food crops.

Representative profile of Toa silty clay loam, 6 meters west of railroad bridge and 6 meters south, near main office of Colonia Santa Rosa, Naguabo:

Ap—0 to 10 inches, dark-brown (10YR 3/3) silty clay loam; moderate, medium, granular structure; friable, nonsticky and slightly plastic; medium acid; clear, smooth boundary.

B—10 to 16 inches, dark grayish-brown (10YR 4/2) silty clay loam; common, medium, distinct, yellowish-red (5YR 5/6) mottles; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; medium acid; clear, smooth boundary.

C1—16 to 60 inches, grayish-brown (10YR 5/2) clay loam; many, fine, faint, dark-brown (10YR 4/3) mottles; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; thin lenses of sand and gravel fragments, 2 to 3 inches in diameter, at a depth of 30 inches; medium acid; clear, smooth boundary.

C2—60 to 70 inches, dark-brown (7.5YR 4/4) clay loam; many, fine, distinct, gray and brown mottles; massive; friable, nonsticky and slightly plastic; common fine sand grains; common gravel fragments.

The solum is 12 to 28 inches thick. The A horizon has value and chroma of 2 or 3. The B horizon has chroma of 2 to 4 and weak, fine or medium, subangular blocky structure. The C horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 2 to 4. Reaction is slightly acid or medium acid.

The Toa soils occupy the same landscape as the Bajura, Fortuna, Coloso, and Reilly soils. The Toa soils are better drained and coarser textured throughout than the Bajura and Fortuna soils. They are coarser textured in the lower horizons and better drained than the Coloso soils. The Toa soils are finer textured than the Reilly soils and lack their underlying sand and gravel.

Tt—Toa silty clay loam. This nearly level soil is on river flood plains in the humid coastal plains. Included with it in mapping were areas of Coloso, Fortuna, and Bajura soils.

This soil is suited to cultivated crops and can be used for food crops, sugarcane, grasses, and pasture (fig. 5). It needs ordinary management and practices that help to maintain fertility and good tilth. Capability unit I–2.

Utuado Series

The Utuado series consists of deep, well-drained soils that have moderately rapid permeability. These soils formed in moderately fine textured or medium-textured, highly weathered residuum derived from igneous rock. They are on mountain side slopes in the plutonic uplands. Slopes are 40 to 100 percent. The average annual precipitation is 185 inches, and the average annual temperature is 72° F.

In a representative profile, the surface layer is dark-brown, very strongly acid clay loam about 5 inches thick. Below that is yellowish-brown, very strongly acid, friable clay loam 13 inches thick. Yellowish-brown, very friable loam is between depths of 18 and 23 inches. The underlying material is pale-brown and very pale brown, very friable sandy loam that extends to a depth of 72 inches or more.

These soils have a moderate to low available water capacity and medium fertility. Runoff is rapid. The soils have been in hardwood trees, sierra palms, and tree ferns for many years.

Representative profile of Utuado clay loam, 40 to 60

Figure 5.—A recently plowed field on Toa silty clay loam. This soil has high fertility and is easy to work. It is suited to most cultivated crops.

percent slopes, in an area of the Utuado-Picacho-Stony rock land association, very steep, 25 meters southeast of kilometer marker 21.0 on Highway No. 191:

A1—0 to 5 inches, dark-brown (10YR 3/3) clay loam; moderate, medium, granular structure; friable, slightly sticky and slightly plastic; many fine, medium, and large roots; few fine quartz grains; very strongly acid; gradual, smooth boundary.

B2—5 to 18 inches, yellowish-brown (10YR 5/6) heavy clay loam; weak, coarse, subangular blocky structure breaking to weak, fine, subangular blocky; friable, slightly sticky and slightly plastic; common fine roots; common fine pores; very thin patchy clay films; few fine quartz grains; few, fine, dark minerals; very strongly acid; gradual, wavy boundary.

B3—18 to 23 inches, yellowish-brown (10YR 5/4) loam; very weak, coarse, subangular blocky structure; very friable, slightly sticky and slightly plastic; few fine and medium roots; common fine pores; common fine quartz grains; very strongly acid; gradual, wavy boundary.

C1—23 to 36 inches, pale-brown (10YR 6/3) sandy loam; massive breaking to very weak, coarse, subangular blocky structure; very friable, nonsticky and nonplastic; many fine quartz grains; many, flaky, shiny minerals; common, fine, dark minerals; very strongly acid; diffuse, wavy boundary.

C2—26 to 52 inches, very pale brown (10YR 7/3) sandy loam; common, fine, distinct, dark-brown mottles; massive breaking to very weak, coarse, subangular blocky structure; very friable, nonsticky and nonplastic; many fine quartz grains; many, flaky, shiny minerals; many, fine, dark minerals; very strongly acid; diffuse, wavy boundary.

C3—52 to 72 inches+, very pale brown (10YR 7/3) sandy loam; many, fine, distinct, dark-brown, brown, and yellowish-brown mottles; massive; very friable, nonsticky and nonplastic; very strongly acid.

The solum is 18 to 31 inches thick. The A horizon has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 to 4. It ranges from loam to clay loam. The B horizon has hue of 10YR or 7.5 YR, value of 4 to 6, and chroma of 4 to 8. It ranges from clay loam or sandy clay loam to loam and has weak or very weak, fine to coarse, subangular blocky structure. The C horizon has hue of 10YR or 7.5YR, value of 4 to 7, and chroma of 2 to 6. It ranges from sandy loam to loam. Quartz grains vary from few to many throughout the profile. Reaction ranges from strongly acid to extremely acid.

The Utuado soils are on the same landscape as the Ciales, Yunque, Los Guineos, and Picacho soils. Unlike the Ciales, Yunque, and Los Guineos soils, the Utuado soils lack a B2t horizon; they are coarser textured than the Yunque and Los Guineos soils. The Utuado soils are coarser textured than the Picacho soils and lack their low-chroma mottles.

UpF—Utuado-Picacho-Stony rock land association, very steep. This mapping unit is on mountains in the rain forest. It occupies narrow upper side slopes where slopes range from 20 to 50 percent, mid side slopes where slopes range from 50 to 100 percent, and lower side slopes adjacent to drainageways where slopes range from 30 to 100 percent.

The composition of this unit is more variable than that of most other units in the survey area but has been controlled well enough to interpret for the expected use of the soils. About 40 percent of this unit is Utuado soils, 26 percent is Picacho soils, and 19 percent is Stony rock land. The remaining area is minor soils that vary in texture and color.

The soils of this unit occur in uniform patterns; the Picacho soils are on the upper side slopes and the Utuado soils are on the mid side slopes. Stony rock land is on the lower part of the side slopes adjacent to the drainageways. Gray and bluish volcanic rocks cover 90 to 100 percent of the surface, and loose fragments that range from 6 to 60 inches in diameter are at the base of the rock cliffs.

All of this mapping unit is in hardwood trees. Because of the very steep slopes, its use is limited to forest, habitat for wildlife, and water catchment. The soils are desirable for recreation because of their scenic value, but they have severe limitations for paths, trails, and roads because they are continuously wet and are susceptible to slippage in roadbanks. Capability unit VIIs-3; woodland suitability group 3r3.

Vayas Series

The Vayas series consists of deep soils that are poorly drained and slowly permeable. These soils formed in fine-textured sediment of mixed origin. They are on weakly dissected river flood plains. Slopes are 0 to 2 percent. The climate is semiarid tropical. The average annual precipitation is 30 to 40 inches, and the average annual temperature is 79° F. Depth to the water table ranges from 30 to 60 inches.

In a representative profile, the surface layer is very dark grayish-brown, neutral silty clay about 8 inches thick. Below that is very dark grayish-brown, firm, mottled silty clay 5 inches thick. Brown, friable, mottled silty clay and silty clay loam are between depths of 13 and 30 inches. These are underlain by olive-brown, friable, mottled silt loam and fine sandy loam that extends to a depth of 54 inches.

These soils have a high available water capacity and high natural fertility. They are difficult to work and have been in sugarcane and pasture for many years.

Representative profile of Vayas silty clay, frequently flooded, 24 meters south of farm railroad track, and 0.2 kilometer west of Josefa Machinery Shop within the Hacienda Josefa:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silty clay; few, fine, faint, very dark gray (5Y 3/1) mottles; massive parting to weak, coarse, subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; few pores; few pebbles; black stains along root channels; neutral; gradual, smooth boundary.

B—8 to 13 inches, very dark grayish-brown (10YR 3/2) silty clay; common, fine, distinct, dark-gray (5Y 3/2) and dark yellowish-brown (10YR 4/4) mottles; weak, medium and coarse, subangular blocky structure; firm, slightly sticky and slightly plastic; clay coatings along root channels and pores; few pores; few pebbles; black stains along root channels; neutral; abrupt, smooth boundary.

C1—13 to 21 inches, brown (10YR 4/3) silty clay; many, fine, distinct, olive-gray (5Y 5/2) and dark yellowish-brown (10YR 4/2) mottles; massive; friable, slightly sticky and slightly plastic; few pores; dead roots; black stains and coatings along root channels; mildly alkaline; clear, smooth boundary.

C2—21 to 30 inches, brown (10YR 4/3) silty clay loam; many, fine, distinct, olive-gray (5Y 4/2) and dark-brown (7.5YR 4/4) mottles; massive; friable, slightly sticky and slightly plastic; few pores; few clay coatings along root channels; mildly alkaline; clear, smooth boundary.

C3—30 to 44 inches, olive-brown (2.5Y 4/4) silt loam; common, fine, distinct, olive (5Y 4/3) mottles; massive; friable, nonsticky and nonplastic; mildly alkaline; clear, smooth boundary.

C4—44 to 54 inches, olive-brown (2.5Y 4/4) fine sandy loam; common, fine, distinct, olive (5Y 4/3) mottles; massive; friable, nonsticky and nonplastic; mildly alkaline.

The solum is 12 to 18 inches thick. The A horizon has value and chroma of 2 or 3. The B horizon has value of 3 or 4 and chroma of 2 or less. It has gray, dark-gray, and dark yellowish-brown mottles. It is silty clay or clay and has weak, fine to coarse, subangular blocky structure. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 3 or 4. Reaction is neutral to moderately alkaline.

The Vayas soils are on the same landscape as the Vives, Cartagena, and Poncena soils. Unlike the Vives soils, they are poorly drained and have low-chroma mottles. The Vayas soils lack the high shrink-swell potential of the Cartagena and Poncena soils, and unlike the Poncena soils, they are poorly drained and have a B horizon.

Va—Vayas silty clay loam, occasionally flooded. This nearly level soil is on alluvial flood plains in the semiarid part of the survey area. Included with it in mapping were small areas of Cartagena soils.

Slow permeability, poor drainage, the hazard of flooding, and poor workability are moderate limitations for farming. If the soil is properly drained and managed, it is suited to sugarcane, cut grasses, and pasture. Capability units IIw-4 nonirrigated and IIw-4 irrigated.

Vc—Vayas silty clay, frequently flooded. This nearly level soil is on river flood plains. It has the profile described as representative of the series. Included with this soil in mapping were areas of Cartagena and Vives soils.

The hazard of flooding, poor drainage, slow permeability, and poor workability are moderate limitations for farming. If the soil is properly drained and managed, it is suited to sugarcane, cut grasses, and pasture. Capability units IIw-4 nonirrigated and IIw-4 irrigated.

Vega Alta Series

The Vega Alta series consists of deep soils that are well drained and moderately permeable. These soils formed in fine-textured, red, brown, and gray coastal plain sediment that is rich in iron. They are on coastal plains and terraces. Slopes are 2 to 12 percent. The climate is humid tropical. The average annual precipitation is 76 inches, and the average annual temperature is 77° F.

In a representative profile, the surface layer is dark yellowish-brown, strongly acid silty clay loam about 9 inches thick. Below this layer is yellowish-brown and red, firm or very firm clay 19 inches thick. The next layer is red, yellowish-brown, and light-gray, firm clay that extends to a depth of 60 inches.

These soils have a moderate available water capacity and medium fertility. They are somewhat difficult to work. Runoff is slow to medium. Most of the acreage is used for sugarcane, cut grasses, and pasture, but there are small areas in food crops and brush.

Representative profile of Vega Alta silty clay loam, 2 to 5 percent slopes, 15 meters west of trail and 0.3 kilometer north from kilometer marker 2.1 on Highway No. 194, municipality of Fajardo:

A1—0 to 9 inches, dark yellowish-brown (10YR 4/4) silty clay loam, light yellowish brown (10YR 6/4), dry; weak, medium, subangular blocky structure; firm, nonsticky and slightly plastic; common fine roots; strongly acid; clear, smooth boundary.

B21t—9 to 20 inches, mixed yellowish-brown (10YR 5/4) and red (2.5YR 4/6) clay; weak, fine to medium, subangular blocky structure; firm, slightly sticky and slightly plastic; common pores; common fine roots; common clay films on ped surfaces and pores; about 5 percent, by volume, is plinthite; few black concretions; very strongly acid; clear, smooth boundary.

B22t—20 to 28 inches, mixed red (10YR 4/8) and yellowish-brown (10YR 5/4, 5/6) clay; moderate, medium, subangular blocky structure; very firm, slightly sticky and plastic; many clay films on ped surfaces; about 5 percent, by volume, is plinthite; few shale fragments; few pores; very strongly acid; clear, wavy boundary.

B23t—28 to 60 inches, mixed red (10R 4/8), yellowish-brown (10YR 5/8), and light-gray (10YR 7/1) clay; weak, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; few clay films on ped surfaces; about 5 percent, by volume, is plinthite; few shale fragments; very strongly acid.

The solum is more than 60 inches thick. The A horizon has hue of 10YR or 7.5YR and value and chroma of 4 to 6. The B2t horizon has hue of 2.5YR, 7.5YR, 10R, or 10YR, value of 4 to 7, and chroma of 1 to 8. It has weak or moderate, fine or medium, subangular blocky structure. Plinthite makes up 5 to 10 percent of the B2t horizon. Reaction is strongly acid or very strongly acid.

The Vega Alta soils occupy the same landscape as the Vega Baja and Fajardo soils. The Vega Alta soils are better drained than those soils, and they contain plinthite.

VeB—Vega Alta silty clay loam, 2 to 5 percent slopes. This soil is on coastal plains and terraces in the humid part of the survey area. It has the profile described as representative of the series. Included with this soil in mapping were areas of Vega Baja and Fajardo soils.

This soil has moderate limitations for farming because of the hazard of erosion. If it is properly managed, the soil is suited to food crops, sugarcane, and pasture. Capability unit IIe–4.

VeC—Vega Alta silty clay loam, 5 to 12 percent slopes. This soil is on coastal plains and terraces in the humid part of the survey area. Included with it in mapping were small areas of Fajardo and Vega Baja soils.

This soil has moderate limitations for farming because of slope and the hazard of erosion. If proper management and conservation practices are used, the soil is suited to sugarcane, cut grasses, and pasture. Capability unit IIIe–8.

Vega Baja Series

The Vega Baja series consists of deep soils that are somewhat poorly drained and slowly permeable. These soils formed in fine-textured, mixed sediment. They are on coastal plains and alluvial fans. Slopes are 0 to 3 percent. The climate is humid tropical. The average annual precipitation is 76 inches, and the average annual temperature is 77° F.

In a representative profile, the surface layer is brown to dark-brown, slightly acid silty clay loam about 12 inches thick. Below that is dark grayish-brown, firm, mottled silty clay 11 inches thick. The underlying material is yellowish-brown, firm, mottled clay that extends to a depth of 48 inches.

These soils have a high available water capacity and medium fertility. Runoff is slow. The soils are difficult to work and have been in sugarcane and pasture for many years.

Representative profile of Vega Baja silty clay loam, 0 to 3 percent slopes, 0.9 kilometer west from kilometer marker 0.8 on Highway No. 976, 90 meters southwest from Land Authority Office, Colonia San Pedro, Fajardo, and 38 meters south from junction of farm roads:

Ap—0 to 12 inches, brown to dark-brown (10YR 4/3) silty clay loam; weak, fine, subangular blocky structure parting to granular; friable, slightly sticky and slightly plastic; slightly acid; abrupt, wavy boundary.

B2t—12 to 23 inches, dark grayish-brown (10YR 4/2) silty clay; common, medium, distinct, brownish-yellow (10YR 6/6) mottles and few, distinct, red (2.5YR 4/8) mottles; weak, medium, subangular blocky structure; firm, slightly sticky and slightly plastic; common black concretions; medium acid; abrupt, wavy boundary.

C1—23 to 30 inches, yellowish-brown (10YR 5/8) clay; common, medium, distinct, gray (2.5Y 5/0) mottles; few, fine, distinct, red (2.5YR 4/6) mottles; and common, fine, prominent, dark-gray (2.5Y 4/0) mottles; massive; firm, slightly sticky and plastic; common black concretions; slightly acid; abrupt, wavy boundary.

C2—30 to 48 inches, yellowish-brown (10YR 5/8) clay; common, medium, prominent, greenish-gray (5BG 6/1) mottles; massive; firm, slightly sticky and slightly plastic; few gravel fragments; few black concretions; medium acid.

The solum is 14 to 32 inches thick. The A horizon has value and chroma of 3 or 4. The B horizon has chroma of 2 or 3. Black concretions range from few to many. Reaction is slightly acid or medium acid.

The Vega Baja soils are on the same landscape as the Vega Alta, Coloso, Bajura, and Toa soils. Unlike the Vega Alta soils, the Vega Baja soils are somewhat poorly drained and lack red colors. They have a B2t horizon that the Coloso soils lack. The Vega Baja soils are not so poorly drained as the Bajura soils and lack their high shrink-swell potential. They are finer textured than the Toa soils, and unlike those soils, they are somewhat poorly drained.

VgA—Vega Baja silty clay loam, 0 to 3 percent slopes. This soil is on coastal plains and alluvial fans in the humid part of the survey area. Included with it in mapping were small areas of Coloso, Bajura, and Toa soils.

This soil has moderate limitations for farming because it is somewhat poorly drained and is susceptible to flooding. If it is properly drained and managed, the soil is suited to sugarcane, cut grasses, and pasture. Capability unit IIw–1.

Via Series

The Via series consists of deep soils that are well drained and moderately permeable. These soils have formed in moderately fine textured sediment that is underlain by coarse-textured, gravelly or cobbly sediment. They are on terraces. Slopes are 3 to 10 percent. The climate is humid tropical. The average temperature is 78° F.

In a representative profile, the surface layer is dark grayish-brown, strongly acid silty clay loam about 8 inches thick. Below that layer is reddish-brown and yellowish-red, firm clay loam 39 inches thick. The underlying material is dark-brown, firm gravelly clay loam that extends to a depth of 62 inches.

These soils have a moderate available water capacity, and high fertility. They are easy to work. Runoff is slow. Most of the acreage is used for sugarcane and pasture, but some areas are used for food crops.

Representative profile of Via silty clay loam, 3 to 10 percent slopes, 0.7 kilometer west of kilometer marker 21.9 on Highway No. 3 and 1,050 meters east of schoolhouse:

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) silty clay loam, brown (10YR 5/3), dry; weak, fine, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; many fine roots; fine dark concretions; few worm casts; few cobbles and pebbles at contact with B horizon; strongly acid; abrupt, smooth boundary.

B21t—8 to 23 inches, reddish-brown (5YR 4/4) clay loam; weak, medium, subangular blocky structure; very hard, firm, slightly sticky and slightly plastic; common fine roots; few, thin, patchy clay films on vertical ped surfaces; many, fine, dark mineral grains; common fine rock fragments; slightly acid; clear, smooth boundary.

B22t—23 to 47 inches, yellowish-red (5YR 4/8) clay loam; weak, medium, subangular blocky structure; very hard, firm, slightly sticky and slightly plastic; few fine roots; thin patchy clay films; common, fine, dark minerals; many fine and medium rock fragments; slightly acid; gradual, wavy boundary.

IIC—47 to 62 inches, dark-brown (7.5YR 4/4) gravelly clay loam; structureless; hard, firm, slightly sticky; more than 70 percent, by volume, coarse fragments; medium acid.

Thickness of the solum and depth to the gravelly horizons range from 30 to 60 inches. The Ap horizon has hue of 10YR or 5YR, value of 4 or 5, and chroma of 2 or 3. The B horizon has hue of 7.5YR or 5YR and chroma of 4 to 8. It has weak, fine or medium, subangular blocky structure. Reaction in the B2t horizon is slightly acid or medium acid.

The Via soils occupy the same landscape as the Rio Arriba, Mabi, and Junquitos soils. They are coarser textured than the Rio Arriba and Mabi soils and lack their high shrink-swell potential. Unlike the Junquitos soils, the Via soils lack low-chroma mottles in the B horizon.

VlC—Via silty clay loam, 3 to 10 percent slopes. This soil is on terraces in the humid part of the survey area. Included with it in mapping were small areas of Rio Arriba, Junquitos, and Mabi soils.

This soil is suited to food crops, sugarcane, and pasture. Good management and conservation practices should be used to control erosion. Capability unit IIIe–9.

Vieques Series

The Vieques series consists of moderately deep, well-drained soils that have moderately rapid permeability. These soils formed in partly weathered granitic rocks. They are on side slopes and ridgetops in the dry uplands. Slopes are 5 to 40 percent. The climate is semiarid tropical. The average annual precipitation is 35 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is dark-brown, slightly acid loam about 5 inches thick. Below that layer is brown to dark-brown, friable sandy clay loam 10 inches thick. The underlying material is yellowish-brown, loose gravelly coarse sand 23 inches thick. Consolidated granitic rock is at a depth of 38 inches.

These soils have a low available water capacity and medium fertility, and they are susceptible to erosion. They have been in native pasture and brush, but some areas are used for sugarcane.

Representative profile of Vieques loam, 12 to 40 percent slopes, eroded, 30 meters southwest from kilometer marker 1.6 on Highway No. 993, island of Vieques:

A1—0 to 5 inches, dark-brown (10YR 3/3) loam; weak, fine, granular structure; soft, friable, nonsticky and nonplastic; common fine roots; slightly acid; clear, smooth boundary.

B—5 to 15 inches, brown to dark-brown (7.5YR 4/4) sandy clay loam; weak, coarse, subangular blocky structure; slightly hard, friable, nonsticky and slightly plastic; few fine roots; krotovinas filled with material from A1 horizon; common rock fragments that vary from 2 to 5 millimeters in size; neutral; gradual, wavy boundary.

C—15 to 38 inches, yellowish-brown (10YR 5/4) gravelly coarse sand, 60 percent coarse fragments of partially weathered plutonic rocks.

R—38 inches, consolidated granitic rock.

The solum is 12 to 20 inches thick. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 3 or 4. The B horizon has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 3 or 4. It has weak, medium or coarse, subangular blocky structure. The C horizon has value of 4 or 5 and chroma of 4 to 6. Depth to consolidated granitic rock is 32 to 50 inches. Reaction is slightly acid to mildly alkaline.

The Vieques soils are on the same landscape as the Descalabrado, Coamo, and Guayama soils. The Vieques soils are deeper to rock than the Descalabrado soils, and they are coarser textured than the Coamo soils. The Vieques soils lack the red colors of the Guayama soils.

VmC—Vieques loam, 5 to 12 percent slopes. This soil is on side slopes on the island of Vieques. Its profile is similar to the one described as representative of the series, but its surface layer is 1 or 2 inches thicker. Included with this soil in mapping were areas of Guayama and Descalabrado soils.

This soil has severe limitations for farming because of low rainfall and the hazard of erosion. It is not irrigated. The soil has been in sugarcane and pasture that has low carrying capacity. Capability unit IVe–9; woodland suitability group 3d5.

VmE2—Vieques loam, 12 to 40 percent slopes, eroded. This soil is on side slopes and ridgetops on the island of Vieques. It has the profile described as representative of the series. Most of the original surface layer has been eroded. Included with this soil in mapping were small areas of Guayama and Descalabrado soils.

This soil has severe limitations for farming because it is steep and susceptible to erosion. It is suited to pasture and wildlife habitat. Capability unit VIe–5; woodland suitability group 3d5.

Vives Series

The Vives series consists of deep soils that are well drained and moderately permeable. These soils formed in moderately fine textured sediment of mixed origin. They are on river flood plains and on alluvial fans and terraces above the present river flood plains. Slopes are 0 to 7 percent. The climate is semiarid tropical. The average annual precipitation is 25 to 45 inches, and the average annual temperature is about 79° F.

In a representative profile, the surface layer is very dark grayish-brown, neutral, mottled clay about 9 inches thick. The next layer is yellowish-red and reddish-brown clay loam that has fine rock fragments and is 23 inches thick. The underlying material is brown, friable clay loam that extends to a depth of 50 inches.

These soils have a high available water capacity and high natural fertility. They are easily worked, and they have been in sugarcane for many years.

Representative profile of Vives clay, 2 to 7 percent slopes, 1.4 kilometers north of kilometer marker 150.8 on Highway No. 3:

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) clay; few, medium, prominent, reddish-brown (5YR

4/4) mottles; weak, fine, subangular blocky structure; firm, slightly sticky and plastic; many fine roots; many fine rock fragments; many fine charcoal pieces; neutral; abrupt, wavy boundary.

B2—9 to 23 inches, yellowish-red (5YR 4/6) clay loam; weak, medium, subangular blocky structure; firm, slightly sticky and plastic; common fine roots; few fine pores; many fine rock fragments; many dark coatings in root channels; neutral; clear, wavy boundary.

B3—23 to 32 inches, reddish-brown (5YR 4/4) clay loam; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; few fine roots; few fine pores; few fine rock fragments; neutral; clear, wavy boundary.

C1—32 to 43 inches, brown (7.5YR 4/4) clay loam; massive; friable, nonsticky and slightly plastic; many, fine, subrounded rock fragments; neutral; clear, smooth boundary.

C2—43 to 50 inches, brown (7.5YR 4/4) clay loam; massive; friable, nonsticky and slightly plastic; many lime splotches; calcareous; moderately alkaline.

The solum is 20 to 40 inches thick. The A horizon has hue of 10YR or 7.5YR and value and chroma of 2 to 4. The B2 horizon has hue of 5YR or 7.5YR and chroma of 4 to 6. It ranges from clay loam to clay and has weak, fine or medium, subangular blocky structure. Clay films are few and patchy. The C horizon has hue of 7.5YR or 5YR and chroma of 4 to 6. Reaction is slightly acid to moderately alkaline.

The Vives soils are on the same landscape as the Machete and Amelia soils. They lack the B2t horizon of the Machete soils. Unlike the Amelia soils, the Vives soils lack the large amount of gravel in the profile.

Vs—Vives silty clay loam, high bottom. This nearly level soil is on river flood plains in the semiarid part of the survey area. Included with it in mapping were areas of Arenales and Guamani soils.

This soil has moderate limitations for farming because rainfall is low. Most of the acreage is in sugarcane. If the soil is properly irrigated and managed, it is suited to many kinds of crops and to sugarcane and pasture. Capability units IIc–1 nonirrigated and I–3 irrigated.

VvA—Vives clay, 0 to 2 percent slopes. This soil is on alluvial fans and terraces in the semiarid part of the survey area. Included with it in mapping were small areas of Machete soils and other Vives soils.

This soil has moderate limitations for farming because rainfall is low. Most of the acreage is planted to sugarcane. The soil is suited to sugarcane, food crops, and pasture. Capability units IIc–1 nonirrigated and I–3 irrigated.

VvB—Vives clay, 2 to 7 percent slopes. This soil is on alluvial fans and terraces in the semiarid part of the survey area. It has the profile described as representative of the series. Included with this soil in mapping were small areas of Machete and Amelia soils.

This soil has moderate limitations for farming because of low rainfall, slope, and the hazard of erosion. If it is irrigated, the soil is suited to many kinds of food crops and to sugarcane. Capability units IIIc–2 nonirrigated and IIe–1 irrigated.

Vivi Series

The Vivi series consists of deep soils that are well drained and rapidly permeable. These soils formed in moderately coarse textured and medium-textured, stratified sediment derived from plutonic rocks. They are on the river flood plains. Slopes are 0 to 2 percent. The climate is humid tropical. The average annual precipitation is 80 to 90 inches, and the average annual temperature is 78° F.

In a representative profile, the surface layer is very dark grayish-brown, very strongly acid loam about 7 inches thick. The next layer is dark grayish-brown, friable loam 7 inches thick. Below this layer is dark-brown, dark grayish-brown, and very dark grayish-brown, friable to loose very fine sandy loam, loam, coarse sand, and sandy loam that extends to a depth of 60 inches.

These soils have a moderate available water capacity and are easily worked. Runoff is slow. The soils have been in sugarcane for many years, and some areas are in pasture.

Representative profile of Vivi loam, 300 meters north of kilometer marker 4.3 on Highway No. 901:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, granular structure; very friable, nonsticky and nonplastic; many fine roots; many fine quartz crystals; very strongly acid; clear, smooth boundary.

B—7 to 14 inches, dark grayish-brown (10YR 4/2) loam; weak, medium, subangular blocky structure; friable, nonsticky and nonplastic; common fine roots; many fine quartz crystals; strongly acid; clear, smooth boundary.

C1—14 to 20 inches, dark-brown (10YR 3/3) very fine sandy loam; massive; friable, nonsticky and nonplastic; few fine roots; many fine quartz crystals; strongly acid; clear, smooth boundary.

C2—20 to 30 inches, very dark grayish-brown (10YR 3/2) loam; massive; friable, nonsticky and nonplastic; many fine quartz crystals; strongly acid; clear, smooth boundary.

C3—30 to 36 inches, dark grayish-brown (10YR 4/2) coarse sand; single grained; loose, nonsticky and nonplastic; many fine quartz crystals; strongly acid; clear, smooth boundary.

C4—36 to 60 inches, dark grayish-brown (10YR 4/2) sandy loam; common, medium, distinct, dark-brown (7.5YR 4/4) mottles; massive; very friable, nonsticky and slightly plastic; many fine quartz grains; strongly acid.

The solum is 10 to 22 inches thick. The Ap horizon has value and chroma of 2 or 3. The B horizon has chroma of 2 or 3 and has weak, fine or medium, subangular blocky structure. The C horizon has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 or 3. Reaction is strongly acid or very strongly acid.

The Vivi soils are on the same landscape as the Maunabo, Coloso, Talante, and Reilly soils. They are coarser textured and better drained than the Maunabo, Coloso, and Talante soils. The Vivi soils are deeper to sand and gravel than the Reilly soils, and unlike those soils, they have a B horizon.

Vw—Vivi loam. This nearly level soil is on river flood plains in the humid part of the survey area. Small areas of Reilly and Coloso soils were included with it in mapping.

This soil has moderate limitations for farming because it is rapidly permeable. It has been planted to sugarcane. If the soil is properly managed and irrigated, it is suited to food crops and sugarcane. Capability unit IIs–3.

Wet Alluvial Land

Wet alluvial land (Wa) consists of lagoonlike areas or depressions on the flood plains of the river and streams that drain the humid part of the survey area.

The water table is at or near the surface most of the year. During rainy periods the areas are covered with water. The soils range from loam to clay in texture.

Because of the high water table, lack of outlets, and high cost of reclamation, this land type is not suited to cultivated crops and is of little value for pasture, but it provides good habitat for wildlife. Capability unit VIIIw-2.

Yunes Series

The Yunes series consists of shallow soils that are well drained, strongly acid, and moderately permeable. These soils formed in very gravelly residuum of shaly sedimentary rocks. They are on side slopes and ridgetops in strongly dissected uplands. Slopes are 20 to 60 percent. The climate is humid tropical. The average annual precipitation is 76 inches, and the average annual temperature is 77° F.

In a representative profile, the surface layer is dark reddish-brown silty clay loam about 2 inches thick. Below this layer is dark-brown, friable gravelly silty clay loam that extends to a depth of 16 inches. It is underlain by bedded, fragmental shale.

These soils have a low available water capacity, are susceptible to erosion, and are difficult to work. They have been in native pasture and brush for many years.

Representative profile of Yunes silty clay loam, 20 to 60 percent slopes, eroded, 1 kilometer east of District Hospital, Bermudez Farm, municipality of Fajardo:

A1—0 to 2 inches, dark reddish-brown (5YR 3/2) silty clay loam; moderate, medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many fine roots; common fine shale fragments; strongly acid; abrupt, smooth boundary.

B2—2 to 11 inches, dark-brown (7.5YR 3/2) gravelly silty clay loam; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many fine roots; 60 percent, by volume, is shale fragments; strongly acid; abrupt, smooth boundary.

B3—11 to 16 inches, dark-brown (7.5YR 4/4) gravelly silty clay loam; weak, medium, subangular blocky structure; friable, slightly sticky and slightly plastic; 80 percent, by volume, is shale fragments; strongly acid; abrupt, smooth boundary.

C—16 inches, bedded, fragmental, mixed light-red (2.5YR 6/8), strong-brown (7.5YR 5/8), and pink (7.5YR 7/4) shale; thickness of beds is from 1 to 4 inches; this material can be dug with difficulty with a spade when moist.

Thickness of the solum and depth to fragmental shale range from 10 to 20 inches. The A horizon has hue of 5YR or 7.5YR and value and chroma of 2 or 3. The B horizon has hue of 5YR or 7.5YR, value of 3 or 4, and chroma of 2 to 4. It ranges from gravelly silty clay loam to gravelly clay loam. Reaction is strongly acid or very strongly acid.

The Yunes soils occupy the same landscape as the Caguabo soils. Unlike the Caguabo soils, the Yunes soils are strongly acid and lack hard rock.

YuF2—Yunes silty clay loam, 20 to 60 percent slopes, eroded. This soil is on side slopes and ridgetops in the humid, mountainous part of the survey area.

This soil is not suited to clean-cultivated crops. Slope, shallowness, and the hazard of erosion are severe limitations that limit its use for pasture and wildlife. Capability unit VIIs-1; woodland suitability group 4d5.

Yunque Series

The Yunque series consists of deep soils that are moderately well drained and moderately permeable. These soils formed in fine-textured, highly weathered residuum of volcanic rocks. They are on upper side slopes and ridgetops in strongly dissected uplands. Slopes are 10 to 35 percent. The average annual precipitation is 185 inches, and the average annual temperature is 72° F.

In a representative profile, the surface layer is dark yellowish-brown, very strongly acid silty clay about 8 inches thick. Yellowish-brown, firm and friable clay is between depths of 8 and 51 inches. Below this layer is yellowish-red, friable clay that has red and reddish-yellow mottles and extends to a depth of more than 68 inches.

These soils have a high available water capacity and medium fertility. Runoff is medium. The soils have been in hardwood trees and tree ferns for many years.

In this survey area, the Yunque soils are mapped only in an association with Los Guineos soils and Stony rock land.

Representative profile of Yunque silty clay, 12 to 20 percent slopes, in an area of the Los Guineos-Yunque-Stony rock land association, steep, 25 meters southeast from kilometer marker 11.9 on Highway No. 186:

A1—0 to 8 inches, dark yellowish-brown (10YR 4/4) silty clay; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; many fine roots; few fine pores; few, fine, dark minerals; few fine rock fragments; few krotovinas; very strongly acid; clear, smooth boundary.

B21t—8 to 20 inches, yellowish-brown (10YR 5/6) clay; few, fine, faint, yellowish-red mottles; weak, medium, subangular blocky structure; firm, sticky and slightly plastic; common fine roots; few fine pores; thin continuous clay films; few, fine, coated rock fragments; few krotovinas; very strongly acid; gradual, smooth boundary.

B22t—20 to 38 inches, yellowish-brown (10YR 5/8) clay; few, fine, faint, yellowish-red mottles; weak, medium, subangular blocky structure breaking to weak, fine, subangular blocky; firm, sticky and slightly plastic; few fine roots; few fine pores; thin continuous clay films; few, fine, coated rock fragments; few krotovinas; few dark minerals; very strongly acid; gradual, smooth boundary.

B23t—38 to 51 inches, yellowish-brown (10YR 5/8) clay; many, medium, distinct, red (2.5YR 4/8) mottles; weak, medium, subangular blocky structure; friable, sticky and slightly plastic; few pores; few, thin, patchy clay films; few dark concretions; very strongly acid; clear, smooth boundary.

B3—51 to 68 inches+, yellowish-red (5YR 4/8) clay; common, distinct, red (2.5YR 4/8) and reddish-yellow (7.5YR 6/8) mottles; weak, fine, subangular blocky structure; friable, slightly sticky and slightly plastic; few pores; very few, thin, patchy clay films; few dark minerals; strongly acid.

The solum is more than 60 inches thick. The A horizon has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 to 4. It is silty clay loam or silty clay. The B2 horizon has dominant hue of 10YR or 7.5YR, value of 5 or 6, and chroma of 4 to 8. It is silty clay or clay and has weak or moderate, fine or medium, subangular blocky structure. Clay films vary from thick continuous to thin patchy. The B3 horizon has hue of 5YR, 7.5YR, or 2.5YR, value of 4 to 6, and chroma of 6 to 8. It is silty clay or clay. Mean annual soil temperature at a depth of 20 inches is 66° to 72° F., and the difference between mean summer and mean winter soil temperatures is less than 9° F. Reaction is very strongly acid or strongly acid.

The Yunque soils are on the same landscape as the Utuado, Ciales, Picacho, and Los Guineos soils. The Yunque soils are finer textured than the Utuado soils, and unlike those soils they have a B2t horizon. They lack the low-chroma mottles in the B2t horizon of the Ciales and Picacho soils. The Yunque soils have a thicker B2t horizon than the Los Guineos soils.

Use and Management of the Soils

In this section the system of capability grouping used by the Soil Conservation Service is explained and the capability units in the Humacao Area are described. Estimated yields for the principal crops and pasture grasses under two levels of management are given. Management of the soils for woodland is also discussed. Information about the soil properties and limitations that affect engineering practices and recreation uses is given, mainly in tables.

Capability Grouping

Some readers, particularly those who farm on a large scale, may find it practical to use and manage alike some of the different kinds of soil on their farm. These readers can make good use of the capability classification system, a grouping that shows, in a general way, the suitability of soils for most kinds of farming.

The grouping is based on limitations of soils when used for field crops, the risk of damage when they are farmed, and the way the soils respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to horticultural crops or other crops that require special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations for forest trees or for engineering.

In the capability system, soils are grouped at three levels; the class, the subclass, and the unit. The classes, subclasses, and units in the Humacao Area are described in the list that follows. The capability unit for each soil is listed in the "Guide to Mapping Units" and at the end of the mapping unit description in the section "Descriptions of the Soils."

Class I. Soils that have few limitations that restrict their use.
- (No subclasses)
  - Unit I–1. Deep, nearly level, well-drained, strongly acid, medium-textured soils; on stream terraces and alluvial fans in the semiarid area.
  - Unit I–2. Deep, nearly level, moderately well drained, medium acid, moderately fine textured soils; on river flood plains in the humid area.
  - Unit I–3. Deep, nearly level, well-drained, neutral, fine textured and moderately fine textured soils; on stream terraces and alluvial fans in the semiarid area.

Class II. Soils that have moderate limitations that reduce the choice of plants or require moderate conservation practices.
- Subclass IIe. Soils subject to moderate erosion if they are not protected.
  - Unit IIe–1. Deep, gently sloping, well-drained, neutral and slightly acid, fine textured and moderately fine textured soils; on stream terraces and alluvial fans in the semiarid area.
  - Unit IIe–2. Deep, gently sloping, well-drained, strongly acid, medium-textured soils; on stream terraces in the humid area.
  - Unit IIe–3. Deep, gently sloping, well-drained, strongly acid, medium-textured soils; on stream terraces and alluvial fans in the semiarid area.
  - Unit IIe–4. Deep, gently sloping, well-drained, strongly acid, moderately fine textured soils; on coastal plains and terraces in the humid area.
- Subclass IIw. Soils that have moderate limitations because of excess water.
  - Unit IIw–1. Deep, nearly level to gently sloping, somewhat poorly drained, slightly acid, moderately fine textured and fine textured soils; on river flood plains, coastal plains, and alluvial fans in the humid area.
  - Unit IIw–2. Deep, gently sloping to strongly sloping, somewhat poorly drained, medium acid, fine-textured soils; on alluvial fans and terraces in the humid area.
  - Unit IIw–3. Deep, nearly level to gently sloping, somewhat poorly drained, very strongly acid, fine-textured soils, on alluvial fans, foot slopes, and terraces in the humid area.
  - Unit IIw–4. Deep, nearly level, poorly drained, neutral, fine textured and moderately fine textured soils; on river flood plains in the semiarid area.
  - Unit IIw–5. Deep, nearly level, somewhat poorly drained, slightly acid, moderately coarse textured soils that are underlain by sand; in the humid area.
- Subclass IIs. Soils that have moderate limitations because of tilth or low available water capacity.
  - Unit IIs–1. Deep, nearly level to gently sloping, moderately well drained and somewhat poorly drained, mildly alkaline to slightly acid, fine-textured soils that have expansive clays; on coastal plains, alluvial fans, and terraces in the semiarid area.
  - Unit IIs–2. Deep, gently sloping, moderately well drained, very strongly acid, fine-textured soils; on alluvial fans and terraces in the humid area.
  - Unit IIs–3. Deep, nearly level, well-drained, very strongly acid, medium-textured soils; on river flood plains in the humid area.
- Subclass IIc. Soils limited by lack of water.
  - Unit IIc–1. Deep, nearly level, well-drained, neutral, moderately fine textured soils; on

flood plains, alluvial fans, and terraces in the semiarid area.

Unit IIc–2. Deep, nearly level, well-drained, strongly acid, medium-textured soils; on stream terraces and alluvial fans in the semiarid area.

Class III. Soils that have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.

Unit IIIe–1. Deep, strongly sloping, well-drained, very strongly acid, fine-textured soils; on terraces and foot slopes in the humid area.

Unit IIIe–2. Deep, strongly sloping, somewhat poorly drained, strongly acid, moderately coarse textured soils; on foot slopes and side slopes in the humid area.

Unit IIIe–3. Moderately deep, gently sloping to strongly sloping, well-drained, strongly acid, moderately fine textured soils; on foot slopes in the humid area.

Unit IIIe–4. Moderately deep, gently sloping to strongly sloping, well-drained, strongly acid, moderately fine textured soils; on foot slopes in the semiarid area.

Unit IIIe–5. Moderately deep, strongly sloping, moderately well drained, strongly acid, moderately fine textured, gravelly soils; on foot slopes in the humid area.

Unit IIIe–6. Deep, gently sloping to strongly sloping, well-drained, very strongly acid, moderately fine textured soils; on hilltops and foot slopes in the humid area.

Unit IIIe–7. Deep, strongly sloping, moderately well drained to somewhat poorly drained, very strongly acid, and extremely acid, fine-textured soils; on foot slopes, alluvial fans, and terraces in the humid area.

Unit IIIe–8. Deep, strongly sloping, well-drained, strongly acid, moderately fine textured soils; on coastal plains and terraces in the humid area.

Unit IIIe–9. Deep, gently sloping to strongly sloping, well-drained, strongly acid, moderately fine textured soils that are underlain by gravelly clay loam; on terraces in the humid area.

Unit IIIe–10. Deep, gently sloping to strongly sloping, well-drained, very strongly acid, medium-textured soils that are underlain by coarser textured material; on stream terraces and alluvial fans in the humid area.

Subclass IIIw. Soils that have severe limitations because of excess water.

Unit IIIw–1. Deep, nearly level, poorly drained, slightly acid, fine-textured soils; on flood plains in the humid area.

Unit IIIw–2. Deep, gently sloping, somewhat poorly drained, extremely acid, medium-textured soils; on terraces and alluvial fans in the humid area.

Unit IIIw–3. Deep, nearly level, poorly drained, very strongly acid, moderately fine textured soils that are underlain by sand; on flood plains in the humid area.

Unit IIIw–4. Deep, nearly level, poorly drained, strongly acid, fine-textured soils; on flood plains in the humid area.

Subclass IIIs. Soils that have severe limitations because of poor workability, gravel, shallowness to rock, or low available water capacity.

Unit IIIs–1. Deep, gently sloping, well-drained, medium acid, moderately fine textured, gravelly soils; on foot slopes and alluvial fans in the semiarid area.

Unit IIIs–2. Deep, nearly level, well-drained, moderately fine textured, slightly acid, friable soils that are underlain by cobbles, gravel, and sand; on flood plains in the semiarid area.

Unit IIIs–3. Moderately deep, gently sloping, well-drained, medium acid, fine-textured soils; on foot slopes in the semiarid area.

Subclass IIIc. Soils severely limited by lack of water.

Unit IIIc–1. Deep, nearly level to gently sloping, moderately well drained to somewhat poorly drained, mildly alkaline to slightly acid, fine-textured soils that have expansive clays throughout; on coastal plains, terraces, and alluvial fans.

Unit IIIc–2. Deep, gently sloping, well-drained, moderately alkaline to slightly acid, fine textured and moderately fine textured soils; on alluvial fans and terraces.

Unit IIIc–3. Deep, gently sloping, well-drained, strongly acid, medium-textured soils; on stream terraces and alluvial fans.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe. Soils subject to very severe erosion if they are cultivated and not protected.

Unit IVe–1. Deep, strongly sloping, somewhat poorly drained, extremely acid, medium-textured soils; on alluvial fans and foot slopes in the humid area.

Unit IVe–2. Deep, moderately steep, somewhat poorly drained, strongly acid, moderately coarse textured soils; on foot slopes in the humid area.

Unit IVe–3. Deep, strongly sloping, well-drained, very strongly alkaline to slightly acid, moderately fine textured soils that are underlain by gravel or secondary lime; on alluvial fans, terraces, and foot slopes in the semiarid area.

Unit IVe–4. Moderately deep, strongly sloping, well-drained, medium acid, fine-textured soils; on foot slopes and low rolling hills in the semiarid area.

Unit IVe–5. Deep, moderately steep and steep, well drained and moderately well drained, very strongly acid and extremely acid, fine textured and moderately fine textured soils; on uplands in the humid area.

Unit IVe–6. Moderately deep, moderately

steep, well-drained, medium acid, moderately fine textured soils; on side slopes in the humid area.

Unit IVe–7. Deep, moderately steep, well-drained, strongly acid, moderately fine textured soils; on uplands in the humid area.

Unit IVe–8. Deep, strongly sloping, well-drained, medium acid, moderately fine textured, gravelly soils; on foot slopes in the semiarid area.

Unit IVe–9. Strongly sloping, well-drained, slightly acid, medium-textured soils that are shallow to sand and are underlain by hard rock at a depth of 32 to 50 inches; on semiarid uplands.

Unit IVe–10. Deep, moderately steep, somewhat poorly drained, very strongly acid, fine-textured soils; on foot slopes in the humid area.

Unit IVe–11. Deep, steep, well-drained, very strongly acid, medium-textured soils on humid uplands.

Subclass IVw. Soils that have very severe limitations because of excess water.

Unit IVw–1. Deep, nearly level, poorly drained, very strongly acid, fine-textured soils that are underlain by organic material at a depth of 15 to 30 inches; on coastal lowlands in the humid area.

Unit IVw–2. Deep, nearly level, poorly drained, mildly alkaline, fine-textured soils that are underlain by organic material at a depth of 12 to 22 inches; on coastal lowlands in the semiarid area.

Subclass IVs. Soils that have very severe limitations because of shallowness, gravel, poor tilth, low available water capacity, or permeability.

Unit IVs–1. Deep, nearly level, moderately alkaline, very friable, excessively drained, moderately coarse textured soils that are underlain by sand and gravel at a depth of 8 to 10 inches, and have a low available water capacity; on flood plains and alluvial fans in the semiarid area.

Unit IVs–2. Strongly sloping, well-drained, neutral, moderately fine textured soils that are shallow to hard rock; on side slopes in the semiarid area.

Unit IVs–3. Nearly level, excessively drained, medium acid, moderately coarse textured soils that are shallow to sand and gravel; on flood plains in the humid area.

Subclass IVc. Soils very severely limited by lack of water.

Unit IVc–1. Deep, nearly level, well-drained, moderately fine textured, slightly acid, friable soils that are underlain by cobbles, gravel, and sand at a depth of 12 to 20 inches; on flood plains in the semiarid area.

Unit IVc–2. Moderately deep, gently sloping to strongly sloping, strongly acid to neutral, well-drained, fine-textured and moderately fine textured soils; on foot slopes.

Unit IVc–3. Deep, gently sloping, well-drained, medium acid, moderately fine textured, gravelly soils; on foot slopes and alluvial fans in the semiarid area.

Class V. Soils that are subject to little or no erosion but that have other limitations, impractical to remove, that limit their use largely to pasture, woodland, or wildlife habitat.

Subclass Vs. Soils that have severe limitations because of excess stones.

Unit Vs–1. Nearly level, medium-textured, stony soils that contain about 70 percent, by volume, stones that range from 3 to 10 inches in diameter; on flood plains of streams and rivers.

Class VI. Soils that have severe limitations that make them generally unsuitable for cultivation and that limit their use largely to pasture, woodland, or wildlife food and cover.

Subclass VIe. Soils severely limited, chiefly by risk of erosion if a protective cover is not maintained.

Unit VIe–1. Moderately deep, steep, well-drained, strongly acid to extremely acid, fine textured and moderately fine textured soils; on humid uplands.

Unit VIe–2. Deep, steep and very steep, well drained and moderately well drained, moderately fine textured, very strongly acid soils; on uplands where rainfall is high.

Unit VIe–3. Deep, moderately steep to steep, well-drained, strongly acid, medium-textured to moderately fine textured soils; on humid uplands.

Unit VIe–4. Moderately deep, steep, well-drained, medium acid, moderately fine textured soils; on humid uplands.

Unit VIe–5. Moderately steep to steep, well-drained, medium-textured soils that are shallow to sand and are underlain by rock at a depth of 36 to 50 inches; on semiarid uplands.

Subclass VIs. Soils generally unsuitable for cultivation and limited for other uses by their low available water capacity or shallowness to gravel or hard rock.

Unit VIs–1. Deep, nearly level, excessively drained, moderately alkaline, coarse-textured soils that have a very low available water capacity; along the coast.

Unit VIs–2. Moderately steep, well-drained, slightly acid, moderately fine textured soils that are shallow to hard rock; on humid uplands.

Unit VIs–3. Deep, nearly level, excessively drained, very strongly acid, coarse-textured soils that have a low available water capacity; along the coast.

Subclass VIc. Soils severely limited by the lack of rainfall.

Unit VIc–1. Deep, nearly level, excessively drained, mildly alkaline, friable, moderately coarse textured soils that are underlain by gravel and sand at a depth of 8 to 10 inches and have a low available water capacity; on flood plains.

Class VII. Soils that have very severe limitations that make them unsuitable for cultivation and restrict their use largely to pasture, woodland, or wildlife food and cover.

Subclass VIIe. Soils very severely limited, chiefly by risk of erosion unless protective cover is maintained.

Unit VIIe–1. Deep and moderately deep, very steep, well drained and moderately well drained, extremely acid, moderately fine textured soils; on humid uplands.

Unit VIIe–2. Very steep, strongly acid, well-drained, medium-textured soils that are moderately deep to weathered rock; on humid uplands.

Unit VIIe–3. Shallow and deep, steep and very steep, poorly drained and moderately well drained, strongly acid to extremely acid, moderately fine textured soils; in rain forest. There are rocks in some mapping units.

Subclass VIIw. Soils that have very severe limitations because of excess water.

Unit VIIw–1. Deep, nearly level, slightly acid, poorly drained, fine-textured, saline soils; on coastal lowlands.

Subclass VIIs. Soils very severely limited by shallowness, stoniness, or a low available water capacity.

Unit VIIs–1. Moderately steep to very steep, well-drained, moderately coarse textured to moderately fine textured soils that are shallow and moderately deep to hard rock; on humid uplands. Stones on the surface are common.

Unit VIIs–2. Deep, very steep, well-drained, very strongly acid, fine-textured soils; on humid uplands. About 50 percent of the unit consists of areas covered with stones and boulders.

Unit VIIs–3. Deep and moderately deep, steep and very steep, well drained and moderately well drained, very strongly acid, moderately fine textured soils; in rain forest. A large percent of the unit consists of stony rock land.

Unit VIIs–4. Steep to very steep, well-drained, neutral, moderately fine textured soils that are shallow to rock; on semiarid uplands.

Unit VIIs–5. Shallow and moderately deep, very steep, well-drained, strongly acid to slightly acid, medium-textured soils; on humid uplands. Boulders cover 40 to 50 percent of the surface.

Unit VIIs–6. Steep, poorly drained, very strongly acid, moderately fine textured soils that are shallow to hard rock; on humid uplands.

Unit VIIs–7. Deep, nearly level to gently sloping, excessively drained, neutral soils that are sandy throughout and have a very low available water capacity; along the coast.

Class VIII. Soils and landforms that have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes.

Subclass VIIIw. Extremely wet soils or marshes.

Unit VIIIw–1. This unit consists of extremely wet areas on coastal lowlands that are periodically flooded by seawater. Texture of the soil material ranges widely and includes organic material. Only mangrove trees and other salt-tolerant vegetation grow in these areas. Cost of reclamation is high.

Unit VIIIw–2. This unit consists of low lagoonlike areas on the flood plains of the rivers and streams that drain the humid part of the survey area. The water table is at or near the surface most of the year. Texture of the soils ranges from loam to clay.

Subclass VIIIs. Very shallow, stony or sandy soils, rock, or soil material that has no potential for agriculture.

Unit VIIIs–1. This unit consists of narrow strips of light-colored beach sands along the coast. The sands are excessively drained, and saltwater is at variable depths.

Unit VIIIs–2. This unit consists of the high, jagged mountain peaks and long, very steep side slopes in the rain forest and in the mountains. Rock outcrops, loose stones, and boulders cover about 50 to 90 percent of the surface.

Estimated Yields

The estimated average yields per acre of principal crops grown in the Humacao Area are shown in table 2, and those of the principal grasses are shown in table 3. In columns A are yields expected under management common in the survey area, and in columns B are yields to be expected under improved management.

The yields are based on research data, on long-term records compiled at the sugarmills, and on information obtained from farmers and other agricultural workers.

The yields under management common in the area are the average of yields obtained during the period of the survey. They include those obtained by a few farmers practicing improved management, a few practicing poor management, and many practicing average management. Average yields mainly reflect common management practices.

Improved management includes the following practices:

1. Application of fertilizer according to the results of soil tests.
2. Adequate preparation of the seedbed, including leveling and smoothing, if feasible.
3. Drainage and control of water if needed.
4. Use of improved crop varieties.
5. Effective use of irrigation water.
6. Cultivation within the proper moisture content and to the proper depth.
7. Control of weeds, insects, and other pests and of plant diseases.
8. Harvesting crops at the proper time.
9. Management of crop residue so that the burn-

ing of sugarcane residue and other crop residue is avoided.

10. Protection from overgrazing.

Use of the Soils for Woodland[2]

When Puerto Rico was colonized in the early 1500's, the island was completely covered by forests, but land clearing for farms was soon begun. By 1880, most of the forests had been cut. Some areas were not suitable for permanent cultivation and were abandoned when their fertility was lost. Later some of these areas were again cleared, cultivated, and abandoned. Land thus abandoned generally was taken over by inferior volunteer trees.

At present, about 15 percent of the Humacao Area is covered by forest, both commercial and noncommercial. This includes the Caribbean National Forest. Nearly half of this total requires timber stand improvement or reforestation.

Forest is an excellent use of the soils in the Humacao Area for the protection of soil and water resources. Forest cover can minimize floods, reduce the amount of soil material lost as sediment in rivers, and hold runoff into periods of dry weather. In using the soils for forest in the Humacao Area, some natural noncommercial forests need to be converted to commercial, other noncommercial forests need to be protected and left in their natural state, and trees need to be planted in some nonforested areas.

The soils of the Humacao Area have been placed in woodland suitability groups to assist owners in planning the use of their soils for wood crops. Each group is made up of soils that are suited to the same kinds of trees, that need about the same management where the vegetation on them is similar, and that have the same potential production.

Each woodland group is identified by a three-part symbol, such as 1o1, 2w1, or 3w3. The potential productivity of the soils in the group is indicated by the first number in the symbol: 1 indicates very high potential productivity; 2, high; 3, moderately high; 4, moderate; and 5, low. These ratings are based on estimates of the productivity in board feet per acre per year of suitable tree species.

The second part of the woodland suitability group symbol is a lowercase letter. In this survey area, the letters *c*, *d*, *r*, and *o* are used. Except for the *o*, the letter indicates an important soil property that imposes a hazard or limitation in managing the soils of the group for trees. The letter *o* shows that the soils have few limitations that restrict their use for trees. The letter *c* means that the soils have limitations because of the kind or amount of clay in the upper part of the soil profile. The letter *d* stands for soils that have a restricted rooting depth. Soils that are shallow to hard rock or to layers in the soil that restrict roots are examples. The letter *r* shows that the main limitation is steep slopes and that there is a hazard of erosion and possibly limitations to the use of equipment. In this survey area, *r* is used if slopes are greater than 40 percent.

The last part of the symbol, another number, differentiates woodland suitability groups that have identical first and second parts in their identifying symbol. Soils in woodland suitability group 3w1, for example, require somewhat different management than soils in group 3w2.

In the Humacao Area, many thousands of acres of soils that can produce forest trees are not placed in woodland suitability groups, because they are prime areas for growing sugarcane and for other farm uses and they are not likely to be planted to forest.

Land types are not placed in woodland suitability groups, because they are not suitable for commercial forest. They are too rocky, too exposed to wind and sun, too steep, or infertile. Among these are Rock land, Rough stony land, Tidal swamp, Tidal flats, Cobbly alluvial land, Wet alluvial land, Coastal beaches, Leveled clayey land, and Salt water marsh. These areas are not suitable for planting trees, but the existing woodland cover should be protected.

Table 4 gives a brief description of the woodland suitability groups in the Humacao Area and lists suitable tree species and their potential productivity for each group. Also, each woodland suitability group is rated for various hazards and limitations that affect management. These ratings are *slight*, *moderate*, and *severe*, and they are explained in the following paragraphs.

Seedling mortality refers to the expected degree of mortality of naturally occurring or planted tree seedlings as influenced by kinds of soil or topographic conditions. Plant competition is assumed not to be a factor, and seed supplies are assumed to be adequate. A rating of *slight* indicates a loss of 0 to 25 percent of the seedlings; *moderate* indicates a loss of 25 to 50 percent; and *severe* indicates a loss of more than 50 percent.

Erosion hazard refers to the potential erodibility of the soil and the hazard it causes. A rating of *slight* means that no special techniques in management are required. *Moderate* means that some provision in management must be made to control accelerated erosion. Roads, skid trails, fire lanes, and landing construction require some special techniques. *Severe* means that special techniques in management and special attention to roads, skid trails, fire lanes, and landing construction and maintenance are necessary to minimize accelerated erosion.

Equipment limitations depend on soil characteristics that restrict or prohibit the use of harvesting equipment, either seasonally or continually. A rating of *slight* means that there are no restrictions in the kind of equipment or the time of year it is used. *Moderate* means that the use of equipment is restricted for 3 months of the year or less. *Severe* means that special equipment is needed and that its use is severely restricted for more than 3 months of the year.

Engineering Uses of the Soils[3]

This section is useful to planning commissions, town

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[2] By ROBERT W. NOBLES, project leader, Cooperative Forestry Institute of Tropical Forestry, Forest Service, U.S. Department of Agriculture.

[3] PEDRO CATONI, engineer, Soil Conservation Service, helped prepare this section.

TABLE 2.—*Estimated average yields per acre of*

[Yields in A columns are those expected under management common in the survey area, and those in B columns are expected under be grown under the

Soil	Sugarcane					
	Spring		18-month cut		Ratoons	
	A	B	A	B	A	B
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Aceitunas silty clay loam, 5 to 12 percent slopes	40	50	50	60	35	45
Aguadilla loamy sand [1 2]						
Aguadilla sandy loam, moderately wet						
Amelia gravelly clay loam, 2 to 5 percent slopes	35	45	40	60	30	40
Amelia gravelly clay loam, 5 to 12 percent slopes, eroded	30	40	35	50	25	35
Arenales sandy loam	25	35	35	45	20	30
Arenales sandy loam, gravelly substratum	20	30	25	40	20	25
Bajura silty clay, saline						
Bajura clay, frequently flooded	35	45	40	50	25	35
Caguabo clay loam, 12 to 20 percent slopes, eroded						
Caguabo clay loam, 20 to 60 percent slopes, eroded						
Candelero loam, 2 to 5 percent slopes	35	45	40	55	30	40
Candelero loam, 5 to 12 percent slopes, eroded	30	40	35	50	25	35
Cartagena clay	40	55	45	65	30	40
Catano loamy sand [1 2]						
Cayagua sandy loam, 5 to 12 percent slopes, eroded	30	45	35	50	25	40
Cayagua sandy loam, 12 to 20 percent slopes, eroded						
Coamo clay loam, 2 to 5 percent slopes	30	45	25	55	25	40
Coamo clay loam, 5 to 12 percent slopes	25	40	30	50	20	30
Coastal beaches						
Cobbly alluvial land						
Coloso silty clay loam, occasionally flooded	40	60	45	60	35	45
Coloso silty clay	40	50	45	60	35	45
Corcega sandy loam	35	40	40	45	25	30
Daguao silty clay loam, deep variant, 2 to 12 percent slopes	35	45	40	55	25	35
Daguao clay, 20 to 40 percent slopes, eroded						
Descalabrado clay loam, 5 to 12 percent slopes, eroded						
Descalabrado clay loam, 20 to 40 percent slopes, eroded						
Descalabrado and Guayama soils, 20 to 60 percent slopes, eroded						
Descalabrado-Rock land complex, 40 to 60 percent slopes						
Fajardo clay, 2 to 10 percent slopes	35	45	40	55	25	35
Fajardo clay, 2 to 10 percent slopes, eroded	30	40	35	50	20	30
Fortuna clay	40	55	45	65	25	35
Fraternidad clay, 0 to 2 percent slopes	50	65	55	80	40	55
Fraternidad clay, 2 to 5 percent slopes	50	65	55	80	40	55
Guamani silty clay loam	30	40	35	45	25	30
Guayabota silty clay loam, 20 to 40 percent slopes, eroded						
Guayabota-Ciales-Picacho association, very steep						
Guayama clay loam, moderately deep variant, 2 to 12 percent slopes, eroded						
Humacao loam, 2 to 5 percent slopes	35	50	50	60	25	40
Humatas clay, 20 to 40 percent slopes, eroded						
Humatas clay, 40 to 60 percent slopes, eroded						
Humatas-Stony land complex, 40 to 60 percent slopes						
Ingenio silty clay loam, 20 to 40 percent slopes, eroded						
Jacana clay, 2 to 5 percent slopes	35	40	40	55	25	35
Jacana clay, 5 to 12 percent slopes, eroded	30	35	35	50	20	30
Jagueyes loam, 20 to 40 percent slopes, eroded						
Junquitos gravelly clay loam, 5 to 12 percent slopes	35	45	40	50	30	35
Leveled clayey land						
Limones silty clay, 20 to 40 percent slopes, eroded						
Lirios clay loam, 3 to 10 percent slopes, eroded						
Lirios silty clay loam, 20 to 40 percent slopes, eroded						
Los Guineos silty clay loam, 12 to 20 percent slopes						
Los Guineos silty clay loam, 20 to 40 percent slopes, eroded						
Los Guineos silty clay loam, 40 to 60 percent slopes, eroded						
Los Guineos-Yunque-Stony rock land association, steep						
Mabi clay, 0 to 5 percent slopes	40	50	45	60	35	45
Mabi clay, 5 to 12 percent slopes, eroded	35	45	40	55	30	35
Mabi clay, 12 to 20 percent slopes, eroded	35	45	40	55	30	35
Machete loam, 0 to 2 percent slopes	40	55	60	80	35	45
Machete loam, 2 to 5 percent slopes	40	55	60	80	35	45
Made land						

See footnotes at end of table.

principal crops under two levels of management

improved management. Dashes indicate that the crop is not commonly grown on the soil, is not well suited to the soil, or cannot management specified]

Tanniers		Plantains		Bananas		Yams		Tobacco		Sweet potatoes	
A	B	A	B	A	B	A	B	A	B	A	B
Cwt	*Cwt*	*Thousands*	*Thousands*	*Cwt*	*Cwt*	*Cwt*	*Cwt*	*Cwt*	*Cwt*	*Cwt*	*Cwt*
80	100	20	30	45	55	80	125	12	15	40	50
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50	80	---	---	---	---	---	---	---	---	---	---
50	80	18	25	25	35	80	120	---	---	---	---
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55	90	20	30	18	25	80	120	10	20	---	---
80	140	18	30	20	35	140	200	10	20	60	80
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80	100	20	30	30	40	120	200	12	20	60	90
70	85	15	18	40	50	120	190	10	12	---	---
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TABLE 2.—*Estimated average yields per acre of principal*

Soil	Sugarcane					
	Spring		18-month cut		Ratoons	
	A	B	A	B	A	B
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Maunabo clay	35	45	45	60	30	40
Mayo loam, 3 to 10 percent slopes	30	40	40	50	25	35
Meros sand, 1 to 6 percent slopes [1]						
Mucara silty clay loam, 12 to 20 percent slopes, eroded	35	40	40	45	25	30
Mucara silty clay loam, 20 to 40 percent slopes, eroded						
Naranjito silty clay loam, 20 to 40 percent slopes, eroded						
Naranjito silty clay loam, 40 to 60 percent slopes, eroded						
Pandura loam, 12 to 40 percent slopes, eroded [2]						
Pandura loam, 40 to 60 percent slopes, eroded [2]						
Pandura-Very stony land complex, 40 to 60 percent slopes						
Parcelas clay, 5 to 12 percent slopes, eroded	35	45	40	55	30	40
Paso Seco clay, 0 to 5 percent slopes	50	70	60	80	40	50
Patillas clay loam, 12 to 20 percent slopes, eroded	35	40	40	50	25	30
Patillas clay loam, 20 to 40 percent slopes, eroded						
Pinones silty clay	30	40	40	50	25	30
Poncena clay	35	45	45	55	25	30
Pozo Blanco clay loam, 5 to 12 percent slopes, eroded	30	40	40	55	25	30
Reilly soils						
Reparada clay	30	40	40	50	25	30
Rio Arriba clay, 2 to 5 percent slopes	40	50	45	60	30	35
Rio Arriba clay, 5 to 12 percent slopes, eroded	35	45	40	55	25	30
Rock land						
Rough stony land						
Sabana silty clay loam, 20 to 40 percent slopes, eroded						
Sabana silty clay loam, 40 to 60 percent slopes, eroded						
Salt water marsh						
Talante soils	35	40	40	50	25	35
Teja gravelly sandy loam, 12 to 40 percent slopes						
Tidal flats						
Tidal swamp						
Toa silty clay loam	40	50	50	70	35	45
Utuado-Picacho-Stony rock land association, very steep						
Vayas silty clay loam, occasionally flooded	45	55	50	65	40	45
Vayas silty clay, frequently flooded	40	50	45	60	35	40
Vega Alta silty clay loam, 2 to 5 percent slopes	35	40	40	55	30	35
Vega Alta silty clay loam, 5 to 12 percent slopes	35	40	40	55	30	35
Vega Baja silty clay loam, 0 to 3 percent slopes	35	45	45	55	30	40
Via silty clay loam, 3 to 10 percent slopes	35	40	40	50	30	35
Vieques loam, 5 to 12 percent slopes	35	45	45	55	25	30
Vieques loam, 12 to 40 percent slopes, eroded						
Vives silty clay loam, high bottom	55	70	65	85	45	55
Vives clay, 0 to 2 percent slopes	45	60	60	80	35	45
Vives clay, 2 to 7 percent slopes	40	55	55	75	35	40
Vivi loam	35	45	50	60	30	40
Wet alluvial land						
Yunes silty clay loam, 20 to 60 percent slopes, eroded						

[1] This soil produces 8,000 coconuts under management common in the area and 10,000 coconuts under improved management.

and city managers, land developers, engineers, contractors, farmers, and others who need information about soils used as structural material or as foundation on which structures are built.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who–

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.

crops under two levels of management—Continued

Tanniers		Plantains		Bananas		Yams		Tobacco		Sweet potatoes	
A	B	A	B	A	B	A	B	A	B	A	B
Cwt	*Cwt*	*Thousands*	*Thousands*	*Cwt*	*Cwt*	*Cwt*	*Cwt*	*Cwt*	*Cwt*	*Cwt*	*Cwt*
70	90	16	20	40	50	90	110	14	18	60	80
										45	60
										50	70
										60	90
80	120	12	20	40	50	70	120	10	20		
								18	20	75	95

[2] This soil produces 30 hundred weights of cassava under management common in the area and 45 hundred weights under improved management.

3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the soils on which they are built, to help predict performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables. Table 5 shows estimated soil properties significant in engineering. Table 6 gives interpretations for various engineering uses. Table 7 shows the results of engineering laboratory tests on soil samples.

This information, along with the soil map and data

TABLE 3.—*Estimated average yields per acre of principal pasture grasses*

[Yields in A columns are those expected under management common in the survey area, and those in B columns are expected under improved management. Dashes indicate that the crop is not commonly grown on the soil, is not well suited to the soil, or cannot be grown under the management specified]

Soil	Stargrass and pangolagrass		Guineagrass		Paragrass		Merkergrass	
	A	B	A	B	A	B	A	B
	AUM [1]	*AUM* [1]	*AUM* [1]	*AUM* [1]	*AUM* [1]	*AUM* [1]	*AUM* [1]	*AUM* [1]
Aceitunas silty clay loam, 5 to 12 percent slopes	18	24	--	--	12	17	48	60
Aguadilla loamy sand	12	20	--	--	--	--	30	48
Aguadilla sandy loam, moderately wet	12	20	--	--	--	--	30	48
Amelia gravelly clay loam, 2 to 5 percent slopes	--	--	3	6	--	--	--	--
Amelia gravelly clay loam, 5 to 12 percent slopes, eroded	--	--	3	6	--	--	--	--
Arenales sandy loam	--	--	--	--	--	--	--	--
Arenales sandy loam, gravelly substratum	--	--	--	--	--	--	--	--
Bajura silty clay, saline	--	--	--	--	--	--	--	--
Bajura clay, frequently flooded	18	24	--	--	18	24	48	60
Caguabo clay loam, 12 to 20 percent slopes, eroded	8	12	--	--	--	--	--	--
Caguabo clay loam, 20 to 60 percent slopes, eroded	8	12	--	--	--	--	--	--
Candelero loam, 2 to 5 percent slopes	18	24	--	--	18	24	50	60
Candelero loam, 5 to 12 percent slopes, eroded	18	24	--	--	18	24	50	60
Cartagena clay	--	--	3	6	--	--	--	--
Catano loamy sand	12	20	--	--	--	--	30	48
Cayagua sandy loam, 5 to 12 percent slopes, eroded	18	24	--	--	--	--	50	60
Cayagua sandy loam, 12 to 20 percent slopes, eroded	18	24	--	--	--	--	50	60
Coamo clay loam, 2 to 5 percent slopes	--	--	--	--	--	--	--	--
Coamo clay loam, 5 to 12 percent slopes	--	--	--	--	--	--	--	--
Coastal beaches	--	--	--	--	--	--	--	--
Cobbly alluvial land	--	--	--	--	--	--	--	--
Coloso silty clay loam, occasionally flooded	18	24	--	--	18	24	48	60
Coloso silty clay	18	24	--	--	18	24	48	60
Corcega sandy loam	18	24	--	--	18	24	48	60
Daguao silty clay loam, deep variant, 2 to 12 percent slopes	18	24	--	--	--	--	40	60
Daguao clay, 20 to 40 percent slopes, eroded	15	21	--	--	--	--	30	45
Descalabrado clay loam, 5 to 12 percent slopes, eroded	--	--	3	4	--	--	--	--
Descalabrado clay loam, 20 to 40 percent slopes, eroded	--	--	3	4	--	--	--	--
Descalabrado and Guayama soils, 20 to 60 percent slopes, eroded	--	--	3	4	--	--	--	--
Descalabrado-Rock land complex, 40 to 60 percent slopes	--	--	3	4	--	--	--	--
Fajardo clay, 2 to 10 percent slopes	18	24	--	--	--	--	50	60
Fajardo clay, 2 to 10 percent slopes, eroded	18	24	--	--	--	--	50	60
Fortuna clay	18	24	--	--	18	24	48	60
Fraternidad clay, 0 to 2 percent slopes	--	--	3	6	--	--	--	--
Fraternidad clay, 2 to 5 percent slopes	--	--	3	6	--	--	--	--
Guamani silty clay loam	--	--	--	--	--	--	--	--
Guayabota silty clay loam, 20 to 40 percent slopes, eroded	14	20	--	--	--	--	30	48
Guayabota-Ciales-Picacho association, very steep	--	--	--	--	--	--	--	--
Guayama clay loam, moderately deep variant, 2 to 12 percent slopes, eroded	--	--	3	4	--	--	--	--
Humacao loam, 2 to 5 percent slopes	18	24	--	--	--	--	48	60
Humatas clay, 20 to 40 percent slopes, eroded	15	21	--	--	--	--	30	45
Humatas clay, 40 to 60 percent slopes, eroded	15	21	--	--	--	--	30	45
Humatas-Stony land complex, 40 to 60 percent slopes	--	--	--	--	--	--	--	--
Ingenio silty clay loam, 20 to 40 percent slopes, eroded	15	21	--	--	--	--	30	45
Jacana clay, 2 to 5 percent slopes	--	--	3	6	--	--	--	--
Jacana clay, 5 to 12 percent slopes, eroded	--	--	3	6	--	--	--	--
Jagueyes loam, 20 to 40 percent slopes, eroded	15	21	--	--	--	--	30	45
Junquitos gravelly clay loam, 5 to 12 percent slopes	18	24	--	--	--	--	48	60
Leveled clayey land	--	--	--	--	--	--	--	--
Limones silty clay, 20 to 40 percent slopes, eroded	15	21	--	--	--	--	--	--
Lirios clay loam, 3 to 10 percent slopes, eroded	18	24	--	--	--	--	40	60
Lirios silty clay loam, 20 to 40 percent slopes, eroded	15	21	--	--	--	--	30	45
Los Guineos silty clay loam, 12 to 20 percent slopes	14	20	--	--	--	--	30	48
Los Guineos silty clay loam, 20 to 40 percent slopes, eroded	14	20	--	--	--	--	30	48
Los Guineos silty clay loam, 40 to 60 percent slopes, eroded	14	20	--	--	--	--	30	48
Los Guineos-Yunque-Stony rock land association, steep	--	--	--	--	--	--	--	--
Mabi clay, 0 to 5 percent slopes	18	24	--	--	--	--	48	60
Mabi clay, 5 to 12 percent slopes, eroded	18	24	--	--	--	--	48	60
Mabi clay, 12 to 20 percent slopes, eroded	18	24	--	--	--	--	48	60

See footnotes at end of table.

TABLE 3.—*Estimated average yields per acre of principal pasture grasses*—Continued

Soil	Stargrass and pangolagrass		Guineagrass		Paragrass		Merkergrass	
	A	B	A	B	A	B	A	B
	AUM [1]	*AUM* [1]	*AUM* [1]	*AUM* [1]	*AUM* [1]	*AUM* [1]	*AUM* [1]	*AUM* [1]
Machete loam, 0 to 2 percent slopes								
Machete loam, 2 to 5 percent slopes								
Made land								
Maunabo clay	18	24			18	24	48	60
Mayo loam, 3 to 10 percent slopes	18	24					48	60
Meros sand, 1 to 6 percent slopes								
Mucara silty clay loam, 12 to 20 percent slopes, eroded	18	24					48	60
Mucara silty clay loam, 20 to 40 percent slopes, eroded	8	12						
Naranjito silty clay loam, 20 to 40 percent slopes, eroded	15	21					30	45
Naranjito silty clay loam, 40 to 60 percent slopes, eroded	15	21					30	45
Pandura loam, 12 to 40 percent slopes, eroded	7	11					24	40
Pandura loam, 40 to 60 percent slopes, eroded	7	11					24	40
Pandura-Very stony land complex, 40 to 60 percent slopes								
Parcelas clay, 5 to 12 percent slopes, eroded	18	24					50	60
Paso Seco clay, 0 to 5 percent slopes			3	6				
Patillas clay loam, 12 to 20 percent slopes, eroded	18	24					40	60
Patillas clay loam, 20 to 40 percent slopes, eroded	15	21					30	45
Pinones silty clay	18	24			18	24	48	60
Poncena clay			3	6				
Pozo Blanco clay loam, 5 to 12 percent slopes, eroded			3	6				
Reilly soils	18	22					48	60
Reparada clay								
Rio Arriba clay, 2 to 5 percent slopes	18	24			12	17	48	60
Rio Arriba clay, 5 to 12 percent slopes, eroded	18	24			12	17	48	60
Rock land								
Rough stony land								
Sabana silty clay loam, 20 to 40 percent slopes, eroded	8	12						
Sabana silty clay loam, 40 to 60 percent slopes, eroded	8	12						
Salt water marsh								
Talante soils	18	24			18	24	48	60
Teja gravelly sandy loam, 12 to 40 percent slopes	14	20					30	48
Tidal flats								
Tidal swamp								
Toa silty clay loam	18	24					48	60
Utuado-Picacho-Stony rock land association, very steep								
Vayas silty clay loam, occasionally flooded								
Vayas silty clay, frequently flooded								
Vega Alta silty clay loam, 2 to 5 percent slopes	18	24			12	17	48	60
Vega Alta silty clay loam, 5 to 12 percent slopes	18	24			12	17	48	56
Vega Baja silty clay loam, 0 to 3 percent slopes	18	24			18	24	48	60
Via silty clay loam, 3 to 10 percent slopes	18	24					48	60
Vieques loam, 5 to 12 percent slopes								
Vieques loam, 12 to 40 percent slopes, eroded								
Vives silty clay loam, high bottom	18	24					48	60
Vives clay, 0 to 2 percent slopes	18	24					48	60
Vives clay, 2 to 7 percent slopes	18	24					48	60
Vivi loam	18	24					48	60
Wet alluvial land								
Yunes silty clay loam, 20 to 60 percent slopes, eroded	14	20					30	48

[1] AUM is animal-unit-months, a term used to express the carrying capacity of pasture. It is the number of months during the year that 1 acre will provide grazing for 1 animal unit (one cow, one horse, one mule, five hogs, or seven sheep) without damage to the pasture.

in other parts of this publication, can be used to make interpretations in addition to those given in tables 5 and 6, and it also can be used to make useful maps.

This information, however, does not eliminate the need for further investigation at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths of more than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil can include small areas of other kinds of soil that have strongly contrasting properties and different suitability or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists. The Glossary defines many of the terms commonly used in soil science.

TABLE 4.—*Woodland management*

Woodland suitability group and map symbols	Potential productivity		Hazards and limitations that affect management		
	Suitable trees	Average yearly growth per acre	Seedling mortality	Erosion hazard	Equipment limitations
		Board feet			
Group 2c3. Moderately well drained, moderately fine textured, very strongly acid soils that are deep and have slopes of 12 to 40 percent; in a humid climate; at an elevation of more than 500 meters. LsD, LsE2.	Honduras pine Eucalyptus Kadam	1,400 2,000 1,800	Slight	Slight for LsD. Moderate for LsE2.	Moderate.
Group 2c5. Well drained and moderately well drained, fine textured and moderately fine textured, very strongly acid soils that are deep and moderately deep to tuffaceous and plutonic rocks and have slopes of 3 to 40 percent; in a humid climate; at an elevation of less than 500 meters. HtE2, LeE2, LoC2, LrE2, NaE2.	Honduras pine Teak Mahogany	1,100 on HtE2, LoC2, and LrE2. 1,200 on NaE2. 1,300 on LeE2. 250 on HtE2, LoC2, and LrE2. 300 on HtE2, LoC2, and LrE2.	Slight	Slight for LoC2. Moderate for HtE2, LeE2, LrE2, and NaE2.	Slight for LoC2. Moderate for HtE2, LeE2, LrE2, and NaE2.
Group 2r3. Moderately well drained, moderately fine textured, very strongly acid soils that are deep and have slopes of 40 to 60 percent; in a humid climate; at an elevation of more than 500 meters. LsF2.	Honduras pine Eucalyptus Kadam	1,300 2,000 1,800	Slight	Moderate	Severe.
Group 2o2. Well-drained, moderately fine textured, neutral to very strongly alkaline soils that are deep and have slopes of 5 to 12 percent; in a semiarid climate. PrC2.	Mahogany	500	Slight	Slight	Slight.
Group 2o5. Well-drained, medium-textured and moderately fine textured, strongly acid to very strongly acid soils that are deep and moderately deep to plutonic rock and have slopes of 12 to 40 percent; in a humid climate; at an elevation of less than 500 meters. InE2, JgE2, PaE2, PmD2, PmE2.	Honduras pine	1,100 on PaE2, PmD2, and PmE2. 1,200 on JgE2. 1,300 on InE2.	Slight	Slight for PmD2. Moderate for InE2, JgE2, PaE2, and PmE2.	Moderate.
Group 3d5. Well-drained, moderately fine textured and fine textured, neutral to strongly acid soils that are shallow and moderately deep to tuffaceous and plutonic rock and have slopes of 2 to 40 percent; some are underlain by coarse sand; in humid and semiarid climates; at an elevation of less than 500 meters. CbD2, DaC, DcE2, DeC2, DeE2, GyC2, JaB, JaC2, MuD2, MuE2, SaE2, VmC, VmE2.	Honduras pine Kadam Mahogany	800 on CbD2, and SaE2. 900 on DaC2, DcE2, MuD2, and MuE2. 1,400 on CbD2, MuD2, and MuE2. 300 on DeC2, DeE2, GyC2, VmC, and VmE2. 400 on JaB, JaC2, MuD2, and MuE2.	Slight for CbD2, DaC, DcE2, DeC2, DeE2, GyC2, JaB, JaC2, MuD2, MuE2, SaE2, and VmC. Moderate for VmE2.	Slight for CbD2, DaC, DeC2, GyC2, JaB, JaC2, MuD2, and VmC. Moderate for DcE2, DeE2, MuE2, SaE2, and VmE2.	Slight for DaC, DeC2, GyC2, JaB, JaC2, and VmC. Moderate for CbD2, DcE2, DeE2, MuD2, MuE2, SaE2, and VmE2.
Group 3r3. Well drained and moderately well drained, fine textured and moderately fine textured, very strongly acid soils that are deep to tuffaceous and plutonic rock and have slopes of 10 to 100 percent; some are underlain by sandy loam; in places there are rocks on the surface; in a humid climate; at an elevation of more than 500 meters. LyF, UpF.	Honduras pine	800	Severe	Severe	Severe.

TABLE 4.—*Woodland management*—Continued

Woodland suitability group and map symbols	Potential productivity		Hazards and limitations that affect management		
	Suitable trees	Average yearly growth per acre	Seedling mortality	Erosion hazard	Equipment limitations
		Board feet			
Group 3r5. Well-drained, medium-textured to fine-textured, slightly acid to very strongly acid soils that are deep and moderately deep to tuffaceous and plutonic rock and have slopes of 40 to 60 percent; some are underlain by sandy loam; others have rocks on the surface; in a humid climate; at an elevation of less than 500 meters. HtF2, HuF, NaF2, PaF2.	Honduras pine	800 on PaF2. 900 on HtF2, HuF, and NaF2.	Slight on HtF2, HuF, and NaF2. Moderate on PaF2.	Moderate on HtF2, HuF, and NaF2. Severe on PaF2.	Severe.
Group 4d3. Poorly drained and moderately well drained, fine textured and moderately fine textured, very strongly acid and extremely acid soils that are deep and shallow to hard siltstone and have slopes of 5 to more than 60 percent; some are underlain by loam; in tropical rain forest; at an elevation of more than 500 meters. GuE2, GvF.	Honduras pine	800	Moderate	Severe	Severe.
Group 4d5. Well-drained, medium-textured and moderately fine textured, neutral to very strongly acid soils that are shallow and moderately deep to tuffaceous and plutonic rock and have slopes of 12 to 60 percent; some are underlain by sandy loam; others have from 15 to 50 percent of the surface covered by rocks; in humid and semiarid climates; at an elevation of less than 500 meters. CbF2, DgF2, DrF, PdF, SaF2, TeE, YuF2.	Honduras pine Mahogany	600 on TeE. 700 on CbF2, PdF, SaF2, and YuF2. 700 on DgF2, and DrF.	Moderate on CbF2, SaF2, and YuF2. Severe on DgF2, DrF, PdF, and TeE.	Severe	Severe.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*7*) used by SCS engineers, the Department of Defense, and others and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO) (*1*).

In the Unified system, soils are classified according to particle-size distribution, plasticity, liquid limit, and organic matter. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes, for example, CL–ML.

The AASHTO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As additional refinement, the engineering value of a soil material can be indicated by group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHTO classification for tested soils, with group index numbers in parentheses, is shown in table 7; the estimated classification, without group index numbers, is given in table 5 for all the soils mapped in the survey area.

Soil properties significant in engineering

Several estimated soil properties significant in engineering are given in table 5. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Following are explanations of some of the column headings in table 5.

Depth to bedrock is distance from the surface of the soil to the rock layer.

Depth to seasonal high water table is distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in table 5 in the standard

TABLE 5.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The as indicated in the first column of this table. The symbol

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal high water table	Depth from surface	USDA texture	Classification: Unified	Classification: AASHTO
	Feet	*Feet*	*Inches*			
Aceitunas: AcC	>6	>6	0–60	Silty clay loam, clay, and silty clay.	MH	A–7
Aguadilla: Ad, Ag	>6	>6	0–8	Loamy sand	SM	A–2–4
			8–58	Sand	SP	A–3
Amelia: AmB, AmC2	>6	>6	0–46	Gravelly clay loam and gravelly clay.	GC	A–6
Arenales: An, Ar	>6	>6	0–8	Sandy loam	SM	A–2, A–4
			8–24	Loamy sand	SM	A–2
			24–42	Sand	SP or SM	A–1
			42–50	Gravel	GP	A–1
Bajura: Ba, Bc	>6	1½–2½	0–60	Clay	CH	A–7
Caguabo: CbD2, CbF2	1–1½	>6	0–17	Gravelly clay loam	CL	A–6
			17	Hard rock.		
Candelero: CdB, CdC2	>6	2½–5	0–7	Loam	SM or SC	A–4
			7–64	Sandy clay loam	SC	A–6
Cartagena: Ce	>6	2½–5	0–45	Clay and silty clay	CH	A–7
Catano: Cf	>6	>6	0–64	Sand	SP	A–1
Cayagua: CgC2, CgD2	>6	>6	0–4	Sandy loam	SM	A–2
			4–20	Clay	MH	A–7
			20–100	Sandy loam	SM–SC	A–2
Ciales. Mapped only in an association with Guayabota and Picacho soils.	>6	>6	0–7	Silty clay loam	MH	A–7
			7–26	Clay	MH	A–7
			26–60	Clay and silty clay loam.	MH	A–7
Coamo: ClB, ClC	>6	>6	0–15	Clay loam	CL–ML	A–6
			15–38	Clay	MH–CH	A–7
			38–48	Gravelly clay loam	CL	A–6
Coastal beaches: Cm	>6	Wave action	0–60	Sand	SP	A–1
Cobbly alluvial land: Cn. Properties are too variable to be estimated.						
Coloso: Co, Cr	>6	2–4	0–27	Silty clay loam	CL	A–7
			32–60	Clay	CH	A–7
Corcega: Cs	>6	1½–2½	8–14	Silty clay loam	CL	A–7
			14–32	Sandy clay loam	SC	A–2
			32–50	Sand	SP	A–1
Daguao, deep variant: DaC	2–3½	>6	0–35	Clay	MH, CH	A–7
			35–45	Saprolite.		
			45	Hard rock.		
Daguao: DcE2	2–3½	>6	0–21	Clay	MH, CH	A–7
			21–34	Saprolite.		
			34	Hard rock.		

See footnotes at end of table.

significant in engineering

soils in such mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series > means more than; the symbol < means less than]

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
						Inches per hour	*Inches per inch of soil*	*pH*			
100	100	90–100	75–95	70–80	20–30	0.6–2.0	0.10–0.15	4.5–5.0	Moderate	High	High.
100	100	50–75	15–30	[1] NP	[1] NP	6.0–20.0	0.03–0.05	4.5–5.5	Very low	Very low	High.
100	100	50–70	5–15	NP	NP	>20.0	<.03	4.5–6.0	Very low	Very low	High.
60–70	50–60	40–50	35–40	40–50	30–40	0.6–2.0	0.10–0.15	5.6–7.3	Moderate	Low	Moderate.
100	100	60–70	30–40	NP	NP	6.3–20.0	0.07–0.09	6.6–7.8	Very low	Very low	Low.
100	100	50–75	15–30	NP	NP	6.3–20.0	0.05–0.07	7.9–8.4	Very low	Very low	Low.
100	100	50–70	5–15	NP	NP	>20.0	0.03–0.05	7.4–8.4	Very low	Very low	Low.
25–50	25–50	13–35	2–5	NP	NP	>20.0	0.02–0.03	7.4–8.4	Very low	Very low	Low.
100	100	90–100	75–95	60–70	40–50	0.06–0.20	0.15–0.17	5.6–6.0	High	Very high	Moderate.
100	100	90–100	70–80	55–65	17–22	0.6–2.0	0.10–0.15	6.1–6.5	Moderate	Low	Low.
100	100	65–75	35–45	25–35	4–10	0.60–2.0	0.11–0.13	<4.5	Low	High	High.
100	100	80–90	35–50	25–35	15–25	0.06–0.20	0.13–0.15	4.5–5.5	Moderate	High	High.
100	100	90–100	75–95	50–70	40–45	0.06–0.20	0.15–0.18	6.6–8.4	Very high	Very high	Low.
100	100	50–70	5–15	NP	NP	>20.0	<.03	7.9–8.4	Very low	Very low	Low.
100	100	60–70	25–35	14–20	NP	2.0–6.0	0.03–0.05	4.5–5.5	Very low	Very high	Moderate.
100	100	90–100	75–95	70–80	30–40	0.06–0.20	0.15–0.20	4.5–5.5	Moderate	Very high	Moderate.
100	100	60–70	25–35	14–20	NP	6.0–20.0	0.05–0.10	4.5–5.5	Very low	Very high	Moderate.
100	100	95–100	85–95	70–80	27–32	0.6–2.0	0.10–0.12	4.5–5.0	Moderate	High	High.
100	100	90–100	75–95	80–90	35–45	0.06–0.2	0.09–0.11	4.5–5.0	Moderate.		
100	100	95–100	85–95	70–80	10–20	0.6–2.0	0.16–0.18	4.5–5.0	Moderate.		
100	100	90–100	70–80	30–50	10–20	0.6–2.0	0.10–0.15	5.1–5.5	Moderate	Moderate	Low.
100	100	90–100	75–95	60–75	28–35	0.6–2.0	0.10–0.15	7.4–8.4	High	Moderate	Low.
65–85	65–85	55–75	35–50	55–65	17–22	2.0–6.0	0.05–0.10	7.4–8.4	Low	Moderate	Low.
100	100	50–70	5–15	NP	NP	>20.0	<.03	6.6–8.4	Low	High	High.
100	100	45–100	85–95	40–50	25–35	0.06–0.20	0.15–0.20	6.1–6.5	Moderate	High	Moderate.
100	100	90–100	75–95	70–80	48–55	0.06–0.20	0.15–0.20	—	Moderate	High	Moderate.
100	90–100	85–95	75–85	40–50	25–35	0.6–2.0	0.12–0.14	5.6–6.5	Moderate	High	Moderate.
100	90–100	65–80	25–35	25–35	15–25	0.6–2.0	0.09–0.11	5.6–6.5	Low	High	Moderate.
100	100	50–70	5–15	NP	NP	6.0–20.0	0.03–0.05	5.6–6.5	Very low	High	Moderate.
100	100	90–100	75–95	50–60	25–30	0.2–0.6	0.10–0.15	4.5–5.5	High	Moderate	Moderate.
100	100	90–100	75–95	50–60	25–30	0.2–0.6	0.10–0.15	4.5–5.5	High	Moderate	Moderate.

TABLE 5.—*Estimated soil properties*

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal high water table	Depth from surface	USDA texture	Classification Unified	Classification AASHTO
	Feet	*Feet*	*Inches*			
*Descalabrado: DeC2, DeE2, DgF2, DrF. For the Guayama part of DgF2, see the Guayama series. Properties of the Rock land part are too variable to be estimated.	1–1½	>6	0–10	Clay loam	CL	A–6
			10–14	Silty clay	CH	A–7
			14–19	Saprolite.		
			19	Hardrock.		
Fajardo: FaC, FaC2	>6	>3½	0–60	Clay	CH	A–7
Fortuna: Fo	>6	2½–3	0–77	Clay	CH	A–7
Fraternidad: FrA, FrB	>6	>6	0–50	Clay	CH	A–7
Guamani: Gm [2]	>6	>6	0–20	Silty clay loam	CL–ML	A–6
			20–50	Sand and gravel	GP	A–1
*Guayabota: GuE2, GvF. For the Ciales and Picacho parts of GvF, see the Ciales and Picacho series.	1–1½	>6	0–18	Silty clay and silty clay loam.	MH	A–7
			18–20	Hard siltstone.		
Guayama. Mapped only in an undifferentiated group with Descalabrado soils.	1–1½	>6	0–5	Clay loam	CL	A–6
			5–18	Gravelly clay and gravelly clay loam.	GC	A–6
			18	Volcanic rock.		
Guayama, moderately deep variant: GyC2.	1½–2½	>6	0–8	Clay loam	CL–ML	A–6
			8–26	Clay	MH	A–7
			26	Hardrock.		
Humacao: HmB	>6	>6	0–18	Loam	ML	A–4
			18–55	Clay loam	CL–ML	A–6
Humatas: HtE2, HtF2, HuF. Properties of the Stony land part of HuF are too variable to be estimated.	>6	>6	0–60	Clay, silty clay and silty clay loam.	MH	A–7
Ingenio: InE2	>6	>6	0–40	Silty clay and clay	MH	A–7
			40–110	Saprolite silty clay loam and silt loam.	CL–ML	A–4, A–7
Jacana: JaB, JaC2	1½–3	>6	0–26	Clay	CH	A–7
			26	Bedrock.		
Jagueyes: JgE2	>6	>6	0–8	Loam	ML	A–4
			8–52	Clay loam	CL	A–6
			52–95	Loam	ML	A–6
Junquitos: JuC	1½–3	>6	0–7	Gravelly clay	GM	A–6
			7–35	Clay	GH	A–7
			35	Rock fragments.		
Leveled clayey land: Lc	>6	>6	0–60	Clay	MH	A–7
Limones: LeE2	>6	>6	0–72	Clay	MH	A–7
Lirios: LoC2, LrE2	>6	>6	0–23	Clay and silty clay	MH	A–7
			23–50	Silty clay loam	ML	A–7

See footnotes at end of table.

significant in engineering—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
						Inches per hour	*Inches per inch of soil*	*pH*			
100	100	90–100	70–80	30–50	10–20	0.6–2.0	0.10–0.15	6.1–7.3	Moderate	High	Low.
100	100	95–100	90–95	60–70	40–50	0.6–2.0	0.10–0.15	6.1–7.3	Moderate	High	Low.
100	100	90–100	75–95	60–105	60–70	0.06–0.20	0.15–0.20	5.1–6.0	High	Very high	Moderate.
100	100	90–100	75–95	70–80	42–50	0.06–0.20	0.15–0.20	4.5–5.5	High	Very high	Moderate.
100	100	90–100	75–95	50–90	30–60	0.06–0.20	0.15–0.18	6.1–7.8	Very high	Very high	Low.
100	100	95–100	85–95	40–45	15–20	0.6–2.0	0.12–0.14	6.1–7.9	Low	Low	Low.
----	----	----	----	NP	NP	>20.0	<.05	----	Very low	Low	Low.
100	100	95–100	85–95	70–80	27–32	0.06–0.20	0.15–0.20	4.5–5.5	Moderate	Very high	Moderate.
100	100	90–100	70–80	30–50	10–20	0.6–2.0	0.10–0.15	5.1–6.5	Moderate	Moderate	Low.
40–65	40–65	25–50	15–20	30–40	10–20	0.6–2.0	0.10–0.15	5.1–6.5	Moderate.		
100	100	90–100	70–80	30–50	10–20	0.6–2.0	0.10–0.15	5.1–6.5	Moderate	Moderate	Low.
100	100	90–100	75–95	50–60	25–30	0.6–2.0	0.10–0.15	5.1–6.5	Moderate	Moderate	Low.
100	100	80–95	60–75	28–35	4–8	0.6–2.0	0.10–0.12	5.1–6.0	Low	Moderate	Moderate.
100	100	90–100	70–80	25–35	10–20	0.6–2.0	0.12–0.14	5.6–6.5	Moderate	Moderate	Moderate.
100	100	90–100	70–100	40–60	10–24	0.6–2.0	0.11–0.18	4.5–5.0	Moderate	Moderate	Moderate.
100	100	90–100	75–95	50–60	20–24	0.6–2.0	0.10–0.15	4.5–5.5	Moderate	High	Moderate.
100	100	90–100	65–75	40–50	10–20	2.0–6.0	0.08–0.12	4.5–5.0	Low	High	Moderate.
100	100	75–85	70–95	70–75	40–50	0.2–0.6	0.12–0.16	5.6–7.3	High	High	Low.
100	100	85–95	60–70	35–50	6–14	2.0–6.0	0.08–0.12	4.5–5.5	Very low	Low	Moderate.
100	100	90–100	70–80	35–45	15–25	0.6–2.0	0.10–0.14	4.5–5.5	Low	Low	Moderate.
100	100	85–95	60–75	40–50	10–15	2.0–6.0	0.08–0.12	4.5–5.5	Very low	Low	Moderate.
65–75	65–75	55–65	35–45	30–40	5–10	0.6–2.0	0.10–0.15	4.5–5.0	Moderate	High	Moderate.
95–100	95–100	85–95	70–90	60–75	28–35	0.2–0.6	0.13–0.16	5.1–6.5	High	High	Moderate.
100	100	90–100	75–95	80–90	35–45	----	----	4.0–6.5	Moderate.		
100	100	90–100	75–95	80–90	36–44	0.6–2.0	0.15–0.17	4.5–5.5	Moderate	Moderate	Moderate.
100	100	80–90	65–95	55–60	20–29	0.6–2.0	0.10–0.15	4.5–5.5	Moderate	High	High.
100	100	85–90	80–85	40–50	12–20	2.0–6.0	0.08–0.10	4.5–5.0	Low	High	High.

TABLE 5.—*Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification	
	Bedrock	Seasonal high water table			Unified	AASHTO
	Feet	*Feet*	*Inches*			
*Los Guineos: LsD, LsE2, LsF2, LyF. For the Yunque part of LyF, see the Yunque series. Properties of the Stony rock land part of LyF are too variable to be estimated.	>6	>6	0–60	Clay	MH	A–7
Mabi: MaB, MaC2, MaD2	>6	>5	0–60	Clay	CH	A–7
Machete: McA, McB	>6	>6	0–20	Loam	ML	A–6
			20–32	Clay	MH	A–7
			32–45	Sandy clay loam	SC	A–6
			45–60	Loamy sand	SM	A–2
Made land: Md. Properties are too variable to be estimated.						
Maunabo: Me	>6	1½–3½	0–39	Clay and silty clay	CH	A–7
			39–48	Sandy loam	SM	A–2
Mayo: MlC	>6	>6	0–60	Sandy loam and loamy sand.	SM	A–2
Meros: MrB	>6	>6	0–60	Sand	SP	A–1
Mucara: MuD2, MuE2	2–3	>6	0–18	Silty clay loam, silty clay.	CH	A–7
			18–32	Saprolite.		
			32	Bedrock.		
Naranjito: NaE2, NaF2	2–3	>6	0–38	Silty clay loam, clay and clay loam.	MH	A–7
			38	Volcanic rock.		
Pandura: PaE2, PaF2, PdF. Properties of the Very stony land part of PdF are too variable to be estimated.	1–1½	>6	0–7	Loam	ML, SM	A–4
			7–19	Sandy loam	SM	A–2
			19–35	Weathered igneous rock (rippable).		
Parcelas: PeC2	>6	>6	0–60	Clay and clay loam	CH	A–7
Paso Seco: PlB	>6	>6	0–19	Clay	CH	A–7
			19–38	Gravelly clay	GC	A–2
			38–50	Gravelly loam	GM	A–1
Patillas: PmD2, PmE2	>6	>6	0–19	Clay loam	CL–ML	A–6
			19–48	Saprolite, sandy loam	SM	A–2
Picacho. Mapped only in associations with Guayabota and Ciales soils and with Utuado soils and Stony rock land.	>6	>6	0–9	Silty clay loam	MH	A–7
			9–35	Clay	MH	A–7
			35–72	Clay loam, silty clay loam.	MH	A–7
Pinones: Pn	>6	1–2½	0–18	Silty clay	CH	A–7
			18–58	Organic material.		
Poncena: Po	>6	2½–5	0–41	Clay	CH	A–7
Pozo Blanco: PrC2	>6	>6	0–15	Clay loam	CL	A–6
			15–58	Silty soft limestone	CL	A–4

See footnotes at end of table.

significant in engineering—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
						Inches per hour	*Inches per inch of soil*	*pH*			
100	100	95–100	75–100	50–70	11–20	0.6–2.0	0.15–0.20	4.5–5.5	Moderate	High	High.
100	100	85–95	85–90	55–75	45–60	0.06–0.20	0.15–0.20	5.1–6.5	Very high	Very high	Moderate.
100	100	85–100	60–80	20–40	4–6	2.0–6.0	0.08–0.12	4.5–5.5	Low	Low	Moderate.
100	100	90–100	75–95	80–90	36–44	0.6–2.0	0.10–0.14	4.5–5.5	Moderate	Low	Moderate.
100	100	80–90	35–50	25–35	15–25	2.0–6.0	0.08–0.12	4.5–5.5	Low	Low	Moderate.
100	100	50–75	15–30	NP	NP	6.0–20.0	0.03–0.05	4.5–5.5	Very low	Low	Moderate.
100	100	90–100	75–95	70–80	48–55	0.06–0.20	0.15–0.17	4.5–5.5	High	Very high	Moderate.
100	100	60–70	25–35	NP	NP	6.0–20.0	0.03–0.05	4.5–5.5	Very low	Very low	Moderate.
100	100	50–75	15–35	14–20	NP	6.0–20.0	0.05–0.08	4.5–5.5	Very low	Very low	High.
100	100	50–70	5–15	NP	NP	>20.0	<.03	6.6–8.4	Very low	Low	Low.
100	100	90–100	80–90	60–75	28–35	0.6–2.0	0.15–0.17	5.6–6.5	High	High	Low.
100	100	90–100	75–95	50–60	20–24	0.6–2.0	0.15–0.18	4.5–5.5	Moderate	Moderate	Moderate.
100	100	80–95	35–75	35–40	6–12	2.0–6.0	0.08–0.12	5.1–5.5	Low	Low	Moderate.
100	100	60–70	25–35	14–20	NP	6.0–20.0	0.05–0.08	5.6–6.5	Very low	Low	Moderate.
100	100	90–100	75–95	60–90	55–70	0.2–0.6	0.15–0.20	4.5–5.5	High	High	Moderate.
90–100	90–100	80–90	65–85	50–90	30–60	0.06–0.20	0.15–0.18	6.6–7.8	Very high	High	Low.
40–65	40–65	25–50	15–20	50–90	30–60	0.20–0.60	0.10–0.15	6.6–7.8	High	High	Low.
40–65	40–65	25–50	10–15	NP	NP	6.0–20.0	0.03–0.05	6.6–7.8	Low	High	Low.
100	100	90–100	70–80	30–50	10–20	0.6–2.0	0.10–0.14	4.5–5.5	Moderate	Moderate	Moderate.
100	100	60–70	25–35	NP	NP	6.0–20.0	0.05–0.08	4.5–5.5	Low	Moderate	Moderate.
100	100	95–100	85–95	70–80	27–32	0.6–2.0	0.10–0.12	4.5–5.0	Moderate	High	High.
100	100	90–100	75–95	80–90	35–45	0.2–0.6	0.09–0.11	4.5–5.0	Moderate.		
100	100	90–100	80–95	70–80	10–20	0.6–2.0	0.16–0.18	4.5–5.0	Moderate.		
100	100	95–100	90–95	60–90	50–60	<.06	0.15–0.20	4.5–5.0	High	Very high	High.
100	100	90–100	75–95	50–70	40–60	0.06–0.20	0.15–0.20	6.6–8.4	Very high	High	Low.
100	100	90–100	70–80	30–50	10–20	0.6–2.0	0.10–0.15	7.4–7.8	Moderate	High	Low.
85–100	85–100	85–100	75–90	30–40	10–20	2.0–6.3	0.10–0.13	7.9–8.4	Low.		

TABLE 5.—*Estimated soil properties*

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal high water table	Depth from surface	USDA texture	Classification Unified	Classification AASHTO
	Feet	*Feet*	*Inches*			
Reilly: Re	>6	2½–5	0–19	Sandy loam, loamy sand.	SM	A–2
			19–62	Sand and gravel	GP	A–1
Reparada: Rp	>6	1½–2½	0–18	Clay	CH	A–7
			18	Organic material.		
Rio Arriba: RrB, RrC2	>6	>5	0–56	Clay	CH	A–7
Rock land: Rs. Properties are too variable to be estimated.						
Rough stony land: Ru. Properties are too variable to be estimated.						
Sabana: SaE2, SaF2	1–1½	>6	0–18	Silty clay and clay	CH	A–7
			18	Hard rock.		
Salt water marsh: Sm. Properties are too variable to be estimated.						
Talante: Ta	>6	1½–2½	0–10	Clay loam, sandy clay loam.	CL–ML	A–6
			10–18	Loam	ML	A–4
			18–58	Loamy sand, sand	SM	A–1
Teja: TeE	1–1½	>6	0–14	Gravelly sandy loam	GM	A–2
			14	Hard rock.		
Tidal flats: Tf. Properties are too variable to be estimated.						
Tidal swamp: Ts. Properties are too variable to be estimated.						
Toa: Tt	>6	2½–5	0–60	Silty clay loam, clay loam.	CL	A–6
*Utuado: UpF	>6	>6	0–18	Clay loam	ML	A–6
For the Picacho part, see the Picacho series. Properties of the Stony rock land part are too variable to be estimated.			18–72	Sandy loam	SM	A–2, A–4
Vayas: Va, Vc	>6	2½–5	0–21	Silty clay	MH	A–7
			21–44	Silty clay loam	CL	A–7
Vega Alta: VeB, VeC	>6	>6	0–60	Clay, silty clay loam	MH	A–7
Vega Baja: VgA	>6	>5	0–12	Silty clay loam	CL	A–7
			12–48	Silty clay and clay	MH	A–7
Via: VIC	>6	>6	0–47	Silty clay loam, clay loam.	CL–ML	A–6
			47–62	Gravelly clay loam	CL	A–6
Vieques: VmC, VmE2	3–4	>6	0–15	Loam, sandy clay loam.	ML, SM	A–4
			15–38	Gravelly sand	GW	A–1
			38	Granitic rock.		

See footnotes at end of table.

significant in engineering—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
						Inches per hour	*Inches per inch of soil*	*pH*			
100	100	50–75	15–30	NP	NP	6.0–20.0	0.03–0.05	5.6–6.5	Very low	Low	Low.
100	100	90–100	75–95	60–90	50–60	<.06	0.15–0.20	6.6–8.4	High	Very high	Low.
100	100	90–100	75–95	60–90	55–70	0.2–0.6	0.15–0.20	5.6–7.9	High	High	Low.
100	100	90–100	75–95	70–80	50–60	0.6–2.0	0.10–0.15	4.5–5.5	High	High	Moderate.
100	100	80–100	65–80	35–45	10–20	0.6–2.0	0.12–0.14	4.5–5.5	Low	High	Moderate.
100	100	85–95	60–75	30–40	4–10	2.0–6.0	0.08–0.10	4.5–5.5	Very low	High	Moderate.
100	100	50–80	5–35	NP	NP	6.0–20.0	<.03–0.05	4.5–5.5	Very low	High	Moderate.
100	100	60–70	25–35	NP	NP	6.0–20.0	<.03	4.5–5.5	Very low	Low	High.
100	100	90–100	70–95	40–50	25–35	0.6–2.0	0.10–0.15	5.6–7.3	Moderate	Moderate	Low.
100	100	90–100	70–80	30–50	10–20	0.6–2.0	0.10–0.14	4.5–5.5	Low	Moderate	Moderate.
100	100	60–70	30–40	NP	NP	6.0–20.0	0.07–0.09	4.5–5.5	Low	Low	High.
100	100	95–100	90–95	70–80	20–32	0.06–0.6	0.10–0.15	6.6–7.8	Moderate	High	High.
100	100	95–100	85–95	40–50	25–35	0.06–0.6	0.10–0.15	7.4–8.4	Moderate	High	High.
100	100	90–100	75–95	70–80	20–30	0.6–2.0	0.10–0.15	4.5–5.5	Moderate	High	Moderate.
100	100	95–100	85–95	40–50	25–35	0.06–0.20	0.10–0.15	4.5–6.0	Moderate	High	Moderate.
100	100	90–100	75–95	70–80	20–32	0.06–0.20	0.10–0.15	4.5–6.0	Moderate	High	Moderate.
100	100	90–100	70–85	40–45	15–20	0.6–2.0	0.10–0.15	4.0–4.5	Moderate	Moderate	High.
100	100	90–100	70–80	25–35	10–20	2.0–6.0	0.08–0.20	6.1–6.5	Moderate	Moderate	High.
100	100	80–95	35–75	30–40	4–10	2.0–6.0	0.07–0.10	5.1–7.9	Low	Low	Moderate.
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TABLE 5.—*Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification	
	Bedrock	Seasonal high water table			Unified	AASHTO
	Feet	*Feet*	*Inches*			
Vives: Vs, VvA, VvB	>6	>6	0–9	Clay	CL	A–7
			9–50	Clay loam	CL–ML	A–6
Vivi: Vw	>6	>5	0–30	Loam	ML	A–4
			30–60	Sand, sandy loam	SM	A–2
Wet alluvial land: Wa. Properties are too variable to be estimated.						
Yunes: YuF2	1–1½	>6	0–16	Gravelly silty clay loam.	GC	A–6
			16	Mudstone.		

[1] NP means nonplastic.

terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used are defined in the Glossary of this soil survey.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from semisolid to plastic. If the moisture content is further increased, the material changes from plastic to liquid. The plastic limit is the moisture content at which the soil material changes from semisolid to plastic; and the liquid limit, from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 5, but in table 7 the data on liquid limit and plasticity index are based on tests of soil samples.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 5 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinkage and swelling of soils cause much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Corrosivity, as used in table 5, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. Rate of corrosion of uncoated steel is related to soil properties such as drainage, texture, total acidity, and electrical conductivity of the soil material. Ratings of soils for corrosivity for concrete are based mainly on soil texture and acidity. Installations that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. A corrosivity rating of *low* means that there is a low probability of soil-induced corrosion damage. A rating of *high* means that there is a high probability of damage, so that protective measures for steel and more resistant concrete should be used to avoid or minimize damage.

Engineering interpretations of the soils

The estimated interpretations in table 6 are based on the engineering properties of soils shown in table 5, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of the Humacao Area. In table 6, ratings are used to summarize limitation or suitability of the soils for all listed purposes other than for pond reservoir areas, embankments, drainage for

significant in engineering—Continued

Percentage less than 3 inches passing sieve— No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity: Uncoated steel	Corrosivity: Concrete
						Inches per hour	*Inches per inch of soil*	*pH*			
100	100	90–100	75–95	40–45	22–28	0.6–2.0	0.12–0.16	5.1–7.3	Moderate	Moderate	Low.
100	100	90–100	70–80	30–40	10–20	0.6–2.0	0.10–0.15	6.6–7.9	Moderate	Moderate	Low.
100	100	80–95	60–75	25–35	4–7	2.0–6.0	0.07–0.10	4.5–5.5	Low	Low	High.
100	100	50–70	5–35	NP	NP	>20.0	<.03	4.5–5.5	Very low	Low	High.
60–80	55–75	50–70	35–50	25–35	10–20	0.6–2.0	0.07–0.10	4.5–5.5	Low	Moderate	Moderate.

[3] Coarse fraction greater than 3 inches is 5 to 15 percent.

crops and pasture, irrigation, and terraces and diversions. For these particular uses, table 6 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings slight, moderate, and severe. *Slight* means that soil properties generally are favorable for the rated use or, in other words, limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means that soil properties are so unfavorable and so difficult to correct or overcome that major soil reclamation, special design, or intensive maintenance are required.

Soil suitability is rated by the terms *good, fair,* and *poor,* which have meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of some of the columns in table 6.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage, within a depth of 2 to 5 feet, long enough for bacteria to decompose the solids. A lagoon has a nearly level floor; its sides, or embankments, are of compacted soil material. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties that affect the pond floor are permeability, organic matter, and slope, and, if the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified Soil Classification and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Dwellings, as rated in table 6, are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load, and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated the ratings in table 6 apply only to a depth of about 6 feet, so a limitation of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 to 15 feet; nevertheless, every site should be investigated before it is selected.

Local roads and streets, as rated in table 6, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions

TABLE 6.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The
as indicated in the first

Soil series and map symbols	Degree and kind of limitations for—					Suitability as a source of—
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill [1] (Trench type)	Local roads and streets	Road fill
Aceitunas: AcC	Slight where slope is 2 to 8 percent. Moderate where slope is 8 to 12 percent.	Moderate where slope is 2 to 7 percent; moderate permeability. Severe where slope is more than 7 percent.	Moderate: moderate shrink-swell potential.	Severe: clay texture.	Moderate: moderate shrink-swell potential.	Fair: fair traffic-supporting capacity.
Aguadilla: Ad, Ag	Slight [2]	Severe: very rapid permeability.	Slight	Severe: very rapid permeability.	Slight	Good
Amelia: AmB, AmC2	Slight where slope is 2 to 8 percent. Moderate where slope is 8 to 12 percent.	Moderate: moderate permeability.	Slight where slope is 2 to 8 percent. Moderate where slope is 8 to 12 percent.	Slight	Slight where slope is 2 to 8 percent. Moderate where slope is 8 to 12 percent.	Good
Arenales: An, Ar	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding; rapid permeability.	Moderate: subject to flooding.	Good
Bajura: Ba, Bc	Severe: subject to flooding; depth to water table is 1½ to 2½ feet.	Severe: depth to water table is 1½ to 2½ feet; subject to flooding.	Severe: high shrink-swell potential; subject to flooding.	Severe: subject to flooding; clay texture; poorly drained.	Severe: high shrink-swell potential; poorly drained; subject to flooding.	Poor: high shrink-swell potential; poorly drained.
Caguabo: CbD2, CbF2.	Severe: depth to hard rock is 1 to 1½ feet.	Severe: depth to hard rock is 1 to 1½ feet; slope.	Severe: depth to hard rock is 1 to 1½ feet; slope.	Severe: depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Poor: limited thickness of material.
Candelero: CdB, CdC2	Moderate: moderate permeability.	Moderate: moderate permeability.	Moderate: moderate shrink-swell potential.	Moderate: somewhat poorly drained.	Moderate: moderate shrink-swell potential; somewhat poorly drained.	Fair: fair traffic-supporting capacity; somewhat poorly drained.
Cartagena: Ce	Severe: slow permeability.	Slight	Severe: very high shrink-swell potential.	Severe: clay texture; plastic.	Severe: very high shrink-swell potential.	Poor: poor traffic-supporting capacity; very high shrink-swell potential.
Catano: Cf	Slight [2]	Severe: very rapid permeability.	Slight	Severe: very rapid permeability.	Slight	Good
Cayagua: CgC2, CgD2.	Severe: slow permeability.	Severe: rapid permeability in substratum.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Poor to a depth of 20 inches. Good below a depth of 20 inches.

See footnotes at end of table.

engineering properties of the soils

soils in such mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series column of this table]

Suitability as a source of—Continued		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuited	Fair: silty clay loam surface layer; plastic.	Moderate permeability.	Medium compressibility; fair compaction characteristics.	Well drained	No unfavorable features.	No unfavorable features.
Good	Poor: sand throughout.	Very rapid permeability.	Poor slope stability; very rapid permeability.	Excessively drained.	Low available water capacity.	Poor soil stability.
Unsuited	Poor: gravelly	Moderate permeability.	No unfavorable features.	Well drained	No unfavorable features.	Gravelly soil; construction difficult.
Fair for sand. Good for gravel below a depth of 3 feet.	Fair: limited thickness of material.	Rapid permeability.	Rapid permeability; poor slope stability.	Excessively drained.	Low available water capacity.	Poor soil stability.
Unsuited	Poor: poorly drained; clay texture.	Seasonal high water table is at depth of 1½ to 2½ feet.	High compressibility; poor slope stability.	Slow permeability.	Need for drainage; high water table.	Dense clay subsoil.
Unsuited	Poor: limited thickness of material; coarse fragments.	Depth to hard rock is 1 to 1½ feet; seepage.	Limited thickness of material.	Well drained	Slope	Depth to hard rock is 1 to 1½ feet.
Unsuited	Good	Moderate permeability.	No unfavorable features.	Slow permeability.	Area of heavy rainfall.	Limited depth to unfavorable material.
Unsuited	Poor: high clay content.	Seasonal high water table.	High compressibility; poor slope stability.	Slow permeability.	Very slow intake rate.	Dense clay subsoil.
Good for sand	Poor: sand texture throughout.	Very rapid permeability.	Very rapid permeability; poor slope stability; low resistance to piping.	Excessively drained.	Low available water capacity.	Poor soil stability.
Unsuited	Poor: clay texture.	Rapid permeability in substratum.	Fair slope stability; slow permeability.	Slow permeability.	Area of heavy rainfall.	No unfavorable features.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for—					Suitability as a source of—
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill [1] (Trench type)	Local roads and streets	Road fill
Ciales. Mapped only in an association with Guayabota and Picacho soils.	Severe: slope; slow permeability.	Severe: slope.	Severe: slope; poorly drained.	Severe: poorly drained.	Severe: slope; poorly drained.	Poor: poorly drained.
Coamo: ClB, ClC	Slight	Severe: moderately rapid permeability in substratum.	Severe: high shrink-swell potential.	Severe: moderately rapid permeability in substratum.	Moderate: fair traffic-supporting capacity; high shrink-swell potential.	Fair: clay loam and clay texture; high shrink-swell potential.
Coastal beaches: Cm	Severe: water table at or near surface.	Severe: water table at or near surface; subject to flooding.	Severe: water table at or near surface; subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Good
Cobbly alluvial land: Cn.	Severe: cobbles; subject to flooding.	Severe: subject to flooding.	Severe: cobbles; subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Fair: cobbles.
Coloso: Co, Cr	Severe: subject to flooding; depth to water table is 2 to 4 feet.	Severe: subject to flooding.	Severe: subject to flooding; somewhat poorly drained.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: somewhat poorly drained; fair traffic-supporting capacity.
Corcega: Cs	Severe: subject to flooding; depth to water table is 1½ to 2½ feet.	Severe: subject to flooding; rapid permeability below a depth of 32 inches.	Severe: subject to flooding.	Severe: subject to flooding.	Moderate: subject to flooding.	Fair: somewhat poorly drained; water table at a depth of 1½ to 2½ feet.
Daguao, deep variant: DaC.	Severe: slope; depth to hard rock is 2 to 3½ feet.	Severe: slope; depth to hard rock is 2 to 3½ feet.	Severe: slope.	Severe: depth to hard rock is 2 to 3½ feet.	Severe: slope.	Poor: slope.
Daguao: DcE2	Severe: depth to hard rock is 3½ feet.	Severe: slope; depth to hard rock is 3½ feet.	Moderate: slope.	Severe: depth to hard rock is 2 to 3½ feet.	Severe: slope.	Poor: slope.
*Descalabrado: DeC2, DeE2, DgF2, DrF. For Guayama part of DgF2, see Guayama series. For Rock land part of DrF, see Rock land.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Poor: limited thickness of material.
Fajardo: FaC, FaC2	Severe: slow permeability.	Severe: depth to water table is more than 3½ feet.	Severe: high shrink-swell potential.	Severe: clay texture; plastic.	Severe: high shrink-swell potential; poor traffic-supporting capacity.	Poor: high shrink-swell potential; poor traffic-supporting capacity.

See footnotes at end of table.

properties of the soils—Continued

Suitability as a source of—Continued		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuited	Poor: slope; silty clay, loam, and clay texture; poorly drained.	Slope	High compressibility; poor compaction characteristics.	Slow permeability.	Area of heavy rainfall.	Slope.
Unsuited	Fair: clay loam surface layer.	Moderately rapid permeability in substratum.	Medium compressibility; fair slope stability; medium resistance to piping.	Well drained	No unfavorable features.	Dense clay subsoil.
Good	Poor: soluble salts.	Rapid permeability.	Rapid permeability; low compressibility.	Excessively drained.	Permanent salinity.	Sand texture; very rapid permeability.
Unsuited	Poor: coarse fragments.	Coarse fragments; seepage.	Seepage; many cobbles.	Well drained	Many cobbles	Cobbles; hazard of slipping.
Unsuited	Fair: silty clay loam texture.	Seasonal high water table.	High compressibility; poor slope stability.	Slow permeability.	Need for drainage; high water table.	Dense clay subsoil.
Unsuited to a depth of 32 inches. Fair below a depth of 32 inches.	Fair: silty clay loam and sandy clay loam texture.	Rapid permeability below a depth of 32 inches; depth to seasonal high water table is 1½ to 2½ feet.	Poor slope stability; rapid permeability below a depth of 32 inches.	Need for drainage; high water table.	High water table; need for drianage.	Sandy substratum.
Unsuited	Poor: clay texture; slope.	No unfavorable features.	Limited thickness of borrow material; medium compressibility.	Well drained	Area of heavy rainfall.	Depth to hard rock is 2 to 3½ feet.
Unsuited	Poor: clay texture; slope.	No unfavorable features.	Limited thickness of borrow material; medium compressibility.	Well drained	Area of heavy rainfall.	Depth to hard rock is 3½ feet.
Unsuited	Poor: limited thickness of material; coarse fragments.	Depth to hard rock is 1 to 1½ feet.	Limited thickness of material.	Well drained	Slope	Depth to hard rock is 1 to 1½ feet.
Unsuited	Poor: clay texture.	Seasonal high water table.	High compressibility; poor slope stability.	Slow permeability.	High water table; need for drainage.	Dense clay subsoil.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for—					Suitability as a source of—
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill [1] (Trench type)	Local roads and streets	Road fill
Fortuna: Fo	Severe: subject to flooding; depth to water table is 2½ to 3 feet.	Severe: subject to flooding; depth to water table is 2½ to 3 feet.	Severe: subject to flooding; high shrink-swell potential; poorly drained.	Severe: subject to flooding; poorly drained; clay texture.	Severe: subject to flooding; high shrink-swell potential; poorly drained.	Poor: high shrink-swell potential; poorly drained.
Fraternidad: FrA, FrB	Severe: slow permeability.	Slight where slope is 0 to 2 percent. Moderate where slope is 2 to 5 percent.	Severe: very high shrink-swell potential.	Severe: clay texture.	Severe: very high shrink-swell potential.	Poor: very high shrink-swell potential; poor traffic-supporting capacity.
Guamani: Gm	Severe: subject to flooding.	Severe: very rapid permeability.	Severe: subject to flooding.	Severe: subject to flooding.	Moderate: subject to flooding.	Good
*Guayabota: GuE2, GvF. For Ciales and Picacho parts of GvF, see Ciales and Picacho series.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; poorly drained; depth to hard rock is 1 to 1½ feet.	Severe: depth to hard rock is 1 to 1½ feet.	Severe: depth to hard rock is 1 to 1½ feet; slope; poorly drained.	Poor: poorly drained; limited thickness of material; slope.
Guayama. Mapped only in an undifferentiated group with Descalabrado soils.	Severe: slope; depth to bedrock is 1 to 1½ feet.	Severe: slope; depth to bedrock is 1 to 1½ feet.	Severe: slope; depth to bedrock is 1 to 1½ feet.	Severe: slope; depth to bedrock is 1 to 1½ feet.	Severe: slope; depth to bedrock is 1 to 1½ feet.	Poor: slope; depth to bedrock is 1 to 1½ feet.
Guayama, moderately deep variant: GyC2.	Severe: slope; depth to hard rock is 1½ to 2½ feet.	Severe: slope; depth to hard rock is 1½ to 2½ feet.	Severe: slope; depth to hard rock is 1½ to 2½ feet.	Severe: slope; depth to hard rock is 1½ to 2½ feet.	Severe: slope; depth to hard rock is 1½ to 2½ feet.	Poor: limited thickness of material.
Humacao: HmB	Moderate: moderate permeability.	Moderate: moderate permeability.	Slight	Slight	Slight	Fair: moderate shrink-swell potential; fair traffic-supporting capacity.
Humatas: HtE2, HtF2, HuF. Stony land part of HuF is too variable for interpretations to be made.	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Poor: poor traffic-supporting capacity.
Ingenio: InE2	Severe: slope	Severe: slope; moderately rapid permeability.	Severe: slope	Severe: moderately rapid permeability.	Severe: slope	Fair where slope is less than 25 percent. Poor where slope is more than 25 percent.

See footnotes at end of table.

properties of the soils—Continued

Suitability as a source of—Continued		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuited	Poor: clay texture; poorly drained.	Seasonal high water table.	High compressibility; poor slope stability.	Slow permeability.	High water table; need for drainage.	Dense clay subsoil.
Unsuited	Poor: clay texture.	No unfavorable features.	High compressibility; poor slope stability.	Slow permeability.	Very slow intake rate.	Dense clay subsoil.
Unsuited for sand. Fair for gravel below a depth of 20 inches.	Fair: silty clay loam texture.	Very rapid permeability.	Very rapid permeability.	Well drained	Low available water capacity; very rapid permeability.	Sandy and gravelly substratum.
Unsuited	Poor: slope; poorly drained.	Depth to hard rock is 1 to 1½ feet.	Limited thickness of material.	Slow permeability.	Area of heavy rainfall.	Slope.
Unsuited	Poor: slope	Slope	Shallowness to bedrock.	Well drained	Slope	Slope.
Unsuited	Poor: slope; coarse fragments.	Depth to hard rock is 1½ to 2½ feet.	Limited thickness of borrow material.	Well drained	Slope	Depth to hard rock is 1½ to 2½ feet.
Unsuited	Good	Moderate permeability.	Fair slope stability; moderate permeability.	Well drained	Area of heavy rainfall.	No unfavorable features.
Unsuited	Poor: clay texture.	Moderate permeability.	Moderate permeability; medium compressibility; fair slope stability.	Well drained	Area of heavy rainfall.	Slope.
Unsuited	Poor: slope	Moderately rapid permeability.	Fair slope stability; moderately rapid permeability.	Well drained	Area of heavy rainfall.	Slope.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for—					Suitability as a source of—
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill [1] (Trench type)	Local roads and streets	Road fill
Jacana: JaB, JaC2	Severe: depth to bedrock is 1½ to 3 feet.	Severe: depth to bedrock is 1½ to 3 feet.	Severe: high shrink-swell potential.	Severe: depth to bedrock is 1½ to 3 feet.	Severe: high shrink-swell potential; poor traffic-supporting capacity.	Poor: poor traffic-supporting capacity; high shrink-swell potential.
Jagueyes: JgE2	Severe: slope	Severe: slope	Severe: slope	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.	Severe: slope	Fair where slope is less than 25 percent. Poor where slope is more than 25 percent.
Junquitos: JuC	Severe: moderately slow permeability.	Moderate where slope is 2 to 7 percent. Severe where slope is more than 7 percent.	Severe: high shrink-swell potential.	Severe: depth to bedrock is 1½ to 3 feet.	Severe: high shrink-swell potential; poor traffic-supporting capacity.	Poor: high shrink-swell potential.
Leveled clayey land: Lc.	Moderate: moderate permeability.	Moderate: moderate permeability.	Moderate: clay texture.	Moderate: clay texture; moderate permeability.	Moderate: clay texture.	Fair: clay texture.
Limones: LeE2	Severe: slope	Severe: slope	Severe: slope	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.	Severe: slope	Fair where slope is less than 25 percent; fair traffic-supporting capacity; moderate shrink-swell potential. Poor where slope is more than 25 percent.
Lirios: LoC2, LrE2	Slight where slope is less than 8 percent. Moderate where slope is 8 to 15 percent. Severe where slope is more than 15 percent.	Moderate where slope is 2 to 7 percent. Severe where slope is more than 7 percent.	Slight where slope is 3 to 8 percent. Moderate where slope is 8 to 15 percent. Severe where slope is more than 15 percent.	Slight where slope is 3 to 15 percent. Moderate where slope is 15 to 25 percent. Severe where slope is more than 25 percent.	Slight where slope is 3 to 8 percent. Moderate where slope is 8 to 15 percent. Severe where slope is more than 15 percent.	Fair where slope is less than 25 percent: fair traffic-supporting capacity. Poor where slope is more than 25 percent.
*Los Guineos: LsD, LsE2, LsF2, LyF. For Yunque part of LyF, see Yunque series. Stony rock land part of LyF is too variable for interpretations to be made.	Severe: slope	Severe: slope	Severe: slope	Severe: clay texture.	Severe: slope	Poor: poor traffic-supporting capacity; moderate shrink-swell potential.

See footnotes at end of table.

properties of the soils—Continued

Suitability as a source of—Continued		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuited	Poor: clay texture.	Depth to bedrock is 1½ to 3 feet.	High compressibility; limited thickness of material.	Well drained	Very low intake rate; slope.	Dense clay subsoil.
Unsuited	Fair: loam, clay loam and sandy clay loam texture.	Moderate permeability.	Medium compressibility; moderate permeability; fair slope stability.	Moderately well drained.	Area of heavy rainfall.	Slope.
Unsuited	Poor: clay texture.	Depth to bedrock is 1½ to 3 feet.	High compressibility; limited thickness of material.	Moderately slow permeability.	Area of heavy rainfall.	Dense clay subsoil.
Unsuited	Poor: clay texture.	No unfavorable features.	No unfavorable features.	Well drained	No unfavorable features.	No unfavorable features.
Unsuited	Poor: slope	Moderate permeability.	Medium compressibility; fair slope stability.	Moderate permeability.	Area of heavy rainfall.	Slope.
Unsuited	Fair where slope is less than 15 percent. Severe where slope is more than 15 percent.	Moderate permeability.	Medium compressibility; fair slope stability.	Well drained	Area of heavy rainfall.	Dense clay subsoil.
Unsuited	Poor: plastic clay.	Moderate permeability.	Medium compressibility; fair slope stability.	Moderate permeability.	Area of heavy rainfall.	Slope; dense clay subsoil.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for—					Suitability as a source of—
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill [1] (Trench type)	Local roads and streets	Road fill
Mabi: MaB, MaC2, MaD2.	Severe: slow permeability.	Severe: subject to flooding.	Severe: very high shrink-swell potential; subject to flooding; somewhat poorly drained.	Severe: clay texture throughout.	Severe: very high shrink-swell potential.	Poor: very high shrink-swell potential.
Machete: McA, McB	Slight	Severe: moderately rapid permeability.	Slight	Slight	Slight	Good
Made land: Md. Too variable for interpretations to be made.						
Maunabo: Me	Severe: subject to flooding; depth to water table is 1½ to 3½ feet.	Severe: subject to flooding; depth to water table is 1½ to 3½ feet.	Severe: poorly drained; subject to flooding; seasonal high water table; high shrink-swell potential.	Severe: subject to flooding.	Severe: poorly drained; subject to flooding; high shrink-swell potential.	Poor: poorly drained; high shrink-swell potential.
Mayo: MlC	Slight	Severe: rapid permeability.	Slight	Slight	Slight	Good
Meros: MrB	Slight [2]	Severe: very rapid permeability.	Slight	Severe: very rapid permeability.	Slight	Good
Mucara: MuD2, MuE2	Severe: slope; depth to bedrock is 2 to 3 feet.	Severe: slope; depth to bedrock is 2 to 3 feet.	Severe: slope	Severe: depth to bedrock is 2 to 3 feet.	Severe: slope	Poor: poor traffic-supporting capacity; high shrink-swell potential.
Naranjito: NaE2, NaF2.	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Poor: slope
Pandura: PaE2, PaF2, PdF. Very stony land part of PdF is too variable for interpretations to be made.	Severe: slope; depth to bedrock is 1 to 1½ feet.	Severe: slope; depth to bedrock is 1 to 1½ feet.	Severe: slope; depth to bedrock is 1 to 1½ feet.	Severe: depth to bedrock is 1 to 1½ feet.	Severe: depth to bedrock is 1 to 1½ feet.	Fair where slope is less than 25 percent. Poor where slope is more than 25 percent.
Parcelas: PeC2	Severe: moderately slow permeability.	Moderate where slope is 5 to 7 percent. Severe where slope is 7 to 12 percent.	Severe: high shrink-swell potential.	Severe: clay texture.	Severe: high shrink-swell potential; poor traffic-supporting capacity.	Poor: high shrink-swell potential.

See footnotes at end of table.

properties of the soils—Continued

Suitability as a source of—Continued		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuited	Poor: clay texture throughout.	No unfavorable features.	High compressibility; poor slope stability.	Slow permeability.	Area of heavy rainfall.	Dense clay subsoil.
Unsuited	Good	Moderately rapid permeability.	Medium resistance to piping; fair slope stability; moderately rapid permeability.	Well drained	No unfavorable features.	No unfavorable features.
Unsuited	Poor: poorly drained; clay texture.	Depth to water table is 1½ to 3½ feet; rapid permeability in substratum.	High compressibility.	Slow permeability.	Area of heavy rainfall.	Dense clay subsoil.
Unsuited	Good	Rapid permeability.	Low resistance to piping; poor slope stability.	Excessively drained.	Low available water capacity.	No unfavorable features.
Good for sand. Unsuited for gravel.	Poor: sand throughout.	Very rapid permeability.	Very rapid permeability; poor slope stability.	Excessively drained.	Low available water capacity.	Poor stability.
Unsuited	Poor: clay texture.	Moderate permeability; depth to bedrock is 2 to 3 feet.	High compressibility; thin layer of borrow material.	Well drained	Area of heavy rainfall.	Slope; depth to bedrock is 2 to 3 feet.
Unsuited	Poor: slope	Moderate permeability; depth to bedrock is 2 to 3 feet.	Limited thickness of material; medium compressibility.	Well drained	Area of heavy rainfall.	Slope.
Unsuited	Poor: slope	Rapid permeability; depth to bedrock is 1 to 1½ feet.	Limited thickness of material.	Well drained	Area of heavy rainfall.	Slope.
Unsuited	Poor: clay texture.	Moderately slow permeability.	High compressibility; poor slope stability.	Moderately slow permeability.	Area of heavy rainfall.	Dense clay subsoil.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for—					Suitability as a source of—
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill [1] (Trench type)	Local roads and streets	Road fill
Paso Seco: PlB	Severe: slow permeability.	Severe: rapid permeability in substratum.	Severe: very high shrink-swell potential.	Severe: clay texture.	Severe: very high shrink-swell potential.	Poor: very high shrink-swell potential; poor traffic-supporting capacity.
Patillas: PmD2, PmE2	Severe: slope	Severe: slope	Severe: slope	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.	Severe: slope	Fair where slope is less than 25 percent. Poor where slope is more than 25 percent.
Picacho. Mapped only in associations with Guayabota and Ciales soils and with Utuado soils and Stony rock land.	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Poor: slope
Pinones: Pn	Severe: subject to flooding; depth to water table is 1 to 2½ feet; very slow permeability.	Severe: depth to water table is 1 to 2½ feet; subject to flooding.	Severe: high shrink-swell potential; organic material below a depth of 18 inches.	Severe: subject to flooding; organic material below a depth of 18 inches; poorly drained.	Severe: high shrink-swell potential; subject to flooding; poorly drained; organic material below a depth of 18 inches.	Poor: high shrink-swell potential; poorly drained.
Poncena: Po	Severe: slow permeability.	Moderate: depth to water table is 2½ to 5 feet.	Severe: high shrink-swell potential.	Severe: clay texture; plastic.	Severe: high shrink-swell potential.	Poor: high shrink-swell potential.
Pozo Blanco: PrC2	Slight where slope is 5 to 8 percent. Moderate where slope is 8 to 12 percent.	Severe: moderately rapid permeability in substratum.	Slight where slope is 5 to 8 percent. Moderate where slope is 8 to 12 percent.	Slight	Moderate: fair traffic-supporting capacity.	Fair: fair traffic-supporting capacity.
Reilly: Re	Severe: subject to flooding.	Severe: rapid permeability; subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding; rapid permeability.	Severe: subject to flooding.	Good
Reparada: Rp	Severe: subject to flooding; depth to water table is 1½ to 2½ feet; very slow permeability.	Severe: depth to water table is 1½ to 2½ feet; subject to flooding.	Severe: poorly drained; depth to water table is 1½ to 2½ feet; organic material below a depth of 18 inches.	Severe: subject to flooding; organic material below a depth of 18 inches; poorly drained.	Severe: subject to flooding; poorly drained; organic material below a depth of 18 inches.	Poor: high shrink-swell potential.
Rio Arriba: RrB, RrC2.	Severe: moderately slow permeability.	Moderate where slope is 2 to 7 percent. Severe where slope is 7 to 12 percent.	Severe: high shrink-swell potential.	Severe: clay texture.	Severe: high shrink-swell potential; poor traffic-supporting capacity.	Poor: high shrink-swell potential; poor traffic-supporting capacity.

See footnotes at end of table.

properties of the soils—Continued

Suitability as a source of—Continued		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuited	Poor: clay texture.	Rapid permeability in substratum.	High compressibility; poor slope stability.	Slow permeability.	Very slow intake rate.	Dense clay subsoil.
Unsuited	Poor: slope	Rapid permeability in substratum.	Resistance to piping; rapid permeability in substratum.	Well drained	Area of heavy rainfall.	Slope.
Unsuited	Poor: slope; silty clay loam and clay texture.	Slope	Poor compaction characteristics; high compressibility.	Moderately well drained.	Area of heavy rainfall.	Slope.
Unsuited	Poor: poorly drained; silty clay texture.	Depth to water table is 1 to 1½ feet; organic material below a depth of 18 inches.	Limited thickness of borrow material.	High water table	High water table; need for drainage.	Dense clay and organic subsoil.
Unsuited	Poor: clay texture.	Seasonal water table.	High compressibility; poor slope stability.	Slow permeability.	Very low intake rate.	Dense clay subsoil.
Unsuited	Fair: clay loam texture.	Moderately rapid permeability.	Medium resistance to piping; medium compressibility; fair slope stability.	Well drained	Slope	Limited depth to unfavorable material.
Unsuited for sand. Good for gravel.	Poor: coarse fragments.	Rapid permeability.	Limited thickness of borrow material; rapid permeability.	Excessively drained.	Low available water capacity.	Limited depth to coarse material.
Unsuited	Poor: clay texture; poorly drained.	Depth to water table is 1½ to 2½ feet; organic material below a depth of 18 inches.	Limited thickness of borrow material.	High water table	High water table; need for drainage.	Limited depth to unfavorable material.
Unsuited	Poor: clay texture.	No unfavorable features.	High compressibility; poor slope stability.	Moderately slow permeability.	Very low intake rate.	Dense clay subsoil.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for—					Suitability as a source of—
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill [1] (Trench type)	Local roads and streets	Road fill
Rock land: Rs	Severe: rock at or near surface; slope.	Severe: rock at or near surface; slope.	Severe: rock at or near surface; slope.	Severe: rock at or near surface; slope.	Severe: rock at or near surface; slope.	Poor: slope; rock at or near surface.
Rough stony land: Ru.	Severe: rock at or near surface; slope.	Severe: rock at or near surface; slope.	Severe: rock at or near surface; slope.	Severe: rock at or near surface; slope.	Severe: rock at or near surface; slope.	Poor: rock at or near surface; slope.
Sabana: SaE2, SaF2	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet; high shrink-swell potential.	Severe: depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Poor: high shrink-swell potential; slope; limited thickness of material.
Salt water marsh: Sm.	Severe: water table at or near surface; subject to flooding.	Severe: water table at or near surface; subject to flooding.	Severe: water table at or near surface; subject to flooding.	Severe: water table at or near surface; subject to flooding.	Severe: subject to flooding.	Severe: poorly drained.
Talante: Ta	Severe: subject to flooding; depth to water table is 1½ to 2½ feet.	Severe: subject to flooding; depth to water table is 1½ to 2½ feet; rapid permeability in substratum.	Severe: subject to flooding; poorly drained.	Severe: subject to flooding; poorly drained.	Severe: poorly drained; subject to flooding.	Severe: poorly drained.
Teja: TeE	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet; rapid permeability.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Poor: limited thickness of material.
Tidal flats: Tf	Severe: water table at or near surface; subject to flooding.	Severe: water table at or near surface; subject to flooding.	Severe: water table at or near surface; subject to flooding.	Severe: water table at or near surface; subject to flooding.	Severe: subject to flooding.	Poor: poorly drained.
Tidal swamp: Ts. Too variable for interpretations to be made.						
Toa: Tt	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Moderate: subject to flooding.	Fair: silty clay loam surface layer.
*Utuado: UpF. For Picacho part, see Picacho series. Stony rock land part is too variable for interpretations to be made.	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Poor: slope
Vayas: Va, Vc	Severe: subject to flooding; slow permeability; depth to water table is 2½ to 5 feet.	Severe: subject to flooding; depth to water table is 2½ to 5 feet.	Severe: subject to flooding; poorly drained; high shrink-swell potential.	Severe: poorly drained; subject to flooding; clay texture.	Severe: poorly drained; high shrink-swell potential; subject to flooding.	Poor: poorly drained; high shrink-swell potential.

See footnotes at end of table.

properties of the soils—Continued

Suitability as a source of—Continued		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuited	Poor: stoniness; slope.	Slope; rock at or near surface.	Shallowness to bedrock; many stones.	Well drained	Slope; stoniness	Limited depth to bedrock; stoniness.
Unsuited	Poor: stoniness; slope.	Slope; rock at or near surface.	Shallowness to bedrock; many stones.	Well drained	Slope; stoniness	Limited depth to bedrock; stoniness.
Unsuited	Poor: slope; silty clay and clay texture.	Depth to hard rock is 1 to 1½ feet.	Limited thickness of material.	Well drained	Slope	Slope; depth to hard rock is 1 to 1½ feet.
Unsuited	Poor: soluble salts; poorly drained.	Water table at or near surface.	Salinity	Water table at or near surface; salinity.	Need for drainage; salinity.	Concave slope.
Unsuited	Poor: poorly drained.	Rapid permeability in substratum.	Low resistance to piping; poor slope stability.	High water table	High water table; low available water capacity.	Limited depth to unfavorable material.
Unsuited	Poor: slope	Rapid permeability; depth to hard rock is 1 to 1½ feet.	Limited thickness of material.	Well drained	Area of heavy rainfall.	Slope; depth to hard rock is 1 to 1½ feet.
Unsuited	Poor: soluble salts; poorly drained.	Water table at or near surface.	Salinity	Water table at or near surface; salinity.	Permanent salinity.	Level; water table at or near surface.
Unsuited	Good	Moderate permeability.	Medium compressibility; fair slope stability.	Moderate permeability.	No unfavorable features.	No unfavorable features.
Unsuited	Poor: slope	Slope	High susceptibility to piping; fair compaction characteristics.	Well drained	Area of heavy rainfall.	Slope.
Unsuited	Poor: poorly drained; clay texture.	Seasonal high water table.	High compressibility; poor slope stability.	High water table	High water table; need for drainage.	Dense clay subsoil.

TABLE 6.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitations for—					Suitability as a source of—
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Sanitary landfill [1] (Trench type)	Local roads and streets	Road fill
Vega Alta: VeB, VeC	Moderate: moderate permeability.	Moderate: moderate permeability.	Moderate: moderate shrink-swell potential.	Severe: clay texture.	Moderate: moderate shrink-swell potential; fair traffic-supporting capacity.	Fair: moderate shrink-swell potential; fair traffic-supporting capacity.
Vega Baja: VgA	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding; somewhat poorly drained.	Severe: subject to flooding.	Severe: subject to flooding.	Fair: moderate shrink-swell potential; fair traffic-supporting capacity.
Via: VIC	Slight	Severe: moderately rapid permeability.	Moderate: moderate shrink-swell potential.	Slight	Moderate: moderate shrink-swell potential.	Fair: moderate shrink-swell potential; fair traffic-supporting capacity.
Vieques: VmC, VmE2	Severe: depth to hard rock is 3 to 4 feet.	Severe: depth to hard rock is 3 to 4 feet; very rapid permeability in substratum.	Moderate where slope is 5 to 15 percent. Severe where slope is more than 15 percent.	Severe: depth to hard rock is 3 to 4 feet.	Moderate where slope is 5 to 15 percent. Severe where slope is more than 15 percent.	Poor: limited thickness of material.
Vives: Vs, VvA, VvB	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Fair: moderate shrink-swell potential; fair traffic-supporting capacity.
Vivi: Vw	Severe: subject to flooding.	Severe: subject to flooding; rapid permeability.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Good
Wet alluvial land: Wa.	Severe: water table at or near surface; subject to flooding.	Severe: water table at or near surface; subject to flooding.	Severe: water table at or near surface; subject to flooding.	Severe: poorly drained; subject to flooding.	Severe: subject to flooding.	Poor: poorly drained.
Yunes: YuF2	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Poor: limited thickness of material.

[1] Onsite deep studies of the underlying strata, water tables, and hazards of aquifer pollution and drainage into ground water need to be made for landfills deeper than 5 or 6 feet.

properties of the soils—Continued

Suitability as a source of—Continued		Soil features affecting—				
Sand and gravel	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions
Unsuited	Poor: clay texture.	Moderate permeability.	Medium compressibility; fair slope stability.	Well drained	Slope	Dense clay subsoil.
Unsuited	Poor: clay texture.	Moderate permeability.	High compressibility; poor slope stability.	Slow permeability.	No unfavorable features.	Dense clay subsoil.
Unsuited	Fair: clay loam texture.	Moderately rapid permeability.	Medium resistance to piping; fair slope stability.	Well drained	Slope	No unfavorable features.
Unsuited	Fair where slope is less than 15 percent; limited thickness of material. Poor where slope is more than 15 percent.	Moderately rapid to very rapid permeability; depth to hard rock is 3 to 4 feet.	Limited thickness of borrow material; moderately rapid to very rapid permeability.	Well drained	Moderately rapid to very rapid permeability; slope.	No unfavorable features.
Unsuited	Fair: clay and clay loam texture.	Moderate permeability.	Medium compressibility; fair slope stability.	Well drained	No unfavorable features.	No unfavorable features.
Unsuited	Good	Rapid permeability.	Low resistance to piping; poor slope stability.	Well drained	Rapid permeability.	Limited depth to unfavorable material.
Unsuited	Poor: poorly drained.	No unfavorable features.	High compressibility; poor compaction characteristics.	Slow permeability; water table at or near surface.	Need for drainage.	Concave slope; water table at or near surface.
Unsuited	Poor: coarse fragments; slope; limited thickness of material.	Depth to hard rock is 1 to 1½ feet; seepage.	Limited thickness of material.	Well drained	Area of heavy rainfall.	Slope.

[2] Pollution is a hazard to water supplies.

TABLE 7.—*Engineering*

[Test performed by the Bureau of Public Roads in accordance with standard procedures of

Soil name and location	Parent material	Bureau of Public Roads report no.	Depth	Mechanical analysis[1] Percentage passing sieve— No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)
			Inches			
Candelero loam: 30 feet west and 156 feet north from intersection of Highways No. 905 and 3 (345°). (Modal)	Old alluvium.	S–43069	0–7	100	70	38
		S–43071	7–50	100	67	37
Fortuna clay: 1.5 miles northwest of bridge over Anton Ruiz River on Highway No. 3. (Modal)	Alluvium from volcanic rocks.	S–43072	0–5	100	99	94
		S–43073	9–30	100	100	98
Ingenio silty clay loam: 0.6 mile southwest of Surillo School, on Highway No. 908, Tejas ward, Humacao. (Modal)	Granitic rocks.	S–43074	0–7	100	92	73
		S–43075	15–31	100	98	87
		S–43076	40–51	100	98	85
Jagueyes loam: 281° and 1,484 feet from road junction with Highway No. 908. (Modal)	Granitic materials.	S–43083	0–8	100	80	33
		S–43085	8–71	100	82	60
Coloso silty clay: 1.2 miles southeast of Central Roig, Yabucoa, and 30 feet east from intersection of farm roads. (Modal)	Alluvium.	S–43092	0–9	100	93	71
		S–43093	15–25	100	100	93
Limones silty clay loam: 100 feet north of kilometer marker 14.2 on Highway No. 182. (Modal)	Granitic rocks.	S–43095	0–5	100	91	70
		S–43096	9–16	100	93	80
		S–43097	40–54	100	93	80
Mabi clay: 800 feet north and 600 feet west of Gurabo Experiment Station Offices. (Modal)	Alluvium from volcanic rocks.	S–43124	0–7	100	98	90
		S–43125	15–24	100	99	96
		S–43126	38–53	100	99	95
Maunabo clay: 40° 30′ and 1,562 feet from intersection of Highway No. 905 and Highway No. 3. (Modal)	Alluvium from granitic rocks.	S–43105	10–39	100	99	86
Mayo loam: 336° and 6,406 feet from intersection of Highway No. 905 and Highway No. 3. (Modal)	Granitic materials.	S–43106	0–8	100	72	40
		S–43107	8–18	100	62	27
		S–43108	27–34	100	69	32
Pandura loam: 339° 30′ and 7,109 feet from intersection of Highway No. 905 and Highway No. 3. (Modal)	Granitic rocks.	S–43112	0–5	100	73	38
		S–43113	5–12	100	69	30
		S–43114	12–28	100	65	27

[1] Mechanical analyses according to AASHTO Designation T 88 (*1*). Results obtained by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS procedure, the fine material is analyzed by the pipette method and material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity, stability of the subgrade, and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material and the shrink-swell potential indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Road fill is soil material used in embankments for *test data*

the American Association of State Highway and Transportation Officials (AASHTO) (*1*)]

Mechanical analysis [1]—Continued				Liquid limit	Plasticity index	Classification	
Percentage smaller than—							
0.05 mm	0.02 mm	0.005 mm	0.002 mm			Unified [2]	AASHTO [3]
35	25	16	13	27	6	SM–SC	A–4(1)
34	27	22	19	33	15	SC	A–6(2)
91	77	58	45	69	34	MH–CH	A–7–5(20)
96	86	68	57	82	48	CH	A–7–5(20)
72	67	52	40	63	24	MH	A–7–5(17)
85	74	50	35	56	22	MH	A–7–5(16)
82	67	40	27	46	14	ML	A–7–5(11)
31	29	25	21	30	11	SC	A–2–6(0)
59	53	37	26	39	13	CL–ML	A–6(6)
66	53	38	30	48	22	CL–ML	A–7–6(12)
88	76	52	38	59	27	MH–CH	A–7–5(19)
69	67	63	56	74	30	MH	A–7–5(18)
79	77	73	65	78	36	MH	A–7–5(20)
78	72	52	39	59	23	MH	A–7–5(17)
88	78	59	49	68	33	MH	A–7–5(20)
95	90	75	67	102	67	CH	A–7–5(20)
93	88	69	60	87	55	CH	A–7–5(20)
81	72	56	45	57	28	MH–CH	A–7–6(19)
36	28	19	14	31	6	SM	A–4(1)
24	21	14	10	[4] NP	[4] NP	SM	A–2–4(0)
28	23	15	11	NP	NP	SM	A–2–4(0)
34	28	18	14	30	8	SM–SC	A–4(1)
26	21	14	11	NP	NP	SM	A–2–4(0)
23	18	9	7	NP	NP	SM	A–2–4(0)

[2] Based on the Unified Soil Classification System (*7*).

[3] Based on AASHTO Designation M 145–49.

[4] NP means nonplastic.

roads. The suitability ratings reflect (1) the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and (2) the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 6 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source generally has a layer of sand or gravel at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and neither do they indicate quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as in preparing a seedbed; natural fertility of the material or plant response when fertilizer is added to the soil; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments affect suitability, and also considered in the ratings is damage that can result at the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage and piping and that is of favorable stability, shrink-swell potential, shear strength, and compactibility. Stones or organic material in a soil are among factors that are unfavorable.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock or other layers that influence rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulation of salts and alkali; depth of root zone; rate of water intake at the surface; permeability below the surface layer and in fragipan or other layers that restrict movement of water; amount of water held available to plants; and need for drainage, or depth to water table or bedrock.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or to other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Soil test data

Table 7 contains engineering test data for some of the major soil series in the Humacao Area. These tests were made to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limit and plastic limit. The mechanical analyses were made by combined sieve and hydrometer methods.

Tests to determine liquid limit and plastic limit measure the effect of water on the consistence of soil material, as has been explained for table 5.

Use of the Soils for Recreation Facilities

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 8 the soils of the Humacao Area are rated according to limitations that affect their suitability for camp areas, playgrounds, picnic areas, and paths and trails.

In table 8 the soils are rated as having slight, moderate, or severe limitations for the specified uses. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. A *moderate* limitation can be overcome or modified by planning, by design, or by special maintenance. A *severe* limitation means that costly soil reclamation, special design, intense maintenance, or a combination of these, is required.

Camp areas are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required, other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have mild slopes, good drainage, a surface free of rocks and coarse fragments, and are not subject to flooding during periods of heavy use; their surface is firm after rain but not dusty when dry.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrops. They have good drainage and are not subject to flooding during periods of heavy use. Their surface is firm after rain but not dusty when dry. If grading and leveling are required, depth to rock is important.

Picnic areas are attractive natural or landscaped tracts that carry heavy foot traffic. Most of the vehicular traffic, however, is confined to access roads. The best soils are firm when wet but not dusty when dry, are not subject to flooding during the season of use, and do not have slopes or stones that can greatly increase the cost of leveling or of building access roads.

Paths and trails are used for local and cross-country travel by foot or horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks or stones on the surface.

Formation and Classification of the Soils

This section describes the five major factors of soil formation and tells how these factors have affected the soils of the Humacao Area. It also defines the system currently used for classifying soils and shows the classification of the soils in the area by series and higher categories.

Factors of Soil Formation

Soils are formed by the action of soil-forming processes on material deposited or accumulated by geologic

TABLE 8.—*Degree and kind of limitations of the soils for recreation facilities*

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Aceitunas: AcC	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate where slope is less than 7 percent: silty clay loam surface layer. Severe where slope is more than 7 percent.	Moderate: silty clay loam surface layer.
Aguadilla:				
Ad	Slight	Slight	Moderate: loamy sand surface layer.	Moderate: loamy sand surface layer.
Ag	Moderate: subject to flooding.	Slight	Slight	Slight.
Amelia: AmB, AmC2	Moderate: gravelly clay loam surface layer; coarse fragments on surface.	Moderate: gravelly clay loam surface layer; coarse fragments on surface.	Severe: coarse fragments on surface.	Moderate: gravelly clay loam surface layer; coarse fragments on surface.
Arenales: An, Ar	Moderate: subject to flooding.	Moderate: subject to flooding.	Moderate: subject to flooding.	Moderate: sandy loam surface layer; subject to flooding.
Bajura: Ba, Bc	Severe: poorly drained; subject to flooding; clay surface layer.	Severe: poorly drained; subject to flooding; clay surface layer.	Severe: poorly drained; subject to flooding; clay surface layer.	Severe: poorly drained; subject to flooding; clay surface layer.
Caguabo: CbD2, CbF2	Severe: slope	Severe: slope	Severe: slope; depth to hard rock is 1 to 1½ feet.	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.
Candelero: CdB, CdC2	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate where slope is 2 to 6 percent: somewhat poorly drained; slow permeability. Severe where slope is more than 6 percent.	Moderate: somewhat poorly drained.
Cartagena: Ce	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.
Catano: Cf	Slight	Slight	Moderate: sand surface layer.	Moderate: sand surface layer.
Cayagua: CgC2, CgD2	Moderate where slope is less than 15 percent: somewhat poorly drained; slow permeability. Severe where slope is more than 15 percent.	Moderate where slope is less than 15 percent: somewhat poorly drained. Severe where slope is more than 15 percent.	Moderate where slope is less than 6 percent: somewhat poorly drained; slow permeability. Severe where slope is more than 6 percent.	Moderate: somewhat poorly drained.
Coamo: ClB, ClC	Moderate: clay loam surface layer.	Moderate: clay loam surface layer.	Moderate where slope is less than 6 percent. Severe where slope is more than 6 percent.	Moderate: clay loam surface layer.
Coastal beaches: Cm	Severe: wave action	Severe: wave action	Severe: sandy wave action.	Severe: sandy.
Cobbly alluvial land: Cn	Severe: subject to flooding; coarse fragments.	Severe: subject to flooding; coarse fragments.	Severe: subject to flooding; coarse fragments.	Severe: subject to flooding; coarse fragments.
Coloso: Co, Cr	Moderate: somewhat poorly drained; subject to flooding; silty clay loam surface layer.	Moderate: somewhat poorly drained; subject to flooding; silty clay loam surface layer.	Moderate: somewhat poorly drained; subject to flooding; silty clay loam surface layer.	Moderate: somewhat poorly drained; subject to flooding; silty clay loam surface layer.

TABLE 8.—*Degree and kind of limitations of the soils for recreation facilities*—Continued

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Corcega: Cs	Severe: subject to flooding; depth to seasonal high water table is 1½ to 2½ feet; somewhat poorly drained.	Severe: subject to flooding; depth to seasonal high water table is 1½ to 2½ feet; somewhat poorly drained.	Severe: subject to flooding; depth to seasonal high water table is 1½ to 2½ feet; somewhat poorly drained.	Severe: subject to flooding; depth to seasonal high water table is 1½ to 2½ feet; somewhat poorly drained.
Daguao, deep variant: DaC.	Moderate: slope; silty clay loam surface layer.	Moderate: slope; silty clay loam surface layer.	Moderate where slope is less than 6 percent: silty clay loam surface layer. Severe where slope is more than 6 percent.	Moderate: silty clay loam surface layer.
Daguao: DcE2	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Descalabrado: DeC2, DeE2	Moderate where slope is less than 15 percent: clay loam surface layer. Severe where slope is more than 15 percent.	Moderate where slope is less than 15 percent: clay loam surface layer. Severe where slope is more than 15 percent.	Severe: slope; depth to hard rock is 1 to 1½ feet.	Moderate where slope is less than 25 percent; clay loam surface layer.
DgF2	Severe: slope	Severe: slope	Severe: slope; depth to rock is less than 20 inches.	Severe: slope.
DrF	Severe: slope; rockiness.	Severe: slope; rockiness.	Severe: slope; depth to bedrock is 10 to 20 inches; rockiness.	Severe: slope; rockiness.
Fajardo: FaC, FaC2	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.
Fortuna: Fo	Severe: poorly drained; subject to flooding; clay surface layer.	Severe: poorly drained; subject to flooding; clay surface layer.	Severe: poorly drained; subject to flooding; clay surface layer.	Severe: poorly drained; subject to flooding; clay surface layer.
Fraternidad: FrA, FrB	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.
Guamani: Gm	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Guayabota: GuE2	Severe: slope	Severe: slope	Severe: slope; depth to hard rock is 1 to 1½ feet.	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.
GvF	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Guayama, moderately deep variant: GyC2.	Moderate where slope is less than 15 percent: clay loam surface layer.	Moderate where slope is less than 15 percent: clay loam surface layer.	Moderate where slope is less than 6 percent. Severe where slope is more than 6 percent.	Moderate: clay loam surface layer.
Humacao: HmB	Slight	Slight	Slight	Slight.
Humatas: HtE2, HtF2	Severe: clay surface layer.	Severe: clay surface layer.	Severe: slope; clay surface layer.	Severe: clay surface layer.
HuF	Severe: slope; stoniness.	Severe: slope; stoniness.	Severe: slope; stoniness.	Severe: slope; stoniness.
Ingenio: InE2	Severe: slope	Severe: slope	Severe: slope	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.

TABLE 8.—*Degree and kind of limitations of the soils for recreation facilities*—Continued

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Jacana: JaB, JaC2	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.
Jagueyes: JgE2	Severe: slope	Severe: slope	Severe: slope	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.
Junquitos: JuC	Severe: coarse fragments on surface.	Severe: coarse fragments on surface.	Severe: coarse fragments on surface.	Moderate: coarse fragments on surface; gravelly clay loam surface layer.
Leveled clayey land: Lc	Slight	Slight	Slight	Slight.
Limones: LeE2	Severe: slope	Severe: slope	Severe: slope	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.
Lirios: LoC2, LrE2	Moderate where slope is less than 15 percent: silty clay loam surface layer. Severe where slope is more than 15 percent.	Moderate where slope is less than 15 percent: silty clay loam surface layer. Severe where slope is more than 15 percent.	Severe: slope	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.
Los Guineos: LsD, LsE2, LsF2	Moderate where slope is less than 15 percent: silty clay loam surface layer. Severe where slope is more than 15 percent.	Moderate where slope is less than 15 percent: silty clay loam surface layer. Severe where slope is more than 15 percent.	Severe: slope	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.
LyF	Severe: slope; rockiness.	Severe: slope; rockiness.	Severe: slope; rockiness.	Severe: slope; rockiness.
Mabi: MaB, MaC2, MaD2	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.
Machete: McA, McB	Slight	Slight	Slight where slope is 0 to 2 percent. Moderate where slope is 2 to 5 percent.	Slight.
Made land: Md	Slight	Slight	Slight	Slight.
Maunabo: Me	Severe: poorly drained; clay surface layer.	Severe: poorly drained; clay surface layer.	Severe: poorly drained; clay surface layer.	Severe: poorly drained; clay surface layer.
Mayo: MlC	Slight where slope is 3 to 8 percent. Moderate where slope is 8 to 10 percent.	Slight where slope is 3 to 8 percent. Moderate where slope is 8 to 10 percent.	Moderate where slope is less than 6 percent. Severe where slope is more than 6 percent.	Slight.
Meros: MrB	Slight	Slight	Moderate: sand texture.	Moderate: sand texture.
Mucara: MuD2, MuE2	Moderate where slope is less than 15 percent: silty clay loam surface layer. Severe where slope is more than 15 percent.	Moderate where slope is less than 15 percent: silty clay loam surface layer. Severe where slope is more than 15 percent.	Severe: slope	Moderate where slope is less than 25 percent: silty clay loam surface layer. Severe where slope is more than 25 percent.
Naranjito: NaE2, NaF2	Severe: slope	Severe: slope	Severe: slope	Moderate where slope is less than 25 percent: silty clay loam surface layer. Severe where slope is more than 25 percent.

TABLE 8.—*Degree and kind of limitations of the soils for recreation facilities*—Continued

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Pandura:				
PaE2, PaF2	Moderate where slope is less than 15 percent. Severe where slope is more than 15 percent.	Moderate where slope is less than 15 percent. Severe where slope is more than 15 percent.	Severe: slope	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.
PdF	Severe: slope; stoniness.	Severe: slope; stoniness.	Severe: slope; stoniness.	Severe: slope; stoniness.
Parcelas: PeC2	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.
Paso Seco: PlB	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.
Patillas: PmD2, PmE2	Moderate where slope is less than 15 percent: clay loam surface layer. Severe where slope is more than 15 percent.	Moderate where slope is less than 15 percent: clay loam surface layer. Severe where slope is more than 15 percent.	Severe: slope	Moderate where slope is less than 25 percent: clay loam surface layer. Severe where slope is more than 25 percent.
Pinones: Pn	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.	Severe: poorly drained; silty clay surface layer.
Poncena: Po	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.
Pozo Blanco: PrC2	Moderate: slope; clay loam surface layer.	Moderate: slope; clay loam surface layer.	Severe: slope	Moderate: clay loam surface layer.
Reilly: Re	Severe: subject to flooding; coarse fragments on surface.	Severe: subject to flooding; coarse fragments on surface.	Severe: subject to flooding; coarse fragments on surface.	Severe: subject to flooding; coarse fragments on surface.
Reparada: Rp	Severe: clay surface layer; poorly drained; very slow permeability.	Severe: clay surface layer; poorly drained.	Severe: clay surface layer; poorly drained; very slow permeability.	Severe: clay surface layer; poorly drained.
Rio Arriba: RrB, RrC2	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.
Rock land: Rs	Severe: slope; rockiness.	Severe: slope; rockiness.	Severe: slope; rockiness.	Severe: slope; rockiness.
Rough stony land: Ru	Severe: slope; stoniness.	Severe: slope; stoniness.	Severe: slope; stoniness.	Severe: slope; stoniness.
Sabana: SaE2, SaF2	Severe: slope	Severe: slope	Severe: slope; depth to hard rock is 1 to 1½ feet.	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.
Salt water marsh: Sm	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.
Talante: Ta	Moderate: somewhat poorly drained; clay loam and sandy clay loam surface layer; subject to flooding.	Moderate: somewhat poorly drained; clay loam and sandy clay loam surface layer; subject to flooding.	Moderate: somewhat poorly drained; clay loam and sandy clay loam surface layer; subject to flooding.	Moderate: somewhat poorly drained; clay loam and sandy clay loam surface layer; subject to flooding.
Teja: TeE	Severe: slope; coarse fragments on surface.	Severe: slope; coarse fragments on surface.	Severe: slope; coarse fragments on surface; depth to hard rock is 1 to 1½ feet.	Severe: slope; coarse fragments on surface.
Tidal flats: Tf	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.

TABLE 8.—*Degree and kind of limitations of the soils for recreation facilities*—Continued

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Tidal swamp: Ts	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.
Toa: Tt	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Utuado: UpF	Severe: slope; rockiness.	Severe: slope; rockiness.	Severe: slope; rockiness.	Severe: slope; rockiness.
Vayas: Va, Vc	Severe: poorly drained; subject to flooding; silty clay surface layer.	Severe: poorly drained; subject to flooding; silty clay surface layer.	Severe: poorly drained; subject to flooding; silty clay surface layer.	Severe: poorly drained; subject to flooding; silty clay surface layer.
Vega Alta: VeB, VeC	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate where slope is less than 6 percent: silty clay loam surface layer. Severe where slope is more than 6 percent.	Moderate: silty clay loam surface layer.
Vega Baja: VgA	Moderate: silty clay loam surface layer; subject to flooding; somewhat poorly drained.	Moderate: silty clay loam surface layer; subject to flooding; somewhat poorly drained.	Moderate: silty clay loam surface layer; subject to flooding; somewhat poorly drained.	Moderate: silty clay loam surface layer; subject to flooding; somewhat poorly drained.
Via: VIC	Moderate: silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate where slope is less than 6 percent: silty clay loam surface layer. Severe where slope is more than 6 percent.	Moderate: silty clay loam surface layer.
Vieques: VmC, VmE2	Moderate where slope is less than 15 percent. Severe where slope is more than 15 percent.	Moderate where slope is less than 15 percent. Severe where slope is more than 15 percent.	Severe: slope	Slight where slope is less than 15 percent. Moderate where slope is 15 to 25 percent. Severe where slope is more than 25 percent.
Vives: Vs, VvA, VvB	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.	Severe: clay surface layer.
Vivi: Vw	Moderate: subject to flooding.	Slight	Slight	Slight.
Wet alluvial land: Wa	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.
Yunes: YuF2	Severe: slope	Severe: slope	Severe: slope; depth to hard rock is 1 to 1½ feet.	Moderate where slope is less than 25 percent. Severe where slope is more than 25 percent.

forces. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life are active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of the climate and plant and animal life are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a mature soil. The amount of time can be short or long, but some time is always required for soil horizons to form. Usually a long time is required for distinct horizons to develop.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made about the effect of any one unless conditions are specified for the other four.

Parent material

Parent material is the unconsolidated mass from which a soil forms. It largely determines the chemical and mineralogical composition of the soil. To a large extent, the minerals in the parent material determine the kinds and amount of clay in the soil. Many of the soils in the Humacao Area formed in place from material derived from intrusive and extrusive volcanic rocks.

Climate

A soil forms rapidly in the Humacao Area because of the warm tropical climate. This warm climate is favorable throughout the year for rapid chemical and physical reactions, for the decomposition of organic material from plants and animals, and for other soil-forming processes.

The variations in temperature are relatively small within the area, but rainfall varies from place to place, and this accounts for some differences in the soils. Roughly, the four climatic zones in the survey area are the southern part of the area, the central part, the northern part, and the tropical rain forest.

In the southern part, the climate is warm and dry. The average temperatures are 79.9° F. for the year, 76.8° for January, and 82.1° for July. The average annual rainfall is 24 to 45 inches.

In the central part, the climate is warm and humid. The average temperatures are 77.4° for the year, 73.0° for January, and 78.3° for July. The average annual rainfall is 70 to 90 inches.

In the northern part the climate is warm and subhumid. The average temperatures are 78.2° for the year, 74.0° for January, and 79.6° for July. The annual average rainfall is 60 to 80 inches.

In the tropical rain forest, the climate is warm and humid. The average temperatures are 74.1° for the year, 70.7° for January, and 76.5° for July. The average annual rainfall is 100 to 180 inches.

Temperature and rainfall govern the rate of weathering of rocks and the decomposition of minerals. They also influence leaching, eluviation, and illuviation. For example, the soils in the southern part of the survey area, where the climate is semiarid, are not so leached as soils in other parts of the area that originated from the same parent material but have lost bases and nutrients because of the amount of rainfall.

Plants and animals

Plants, animals, fungi, and bacteria are important to soil formation. The changes they bring about depend mainly on the kinds of life processes peculiar to each.

Originally, the Humacao Area was covered by a fairly dense tropical forest. A large part of the area was cleared for cultivation, and when it was later left idle, low brush and native pasture became dominant. Most of the original native vegetation has been destroyed or seriously disturbed, except in the rain forest, but its effect on soil formation is visible.

The vegetation is generally responsible for the amount of organic matter in the soil, the color of the surface layer, and the amount of nutrients. Growing plants provide a cover that helps to reduce erosion and stabilize the surface so that the soil-forming processes can continue. Leaves, twigs, and entire plants accumulate on the surface of forest soils and then decompose as a result of percolating water and of micro-organisms, earthworms, and other forms of animal life acting on the soil. The roots of plants widen cracks in the rocks and thus permit more water to enter the soil. Also, the uprooting of trees influences soil formation by mixing the soil layers and loosening the underlying material.

Earthworms, ants, and many other burrowing animals are extremely active in the Humacao Area and help to keep the soil open and porous. They mix the layers of the soil, mix organic matter into the soil, and help to break down the remains of plants. Earthworms and other small invertebrates feed on organic matter in the upper few inches of the soil. They slowly but continually mix the soil material and, in places, alter it chemically. Bacteria, fungi, and other micro-organisms hasten the weathering of rock minerals and the decay of organic matter.

Relief

The shape of the land surface, the slope, and the depth of the water table have had great influence on the formation of the soils in the survey area. Strongly sloping soils, where runoff is moderate to rapid, generally are well drained, have a bright-colored, unmottled subsoil, and are leached to a greater depth than wet soils in the same general area. About 64 percent of the soils in the Humacao Area are strongly sloping or steep. The more gently sloping soils, where runoff is slower, generally exhibit some evidence of wetness, such as mottling in the subsoil. In level areas or slight depressions, where the water table is at or near the surface for long periods of time, the soils show marked evidence of wetness.

Time

In the formation of soils, time is needed for changes to take place in the parent material, and this is usually a long time when measured in years.

The soils of the Humacao Area range from those that show little or no development to older soils that show pronounced development. Vives and Toa soils are examples of young soils that formed from sediment that washed from the hills and was deposited on river flood plains. Los Guineos and Humatas are two older soils of the uplands where the parent rock has weathered in place for a long time.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*2*) and revised later (*4*). The system currently used by the National Cooperative Soil Survey was developed in the early sixties (*3*) and was adopted in 1965 (*6*). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 9 shows the classification of each soil series of the Humacao Area by family, subgroup, and order, according to the current system. The six categories of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soil. The two exceptions to this are the Entisols and Histosols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Ent-i-sol).

SUBORDER. Each order is divided into suborders primarily on the basis of those soil characteristics that seem to produce classes that have the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is *Aquent* (*Aqu*, meaning water or wet, and *ent*, from Entisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated, those that have a pan that interferes with the growth of roots or movement of water, and thick, dark colored surface horizons. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), dark red and dark brown colors associated with basic rocks, and the like. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is Fluvaquents (*Fluv*, meaning river, *aqu* for wetness or water, and *ent*, from Entisols).

SUBGROUP. Great groups are divided into subgroups, one representing the central (typic) segment of the group, and others called intergrades that have properties of the group and also have one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Tropic Fluvaquents (Fluvaquents of the tropics.)

FAMILY. Soil families are established within a subgroup primarily on the basis of properties important to the growth of plants or the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for characteristics, such as texture and mineralogy, that are used to differentiate families (see table 9). An example is the fine, mixed, acid, isohyperthermic family of Tropic Fluvaquents.

SERIES. The series is a group of soils that have major horizons that, except for texture of the surface layer, are similar in important characteristics and in arrangement in the profile. They are given the name of a geographic location near the place where that series was first observed and mapped. An example is the Teja series.

The nomenclature for the classes in each of the four highest categories is, for the most part, connotative. The formative elements come chiefly from the classical languages. Many of the roots are familiar and thus help us to visualize the soil. For example, the Teja series is classified as a Lithic Troporthents. One can visualize that the Teja soils must have hard rock within 20 inches of the surface (lithic), are continually warm (trop), are the common ones (orth), and are in the Entisol order (Ent). The Teja soils are, in fact, shallow to hard granitic rock, occur in the tropics in humid climate, and are in the Entisol order.

The names are distinctive for the classes in each category, so that a name itself will indicate the category to which a given class belongs. Moreover, the names are designed so that each subgroup by its name is placed in the great group, suborder, and order with which it is identified. For example, the name Lithic Troporthents indicates a class in the subgroup. Furthermore, from the name one can identify the great group (Troporthents), the suborder (Orthents), and the order (Entisol).

Climate [4]

The Humacao Area has a tropical marine climate. The mean annual rainfall varies widely mainly because of the variation in topography and elevation. The area includes one of the driest sections of the island, the semiarid southern coastal plain, as well as the most rainy section, the tropical rain forest in the Luquillo Mountains.

The variation in mean annual temperatures is, as in

[4] By ROBERT J. CALVESBERT, Commonwealth climatologist, Environmental Science Services Administration, San Juan, Puerto Rico.

TABLE 9.—*Classification of the soil series*

Series	Family	Subgroup	Order
Aceitunas	Clayey, oxidic, isohyperthermic	Typic Palehumults	Ultisols.
Aguadilla	Mixed, isohyperthermic	Typic Tropopsamments	Entisols.
Amelia	Clayey-skeletal, mixed, isohyperthermic	Typic Haplustalfs	Alfisols.
Arenales	Mixed, isohyperthermic	Typic Ustipsamments	Entisols.
Bajura	Fine, mixed, nonacid, isohyperthermic	Vertic Tropaquepts	Inceptisols.
Caguabo	Loamy-skeletal, mixed, isohyperthermic	Lithic Eutropepts	Inceptisols.
Candelero	Fine-loamy, mixed, isohyperthermic	Aeric Tropaqualfs	Alfisols.
Cartagena	Fine, mixed, isohyperthermic	Udic Chromusterts	Vertisols.
Catano	Carbonatic, isohyperthermic	Typic Tropopsamments	Entisols.
Cayagua	Fine, mixed, isohyperthermic	Aeric Tropaqualfs	Alfisols.
Ciales	Clayey, mixed, isothermic	Aquic Tropohumults	Ultisols.
Coamo	Fine, mixed, isohyperthermic	Typic Argiustolls	Mollisols.
Coloso	Fine, mixed, nonacid, isohyperthermic	Aeric Tropic Fluvaquents	Entisols.
Corcega	Fine-loamy over sandy or sandy-skeletal, mixed, nonacid, isohyperthermic	Aeric Tropic Fluvaquents	Entisols.
Daguao	Clayey, mixed, isohyperthermic	Typic Tropohumults	Ultisols.
Descalabrado	Clayey, mixed, isohyperthermic	Lithic Vertic Ustropepts	Inceptisols.
Fajardo	Fine, mixed, isohyperthermic	Vertic Paleudalfs	Alfisols.
Fortuna	Fine, mixed, acid, isohyperthermic	Tropic Fluvaquents	Entisols.
Fraternidad	Very fine, montmorillonitic, isohyperthermic	Udic Chromusterts	Vertisols.
Guamani	Fine-loamy over sandy or sandy-skeletal, mixed, isohyperthermic	Fluventic Ustropepts	Inceptisols.
Guayabota	Clayey, mixed, acid, isothermic	Lithic Tropaquepts	Inceptisols.
Guayama	Clayey, mixed, isohyperthermic	Lithic Haplustalfs	Alfisols.
Humacao	Fine-loamy, mixed, isohyperthermic	Fluventic Eutropepts	Inceptisols.
Humatas	Clayey, kaolinitic, isohyperthermic	Typic Tropohumults	Ultisols.
Ingenio	Clayey, mixed, isohyperthermic	Orthoxic Tropudults	Ultisols.
Jacana	Fine, mixed, isohyperthermic	Vertic Ustropepts	Inceptisols.
Jagueyes	Fine-loamy, mixed, isohyperthermic	Orthoxic Tropudults	Ultisols.
Junquitos	Fine, mixed, isohyperthermic	Aquic Eutropepts	Inceptisols.
Limones	Clayey, kaolinitic, isohyperthermic	Epiaquic Orthoxic Tropohumults	Ultisols.
Lirios	Clayey over loamy, mixed, isohyperthermic	Typic Tropudults	Ultisols.
Los Guineos	Clayey, mixed, isothermic	Epiaquic Tropohumults	Ultisols.
Mabi	Fine, montmorillonitic, isohyperthermic	Vertic Eutropepts	Inceptisols.
Machete	Fine, mixed, isohyperthermic	Udic Haplustalfs	Alfisols.
Maunabo	Fine, mixed, acid, isohyperthermic	Typic Tropaquepts	Inceptisols.
Mayo	Coarse-loamy, mixed, isohyperthermic	Typic Dystropepts	Inceptisols.
Meros	Mixed, isohyperthermic	Typic Ustipsamments	Entisols.
Mucara	Clayey, montmorillonitic, isohyperthermic, shallow	Vertic Eutropepts	Inceptisols.
Naranjito	Clayey, mixed, isohyperthermic	Typic Tropohumults	Ultisols.
Pandura	Loamy, mixed, isohyperthermic, shallow	Typic Eutropepts	Inceptisols.
Parcelas	Fine, mixed, isohyperthermic	Vertic Dystropepts	Inceptisols.
Paso Seco	Clayey over loamy-skeletal, mixed, isohyperthermic	Udic Chromusterts	Vertisols.
Patillas	Fine-loamy, mixed, isohyperthermic	Dystropeptic Tropudults	Ultisols.
Picacho	Clayey, mixed, isothermic	Aquic Tropohumults	Ultisols.
Pinones	Fine, mixed, acid, isohyperthermic	Thapto-Histic Tropic Fluvaquents	Entisols.
Poncena	Fine, mixed, isohyperthermic	Udic Pellusterts	Vertisols.
Pozo Blanco	Loamy, carbonatic, isohyperthermic, shallow	Typic Calciustolls	Mollisols.
Reilly	Sandy-skeletal, mixed, isohyperthermic	Fluventic Hapludolls	Mollisols.
Reparada	Fine, mixed, nonacid, isohyperthermic	Thapto-Histic Tropic Fluvaquents	Entisols.
Rio Arriba	Fine, mixed, isohyperthermic	Vertic Paleudalfs	Alfisols.
Sabana	Clayey, mixed, isohyperthermic	Lithic Dystropepts	Inceptisols.
Talante	Coarse-loamy over sandy or sandy-skeletal, mixed, acid, isohyperthermic	Aeric Tropic Fluvaquents	Entisols.
Teja	Loamy-skeletal, mixed, acid, isohyperthermic	Lithic Troporthents	Entisols.
Toa	Fine, mixed, isohyperthermic	Fluventic Hapludolls	Mollisols.
Utuado	Fine-loamy, mixed, isothermic	Typic Humitropepts	Inceptisols.
Vayas	Fine, mixed, nonacid, isohyperthermic	Tropic Fluvaquents	Entisols.
Vega Alta	Clayey, mixed, isohyperthermic	Plinthic Tropudults	Ultisols.
Vega Baja	Fine, mixed, isohyperthermic	Aeric Tropaqualfs	Alfisols.
Via	Fine-loamy, mixed, isohyperthermic	Typic Tropudalfs	Alfisols.
Vieques	Fine-loamy over sandy or sandy-skeletal, mixed, isohyperthermic	Typic Ustropepts	Inceptisols.
Vives	Fine-loamy, mixed, isohyperthermic	Fluventic Ustropepts	Inceptisols.
Vivi	Coarse-loamy, mixed, isohyperthermic	Fluventic Eutropepts	Inceptisols.
Yunes	Loamy-skeletal, mixed, isohyperthermic, shallow	Typic Dystropepts	Inceptisols.
Yunque	Clayey, mixed, isothermic	Epiaquic Palehumults	Ultisols.

most of Puerto Rico, quite small. The area is under the influence of the easterly trade winds the year round and has a definite land and sea breeze pattern caused by the differential daytime heating and nighttime cooling of the land and sea.

Tropical storms and hurricanes occasionally strike directly, but more often they pass some distance away although their wind and rain affect the area for several days.

There are a number of microclimates in this eastern section of Puerto Rico, mainly as the result of a variety of rainfall patterns and, to a lesser extent, the variance in relative humidity, temperature, and evaporation. Temperature and precipitation data for five locations in the Humacao Area are given in table 10.

Mean annual rainfall ranges from 42 inches in the Aguirre area of the southern coast to 180 inches in the Luquillo rain forest. There is no dry season nor a wet season, but there is a relatively drier period, usually from December through April in the southern part of the area and from January through April in the northern part, and a period of heavier rainfall from May through November in the south and May through December in the north. There are two peak periods of heavier rains in May and October. Monthly totals range from 0.76 inch to 5.93 inches on the southern coast and from 2.87 to 10.87 inches in the eastern interior around Humacao.

Much of the rain falls in short, convective showers, but very heavy rains lasting several days are caused by the polar trough, locally called vaguada, that moves from west to east as a weakening cold front out of the continental mainland. These rains occur several times during winter and are usually accompanied by gusty winds. The easterly wave, a pressure trough moving from east to west, also can bring heavy rains over the southeastern part of the island late in spring and in summer. Finally, hurricanes and tropical storms can produce very heavy rains in the fall when moving directly over the area or passing offshore as far as 100 miles out to sea. Of the last 6 major hurricanes that have hit Puerto Rico since 1893, 5 have entered the island on the southeastern coast between Fajardo and Aguirre.

Under the effect of these three types of rainmakers, the area can receive as much as 10 inches of rain in a 24-hour period. On the average this happens about once every 10 years. On the average about 5.50 inches of rainfall in 24 hours occurs at least once a year somewhere in the area. Usually the heavier rainfalls cause some flooding.

Extreme droughts that have a devasting effect on agriculture and on the general economy occur in the area. Water supplies become low enough to require the rationing of irrigation water and the curtailing of use of water for human consumption from the reservoirs. In 1967, during the most severe drought on record, the southern coastal stations averaged only 19 inches of rain during the year, the southern slopes area averaged 38 inches, and the northern interior stations averaged 44 to 49 inches. These droughts usually last about 6 months to a year and half. Although no definite cycle of occurrence is indicated, a severe to extreme drought occurs about once every 10 to 12 years and several shorter dry spells occur in between.

Mean annual maximum temperatures in Humacao range from 82.0° F. in January to 88.2°in August. The mean annual minimum temperatures vary from 64.0° in January to 73.2° in June. The highest maximum temperature recorded during a 30-year period (1931 to 1960) was 95°, and the lowest minimum was 53°. The higher the elevation on the Luquillo Mountains, the narrower the daily temperature range. In the rain forest itself, the mean maximum temperature is 77° and the mean minimum is 64°. Normally the widest temperature ranges are in places between the higher terrain of the rain forest and the sea-level areas near the ocean where the water has a tempering effect on the daily temperatures.

The prevailing wind direction reflects the easterly trade winds. The section on the east coast, around Fajardo and the Roosevelt Roads Naval Air Station, receives a surface flow from a quadrant encompassing northeast to southeast about 75 percent of the time annually and as much as 95 percent of the time in July when the easterlies are at their strongest. The differential heating of the land and sea during the day tends to give a more northerly component to the flow on the northern side of the island and a more southerly component on the southern side. During the night a land breeze causes a prevailing southeasterly flow in the north and a prevailing northeasterly flow over the southern coast.

About 40 percent of the time, the windspeed is 8 to 12 miles per hour, about 30 percent of the time it is 7 miles per hour or less, and the rest of the time it is more than 12 miles per hour. Windbreaks are effective in some of the higher exposed areas and especially along the eastern and northern coasts where the wind has an open fetch across the sea. The highest windspeeds occur as hurricanes pass through the area. Windspeed as high as 165 miles per hour has been registered and 190 miles per hour estimated on the northern coast during the entry of Hurricane San Felipe in the Guayama area. Based on wind data kept at San Juan for a long period of time, it is estimated that hurricane winds of 75 miles per hour or more occur on the average of about once every 24 years.

Average evaporation rates are higher than the average rainfall as shown in table 11.

Hail is rare and occurs once or twice a year, usually in May or September, but only in the northern and interior parts of the area.

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TABLE 10.—*Temperature and rainfall data from selected stations*

Month	Temperature				Rainfall		
	Average daily maximum	Average daily minimum	Average monthly highest maximum	Average monthly lowest minimum	Average monthly total	One year in 10 will have— Less than—	One year in 10 will have— Equal to or more than—
	°F	°F	°F	°F	Inches	Inches	Inches
HUMACAO							
January	82.0	64.0	84.9	59.1	4.23	1.82	7.11
February	82.7	64.2	86.3	59.2	3.30	1.16	6.23
March	84.5	65.7	88.2	59.8	2.87	.85	5.43
April	85.8	68.5	89.0	64.4	5.22	1.51	9.92
May	86.2	71.5	89.4	66.3	10.26	4.79	16.79
June	87.1	73.2	89.8	69.3	9.53	4.84	14.90
July	87.5	72.9	90.1	69.5	8.65	4.42	13.52
August	88.2	72.4	91.4	69.3	9.41	6.12	13.04
September	87.8	71.7	91.3	67.9	10.87	6.47	15.81
October	87.3	70.4	90.7	66.8	9.96	6.16	14.21
November	85.2	68.1	88.7	63.1	8.16	3.08	14.36
December	82.8	65.5	86.5	60.2	5.59	2.27	9.60
Year	85.6	69.0	[1] 92.6	[2] 57.3	88.05	35.79	151.09
AGUIRRE							
January	85.9	68.0	88.9	63.6	1.07	0.26	2.13
February	85.7	67.9	88.8	63.5	1.29	.15	2.94
March	86.3	68.9	89.3	64.8	.76	.16	1.63
April	87.0	70.7	89.8	66.7	2.37	.38	6.54
May	88.1	72.8	90.9	68.5	4.94	1.93	8.53
June	89.0	74.2	91.4	70.8	4.73	1.78	8.31
July	89.8	74.5	92.8	71.3	4.17	1.26	8.34
August	90.5	74.6	94.4	71.3	5.28	2.56	8.37
September	90.5	73.8	93.5	69.8	5.93	1.74	9.92
October	90.1	73.3	93.4	69.3	5.77	1.09	10.26
November	89.1	71.7	92.3	67.9	4.36	.72	9.39
December	87.3	69.8	90.2	65.5	2.10	.35	4.50
Year	88.3	71.7	[1] 95.2	[2] 62.3	42.77	30.13	56.49
FAJARDO							
January	82.9	69.5	85.6	63.0	3.40	1.44	5.73
February	83.1	69.0	85.9	62.9	2.78	.57	5.73
March	83.9	69.9	87.0	62.9	2.32	.90	4.05
April	84.8	71.7	88.2	66.6	4.32	1.53	7.75
May	86.3	73.9	89.6	68.8	7.97	3.68	14.09
June	87.1	75.3	89.4	70.0	6.12	2.53	10.41
July	87.7	75.7	89.1	70.9	6.06	2.49	10.37
August	88.3	75.8	90.0	71.1	6.80	4.08	9.84
September	88.4	74.7	90.5	69.6	7.75	4.09	12.01
October	88.0	73.5	90.6	68.8	8.01	4.64	11.83
November	86.2	72.2	88.6	66.7	6.08	2.57	10.26
December	84.1	71.0	86.5	64.9	4.40	2.05	7.21
Year	85.9	72.7	[1] 91.6	[2] 60.9	66.01	33.53	103.50

illus. [Supplements issued in March 1967, September 1968, and April 1969]

(7) United States Department of Defense. 1968. Unified soil classification system for roads, airfields, embankments and foundations. MIL–STD–619B, 30 pp., illus.

Glossary

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvial fan. A fan-shaped deposit of sand, gravel, and fine material dropped by a stream where its gradient lessens abruptly.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

TABLE 10.—*Temperature and rainfall data from selected stations*—Continued

VIEQUES

Month	Temperature				Rainfall		
	Average daily maximum	Average daily minimum	Average monthly highest maximum	Average monthly lowest minimum	Average monthly total	One year in 10 will have— Less than—	Equal to or more than—
	°F	°F	°F	°F	Inches	Inches	Inches
January	84.4	68.9	87.7	64.4	2.21	0.62	4.13
February	84.7	69.3	88.1	64.1	1.84	.41	3.86
March	85.7	68.9	88.7	64.5	1.55	.28	3.19
April	86.6	70.5	89.8	66.6	2.62	.72	5.88
May	87.8	73.3	90.5	68.5	3.46	1.09	6.45
June	88.9	74.5	91.2	69.9	3.87	1.39	6.88
July	89.6	74.8	92.0	70.8	3.60	1.24	6.54
August	90.2	75.0	92.8	70.8	4.67	2.27	7.52
September	89.2	74.7	92.2	70.0	5.76	2.18	10.09
October	88.8	73.9	91.1	69.8	5.57	1.76	10.41
November	87.5	72.4	90.5	67.4	4.52	1.72	7.93
December	85.6	70.2	88.5	65.4	3.20	.91	5.80
Year	87.4	72.2	[1] 93.8	[2] 62.5	42.88	31.70	54.00

CANOVANAS

Month	Average daily maximum	Average daily minimum	Average monthly highest maximum	Average monthly lowest minimum	Average monthly total	Less than—	Equal to or more than—
January	83.1	65.4	87.3	59.5	4.96	2.00	10.04
February	83.6	65.1	88.0	58.7	3.57	.90	7.05
March	84.9	65.8	89.1	59.5	2.82	.89	5.25
April	86.2	67.9	90.7	62.0	4.50	1.58	8.07
May	87.9	70.3	91.4	64.8	8.25	3.28	14.26
June	88.5	71.7	91.4	66.2	7.08	3.84	12.55
July	88.0	72.3	90.8	66.8	7.80	3.92	12.22
August	88.7	72.9	91.9	70.2	7.65	4.36	11.34
September	88.8	71.6	91.9	66.6	7.23	3.32	11.79
October	88.7	70.6	92.4	65.6	6.18	3.97	9.06
November	86.3	69.1	90.4	61.7	6.79	3.16	11.10
December	84.0	67.2	88.5	61.3	6.01	2.84	9.78
Year	86.6	69.2	[1] 93.5	[2] 57.9	72.84	57.59	88.59

[1] Average annual highest temperature.
[2] Average annual lowest temperature.

TABLE 11.—*Mean evaporation rates, in inches, for three locations*

Location	January	February	March	April	May	June	July	August	September	October	November	December	Annual
San Juan	5.82	6.01	7.88	7.93	7.50	7.36	8.06	7.66	6.43	5.91	5.34	5.69	81.59
Aguirre	5.26	5.75	7.41	7.60	7.72	7.69	8.02	7.84	6.54	6.04	5.06	4.92	79.85
Gurabo	3.84	4.48	5.68	6.16	6.09	6.28	6.21	6.04	5.25	4.94	3.82	3.71	62.50

Chert. A compact, siliceous rock formed of chalcedonic or opaline silica, or both, that is of organic or precipitated origin.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Plutonic rock. A general term applied to the class of igneous rocks that have crystallized at great depths and are generally granitoid in texture.

Pressure faces. Structural faces that show more evidence of clay than the natural ped surfaces but that do not have clay films. Probably caused by the shrinking and swelling of the soil.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Runoff (hydraulics). The part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called groundwater runoff or seepage flow from ground water.

Saline-alkali soil. A soil that contains a harmful concentration of salts and exchangeable sodium; or contains harmful salts and has a highly alkaline reaction; or contains harmful salts and exchangeable sodium and is strongly alkaline in reaction. The salts, exchangeable sodium, and alkaline reaction occur in the soil in such location that the growth of most crop plants is less than normal.

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Saprolite. Disintegrated and somewhat decomposed but untransported rock.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on relatively steep slopes and in swelling clays, where there is marked change in moisture content.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: *Very coarse sand* (2.0 to 1.0

millimeter); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.05 to 0.002 millimeter); and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeter); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); IV (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Upland (geology). Land consisting of material unworked by water in recent geologic time and lying, in general, at a higher elevation than the alluvial plain or stream terrace. Land above the lowland along rivers.

Variant, soil. A soil having properties sufficiently different from those of other known soils to suggest establishing a new soil series, but a soil of such limited known area that creation of a new series is not believed to be justified.

Volcanic rock. The class of igneous rocks that have been poured out or ejected at or near the surface. The form is synonymous with extrusive rock and effusive rock.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Weathering. All physical and chemical changes produced in rocks at or near the earth's surface by atmospheric agents. These changes result in more or less complete disintegration and decomposition of the rock.

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GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which the mapping unit belongs. The system of capability grouping is explained in the section that begins on page 49. The system of woodland suitability grouping is explained in the section that begins on page 53.

Map symbol	Mapping unit	Page	Capability unit Nonirrigated Symbol	Capability unit Irrigated Symbol	Woodland suitability group Symbol
AcC	Aceitunas silty clay loam, 5 to 12 percent slopes	7	IIIe-1	------	---
Ad	Aguadilla loamy sand	7	VIs-3	------	---
Ag	Aguadilla sandy loam, moderately wet	7	VIs-3	------	---
AmB	Amelia gravelly clay loam, 2 to 5 percent slopes	8	IVc-3	IIIs-1	---
AmC2	Amelia gravelly clay loam, 5 to 12 percent slopes, eroded	8	IVe-8	------	---
An	Arenales sandy loam	8	VIc-1	IVs-1	---
Ar	Arenales sandy loam, gravelly substratum	8	VIc-1	IVs-1	---
Ba	Bajura silty clay, saline	9	VIIw-1	------	---
Bc	Bajura clay, frequently flooded	9	IIIw-1	------	---
CbD2	Caguabo clay loam, 12 to 20 percent slopes, eroded	10	VIs-2	------	3d5
CbF2	Caguabo clay loam, 20 to 60 percent slopes, eroded	10	VIIs-1	------	3d5, 4d5
CdB	Candelero loam, 2 to 5 percent slopes	11	IIIw-2	------	---
CdC2	Candelero loam, 5 to 12 percent slopes, eroded	11	IVe-1	------	---
Ce	Cartagena clay	12	IIIc-1	IIs-1	---
Cf	Catano loamy sand	12	VIs-1	------	---
CgC2	Cayagua sandy loam, 5 to 12 percent slopes, eroded	13	IIIe-2	------	---
CgD2	Cayagua sandy loam, 12 to 20 percent slopes, eroded	13	IVe-2	------	---
ClB	Coamo clay loam, 2 to 5 percent slopes	14	IIIc-2	IIe-1	---
ClC	Coamo clay loam, 5 to 12 percent slopes	14	IVe-3	------	---
Cm	Coastal beaches	14	VIIIs-1	------	---
Cn	Cobbly alluvial land	14	Vs-1	------	---
Co	Coloso silty clay loam, occasionally flooded	15	IIw-1	------	---
Cr	Coloso silty clay	15	IIw-1	------	---
Cs	Corcega sandy loam	15	IIw-5	------	---
DaC	Daguao silty clay loam, deep variant, 2 to 12 percent slopes	16	IIIe-3	------	3d5
DcE2	Daguao clay, 20 to 40 percent slopes, eroded	16	VIe-1	------	3d5
DeC2	Descalabrado clay loam, 5 to 12 percent slopes, eroded	17	IVs-2	------	3d5
DeE2	Descalabrado clay loam, 20 to 40 percent slopes, eroded	17	VIIs-4	------	3d5
DgF2	Descalabrado and Guayama soils, 20 to 60 percent slopes, eroded	17	VIIs-4	------	4d5
DrF	Descalabrado-Rock land complex, 40 to 60 percent slopes	17	VIIs-4	------	4d5
FaC	Fajardo clay, 2 to 10 percent slopes	18	IIw-2	------	---
FaC2	Fajardo clay, 2 to 10 percent slopes, eroded	18	IIw-2	------	---
Fo	Fortuna clay	19	IIIw-4	------	---
FrA	Fraternidad clay, 0 to 2 percent slopes	19	IIIc-1	IIs-1	---
FrB	Fraternidad clay, 2 to 5 percent slopes	19	IIIc-1	IIs-1	---
Gm	Guamani silty clay loam	20	IVc-1	IIIs-2	---
GuE2	Guayabota silty clay loam, 20 to 40 percent slopes, eroded	21	VIIs-6	------	4d3
GvF	Guayabota-Ciales-Picacho association, very steep	21	VIIe-3	------	4d3
GyC2	Guayama clay loam, moderately deep variant, 2 to 12 percent slopes, eroded	22	IVc-2	IIIe-4	3d5
HmB	Humacao loam, 2 to 5 percent slopes	22	IIe-2	------	---
HtE2	Humatas clay, 20 to 40 percent slopes, eroded	23	IVe-5	------	2c5
HtF2	Humatas clay, 40 to 60 percent slopes, eroded	23	VIe-2	------	3r5
HuF	Humatas-Stony land complex, 40 to 60 percent slopes	23	VIIs-2	------	3r5
InE2	Ingenio silty clay loam, 20 to 40 percent slopes, eroded	24	IVe-5	------	2o5
JaB	Jacana clay, 2 to 5 percent slopes	25	IVc-2	IIIs-3	3d5
JaC2	Jacana clay, 5 to 12 percent slopes, eroded	25	IVe-4	------	3d5
JgE2	Jagueyes loam, 20 to 40 percent slopes, eroded	25	IVe-11	------	2o5
JuC	Junquitos gravelly clay loam, 5 to 12 percent slopes	26	IIIe-5	------	---
Lc	Leveled clayey land	26	------	------	---

Map symbol	Mapping unit	Page	Capability unit Nonirrigated Symbol	Capability unit Irrigated Symbol	Woodland suitability group Symbol
LeE2	Limones silty clay, 20 to 40 percent slopes, eroded	27	IVe-5	------	2c5
LoC2	Lirios clay loam, 3 to 10 percent slopes, eroded	27	IIIe-6	------	2c5
LrE2	Lirios silty clay loam, 20 to 40 percent slopes, eroded	27	IVe-5	------	2c5
LsD	Los Guineos silty clay loam, 12 to 20 percent slopes	28	IVe-5	------	2c3
LsE2	Los Guineos silty clay loam, 20 to 40 percent slopes, eroded	28	VIe-2	------	2c3
LsF2	Los Guineos silty clay loam, 40 to 60 percent slopes, eroded	28	VIIe-1	------	2r3
LyF	Los Guineos-Yunque-Stony rock land association, steep	28	VIIe-3	------	3r3
MaB	Mabi clay, 0 to 5 percent slopes	29	IIw-3	------	---
MaC2	Mabi clay, 5 to 12 percent slopes, eroded	30	IIIe-7	------	---
MaD2	Mabi clay, 12 to 20 percent slopes, eroded	30	IVe-10	------	---
McA	Machete loam, 0 to 2 percent slopes	30	IIc-2	I-1	---
McB	Machete loam, 2 to 5 percent slopes	30	IIIc-3	IIe-3	---
Md	Made land	30	------	------	--
Me	Maunabo clay	31	IIIw-4	------	---
MlC	Mayo loam, 3 to 10 percent slopes	32	IIIe-10	------	---
MrB	Meros sand, 1 to 6 percent slopes	32	VIIs-7	------	---
MuD2	Mucara silty clay loam, 12 to 20 percent slopes, eroded	33	IVe-6	------	3d5
MuE2	Mucara silty clay loam, 20 to 40 percent slopes, eroded	33	VIe-4	------	3d5
NaE2	Naranjito silty clay loam, 20 to 40 percent slopes, eroded	33	VIe-1	------	2c5
NaF2	Naranjito silty clay loam, 40 to 60 percent slopes, eroded	33	VIIe-1	------	3r5
PaE2	Pandura loam, 12 to 40 percent slopes, eroded	34	VIe-3	------	2o5
PaF2	Pandura loam, 40 to 60 percent slopes, eroded	34	VIIe-2	------	3r5
PdF	Pandura-Very stony land complex, 40 to 60 percent slopes	34	VIIs-5	------	4d5
PeC2	Parcelas clay, 5 to 12 percent slopes, eroded	35	IIIe-7	------	---
PlB	Paso Seco clay, 0 to 5 percent slopes	35	IIIc-1	IIs-1	---
PmD2	Patillas clay loam, 12 to 20 percent slopes, eroded	36	IVe-7	------	2o5
PmE2	Patillas clay loam, 20 to 40 percent slopes, eroded	36	VIe-3	------	2o5
Pn	Pinones silty clay	37	IVw-1	------	---
Po	Poncena clay	38	IIIc-1	IIs-1	---
PrC2	Pozo Blanco clay loam, 5 to 12 percent slopes, eroded	38	IVe-3	------	2o2
Re	Reilly soils	39	IVs-3	------	---
Rp	Reparada clay	39	IVw-2	------	---
RrB	Rio Arriba clay, 2 to 5 percent slopes	40	IIs-2	------	---
RrC2	Rio Arriba clay, 5 to 12 percent slopes, eroded	40	IIIe-7	------	---
Rs	Rock land	40	VIIIs-2	------	---
Ru	Rough stony land	40	VIIIs-2	------	---
SaE2	Sabana silty clay loam, 20 to 40 percent slopes, eroded	40	VIIs-1	------	3d5
SaF2	Sabana silty clay loam, 40 to 60 percent slopes, eroded	41	VIIs-1	------	4d5
Sm	Salt water marsh	41	VIIIw-1	------	---
Ta	Talante soils	41	IIIw-3	------	---
TeE	Teja gravelly sandy loam, 12 to 40 percent slopes	42	VIIs-1	------	4d5
Tf	Tidal flats	42	VIIIw-1	------	---
Ts	Tidal swamp	42	VIIIw-1	------	---
Tt	Toa silty clay loam	42	I-2	------	---
UpF	Utuado-Picacho-Stony rock land association, very steep	43	VIIs-3	------	3r3
Va	Vayas silty clay loam, occasionally flooded	44	IIw-4	IIw-4	---
Vc	Vayas silty clay, frequently flooded	44	IIw-4	IIw-4	---
VeB	Vega Alta silty clay loam, 2 to 5 percent slopes	45	IIe-4	------	---
VeC	Vega Alta silty clay loam, 5 to 12 percent slopes	45	IIIe-8	------	---
VgA	Vega Baja silty clay loam, 0 to 3 percent slopes	45	IIw-1	------	---
VlC	Via silty clay loam, 3 to 10 percent slopes	46	IIIe-9	------	---
VmC	Vieques loam, 5 to 12 percent slopes	46	IVe-9	------	3d5
VmE2	Vieques loam, 12 to 40 percent slopes, eroded	46	VIe-5	------	3d5
Vs	Vives silty clay loam, high bottom	47	IIc-1	I-3	---
VvA	Vives clay, 0 to 2 percent slopes	47	IIc-1	I-3	---

Map symbol	Mapping unit	Page	Capability unit: Nonirrigated Symbol	Capability unit: Irrigated Symbol	Woodland suitability group Symbol
VvB	Vives clay, 2 to 7 percent slopes	47	IIIc-2	IIe-1	---
Vw	Vivi loam	47	IIs-3	------	---
Wa	Wet alluvial land	47	VIIIw-2	------	---
YuF2	Yunes silty clay loam, 20 to 60 percent slopes, eroded	48	VIIs-1	------	4d5

NRCS Accessibility Statement

SAP ATTACHMENT 2

EQUIPMENT USER MANUALS

USER INSTRUCTION MANUAL

INNOV-X SYSTEMS
ALPHA SERIES™
X-Ray Fluorescence Spectrometers

March 2007
P/N 100392
Revision B

Innov-X Systems, Inc.
100 Sylvan Road, Suite 100
Woburn, MA 01801

Toll Free: 866-446-6689 FAX: 781-938-0128
Web-Site: www.innov-xsys.com

Innov-X Systems, Inc.
100 Sylvan Road, Suite 100
Woburn, MA 01801
Toll Free 866-446-6689 FAX 781-938-0128
Web-Site: www.innov-xsys.com

TABLE OF CONTENTS

Chapter 1 Introduction

1.0 INSPECTING YOUR INNOV-X ANALYZER

Upon receipt:

1. Locate and remove the shipping papers and documentation from under the lid's foam padding.
2. Remove the Innov-X Analyzer and all of the components from the protective carrying case and identify each on the enclosed shipping list.
3. Connect the battery charger to an 110V-240V AC power source. Place one Li-ion battery on the charger and charge it for at least 2 hours.   Charge the second battery.
4. Charge the HP iPAQ using the attached AC adaptor for at least ½ hour.
5. Read and review the "Quick Start" section of the User's Manual. Innov-X recommends that you read the entire manual.
6. Install the fully charged battery into the analyzer.
7. Press the ON/OFF button on the back of the analyzer and the power button on the iPAQ.
8. Select Innov-X from the start menu located in the upper left hand corner of iPAQ screen.
9. Select the desired analysis mode (i.e., Analytical, FastID, Pass/Fail or Soil). The instrument will undergo a one minute hardware initialization period.
10. Standardize the instrument with the 316 Stainless Steel mask.   Standardize the instrument every 4 hours or as directed by the display.
11. Release the software trigger lock and analyze a sample of known composition, in order to verify the correct operation of the analyzer.
12. Analyze samples of unknown composition.

1.1 COMPONENTS INCLUDED WITH THE ANALYZER

Shown here are the various items which are included with the Innov-X portable XRF analyzer. Unless otherwise noted, all items are standard accessories.

Analyzer, with iPAQ attached.

Two, Li-ion batteries (one shown).

Battery charger and an AC adaptor. Battery shown mounted in charging system.

Standardization cap and weld mask (optional)

The standard standardization cap has no weld slit.

iPAQ cradle and AC adaptor. The cradle is used to connect the iPAQ to a PC for downloading data and reports.

Testing stand. This is the benchtop docking station for the analyzer. It is an optional accessory

1.2 QUICK START INSTRUCTIONS

The following section provides a quick overview to using the Innov-X portable XRF analyzer. This is intended to provide the basic startup and operational instruction needed to perform simple analyses. It is highly recommended that the user read the sections on Radiation Safety (Chapter 3) and the detailed description on operation (Chapter 4). The following Quick Start information is also provided as a separate, bound, laminated publication for quick reference.

1. Place a battery in the analyzer.
2. Power on the Analyzer (On/Off switch located on back of analyzer)
3. Power on the iPAQ (Button located in upper right hand corner of iPAQ)
4. Select Innov-X from the start menu located in the upper left hand corner of iPAQ screen.
5. Read the radiation safety notice and acknowledge that you are a certified user by pressing Start.
6. Select Desired Mode.
7. The analyzer will undergo a 60 second hardware initialization.
8. Place a standardization clip on the nose of the analyzer. Tap the button on the screen to standardize. ***(Manual section 4.4 Standardization)***
9. When standardization is complete, remove the standardization clip.

10. Release the software trigger lock by tapping the locked icon on the iPAQ screen and tapping yes in response to the software prompt.
11. Test standard to verify instrument performance.
12. Results will display on screen. Subsequent tests may be started from either the Results or Analysis screens.

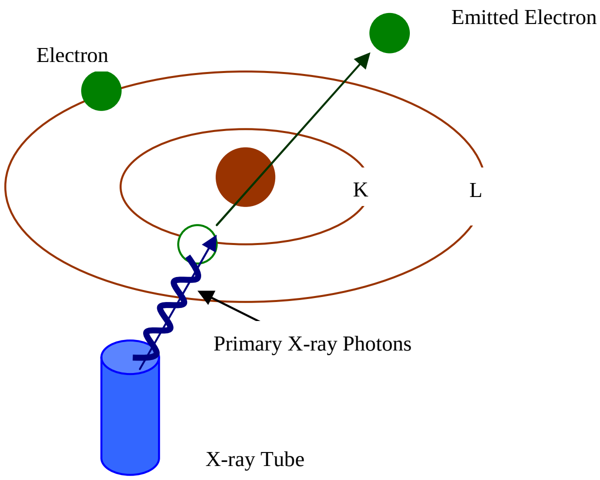
1.3 INTRODUCTION TO XRF: X-RAY FLUORESCENCE SPECTROMETRY OVERVIEW

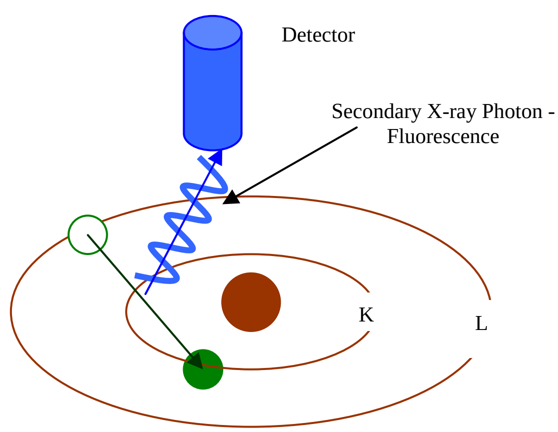
Basic Theory

Although most commonly known for diagnostic use in the medical field, the use of x-rays forms the basis of many powerful analytical measurement techniques, including X-ray Fluorescence (XRF) Spectrometry.

XRF Spectrometry is used to identify elements in a substance and quantify the amount of those elements present. An element is identified by its characteristic X-ray emission wavelength (λ) or energy (E). The amount of an element present is quantified by measuring the intensity of its characteristic line. XRF Spectrometry ultimately determines the elemental composition of a material.

All atoms have a fixed number of electrons (negatively charged particles) arranged in orbitals around the nucleus. The number of electrons in a given atom is equal to the number of protons (positively charged particles) in the nucleus; and, the number of protons is indicated by the Atomic Number in the Periodic Table of Elements. Each Atomic Number is assigned an elemental name, such as Iron (Fe), with Atomic Number 26. Energy Dispersive (ED) XRF and Wavelength Dispersive (WD) XRF Spectrometry typically utilize activity in the first three electron orbitals, the K, L, and M lines, where K is closest to the nucleus. Each electron orbital corresponds to a specific and different energy level for a given element.





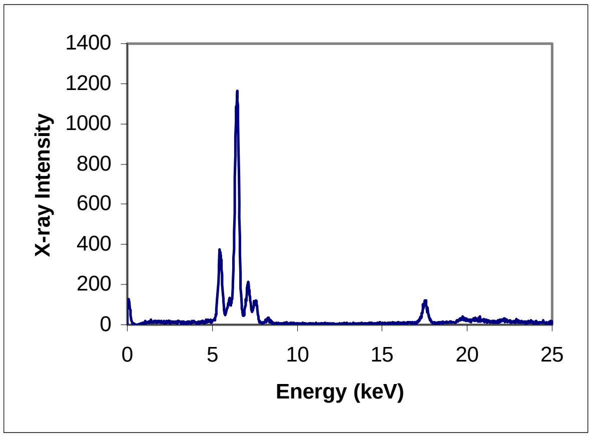
In XRF Spectrometry, high-energy primary X-ray photons are emitted from a source (X-ray tube) and strike the sample. The primary photons from the X-ray tube have enough energy to knock electrons out of the innermost, K or L, orbitals. When this occurs, the atoms become ions, which are unstable. Electrons seek stability; therefore, an electron from an outer orbital, L or M, will move into the newly vacant space at the inner orbital. As the electron from the outer orbital moves into the inner orbital space, it emits an energy known as a secondary X-ray photon. This phenomenon is called fluorescence. The secondary X-ray produced is characteristic of a specific element. The energy (E) of the emitted fluorescent X-ray photon is determined by the difference in energies between the initial and final orbitals of the individual transitions.

This is described by the formula

$$E=hc/\lambda$$

where h is Planck's constant; c is the velocity of light; and λ is the characteristic wavelength of the photon.

Wavelengths are inversely proportional to the energies; they are characteristic for each element. For example the Kα energy for Iron (Fe) is about 6.4keV. The number of element-specific characteristic X-rays produced in a sample over a given period of time, or the intensity, can be measured to determine the quantity of a given element in a sample. Typical spectra for EDXRF Spectrometry appear as a plot of Energy (E) versus the Intensity (I).



History

Wilhelm Roentgen discovered X-rays in 1895. Methods for identifying and quantifying elements using XRF were first published by Henry Moseley in 1913. Much research and development of XRF continued after Moseley's pioneering work, especially during WWII when rapid developments in the aircraft, automotive, steel and other metals industries heightened the need to identify alloys quickly and reliably. However, the first commercial XRF Spectrometers weren't available until the early 1950's. Those systems were based on WDXRF technology and measured the characteristic wavelength of an element, one element at a time. Although the use of these systems was critical for elemental analyses, they were large, expensive, and required highly skilled operators to use and maintain them.

In the late 1960's, EDXRF technology, which measures the characteristic energy of an element, began to rival the use of WDXRF due to the development of Si (Li) solid state detectors, which offered better energy resolution of the signal. EDXRF systems offered the potential of collecting and displaying information on all of the elements in a sample at the same time, as opposed to one at a time with typical WDXRF systems. Many of the early EDXRF systems used radioisotopes for excitation instead of X-ray tubes, which could require changing sources to determine all the elements of interest. Some of those early EDXRF systems did not easily resolve multiple elements in a single analytical run.

As can be imagined, the equipment and applications of XRF Spectrometers have developed tremendously since the 1960's. Advancements in technology, electronics, computers, software and the use and modification of them for XRF Spectrometers by instrument manufacturers, research scientists & engineers, and industrial users alike have led to the current state of the art in XRF Spectrometers. Now a mature technology, XRF Spectrometry is routinely used for R&D, QC and analytical services in support of production.

Elemental Analysis

XRF Spectrometry is the choice of many analysts for elemental analysis when compared to the other techniques available. Wet chemistry instrument techniques for elemental analysis require destructive and time-consuming specimen preparation, often using concentrated acids or other hazardous materials. Not only is the sample destroyed, waste streams are generated during the analytical process that need to be disposed of, many of which are hazardous. These wet chemistry elemental analysis techniques often take twenty minutes to several hours for specimen preparation and analysis time. All of these factors lead to a relatively high cost per sample. However, if PPB and lower elemental concentrations are the primary measurement need, wet chemistry instrument elemental analysis techniques are necessary.

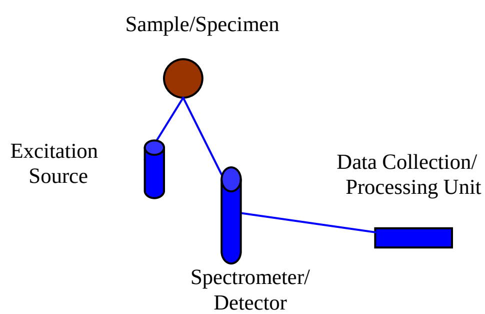
XRF Spectrometry easily and quickly identifies and quantifies elements over a wide dynamic concentration range, from PPM levels up to virtually 100% by weight. XRF Spectrometry does not destroy the sample and requires little, if any, specimen preparation. It has a very fast overall sample turnaround time. These factors lead to a significant reduction in the per sample analytical cost when compared to other elemental analysis techniques.

All elemental analysis techniques experience interferences, both chemical and physical in nature, and must be corrected or compensated for in order to achieve adequate analytical results. Most wet chemistry instrument techniques for elemental analysis suffer from interferences that are corrected for by both extensive and complex specimen preparation techniques, instrumentation advancements, and by mathematical corrections in the system's software. In XRF Spectrometry, the primary interference is from other specific elements in a substance that can influence (matrix effects) the analysis of the element(s) of interest. However, these interferences are well known and documented; and, instrumentation advancements and mathematical corrections in the system's software easily and quickly correct for them. In certain cases, the geometry of the sample can effect XRF analysis, but this is easily compensated for by grinding or polishing the sample, or by pressing a pellet or making glass beads.

Quantitative analysis for XRF Spectrometry is typically performed using Empirical Methods (calibration curves using standards similar in property to the unknown) or Fundamental Parameters (FP). FP is frequently preferred because it allows elemental analysis to be performed with no standards or calibration curves. This enables the analyst to use the system immediately, without having to spend additional time setting up individual calibration curves for the various elements and materials of interest. The capabilities of modern computers allow the use of this no-standard mathematical analysis, FP, accompanied by stored libraries of known materials, to determine not only the elemental composition of an unknown material quickly and easily, but even to identify the unknown material itself.

EDXRF Spectrometers

EDXRF Spectrometer systems are mechanically very simple; essentially there are no moving parts. An EDXRF system typically has three major components: an excitation source, a spectrometer/detector, and a data collection/processing unit. The ease of use, rapid analysis time, lower initial purchase price and substantially lower long-term maintenance costs of EDXRF Spectrometers have led to having more systems in use today worldwide than WDXRF Spectrometer systems.



EDXRF has been found most useful for scrap alloy sorting, forensic science, environmental analysis, archaeometry and a myriad of other elemental field-oriented analyses.

Handheld EDXRF Spectrometers for Field Analyses

It is clear that a future trend for elemental analysis is in rapid site investigation using techniques that are fast, inexpensive, reliable, and long-term cost effective. There is a need for immediate decisions to be made during the delivery of materials, industrial processing, and in the field for positive materials identification or environmental site assessment and remediation. It is also clear that EDXRF Spectrometry is the most suitable elemental analysis technique available for field analysis due to its simplicity, speed, precision, accuracy, reliability, and overall cost effectiveness.

Recent technological developments in cell phones, pocket PC's and other portable consumer electronics have led to the advancement of many high-performance, miniature components. X-ray equipment manufacturers began to take advantage of these developments in the late 1990's and developed Handheld EDXRF systems. An obvious advantage of Handheld EDXRF systems is that the analyzer is taken to the sample as opposed to bringing the sample to the analyzer and configuring it to fit in an analysis chamber. In addition to the per sample analytical cost savings, a key factor in using non-destructive EDXRF analysis, especially in the field, is the overall project cost savings due to improved and more timely decision making. The use of EDXRF for immediate positive materials identification or to guide an environmental site characterization will generally reduce the overall time required in the field due to the quick turnaround for the sample analysis; this invariably reduces the overall costs of analytical field work.

Of course, Handheld EDXRF technology has continued to evolve in concert with portable consumer electronic developments. Just like the early Benchtop EDXRF systems, early Handheld EDXRF systems used radioisotopes for excitation. There are several practical problems with the use of radioactive isotopes for handheld systems. The source decays and loses its testing speed over time. In addition to the loss in analytical capabilities, the sources have to be replaced incurring a cost. The use of radioactive isotopes also requires licensing (state-to-state in the US) and a radioactive materials control program; they are difficult to ship and transport, as they require hazardous materials declarations and/or permits. Consequently, the newest and most exciting development in Handheld EDXRF technology is the use of battery operated, miniature X-ray tubes, which was pioneered by the staff at Innov-X Systems.

Innov-X Systems Handheld EDXRF Spectrometers

Innov-X Systems specializes in Handheld EDXRF technology with the most advanced miniature components available for X-ray Tube sources, detectors, and PC 's. Innov-X Systems Handheld EDXRF Spectrometers are ideally suited for field analysis of alloys, lead-based paint, environmental soils, filters, dust wipes, forensics, archaeometry, and a variety of other elemental analyses in the field or around the plant. Innov-X Systems EDXRF Spectrometers are affordable, easy to use, reliable, and overall cost effective. The Innov-X Systems Handheld EDXRF units incorporate state-of the art components including a battery operated miniature X-ray tube, a high-resolution silicon pin detector, high speed data acquisition circuitry, and a Compaq IPAQ Pocket PC® handheld computer for calculations, results and operator interface.

Innov-X Systems EDXRF Spectrometers offer the following invaluable features:

- Portable
- Battery operated, rechargeable
- X-ray Tube-based (Ag or W anode, 10-40kV, 10-100uA)
- Si PiN diode detector.
- Integrated pocket PC
- Pistol-shaped design for difficult testing locations and welds
- Auto-compensation for irregular or small samples
- Fundamental Parameters for no-standard analyses
- Stored Grade Libraries for rapid Grade ID's
- Stored Fingerprint Libraries for rapid material ID's

- Docking station available for use as standard benchtop unit
- Results shown after a few seconds of testing time.

For more information on how to utilize your Innov-X Systems Handheld EDXRF Spectrometer optimally, please review this Instruction Manual or contact us directly.

Chapter 2. Usage and Assembly of Accessories

2.0 ACCESSORIES

This chapter describes the various accessories that are provided with an Innov-X XRF analysis system. Included are:

- Batteries
- Battery Charger
- iPAQ cradle and charger
- Standardization Clip or Standardization Clip/Welding mask
- Test Stand Assembly: Alpha Configured for iPAQ (optional – P/N A010)
- Test Stand Assembly: Alpha Configured for PC Software (optional – P/N A010-C))

2.1 ANALYZER BATTERY

The Innov-X Systems XRF Analyzer is powered by a replaceable, rechargeable Lithium ion battery. In addition, the iPAQ has its own internal battery.

Innov-X Systems Main Battery

The Innov-X Analyzer uses a rechargeable Lithium Ion Smart Battery. A picture of the battery is shown in Fig. 2.1. Two batteries are included with each analyzer. The batteries are charged an external battery charger. Batteries typically function for 4 to 8 hours, depending on usage patterns. Heavier duty cycles deplete the battery more quickly. Therefore, users who do longer and more frequent tests will need to replace their batteries more often than users who take shorter or fewer tests.

Figure 2.1. Li-ion Battery for analyzer

Replacement batteries can be purchased directly by calling Innov-X Systems at 781-938-5005. (P/N A003)

Battery power indicators:

There are two ways of determining the charge remaining on a battery: the LED indicator on the battery and the battery status icon on the analyzer screen. The battery icon, when tapped, will indicate the percent charge remaining on a battery inside the analyzer. Additionally, the battery icon will change from green to yellow when the battery gets low, indicating it has about 15 minutes left of charge.

To use the battery LED, push the button below the indicator. The lighting will indicate the % of charge. If possible, try to use batteries with at least 50% of their full charge, according to the indicator.

2.2 CHANGING A BATTERY

To change a battery, perform the following steps:

1. Hold the instrument by the handle, upside down, so the bottom of the instrument base is pointing upward. Please refer to Fig. 2.2.
2. Hold the instrument so that the nose is pointing away from the operator.

3. Open the battery door on the bottom of the handle. The batteries have a small tab attached for ease of removal.
4. Pull out the existing battery, and replace with a new battery.
5. Insert the charged battery into the analyzer such that the connectors on the top of the battery are facing to the right. Note that the battery slot is keyed so that the battery can only be inserted one way.

Figure 2.2a. Instrument handle. Pull the rubber latch and lift door. Reach into opening and remove battery.

Figure 2.2b Insert new battery into opening.

2.3 BATTERY CHARGER

The battery charger is shown in Fig. 2.3. It takes about 2 hours to completely charge a battery. The status of the charger is shown by two lights on the power adaptor. Table 2.1 lists the information conveyed by the lights.

Figure 2.3. Battery charger.

Left Light	Right light	Status
On	Off	Battery is charging
On	On	Battery is 80% charged
Off	On	Battery is completely charged
Blink	Blink	Error. Remove battery and replace on charger. If error persists, call Innov-X Systems Technical support.
Off	Off	No battery is on charger

Table 2.1 Battery charger status lights

2.4 HP IPAQ POCKET PC BATTERY

The iPAQ has an internal rechargeable battery, which can be recharged by using the power adaptor that is included with the unit. This adaptor can be connected either to the iPAQ itself, or to the cradle. If it is connected to the cradle, and plugged in, the iPAQ will recharge whenever it is placed in the cradle. In addition, the iPAQ Battery will recharge whenever the iPAQ is mounted in an Innov-X analyzer which is powered, but not actively taking a test. The amber light on the top of the iPAQ will blink whenever the battery is charging. It will remain solid when the battery is completely charged.

Since the iPAQ will be recharged whenever the Innov-X Systems Analyzer is in use, it may never be necessary to use the iPAQ power adaptor. However, care should be taken when the analyzer is not used for a period of several days, as the iPAQ uses some power even when it is powered off. It is therefore possible to completely discharge the battery simply by not using the iPAQ for several days, or by using it for several hours without recharging it.

If you do not use your Innov-X Analyzer on a daily basis, or if you will have a down period of more than several days, it is recommended that you remove the iPAQ from the Analyzer when it is not in use and plug in the iPAQ to a power outlet to recharge it. This will ensure that your iPAQ is always charged and ready for use. You should also always plug in the power cord whenever the iPAQ is removed from the analyzer for data transfer.

If you do allow the iPAQ battery to discharge significantly, either by allowing it to sit too long unused, or by using it for a period of time without it being connected to a power source, it may not be possible to operate your analyzer. If this happens, the Innov-X software will provide an error message indicating that the iPAQ battery is too low. Recharge the iPAQ for at least a half an hour before attempting another measurement.

If the iPAQ battery is completely discharged, it will not be possible to turn on the iPAQ until it is recharged. A complete power failure will erase anything that is stored in the Main Memory of the iPAQ. All Innov-X program and data files are stored on the storage card, rather than in Main Memory, so you will not lose any data or have to reinstall the Innov-X software.

1. If the battery on the iPAQ is completely discharged, charge it for at least one half hour.
2. You will be required to follow the prompts on the iPAQ screen before you can use the iPAQ. This procedure involves realigning the screen by tapping in several spots, and going through a quick tutorial.
3. The iPAQ will reinitialize the Innov-X Systems software. A message will appear indicating that this is going to happen. You must tap ok to initialize.
4. The software will open automatically; a message will appear indicating that several registries have been restored. Tap ok to dismiss this message.
5. Set the clock to the current time. **Note, this is very important,** as your data is indexed by date. If the date in the iPAQ is incorrect, you may not be able to locate your results. The instrument will not allow you to take a reading until the date has been changed.
   a. From the Start Menu, tap Settings.
   b. Select the System tab, and tap clock.
   c. Set the proper date. Further details about this procedure can be found in the HP iPAQ user's manual.

2.5 REMOVING the IPAQ FROM the ANALYZER

It is very important to properly remove the iPAQ Pocket PC from the analyzer to avoid damaging the connector on the back of the iPAQ.

In order to remove the iPAQ, push the iPAQ retainer shown in Fig. 2.4 towards the front of the analyzer. Holding the retainer forward, grab the iPAQ from the sides, slide the iPAQ forward until it is clear of its connector, then tilt the front end up enough so it clears the front holder allowing the iPAQ to be lifted out of the instrument.

<u>NOTE:</u> Never grab the iPAQ and twist it side-to-side to remove it from the analyzer. Always move the iPAQ retainer forward as instructed above, slide the iPAQ forward and remove from the analyzer.

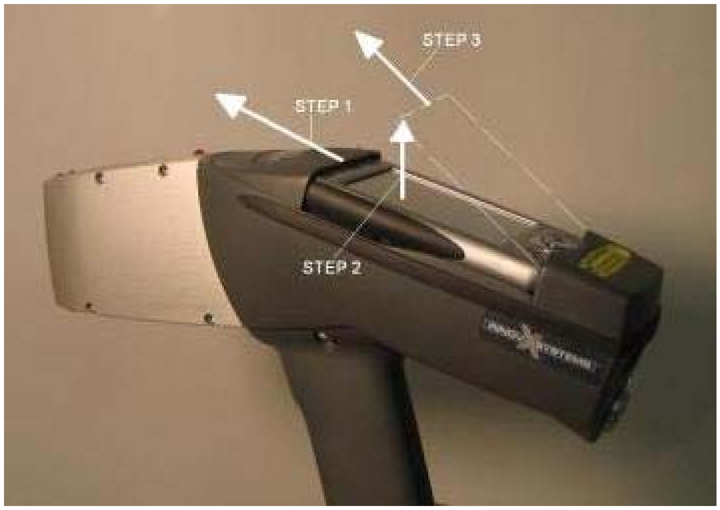


Figure 2.4. Removing the iPAQ from the analyzer.

2.6 STANDARDIZATION CAP and/or WELD TESTING MASK

All analyzers are supplied with either a standardization cap or a combination standardization cap welding mask. The standardization mask is the standard accessory. Welding masks can be purchased as an additional accessory, or in lieu of the standardization mask.

Standardization Cap

The cap clips on the front end of the analyzer and is used to standardize the system as described in Chapter 4. To attach the cap, snap it onto the nose of the analyzer over the Kapton window.

Combination Standardization Cap/Welding Mask

The standardization/welding mask is shown in Fig. 2.5. The cap clips onto the front end of the analyzer and is used to standardize the system as described in Chapter 4. To attach the cap, snap it onto the nose of the analyzer over the Kapton window. Be sure that when attaching the cap, that the solid end (as opposed to the end with the ¼" wide slit) is covering the window. To remove the mask, slide it off to either side.

The opposite end of the standardization cap serves as a welding mask. This mask is used to shield the base metal from analysis, when analyzing a weld. It is important to use this mask since failure to do so will produce an alloy chemistry that is a mixture of the base metal and the actual weld. For best results:

a. Use the welding mask only for welds that are larger than the opening in the mask;
b. Make solid contact between the surface of the mask and the material to test;
c. Use the mask only in the Analytical Mode – not with the standard Fast ID library;
d. Consider using longer test periods to compensate for the smaller testing area – especially with more difficult separations.

If it is desirable to use the welding mask in FastID mode, a user can create a special "Welding Mask Library." Teach all relevant alloys with the welding mask is in position. Make sure these fingerprints are saved in library that contains ONLY fingerprints taught with a welding mask. When measuring a weld, make sure the "Weld" library is the only one selected. By creating a special finger print library using the welding mask, a user can get good results in the Fast ID Mode as well.

Figure 2.5 Standardization cap and welding mask. (Optional accessory)
The standard standardization cap does not have the welding slit.

2.7 TEST STAND: Alpha Configured for iPAQ (Windows CE®)

The test stand is designed as a docking station for the Alpha portable analyzer. It can be used as a bench-top system, or to test small samples.
There are two basic configurations for the Alpha-based test stand:

1. Utilizing the Windows CE operating system on the HP iPAQ computer running a proprietary Innov-X software application.(P/N A010)
2. Utilizing the Windows XP operating system on a customer-furnished PC (lap-top or desk-top) running a proprietary Innov-X software application.(P/N A010-C)

Configuration 1 is described in Section 2.7.

Note: Canadian users will require proof of XRF Operator Certification before the IPAQ and software can be shipped to them for hand-held operation.
See Section 2.9.1 for Canadian Regulatory Reference and Contact Point.

Configuration 2 is described in Section 2.8

A list of components is provided below.
An assembled stand (P/N A010) is shown in Figure 2.6:

Components of the test stand:

- Three (3) short legs
- Three (3) long legs
- Lower Stand
- Upper Stand
- Four (4) knobs for top plate
- Test stand cradle
- Clip for cradle.
- Adaptor cable (connects serial connector on iPAQ cradle to auxiliary port on analyzer)

Figure 2.6. Assembled Test Stand:
Analyzer Configured for iPAQ. (P/N A010)

Test Stand Assembly

1. Insert the three Short Legs through the holes in the Lower Stand by inserting the threaded screw through the holes. This will balance the Lower Stand on the table top. (Fig. 2.7).

Figure 2.7. Mounting Lower Stand onto Short Legs.

2. Mount the three Long Legs onto the Lower Stand by inserting the threaded screws from the Short Legs into the holes on the Long Legs and turning until snug. Remove iPAQ from analyzer by following the instructions in Figure 2.4. Place the analyzer into the gap in the Lower Stand as shown. (Fig. 2.8).

Figure 2.8. Mounting Long Legs onto Lower Stand and inserting analyzer.

3. Mount the Upper Stand onto the Long Legs. The Upper Stand has holes for the screws at the end of each of the Long Legs. The Upper Stand will also fit snugly over the front end of the analyzer. Be sure that the Upper Stand is mounted so that all three screws are inserted through the holes, and the front end of the analyzer is flush with the top surface of the upper stand. (Fig. 2.9).

Figure 2.9. Mounting Upper Stand onto Test Stand.

5. Put three knobs to secure test stand onto analyzer. The iPAQ clip can be secured with any of the knobs. This clip grabs the base of the iPAQ cradle to hold the iPAQ securely in place.

6. Place the iPAQ in the cradle and connect it to the Auxiliary Port on the analyzer using the serial cable adaptor.

Figure 2.10. Connecting iPAQ to Auxiliary Port on analyzer.

2.8 TEST STAND: Alpha Configured for PC Software (Windows XP®)

The test stand is designed as a docking station for the Alpha portable analyzer. It can be used as a bench-top system, or to test small samples.
There are two basic configurations for the Alpha-based test stand:

1. Utilizing Windows CE operating system on the HP iPAQ computer running a proprietary Innov-X software application. (P/N A010)
2. Utilizing the Windows XP operating system on a customer-furnished PC (lap-top or desk-top) running a proprietary Innov-X software application.(P/N A010-C)

A list of components is provided below.
An assembled stand (P/N A010-C) is shown in Figure 2.11:

Components of the test stand:

- Three (3) short legs
- Three (3) long legs
- Lower Stand with Cradle
- Upper Stand with hinged safety enclosure
- Three (3) knobs for top plate of Upper Stand
- Short adaptor cable (connects Test Stand junction to auxiliary port on analyzer)
- Long adaptor cable (connects Test Stand junction to serial port of user-furnished computer.

Configuration (1) is described in Section 2.7.

NOTE Canadian users will require proof of XRF Operator Certification before the IPAQ and software can be shipped to them for hand-held operation.
See Section 2.9.1 for Canadian Regulatory Reference and Contact Point.

Configuration (2) is described in Section 2.8

Figure 2.11. Assembled Test Stand:
Alpha instrument configured for PC (P/N A010-C)

Test Stand Assembly

1. Insert the three Short Legs through the holes in the Lower Stand by inserting the threaded screw through the holes.
   This balances the Lower Stand on the table top. (Fig. 2.12).

Figure 2.12. Mounting Lower Stand onto Short Legs.

2. Mount the three Long Legs onto the Lower Stand by inserting the threaded screws from the Short Legs into the holes on the Long Legs and turning until snug. (Fig. 2.13).

   Note the instrument cradle at the top-side center of the Lower Stand.

Figure 2.13. Mounting Long Legs onto Lower Stand.

Prepare the Analyzer for Test Stand use with the following steps:

3. If necessary, remove iPAQ from analyzer by following the instructions in Section 2.5 and Figure 2.4.

The Analyzer could be operated with Li-ion Battery packs, however for the following instructions, we will configure the Test Stand utilizing the AC Power Adaptor.

Figure 2.14. Rubber Boot Removed from Handle

4. Remove the rubber boot that secures the Li-ion battery pack. (Figure 2.14)

5. Insert the he AC Power Adaptor’s rectangular battery extension into the instrument’s handle.
   Ensure that the battery extension is pushed in firmly. (Figure 2.15)

Figure 2.15. AC Power Adaptor

6. Place the analyzer into the cradle located on the upper surface of the Lower Stand as shown. (Fig. 2.16).

Figure 2.16. Analyzer Mounted in Cradle

7. Before mounting the Upper Stand assembly, turn it over to review the orientation of the two serial control cables. (Figure 2.17)

8. At this time, securely attach the long serial cable to the inside serial connector.

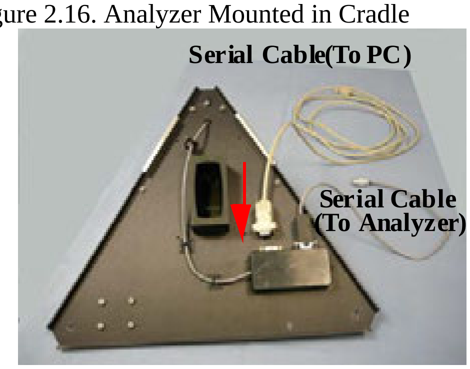


Figure 2.17. Serial Cables Junction Box

9. Mount the Upper Stand assembly onto the Long Legs. The Upper Stand has holes for the screws at the end of each of the Long Legs.
A portal in the Upper Stand fits snugly over the nose of the analyzer. (Figure 2.18)

   Ensure that the Upper Stand is mounted so that all three screws are inserted through the holes, and the front end (housing the sampling window) of the analyzer nose is flush with the top surface of the upper stand.

Figure 2.18. Mounting Upper Stand onto Test Stand.

10. Use the three knobs to secure the Upper Stand assembly to the Long Legs.

Figure 2.19 Fastening Knobs

Connect Analyzer to Computer

1. Connect the short serial cable from the Upper Stand assembly to the rear port of the analyzer. (Figure 2.20)

2. Connect the long serial cable from the Upper Stand assembly to the serial port of the customer-furnished PC.

TIP:
If this computer does not have an available serial port, use the serial-to-PC adapter (supplied) and connect to a USB port.

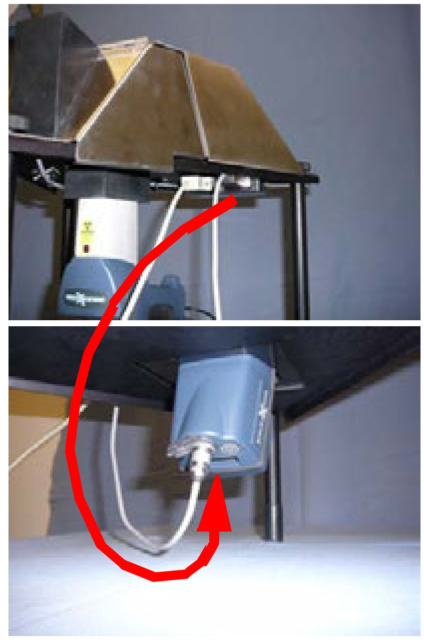


Figure 2.20. Connect Short Cable to Port on Analyzer.

Configure Test Stand

1. Turn power on by depressing the power button on the analyzer. (Figure 2.21) Ensure green light comes on.
2. Load the PCSW on to the PC following instructions included with the supplied CD.
   Ensure PCSW is able to communicate with the analyzer.

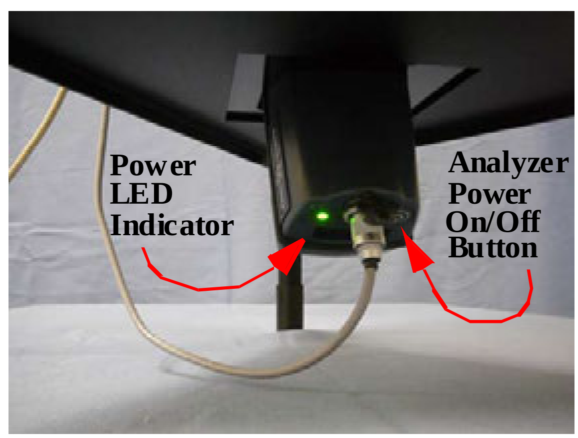


Figure 2.21 Analyzer Power On/Off Button and Indicator LED.

Operating Test Stand

1. Double-click on the Innov-X PC icon on the PC desktop to start the software.

   Cover must be **fully closed** for the standardization procedure or sample testing to start.

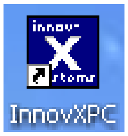


Figure 2.22 Innov-X Desk-top Software Application

2. Standardize the instrument using the round 316 standard (standardization coupon) provided. (Figure 2.23)

3. Select required mode from the options tab, set testing parameters and proceed with the analyses.

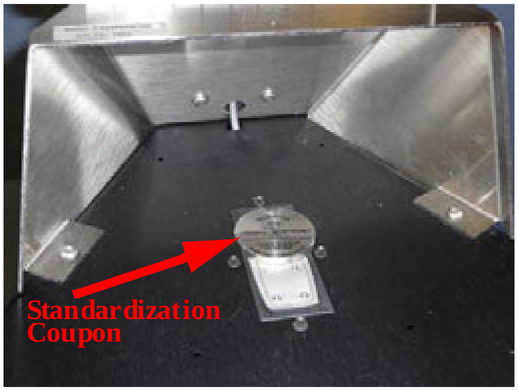


Figure 2.23. Standardization Coupon Positioned Over Sampling Window

NOTE: The red light on the test stand flashes when the x-rays are on during a test.

See Figure 2.24 for Top View of Test Stand.

Figure 2.24 Top View of Test Stand
(P/N A010-C)
Shows Canadian Radiation Caution Label

NOTE:

- If the cover is **raised** while the red light is flashing the test is **aborted immediately**.
- The test is aborted if there is **no sample** present on the window, even if the cover is closed.

TIP:

- If the test aborts when a very small sample is placed on the window, try putting a larger sample or more pieces of the same sample on the analyzer window.

2.9 MODE CONVERSION

To convert from desk-top, PC-based (Model No. A010-C) operation to hand-held, iPAQ-based (Model No. A010) operation use these steps:

- Remove the analyzer from the stand.
- Install an iPAQ pocket PC containing a flash card with the software and instrument parameters required to run the instrument.

NOTE: Canadian users will require proof of XRF Operator Certification before the IPAQ and software can be shipped to them for hand-held operation.

2.9.1 Canadian Regulatory Reference and Contact Point

Important Notice for all Canadian Users:
Canadian Federal Regulations (Radiation Emitting Devices (RED) Act and Regulations) require that all Canadian users must be certified. The certification program has been developed jointly by Health Canada and Natural Resources Canada in accordance with the requirements of International Standard ISO 20807:2004. Within the context of ISO 20807:2004, NRCan is the "Certification body".
For this certification contact: Natural Resources Canada, Nondestructive Testing Certification, CANMET, 568 Booth St., Ottawa, ON, K1A 0G1; Tel: (613) 943-1300; Fax (613) 943-8297.
Users are advised to contact their appropriate federal/provincial/territorial radiation protection agency for applicable rules of operation.

Chapter 3 Safety Information

3.0 IMPORTANT SAFETY INFORMATION

THE XRF SHOULD NOT BE POINTED AT ANYONE OR ANY BODY PART, ENERGIZED OR DE-ENERGIZED! The safe and proper operation of the Innov-X XRF instruments is the highest priority. These instruments produce ionizing radiation and should **ONLY** be operated by individuals, who have been trained by Innov-X Systems, Inc. and received a manufacturer's training certificate. Innov-X recommends that operators and companies implement a written Radiation Safety Program, with safety components specific to the site and application of use of the instrument. The Radiation Safety Program should be reviewed annually and revised appropriately by a competent individual.

Innov-X analyzers must be used by trained operators, according to the instructions presented in this manual. Improper usage may circumvent safety protections and could potentially cause harm to the user. Pay attention to all warning labels and messages.

Important Notice for all Canadian Users:
Canadian Federal Regulations (Radiation Emitting Devices (RED) Act and Regulations) require that all Canadian users must be certified. The certification program has been developed jointly by Health Canada and Natural Resources Canada in accordance with the requirements of International Standard ISO 20807:2004. Within the context of ISO 20807:2004, NRCan is the "Certification body".
For this certification contact: Natural Resources Canada, Nondestructive Testing Certification, CANMET, 568 Booth St., Ottawa, ON, K1A 0G1; Tel: (613) 943-1300; Fax (613) 943-8297.
Users are advised to contact their appropriate federal/provincial/territorial radiation protection agency for applicable rules of operation.

The Innov-X analyzer is a very safe instrument when used according to manufacturer's recommended safety procedures as detailed in this chapter.

Radiation levels during testing are < 0.1 mR/hr on all surfaces of the analyzer except at or near the exit port

for the radiation. This means that if an operator follows standard operating procedures, they will not obtain any detectable radiation dose above naturally occurring background radiation, on their hand while holding the analyzer, or on any area of their body.

This chapter details specifics of the radiation levels. It covers both standard (safe) and un-safe methods of operation, it provides radiation emission information, and also provides dose estimates for unsafe operations.

3.1 GENERAL SAFETY PRECAUTIONS AND INFORMATION:

Retain and follow all product safety and operating instructions. Observe all warnings on the product and in the operating instructions. To reduce the risk of bodily injury, electric shock, fire and damage to the equipment, observe the following precautions:

Heed service markings. Except as explained in this documentation, do not service any Innov-X product yourself. Opening or removing covers may expose you to electric shock. Service needed on components inside these compartments should be done only by Innov-X Systems, INC.

Damage requiring service:

- The power cord, plug or battery contacts for the battery charger are damaged.
- Liquid has been spilled or an object has fallen onto the instrument.
- The instrument has been exposed to rain or water.
- The instrument has been dropped or damaged.
- There are noticeable signs of overheating.
- The instrument does not operate normally when you follow operating instructions.

Safety Precautions:

Use the correct external power source: Ensure that the voltage is appropriate (100V-240 V/ 50-60 Hz) for charging the battery packs. Do not overload an electrical outlet, power strip, or convenience receptacle. The overall load should not exceed 80% of the branch circuit rating.

Use cables and power cords properly:
Plug the battery charger into a grounded electrical outlet that is easily accessible at all times. Do not pull on cords and cables. When unplugging the cord form the electrical outlet, grasp and pull the cord by the plug.

Handle battery packs properly; do not: disassemble, crush, puncture, short external contacts, dispose of in fire or water, or expose a battery pack to temperatures higher than 60 ^{o}C (140 ^{o}F).Do not attempt to open or service a battery pack.

WARNING: Danger of explosion if battery is incorrectly substituted. Replace only with Innov-X specified batteries. Used batteries may be returned to Innov-X Systems for disposal.

3.2 INNOV-X SYSTEMS – RECOMMENDED RADIATION SAFETY TRAINING COMPONENTS

Individual Companies and States have specific regulations and guidelines for the use of X-ray tube generated ionizing radiation. The purpose of the recommendations below is to provide generic guidance for an ALARA - best practice - approach to radiation safety. These recommendations do not replace the requirement to understand and comply with the specific policies of any state or organization.

1. **Proper Usage.** Never point the instrument at another person. Never point the instrument into the air and perform a test. Never hold a sample in your hand and test that part of the sample.
2. **Establish Controlled Areas.** The location of storage and use should be of restricted access to limit potential exposure to ionizing radiation. In use, the target should not be hand held and the area at least three paces beyond the target should be unoccupied.
3. **Specific Controls.** The instrument should be stored, in a locked case, or locked cabinets when not in use. When in use, it must remain in the direct control of a factory trained, certified operator.
4. **Time - Distance - Shielding Policies**. Operators should minimize the time around the energized instrument, maximize the distance from the instrument window, and shoot into high density materials whenever possible. Under no circumstances should the operator point the instrument at themselves or others.

5. **Prevent Exposure to Ionizing Radiation**. - All reasonable measures, including labeling, operator training and certification, and the concepts of time, distance, & shielding, should be implemented to limit radiation exposure to ***as low as reasonably achievable*** (ALARA).
6. **Personal Monitoring.** Radiation control regulations may require implementation of a radiation monitoring program, where each instrument operator wears a film badge or TLD detector for an initial period of 1 year to establish a baseline exposure record. Continuing radiation monitoring after this period is recommended, but may be discontinued if accepted by radiation control regulators. Please refer to Sect. 3.10 for a list of providers of film badges.

3.3 INNOV-X SAFETY FEATURES

The Innov-X analyzer is very safe when used correctly, however the analyzer does emit radiation through the analyzer window, and all precautions must be taken to reduce exposure to this radiation. In order to minimize the possibility of accidental exposure, the following safety features are standard in all Innov-X analyzers.

1. "Deadman" trigger. The trigger must be held for the duration of the test. This requires that the user consciously depress the trigger whenever x-rays are emitted, and ensures that the analyzer is attended at all times while x-rays are emitted.

   Upon completion of safety training, an INNOV-X certified trainer may deactivate this feature upon request. The deactivation of the trigger is recommended only if long tests are required (such as for soil mode) and if the unit is used primarily by only 1 or 2 users who utilize it frequently, in a very controlled environment. In situations where multiple users are sharing the unit, it is recommended that the deadman trigger remain active.

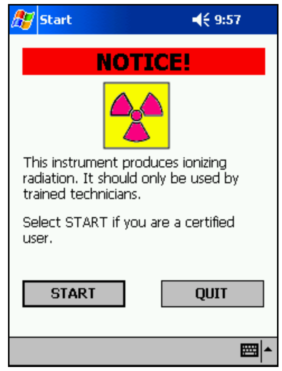
   Note: Canadian Regulations <u>require</u> that the deadman trigger be used at all times. This feature will not be disabled for usage in Canada.

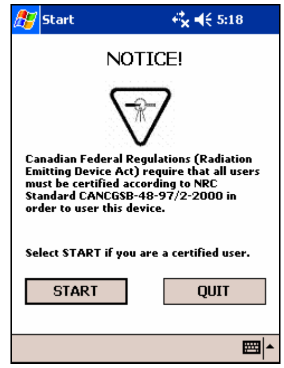
2. Software Trigger lock. Before using the trigger, the user must tap on a lock icon located in the lower right hand corner of the iPAQ screen. The user must then confirm that they wish to unlock the trigger. If the instrument is used continuously, the software trigger lock will remain off. If five minutes elapse between tests, the trigger will lock automatically.

3. Software Proximity sensor. The software requires that a sample be present in front of the analyzing window. This prevents the accidental exposure of bystanders to an open beam. If the analyzer detects that a sample is not present, it will abort the test and shut off x-rays two seconds after the test is started.

3.4 PERFORMING A TEST FOLLOWING APPROPRIATE RADIATION SAFETY PROCEDURES

Starting the Analyzer:





When an operator opens the Innov-X software on the iPAQ, he or she will be presented with one of the displays shown to the right. Provided an operator has received training from an authorized Innov-X trainer, he/she should tap the START button to begin using the analyzer.

In Canada, INNOV-X ANALYZERS MUST BE OPERATED BY CERTIFIED USERS ONLY!

From this point the operator is presented with the main menu of the analyzer to choose an operating mode and begin testing (described in Chapter 4). The remainder of this section is dedicated to operational and safety aspects that pertain to safe use and storage of the analyzer.

Starting a test using the trigger.

When the trigger is depressed, the analyzer supplies power to the x-ray tube and opens the shutter to emit x-rays.

If deadman trigger is enabled, the trigger must be depressed for the duration of the test. Releasing the trigger will close the shutter and immediately end the test. If deadman trigger is disabled, pulling the trigger once will start a test, pulling it again will stop it.

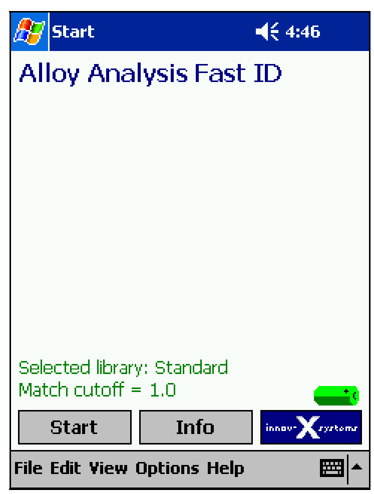
Figure 3.1 Handle of analyzer. Trigger is located at top of handle.

Starting a Test Using the “Start” Icon on the iPAQ Screen

This feature is disabled in all units shipped. It will become active only if the “deadman” trigger is disabled.

An operator may also begin a test by pressing the **Start** button on the touch screen, as shown at the right. The **Start** button, rather than the trigger, is generally used when the analyzer is docked into the testing stand.

This Feature is not available in Canada. All tests must be started via the trigger.



3.5 CORRECT AND INCORRECT INSTRUMENT USAGE:

The Innov-X XRF analyzer can be used in several different testing configurations. Safety guidelines are described for each configuration.

Configuration 1: Usage as a Handheld Alloy Analyzer:

In this configuration the analyzer is held in the hand, placed on various types of samples and a test is performed. Samples include pipes, valves, large pieces of scrap metal, basically any sample large enough to be tested in place, rather than held in the operator's hand. Point the instrument at a metal sample such that no part of your body including hands and/or fingers is near the aperture of the analyzer where x-rays are emitted.

Using the analyzer in this manner assures that the operator will not obtain a radiation dose to any body part or extremity in excess of naturally occurring background radiation. The radiation at any surface of the analyzer is < 0.1 mR/hr except at the exit port and the immediate area around the exit port.

The user should take care that personnel are not located within 3' (1 m) of the front end of the analyzer during testing, in the direction of the x-ray beam. Provided the analysis window is completely covered, there is virtually no radiation being emitted around the area of the sample. However, if a small component or curved surface is being analyzed, some radiation will be detectable.

Configuration 2: Usage in the Testing Stand

Innov-X strongly recommends that testing small pieces or small samples (rod, fasteners, turnings, XRF sample cups, bagged samples, etc.) be analyzed using the Innov-X Testing Stand. This allows the sample to be placed onto the analysis window of the analyzer without requiring the sample to be held by the operator. See figure below titled "Testing Stand Operation."

Note for Canadian Usage: The testing stand is not available for use in Canada at this time because it has not received regulatory approval yet. When an interlocked version of the testing stand has received regulatory approval, it will be available for sale into Canada. Please contact Innov-X Systems for an update on this process at 781-938-5005.

Figure 3.2 Testing Stand Operation. Please refer to **Section 2.7: Testing Stand** for assembly instructions.

Warning: Innov-X strongly recommends that operators do NOT hold samples in their hand for testing. Never hold a small sample in your hand, and test that sample, such that your hand is exposed to the x-ray beam being emitted from the analyzer. This type of testing produces a small but non-negligible radiation dose to the operator's hand. Please see **Section 3.7: Radiation Doses for Several Scenarios** for dose levels. Also, see **Figure 3.4** for an example of incorrect usage.

Figure 3.2.

Testing of Small Components:

Operators often are required to test small components, particularly in the field of alloy analysis. Examples of small samples include turnings, weld rod, wires, fasteners, nuts and/or bolts.

There are specific procedures to test small components. These procedures should be followed at all times. **Never hold a small part with your fingers or in the palm of your hand and perform a test. Doing so may deliver a significant dose of radiation to your fingers or hand.** Please refer to the Examples of Mis-use below.

Method 1: Testing a sample lying on a flat surface.

Figures 3.2.: Performing a testing for a sample lying on the surface of a table. This is a good way to test small samples, rather than holding them in your hand.

To analyzer small sample:
- Place the sample onto a flat surface.
- Place the window of the analyzer onto the sample and begin the test.

Safety Precautions:

Do not test samples in this manner at a desk or table where the operator is sitting. If the desk is made of wood or another non-metallic material, some radiation will penetrate the desk and may provide exposure to legs or feet if the operator is sitting at the desk or table.

Analytical Precautions:

If the sample does not completely cover the window, be sure the surface used does not contain metals or even trace levels of metals, as this may affect the accuracy of the XRF result. The XRF may report the presence of additional metals in the surface material. For this type of testing, it is good to place the sample onto a piece of 1100series aluminum alloy and perform the analysis. The operator should disable the aluminum analysis capability (See Section 8.3.3 in the manual for instructions).

Method 2: Use the testing stand as described above (see also Fig. 3.2).

Examples of Incorrect and Possible Unsafe Operation:

Improper Operation, DO NOT TEST SAMPLES LIKE THIS:

Exposure to the operator's hand/fingers will likely be minimal for this type of a testing, because the operator's hands and fingers are not in the primary beam. However, Innov-X believes that this type of the analyzer sets a poor safety precedent in that any operation where the operator places their fingers or hands near the window should not be permitted.

Figure 3.3. Incorrect Usage. While the dose to the operator's fingers/hand is negligible, testing this way sets a poor safety example for other operators, possibly encouraging other unsafe usage. Innov-X strongly recommends against this type of testing.

DO NOT TEST SAMPLES LIKE THIS:
Never hold a sample in your hand such that any part of your body or appendages are exposed to the x-ray beam. Testing samples in this way may generate significant radiation exposure (up to 27 R/hr) to the operator's fingers.

Figure 4.4 Extreme example of incorrect usage. An operator should NEVER hold small samples by hand

3.6 RADIATION WARNING LIGHTS AND LABELING:

3.6.1 Main Power switch and Indicator Light:

The main power switch is found on the rear of the unit and is shown in the figure to the left. Pressing the switch for several seconds will turn on the main power. A green LED indicates the main power is on. The main power must be turned on in order to operate the unit however, this switch DOES NOT turn on the x-ray tube. No power will be supplied to the x-ray tube unit the Innov-X software is started.

3.6.2 Probe Light and Probe Label:

The Innov-X analyzer is equipped with warning lights that alert the operator when the tube is receiving power, and when x-rays are being emitted from the analyzer. Please see Fig. 3.5.

When the red light on the front nose of the analyzer is ON continuously (not blinking), this indicates the x-ray tube is receiving a low level of electrical power and the shutter is closed. The system is producing a low level of x-rays internally in this condition, but the shutter is providing adequate shielding to keep x-ray levels below levels of detection. The instrument is safe to be carried around or set down in this configuration.

When the red light is blinking, this indicates the tube is powered, the shutter is open and the analyzer is emitting x-ray radiation out of the analysis window. The analyzer should only be pointed at a sample, or be in the testing stand with a sample resting on the window, in this configuration.

3.6.3 Display on Back of Analyzer:

The display on the back of the analyzer, shown in Fig. 3.6, provides a “testing” message to indicate that the x-ray tube is energized and the shutter is open. This display is for testing conditions (i.e. overhead) where the operator cannot see the Probe Light or the iPAQ display.

3.6.4 Label Behind iPAQ:

The analyzer also has a label just below the iPAQ indicating, as shown in Figure 3.7:

CAUTION: Radiation. This Equipment Produces Radiation When Energized.

This label is required by most regulatory agencies. The term “When Energized” refers to the condition where the tube is fully energized and the shutter is open. This condition is also indicated by the red blinking light on the probe.

Figure 3.5. Probe light and labeling. When the light is on continuously, the x-ray tube is receiving minimal power and it is producing a minimum level of x-rays. The shutter is also closed so there is no radiation exposure to the operator or bystanders.

Figure 3.6. Back light on analyzer.

Figure 3.7. Label behind iPAQ. Top version is used in Canada

3.7 RADIATION LEVELS FROM ANALYZER

Two pictures of the analyzer are shown below. In the first picture, all the relevant components referenced in this radiation safety section are displayed and labeled. The second picture shows a close-up of the front end of the window. The four sides A, B, C and D are indicated on this picture because they are referenced in terms of radiation levels output by the analyzer. The measured radiation levels for standard operating conditions are shown in the figures and tables below. Standard operating conditions are tube voltage operating at 35 kV, tube current of 5 uA, and 2 mm aluminum filtration.

Figure 3.8 Innov-X Analyzer, Side View

Figure 3.9 Innov-X Analyzer, Front View

Radiation Levels (mrem/hr) for Alloy Analysis, Standard Beam Conditions: 35kV, 5 uA, 2mm aluminum filtering:

Sample at Window	Trigger	Location A (Top)	Location B (Right Side)	Location C (Bottom)	Location D (Left Side)
Blank (Air)	<0.1	<0.1	<0.1	<0.1	<0.1
Metal	<0.1	<0.1	<0.1	<0.1	<0.1

Table 3.1. Dose rates (units of mrem/hr) at various locations with a metal sample covering the window and with no sample present. For "no sample" the analyzer is shooting the x-ray beam into air.

As shown in the Table 3-1, the dose to the operator's hand is negligible. The radiation levels at the side surfaces of the instrument snout (aluminum housing) are all <0.1 mrem/hour. Despite these low levels of radiation, there is no reason for any body part to be in the locations denoted A, B, C and D!

Table 3-2 shows the radiation levels directly in the x-ray beam that is emitted from the analyzer. Radiation levels at the exit aperture (or "port") are substantial. There is no reason for the operator or any personnel to be exposed by the direct beam. Operators should never hold samples in their fingers or cupped in their hands, as this may generate a significant radiation exposure.

Operations should never point the analyzer at another person and start a test, as this may also provide significant exposure to the person if they are within a few inches of the port of the instrument.

Radiation Levels in the Primary Beam Versus Distance from Port:
For Alloy Analysis, Standard Beam Conditions: 35kV, 5 uA, 2mm aluminum filtering:

Tube Conditions	At Trigger, or any part of operator's body.	At Window	4 inches	12 inches	36 inches	48 inches
35 kV, 5 uA, 2 mm Al	<0.05	28,160	2,080	186	24	14

filtering						
15 kV, 25 uA, thinner filter material	< 0.05	27,780	1,620	145	19	11

Table 3.2. Dose rates (units of mrem/hr) in the direct x-ray beam being emitted from the analyzer

3.8 RADIATION DOSES FOR SEVERAL SCENARIOS

In this section we provide data, concrete examples of use and misuse of the analyzer and common questions and answers we encounter when training personnel on the safe use of the Innov-X analyzer. The goal is to explain scenarios of safe versus improper usage of the analyzer.

The table below presents radiation doses for normal operating conditions and also for examples of misuse of the analyzer and even extreme misuse. Innov-X provides installation training that includes detailed radiation safety training and documentation designed to prevent misuse of the analyzer

Example of Instrument Usage	Radiation Exposure and Comments
Normal Operation - Dose to Hand: User analyzes samples according to standard operating procedures described in this manual. Assumption: Operator using system with x-ray tube ON for 8 hours/day, 5 days/week, 50 weeks/year. (Practically constant usage).	Maximum exposure is to operator's hand, at the trigger. Exposure is < 0.1 mrem/hr. Annual exposure to hand is then < 200 mrem (2mSv). US: Maximum exposure under OSHA regulations is 50,000 mrem annually. Thus continuous operation provides a dose that is at least 250 times lower than maximum allowed by OSHA. Canada: Maximum exposure under ICRP regulations is 500 mSv for radiation workers and 50 mSv for the general public. Thus continuous operation provides a dosage 250 times lower for a radiation worker and and 25 times lower for the general public.
Normal Operation – Dose to Torso: Analyzer is used under the same operating conditions described above.	Exposure to Torso is so low it cannot be measured. To be conservative we use the same figure as the trigger, <0.1 mrem hr. Annual exposure using operating conditions above is < 40 mrem. (0.4 mSv) Maximum allowed is 5,000 mrem under OSHA and 20 mSv under ICRP for radiation workers (1 mSv for general public).

For the x-ray energy emitted by portable XRF analyzers (10-60 keV region), the bone in the fingers will absorb radiation about 3-5 times more than soft tissue, so the bone would be at an elevated radiation risk compared to soft tissue. For this reason no person shall hold a test specimen in front of the window with the fingers in the direct beam, or direct the beam at any part of the human body. Reference: Health Physics 66(4):463-471;1994.

Misuse Example 1:
Operator holds samples in front of window with fingers, such that fingers are directly in the primary beam. Do not do this!.

For fingers at the port, in the primary beam, the maximum dose to the fingers is 28,160 mrem/hr. Assume an operator performs a 10 sec test (typical). The dose to the operator's fingers or hand is 28,160 x (10/3600) = 78 mrem. If the operator did this 641 times/year they would exceed the allowable annual dose of 50,000 mrem to an extremity. In Canada, the maximum allowed dose is 500 mSv/year (Canada ICRP radiation worker) or 50 mSv/year (Canada ICRP general public).

If the test time was 30 seconds instead of 10 seconds, the operator would receive a dose of 234 mrem for each exposure, and thus would exceed the annual safe limit of 50,000 mrem after 213 tests.

Even though it is unlikely to make this mistake so many times in a year, do not even do it once. Take the extra time to test a sample on a surface or use a testing stand. **Note: If the operator takes an average of only two shortcuts per week and places his/her fingers within the primary x-ray beam at the window, they will exceed the annual dose rate.**

Misuse Example 2:
Operator places analyzer against body and pulls the trigger to start a test. Analyzer tests to preset testing time (usually 10 seconds) unless operator pulls trigger again to stop test. This applies to analyzer being in contact with operator or with bystander.

Dose at exit of sampling window is 28,160 mrem/hr.

Dose for a 10 second exposure with analyzer in contact with Torso: 78 mrem (.78 mSv).
US: If an operator did this act 64 times in a year, the operator would exceed the annual safe dosage to the torso of 5,000 mrem/year. The maximum dose of 5,000 mrem/year is a whole body limit, which does not truly apply in this case because the x-ray beam size is small (about 2 cm^2 area – 1.5 cm x 1 .3 cm – at the port). Applying correction factors for the beam size is complex and beyond the scope of this manual. The important point is that for proper operation there is no reason to ever exposure any part of the human body directly to the x-ray source. This example serves to provide estimated exposure in the event this occurs.

If the testing time was 30 seconds instead of 10 seconds, thus the operator placed the port against his body or that of a bystander and performed a 30 second test, the dose would be 234 mrem. This is about the same as a mammogram. Repeating this gross mis-use 22 times would exceed the annual allowable limits.

Canada: Radiation worker would have to repeat this example (234 mrem exposure) of gross misuse 8 times to achieve the ICRP level of 20 mSv. (general public 1.3 times to achieve limit of 1mSv)

Misuse Example 3:
Operator manages to initiate a test for 10 seconds and exposes a bystander that is standing 12" away from analyzer port. What is exposure to bystander?

Note: The proximity sensor would automatically shut down the x-ray tube after 2 seconds, so this is an extremely improbable occurrence.

Note 2: Equations to scale these to other scenarios involving longer or shorter tests, and bystander being at distances other than 12" are provided at right.

Dose to bystander at 1 foot is 350 mrem/hr. For a 10 second exposure dose is 1 mrem. This is 5,000 times lower than the allowable dose to a worker in a year. This would have to happen 5,000 times to for that worker or bystander to obtain the maximum allowable dose.

Formula for calculating other scenarios:

$$Dose = 1mrem \left(\frac{13.25}{D + 1.25} \right)^2 x \left(\frac{t}{10} \right)$$

D = distance from port in inches
T = testing time

Example: Bystander is 3' away from port for a 30 second test. In this case the dose is calculated as:

$$Dose = 1mr \left(\frac{13.25}{36 + 1.25} \right)^2 x \left(\frac{30}{10} \right) = 0.38mrem$$

US OSHA: Maximum allowable level is 5,000 mrem assuming bystander's torso is exposed. Thus, this misuse would have to occur 12,500 times in a year to the same bystander before that bystander achieved his maximum allowed dose.
ICRP: 5000 times for rad worker, 250 for general public

Comparative: Radiation Doses from Typical Exposures to Ionizing Radiation

Common medical and/or dental x-rays:	20-30 mrem each.
Mammogram:	100-200 mrem
Flying in a commercial jet coast to coast (6 hrs.):	1-2 mrem.
Daily exposure from background radiation: * depends on geographic location	0.3 to 0.5 mrem/day

Table 3.3 Radiation Doses from Typical Exposures to Ionizing Radiation

From the above table, a single case of analyzer misuse, thus producing a one-time exposure of 70-250 mrem, is comparable with single-event common medical x-ray procedures such as an annual chest x-ray or mammogram, or 25-50 airline flights in a year, and thus is not considered harmful. Regular misuse, such as taking safety shortcuts twice weekly, produces radiation exposure that greatly exceeds these typical levels and should be avoided entirely.

3.9 COMMON QUESTIONS AND ANSWERS REGARDING RADIATION SAFETY

Question: When I'm shooting a piece of pipe or valve on a rack or on a table top, is there any exposure to people standing in other locations, or standing several feet away from the analyzer?

Answer: Even a thin amount of a dense metal sample (1-2 mm thickness, not Al alloy) is enough to completely attenuate the x-ray beam emitted from the Innov-X analyzer. Shooting a piece of material that covers the sampling window on the analyzer will completely shield any bystanders from radiation exposure. However, good practice recommends that the area for at least 4-5 feet in front of the analyzer is clear of people.

Question: If I forgot to switch the safety on the trigger to “ON”, I pick up the analyzer and accidentally pull the trigger, is that dangerous to nearby personnel?

Answer: No, this example of misuse is not dangerous, but it may produce a non-negligible radiation exposure to nearby personnel. For an exposure to occur, the following things must happen. First, you must be holding the analyzer so that a bystander is actually standing in the x-ray beam being emitted. Just being near the analyzer is totally safe otherwise. Second, the bystander must be within 1-3 feet from the nose of the analyzer in addition to being in the beam path, to receive any appreciable dose. If all of these conditions are true, the dose received by a bystander is still extremely low. It ranges between 0.1 to 0.5 mrem depending on the exact location of the bystander. This dose is 10,000 to 50,000 times less than the allowed dose. Please see Misuse Example 4 in the table above.

Question: Do I need to create restricted areas where I am using the analyzer?

Answer: No, provided you are following normal operating procedures there is no reason to restrict access to an area where the analyzer is in use. The operator should take precautions to keep any personnel more than 3 feet away from the sampling window of the analyzer in the event of accidental misuse as detailed above. Should the operator also elect to test small components like weld rod as shown in Figure 3.3, the operator should also be sure that no personnel are standing within about 4-5 feet of the sampling window.

Question: How does the x-ray tube in the Innov-X system compare to a radiography system used for taking images of metal parts.

Answer: The x-ray tube used in the Innov-X system produces between 1,000 and 10,000 times lower power than most radiography systems (0.5-1 watt for Innov-X versus kW for radiography systems). This is because a portable XRF is designed to perform surface analysis of alloys and other samples, whereas radiography systems are designed to shoot x-rays entirely through metal components in order to obtain an image on the other side of the object being bombarded with x-rays. For example, many tube-based radiography systems use a 300-400 kV tube and currents in the tens or hundreds of milliamps (mA). The Innov-X analyzer uses a tube operating at 35 kV and 5-30 micro-amps. The radiation levels produced are therefore thousands or tens of thousands times lower with the Innov-X system.

Question: Should we use dosimeter badges with the Innov-X analyzer.

Answer: Dosimeter badges are required by some states, and optional by other states. Innov-X recommends that operators wear badges, at least for the first year of operation, as a general precaution to flag any misuse of the analyzer. Dosimeter badges are available for the torso (generally worn on the belt loop or shirt pocket) and are available as “ring” badges. The best single badge to obtain is a ring badge that is worn on a finger, on the opposite hand used to hold the analyzer. This will record accidental exposure for the most likely case – an operator grabbing a small sample and holding it in one hand while analyzing it. Note: these badges generally have a threshold of 10 mrem, and are renewed monthly. So it will take several cases of misuse even to obtain a reading on a typical badge. When purchasing a badge, obtain the type used for x-ray and low energy gamma ray radiation.

3.10 SAFE GUARDS AND EMERGENCY RESPONSE

The main safeguards to use as an owner of an Innov-X portable XRF are really intended to restrict access to properly trained operators:. **Note: Canadian regulations require certified personnel to use the device, refer to section 3.0 in this chapter.**

1. Keep the system in a controlled location, where only authorized users are likely to have access to the analyzer at any given time.
2. Make a simple sign that is kept with the analyzer indicating that an operator must have completed a training class provided by your company or must have attended an Innov-X training course in order to use the analyzer. Note that when the Innov-X system is turned on, the screen displays a message indicating that the system should only be used by authorized personnel.

Emergency Response:

Because the Innov-X system is a battery operated, x-ray tube based analyzer, the emergency response plan is very simple. If the operator believes the analyzer is locked up in an "OPEN" position, they should do two things:

1. Press the On/Off switch on the base to power the analyzer off. The green LED indicator will turn off, indicating system power is off. At this point it is not possible for the analyzer to be producing x-rays.
2. As an additional precaution, the operator may remove the battery trap door at the bottom of the analyzer (have the nose pointing away from personnel), and pull out the battery. Even if the operator has failed to properly power the system off in Step #1, removing the battery guarantees that no x-rays can be produced. There is no electrical power being provided to the x-ray tube.

Note: It would be highly unusual for an operator to somehow lock up the analyzer with the x-ray tube powered on. This would require the operator to crash the iPAQ during an analysis. If this happens the analyzer will shut off the x-ray tube 10 seconds after the last communication with the iPAQ. However, if at any time the operator believes the x-ray tube is on and no test is in progress, powering off the analyzer and restarting will automatically shut down the x-ray tube and close the shutter. It will no longer be possible to produce x-rays at this point.

3.11 DOSIMETER BADGES

Dosimeter badges are provided as a monthly service by several companies, listed in this section (see below). The badges are generally provided monthly, and the operator returns the previous month badges to the company for analysis. The operator receives a monthly report showing any personnel with readings higher than typical background radiation.

Dosimeter badges are required by some states, and optional by other states. Innov-X recommends that operators wear badges, at least for the first year of operation, as a general precaution to flag any misuse of the analyzer. Dosimeter badges are available for the torso (generally worn on the belt loop or shirt pocket) and are available as "ring" badges. The best single badge to obtain is a ring badge that is worn on a finger, on the opposite hand used to hold the analyzer. This will record accidental exposure for the most likely case – an operator grabbing a small sample and holding it in one hand while analyzing it. Note: these badges generally have a threshold of 10 mrem, and are renewed monthly. So it will take several cases of misuse even to obtain a reading on a typical badge. When purchasing a badge, obtain the type used for x-ray and low energy gamma ray radiation.

<u>Dosimeter Companies:</u>

Here are two companies that provide badges as a regular service. There are certainly many more.

Landauer Inc.
Glenwood, IL
708-755-7000

AEIL
Houston, TX
713-790-9719

3.12 TYPICAL REGISTRATION REQUIREMENTS

Innov-X maintains a database of the registration requirements for every state, including sample registration forms. Most states require some form of registration, and generally they require the registration to be received within 30 days of receipt of the instrument. Some states require no registration, while a few require notification in advance. Please contact Innov-X for specific questions regarding the state where the instrument will be used, or for copies of registration forms.

In general a company will have to provide the following information regarding the device:

1. Purpose of device. Generally this is “Analytical” or “Industrial.” Be sure to inform the state registration office that the device will NOT be used for radiography or for medical uses.
2. Radiation Safety Officer – Monitors training, safe use, and controls access to the instrument.
3. Authorized Users – Trained by Innov-X Factory Authorized Representatives in the safe and proper use of the XRF.
4. Operating parameters of the analyzer – 35 kV, 5-30 micro-amps.
5. Type of system, either fixed, mobile or portable. Generally the correct choice is “Portable.”
6. User Training Specified – Indicate that only individuals receiving manufacturer training, documented by a manufacturer’s training certificate will operate the instrument.
7. Personal Monitoring. This may be required by radiation control authorities. Many registration forms will ask that you indicate whether or not you intend to perform dosimeter monitoring.
8. Copy of Registration & Manual at the Job Site

If you have any questions regarding the type of registration form or filling out the form, please contact Innov-X Systems. Many states may confuse a portable XRF system that uses a tube with medical or industrial radiography systems. This is because of the relative newness of portable tube-based systems. In all likelihood, Innov-X personnel have experience providing the necessary documentation to the state in question, and can readily assist the customer in this process.

Chapter 4 Operation

4.0 OPERATION - GENERAL

Power to the instrument is controlled by the ON/OFF button located at the rear of the analyzer. The green LED next to this button will illuminate when the analyzer power is on. The iPAQ operates on the Microsoft Windows CE ® operating system and is activated separately by the power button on the right top face, just over the display. The trigger is locked via the software.

4.1 WORKING WITH THE HP iPAQ Pocket PC®

The Microsoft Windows CE ® operating system and Innov-X software provided on the iPAQ handheld computer are operated by user input through the touch screen. For comprehensive details on the iPAQ's operation, please refer to the iPAQ reference materials included with your unit.

General tips

- The Start Menu is found in the upper left corner of the iPAQ screen. This is used to launch all applications, including the Innov-X Systems Analyzer software.
- The instrument is designed as a "point and shoot" system that requires little, if any, entry of information for most operations. In the event the user modifies the grade library, enters testing information data, or performs other functions, it will be necessary to enter data via the virtual keyboard, which can be accessed by tapping the keyboard icon in the lower right corner. The iPAQ also includes character recognition software. This can be selected from the drop-down menu to the right of the keyboard icon.
- The File toolbar which will be used to Change Functions, Screens and Options is located at the bottom of the screen.
- It is possible to cut, copy, rename and delete files from within Windows File Explorer by selecting the file to be modified and holding the stylus on the screen for 2 seconds.
- Pressing buttons on the bottom of the iPAQ will perform various functions that are described in the iPAQ documentation. The button on the right hand size of the analyzer is the iPAQ task manager. Pressing this button will show all programs that are currently open. Open files can be closed from this menu. Simply hold the stylus on the file for a few seconds. The option to close the file will appear.

4.2 OPERATION - MAIN SOFTWARE SCREENS

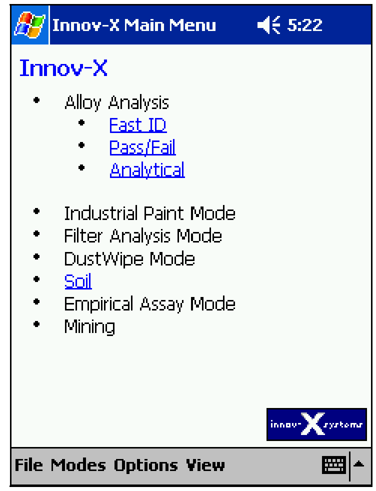
The Innov-X Software consists of three main screens:

- **Main Menu screen:**   Used to select the analysis mode, open the results screen, and change the administrator password.
- **Analysis Screen:** Used to change settings, edit libraries, and perform tests.
- **Results Screen:** Displays results from current reading, allows scrolling back to previous test results.   Allows recorded data to be exported to a comma delimited file which is directly compatible with Microsoft Excel.

4.2.1 Innov-X Main Menu

The main menu below appears upon startup. The Main Menu allows you to choose an analysis mode, as well as perform certain administrative functions such as changing your login password. The modes which are available on the analyzer are shown in blue. For information on adding additional analysis modes to an analyzer, please contact the Innov-X Sales Department at 781-938-5005.

- **Use the Main Menu to select the desired analysis mode.** The analysis mode can be selected by either tapping on the name of the method (shown in blue) or by selecting the appropriate mode from the Modes menu.
- The administrative password can be changed by selecting ***Options → Change Password.***
- It is possible to go directly to the Results Screen by selecting ***View→Results***. If the results screen is opened in this manner, it is possible to view results when the iPAQ is not connected to the analyzer.

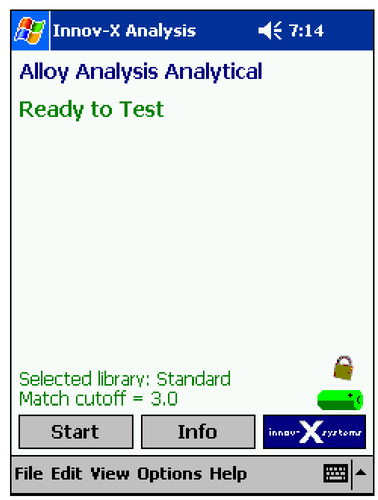


4.2.2 The Analysis Screen

Selecting a mode opens the analysis window for that mode. All data acquisition and analyzer control are done from this window. This window allows the user to start or stop an analysis, change testing parameters, and modify the fingerprint and grade libraries (Alloy Analysis only).

The analysis screen runs continually while during normal instrument operation. From the results menu, it is always possible to go back to the Analysis screen by selecting ***File→Exit*** or by tapping the X in the upper right hand corner of the screen.

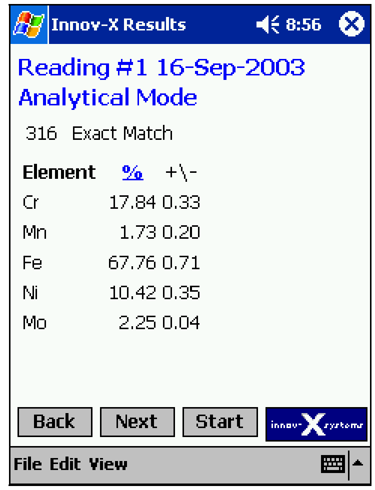
The analysis screen for Analytical mode is shown to the right. Screens from other modes are similar and will be described in later in this manual. The analysis screen shows the name of the mode that is currently active, a start/stop button (which is inactive in most cases), an info button that is used to enter descriptive information for any given test, a trigger lock and a battery indicator. In addition, a message appears directly below the name of the mode which will indicate the current state of the analyzer. Typically it reads “Ready to Test,” but also provides other information in certain circumstances. Any mode specific information will be displayed at the bottom of the screen above the menu choices.



4.2.3 The Results Screen

The Results screen displays the current reading and old data. All data handling functions such as exporting and deleting readings are carried out from this screen. Once the Results Screen is open, the user may start new tests without going back to the analysis screen by pulling and holding the trigger. Tapping the X in the upper right hand corner will return the user to the analysis screen without starting a test. If no analysis mode is running, an Exit button will appear which will close the Results screen.

The Results screen is automatically shown at the completion of any analysis. It can also be accessed from the analysis screen for any mode or the **Main Menu**, by selecting ***View→Results***. Once the Results screen has been opened, the information which is displayed can be changed by selecting options from the View menu. The various viewing options will be described in detail in later chapters.



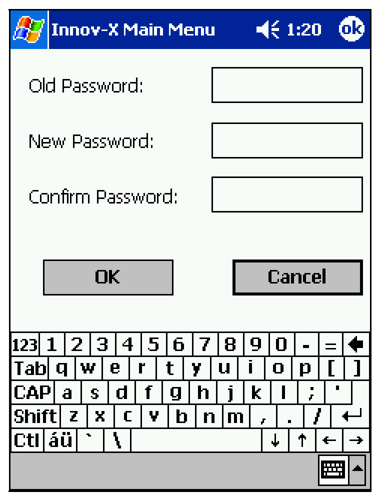
4.3 PASSWORDS - ABOUT PASSWORD PROTECTION

Certain functions such as adding and deleting fingerprints from the libraries, and Pass/Fail setup have been specified as Administrative Level Functions. These functions are described in detail in later sections of the manual. In order to use these functions, a password must be entered. The default password is set as the lowercase letter "z". This password can be entered whenever the system prompts for a password.

Changing the Administrator Password.

The Administrator password may be changed at any time from the **Innov-X Main Menu** by choosing ***Options→Change Password***. When the change password option is selected, this screen will appear.

If you are changing the password for the first time, enter the letter "z"; otherwise enter the current system password. Then, choose a password and enter it twice, once in the "New Password" box and again in the "Confirm Password" box. Passwords may be any combination of letters or numbers.



4.4 STANDARDIZATION

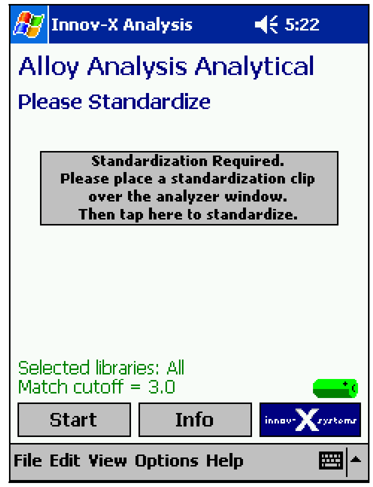
4.4.1 Standardization Procedure

Before performing tests, it is necessary to standardize the instrument. This automated procedure involves collecting a spectrum on a known standard (Alloy 316) and comparing a variety of parameters to values stored when the instrument was calibrated at the factory. If there are any problems with the instrument, they will be indicated by an error message.

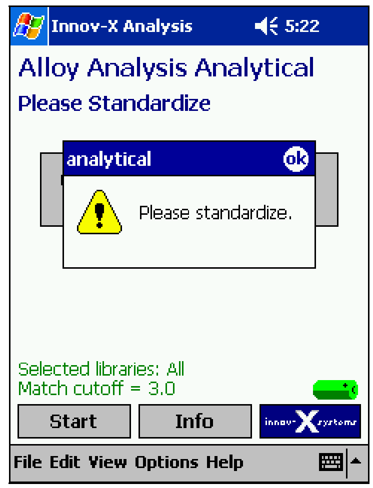
The standardization procedure takes about 1 minute. Standardization must be done any time the analyzer hardware is initiated or restarted and must be repeated if the instrument is operating for more than 4 hours.

It is possible to re-standardize the instrument at any point while the software is running. Standardization is always initiated from the Analysis Screen of any Mode.

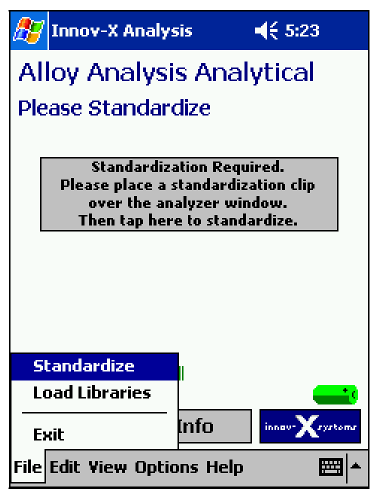
If the analyzer is restarted, you will be required to standardize the instrument before performing any measurements. This is indicated by the message "**Standardization Required. Please place a standardization clip over the analyzer window. Then tap here to standardize.**" on the analysis screen



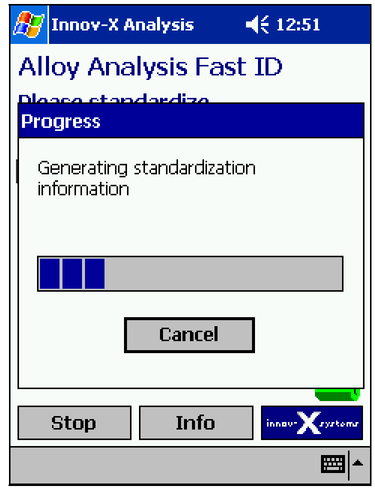
It is not possible to start a test before standardization. If the trigger is pulled before the standardization procedure is completed, a message box will appear. Press **ok** to acknowledge and clear the message.



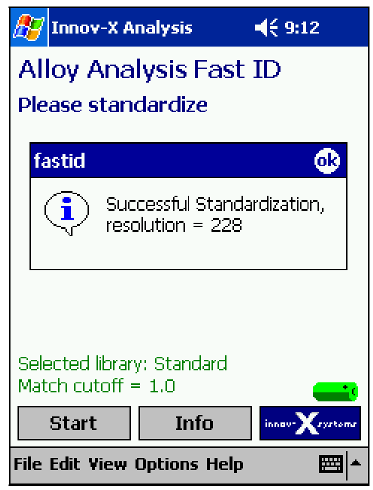
To initiate the standardization procedure, snap the standardization piece on the front of the instrument. Verify that it completely covers the analyzer window. When using a standardization mask with a weld collimator, be sure that the solid portion of the mask covers the analyzer window. Tap the grey box in the center of the screen or select ***File→Standardize*** to begin.



When standardization is in progress, the red light on the top of the instrument will blink, indicating that the X-ray tube is energized and the shutter is open. In addition, a status bar will appear, tracking the progress of the measurement.

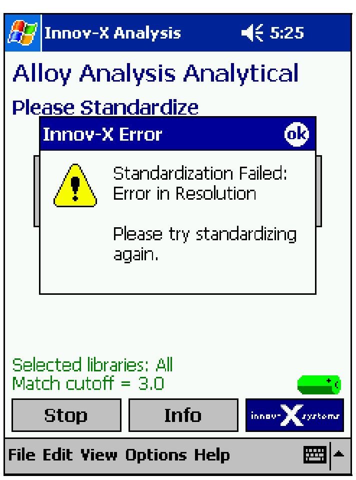


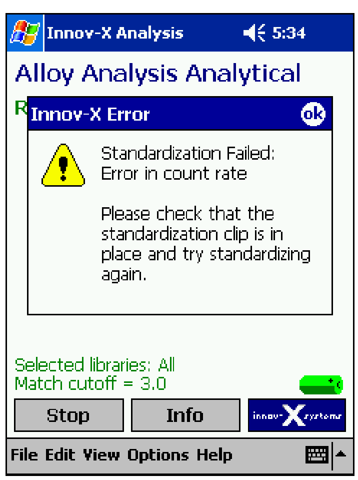
When standardization is complete, the message “Successful Standardization” will appear, along with the resolution of the instrument. Tap **ok** to acknowledge and clear the message. The instrument is ready for testing.



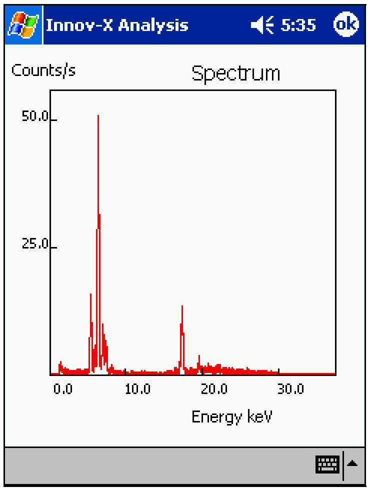
4.4.2 Standardization Errors

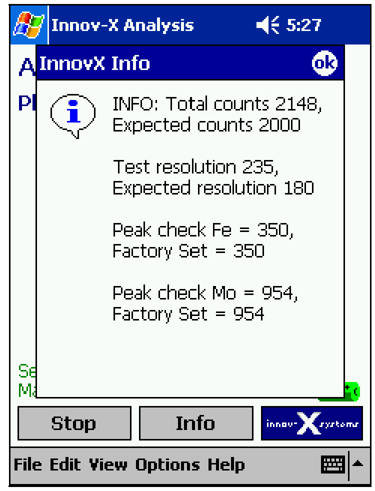
The analyzer performs several diagnostic checks during the standardization process. If the standardization fails, the instrument will prompt the user regarding the next step. Several errors could occur while standardizing: “Wrong Standardization Material,” “Error in Resolution” or “Error in Count Rate”





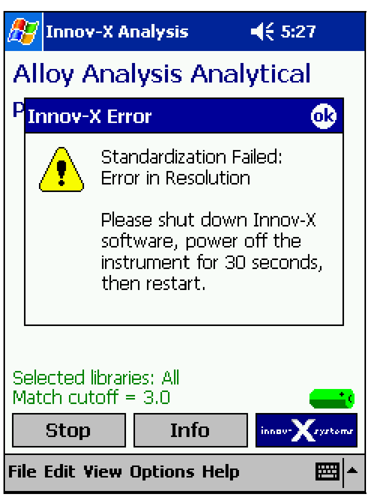
After closing the Standardization Failed message, two additional screens will appear. The first is a picture of the spectrum generated during the standardization. The second is a summary comparing factory set values for resolution, count rate, and peak positions to values calculated during the standardization.

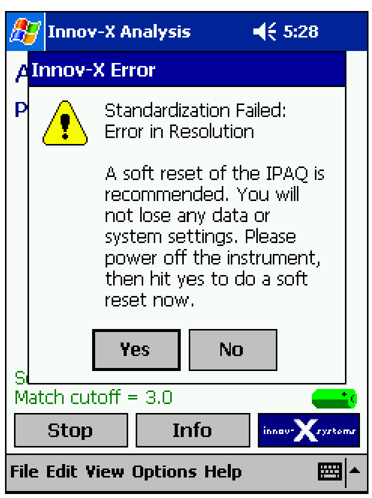


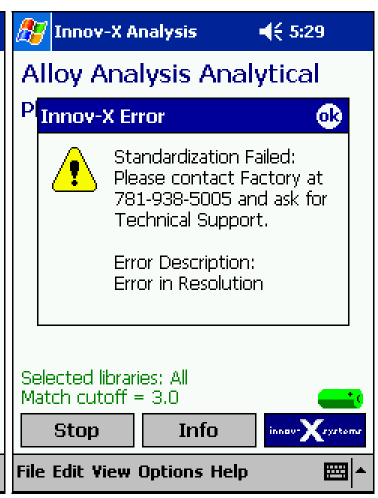


When standardization fails, verify that the standardization mask is in place, and attempt standardization again. To restandardize after a failure, tap the grey box in the center of the display, or choose ***File→Standardize***. If you are using a weld collimator, make sure that the solid part of the mask is covering the window.

If standardization fails again, exit the analysis screen and power off the instrument. Restart and restandardize. If the standardization fails a 3rd time, you will be prompted to perform a soft reset of the iPAQ. Selecting Yes on this screen will automatically soft reset the IPAQ. You should also power cycle the instrument. Restart and restandardize. If the standardization fails again, replace the battery in the instrument and attempt another standardization. If this fails, please contact the Innov-X Systems service center at **781-938-5005.**

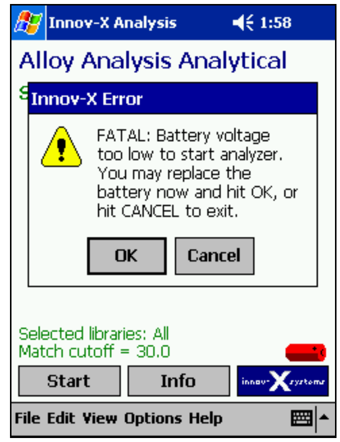




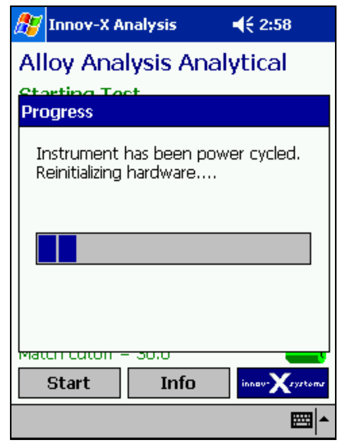


4.4.3 Battery Replacement and Initialization/Standardization

When the battery is too low to take a measurement, an error message will appear:



In order to continue testing, replace the battery immediately, and then tap "OK." The analysis screen will remain open, and the instrument will reinitialize. This process will take 1 minute. It is not necessary to re-standardize, provided that less than 4 hours has elapsed since the last standardization and the battery swap is completed within 10 minutes.

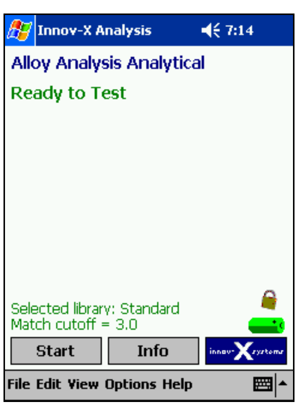


After re-initialization is completed, testing can continue.

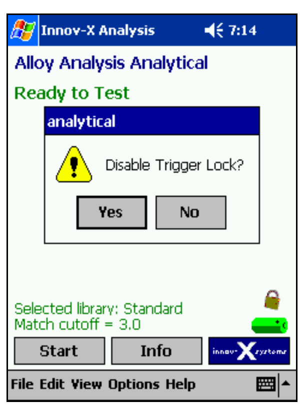
If the battery is not replaced, and cancel is selected, the Analysis screen will close. When the software is restarted, the instrument will go through a complete 1 minute initialization and will require standardization.

4.5 THE SOFTWARE TRIGGER LOCK

Innov-X analyzers are equipped with a software trigger lock which prevents the trigger from being actuated unintentionally. The lock is released by tapping an icon on the iPAQ screen. Once the lock is released, it will remain unlocked for subsequent tests, until more than five minutes has elapsed between tests. At that point, the trigger lock will be activated and will need to be disabled before additional testing can commence.



Tap the lock icon located directly above the battery indicator.



Select yes to disable the trigger lock

The open lock icon indicates when the trigger is disabled.

4.6 TEST INFORMATION - LABEL INPUT

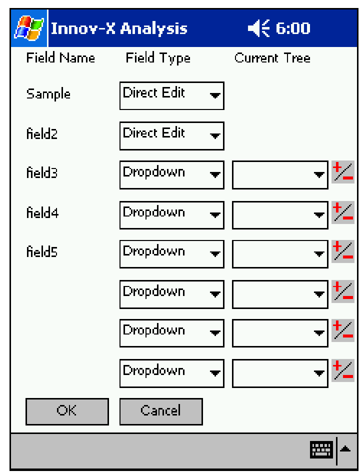
Information such as sample name, and identifying characteristics can be stored with each measurement. This is done from the test information (Test Info) screen which can be accessed from the **Analysis Screen** of any mode by tapping the **Info** button, or selecting ***Edit→Edit Test Information***.

The **Test Info** screen consists of eight fields. The name and format of each field can be changed by using the **Modify Test Info Template** feature described in section ***4*.6.1 Modifying the Test Info Template**. The process of entering test information prior to each analysis is described in section **4.6.2 Entering Test Information**. Finally, the process of entering or changing test information after the analysis has been completed is described in section **4.6.3 Editing Test Info from the Results Screen**.

4.6.1 Modifying the Test Info Template

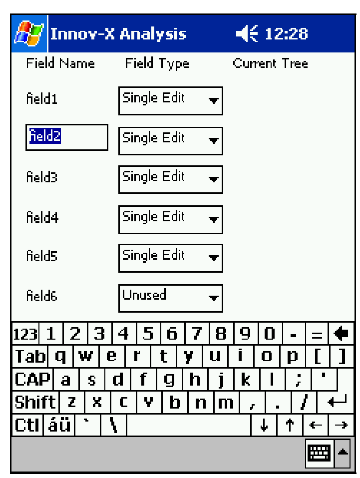
Test Info fields are modified via the Modify Test Info Template option found in the edit menu on the analysis screen in every software mode. Each field can be designated to be Direct Entry, Drop-down, or Tree. Direct entry fields allow users to enter characters directly from the virtual keyboard, or a bar code reader. Drop down menus provide a list of options to choose from. Trees are more complicated drop-downs; which allow users to subdivide large numbers of choices for ease in quickly locating the correct label. For example, a user may set up a tree with several parts for a main assembly. Subassemblies for the parts can be linked to their parent parts.

To make any changes to the Test Info format, select ***Edit ⟶Modify Test Info Template*** from the analysis screen of any Mode. Modifications of Test Info screens are specific to each mode, and will need to be made to each mode if more than one is used.

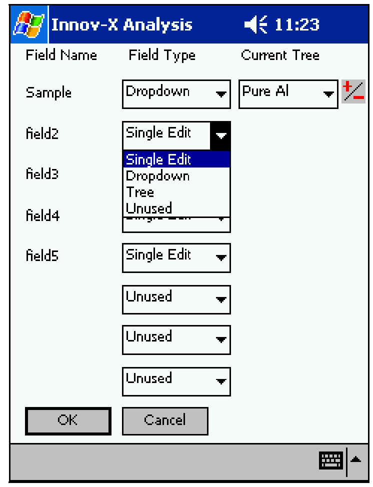


4.6.1a Changing Field Names

Field names can be edited by tapping on the current name. This will open an editable text box. A new name can be entered with the virtual keyboard. Selecting another cell or tapping **ok** will save this info.



4.6.1b Selecting Field Type

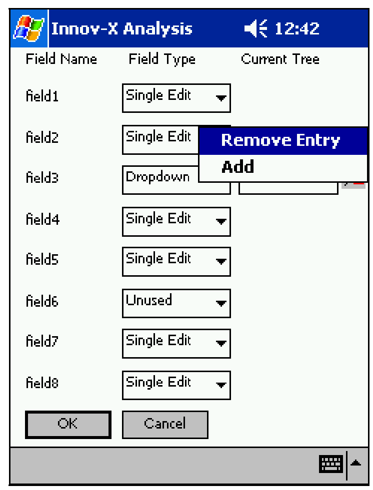


From the Modify Test Info screen, the type of field can be selected from a drop-down menu. Simply tap the arrow in the Field Type box for the field being modified.

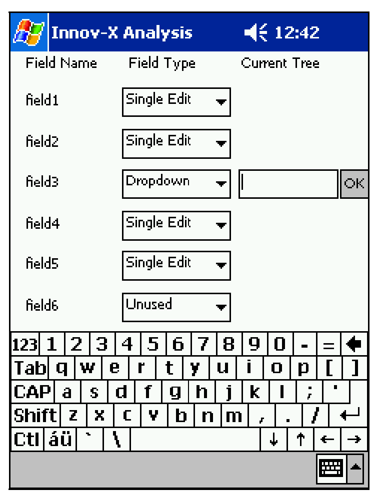
- Select **Direct Edit** for a text field which will accept data from the virtual keyboard, or a bar code scanner.
- Select **Drop-down** for a drop-down list
- Select **Tree** for a Drop-down menu with many choices, some of which may be grouped into categories and subcategories.

Select **Unused** to eliminate the field from the Test Info screen.

4.6.1c Changing Drop-down Menu Entries



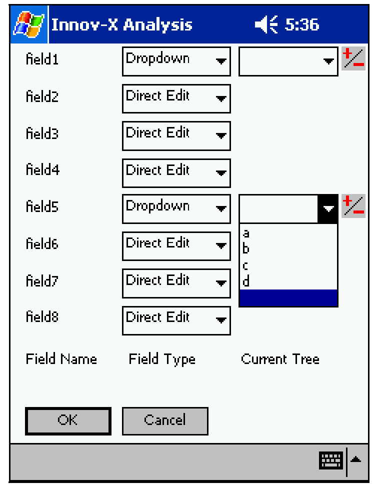
Once a field has been designated a drop-down menu, entries can be added or deleted by clicking the **+/-** symbol to the right of the field. Two choices will appear; **Remove Entry** and **Add**.
To delete a drop-down entry, first select the label to be deleted, then press **+/-** and tap **Remove Entry**.



To add an entry from a drop-down list, tap the **+/-** symbol next to appropriate field, and select **Add**. Type the new info into the blank text box that appears. Select **OK** and the entry will be added to the drop-down menu.

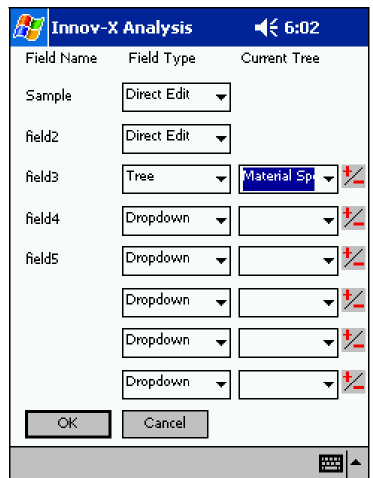
Repeat the process above to complete the complete drop-down list.

If it is anticipated that a drop-down field will not be used for all samples, enter an empty field as a choice so you can choose to leave the field blank.

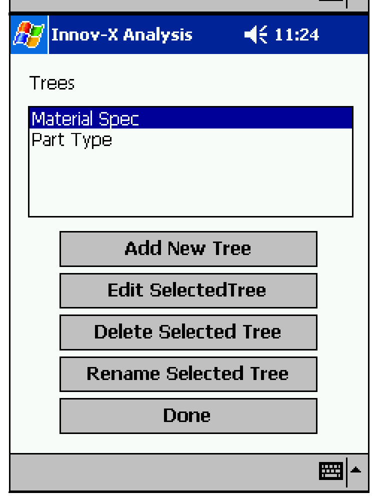


4.6.1d Changing Tree lists.

Once a field has been designated a tree, modifications to the contents of the tree can be made by tapping the **+/-** symbol to the right of the tree.



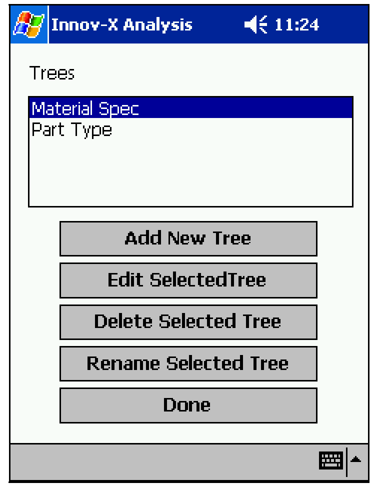
All modifications to trees are made from the menu shown on the right.



It is possible to add, edit, delete or rename trees. Select the appropriate choice from the menu to perform any of these functions.

When you have finished creating/editing your tree, highlight it and select **Done.**

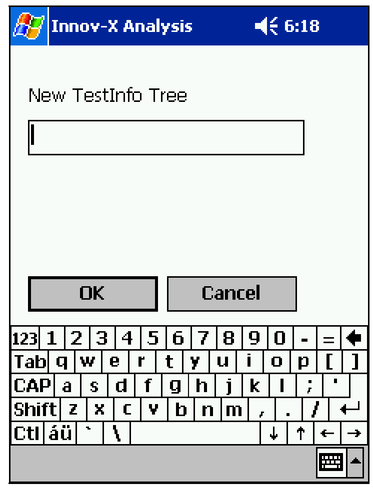
The following is an example of how a user might create a tree:
A manufacturer of tubes and valves tests all parts to ensure that they're made of the proper material. The company's QC procedure involves labeling each test with the part number of the item. Rather than forcing operators to look through a long list of part numbers, a tree is created in order to subdivide the parts number into groups based on part type.



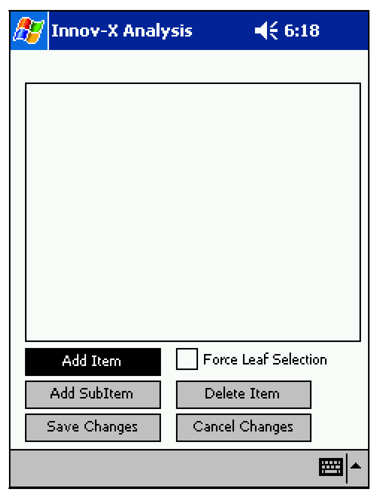
The procedure for creating the tree is as follows:

Select: Add New Tree:

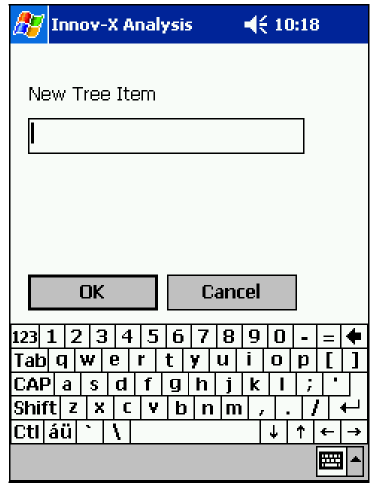
Enter the Name of the Tree in the text box and select OK.



Tap Add to add the first item

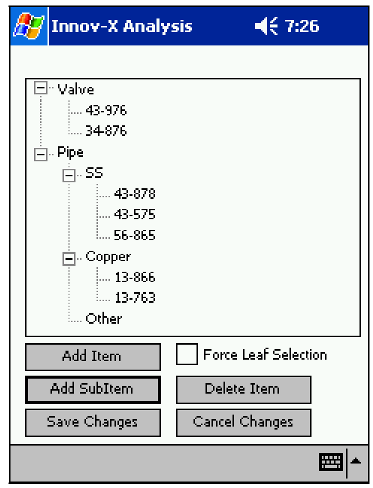


Enter the name of the item



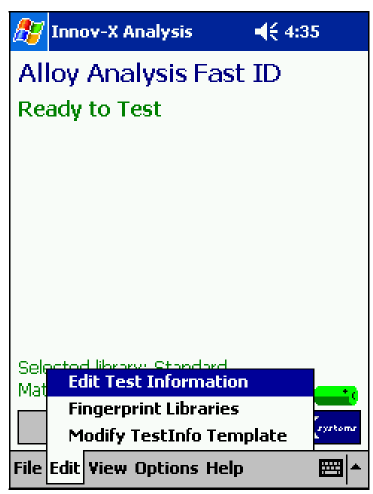
Once the tree is started, continue to Tap Add Item to add a top level menu item, or select an item and tap Add SubItem to link a subcategory to the item. Continue until all items have been added.

In this example, the part numbers for pipes and valves are separated into categories. The pipes are further subdivided by material type.

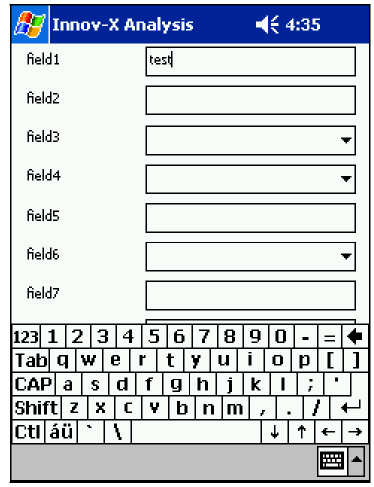


4.6.2 Entering Test Information

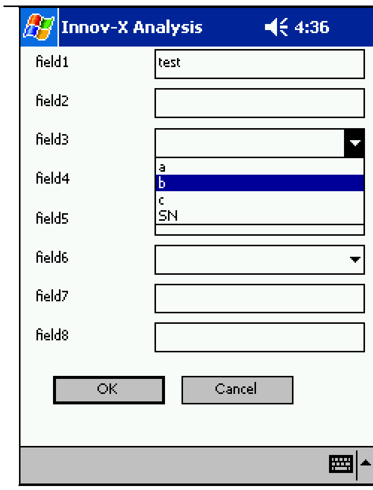
1. To enter the Test Info screen, you must be in the Analysis Screen. If the Results Screen is open, tap the ⊗ in the upper right hand corner to return to the Analysis Screen. From the Analysis Screen, select ***Edit→Edit Test Information,*** or tap the **Info** icon.



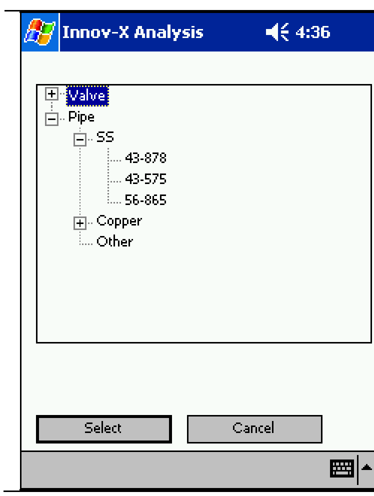
2. To enter a unique sample name or number, select a direct entry field by tapping anywhere within the field. Use the virtual keyboard to enter the information.



3. To select information from one of the drop-down menus, tap the arrow to the right of the box. Select the desired entry.



4. Some drop-down fields are formatted as trees. To select information from these fields, tap the arrow to the right of the box. A screen will appear showing options. The plus (+) symbol will appear before some choices indicating the presence of sub-items. Tap on the + symbol to expand the menu. Tap on any item or sub-item to select it, then press **Select**.

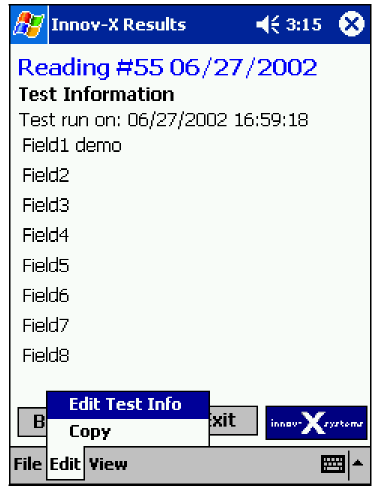


5. When all the necessary data have been entered. select OK
6. The information entered in the test info screen will be saved with each reading until the test info screen is modified again.

4.6.3 Editing Test Info from the results screen

Test information can be edited, or added to a test after its completion.

- From the results screen, scroll to the reading to be modified.
- Select ***View →Test Info*** to see in the information which is already stored.
- Select ***Edit → Edit Test Info*** to bring up the editing menu.



You will then be presented with the same test information screen described in **Section 4.5.2: Entering Test Information.**

4.7 EXPORTING AND ERASING DATA

Because the memory of the iPAQ is limited, you should periodically backup the data on your analyzer, and erase the memory. Depending on test volume, it is recommended that all data is erased on a weekly or monthly basis.

4.7.1 Installing ActiveSync

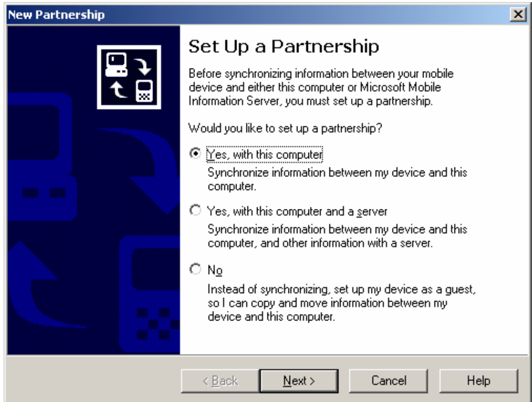
In order to copy files between the iPAQ and a desktop PC, Microsoft Active Sync Software must be installed on the desktop PC. Innov-X strongly recommends that you download the latest version of ActiveSync from the internet. ActiveSync v3.7 may be downloaded from http://www.microsoft.com/windowsmobile/resources/downloads/pocketpc/activesync37.mspx

If it is not possible to download the latest version, an ActiveSync CD (v3.5) was shipped with your analyzer. Check behind the foam in the instrument case.

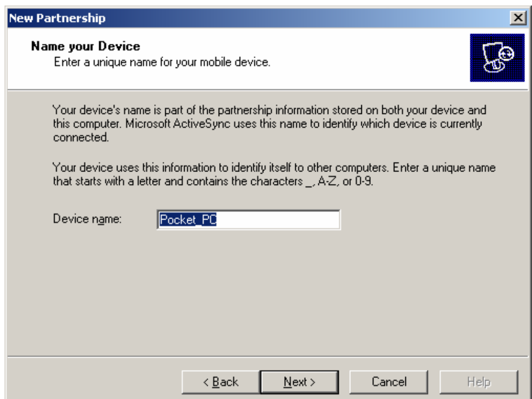
The iPAQ cradle should be hooked up to the USB port on the desktop computer before installing software.

The Procedure for installing and setting up ActiveSync is as follows:

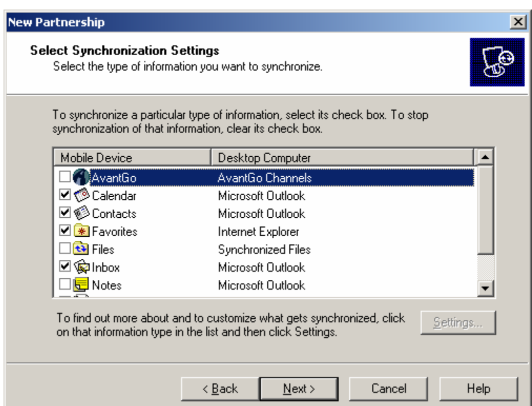
1. Insert the ActiveSync CD in your CD Drive. It will start automatically. The CD contains information about Getting Started with Your Pocket PC. This changes periodically, so it's difficult to describe exactly what the screens will look like. Step through the screens until you see the option "Install ActiveSync." Select this to start the installation process.
2. Follow the prompts on the screen. When given the choice, select "Run this program from its current location" and click OK.
3. Complete the install process. You will be required to restart your computer in order to complete the installation.
4. After restarting your computer, dock the iPAQ in the cradle. The iPAQ should automatically communicate with your computer. If it doesn't, check the connections and try removing the iPAQ and reseating it. If that doesn't work, try doing a soft reset on the iPAQ
5. When the computer communicates, you will be prompted to "Set Up a Partnership." Select "Yes, with this computer"



6. Enter a name for your iPAQ and click next.



7. You will be prompted to "Select Synchronization Settings." **Select "Files" only**. ***It is important to make sure that* Files *is the only item checked. Otherwise, the files such as address books and emails will be copied from the desktop computer to the iPAQ.***



8. Step through the rest of the process.

9. A folder will automatically be created on the PC's desktop with the name of the device entered in step 8 above. Results files saved on the iPAQ will automatically be synched and will be stored in this folder. Opening this folder and clicking on the name of the file will open the file in Excel.

10. After ActiveSync is set up correctly, copying results to a desktop computer will consist of

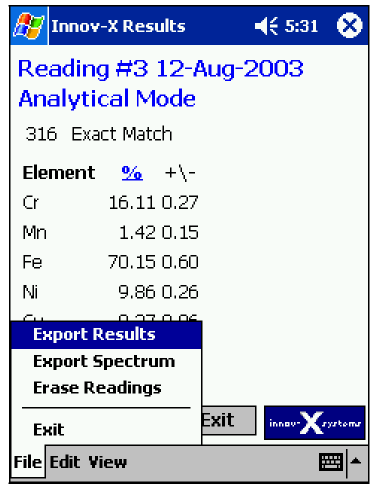
a. Exporting results on the iPAQ. (described in section 4.6.2)
b. Synching the iPAQ to the computer
c. Opening the results in Excel for viewing, or printing.

4.7.2 Exporting Results

All data from your Innov-X Systems analyzer can be exported as a comma delimited text file (csv). This format allows the data to be easily exported to spreadsheet programs. It is possible to export all data from a single day, or to export all data saved in the iPAQ. Results and spectra are exported separately.

To export or erase data, you must be in the Results Screen. This is automatically opened when a reading is taken, or can be accessed by choosing ***View→Results*** from any analysis screen.

From the results screen, select ***File→Export Results***

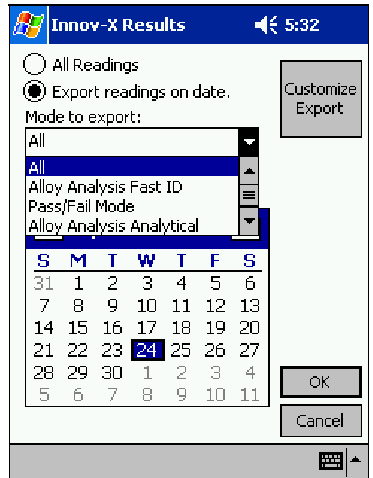


You can choose to export All Readings or just Readings on a specific date. Choosing **All Readings**: will export all readings saved in memory and is a good choice if you want to backup all data stored on the instrument before deleting. If a large number of readings stored, this option will take several minutes.

Choosing **Export Readings on date** requires that you pick a date from the calendar below. It is strongly recommended that you use this option and export data on a daily basis.

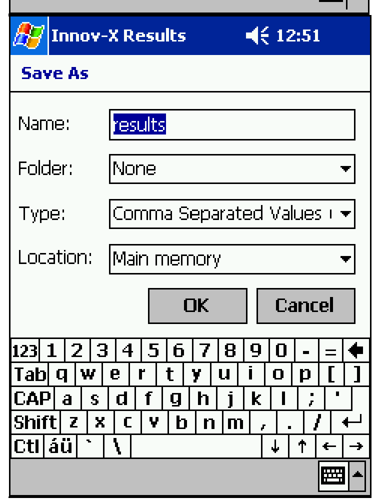
The customize export option allows users with administrative password privileges to customize the format in which data is exported. This is described in **Section 4.7.3: Customizing Results Export**.

After choosing which readings to export, you may choose to export all data, or just data from a specific mode. Selecting the arrow to the right of the mode to export will open a drop-down menu. Select the mode for which you want to export data.

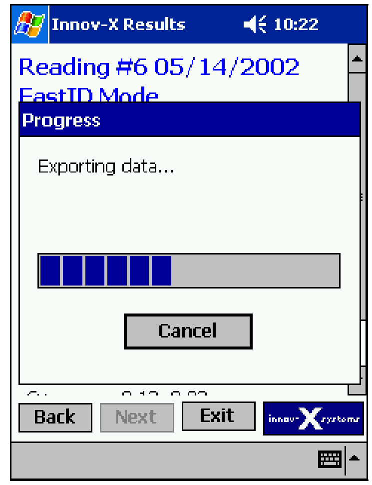


All standardization data are stored as results files. These data are automatically included in exported results files when the selected “Mode to export” is **All.** Additionally, it is possible to export only the standardization data by selecting **Standardization** as the “Mode to export.”

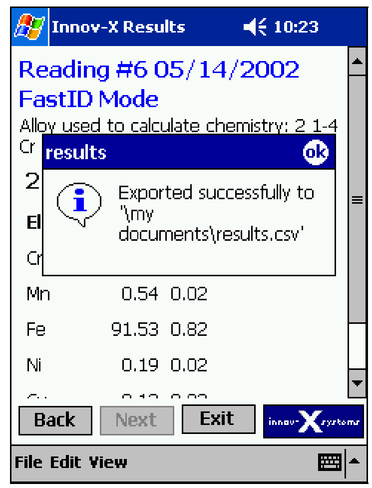
When the proper selections have been made, select **OK**. A **Save As** box will appear. Select the folder in which you want to save the data, and name the file. The file Type will always be **Comma Separated Values**. The recommended Location is Main memory and Folder is **None.** This will export files into the “My Documents” folder in the main Memory of the iPAQ.
If you select a File Name which already exists, you will be asked if you want to replace the existing file. If you do, select **Yes**. Otherwise select **No** and choose another file name.



A status bar will indicate the progress of the export. It may take several minutes to export many readings. Daily downloading and weekly erasing of data simplifies and shortens this procedure.



When all readings are exported, a message will appear confirming the export. Tap **ok** to acknowledge and clear the reading.



4.7.3 Customizing Results Export

All units come with a standard results export format which reports a variety of information relevant to a test. Users can select which fields are exported as well as modify the order.

To modify exported results files, select **File ⟶Export Readings** from the Results screen.

Tap the **Customize Export** box.

Enter the administrative level password when prompted.

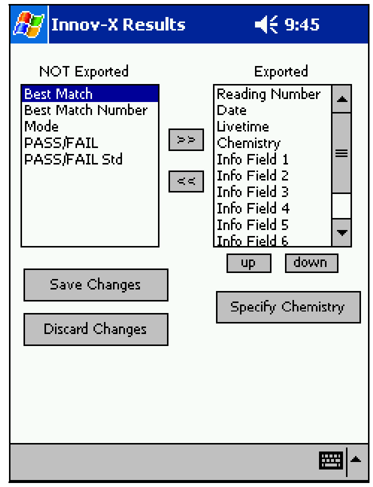
Two columns appear on the screen; the column on the left lists fields which will NOT be exported, and the right-hand column lists fields which will be exported.

Fields can be moved from one column to another via the >> and << buttons located in the center of the screen

Exported field order can be changed by using the **Up/Down** buttons. Select a field and move it up or down as desired

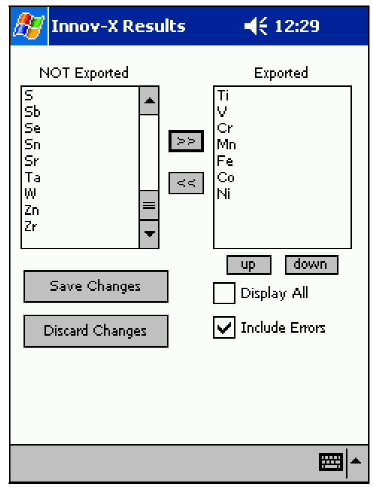
Once all changes have been made, choose **Specify Chemistry** if changes need to be made to the list of exported elements.

In chemistry is not edited, select **Save Changes** to keep the modified settings, or **Discard Changes** to ignore any changes.



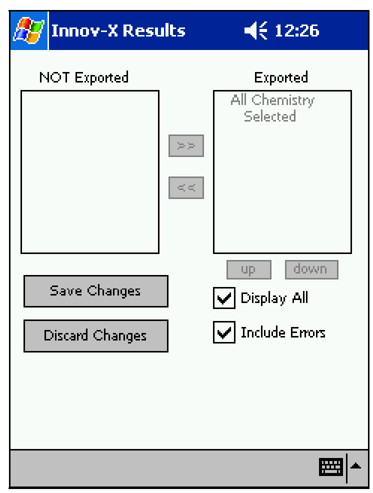
The Specify Chemistry screen resembles the previous screen. Move elements to the appropriate column, depending on whether or not an element should appear in exported files.

Select **Include Errors** to export the error associated with each measurement.



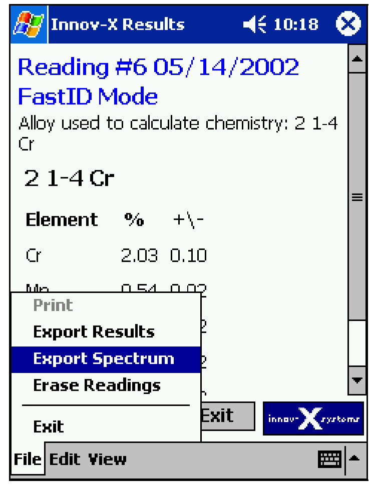
Select **Display All** to include all measured elements. *This setting is recommended, as it will ensure that all data measured with the instrument is exported.*

When all changes have been made, tap **Save Changes** or **Discard changes,** depending on whether the changes should be saved.

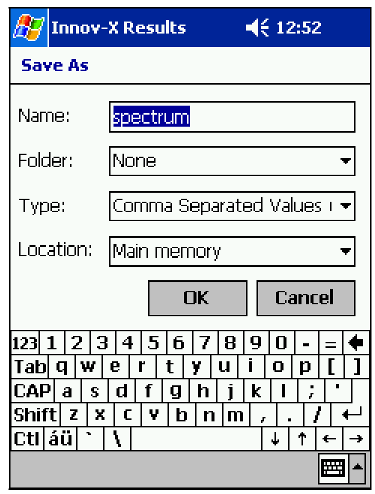


4.7.4 Exporting spectra

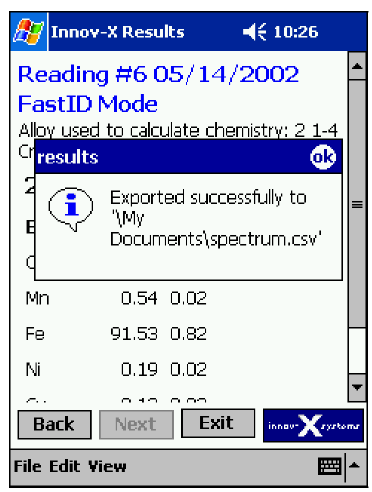
Only one spectrum may be exported at a time. In the results screen, scroll to the reading for which you wish to export the spectrum, and ***Select File→Export Spectrum***.



Choose the File name, and make sure that **Comma Separated Values** and **Main Memory** are selected. This will save the spectrum to the My Documents folder in the Main Memory of the iPAQ.



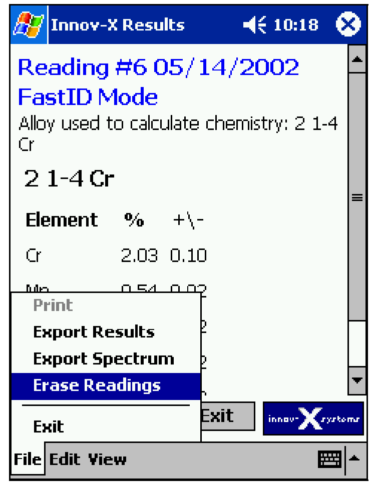
A message will appear indicating a successful export. Tap **ok** to acknowledge and clear the window.



4.7.5 Erasing readings

It is possible to erase a single reading, a range of readings, all readings from a specific data, or all readings before a specific date.

In order to erase a single reading, the reading to be erased must displayed on the screen before selecting delete. If necessary scroll to the reading you wish to delete.



In order to select a range of readings, you must have a reading open from the date you wish to delete the readings. If a reading from the desired date is not open, you may select ***View→Go to date***, and select the appropriate date.

The reading displayed in the results screen is not relevant if you want to delete all readings from a specific date, or all readings before a specific date .

From the results screen, select ***File→Erase Readings.***

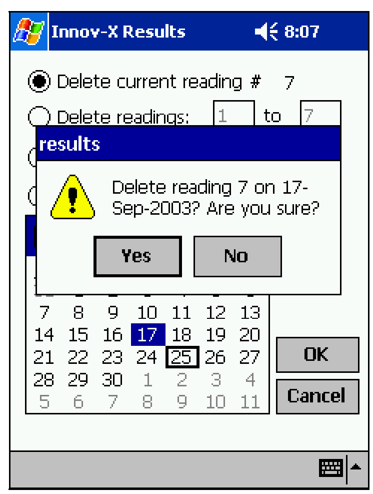
A message box will appear prompting you to enter your password. Enter your administrative level password and select **OK**.

A dialogue box will appear allowing a choice of which results to delete. Select the appropriate choice:

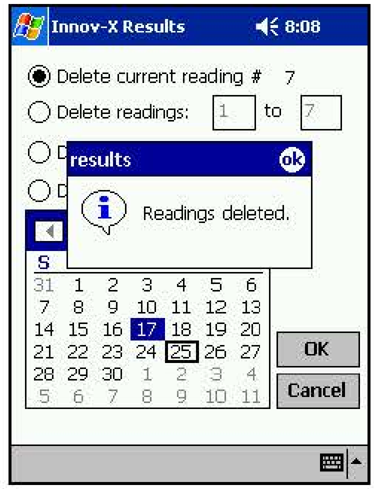
- Selecting **Delete current reading** will delete the reading that is currently open.
- Choosing **Delete readings XX to XX** will delete a range of readings from the date of the reading that is currently open.
- **Delete all readings on date** deletes all readings from a specific day.
- **Delete readings before date** deletes all readings taken prior to a specific day.

If you select **Delete all readings on date** or **Delete readings before date**, you must specify a date from the calendar. The default date is the current date.

When you've selected the readings to delete, Click **OK**. You will be asked if you're sure you want to proceed. If you want to proceed with the data erase, select **Yes**. Otherwise, click **No.**



A message will indicate the readings were successfully deleted. Tap **ok** to acknowledge and clear the message window.



Chapter 5 ALLOY ANALYSIS

5.0 ALLOY ANALYSIS INTRODUCTION

Three different modes exist for the analysis of alloys:

- **FastID Mode**
- **Pass/Fail Mode**
- **Analytical Mode**

Systems may be purchased with any combination of the three modes. Instruments can be upgraded for a fee at any point after purchase. General introductions to each of the modes, as well as basic operations are found in this chapter. Subsequent chapters describe each of the modes in greater detail.

FastID MODE

FastID mode is designed to quickly identify an alloy by matching the spectral signature of an unknown sample to the saved spectral signatures of reference standards in the FastID library. This mode can provide alloy chemistry if concentration data are entered for the standards. Chemistry results are a linear extrapolation from standard intensity data. FastID Mode is suited for determining accurate chemistry for alloys for which standards are available AND are loaded into the library. A standard library, as well as 3 user libraries can be used for matching. All libraries can be edited.

PASS/FAIL MODE

Pass/Fail mode is used to quickly test alloys to ensure that they meet quality control criteria. The operator chooses a stored spectral fingerprint which the system uses as a reference standard. Samples are compared to the reference, and a Pass or Fail result is displayed. Pass/Fail decision criteria can be spectral signature matching or concentration ranges for one or more elements. Pass/Fail mode uses the same fingerprint library as FastID mode.

ANALYTICAL MODE

Analytical Mode provides a full analysis of alloy chemistry using the method of fundamental parameters, as well as a grade match based on minimum and maximum grade specifications. This method uses a factory calibration, and requires no additional user supplied standards. In addition using the comprehensive grade library included with the analyzer, users may enter additional grade table specifications.

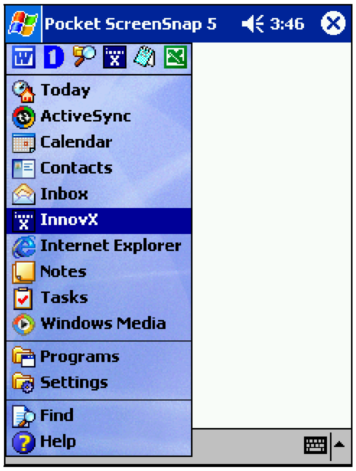
5.1 ALLOY ANALYSIS – STARTING THE INSTRUMENT AND TAKING A MEASUREMENT USING THE STANDARD LIBRARY

The basic startup and testing procedure is described below. Most screen shots were taken using **FastID Mode**; however, the basic procedure is the same for all three alloy modes.

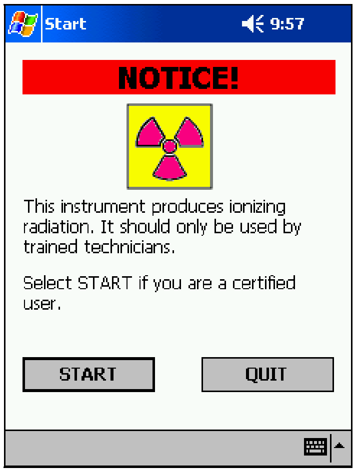
BASIC OPERATION

All Innov-X Systems Analyzers are shipped with a standard set of reference alloy standards that makes it possible to identify approximately 200 common alloys (35 in FastID). A list of the references in the library is provided in Appendix III. When you first receive your analyzer, it is recommended that you start by analyzing the 316 standardization piece included with your analyzer to gain an understanding of how the analyzer works.

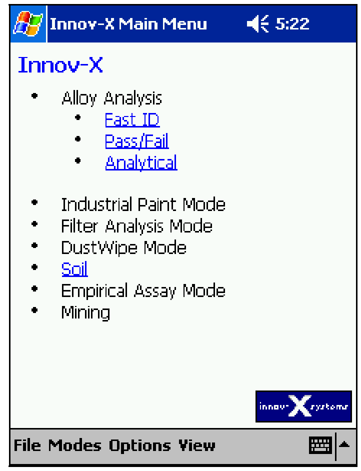
1. Install a freshly charged battery in the instrument.
2. Turn on the analyzer by pressing the power switch located at the back of the analyzer.
3. Verify that the iPAQ is correctly seated on the top of the unit. If the iPAQ is properly connected, the amber light on the upper right side of the iPAQ next to the power button will blink, indicating that the iPAQ is receiving charge from the analyzer.
4. If the iPAQ is not on, turn it on by pressing the power button on the upper right side of the iPAQ.
5. Start the Innov-X Systems Software by selecting the Start Menu from the upper left hand corner of the iPAQ screen. Select the Innov-X Systems Software from the drop down menu.



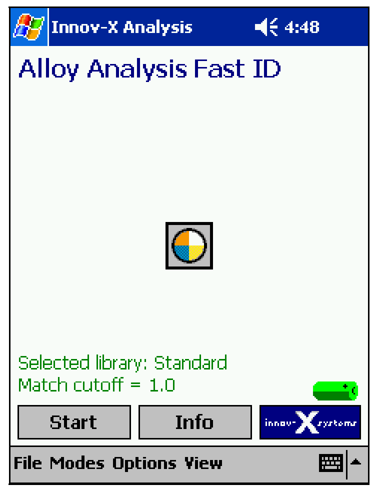
6. A notice will appear reminding the user that this instrument produces ionizing radiation and requires a trained user. . Select **START** to start the Innov-X Systems Software package. Selecting **QUIT** will exit the Innov-X Software.



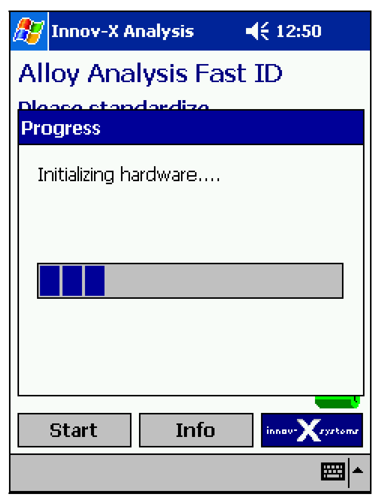
7. The Main Menu will open. Tap the name of the Mode you will be using to open it. First time users should Analytical Mode.



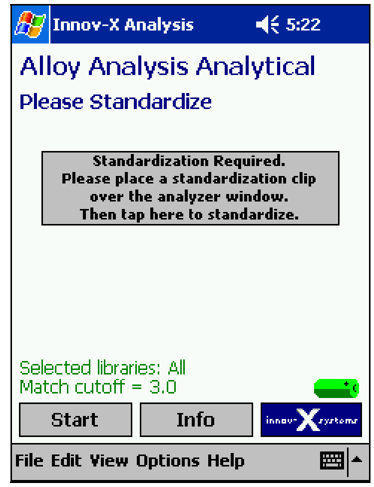
8. There may be a brief pause while the instrument loads the various parameters needed for operation. While this occurs, an icon will appear in the center of the iPAQ screen.



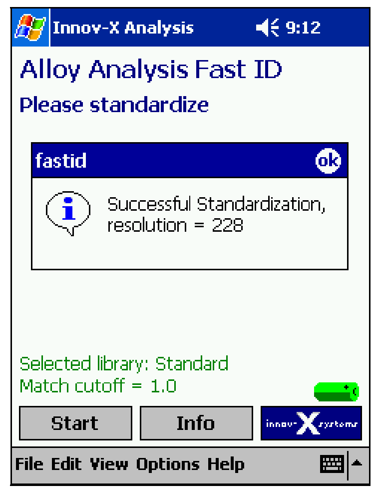
9. Once the analysis mode has been selected, the instrument will go through a 1 minute hardware initiation during which the electronics will stabilize and the detector cooling will be initialized.



10. The message "**Standardization Required. Please place a standardization clip over the analyzer window. Then tap here to standardize.**" will appear. Standardization is required before testing can begin. Place the standardization clip in front of the analyzer window. Tap the message box. Standardization will take approximately 1 minute; a status bar will be displayed throughout the measurement. Standardization is described in more detail in **Section 4.4: Standardization**.

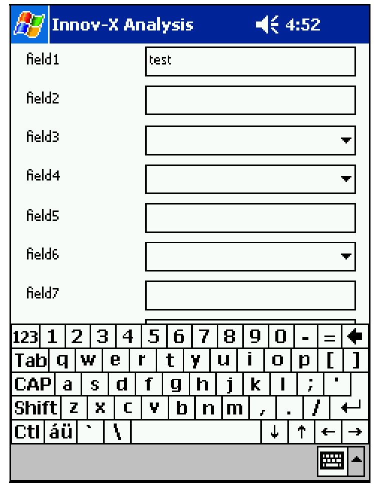


11. When standardization is complete, the resolution of the analyzer will be displayed. Tap **ok** to acknowledge and clear this screen.



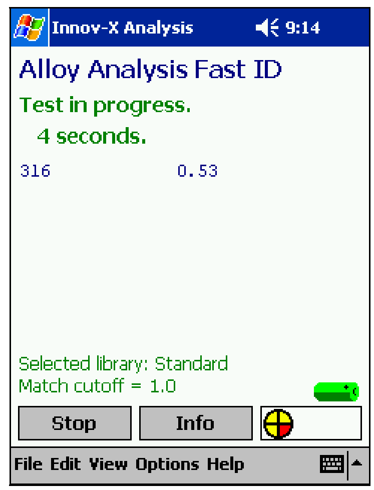
12. The analyzer is now ready to take a measurement. The Trigger lock must be unlocked before pulling the trigger will start a test.

13. If you wish to enter a sample name or sample identifying characteristics, select ***Edit→Test Info***. Enter information in text fields, or select items from drop down menus. Select **ok** to close the Test Info window. The format of this screen may vary depending on user settings. See **Section 4.6: Test Information** for more information.

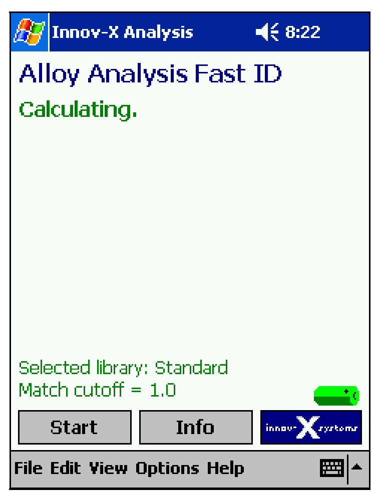


14. Hold the analyzer to the sample to be analyzed. Make sure the sample is as flush against the analyzing window as is possible. You may start an analysis by pulling and holding the trigger. Releasing the trigger will abort the test.

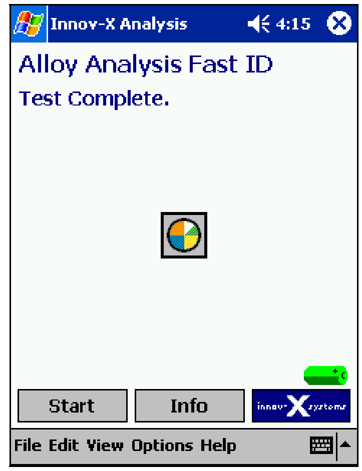
    a. After an analysis is started, the message "**Test in Progress**." will appear, followed by the number of seconds elapsed during the measurement. For the duration of the test, the red light on top of the instrument will blink, and the "testing" icon will appear in the lower right corner of the IPAQ.



    b. When the measurement is complete, the analysis screen will display the word **Calculating**. There may be a slight delay while the instrument calculates the results. This will be indicated by the appearance of a "calculating" icon in the lower right hand corner of the iPAQ screen. Because the FastID calculation is very rapid, this icon is rarely seen, however there may be a few second calculation for Analytical Mode.

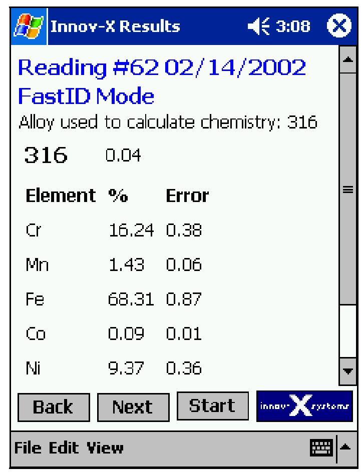


c. When the calculations are complete, there will be a slight delay the first time the results screen is opened. An icon will appear in the center of the screen during this delay. This indicates that the results program is loading and re-indexing all saved results.



15. The Results screen will display the results. The information displayed on the screen may be changed by selecting one of the options under the View menu. This is described later in this chapter under the Results section. If you analyzed the standardization piece, the grade identification should be listed as 316.

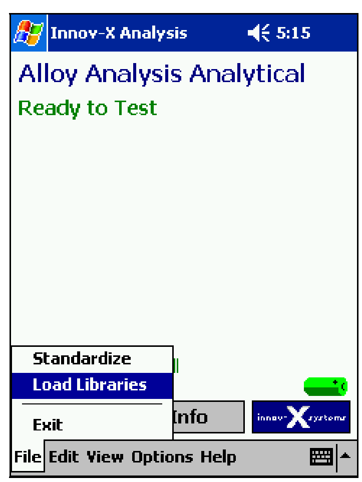
16. Once the results screen is open, subsequent readings may be started by depressing the trigger. If at any point, you wish to return to the analysis screen, select ***File→Exit*** or tap the X in the upper right hand corner of the screen.



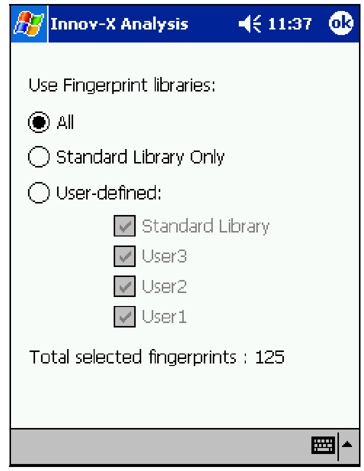
5.2 SELECTING A LIBRARY

The Innov-X Software can search any one of four libraries when in **FastID** or **Analytical Modes**. **ALWAYS VERIFY THAT THE CORRECT LIBRARY IS BEING SEARCHED.** More detailed information on library functions can be found in Chapter 5.

To select which library to search, go to the **FastID** Analysis Screen or the **Analytical** Analysis Screen – whichever mode is in use – then select ***File→Load Libraries .***



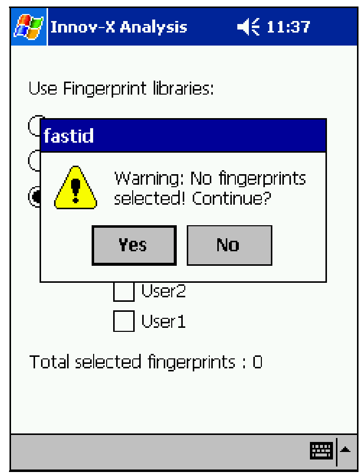
A menu appears. The first line will read **Use Grade Libraries** for Analytical Mode and **Use Fingerprints** for FastID Mode



Choose the Fingerprint or Grade Libraries you wish to search. For the most comprehensive search, select **All** libraries. This will search the entire Standard Library, as well as any fingerprints or grades that have been added by the user.

Users who are primarily concerned with sorting the most common specialty, stainless, nickel and high temperature alloys should always search the **Standard Library**. This will ensure that the factory-installed library will be searched. The Standard Library can be searched by itself, or in combination with any of the other libraries.

Users who are sorting a small group of alloys may prefer to create their own libraries using their own standards. In this case, only the appropriate user library should be selected.



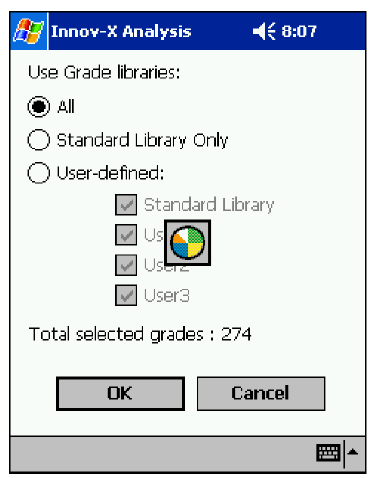
When loading libraries from the ***File→Load Libraries*** Menu, the number of fingerprints or grades in the selected libraries is displayed at the bottom of the screen. For best results especially when measuring complete unknowns, a large number of fingerprints should be selected because the analyzer cannot identify an alloy that is not in a library.

Since there is a good chance that searching a small number of libraries will result in No Matches, a warning message will appear if you select 10 or fewer grades or fingerprints.

Select **No** to return back to the Use Fingerprint Libraries screen to make another selection.

Select **Yes** to continue with the selected library. Keep in mind that with fewer fingerprints or grades being searched, you will likely get a larger number of No Matches.

If no fingerprints are selected, it will not be possible to get any valid results in FastID. If a user continues with no fingerprints selected, it will be necessary to teach fingerprints in the selected library before proceeding with the analysis. In Analytical Mode, chemistry will be calculated, but no grade matches will be displayed if no grades are loaded.



There will often be a pause of several seconds while the instrument loads the new libraries. A revolving icon will appear in the center of the screen indicating that the libraries are loading.

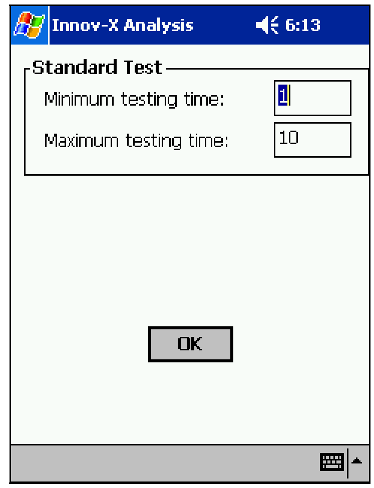
5.3 SETTING THE ANALYSIS TIME

The software allows the user to set up minimum and maximum testing times.

The minimum testing time must elapse in order for results to be calculated. If a test is stopped before the minimum testing time, it will be treated as an aborted test, and no results will be calculated. Additionally, if the Live Update feature described in section 5.4 is active, results will not be displayed on the screen until after the minimum time period.

The test will end automatically when the maximum testing time is reached. A test can be ended manually at any time by releasing the trigger.

To change Testing times:



From any analysis screen, select ***Options→Set Testing Times***

Typical settings for standard test times, in seconds are:
Minimum testing time: 3
Maximum testing time: 10.
However, these values may be changed depending on the application and the desired results.

Alloy system equipped with Analytical ***Smartbeam*** will have an option for setting the test time in this screen as well. ***Smartbeam*** is discussed in chapter 8.

The minimum testing time is required to be no less than 1 second. An error message will appear if the time is set to be less than 1 second. Clear this message by selecting **ok**. The time will default to a minimum time of 1 second. This value may be used, or another value may be entered. Select **OK** to close the window.

You will not be allowed to exit the **Set Testing Times** window unless a valid minimum testing time has been entered.

Recommended Testing Times:

For most alloys, the recommended testing time is 5-10 seconds to obtain a unique grade ID and good alloy chemistry. For some alloys that only differ by small amounts of one or two elements, it may be necessary to perform longer tests. Examples include Low alloy steels 4140 and 4340. Alloys which differ by less than 1% of Ti or V require the optional ***Smartbeam*** feature for quick separation.

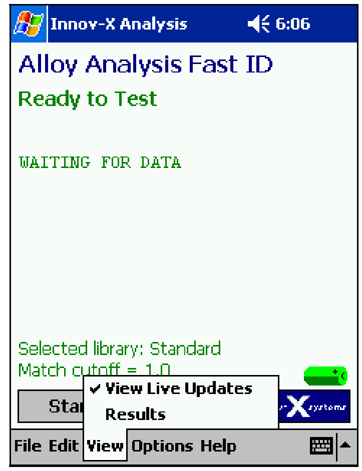
The maximum testing time will determine the length of a test. The analysis will automatically stop if the maximum testing time is reached. Normal maximum testing times will range from 5 to 20 seconds. Fundamentally, if the goal of the analysis is primarily grade identification, shorter analysis times are used. If greater precision is required in the calculation of chemistry or if an alloy separation is particularly difficult, longer test times may be used.

It should be noted that the pre-set time refers to the length of time the analyzer is actively collecting data from the detector. The total analysis time can be slightly longer than the maximum test time due to the small amount of time required to process the data and calculate the results.

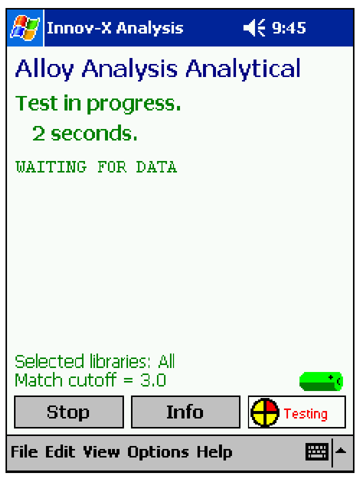
5.4 LIVE UPDATE DISPLAY

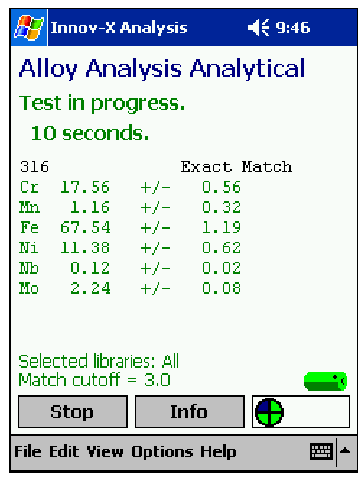
In addition to viewing completed tests in the results screen, the analyzer will display screen updates as the results are calculated during a test. This allows users to decide when to stop tests based on the precision of the reading.

To switch Live Updates on or off, select ***View→Live Updates***. A check mark will indicate if Live Updates are turned on.



When the Live Updates feature is on, and a test is in progress, the screen will show the message "WAITING FOR DATA" until the minimum testing time set in ***Options → Set Testing Times*** has elapsed. After that, chemistry and the errors on the chemistry will be displayed. This feature allows the user to stop the test as soon as the desired precision is reached.





If too short a maximum test time is set, the test may end before the desired precision is reached. As a result, some users who prefer to end tests based on the screen display may choose to set long maximum test times (60 seconds or so) and manually end all tests.

5.5 SAMPLE CONSIDERATIONS

5.5.1 Coated or Painted Samples

Innov-X Alloy Analyzers are capable of analyzing a wide variety of sample shapes and types. However, it is important to understand that XRF is fundamentally a surface analysis technique. X-rays penetrate a very short distance into most alloy samples. Therefore, the analyzer will detect what is on the surface of an alloy, rather than what comprises the bulk of the material. If a material has been coated, plated, painted, or has had some sort of surface treatment, such as heat treating, it may be misidentified. For example, a steel piece that has been painted grey will show high concentrations of titanium from the paint, and may be misidentified as a titanium alloy. In addition, large amounts of metal dust or turnings on a surface may be detected by the analyzer.

To ensure proper identification of coated materials, an area slightly larger than the analyzing window should be ground to remove the coating. This will allow the analyzer to measure the alloy rather than the coating. It is not necessary to completely clean and polish all materials, however, obvious metal dust should be removed.

5.5.2 Mixed samples, Heterogeneous materials

Often finished metal pieces may consist of more than one type of metal. In addition, some users may wish to measure mixed turnings, or an assortment of small pieces. In these cases, the user should remember that the analyzer will measure the entire area covered by the analyzing window and report an average chemistry. For turnings, this is useful, as the analyzer will provide an average composition. However, if two or more pieces of metal cover the window, the results will also be just an average reading, and may tell very little about the composition of one piece or the other. When shooting metal pieces, or welds, it is important to make sure that only the metal of interest is covering the analyzing window. It may be possible to use a welding mask to narrow in on the area of interest.

Keep in mind, that a welding mask should only be used in Analytical mode, unless fingerprints have been taught in FastID using the mask.

5.5.3 Small and irregularly shaped samples

All Innov-X Systems alloy software modes are able to measure parts that are smaller than the analyzing window; however, it is usually necessary to increase the testing time. The precision on measurements of small parts is reduced; since the signal from smaller samples is less then it is for samples that completely cover the window. It is also a good idea to try to maximize the material in contact with the window. If possible, analyze the largest flattest side of an irregularly shaped object.

5.5.4 Invisible elements

Since the Innov-X Systems Alloy Analyzer cannot directly analyze light elements such as carbon, aluminum and silicon, samples containing large amounts of these elements may not read correctly in Analytical Mode, depending on certain instrument settings. These settings are described in **Section 8.3.3: Light Element Analysis**.

Please read this section and familiarize yourself with the issues pertaining to Light Element analysis before attempting to analyze Aluminum alloys or other alloys containing significant amounts of non-detectable elements.

Chapter 6
Alloy Analysis—FastID Mode

6.0 INTRODUCTION TO FastID MODE

FastID mode is designed to quickly identify an alloy by comparing and matching the spectral signature of an unknown sample to spectral signatures of reference standards stored in a library. This mode can provide alloy chemistry if concentration data is entered for the standards. These chemistry data are a linear extrapolation from standard intensity data.

The system is typically shipped with a library of approximately 35 stored spectral "fingerprint" reference standards and chemical assays for these standards. Some systems may be shipped with additional fingerprints, or with no fingerprints, depending on the details of the order. To identify one of the alloys contained in the standard library, no user calibration or input is required. The operator simply tests a sample, and the instrument determines the correct alloy grade by matching to the library of spectral fingerprints. The instrument then calculates the chemistry by using the stored elemental assays using the identified grade as a reference standard. The user may easily add up to 300 additional reference standards and assays if desired.

Warning: Because **FastID** Mode performs a spectral match to a library of reference standards, it is very important that a stored reference standard be in the FastID library that is being searched. For this reason, this mode is best suited for alloy verification, where in general the operator is checking that the alloy is the expected type. Thus, the operator can assure before commencing testing that a reference standard for that alloy is in the library.

FastID is ideal for most PMI, in-service PMI and QA/QC applications. This mode offers the best combination of speed and precision. By matching the sample spectra to a stored spectrum from a certified standard, the analyzer is able to make its chemistry calculation based on a calibration file created especially for the matching grade. This spectral matching technique offers the best combination of speed and accuracy. Some of the advantages of **FastID** mode include:

- Provides a grade and chemistry in as little as 5 seconds. This is the best precision for shortest test time, when compared to other modes. Matching the sample's spectral fingerprint first allows FastID to select from hundreds of certified spectra and use the single best set of calibration data for that sample. The benefit is the fastest AND most precise chemistry calculation.
- Operator may add up to 300 additional alloy grades and assays (alloy chemistries) — password protected.
- Instrument offers 3 separate grade libraries for multiple users, or multiple departments. User can choose to search one or more libraries.

6.1 ANALYZING A SAMPLE

Once the instrument is standardized (see **Section 4.4: Standardization**), your analyzer is ready for routine measurement.

1. Hold the analyzer up to the sample to be tested. Make sure the part of the sample you wish to analyze is in contact with the window on the front of the probe.
2. Unlock the trigger by tapping on the icon located on the iPAQ Screen directly above the battery indicator. Select Yes when prompted.
3. Pull the trigger to start the measurement. The trigger must remain depressed for the duration of the test.

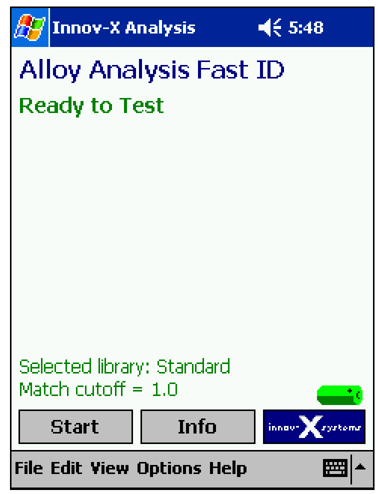
4. While the analysis is in progress**,** the red LED on top of the instrument will blink, and the screen will display **Test in Progress**. In addition a “testing” icon will appear in the lower right hand corner of the iPAQ screen. All these indicators show that the X-ray tube is energized and the shutter is open. During the testing time, it is important to keep the analyzer flush with the sample surface.
5. A test can be aborted at any time by releasing the trigger.
6. Once the measurement is complete, the results screen will automatically open. The results will be displayed in one of three forms, depending on the view that is selected.
7. Subsequent measurements can be started from the Results screen by pulling and holding the trigger.

6.1.1 Troubleshooting

There are certain parameters that must be correct in order for the analyzer to take a measurement. The instrument must be set to search a library containing fingerprints, and the match number must be valid. The Analysis Screen displays the match number cutoff and selected libraries. This information is shown in green lettering, at the bottom of the screen.

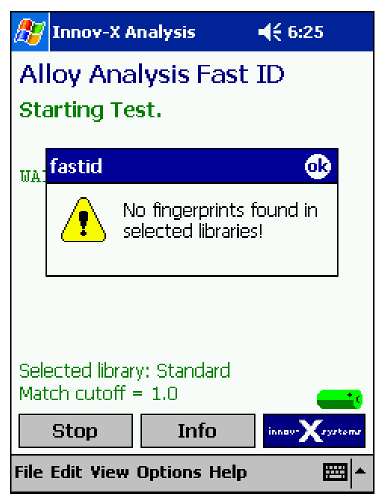
The selected library(ies) are listed. This is designed to allow the user to quickly verify that the correct library is being searched. The display will show “All” if all libraries are selected, or the names of the selected libraries. To change to Selected Libraries, choose ***File→Load Libraries***. It is recommended that all libraries are selected, unless it is necessary to search only a subset of stored fingerprints or grades.

The Match number is displayed to provide a quick check that the match number is set correctly. The factory set value for match numbers in FastID is 1. To change the match number, select ***Options→Fingerprint Settings***. More information about Match numbers can be found in the Advanced Features at the end of this section.



No Fingerprints Selected

It is impossible to start a test if no fingerprints are selected. If this is attempted, the following error message will result. Tap **ok** to acknowledge and clear the message box and select ***File→Load Libraries*** to choose libraries containing a valid number of fingerprints. See **Section 9.1.2: Loading Libraries** for more information.



Match cutoff too low

If the match cutoff is set too low, the instrument may fail to match alloys. Typically, the FastID match cutoff is set to 1. See the advanced features section at the end of this section for more information.

6.2 RESULTS DISPLAY

There are 3 possible ways to view information in the results screen; a user can view the Grade ID, the Grade ID and Chemistry, or the Raw Spectral Data. In addition, any test information entered for a reading may be viewed.

Regardless of what information is viewed, all results screens have similar characteristics. The **Date** and **Reading number** are shown at the top. Reading Numbers are useful for identifying readings. The first reading of a day will always be reading #1, thereafter; all readings within that day are labeled sequentially. Below the Date and Reading Number, the **Mode** used to acquire that reading will be listed.

Three buttons appear at the bottom of the screen: **Back, Next** and **Start**. **Back** and **Next** are used to scroll through stored data. The Start and Stop buttons are not active in most cases, and are normally only used in conjunction with a testing stand.

The results screens will show one of three possible results:

Successful Match
If an unknown alloy is a match to one of the grades contained in the Fingerprint libraries, a Grade ID will be shown.

Multiple Matches
In some cases, more than one grade will be shown as possible matches. This indicates that there was not enough statistical information to definitively separate two or more alloys, or the alloys are simply too similar to separate with portable XRF. The actual identification of the unknown alloy may be any one of the two grades listed.

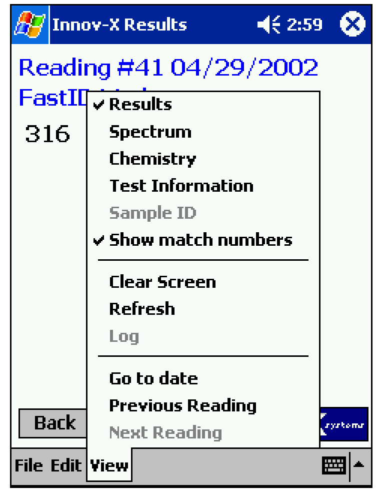
There are two procedures that may make it possible to separate the alloys:

1. Use a longer testing time. This will improve the measurement precision and may allow the alloys to be separated.
2. Define a specific element or elements that are different in the two alloys, which the analyzer can use to refine the identification. Please see Advanced Features later in this section for instructions to do this.

No Match
If no matches are found to the library, the words “no match” will be shown on the screen. If this occurs there may be several causes:

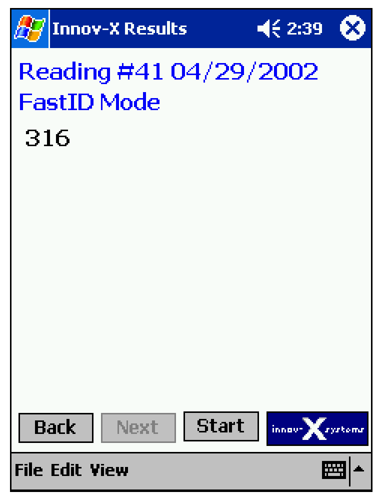
a. The alloy is not contained in the fingerprint library. Try using Analytical Mode to test the sample. Analytical Mode can provide chemistry information without requiring a library match. Alternatively, it is possible to add a standard to a library. This is described in Chapter 5.
b. The alloy may be coated. Try grinding or filing or sanding away any coating and repeat the test.
c. The testing time was too short. Trying increasing the testing time and measuring the sample again.
d. The match number is too low. See “Setting the Match cutoff” in the Advanced Features section of this chapter.

To change the appearance of the Results Screen click ***View***, and select one of four choices: **Results**, **Chemistry, Spectrum** or **Test Information**. The active view will be denoted with a check mark.



6.2.1 Results Screen

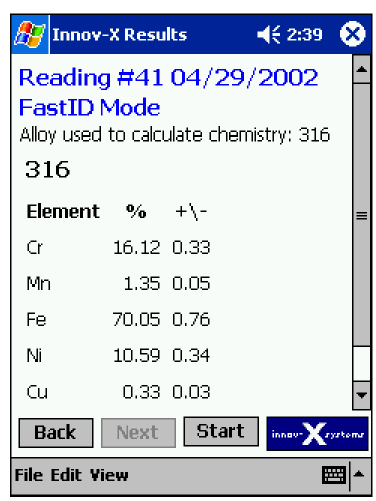
This is the simplest screen. It displays only the Grade ID, and no extraneous information. This view is recommended if the primary goal of the analysis is grade identification, and it is not necessary to examine the chemistry results for every test.



Typically, one or more Grade IDs will be shown, or the words "No Match." In some cases, a number may be displayed after the grade identification. This is known as the match number. This number can be eliminated by Selecting ***View→Show Match Numbers***. This selection acts as a toggle. If ***View→Show Match Numbers*** is checked, match numbers will be displayed. Match numbers are described in greater detail in the Advanced Features part of this Chapter.

6.2.2 Chemistry Screen

This screen is the most versatile as it displays the Chemistry values, the uncertainty in the measurement and the Grade Identification. The Grade is listed at the top of the screen. The concentration (as a %) for all detected elements is then listed. After each concentration, the uncertainty in the measurement is shown. This is calculated as the 1-sigma error on the counting statistics.

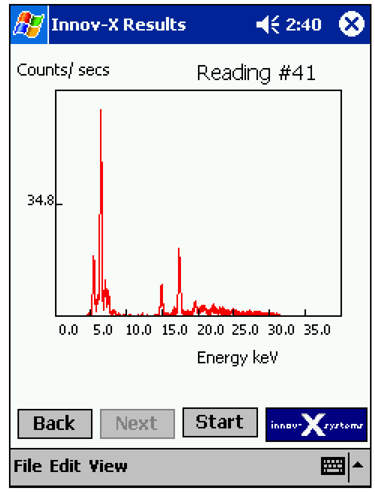


In cases where two or more matches shown, the results are based only on the first match listed. As a result there is some uncertainty associated with the chemistry values; however, given that two alloys are too close to separate, the chemistries should be fairly accurate.

Since **FastID** mode calculates chemistry results from standard assays, it cannot calculate chemistries for alloys that do not have assays stored in the fingerprint library. If no chemistries values have been entered in the library for any particular match, the message "Chemistry Values not calculated" will appear on the screen.

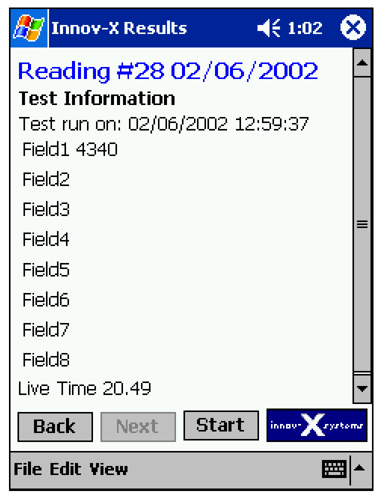
6.2.3 Spectrum Screen

This screen displays a plot of the x-ray fluorescence spectrum for an individual test, plotting the number of counts on the y axis versus the energy of the fluorescence x-rays on the x-axis. This spectrum is a unique energy signature resulting from the unique chemistry of the sample being tested.



6.2.4 Test Info Screen

The test information screen shows any information that was entered before starting a test.



6.3 ADVANCED FEATURES

This section we reviews two advanced features:

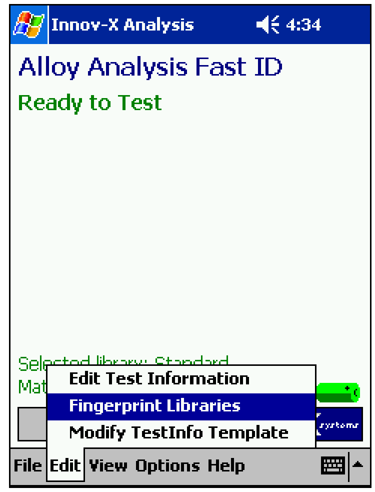
- Using Specific Regions to Separate Similar Alloys:
- Modifying the Fingerprint Cutoff Value

6.3.1 Specific Regions

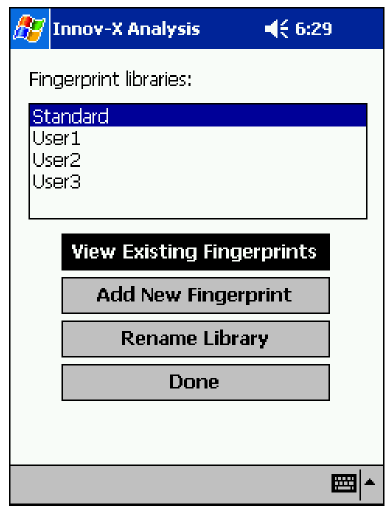
Some alloys only differ by a small concentration of a single element. For these alloys it may be necessary for the analyzer to examine the specific element or elements when performing a spectral match. In most cases, alloys that are difficult to separate when looking at all the elements may be easily separable if the analyzer is told to focus on one or more specific regions.

In order to instruct the analyzer to use one or more specific elemental regions, perform the following steps. This procedure can also be performed when reference standards are added by the user. For these instructions please refer the section on Adding a Fingerprint in Chapter 9. It is important to define the same specific elemental regions for all close alloys.

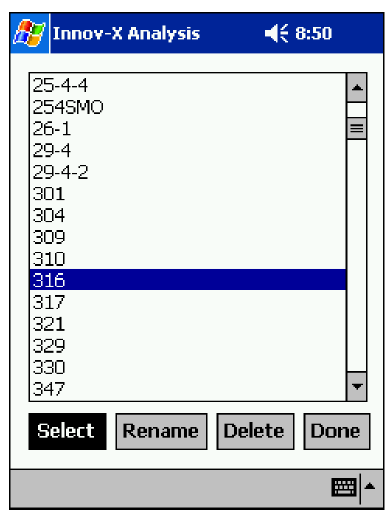
1. From the Analytical Menu, Select ***Edit→Fingerprint Libraries*** from FastID.



2. Select the library containing the alloy and click **View Existing Fingerprints**.

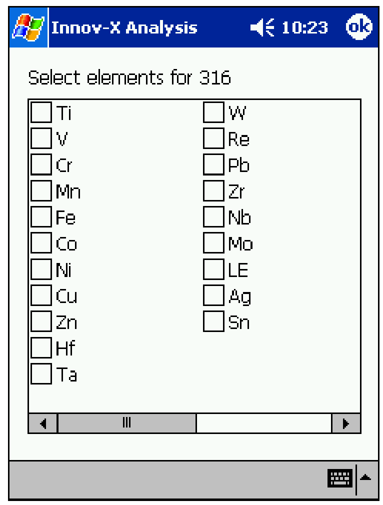


3. A list of the entries contain in the selected library will appear. Select the desired fingerprint.



4. Click the **edit** option underneath the heading **Elements**.

5. Tap the box for the element or elements you want to use for specific regions. A check will appear in that box. To disable this element, tap the element box again. The check will be removed. Select **ok**.



6.3.2 Modifying the Fingerprint Cutoff

In FastID Mode, the alloy matching is performed by comparing the x-ray spectrum of the sample to a library of reference spectra. Provided the sample spectrum is a close enough match to one or more reference spectra, the alloy grade(s) of the reference spectra is (are) displayed as the match. To determine a good match, a fingerprint match number is calculated by the analyzer by comparing the sample spectrum to the reference spectra. If the match number is below a pre-set cutoff value, then the sample is displayed as a good match to that particular reference standard. Ranges of match numbers are:

< 0.2	Excellent match
0.2-0.5	Good match
0.5-1.0	Reasonable match
1.0-2	Poor match
> 2.0	Sample is very different from reference standard.

Note: Factory default value = 1

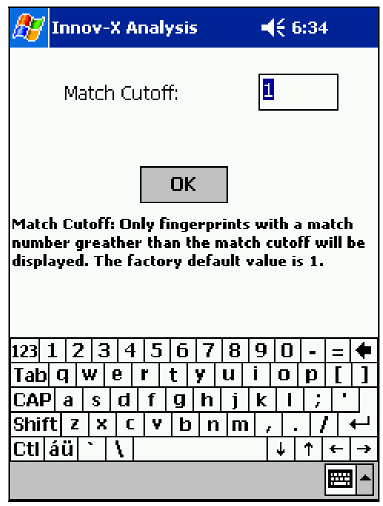
Generally, alloys within the same grade produce either excellent or good matches. Variations in match number occur because the reference standard has a slightly different chemistry than the sample being tested, even if they are the same grade. This is due to the usual grade-to-grade variations in the alloy chemistry. Testing small parts or parts with some surface oxidation may also elevate the match number.

Reasons to change the Fingerprint Cutoff:

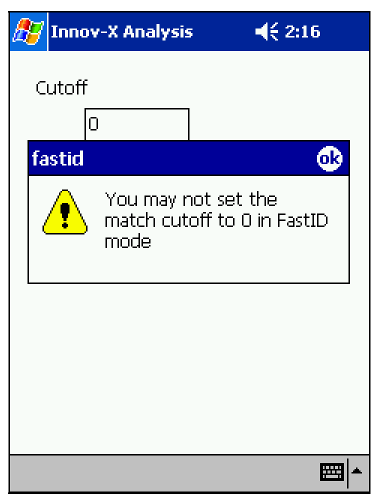
1. For sorting easily separated alloys such as 304 and 316, or alloys from different alloy bases, it is generally ok to raise the cutoff. This may be desirable if there is surface contamination like dirt, oil or mild oxidation, very small components like weld wire or turnings, or other things that may elevate the match number. It is advisable only to do this if the alloy sort being performed is known to be very easy for XRF technology.
2. The match cutoff may have been set to an extremely low number for a specific separation. If the match cutoff is too low, only very close matches will pass. Otherwise the result NO MATCH will be displayed.

How to Modify the Fingerprint Cutoff Value:

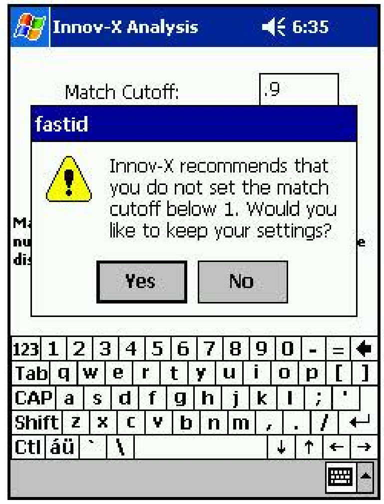
To change the Match number cutoff, from the Analysis Screen, select ***Options→Fingerprint Settings.*** The screen shown at the right will appear. Highlight the number shown in the box, tap the keyboard icon to bring up a keyboard, and enter a new cutoff value. Then tap OK.



If zero is entered for a match number, an error message will appear. Select ok to clear the message box, and select a valid match number. It will not be possible to close the Set Testing Times window with zero selected as a match number.



If the Match number is set to be a value below 1, a warning message will appear. Selecting **Yes** will keep the setting. Selecting **No** will allow the user to choose a new match number. Remember, the factory recommended setting for Match Number in FastID mode is 1.



Chapter 7 Alloy Analysis—Pass/Fail

7.0 INTRODUCTION TO PASS/FAIL MODE

Pass/Fail mode is designed for high-throughput alloy sorting and quality control. All sorting is done by comparison to a reference standard which is chosen by the operator.

Analyzed samples are compared to the reference samples, and results are displayed as a PASS or a FAIL, depending on whether they match the reference standard. Pass/Fail criteria may be based on the quality of fit to the spectral fingerprint or on elemental chemistry. Pass/Fail ranges may be implemented for one or more elements. This mode offers a full range of options from the simplest sorting of mixed loads in a recycling facility to QC on specific element(s) in even the most complex superalloys.

Two options exist for Pass/Fail mode: **Fingerprint** and **Chemistry**. Fingerprint matching should be used when the goal of the analysis is to determine whether or not analyzed samples are a specific grade. Chemistry should be used when it is important to determine whether the chemistries for specific elements fall within specified min/max grade specifications.

Fingerprint Pass/Fail uses the same method used in FastID to determine matches. Data from analyzed samples are compared to the fingerprint of a reference standard. If the differences between the fingerprints are small enough, the sample is judged to be of the same grade as the reference sample. This method requires only that a valid fingerprint for the reference standard is contained in the library.

Chemistry Pass/Fail. In addition to requiring that an alloy matches the fingerprint of a specific alloy, it requires that all detected elements fall within specified ranges.

The process followed in chemistry Pass/Fail is as follows:
1. Analyzer uses the fingerprint method to determine whether the sample matches the reference sample. If it does not, it automatically fails.
2. In the case of a match in step one, the chemistry of the alloy is calculated from assays stored for the standard fingerprint.
3. The calculated chemistry for each element is compared to the values stored in a Grade Table. In order for a sample to pass, all the chemistries must be within n standard deviations of the min and max values specified in the grade table, where n is a number which can be specified by the user.

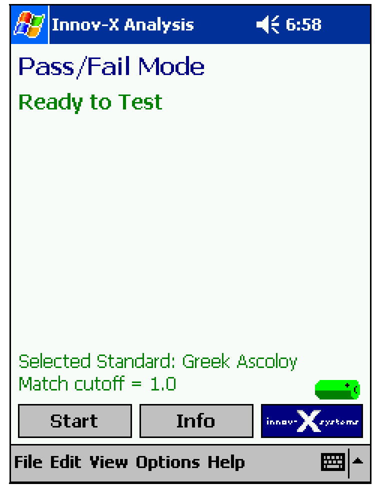
This method requires that a valid fingerprint, assays for that fingerprint, and Min/Max values are saved in the library.

7.1 USING PASS/FAIL

Before starting Pass/Fail mode, make sure that a signature for the reference sample you will be using is stored in the Fingerprint Library. You may use a fingerprint stored in the standard library, or you may add your own standard. To add a standard to the fingerprint library, follow the procedure listed in Chapter 9.

To start Pass/Fail mode, select Pass/Fail from the Main Menu. As with all modes, you will be informed if you must standardize the instrument before you can proceed with a measurement. Refer to the Chapter 4 for information on starting the analyzer and taking a measurement.

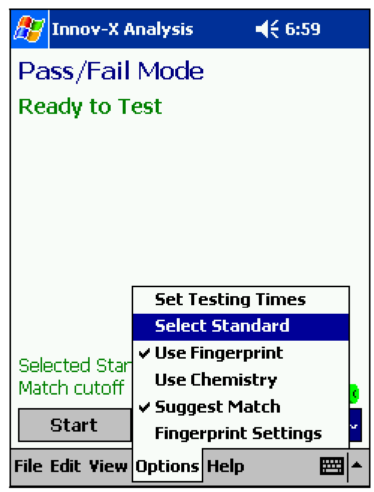
The Pass/Fail screen always shows the Selected Standard. This is the reference sample to which all other samples will be compared. Upon opening the mode, verify that the correct standard is selected.



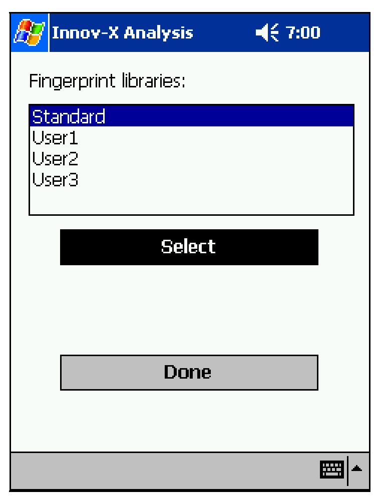
7.1.1. Selecting a Reference Standard

Once the standard you want to use is stored in a fingerprint library, select ***Options→Select Standard.***

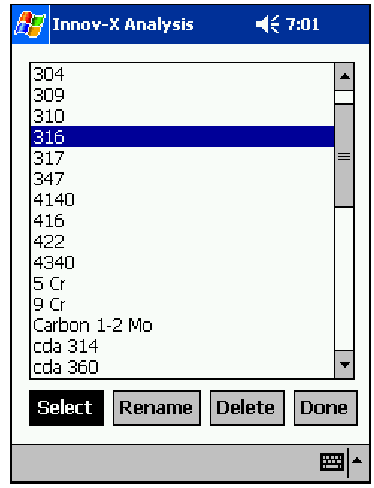
Enter your administrative level password when prompted.



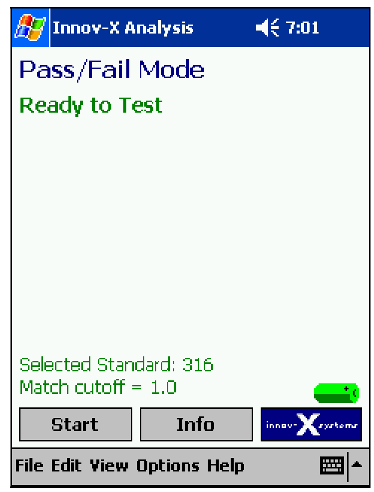
Select the library in which the fingerprint of your standard sample is stored. Choose the library and click **Select**.



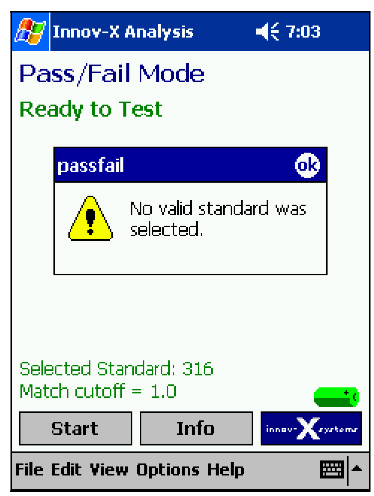
Select the name of your reference standard and click **Select**.



Verify that the proper standard is on displayed on the screen.



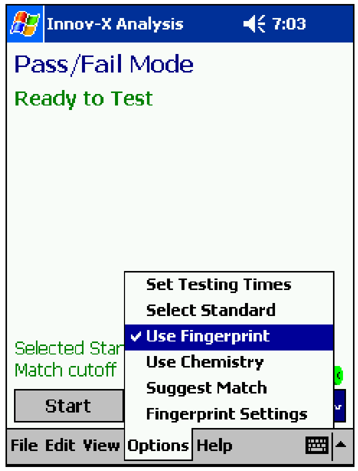
If you fail to select a standard, the instrument will always default to the last standard used. If a valid standard has not been selected, a warning message will appear. It will be impossible to start a test until a standard has been selected.

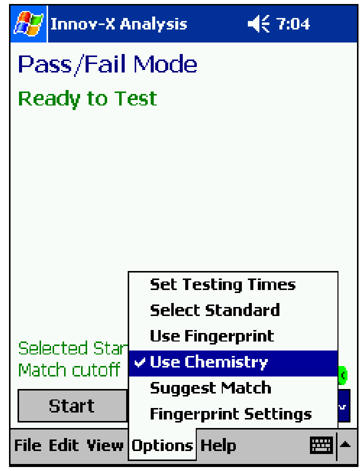


7.1.2. Select Pass/Fail Method

To use the fingerprint method and simply compare unknowns to a stored fingerprint, select ***Options* → *Use Fingerprint***.

Select **Options** → ***Use Chemistry*** from the menu if your Pass/Fail criteria will be chemistry-based.





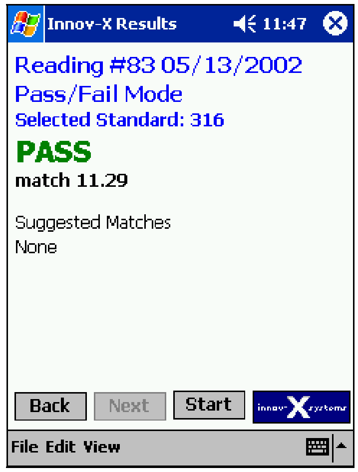
7.2 ANALYZING A SAMPLE

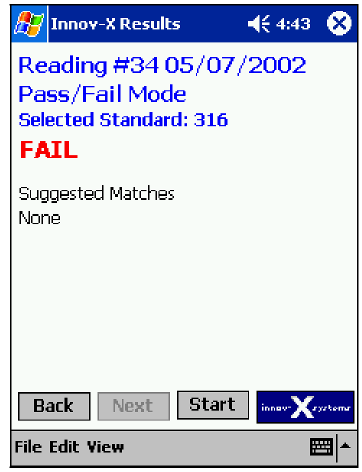
Once the instrument is successfully standardized as is described in section 4.4, your analyzer is ready for routine measurement.

1. Hold the analyzer up to the sample to be tested. Make sure the part of the sample you wish to analyze is in contact with the window on the front of the probe.
2. Unlock the trigger by tapping on the icon located on the iPAQ Screen directly above the battery indicator. Select Yes when prompted.
3. Pull the trigger to start the measurement. It is necessary to hold the trigger for the duration of the measurement.
4. While the analysis is in progress, the red LED on top of the instrument will blink, and the screen will say "Test in Progress." In addition a "testing" icon will appear in the lower right hand corner of the iPAQ screen. All these indicators show that the X-ray tube is energized, and the shutter is open. During the testing time, it is important to keep the analyzer in contact with the sample surface, and to keep all body parts away from the measuring window.
5. A test can be aborted at any time by pulling the trigger, or by tapping **Stop** on the iPAQ screen.
6. Once the measurement is complete, the results screen will automatically open. The results will be displayed in one of two formats, depending on the view that is selected.

7.2.1 Use Fingerprint

Since Pass/Fail by fingerprint requires only that a valid fingerprint is selected, the analysis is very straightforward. Taking a measurement will open the results screen which will display the results of the measurement.

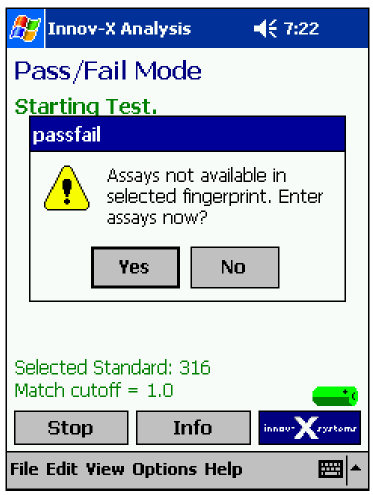


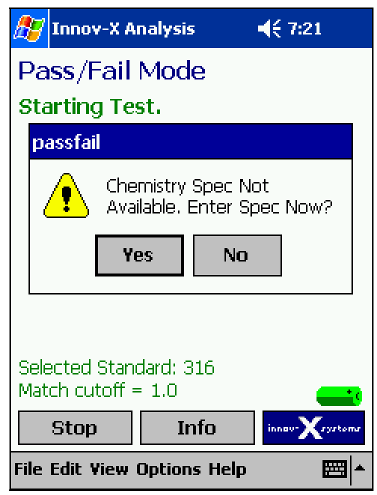


The results for Pass/Fail using Fingerprint comparison is very simple. Choosing ***View→Results*** will show only the reading, number, date, mode, selected standard and the result of the test; either the word **PASS** or **FAIL**. In the event of a failure, if the Advanced Feature: **Suggest Match** is enabled; possible Grade IDs will be displayed on the screen.

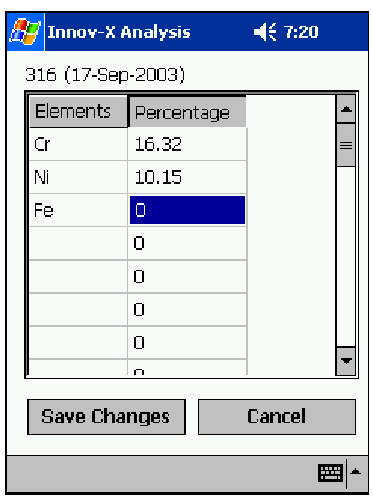
7.2.2. Use Chemistry

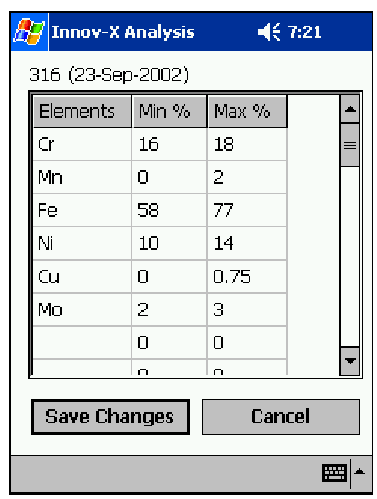
In order to get a valid reading with Use Chemistry selected, a fingerprint with an assay, and a grade table must exist. Since multiple parameters are required, it is strongly suggested that a known alloy grade is tested to make sure all parameters are set up correctly.





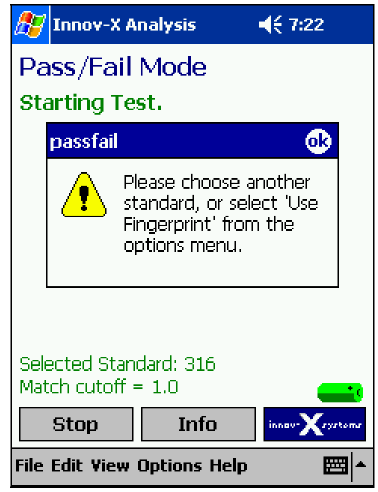
If a parameter is missing for a selected standard, a warning message will appear when the test is started indicating what needs to be added:





Selecting **Yes** to either of these screens will bring up either the Assays, or the Grade tables screen. Enter standard values in the assay table, and allowable Min/Max specifications in the Grade Table screen. Further information on either of these screens can be found in Chapter 9.

If you do not want to enter assays or grade libraries select No in response to the error message. You will not be able to take a reading until you either choose another standard or select Use Fingerprint.

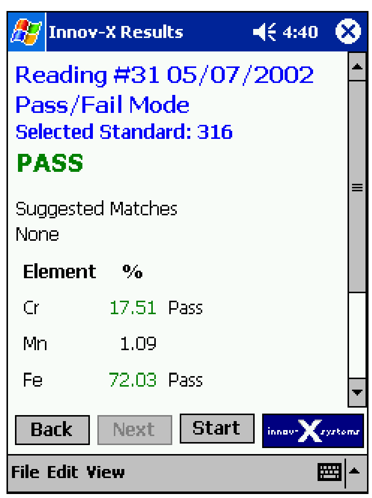


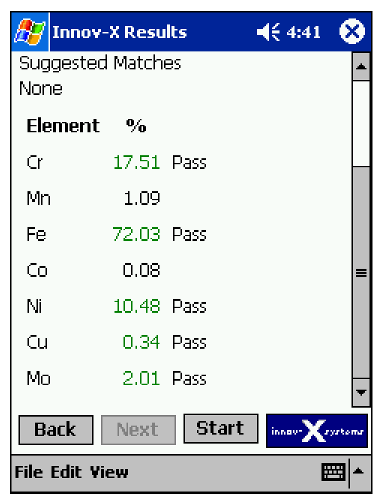
It is important that an assay is entered for every element that is listed in the grade table. If an assay is not listed for an element, the chemistry will not be calculated for that element. If this is the case, there will be no value to compare to the Min/Max spec. This will result in an automatic failure for every sample. Make sure that a standard sample is measured to ensure it is possible to get a PASS result.

Results—Use Chemistry

In addition to the PASS or FAIL results, the Chemistry results screen will show the calculated chemistry results. The percentage reading for each element will be color coded to show whether the value is within spec. A green color indicates that the reading is within specifications; a red color indicates the element is out of spec. If no Min/Max specification is provided for an element, the concentration will be shown in black. Any elements that don't have Min/Max specs will not be used as criteria for determining Pass or Fail.

If the list of elements exceeds the room available on the screen, it will be necessary to scroll down to see the complete list.

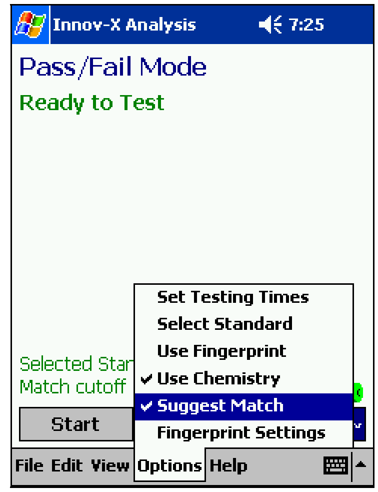




7.3 ADVANCED FEATURES

Suggest Match: Suggest Match is designed to provide information about a sample in the event of a **FAIL** result. When suggest match is enabled, the software will search the library and provide a list of one or more possible Grade IDs if the sample fails to match the selected standard.

To activate Suggest Match, Select ***Options→Suggest Match***. Once suggest match has been selected, it will remain active until it is deselected. A checkmark before the menu selection will indicate that the option is enabled.



If suggest match is enabled, the analyzer will search all active libraries for the sample(s) with the lowest match number. The match number is an indication of the degree to which the analyzed sample matches a library entry. The number is unit-less, and will vary depending on a variety of parameters. In general, the closer a match number is to zero, the better the match.

Suggested results will appear only in the results screen, not in the chemistry screen. The display will indicate a no-match, or display the suggested match. In many cases, a single match will appear. However, in cases where it is impossible to statistically separate two or more matches; all close matches will be displayed on the screen. Keep in mind that a suggested match is not necessarily a correct grade identification. It is simply the closest matching grade found in the fingerprint library.

Chapter 8
Alloy Analysis—Analytical Mode

8.0 INTRODUCTION TO ANALYTICAL MODE

Analytical mode utilizes a Fundamental Parameters (FP) algorithm to determine elemental chemistry. This method calculates chemistry from the spectral data, without the requirement of stored fingerprints. The Analytical FP calibration is done at the factory, and requires no user set-up or recalibration. The software also searches an alloy grade library to produce a grade match to calculated chemistry, based on the calculated chemistry. Analytical mode can provide a grade ID and chemistry in as little as 2-3 seconds, with increased precision for longer test times.

The FP method utilized in Analytical mode is ideal for applications that require analysis of proprietary or uncommon alloys, for monitoring chemistry of tramp elements, or for monitoring chemistry during processing. The fundamental parameters method is also ideal for obtaining an average chemistry of turnings, especially mixed turnings.

In many ways, analytical mode is the easiest to use of all the modes, since it is possible to acquire good solid chemistry data and grade identifications by using only the instrument default setup. Users who are analyzing complete unknowns or samples from a wide variety of alloy families may find this to be the most appropriate mode for their needs.

Determination of Grade Identification:

Analytical mode utilizes a Grade Library consisting of a set of minimum and maximum values for each element in an alloy. The factory installed standard grade library contains 250 alloy grades. The Operator may add up to 300 additional alloys. These alloys may be added to any of the 3 user libraries or to the standard Grade Library. For the sake of simplicity, we recommend any alloys added be added to the user libraries and not the Standard (Factory) library. The libraries may be searched individually or together. All libraries, including the standard library, may be edited by the user.

Analytical mode calculates chemical composition using a fundamental parameters algorithm. Once these values are calculated, they are compared to the grade tables stored in the grade library. The software calculates a number, called a Match Number, which is an indication of how close the chemistry of a measured alloy is to the library values. The lower this number, the better the match. A match number of 0 is an exact match, meaning that the calculated chemistry for all elements falls within the grade table specifications.

The presence of tramp elements, as well as uncertainty associated with any measurement, makes it possible for a valid match to fail to register as an Exact Match. Therefore, a cutoff value is set to determine whether or not a grade is considered a match. If the Match Number is below the cutoff value, it is considered to be a good match. The default cutoff value is set at a value that works for a wide range of alloys, but it may need to be adjusted for certain specialty applications.

8.1 USING ANALYTICAL MODE

A detailed startup procedure is described in chapter 4. The procedure is summarized here:

1. From the main menu, select Analytical Mode by tapping on the word “Analytical”.
2. Hold the analyzer up to the sample to be tested. Ensure that the sample is as flat as possible against the window, and is covering as much of the window as possible.

3. Unlock the trigger by tapping on the icon located on the iPAQ Screen directly above the battery indicator. Select Yes when prompted.
4. Start the measurement by pulling the trigger. When a test is in progress, the words "Test in Progress" will be displayed, along with the elapsed time of the measurement and a "testing" icon. The LED on the front of the instrument will blink, indicating that the X-ray tube is on, and the shutter is open.
5. Make sure the sample maintains contact with the analysis window for the entire duration of the test.
6. When the test is complete, the words "Test Complete" will appear. For the first reading of the day, there will be a slight delay while the results screen is opened. This will be indicated by the appearance of a rotating icon in the center of the screen.
7. After taking the initial measurement, tests can be started from the results screen by pulling the trigger. This will close the results screen and display the analysis screen, which will show the progress of the test.

8.2 RESULTS DISPLAY

There are 3 possible ways to view information in the results screen; a user can view the Grade ID, the Grade ID and Chemistry, or the Raw Spectral Data. In addition, any test information entered for a reading may be viewed.

Regardless of what information is viewed, all results screens have similar characteristics. The **Date** and **Reading number** are shown at the top. Reading Numbers are useful for identifying readings. The first reading of a day will always be reading #1, thereafter; all readings within that day are labeled sequentially. Below the Date and Reading Number, the Mode used to acquire that reading will be listed.

Three buttons appear at the bottom of the screen: **Back, Next** and **Start**. **Back** and **Next** are used to scroll through stored data. The **Start** button is inactive in most cases, but may be used in conjunction with the test stand.

The results screens will show one of three possible results:

Successful Match
If an unknown alloy is a match to one of the grades contained in the Fingerprint libraries, a grade ID will be shown.

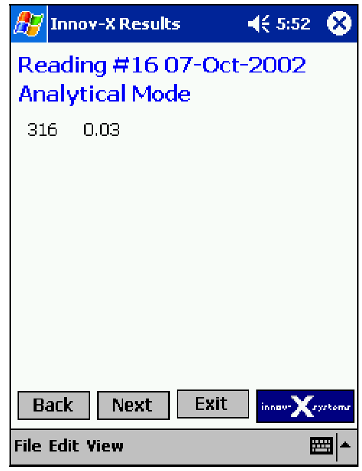
Multiple Matches
In some cases, more than one grade will be shown as possible matches. This indicates that there was not enough statistical information to definitively separate two or more alloys. The actual identification of the unknown alloy may be any one of the grades listed. Increasing the testing time may make it possible to separate the alloys.

No Match
If no matches are found to the library, the words "no match" will be shown on the screen. If this occurs there may be several causes:

a. The alloy does not meet any of the specifications in the Grade Library.
b. The alloy may be coated. Try grinding or filing or sanding away the coating and repeat the test.
c. The testing time was too short. Trying increasing the testing time and measuring the sample again.
d. The match number is too low. See **Section 8.3.1: Nearest Match/Exact Match** for more information.

To change the appearance of the Results Screen click ***View***, and select one of four choices: **Results**, **Chemistry, Spectrum or Test Information**. The active view will be denoted with a check mark.

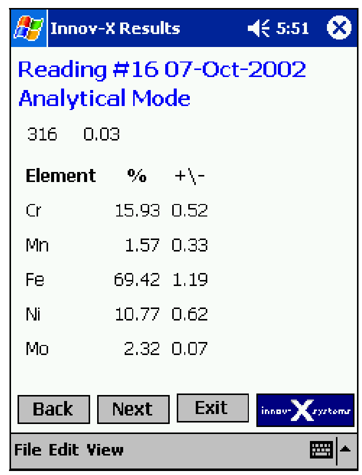
8.2.1 Results Screen



This is the simplest screen. It displays only the Grade ID, and no extraneous information. This view is recommended if the primary goal of the analysis is grade identification, and it is not necessary to examine the chemistry results for every test.

Typically, one or more Grade IDs will be shown, or the words "No Match." In some cases, a number may be displayed after the grade identification. This is known as the match number. This number can be eliminated by Selecting ***View→Show Match Numbers***. This selection acts as a toggle. If ***View→Show Match Numbers*** is checked, match numbers will be displayed. Match numbers are described in greater detail in the Advanced Features part of this Chapter.

8.2.2 Chemistry Screen

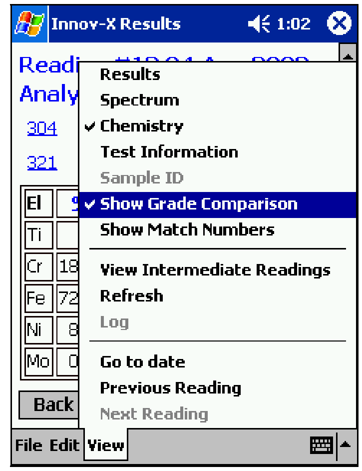


This screen is the most versatile as it displays the Chemistry values, the uncertainty in the measurement and the Grade Identification.

The Grade is listed at the top of the screen. The concentration in percent for all detected elements is then listed. After each element's chemistry, the uncertainty in the measurement is shown. This is calculated as the 1-sigma error on the counting statistics.

8.2.2A Grade Comparison

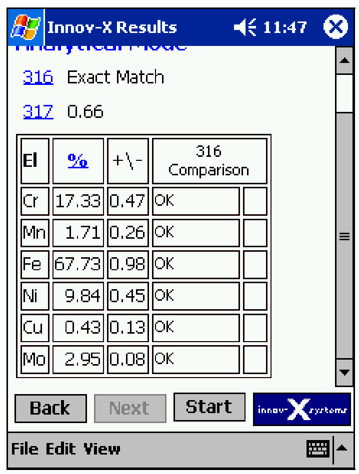
The Show Grade Comparison feature allows users to see at a glance which elements are outside the concentration range specified for a Grade Match. When this feature is activated the results will show up in a table format. If the chemistry of an element, plus or minus the error on the reading, is within the specified range for a specific grade, the word “OK” will appear next to that element. If the chemistry is out of range, the screen will indicate whether the measured elemental value is “low” or “high” and list the corresponding grade specification.



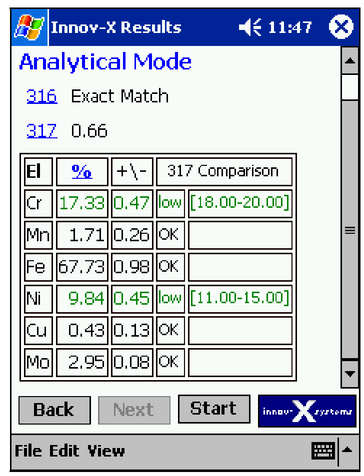
The show Grade Comparison function works only in the Chemistry view. If the results screen is not displaying chemistry results, select **View→Chemistry** from the results screen. Show Grade Comparison can be turned on or off by selecting **View→Show Grade Comparison** from the Results screen. A check mark will appear on the menu if the feature is active.

When Show Grade Comparisons is active, it is possible to show the comparison for any Grade that appears as a match for the analyzed sample. Select which grade comparison to view by tapping on the name of that grade.

The figures show the results for the measurement of 316. Both 316 and 317 show up as matches, however, 316 shows up as an “exact match” while 317 has a higher match number. The grade comparison shows that all the elemental concentrations are within specification for 316, while the Cr and Ni are both lower than specified for 317. Obviously, 316 is a better match and is the correct grade identification for the alloy.



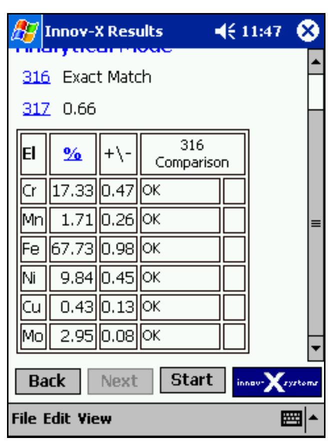
Grade comparison for 316. Select grade to compare by tapping on the name of the grade.



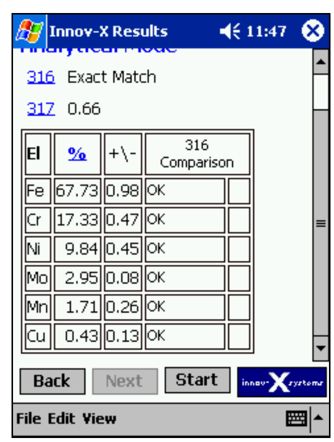
Comparison of chemistry with 317 grade spec.

8.2.2B Changing the order in which elements are displayed

Users may order detected elements in two ways; by emission line energy, or in order of decreasing concentration. To change the order, simply tap on the blue “%” header above the column displaying elemental chemistry. Tapping this header will switch the order. Tapping again will return the list to its original order.



Element list sorted by increasing emission line energy.

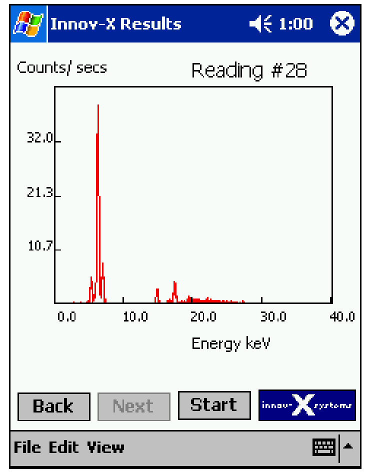


Element list sorted in order of decreasing composition.

8.2.3 Spectrum Screen

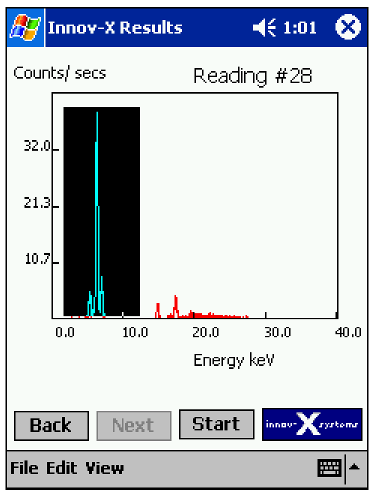
This screen displays a plot of the x-ray fluorescence spectrum for an individual test, plotting the intensity on the y-axis versus the energy of the fluorescence x-rays on the x-axis.

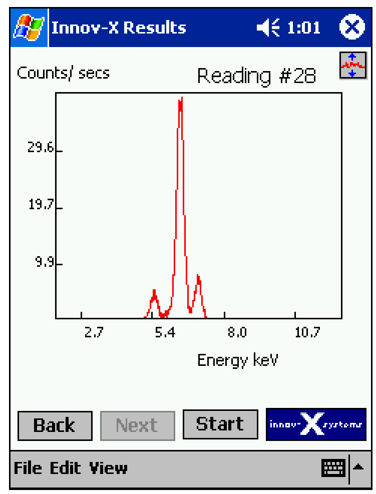
Tapping on the spectra will show the energy scale and count rate at the selected point.



It is possible to zoom in on certain areas of the graph by selecting one corner and drawing out the out the region

Tapping the symbol in the upper right hand corner beneath the X will restore the graph to full scale.





8.2.4 Test Info Screen

The test information screen shows any information that was entered in **Test Information** before the test was started.

8.3 ADVANCED FEATURES

8.3.1 Nearest Match/Exact Match

After calculating chemistry with the Fundamental Parameters algorithm, the analyzer software searches the Grade Library for alloy specifications which are close to the calculated chemistries. In order to evaluate which alloy is the best match for the measured sample, a number is calculated which compares the measured samples to the Grade Table. This number, referred to as a match number, is a measure of the difference between the measured chemistry and Minimum and Maximum specifications for the various alloys. A Match number of zero (0) indicates that measured chemistry is an "EXACT MATCH;" the measured chemistry for all detected elements falls within specifications. It is possible to have good matches that are not "EXACT," as there are uncertainties associated with any measurement. The presence of tramp elements (small amounts of unspecified elements) may also elevate the match number on valid matches.

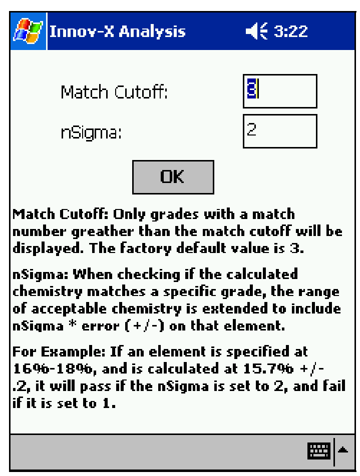
It is possible to specify whether the analyzer will report all possible matches, or just Exact Matches. These two options are referred to as Exact Match and Nearest Match. To switch between Exact and Nearest Match modes, select ***Options***. Clicking on ***Exact Match*** works as a toggle. If a checkmark appears before the words "Exact Match," Exact match is enabled. Otherwise, Nearest Match is the active method.

- **Nearest Match** When the analyzer is in Nearest Match mode, it calculates chemistries using the fundamental parameters algorithm, and searches the grade libraries and determines which alloy(s) is the closest match to the calculated results. The analyzer determines whether a grade is considered a match by comparing the calculated Match Number for that alloy to a cutoff value. This cutoff value is user modifiable. Typically this cutoff value is set at 3 and should not be changed, except in very special circumstances.

- **Exact Match** Exact match requires that all chemistry values are within a user settable error band of the min/max values specified in the Grade Libraries. The allowable error band can be changed by modifying the "nSigma" value. If nSigma is set as 0, all chemistry values must fall within the Grade Specifications. If nSigma is set as 2, for example, the chemistry value +/- 2*precision must fall within the Grade Specifications.

  Both the nSigma and Match Cutoff values are changed by selecting ***Options→Grade Library Settings.***

  A brief description of each field appears on this screen

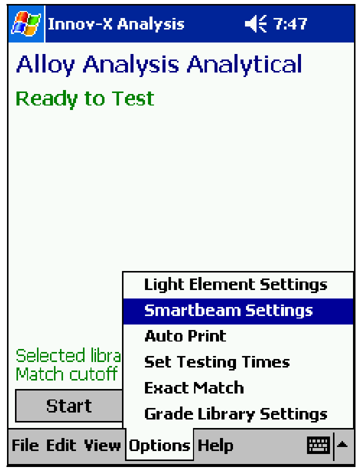


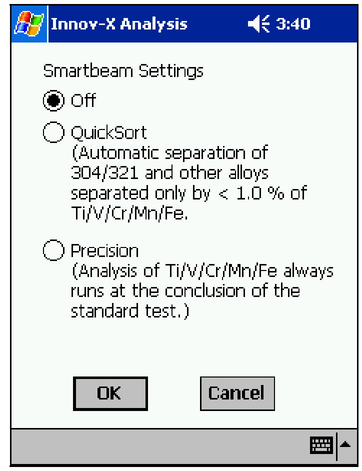
8.3.2 *Smartbeam* (optional feature)

Smartbeam adjusts the voltage, current and filtering to optimize detection of Ti and V in alloy samples. This feature is designed to provide quick, accurate separations of alloys which contain low concentrations (<1.0 %) of Ti and V, and to provide accurate and precise measurements of these elements.

Users can configure ***Smartbeam*** in two different ways: **Quicksort** mode provides automatic separation of alloys separated by a small amount of Ti or V. This mode *automatically* turns on ***Smartbeam*** and does a test with a second beam condition; if an alloy is found to match two alloy grades that only differ by a small amount of Ti or V. **Precision** mode forces ***Smartbeam*** on for every test in order to get precise chemistry on Ti and V at low levels. ***Smartbeam*** can also be disabled when it is not required.

Smartbeam settings:
To configure ***Smartbeam***, Select **Options→Smartbeam Settings** from the Analytical "Ready to Test" screen. A screen will appear providing three options.





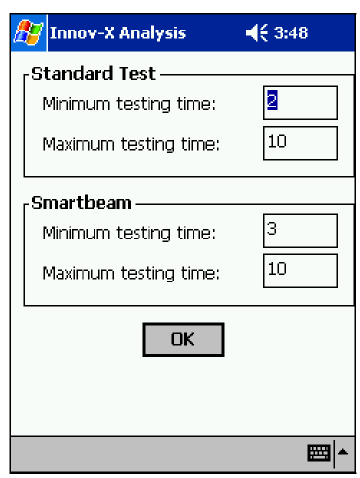
***Smartbeam* Off:**
If ***Smartbeam*** is disabled, the analyzer will perform a single, one beam analysis. This will separate most alloys; however a short test will not be sufficient to separate alloys which differ by a small amount of Ti or V. This is the recommended mode if the separation of alloys such as 304 and 321 is not required.

Quicksort:
Quicksort is the recommended ***Smartbeam*** setting for most applications. It allows for the quickest throughput of samples while maintaining the ability to separate alloys which require ***Smartbeam***. The analyzer automatically switches to a second beam condition when presented with a sample which closely matches two grades that differ by a small amount of Ti and/or V.

Precision:
This mode does a two beam test on all samples. Precision mode is only recommended for users who require precise chemistry on low concentrations of Ti and V. This is the most infrequently used ***Smartbeam*** option.

8.3.2A Setting ***Smartbeam*** Testing time

The Options **Set→Testing Times** screen for instruments equipped with ***Smartbeam*** allows users to set the smart beam testing times, as well as those for the Standard Test. Typical Testing times are shown.



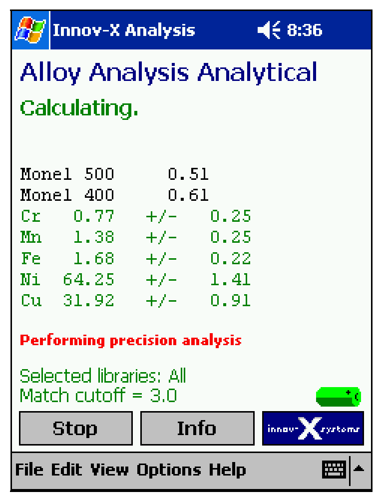
8.3.2B Testing with *Smartbeam* Enabled

Once ***Smartbeam*** is enabled, users will operate the instrument exactly as they do when ***Smartbeam*** is disabled. Tests are started and stopped via the trigger. The analyzer will start by testing using standard beam conditions, then switch to the second beam condition automatically, if appropriate.

If Quicksort is active, the instrument will start a test using the standard beam settings. If a sample is found to match two alloys which differ by only a small amount of Ti or V, the instrument will switch to a 2nd beam condition. It will test using the second beam until the maximum testing time for beam 2 has elapsed. When the analyzer switches to 2nd beam conditions, it will display the name of the two alloys being separated.

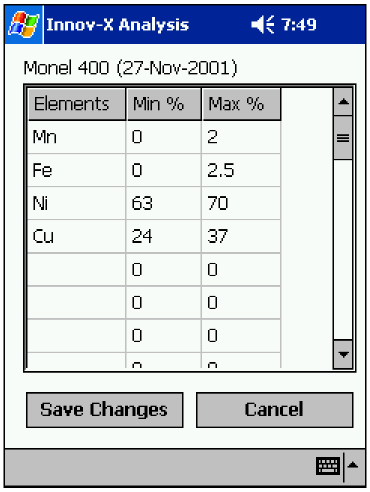
If the alloy has a unique ID, or if the best matches differ by something other than a small amount of Ti or V, the analyzer will function as it does with Smartbeam deactivated.

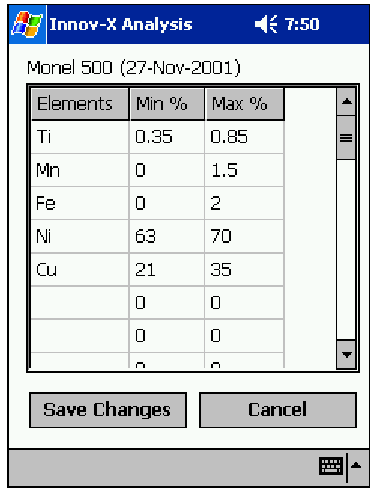
If Precision mode is active, the instrument will automatically switch to the second beam condition after the set time has elapsed for the standard beam. When the second beam is active the words "Performing precision analysis" will appear on the screen. The second beam will be active for the amount of time specified in the **Set Testing Times** screen, under the ***Smartbeam*** heading. At the completion of the test, a final result which reflects information from both beam settings will be displayed.



8.3.2C Creating alloy grades which utilize Quicksort *Smartbeam* Separation Mode.

When Quicksort is activated, the software uses the grade library to determine which alloys require a second beam analysis for separation. If the grade specifications for two alloys overlap completely, with the exception of Ti and/or V, Quicksort will use a second beam test. For example, the grade specifications for Monel 400 and 500 are shown below. They do not completely overlap, however, there are numerous concentrations which fall within the specifications of both grades. A second beam test will be required if a sample matches both of these alloys because Ti is specified in 500, but not 400.



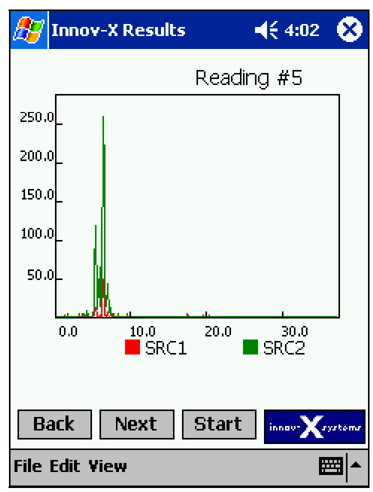


The most common grades requiring ***Smartbeam*** for quick separation; 304/321 and Monel 400/Monel 500 are included in the library. Users may add alloys to the library simply by entering the grade specifications. Quicksort will automatically use the second beam if a sample matches 2 alloys whose grade library specifications differ by <1% of Ti or V.

8.3.2D ***Smartbeam*** Results

The Chemistry results screen for ***Smartbeam*** tests is identical to that for standard tests. A single result is shown which includes information from both beams.

The Spectrum screen shows spectral overlays of data from both beams.



8.3.3 Light Element Analysis.

Innov-X Portable analyzers, like all hand-held XRF analyzers, cannot directly detect “light” elements such as Al, Si and Mg. In this manual, and in the software, light elements will be referred to as “LE” for light element. In practice Al is the most common light element of concern in alloys measured, so most of this discussion focuses on how aluminum is handled.

Innov-X analyzers handle light elements in two different ways.

1. **Use of nominal value**. All Analytical results are normalized to 100%. Since Al is invisible to the analyzer; the presence of several percent of Al can cause the other elements to appear too high after normalization. To correct for this, the software can normalize to 100% minus a nominal value for LE.

- Users should enter a nominal value for Al (or any other light element) as LE. If LE is specified for a grade, and the grade is found to be the best match for an alloy, the analyzer will use the average of the min and max specification as a nominal value. The measured results for all other elements will be normalized to 100% minus the LE nominal value.
- This is most useful for compounds which have less than 10% aluminum. This is typically used for titanium alloys and some copper alloys.

This method does not measure LE. It relies on data in the grade libraries. It's designed primarily to reduce the bias on other elements that can be caused by a significant amount of Al or other light elements. The nominal LE value will appear in blue to indicate that it is calculated, not measured.

2. **Calculation of LE using scatter lines**. A portion of x-rays from the x-ray tube are scattered back to the detector. The amount of scatter can provide additional information about the sample. In particular the amount of inelastic scatter, called Compton scatter is increased as the density decreased. As a result, the scatter lines can be used to indirectly calculate the LE concentration in low density samples, such as Aluminum alloys.
   - This method is recommended mainly for aluminum alloys, which typically contain more than 85% aluminum
   - The software will calculate the LE from the scatter lines, and all other elements from their x-ray emission lines. LE will be treated as any other element and included in the grade library search. Thus, Al alloys need to be included in the library for proper identifications.
   - Although this method can determine the amount of LE in an aluminum alloy, it is only sufficient to sort major grades of Al alloys. Many aluminum alloys cannot be separated because they differ by small amounts of Si, Mg or other light elements which cannot be measured. Please contact Innov-X System for more information on the capability of the analyzer for testing Al alloys.

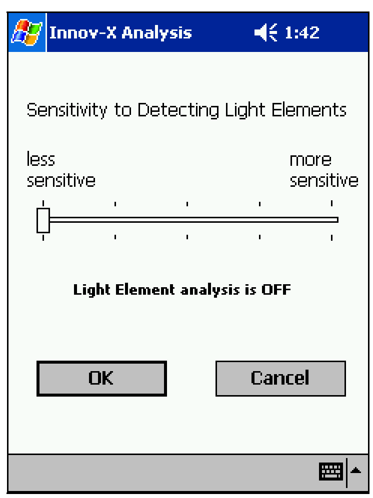
Since the calculation of LE is done indirectly, LE can be reported erroneously in some conditions if the amount of scatter is increased. For example, some customers who produce specialty alloys wrap the samples in plastic before testing. This scatter from the plastic will be erroneously reported as LE. Likewise, irregularly shaped or heterogeneous samples can, on occasion, produce false LE readings.

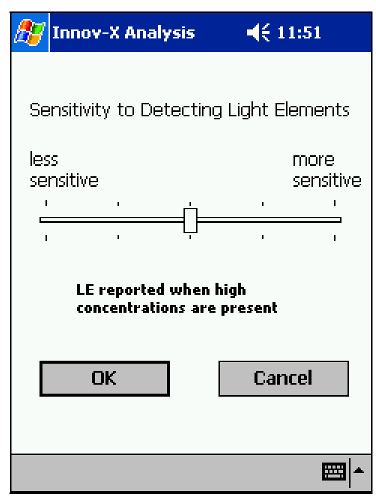
For these reasons, Innov-X allows customers to adjust their analyzer's sensitivity to Light Element detection. To change the LE sensitivity, select ***Options→Light Element Settings***.

If aluminum alloys are never measured, the slider bar should be positioned all the way to the left. This will ensure that Light elements are not erroneously detected. The default setting for all analyzers disables *Light Element analysis.*

Customers who measure Al alloys should set the slider to the middle of the screen.

The most sensitive setting should be used only in special cases, when recommended by Innov-X Application staff.





Chapter 9 Alloy Analysis—Libraries

9.0 LIBRARIES

All reference data for alloy identification is stored in a standard database, or library. Libraries are all completely editable by a user with password privileges.

There are two types of library entries: Fingerprints and grade tables. Fingerprints are used in both FastID and Pass/Fail modes. Fingerprint files contain a variety of information about a standard sample, including a spectral fingerprint, assay information, and a link to a grade library entry. Grade tables contain minimum and maximum specifications for each element present in an alloy. Grade tables are used in Analytical mode, as well as in Pass/Fail if use chemistry is selected.

A library entry may contain a variety of information about the sample. This information includes:

1. Fingerprint files (editable through FastID or Pass/Fail Modes). These files may contain:
   - Spectral signatures. Signatures or fingerprints are the basis for identifying samples in both FastID and Pass/Fail Modes.
   - Specific Elements—This information is used by the FastID Specific regions Advanced feature. This is used to separate alloys that are very close and differ by only one or two elements. Certain elemental regions are selected for comparison.
   - Assays—These assays are used by FastID and Pass/Fail mode to calculate chemistry.
   - Min/Max Ranges. These are used in Pass/Fail mode for matching by chemistry. Creating Min/Max tables in Fingerprint mode results in a grade table that can be used and edited in analytical Mode.

2. Grade tables (editable through analytical mode)
   - Grade tables include a list of minimum and maximum specifications for use in grade matching.

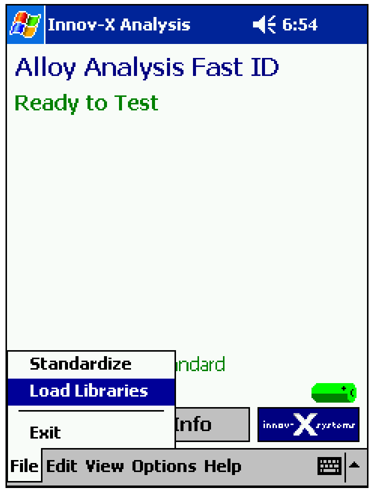
The spectral signature is automatically stored when the user adds a fingerprint to a library in FastID mode. The remaining information can be entered by the user if it is relevant. In order to calculate chemistry in either FastID or Pass/Fail, an assay must be entered. A grade table must exist to use Pass/Fail chemistry, or to get a grade ID in Analytical mode.

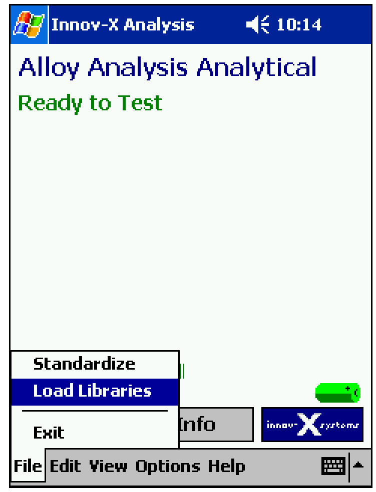
9.1 SELECTING A LIBRARY.

There are four libraries available. Each library can contain both Fingerprints and Grade Tables. The first library is the Standard Library which contains up to 300 fingerprints or grades and is supplied with every analyzer. Typically 35 FastID, and 200 Grade Tables are supplied with new analyzers. The remaining three libraries are empty, and are available for users to use create their own custom libraries. Users may add standards to any of the custom libraries, as well as to the standard library, however, it is good practice to make changes only to the user libraries.

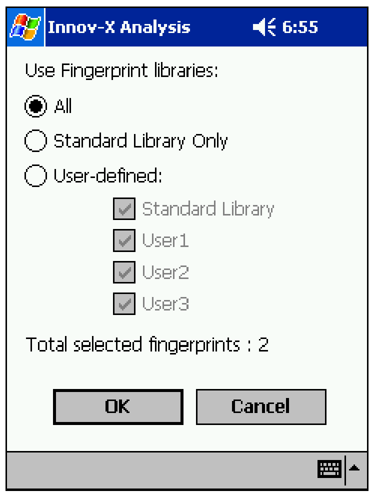
Each of the libraries may be searched individually, or in combination with any or all of the other libraries. The default setup searches all four libraries. It is possible to search any library in FastID. Pass/Fail will use only one fingerprint, so it is not necessary to select a library to search.

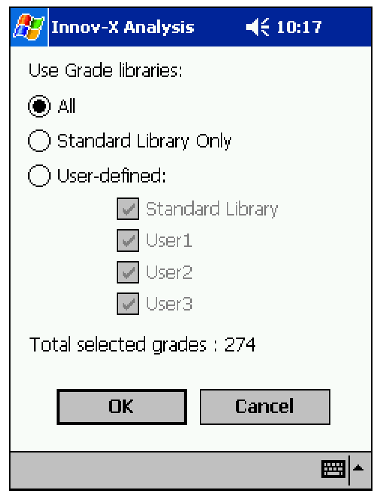
To select which library to search, select ***File→Load Libraries*** from either the FastID or the Analytical Analysis Screen.





A menu will appear. The first line reads **Use Grade Libraries** for Analytical Mode or will read **Use Fingerprints** for FastID Mode.





Choose the Fingerprint or Grade Libraries you wish to search. For the most general search, select **All** libraries. This will search the entire Standard Library, as well as any fingerprints that have been added by the user.

Users who are primarily concerned with sorting the most common specialty, stainless, nickel and high temperature alloys should always search the **Standard Library**.

Users who are sorting a small group of alloys may prefer to create their own libraries using their own standards. In this case, only the appropriate user library should be selected.

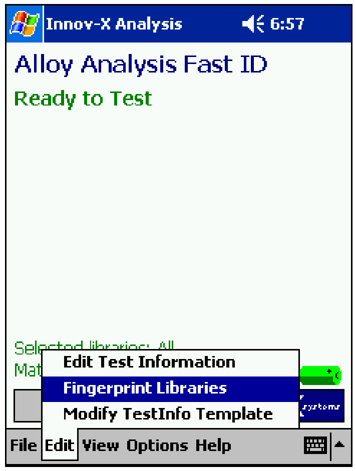
9.2 EDITING LIBRARY FUNCTIONS

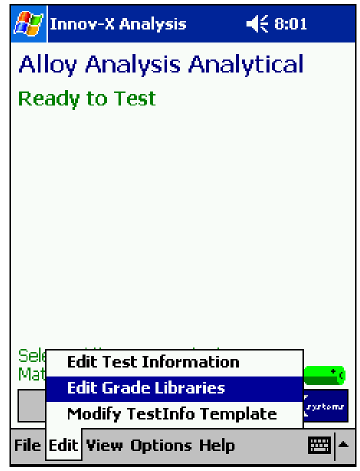
Innov-X Systems libraries are completely user editable. Library entries may be added, deleted, renamed, and the information contained within them, such as assays and min/max grade tables, can be modified.

The information contained in libraries is essential to the proper functioning of your analyzer. Care should be taken when editing libraries as incorrect settings may result in incorrect grade identification.

It is recommended that the standard library is not modified. All new alloys should be added to a user library.

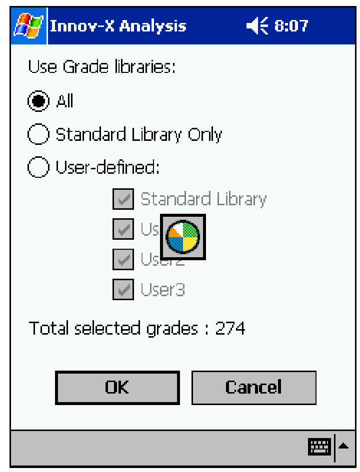
The edit libraries menu is reached by selecting either ***Edit→Grade Librarie***s from Analytical Mode, or by selecting ***Edit→Fingerprint Libraries*** from FastID or Pass/Fail modes.





All library functions require an administrative level password. The password needs to be entered only once during each editing session. The default administrator password is a lowercase **z**. This password can be changed from the main menu.

When you are finished with any edits, there may be a slight pause while the analyzer loads and re-indexes the library. This will be indicated by the following graphic, which will rotate in the center of the screen.

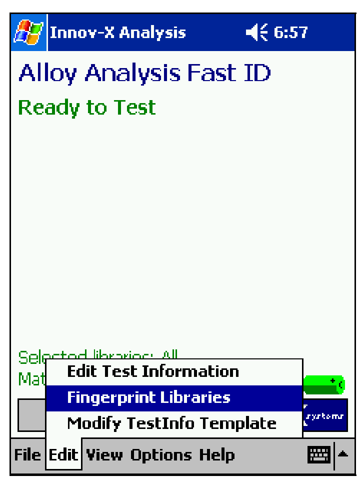


Functions such as renaming and deleting libraries are the same for both Fingerprint Libraries and Grade Libraries. They will therefore be described together in the following sections. Editing library contents and adding new library entries require different procedures for different library types and will be described separately at the end of the chapter.

9.3 CHANGING LIBRARY NAMES

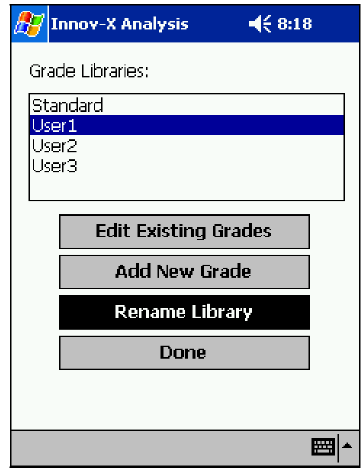
The default names for the libraries are Standard Library, User1, User2 and User3. It is possible to change the name of each of the User Libraries; however, the Standard Library can not be renamed. When a library is renamed, the new name will be used for all alloy modes, regardless of the mode that was active when the name was changed.

1. Library names can be changed either by selecting ***Edit→Grade libraries*** from Analytical Mode or by selecting ***Edit→Fingerprint libraries*** from Pass/Fail or FastID Mode.

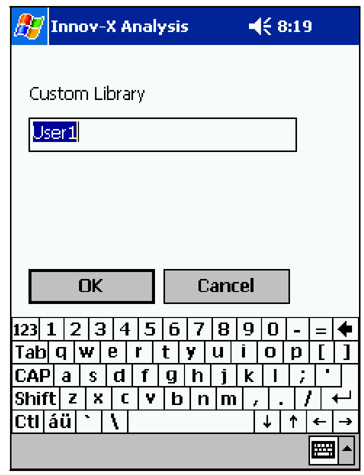


2. To rename a library, select it and tap **Rename Library.**

3. Enter the administrative password when prompted.



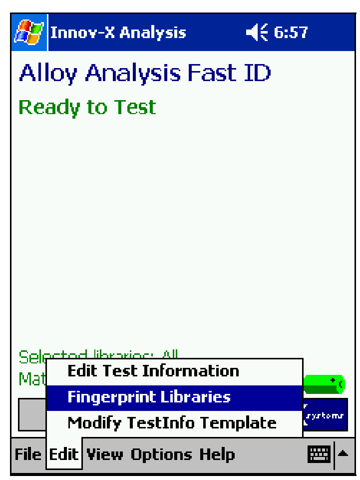
4. Type in the new name. The name may include any combination of letters or numbers, but may not include the characters "/", "." , "+", "_" or "?" . Enter the new name via the virtual keyboard. Tap **OK** to save the new name. If you do not wish to modify the name, select **Cancel.**



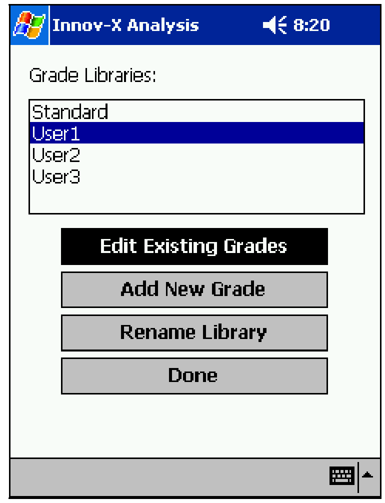
9.4 CHANGING THE NAMES OF INDIVIDUAL FINGERPRINTS OR GRADE ENTRIES.

If typographical errors are made when entering the name of a library entry, the name may be edited. Care should be taken when renaming a library entry. The name must correspond to the data saved in the file. An incorrect Fingerprint or Grade name will result in a wrong Grade ID

1. From the Analytical Menu, Select ***Edit→Grade Libraries,*** or select ***Edit→Fingerprint Libraries*** from FastID or Pass/Fail.

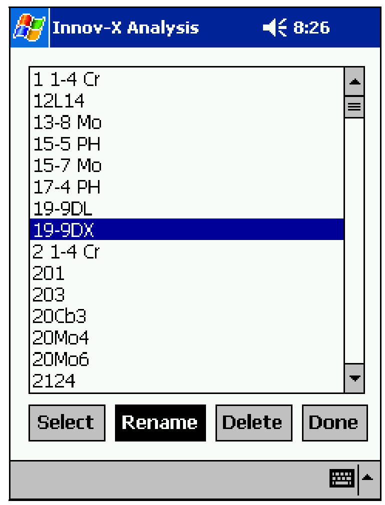


2. Select the library containing the entry you wish to rename and tap **Edit Existing Grades.**

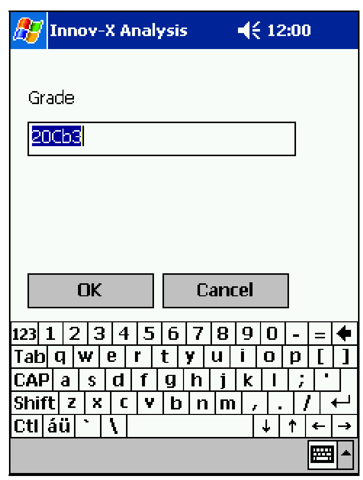


3. A list of the entries contain in the selected library will appear. Select the name to be changed, and click **Rename**. . The name may include any combination of letters or numbers, but may not include the characters /, . , +, _ or ?.

4. You will be prompted for your password.



5. Type the new name in the dialogue box. Select **OK** to accept the new name, or **Cancel** to exit without saving changes.

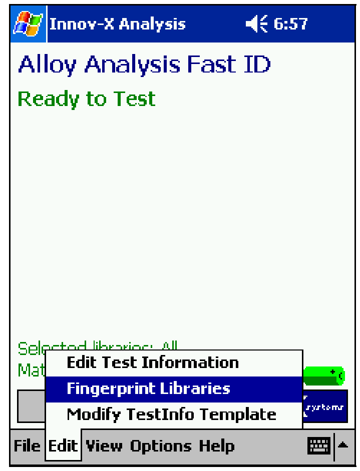


Note, because Grade Table information is stored in Fingerprint files, renaming a fingerprint file will also rename the corresponding Grade Table. However, the reverse is not true. Renaming a Grade Table entry will not rename the fingerprint with the same name. If a grade name is changed, that grade will not be useable in Pass/Fail Mode if **Use Chemistry** is selected.

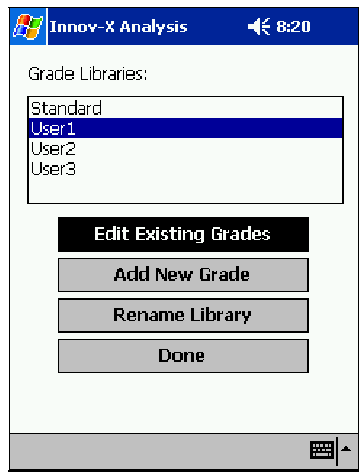
9.5 DELETING A GRADE OR A FINGERPRINT

Caution: Deleting a library entry will permanently delete the Fingerprint and Assay (FastID/PassFail) or the Grade Table (Analytical). Proceed with caution.

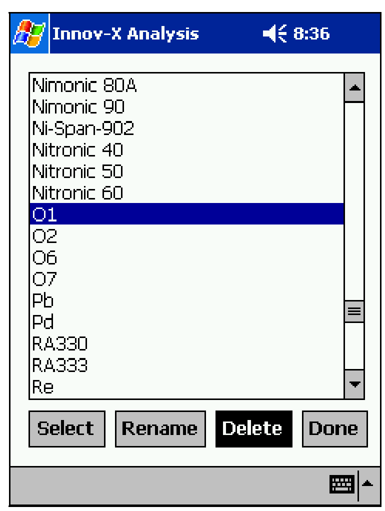
1. From the Analytical Menu, Select ***Edit→Grade Libraries,*** or select ***Edit→Fingerprint Libraries*** from FastID or Pass/Fail.



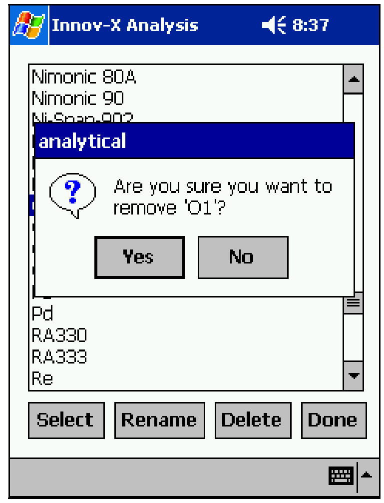
2. Select the library containing the entry you wish to delete and tap **Edit Existing Grades.**



3. Select the sample to be deleted and tap **Delete**.
4. Enter password when prompted.

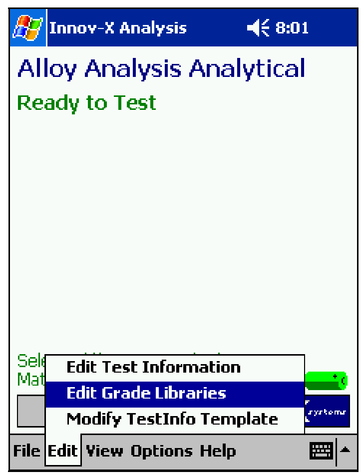


5. You must select **Yes** to confirm deletion. Otherwise select **No**.



9.6 ADDING A GRADE

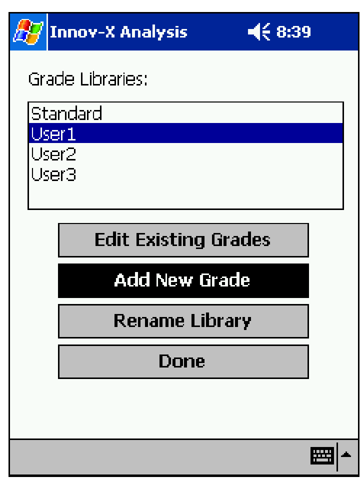
If you wish to add a grade to a library, you must have a list of the minimum and maximum allowable concentrations of each element in the library. It is important to include ALL elements that may be present in an alloy, including the balance element. Pay special attention to tramp elements that may not be specified but may be contained in an alloy of that grade. For example, many stainless alloys may contain small amounts of Molybdenum. If Mo is not included in the grade table, but is detected in sample, the sample may not be correctly identified. In a case like this, it is recommended that a maximum allowable specification is entered, such as 0-.5%.



Follow this simple procedure to add a grade:

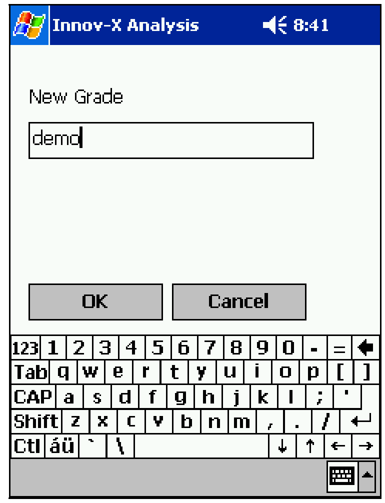
1. From Analytical Mode, Choose **Edit→Grade Libraries**.

2. Select the Library to which you want to add an entry, and tap **Add New Grade**. Enter your password when prompted.

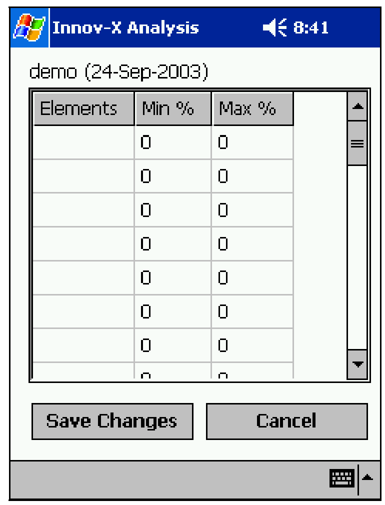


There is a limit of 100 entries in each of the libraries. If you attempt to add a grade to a library which already contains 100 entries, the message "Maximum number of user-defined libraries already exist" will appear. You must either select another library or delete a grade from the current library.

3. Enter the name of the new Grade, and tap **OK**.

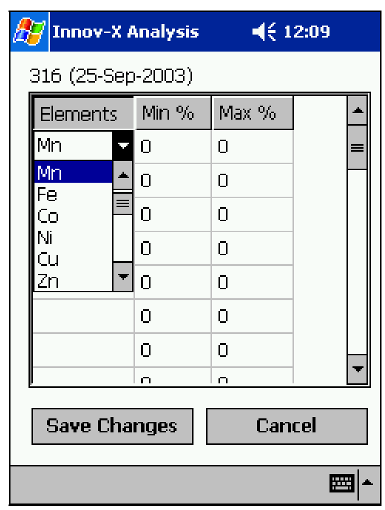


4. A new Min/Max Table will appear. It will contain no elements. A value of zero will be entered for all Min and Max values.



5. To select an element name, click twice in a box in the "Elements" Column of the table. This will bring up a drop down menu.

   You may scroll down an element, or you may advance to a specific element by pressing the first letter of the element on the virtual keyboard. Each time you press a letter, you will go to the next element in the list beginning with that letter. For example, the first time you select M, you will advance to Mn. Selecting M again will advance to Mo.

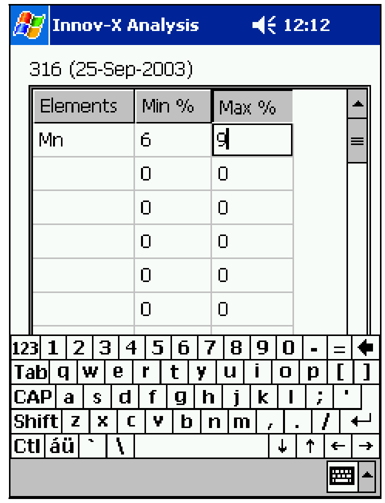


6. To enter a minimum or maximum value, tap in the appropriate space to select it, then enter the desired value.

   a. If an element is listed as being between 6 and 9 %, enter a 6 in the Min % column and a 9 in the Max % column.

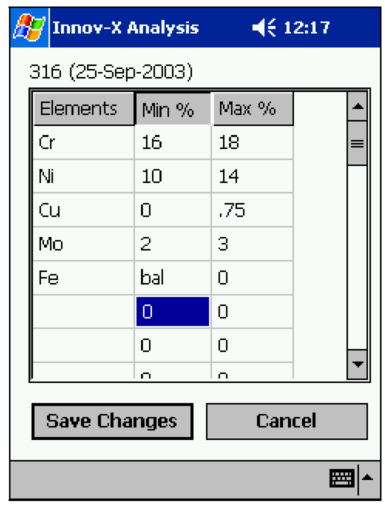
   b. If a maximum value is specified for an element, enter 0 in the Min % column and the maximum specification in the Max % column.

   c. To enter a spec that has only a minimum value specified, enter the value in the Min %column and 100 in the Max %column.

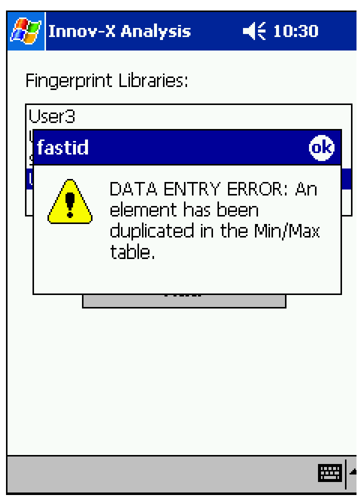


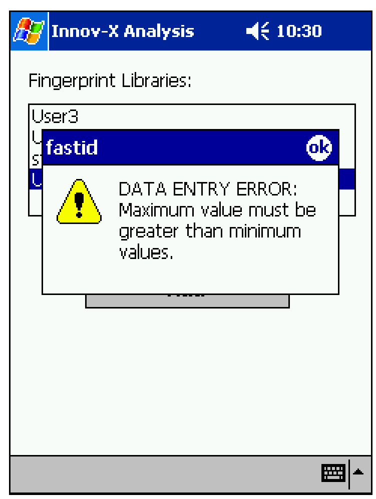
7. Repeat for all relevant elements. Bal may be entered for the balance element.

8. Tap **Save Changes**.



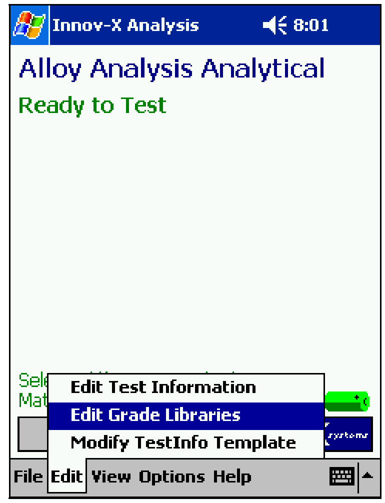
The software requires that the minimum value is less than the maximum value for each element, and that each element is only entered once. If there is a problem with the data entered, a warning message will appear. Click **ok**. The Min/Max table will appear. You must correct any errors before you are allowed to save the data.



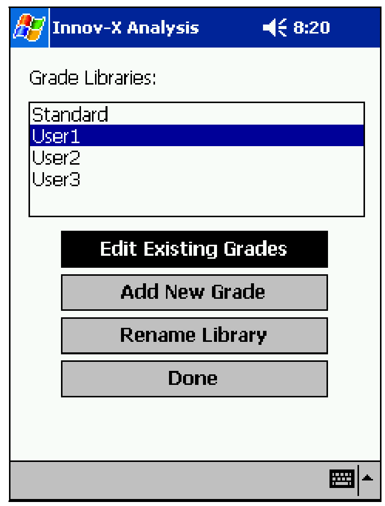


9.7 ANALYTICAL MODE--EDITING A GRADE

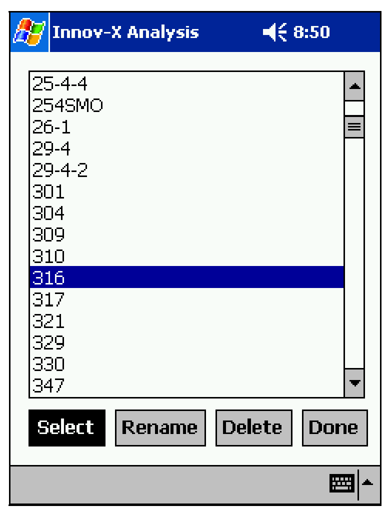
1. From Analytical Mode, Choose ***Edit→Grade Libraries***.



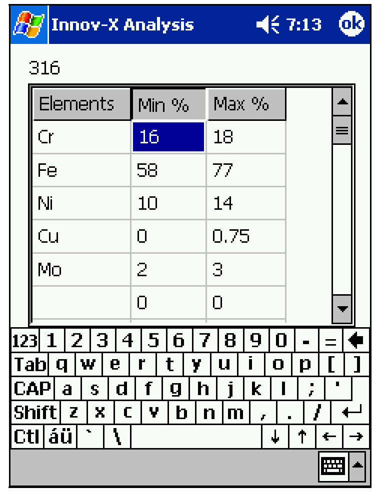
2. Select the library containing the entry you wish to rename and tap **Edit Existing Grades**.



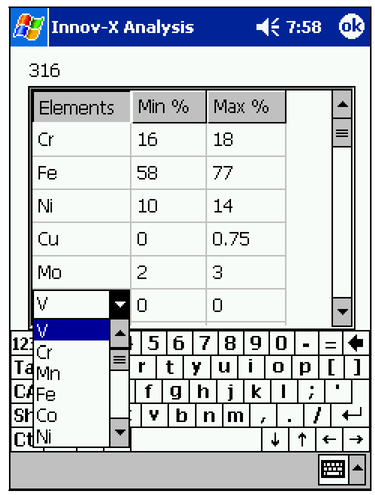
3. A list will appear showing the entries in the library. Tap on the grade name you wish to modify and tap **Select** to bring up the specifications.



4. Element specific minimum and maximum values are shown. Only elements with specified values are shown on the list. To modify min or max values for any listed element, select the appropriate field and enter the new value using the virtual keyboard.

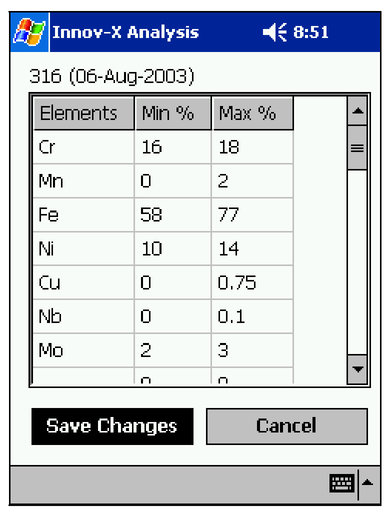


5. To add specifications for an element that is not present, tap twice in an empty box in the Elements column. Use the drop-down menu to select a new element in the field directly below the last listed element.



6. Repeat for all relevant elements.

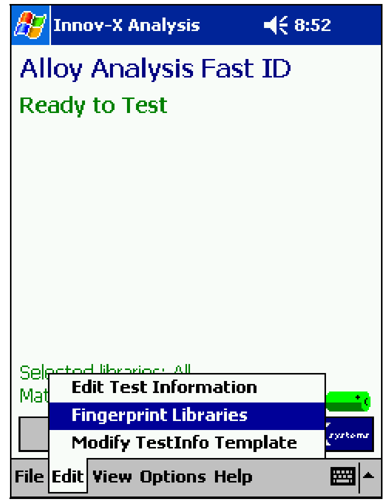
7. Tap **Save Changes**.



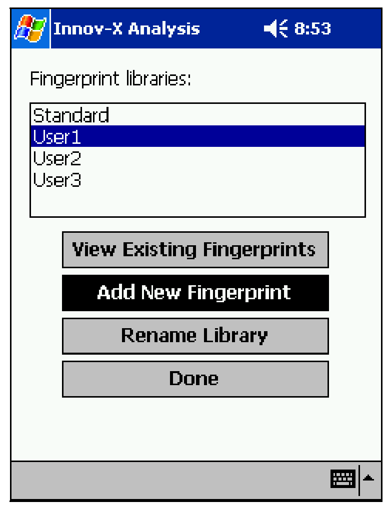
9.8 ADDING A FINGERPRINT

Adding a standard to a fingerprint library requires a sample of the material to use to create a fingerprint. In order to calculate chemistry for this type of alloy, assay values must be available and must be entered into the software. Since assay values are used to calculated chemistries for other alloys, it is important that this information is very accurate. When possible, it is strongly recommended that a certified standard be used.

1. From the FastID Analysis Screen, Choose ***Edit→Fingerprint Libraries***.

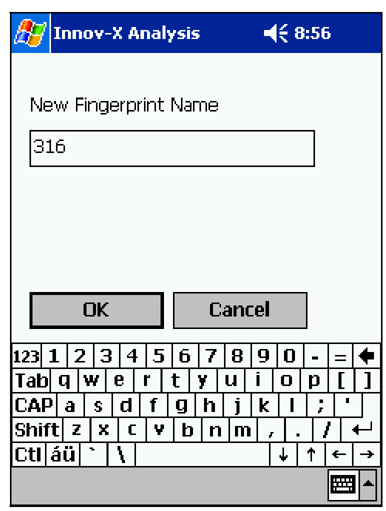


2. Select the Library to which you want to add an entry, and tap **Add New Fingerprint.** Enter your password when prompted. Remember that your password is the lowercase letter **z** unless it has been changed.

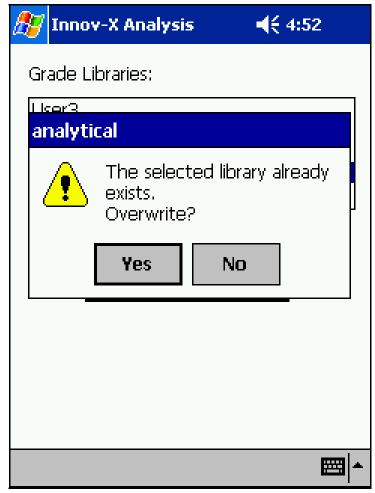


The size of the libraries is limited to 300 entries in the standard grade library, and 100 in each of the custom libraries. If the library is full, a message will appear telling you to either delete a grade, or choose a different library.

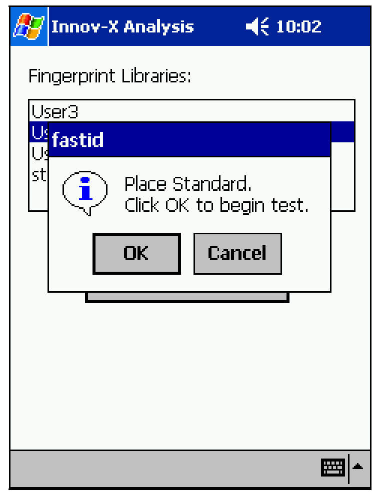
3. Enter the name of the new Fingerprint, and tap **OK**. The alloy name may be any combination of letters or numbers but may not include symbols such as ?, /, ., or +.



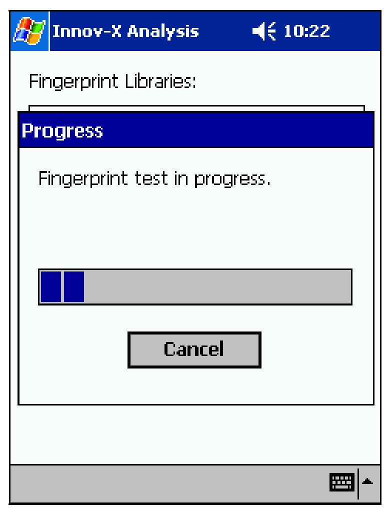
4. If you enter a sample name that is already stored in the library, you will receive a warning message. If you wish to overwrite the existing file tap **Yes,** otherwise select **No** and choose another name.



5. The analyzer will prompt you to place the sample.



6. Place the sample in front of the analyzer window and tap **OK**. The analyzer will acquire a spectrum for storage in the library. The fingerprinting process will take 30 seconds. It is very important that the analyzer window remain in contact with the standard for the entire duration of the fingerprint measurement.

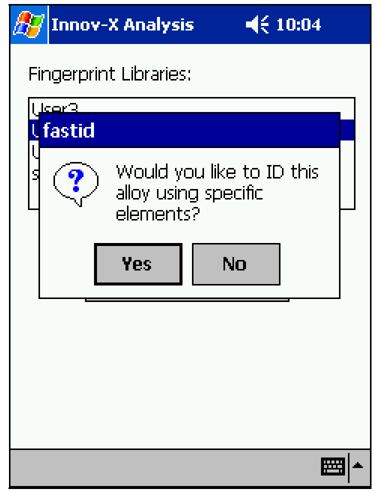


7. When the fingerprint has been stored, you will be asked if you want to enter specific elements.

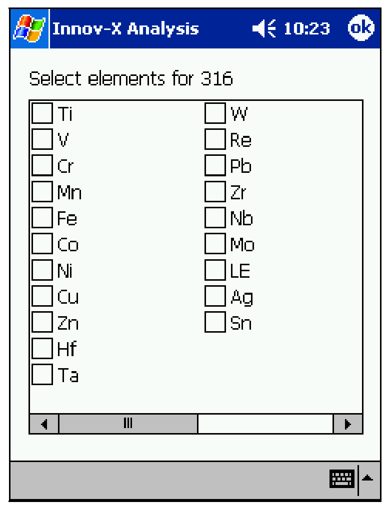
   Using specific elements is described in more detail in the FastID section of this manual. It is useful in situations where you are trying to separate two or more similar alloys that differ only in the composition of one or two elements. Note that this feature is not often used. Most users will select **No**

   If you wish to utilize this function, select **Yes**, otherwise, select **No**.

   If **No** is selected, skip to step number 10.



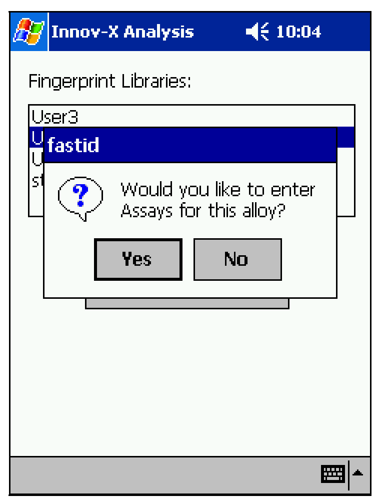
8. To enter specific elements, select the elements you wish to use by checking the box to the left of the element name. Usually, only one or two elements will be selected. Tap **ok** when you are finished



9. After specific elements have been selected, or after selecting **No** in step 8, you will be asked whether you want to enter assays.

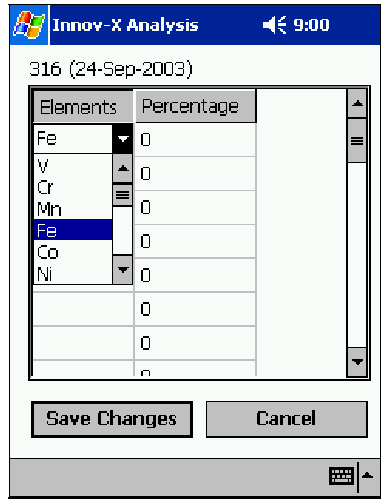
   In order for the Innov-X Systems Software to calculate chemistries in FastID or Pass/Fail Modes, assays must be entered.

   If you do not wish to enter assays, or they are not available, select **No**. If you select **No**, you will be able to use this Fingerprint for Grade Identification in FastID, and using the **Fingerprint** method in Pass/Fail. However, it will not be possible for the instrument to calculated chemistries for alloys matching this fingerprint. Skip to step 12 if **No** is selected.



10. A blank table will appear. Enter the element name and assay into this table.

    a. To select an element name, click twice in a box in the "Elements" Column of the table. This will bring up a drop down menu. Scroll down to the element you wish to select, or select the first letter in the element symbol using the keyboard.

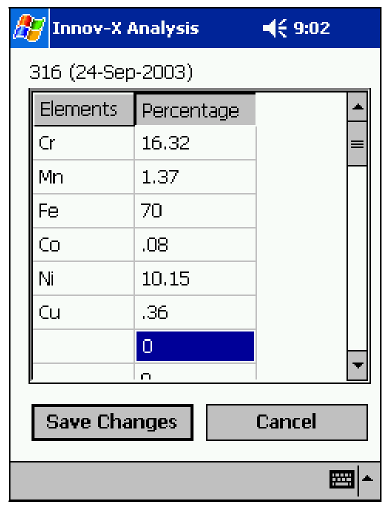


    b. Enter the assay for the selected element in the next column.

    The software will automatically calculate the value of a balance component if "bal" is typed into the percentage column.

    Keep in mind typical detection limits of the instrument when entering assays. As a general rule, do not enter assays which are below 0.3%.

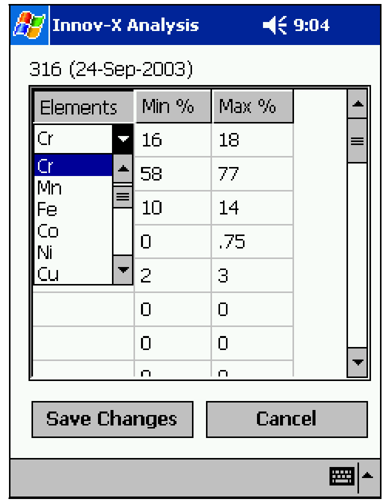
    c. When all assays have been entered, tap **Save Changes**.



11. After entering assays (or if no was selected in step 10), the system will ask if you want to enter Min/Max ranges. This is recommended only if you will be using both Analytical and FastID to identify this standard alloy, or if you will be using Pass/Fail mode with **Use Chemistry** activated. The vast majority of users will select **No** in answer to this question.

    If you wish to enter Min/Max ranges, select **Yes;** otherwise select **No**. If you select **No**, the process of entering a fingerprint is complete.

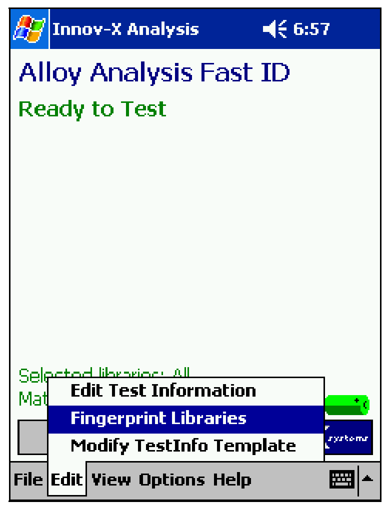
12. Enter your Min and Max ranges for each of the elements in your sample. If you have any questions about this procedure, you can refer to the description in **Section 9.6**: **Adding a Grade**.



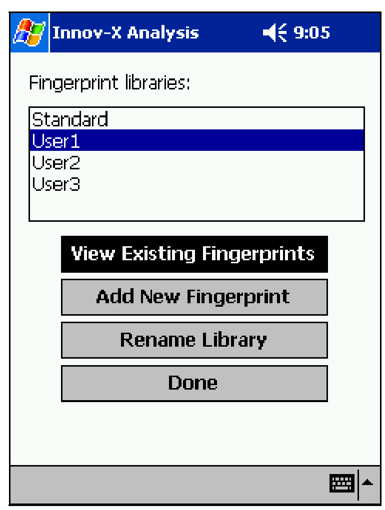
9.9 EDITING FINGERPRINT LIBRARIES

It is possible to edit Assays, Specific Regions and Min/Max (Grade Tables) for existing elements.

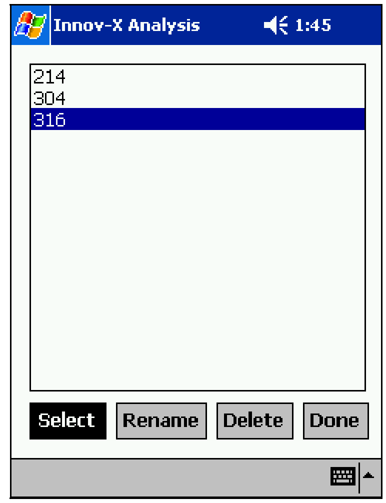
1. From the Fast ID Analysis Screen, Choose ***Edit→Fingerprint Libraries***.



2. Select the Library containing the fingerprint you want to modify and select **View Existing Fingerprints**.

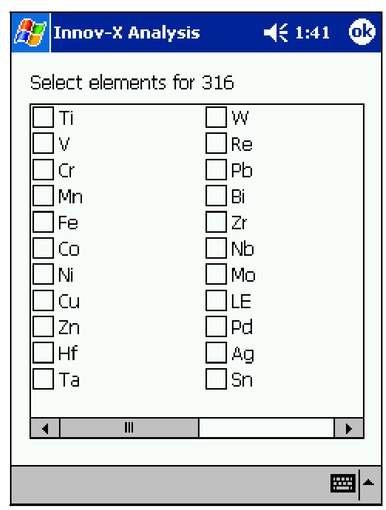


3. A list will appear showing the entries in the library. Tap on the grade name you wish to modify and tap **Select** to bring up the specifications. Refer to the **Section 9.8: Adding a Fingerprint** for more information on any of these features.

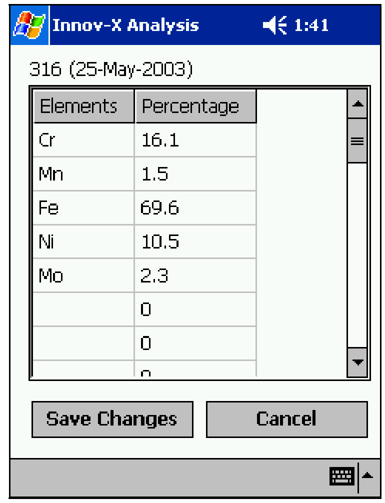


4. The fingerprint info screen will be selected. If any assays are stored with the fingerprint, they will be shown here. To edit, tap the words **edit** or **view/edit** below the information you wish to enter.

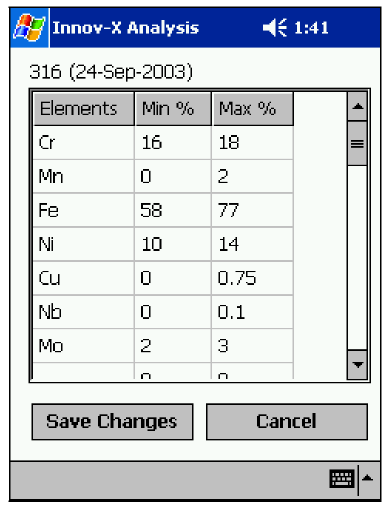
5. Editing elements brings up the specific elements screen. Select elements you wish to use. Press **ok** to select.



6. If you wish to enter assays, enter the elements contained in the sample and the certified values.



7. Min/Max **View/Edit** allows you to enter minimum and maximum specifications for each element.



Chapter 10S Soil Analysis

The Innov-X analyzer can be used to analyze in situ (directly on the ground), bagged or prepared soil samples. A guide to Soil analysis using field portable X-ray fluorescence is found in the appendix. This document summarizes EPA Method 6200 which is the standard protocol for field screening. It also provides information on prepared sample testing.

10.0 CHECK STANDARDS

It is recommended that a check standard is measured after each standardization, and periodically throughout the day. Innov-X provides several NIST certified standards for verification. The certified values for these samples are provided in the appendix. At least one standard should be measured for a minimum of 1 minute. Elemental concentrations for elements of interest plus or minus the error on the reading should be within 20% of the standard value. The Field screening guide in the appendix describes in more detail recommended quality assurance considerations.

The standards provided with the XRF analyzer are contained in XRF sample cups with a Mylar window (through which the soil can be viewed) on one side, and a solid cap on the other side. Samples should be measured in the sample cup, through the Mylar window. The best way to measure a prepared sample is using the test stand. If this is not available, the sample may be placed on the ground, and the analyzer may be pointed downwards in full contact with the soil cup. Do not hold the soil cup in your hand while measuring.

10.1 SAMPLE PRESENTATION

In situ testing:

In situ testing is performed by pointing the analyzer at the ground. Any grass or large rocks should be cleared away and the analyzer should be held such that the front of the probe head is held flush to the ground.

Since dirt can accumulate on the analyzer window, it is recommended that the window is wiped clean after each analysis. The window should also be checked to ensure it is not ripped or punctured. Instructions for replacing the window are found in the appendix.

Bagged or prepared sample testing:

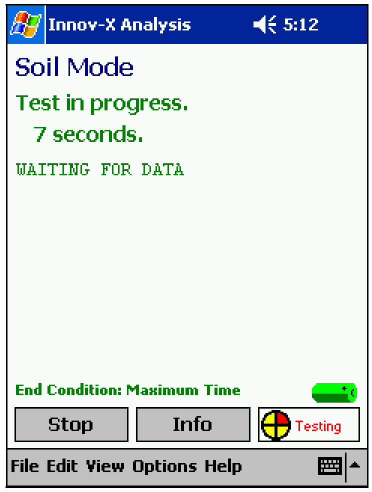
It is strongly recommended that all prepared samples be analyzed in the testing stand. Samples should be placed on top of the testing stand, completely covering the window. **Never hold prepared or bagged samples while testing,** as this could expose the operator to the x-ray beam.

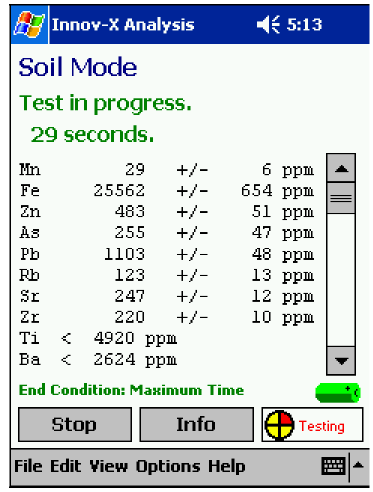
Avoid measuring very thin samples, as this can affect results. Prepare samples cups to contain at least 0.5 inches of packed samples. When analyzing bagged samples, make sure that sufficient sample exists in the bag to completely cover the window with a sample thickness of a minimum of 0.5 inches.

10.2 TESTING IN SOIL MODE

After the instrument has been standardized, testing can begin. Simply pull the trigger or press **Start** on the iPAQ screen to begin the test. The red warning light on the top of the instrument will blink, indicating X-rays are being emitted. The screen will display the words “Test in progress” and the time elapsed. The word “Testing” will blink on and off in the low right hand corner of the screen.

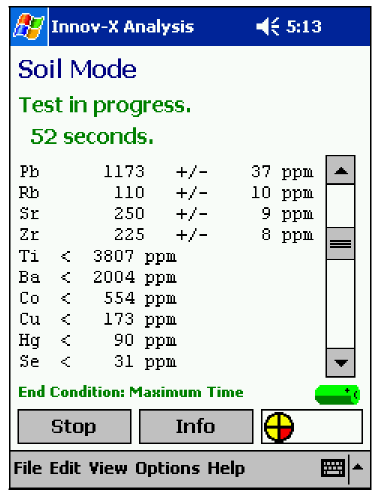
After a minimum time has elapsed, intermediate results will be displayed on the screen. Until this minimum time has elapsed, the words "WAITING FOR DATA" will appear instead. This minimum time can be set by the user by selecting ***Options→Set Testing Times***, which is described in **Section 10.4: Soil Mode Options.** Each line of the results display shows the name of an element, its calculated concentration and the error on the measurement. This error is the 1 sigma error on the counting statistics of the measurement. The error will decrease with increased testing time.





Too many elements are measured in soil mode to display them at one time. However, is possible to use the scroll bar located to the right of the chemistry display to view other elements. The complete display shows detected elements first, listed in order of emission line energy, from lowest to highest. Following the detected elements are the elements which are below the detection limit of the instrument. These elements are shown as less than a calculated LOD. This LOD is defined as three times the error on the counting statistics of the measurement.

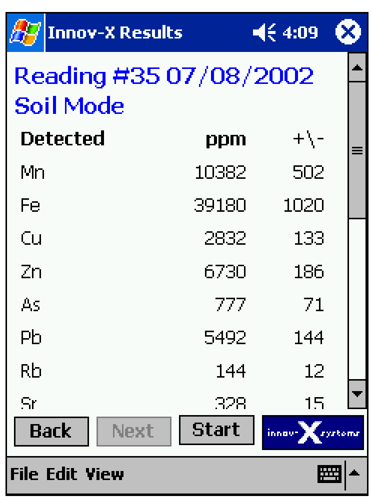
When the measurement is complete the results screen will open, displaying the final results of the measurement.

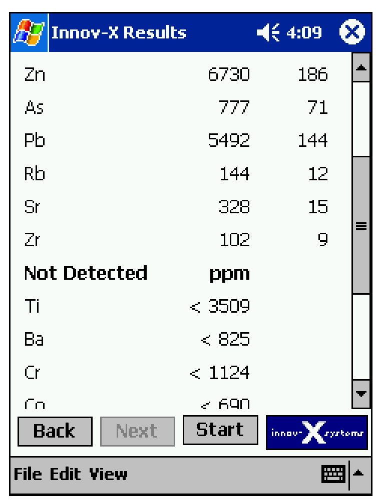


10.3 SOIL RESULTS SCREEN

10.3.1 Results View Menu

The standard Soil Mode results screen displays the concentration (in ppm) and error in measurement for detected elements, followed by the list of non-detected elements with the calculated limit of detection for each element for that test. If the display does not show soil chemistry results, change the display by selecting ***View→Results***.



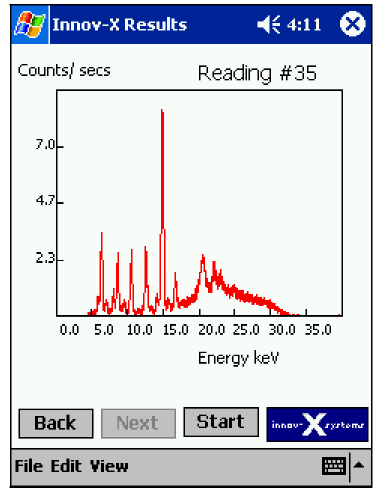


The standard soil chemistry display can be modified by using the View Menu. As with all Innov-X analytical modes, it is possible to view spectra and Test Information.

10.3.2 Spectrum Screen

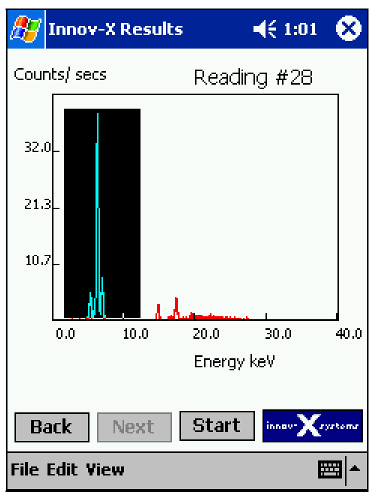
This screen displays a plot of the x-ray fluorescence spectrum for an individual test, plotting the intensity on the y-axis versus the energy of the fluorescence x-rays on the x-axis.

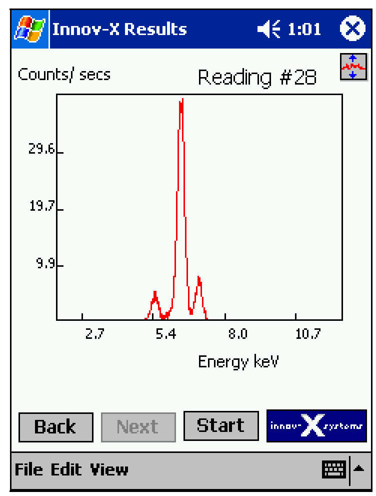
Tapping on the spectra will show the energy scale and counts rate at the selected point



It is possible to zoom in on certain areas of the graph by selecting one corner and drawing out the region

Tapping the symbol in the upper right hand corner beneath the X will restore the graph to full scale.





10.3.3 Test Info Screen

The test information screen shows any test information that was entered prior to the start of the test. Changes to that test information can be made by selecting **Edit→Test Information.**

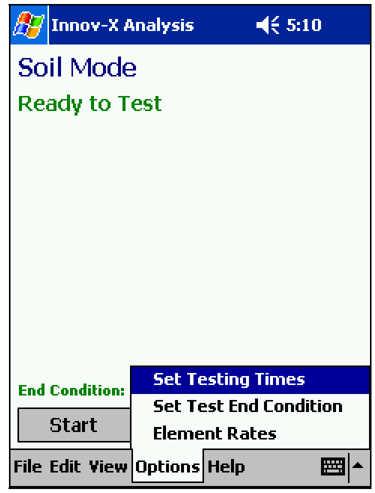
10.4 SOIL MODE OPTIONS

The length of tests in Soil Mode is user settable. Users may select a minimum testing time, and as well as choose from a variety of test end conditions.

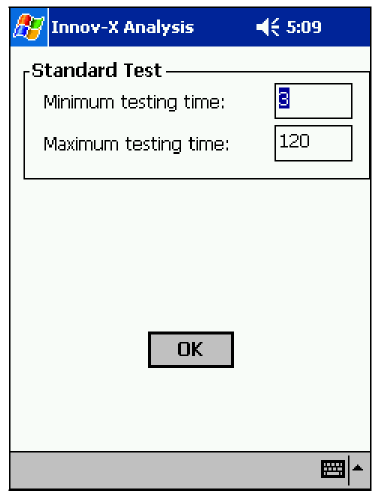
The options related to test time are contained in two menus: ***Options→Set Testing Times***, and ***Options→Set Test End Condition. Set Testing Times*** contains minimum and maximum testing time information, while ***Set Test End Condition*** allows the user to select test end conditions.

10.4.1 Set Testing Times

To set the minimum and maximum test lengths, select **Options→Set Testing Times**



A screen appears prompting you to enter a Minimum and Maximum Testing times. Instruments equipped with the optional LEAP package will be able to set Light Element Testing times in this screen, as well.



The minimum testing time is the required time that must elapse before results can be calculated. Live Update results will not be displayed on the screen until the minimum has elapsed, likewise a test must complete the minimum time before any test end condition can be used. If a test is stopped before the minimum testing time has elapsed, the test will be aborted, and no results will be calculated.

Maximum testing time is relevant only if "Maximum Testing Time" is selected from **Set Test End Condition**. This will automatically end the test at a preset testing time. Typically, the maximum testing time will be in excess of 30 seconds, and may be 1 or 2 minutes, depending on detection limits and desired precision.

It should be noted, that all testing times in this section refer to "Real Time," the time the measurement takes when timed on a normal clock. The time stored with each analytical result (accessible by selecting **View→Test Information** from the Results screen), refers to the test's "Live Time". This is the amount of time that the analyzer hardware was collecting spectra. Since there is some detector dead time associated with a measurement, the live time of a test will be slightly shorter than the preset "Real time".

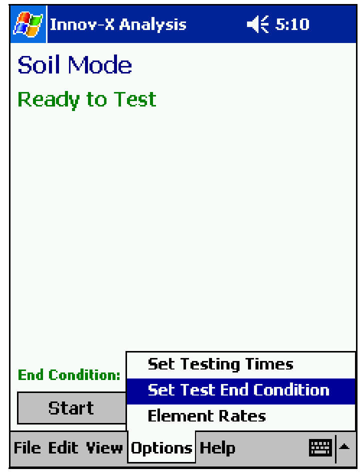
10.4.2 Soil Mode Test End Condition

Four options exist for the test end criteria in soil mode. Depending on your application, you may choose to end the test manually, at a preset testing time, or when the uncertainty in the measurement is within a specified relative standard deviation of the reading. Additionally, you can set up an action level for a single element. As soon as the measuring statistics are good enough to ensure that that the reading is above, below or at the action level, the test will end automatically. This allows for very rapid tests for elements that are well above or below an action level.

In all modes, pressing Stop, or pulling the trigger will end the test. If the minimum testing time has elapsed, results will be calculated. Otherwise the test will be aborted without calculating results.

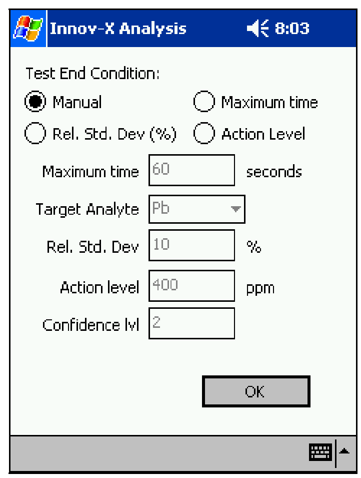
Changes to the test end condition are made by selecting ***Options→Set Test End Condition***

The currently selected end condition will be displayed at the bottom of the screen above the Start button on the Ready To Test screen.



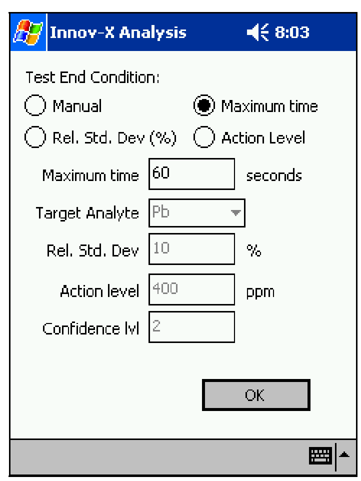
Manual: This option allows you to look at the results which are being continually updated on the screen and determine when the results look satisfactory. The test will continue until the trigger is pulled, or **Stop** is tapped on the iPAQ screen. Results will be calculated if the testing time has exceeded the Minimum Test time which is set up in ***Options→Set Testing Times***. In order to preserve battery life, the software will stop if the testing time exceeds 300 seconds, since there is little to no advantage to continuing a test beyond 300 seconds.

To use Manual Test End Condition, simply choose ***Options→Set Test End Condition*** and select **Manual**. Press **OK** to return to the analysis screen.



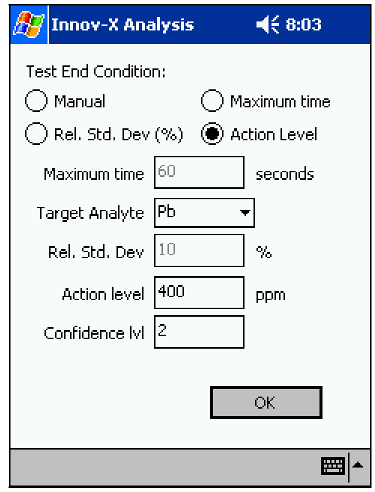
Maximum Time: If Maximum Time is selected, the test will continue until the preset time is reached. This is useful if you wish to do a set of measurements with the same testing time.

To choose to end test based on a maximum time, select ***Options→Set Test End Condition*** and select **Maximum Time**. Enter the desired testing time in the appropriate box. Tap OK to save your selections.



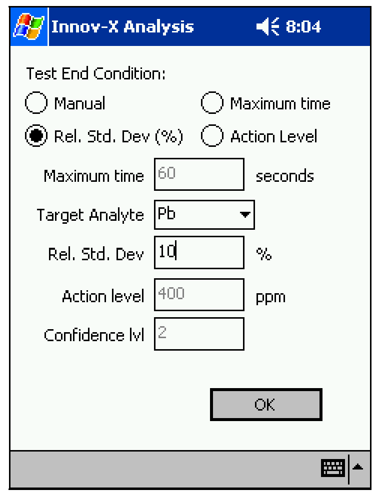
Action Level: System ends test when result for target analyte including chosen precision level is above or below pre-set action level.

To choose to end a test based on an Action Level, select ***Options→Set Test End Condition*** and select **Action Level**. Select a target analyte, specify an action level in ppm, and a confidence level. This confidence level refers to the number of sigma required for the precision. This should typically be set to 2. Tap **OK** to save your selections.



Relative Standard Deviation (RSD): When RSD is selected as a test end criteria, the system will end a test when the relative standard deviation on a target analyte reaches a pre-set level. This standard deviation is specified as a percentage of the reading. For example, if the measured value for an analyte was 1000 ppm, and the RSD was set to 10, the reading would stop when the error reached 100 ppm, or 10% of 1000.

To choose to end a test based on a Relative Standard Deviation, select ***Options→Set Test End Condition*** and select **Rel. Std. Dev (%).** Select a target analyte and the desired Relative Standard Deviation. Tap **OK** to save your selections.



10.5 LEAP Mode (Light Element Analysis Program):

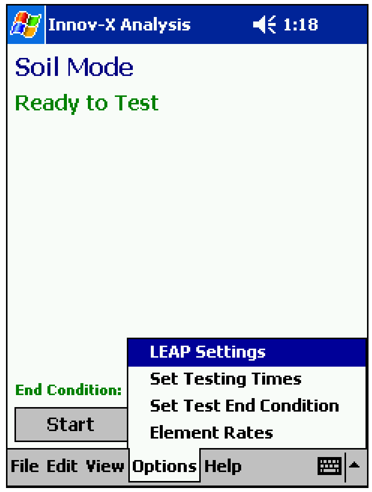
This is a factory installed optional module. Instruments can be upgraded to LEAP capabilities. Please contact the Innov-X Systems Sales department for information and pricing.

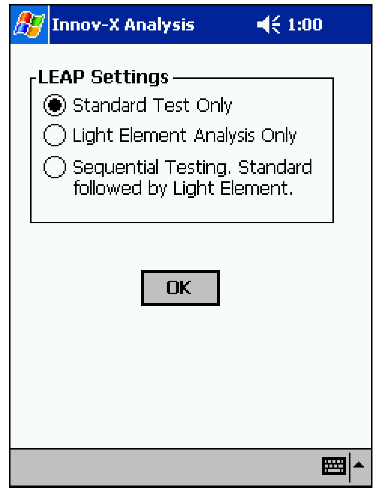
The LEAP module provides the lowest possible detection limits for elements lighter than iron. The standard LEAP package includes the elements Ti, Ba and Cr. Elements as low as Phosphorus can be detected with the Advanced LEAP package which includes a thin window detector.

The standard x-ray beam conditions used by Innov-X environmental analyzers are designed to provide good excitation for a wide range of detected elements. However it is not possible to select one beam condition which provides the absolute best excitation conditions for all elements of interest. Elements such as Chromium produce lower energy x-rays then other elements analyzed. These lower energy x-rays are not as effectively excited by the standard conditions. LEAP works by changing the X-ray tube beam conditions to settings which are optimized for the detection of elements lighter than iron. Instruments are factory calibrated with the LEAP beam conditions for all applicable elements.

10.5.1 LEAP Settings

To activate LEAP, select ***Options→LEAP Settings*** from the Soil analysis screen. This brings up the menu shown below on the right.



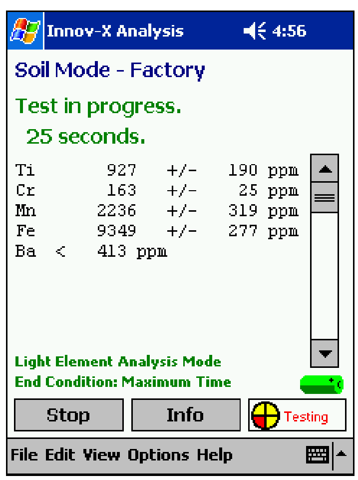


Standard Test Only: The analyzer will provide analysis for the standard suite of elements.

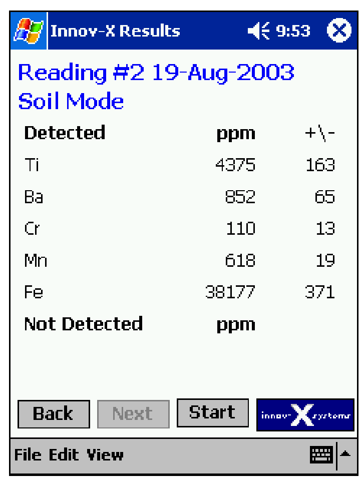
Light Element Analysis Only: The analyzer will provide analysis for elements in the LEAP suite (Typically Ti, Ba and Cr)

Sequential Testing: When sequential testing is selected, all tests will start with an analysis of elements in the standard suite. If that test ends due to reaching the selected end condition of Maximum Test Time, Action Level, or RSD, then the analyzer will immediately begin a second test analyzing the LEAP suite of elements. At the conclusion of this test, the Results screen will open with two new entries. The first summarizes the standard test results, while the second summarizes the LEAP results. For safety reasons, the second test will not begin if the test ends due to user intervention (pulling the trigger or hitting Stop). In this case, the Results screen will open with only one reading.

If Light Element Analysis Only is activated, the words “Light Element Analysis Mode” will appear above the currently selected End Condition. Instrument operation in this mode is identical to Standard (Non-LEAP) analysis. Tests can be started or stopped either by pulling the trigger, or by tapping the Start/Stop button on the iPAQ screen. The results screen for a test will show results for all elements analyzed with the LEAP mode.

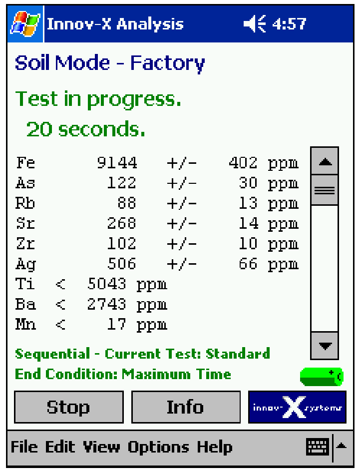


Test in progress screen, LEAP Only, Live Updates on

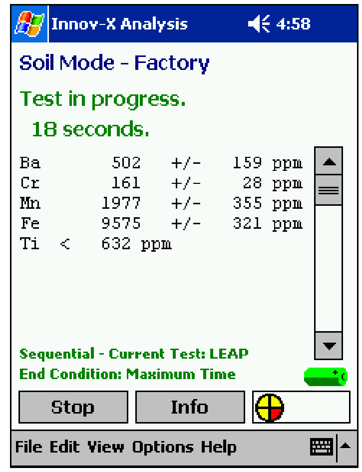


Results Screen Showing LEAP results

If Sequential testing is selected, the words "Sequential – Current Test: Standard" will appear above the currently selected End Condition. When a test is started, the instrument will appear to operate in the same manner as a Standard test. However, if the test ends according to the specified end condition (excluding Manual), the results screen will not open. Instead, the timer will reset to 0, and the description of the current test will change from "Standard" to "LEAP". The live update screen will begin to show analysis for all LEAP elements.



Test in progress screen, Sequential.
First Test – Standard Analysis.

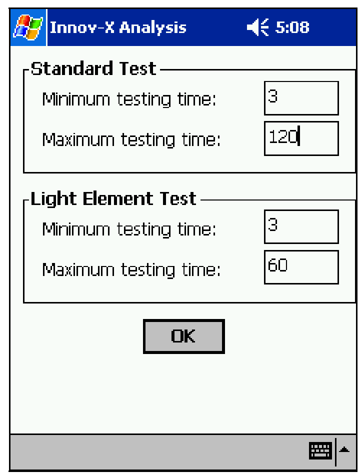


Test in progress screen, Sequential.
Second Test – LEAP Analysis

10.5.2 Testing Times

To set the minimum and maximum test lengths for LEAP analysis, select **Options→Set Testing Times.**

The testing time screen includes an extra section labeled "Light Element Test" that is not found on non-LEAP systems. These are the minimum and maximum test lengths for any LEAP tests.



As with standard tests, the minimum testing time is the required time that must elapse before results can be calculated. Live Update results will not be displayed on the screen until the minimum has elapsed, likewise a test must complete the minimum time before any test end condition can be used. If a test is stopped before the minimum testing time has elapsed, the test will be aborted, and no results will be calculated.

11.0RW RoHS/WEEE Testing Mode

Toxic Metals in consumer electronics are the focus of EU regulations that have worldwide ramifications. These new directives currently include the Restriction of Hazardous Substances (RoHS) which designates maximum allowable levels of Pb, Cd, Cr^{6+}, Hg and certain Br-containing flame retardants (PBB and PBDE) in new electrical and electronic equipment sold into the EU. The Waste Electrical/Electronic Equipment (WEEE) Directive requires separate collection and recycling in the EU of WEEE with Hg-containing components and polymers containing Br-flame retardant.

The limits for RoHS elements are:

- <0. 1% Pb, Cr6+, Hg, Br (as flame retardants, PBB and PBDE)
- <0.01% Cd

The Innov-X analyzer is a valuable screening tool for RoHS Compliance It can be used to directly analyze the amount of toxic metals in electronics, as well as to quickly identify whether a plastic is PVC or contains a brominated flame retardant. XRF measures total elemental composition, regardless of speciation of the element. Therefore, it will report total Chromium which will include the concentration of hexavalent chromium plus any other forms of Cr. Likewise, the analyzer will report total bromine and cannot distinguish the type of brominated flame retardant that is present in analyzed materials.

In order for XRF to be quantitative, samples must be homogeneous, completely cover the window, and have a certain minimum sample thickness: 5 mm for Polymers & light alloys: 1 5mm for liquid samples, and 1 mm for other alloys. If samples are heterogeneous, too thin, or too small, only qualitative screening is possible.

The IEC-ACEA (International Electro-technical Commission – Advisory Committee on Environmental Aspects) recommends hand-held XRF for screening.

11.1 SOFTWARE OVERVIEW

The RoHS software automatically determines whether a sample is an alloy, polymer or mixed. (Mixed indicates heterogeneous samples consisting of both polymer and alloy such as wires or circuit boards) It then uses tube settings and algorithms which are best suited to each sample type. It starts with tube settings which are appropriate for analyzing a polymer sample. If the sample is determined to be a polymer or mixed, the test will continue, and a calibration based on a polymer matrix will be used. If the sample is found to be a metal alloy, the analyzer will switch to a secondary test, using an alloy matrix calibration, in order to determine correct alloy concentrations.

The software will determine if each RoHS element passes, fails, or is inconclusive when compared to a set of stored criteria. These criteria can be either those recommended by the IEC, or ones added by the user.

11.2 CHECK STANDARDS

It is recommended that a check standard be measured after each standardization, and periodically throughout the day. Innov-X provides 2 certified standards for verification. At least one standard should be measured for a minimum of 2 minutes. Elemental concentrations for elements of interest plus or minus the error on the reading should be within 20% of the standard value.

The standards provided with the XRF analyzer are contained in XRF sample cups with a Mylar window (through which the plastic pellets can be viewed) on one side, and a solid cap on the other side. Samples should be measured in the sample cup, through the Mylar window. The best way to measure these samples, as well as other small samples, is using the test stand. If this is not available, the sample may be placed on the ground, and the analyzer may be pointed downwards in full contact with the sample cup. Do not hold the cup in your hand while measuring. Care should be taken to insure the kapton window of the instrument is intact or the analyzer can be damaged by small components.

11.3 SAMPLE PRESENTATION

Since many pieces of plastic analyzed for ROHS/WEEE compliance are very small, care must be taken to measure them in a safe and accurate manner. Small pieces should always be analyzed in the test stand. Samples should NEVER be held by hand when analyzing, as this could expose the operator to the x-ray beam. Samples should be arranged to cover as much of the window as possible. Users should be mindful of the minimum thickness recommendations of the IEC, as mentioned in the introduction. If a test stand is not used, and samples are placed on a table, the user should be aware that elements in the table could be picked up and reported in a reading. Refer to Chapter 3 in this Manual for more information about radiation safety considerations with regards to safely analyzing small samples.

11.4 TESTING IN RoHS/WEEE MODE

After the instrument has been standardized, testing can begin. Simply pull the trigger or press **Start** on the iPAQ screen to begin the test. The red warning light on the top of the instrument will blink, indicating X-rays are being emitted. The screen will display the words “Test in progress” and the time elapsed. The word “Testing” will blink on and off in the low right hand corner of the screen.

After a minimum time has elapsed, intermediate results will be displayed on the screen. Until this minimum time has elapsed, the words “WAITING FOR DATA” will appear instead. This minimum time can be set by the user by selecting ***Options→Set Testing Times***, which is described in later in this manual.

After a few seconds the type of sample will be displayed (alloy/polymer/mixed). If the sample is an alloy, a second test will start to determine alloy chemistry. Otherwise, the original test will continue.

If an element is detected, each line of the results display shows the name of an element, its calculated concentration and the error on the measurement. This error is the 1 sigma error on the counting statistics of the measurement. The error will decrease with increased testing time. The software will also indicate whether each element is measured as pass/fail or inconclusive as compared to the pre-set action level.

If an element is not detected, the calculated detection limit for that element in that particular test will be reported. The LOD is the 3 sigma error on the measurement. The analyzer will display Pass if the calculated detection limit is sufficiently below the action level. If the LOD is above the detection limit, the reading is inconclusive. Increasing the testing time will lower the detection limits.

11.5 RESULTS SCREEN

11.5.1 Results View Menu

The standard results screen displays the concentration (in ppm or percent, depending on level) followed by the error in measurement for detected element. Elements which are below detection limit will be shown in the form <LOD where LOD is the 3-sigma detection limit for the element in the test. A Pass/Fail/Inc. classification will be shown for each element, as well as for the overall sample.

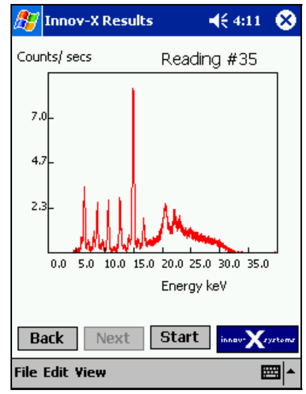
If the display does not show chemistry results, change the display by selecting ***View→Results***.

The standard chemistry display can be modified by using the View Menu. As with all Innov-X analytical modes, it is possible to view spectra and Test Information.

11.5.2 Spectrum Screen

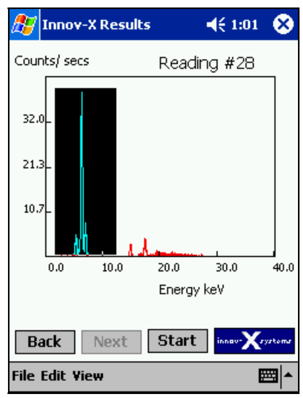
This screen displays a plot of the x-ray fluorescence spectrum for an individual test, plotting the intensity on the y-axis versus the energy of the fluorescence x-rays on the x-axis.

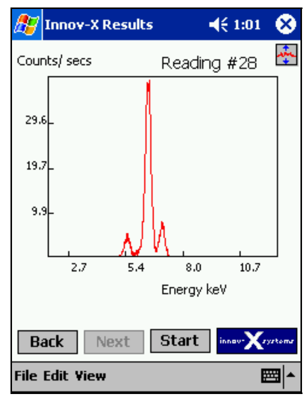
Tapping on the spectra will show the energy scale and counts rate at the selected point



It is possible to zoom in on certain areas of the graph by selecting one corner and drawing out the region

Tapping the symbol in the upper right hand corner beneath the X will restore the graph to full scale.





11.5.3 Test Info Screen

The test information screen shows any test information that was entered prior to the start of the test. Changes to that test information can be made by selecting **Edit→Test Information.**

11.6 RoHS/WEEE OPTIONAL USER SETTINGS

11.6.1 Setting Action Levels

The analyzer has the ability to utilize the IEC screening levels or allow the user to store customized screening criteria. The software can identify which individual elements pass or fail when compared to the set criteria, and also decide whether the overall sample is Pass/Fail/Inconclusive.

IEC Quantitative Screening Requirements.

- 1) "PASS" - Result for all elements is lower than the lower limits listed in Table 1: "PASS".
- 2) "FAIL" - Result for any of the elements higher than the higher limits listed in Table 1: "FAIL".
- 3) "INCONCLUSIVE" - If the result of the quantitative analysis, for any of the elements Hg, Pb or Cd, is in the region defined as intermediate, or if the result of the elements Br and Cr is higher

than the higher limits listed in Table 1, the analysis is inconclusive. Additional investigation must be performed. The test is "INCONCLUSIVE".

Element	Polymer Materials	Metallic Materials	Electronics
Cd	$P \le (70-3\sigma) < X < (130+3\sigma) \le F$	$P \le (70-3\sigma) < X < (130+3\sigma) \le F$	$LOD < X < (150+3\sigma) \le F$
Pb	$P \le (700-3\sigma) < X < (1300+3\sigma) \le F$	$P \le (700-3\sigma) < X < (1300+3\sigma) \le F$	$P \le (500-3\sigma) < X < (1500+3\sigma) \le F$
Hg	$P \le (700-3\sigma) < X < (1300+3\sigma) \le F$	$P \le (700-3\sigma) < X < (1300+3\sigma) \le F$	$P \le (500-3\sigma) < X < (1500+3\sigma) \le F$
Br	$P \le (300-3\sigma) < X$	N/A	$P \le (250-3\sigma) < X$
Cr	$P \le (700-3\sigma) < X$	$P \le (700-3\sigma) < X$	$P \le (500-3\sigma) < X$

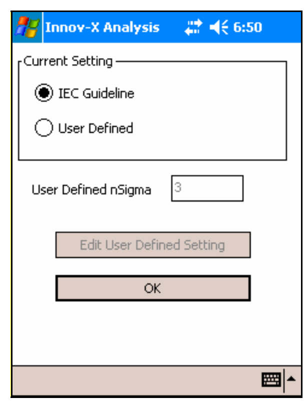
Table 1: IEC Screening guideline

It should be noted that the IEC Guidelines dictate that samples containing Br and Cr are always labeled "inconclusive" rather than "fail" if the concentrations of these elements exceeds the regulatory levels. This is due to the fact that XRF cannot determine whether these elements are present as the regulated substances PBDE or Cr^{6+}. Laboratory testing by other techniques is required to confirm the chemical form Br and Cr are present as. Br is not regulated in metallic materials, and results for Br are not reported when the Alloy calibration of RoHS/WEEE Mode is used. It should also be noted that the IEC does not recommend a clear "pass" screening level for Cd in Electronics components.

To change action levels, Select **Options →Action Level.**
Enter the administrative password.

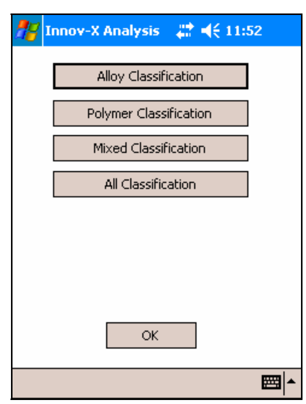
Select desired action levels: IEC Guidelines or User Defined. If Using IEC guidelines, select this option and tap OK

To enter user defined action levels, select "User Defined," and specify the number of n-Sigma to include in the determination. Then tap "Edit User Defined Settings"



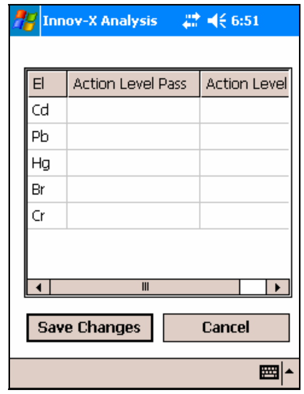
Users may enter separate Pass/Fail criteria for any of the three sample types: Alloy, Polymer or Mixed. Alternatively, by selecting "All classifications" users may set one set of action level criteria which applies to all sample types.

Select the material type and tap "ok"



Enter the action level in ppm for each element.

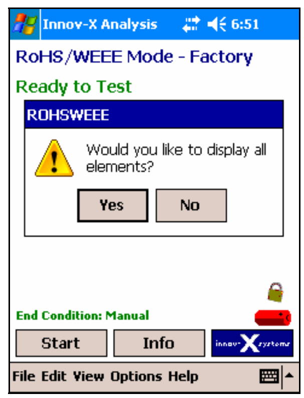
Users may choose a different concentration for Pass and Fail. Anything in the middle will be considered inconclusive. If the determination is to be made on a single concentration, enter the same value for both pass and fail. Setting the "User Defined n-Sigma" to zero will prevent an inconclusive range altogether.



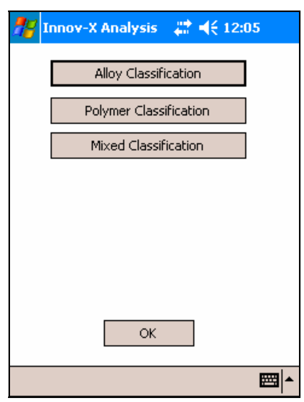
11.6.2 Selecting Elements

RoHS/WEEE systems are typically set up to report only the concentration of the RoHS elements: Cr, Br, Cd, Hg, and Pb in plastic or mixed samples and Cr, Cd, Hg and Pb in alloys. Certain other elements are set up as part of the calibration and can be shown on the screen if desired. The reported concentrations for these elements should be viewed as qualitative, as certified standards are not available for many non-RoHS elements.

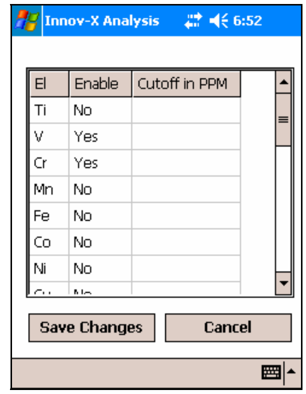
To customize the list of elements displayed on the results screen, select **Options ->Select Display** elements. The message "Would you like to display all elements?" will appear. Enter "Yes" to view all elements, or "No" to select specific elements



Select the type of sample



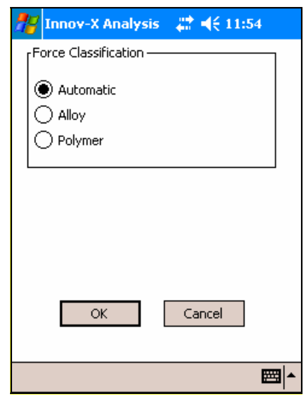
Select “yes” to display an element, or “no” to eliminate it from the display.



It is possible to choose to display elements only if they appear above a certain concentration specified in the “cutoff” column. For example, to display Co only if it appears in a sample about 0.5 %, select “yes” and enter 5000 in the cutoff column. (level must be specified in ppm)

Tap “save changes” when done. It will then be possible to select another classification to set up list of displayed elements.

11.6.3 Force Classification



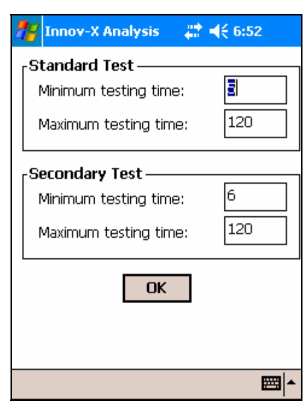
It is strongly recommended that the RoHS/WEEE software be allowed to automatically classify samples as alloy, plastics or mixed. However, in certain situations, it may be necessary to force the software to treat a sample as either an alloy or polymer. To do this, select **Option → Force Classification** and select “Alloy” or “Polymer”. Select “Automatic” to use the automatic classification feature.

11.6.4 Analysis Time

The length of tests is user settable. Users may select a minimum testing time, and as well as choose from a variety of test end conditions.

The options related to test time are contained in two menus: ***Options→Set Testing Times***, and ***Options→Set Test End Condition. Set Testing Times*** contains minimum and maximum testing time information, while ***Set Test End Condition*** allows the user to select different criteria for ending a test.

11.6.4a Set Testing Times



To set the minimum and maximum test lengths, select **Options→Set Testing Times**

A screen will appear prompting you to enter Minimum and Maximum Testing times for a Standard and Secondary test.

The standard testing time will be used for polymer or mixed samples. The secondary test length will apply only if the primary test determines that the sample is an alloy. In this case, the total testing time will include the brief testing time for the standard test plus the length of the secondary test.

The minimum testing time is the required time that must elapse before results can be calculated. Live Update results will not be displayed on the screen until the minimum has elapsed, likewise a test must complete the minimum time before any test end condition can be used. If a test is stopped before the minimum testing time has elapsed, the test will be aborted, and no results will be calculated. No information related to the test will be saved.

It should be noted that all testing times in this section refer to “Real Time,” the total time that the measurement takes when timed on a normal clock. The time stored with each analytical result (accessible by selecting **View→Test Information** from the Results screen), refers to the test’s “Live Time”. This is the amount of time that the analyzer hardware was collecting data. Since there is some detector “dead time” associated with a measurement, the live time of a test will be slightly shorter than the preset “Real time”.

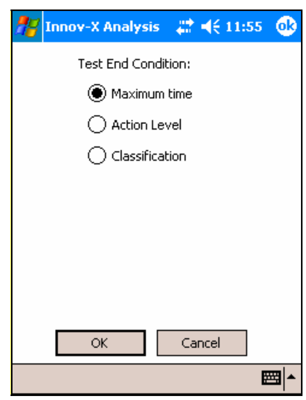
Typical testing times to reach RoHS detection limits will be 120 seconds or longer.

11.6.4b Test End Condition

Three options exist for the test end criteria. You may end your test at the preset testing time which is described in the last section, upon classification (alloy/polymer/PVC/Br plastic etc.), or when a Pass/Fail determination (relative to the action level) is reached.

In all cases, the analysis will stop at the maximum testing time is reached, however if either “Action Level” or “Classification” is chosen, the test may end earlier if the condition is met. As in all analysis modes, pressing Stop, or pulling the trigger will end the test. If the minimum testing time has elapsed, results will be calculated. Otherwise the test will be aborted without calculating results.

Changes to the test end condition are made by selecting ***Options→Set Test End Condition***



- If “Maximum time” is selected, the test will end when the maximum test time is reached.
- If “Action Level” is selected the analysis will end if the analyzer has enough statistics to determine whether a sample Passes or Fails according to the stored action level criteria.
- “Classification” ends a test during the primary test immediately after the sample has been identified as polymer, alloy, or mixed. This mode is recommended for users who are trying to quickly identify plastics with halogenated fire retardants.

12.0F Filter/Thin Film Analysis

Air filters as well as thin films can be analyzed in Filter mode. Typical Thin film measurements consist of shooting a coated material a single time. Units are reported as ug/cm2. Measurements of 37 mm filters consist of shooting the filter in three different spots, once in the center, and two additional times to the side of the center.

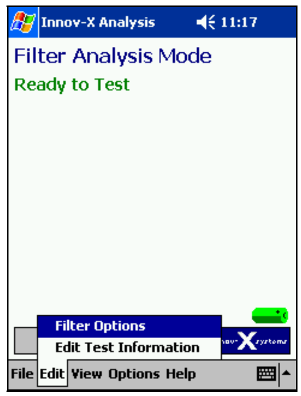
12.1 TESTING IN FILTER MODE

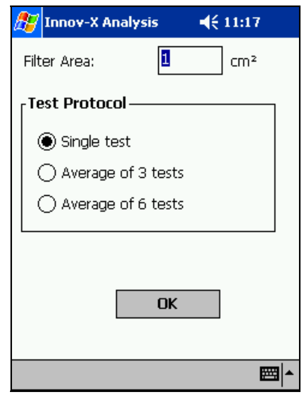
12.1.1 Selecting Test protocol.

Select Edit->Filter option to set the Test protocol.

If you're measuring Filters, and wish to calculate results in terms of ug/filter instead of ug/cm2, you must enter the correct area of the filter.

Select the number of measurements you will want to average: 1, 3 or 6.
Tap ok when you've made your selections.



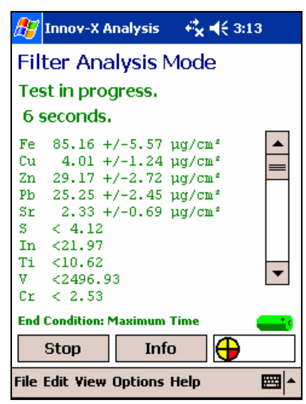


12.1.2 Measuring a sample

After the instrument has been standardized, testing can begin. Place the filter in position 1 or hold the analyzer up to the spot to be measured and tap **Start** on the iPAQ screen. The red warning light on the top of the instrument will blink, indicating X-rays are being emitted. The screen will display the words "Test in progress" and the time elapsed. The word "Testing" will blink on and off in the low right hand corner of the screen.

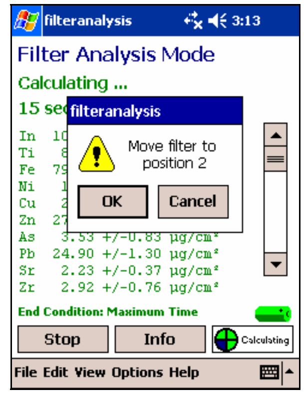
Depending on the instrument settings, real time results may display on the screen after a minimum test time has elapsed. If results are not displayed on the screen, selecting ***View → Live Updates*** will turn this feature on. The minimum time can be set by the user by selecting ***Options → Setup Testing***. Each line of the results display shows the name of an element, as the mass detected on the area of the wipe being measured, and the error on the measurement. This error is defined to be sigma, the error on the counting statistics of the measurement. The error will decrease with increased testing time.

Too many elements are measured in filter mode to display them at one time. As a result, it is possible to use the scroll bar located to the right of the chemistry display to view other elements. The complete display shows detected elements first, listed in order of atomic number, from lightest to heaviest. Following the detected elements are the elements which are below the detection limit of the instrument. These elements are shown as less than a calculated LOD. This LOD is defined as three times the error on the counting statistics of the measurement.



Note, units purchased for the measurement of only one or two elements will display only the calibrated elements, not the entire list.

When the first test is completed, the analyzer will prompt for the next sample.



Move the wipe to the second position and tap "OK." The analyzer will prompt for additional readings. For each one, reposition the sample and tap "OK"

> ‼ Clicking cancel instead of ok will abort the wipe measurement. No results will be saved for this wipe, even if readings have been taken in other positions.
>
> ‼ Stopping any test before the minimum test time has elapsed for that test will abort the wipe measurement. No results will be saved for this wipe, even if readings have been taken in other positions. Minimum test time is typically 5 seconds, and can be changed by selecting ***Options* → *Setup Testing***.

When the last reading is completed, the analyzer will open the results screen and display an average of the readings taken.

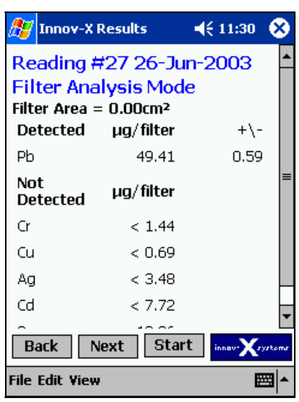
12.2 FILTER RESULTS SCREEN

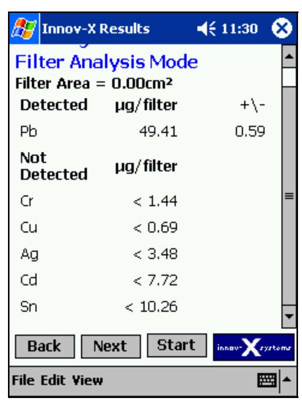
12.2.1 Results View Menu

The standard Filter Results display can be modified by using the View Menu. As with all Innov-X software modes, it is possible to view Spectra and Test Information. In addition, it is possible to view results calculated as ug/filter, or ug/cm^2, and chemistry below LOD.

For normal operation, the results should be displayed on the results screen as soon as it opens. If the display does not show chemistry results, select ***View* → *Results.***

This results screen displays the total loading of detected elements on the wipe as determined by an average of the readings taken on the sample. The error in the measurement is displayed next to the concentration reading. The results may be displayed as either ug/filter or ug/cm^2 .





12.2.2 View Intermediate Readings

Under normal operating conditions, the results screen will display only the average of the readings taken on a sample. It is possible to access the intermediate reading by selecting View→ View Intermediate readings.

Each intermediate reading will be treated as an individual reading. Scrolling backwards from the final average reading will make the intermediate readings available. Each intermediate reading will be identified by the reading number followed by - 1, 2, 3 or 4, which will indicate the order of the tests.

7.2.3 Selecting units for display—Use ug/cm^2 option.

The units displayed on the results screen will be determined by the View →Use ug/ft2 option.   If this option is checked, the results will be calculated using the stored value of area wiped.   If use ug/ft2 is not checked, results will be displayed as ug/wipe.

12.2.4 Chemistry Below LOD

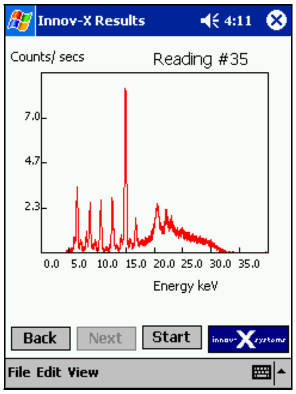
DEFAULT: Chemistry Below LOD should be off.

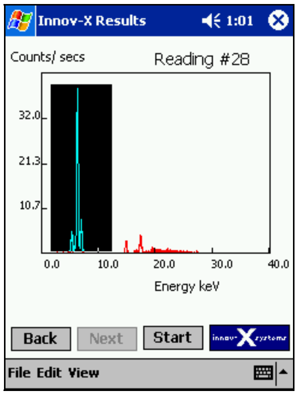
A few select users have requested the ability to be able to see what the calculated chemistry would be for elements below detection limit. This can be done by selecting ***View → Chemistry below LOD***. When this is done, the Elements below LOD are shown as a value in either ug/filter or ug/cm^2 with an error. This is mainly for statistical purposes. These data should not be considered to be valid calculations. As a result, it is recommended that most users do not us this option.

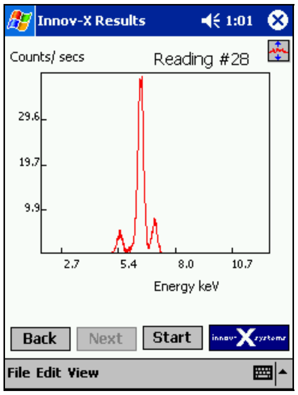
12.2.5 Spectrum Screen

This screen displays a plot of the x-ray fluorescence spectrum for an individual test, plotting the intensity on the y-axis versus the energy of the fluorescence x-rays on the x-axis.

Tapping on the spectra will show the energy scale and counts rate at the selected point. It is possible to zoom in on certain areas of the graph by selecting one corner and drawing out the out the region







Tapping the symbol in the upper right hand corner beneath the X will restore the graph to full scale.

12.2.6 Test Info Screen

The test information screen shows any information that was entered in TEST INFORMATION before starting a test.

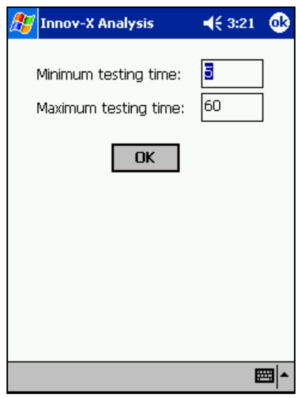
12.3 FILTER MODE OPTIONS

12.3.1 Set Testing Option—setting minimum and maximum testing times

The length of tests in Filter Mode is user settable. Users may select a minimum testing time, and as well as choose from a variety of test end conditions. Recommended testing time is typically 60 seconds, although this will very dramatically with the application. Longer test times will results in lower detection limits, so low concentration samples may be measured for 120 or 180 seconds.

To access the Setup Testing screen, select **Options → Setup Testing**

A screen appears prompting you to enter a Minimum and Maximum Testing time.



The minimum testing time is the required time that must elapse before results can be calculated. Live Update results will not be displayed on the screen until the minimum has elapsed, likewise a test must complete the minimum time before any test end condition can be used. If a test is stopped before the minimum testing time has elapsed, the test will be aborted, and no results will be calculated. Five (5) seconds is a typical minimum testing time.

It should be noted, that all testing times refer to "Real Time," the time the measurement takes when timed on a normal clock. There is some detector dead time associated with a measurement so the length of the test stored in the analyzer may be slightly shorter than the preset time.

13.0 Dust Wipe Analysis

The method for measuring samples consists of shooting a dust wipe either four times or eight times in different locations, and taking an average. The software will prompt the user to move the dust wipe to the proper position, and will automatically average the results. For most wipes, 4 readings on one side will be adequate, however, if the material on the wipes is unevenly distributed, analyzing both sides will provide the best results. It is suggested that a customer test the two methods on their samples, and pick a protocol depending on the goal of the analysis.

13.1 SAMPLE PREPARATION

The recommended dust wipe media is manufactured by Aramsco Lead Wipe. The filters should be folded as shown below in figure 13.1.

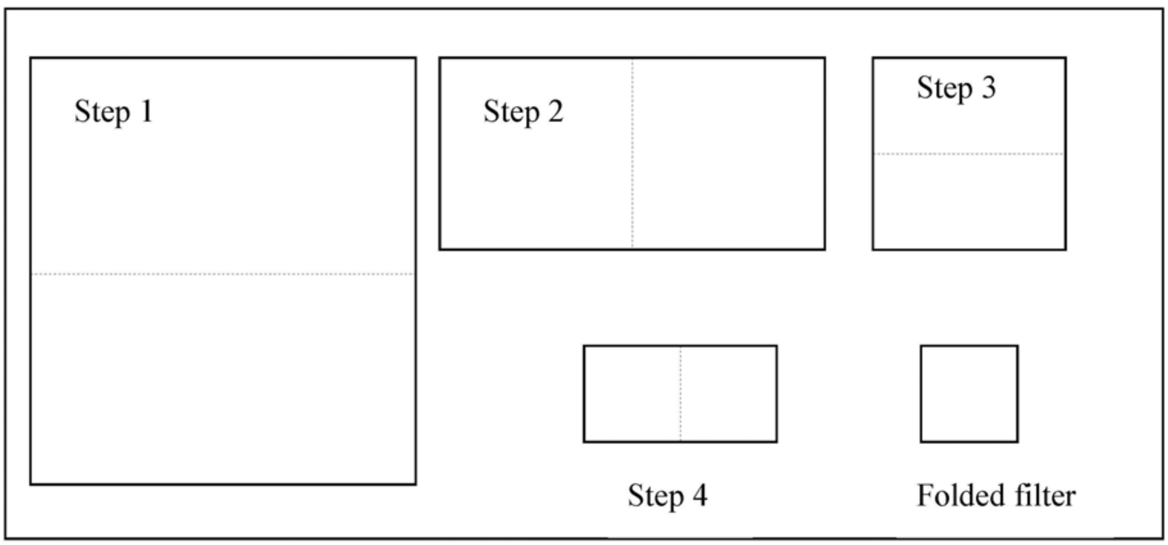
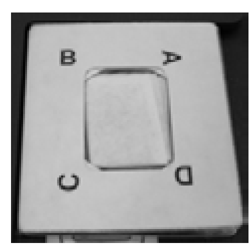


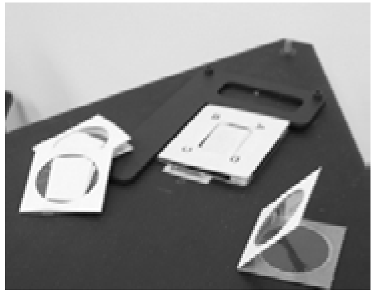
Figure 13.1 Instructions for folding Dust Wipe.

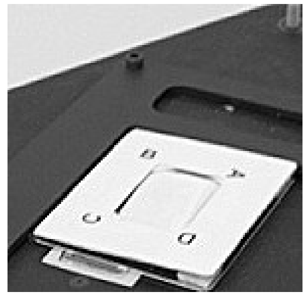
The dust wipe should be centered in a cardboard sample holder, which can be taped or stapled together. If the staple method is used, be aware that the iron in the staples may be detected by the analyzer if placed too close to the analyzing window. Dust wipes should be dried prior to analysis. The cardboard sample holder should be placed in the metal holder as shown:



13.2 POSITIONING THE SAMPLE

The sample should be positioned in the corner of the dust wipe fixture as shown. To start, the letter A should be upright in the upper left hand corner of the fixture. After each measurement, the sample should be turned such that each subsequent letter is positioned properly in the left hand corner.
The sample should not be flipped over unless performing an 8 position analysis. In this case, the first 4 readings should be taken on one side, and the remaining 4 readings should be taken on the other side.

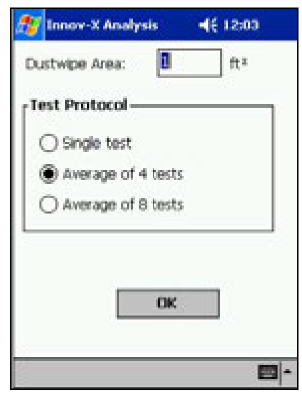




13.3 TESTING IN DUST WIPE MODE

13.3.1 Entering surface area wiped.

The Innov-X dust wipe analyzer can express results as either total loading on a wipe (units of ug/wipe) or as mass per total area wiped (ug/ft^2). In order for the determination of ug/area wiped to be calculated correctly, the area wiped must be entered in the analyzer. This is done by selecting ***Options → Filter Options*** from the Ready to Test screen.



If no value is entered, the default area is set at 1 ft^2. Once the value is changed, the new value will be saved as the default value and will be stored until a subsequent change is made.

13.3.2 Selecting standard testing method

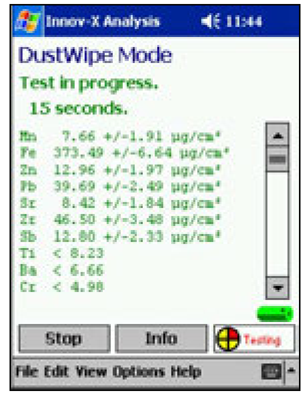
Typically, 4 or eight shots are done on one filter, however, in some cases; users may choose to do a single shot test for a quick screen. Selecting the method of analysis is done by selecting ***Options → Filter Options*** from the Ready to test screen.

Select "Single test" to do a one test quick shot.
Select "Average of 4 tests" for the standard 4 test protocol. All measurements should be done on one side of the wipe.
Select "Average of 8 tests" for the 8 test protocol. The first 4 tests should be done on one side of the wipe. It should then be flipped over and 4 shots done on the other side.

13.3.3 Measuring a Dust wipe.

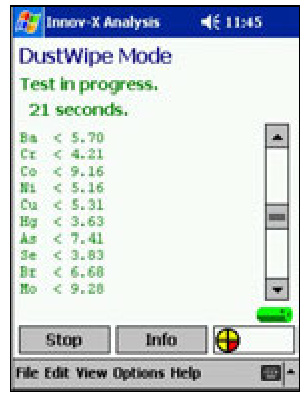
After the instrument has been standardized, testing can begin. Place the folded dust wipe in position 1and tap **Start** on the iPAQ screen. The red warning light on the top of the instrument will blink, indicating X-rays are being emitted. The screen will display the words "Test in progress" and the time elapsed. The word "Testing" will blink on and off in the low right hand corner of the screen.

Depending on the instrument settings, real time results may display on the screen after a minimum test time has elapsed. If results are not displayed on the screen, selecting ***View*** → ***Live Updates*** will turn this feature on. The minimum time can be set by the user by selecting ***Options*** → ***Setup Testing***. Each line of the results display shows the name of an element, as the mass detected on the area of the wipe being measured, and the error on the measurement. This error is defined to be sigma, the error on the counting statistics of the measurement. The error will decrease with increased testing time.



Too many elements are measured in Dust Wipe mode to display them at one time. As a result, it is possible to use the scroll bar located to the right of the chemistry display to view other elements. The complete display shows detected elements first, listed in order of atomic number, from lightest to heaviest. Following the detected elements are the elements which are below the detection limit of the instrument. These elements are shown as less than a calculated LOD. This LOD is defined as three times the error on the counting statistics of the measurement.

> **Note, due to the availability of standards, dust wipe mode supports only 3 elements: Cu, As and Pb. The analyzer will display only the calibrated elements, not the entire list.**



When the first test is completed, the analyzer will prompt for the next sample.

Move the wipe to the second position and tap "OK." The analyzer will prompt for additional readings. For each one, reposition the dust wipe and tap "OK"

> ‼ Clicking cancel instead of ok will abort the wipe measurement. No results will be saved for this wipe, even if readings have been taken in other positions.
>
> ‼ Stopping any test before the minimum test time has elapsed for that test will abort the wipe measurement. No results will be saved for this wipe, even if readings have been taken in other positions. Minimum test time is typically 5 seconds, and can be changed by selecting ***Options*** → ***Setup Testing***.

When the last reading is completed, the analyzer will open the results screen and display an average of the four readings taken on the dust wipe.

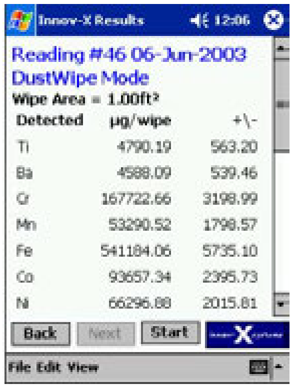
13.4 DUST WIPE RESULTS SCREEN

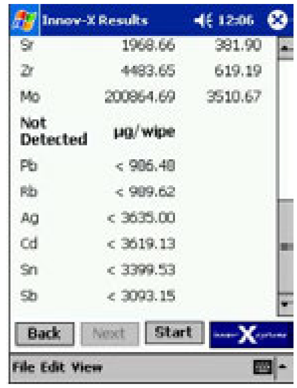
13.4.1 Results View Menu

The standard Dust Wipe Results display can be modified by using the View Menu. As with all Innov-X software modes, it is possible to view Spectra and Test Information. In addition, it is possible to view results calculated as ug/wipe, or ug/ft^2, and chemistry below LOD.

For normal operation, the results should be displayed on the results screen as soon as it opens. If the display does not show Dust Wipe chemistry results, select ***View → Results.***

This results screen displays the total loading of detected elements on the wipe as determined by the 4 tests on the wipe. The error in the measurement is displayed next to the concentration reading. The results may be displayed as either ug/wipe, or ug/ft^2 wiped.



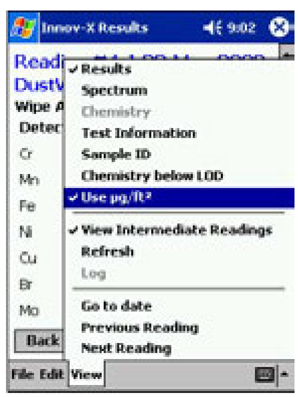


13.4.2 View Intermediate Readings

Under normal operating conditions, the results screen will display only the average of the four readings taken on a dust wipe. It is possible to access the intermediate reading by selecting View→ View Intermediate readings.

Each intermediate reading will be treated as an individual reading. Scrolling backwards from the final average reading will make the intermediate readings available. Each intermediate reading will be identified by the reading number followed by - 1, 2, 3 or 4, which will indicate the order of the tests.

13.4.3 Selecting units for display—Use ug/ft^2 option.



The units displayed on the results screen will be determined by the View →Use ug/ft2 option.   If this option is checked, the results will be calculated using the stored value of area wiped.   If use ug/ft2 is not checked, results will be displayed as ug/wipe.

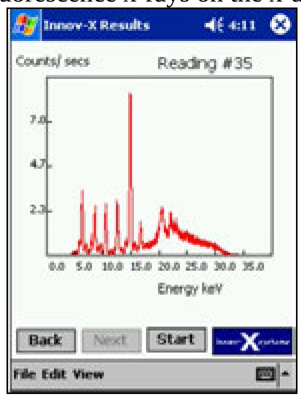
13.4.4 Chemistry Below LOD

DEFAULT: Chemistry Below LOD should be off.

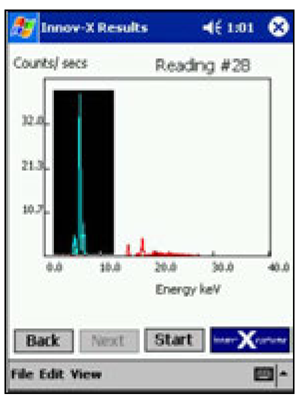
A few select users have requested the ability to be able to see what the calculated chemistry would be for elements below detection limit. This can be done by selecting ***View → Chemistry below LOD***. When this is done, the Elements below LOD are shown as a value in either ug/wipe or ug/ft^2 with an error. This is mainly for statistical purposes. These data should not be considered to be valid calculations. As a result, it is recommended that most users do not us this option.

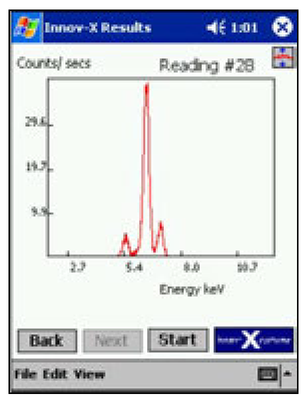
13.4.5 Spectrum Screen

This screen displays a plot of the x-ray fluorescence spectrum for an individual test, plotting the intensity on the y-axis versus the energy of the fluorescence x-rays on the x-axis.



Tapping on the spectra will show the energy scale and counts rate at the selected point. It is possible to zoom in on certain areas of the graph by selecting one corner and drawing out the out the region





Tapping the symbol in the upper right hand corner beneath the X will restore the graph to full scale.

13.4.6 Test Info Screen

The test information screen shows any information that was entered in TEST INFORMATION before starting a test.

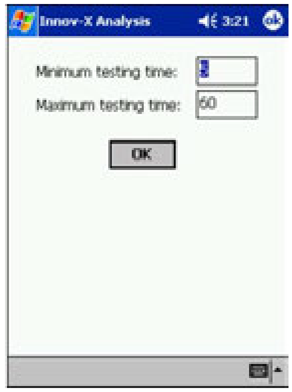
13.5 DUST WIPE MODE OPTIONS

13.5.1 Set Testing Option—setting minimum and maximum testing times

The length of tests in Dust Wipe Mode is user settable. Users may select a minimum testing time, and as well as choose from a variety of test end conditions. Recommended testing time is typically 60 seconds per dust wipe position. Longer test times will results in lower detection limits.

To access the Setup Testing screen, select **Options → Setup Testing**

A screen appears prompting you to enter a Minimum and Maximum Testing time.



The minimum testing time is the required time that must elapse before results can be calculated. Live Update results will not be displayed on the screen until the minimum has elapsed, likewise a test must complete the minimum time before any test end condition can be used. If a test is stopped before the minimum testing time has elapsed, the test will be aborted, and no results will be calculated. Five (5) seconds is a typical minimum testing time.

The test will end when the Max Test time has elapsed. The Max test time is typically 60 seconds in Dust Wipe Mode.

It should be noted, that all testing times refer to “Real Time,” the time the measurement takes when timed on a normal clock. There is some detector dead time associated with a measurement so the length of the test stored in the analyzer may be slightly shorter than the preset time.

14.0E Empirical Analysis

Empirical analysis allows users to utilize their own standards to create calibration curves for custom applications.

14.0 STANDARDS

Empirical Mode requires type specific calibration standards. Certified standards should be used if they are available, otherwise standards should be well-characterized and concentrations should be known to a high degree of accuracy. Standard concentration values should bracket the range of concentrations expected in unknown standards. Standards should be as similar as possible to standards; the sample matrix should be consistent, and the concentration ranges of elements should be similar. All standards and samples should be prepared in an identical fashion to minimize sample preparation errors.

It is recommended that a check standard is measured after each standardization, and periodically throughout the day, to ensure that the instrument is operating correctly. It may be necessary to periodically recalibrate the analyzer in the event of instrument drift.

14.1 CALIBRATION MODELS

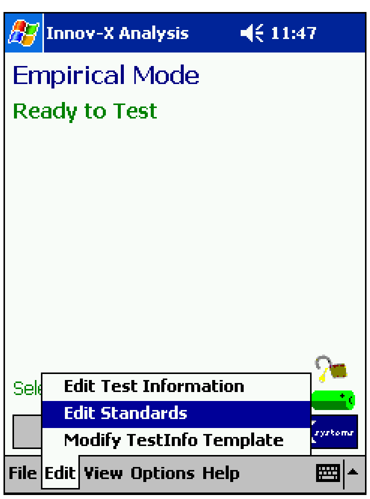
For each application, a calibration model needs to be established. This model consists of a list of elements to be analyzed, a group of measured standards with assays, and calibration curves created from the standards.

The procedure for creating a calibration model and running unknown standards consists of three main steps.

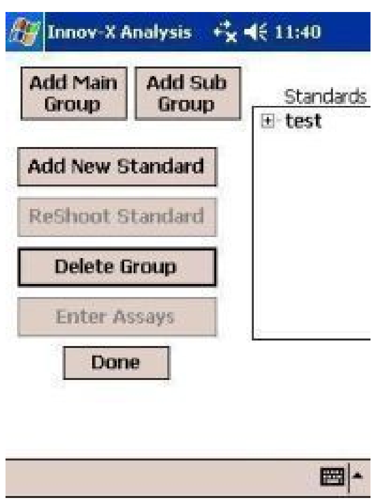
1. Measure standards and enter assays.
2. Create calibration curves for each element using stored standard information.
3. Load model and analyze unknowns

14.1.1 Adding Standards

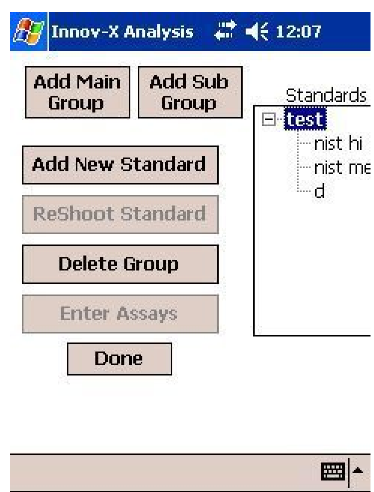
The instrument must be standardized before standards can be added. This procedure is described in depth in chapter 4.



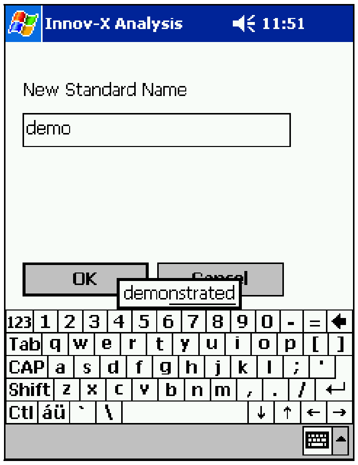
Select **Edit Standards** from the Edit Menu



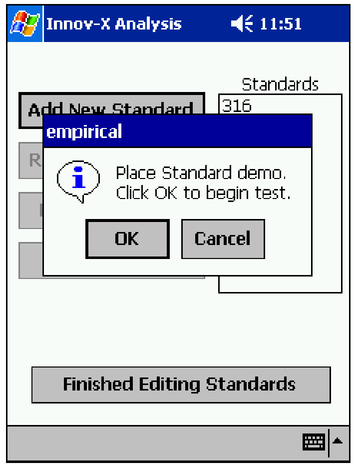
Create a calibration group or add a sub group using "**Add Main Group**" or "**Add Sub Group**"



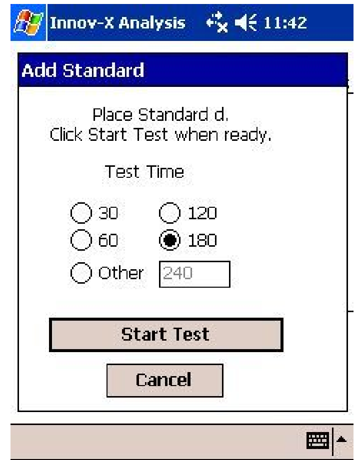
Tap **Add New Standard.** (To modify an existing standard, select the standard, then choose a function.)



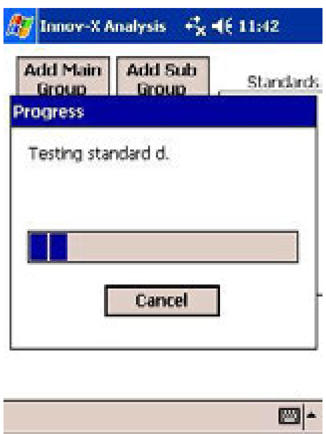
Enter the name of the standard and tap OK.



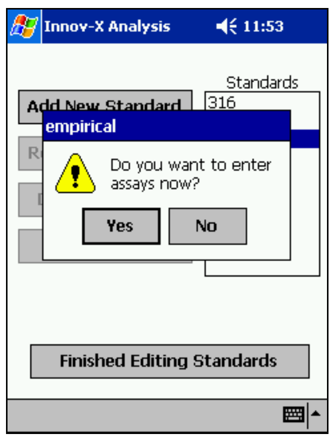
Place the standard in front of the analyzer window and tap OK.



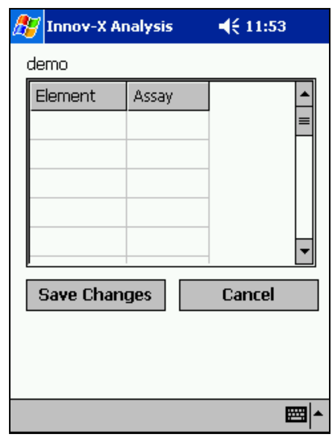
Select a time for the standard test.



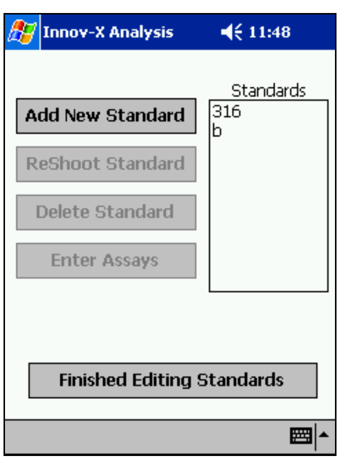
A status bar will indicate the progress of the test.



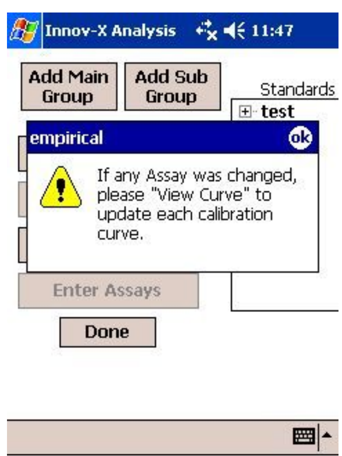
Select Yes to enter assays. Assays can be added at a later date



Enter element names in the left column, and corresponding assays in the left hand column. Save Changes when all assays are entered.



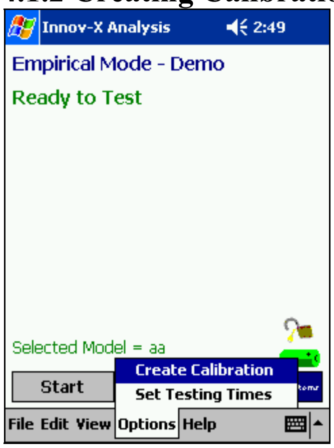
Continue to add additional standards. When all standards are stored, tap "Finished Editing standards."



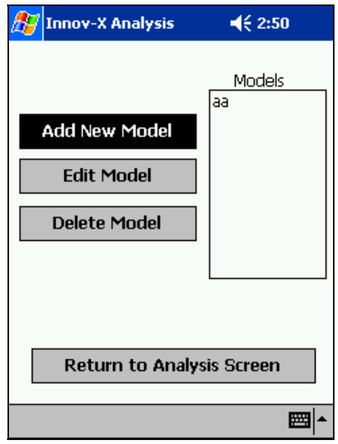
After tapping "Finished Editing Standards", this prompt will appear to "View Curve".

NOTE: When entering assays, it is only necessary to store values for elements of interest. It is not necessary to enter complete chemistries of samples.

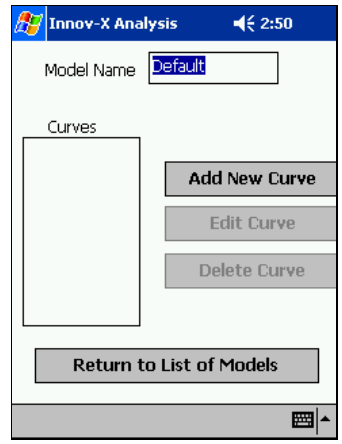
14.1.2 Creating Calibration Curves



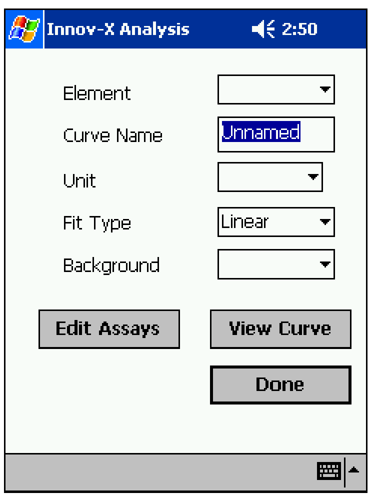
Select **Options →Create Calibration**



Tap **Add New Model**.
To edit an existing model, select the model, then choose function.



Enter a model name, then select **Add New Curve**



Select Element from drop-down menu. Enter a name for the curve. Typically, the curve is named as the element.

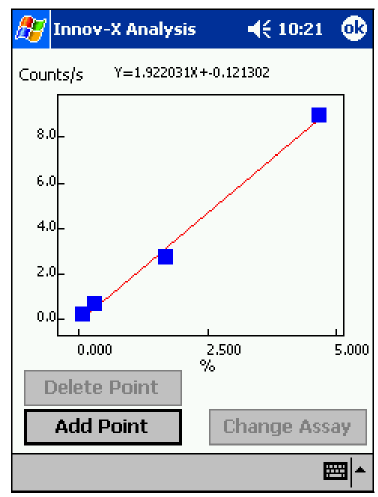
Select addition curve parameters from the menus.
Recommended parameters are:

- Unit (determined by calibration standards)
- Fit Type: Linear
- Background Adj, norm

Assays need to be selected for the curve by clicking **Edit Assays**

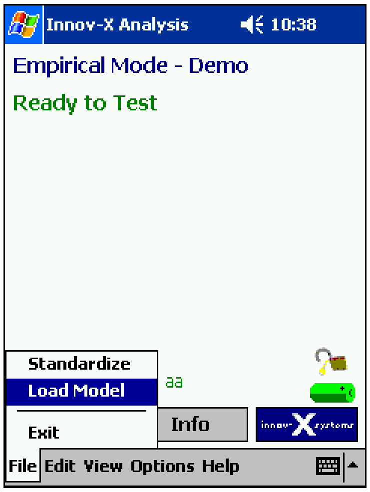
Select **View Curve** to view and/or edit the calibration curves.

ALWAYS CHECK CALIBRATION CURVES BEFORE PROCEEDING WITH TESTING.

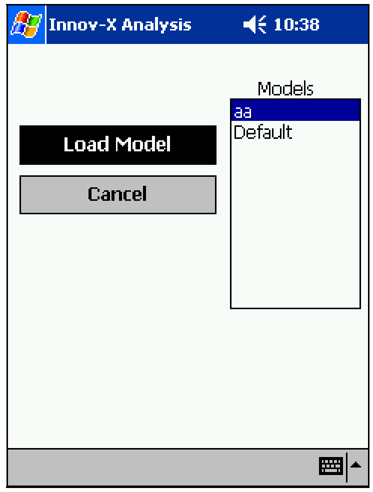


All points on curve should show good agreement with the best fit line. Standards can be added or deleted from this screen.

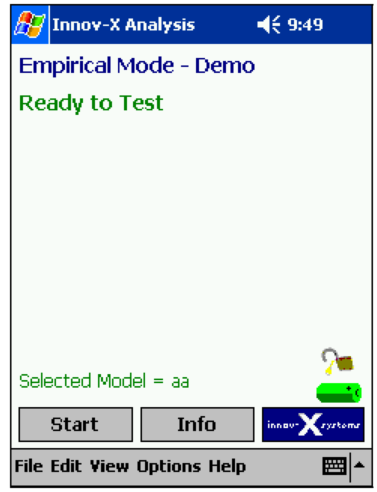
14.1.3 Loading Models



Once a model has been set up, it can be selected at any point by choosing File Load Model and entering the administrative password. (Factory default password is Z)



Select the desired model and tap **Load Model**.



The active model is displayed at the bottom of the screen.

14.2 TESTING IN EMPIRICAL MODE

After the instrument has been standardized and a model has been created and loaded, testing can begin. Simply pull the trigger or press **Start** on the iPAQ screen to begin the test. The red warning light on the top of the instrument will blink, indicating X-rays are being emitted. The screen will display the words “Test in progress” and the time elapsed. The word “Testing” will blink on and off in the low right hand corner of the screen.

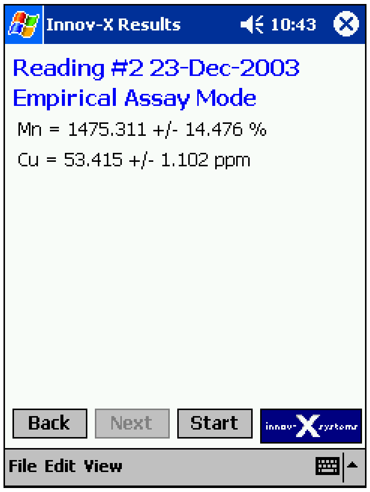
After a minimum time has elapsed, intermediate results will be displayed on the screen. Until this minimum time has elapsed, the words “WAITING FOR DATA” will appear instead. This minimum time can be set by the user by selecting ***Options→Set Testing Times***, which is described in **Section 5.4: Empirical Mode Options.** Each line of the results display shows the name of an element, its calculated concentration and the error on the measurement. This error is the 1 sigma error on the counting statistics of the measurement. The error will decrease with increased testing time

14.3 EMPIRICAL RESULTS SCREEN

14.3.1 Results View Menu

The standard Empirical Mode results screen displays the concentration (in the units specified in the model) and error in measurement for all elements in the calibration model.

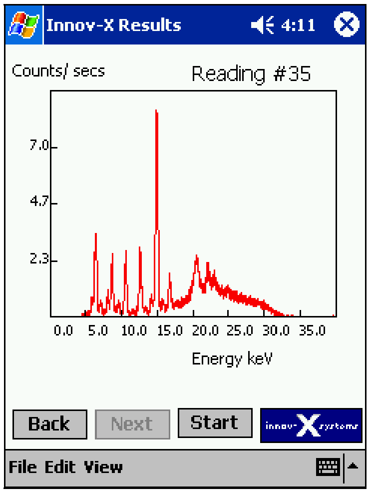
The standard Empirical chemistry display can be modified by using the View Menu. As with all Innov-X analytical modes, it is possible to view spectra and Test Information



14.3.2 Spectrum Screen

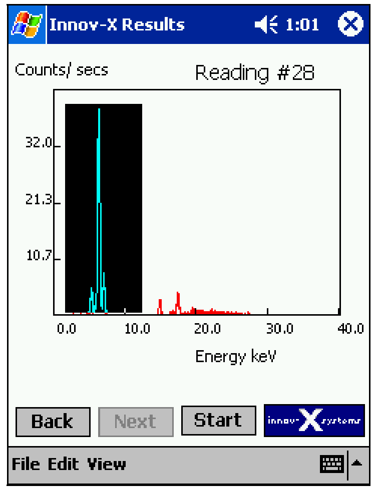
This screen displays a plot of the x-ray fluorescence spectrum for an individual test, plotting the intensity on the y-axis versus the energy of the fluorescence x-rays on the x-axis.

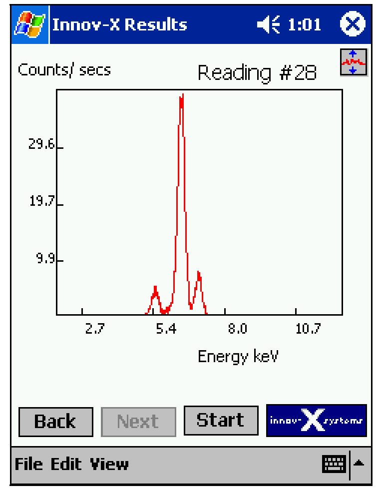
Tapping on the spectra will show the energy scale and counts rate at the selected point



It is possible to zoom in on certain areas of the graph by selecting one corner and drawing out the region

Tapping the symbol in the upper right hand corner beneath the X will restore the graph to full scale.





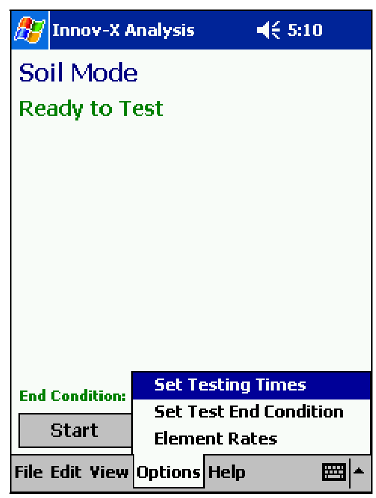
14.3.3 Test Info Screen

The test information screen shows any test information that was entered prior to the start of the test. Changes to that test information can be made by selecting **Edit→Test Information.**

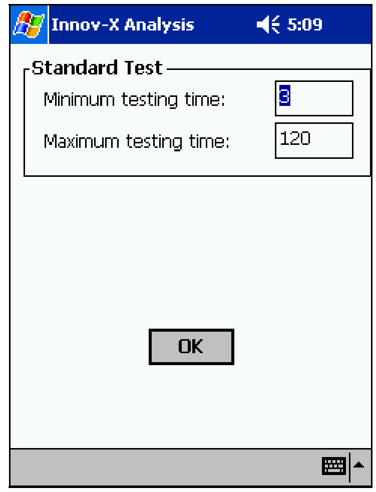
14.4 EMPIRICAL MODE OPTIONS

14.4.1 Set Testing Times

To set the minimum and maximum test lengths, select **Options→Set Testing Times**



A screen appears prompting you to enter Minimum and Maximum Testing times.



The minimum testing time is the required time that must elapse before results can be calculated. Live Update results will not be displayed on the screen until the minimum has elapsed, likewise a test must complete the minimum time before any test end condition can be used. If a test is stopped before the minimum testing time has elapsed, the test will be aborted, and no results will be calculated.

Maximum testing time will automatically end the test at a preset testing time. Typically, the maximum testing time will be in excess of 30 seconds, and may be 1 or 2 minutes, depending on detection limits and desired precision.

It should be noted, that all testing times in this section refer to “Real Time,” the time the measurement takes when timed on a normal clock. The time stored with each analytical result (accessible by selecting **View→Test Information** from the Results screen), refers to the test’s “Live Time”. This is the amount of time that the analyzer hardware was collecting spectra. Since there is some detector dead time associated with a measurement, the live time of a test will be slightly shorter than the preset “Real time”.

Appendix 1: Standard Fingerprint Library

Standard Fast ID Library

Stainless	***Chrome-Moly***	***Nickel Base***
304	1 1/4 Cr	Inco 600
309	2 1/4Cr	Inco 625
310	5 Cr	Inco 718
316	9 Cr	Inco 750
317		Inco 800
321	***Cobalt Base***	Inco 825
347	F-75	Hast C-276
410/416	HS-6	Hast X
	HS-25	Monel 400
Low Alloy		Monel 500
CS	***Copper Base***	Waspaloy
C ½ Mo	70-30	
4140, 4130	90-10	***Ti Base***
4340	CDA 836	CP Ti
		Ti 6-4

Appendix 2: Standard Grade Library

Iron Base Alloys			Ni-base Alloys	
201	Alnico VIII	**Tool Steels**	Ni	Inco 718
203	AL6XN		80-20	Inco 722
301	AMS 350	A2	B-1900	Inco 738
304	AMS 355	A6	B-1900 Hf	Inco 750
309	CD4MCU	A7	Inco 617	Inco 792
310	Custom 450	A10	Inco 625	Inco 800
316	Custom 455	D2, D4	C-1023	Inco 801
317	Duplex 2205	D7	GMR 235	Inco 825
321	Elgiloy	H12	GTD 222	Inco 901
329	Ferallium 255	H13	Hast B	Inco 903
330	Greek Ascoloy	L6	Hast B2	Inco 909
347	Hy Mu 80	O1	Hast C-4	Mar M 002
410/416/420	Kovar	O6	Hast C-22	Mar M 200
410 Cb	Invar 36	O7	Hast C-276	Mar M 246
422	Maraging C200	M1	Hast C-2000	Mar M 247
430/440	Maraging C250	M2	Hast F	Mar M 421
431	Maraging C300	M42	Hast G	Monel 400
434	Maraging C350	M4	Hast G-2	Monel 411
441	N-155	S1	Hast G-3	Monel 500
446	Ni-hard #1	S7	Hast G-30	MP35N
12L14	Ni-hard #4	T1	Hast N	Mu Metal
13-8 Mo	Nitronic 40		Hast R	Nichrome V
15.5 PH	Nitronic 50		Hast S	Nickel 200
17-4 PH	Nitronic 60	**Low-Alloy Cr-Mo Steels**	Hast X	Nim 101
19-9DL	RA333		Hast W	Nim 263
19-9DX	RA330		Haynes 25	Nimonic 75
20Cb3		Carbon steel	Haynes 36	Nimonic 80A
20Mo4		4140	Haynes 214	Nimonic 90
20Mo6		1 1/4 Cr	Haynes 230	Ni-Span 902
25-4-4		2 1/4Cr	Haynes 188	Rene 41
254SMO		5 Cr	Haynes 556	Rene 77
21-6-9		9 Cr	HR-160	Rene 80
26-1 (Ebrite)		C - 1/2 Mo	IN 100	Rene 95
29-4			Inco 600	Rene 125
29-4-2			Inco 601	Supertherm
904 L			Nim 101	Udimet 500
A-286			Nim 263	Udimet 520
Alloy 42			Inco 690	Waspaloy
Alloy 49			Inco 702	
Alnico II			Inco 706	
Alnico V			Inco 713	

Co-base Alloys	Cu-base Alloys	Ti-base Alloys	Misc. Alloys	Pure Elements
Co	Cu	CpTi	97-3	Ag
F-75	70-30	Cp Ti Pd	Cb 103	Cr
FSX 414	80-20	6-4	CP Ta	Hf
HS-1	90-10	6-6-2	Densalloy	Mn
HS-4	CDA 110	6-2-4-2	Tungsten	Mo
HS-6	CDA 314	6-2-4-6	Carbide	Nb
HS-12	CDA 360	3-2.5	Zir 702	Pb
HS-19	CDA 544	5-2.5	Zir 705	Pd
HS-21	CDA 630	15-3-3-3	Zircaloy	Re
			2, 4	
HS-25 (L605)	CDA 706	10-2-3	Zr	Sb
HS-31	CDA 836	Ti-8		Sn
Haynes 188	CDA 863	Ti-12		V
Jetalloy	CDA 875	Ti-17		W
Mar M 302	CDA 903	Ti 6-22-22		Zn
Mar M 509	CDA 932	Ti 13-11-3		Fe
MP 35N	CDA 937	Beta C		
Star J	CDA 954	Ti 6-2-1-1		
Ultimet	CDA 955			
	CDA 8932			

The Standard Grade library holds 250 alloys with specifications. Three additional user libraries are available, each hold 100 alloys. Users may edit all libraries entries and may add or delete grades and fingerprints.

Appendix 3: Troubleshooting Guide—Alloy Analysis

Problem	**Possible Solutions**
Software won't start: Software will not start when the Innov-X Systems Icon is tapped.	The flash card or the iPAQ may not be correctly seated in the black external sleeve. Remove the flash card and press it firmly into its holder. Press the iPAQ down into the black sleeve.
Software won't start: Software doesn't start when the Innov-X System icon is tapped; instead, the following error message occurs: "Cannot find 'startup' (or one of its components). Make sure the path and filename are correct and all the required libraries are available"	The flash card or the iPAQ may not be correctly seated in the black external sleeve. Remove the flash card and press it firmly into its holder. Press the iPAQ down into the black sleeve.
IPAQ locks up: iPAQ screen "locks up" and doesn't respond when screen is tapped or buttons are pressed	Remove the iPAQ from the analyzer and perform a soft reset by pressing the tip of the stylus into the small indentation found on the bottom of the iPAQ. If the iPAQ is lying flat on a table with the screen facing upwards, the reset button is found to the extreme right of the side containing the power plug and connector. .
Analyzer will not standardize	Try again. Choose File -> Standardize to attempt a new standardization. Also be sure the standardization cap is on correctly, and that the solid half is in front of the window. It is OK to try this 2-3 times in the event of a failure. If a repeat attempt fails: Change the battery. In some cases the battery may be too low to provide enough power for tube startup. Follow this procedure: • Reset the iPAQ; • Turn off the analyzer and remove the battery. • Verify that the battery is completely charged. If it is not, replace it with a fresh battery. Even if the battery has been recently recharged, remove it, and replace it in the analyzer. • Restart the analyzer and software. Wait several minutes after the software has initialized before attempting standardization.
Incorrect Alloy ID in FAST ID Mode: Analyzer does not correctly ID sample that was just added to the library in FastID.	Verify that the Alloy was saved in a library which is being searched. ***Use File→Load libraries*** to change the library being search. ***Edit→Fingerprint libraries*** "Show/Modify" can be used to check that the fingerprint was saved in the proper library.

Analyzer gives "No Match" for every sample.	1. Verify that Match Numbers are set to 1 for Fast ID and 3 for Analytical. Change values by selecting ***Options→Fingerprint Setup*** from the Analysis screen for FastID mode, or ***Options→Grade Library Settings* from Analytical mode.** 2. Verify that you are searching the correct library. Use ***File→Load Libraries*** to change the library being searched. Most users should search all libraries. 3. Check to make sure that the analyzing window is clean.
All tests yield incorrect match	Check the date and time on the last result shown. It should show the current date. If it doesn't, check the date on the iPAQ. The Innov-X Systems software indexes stored results by date. If the date is incorrect, results may not be displayed in the correct order.
Results screen doesn't show new readings after a test is completed	Check the date on the iPAQ. The Innov-X Systems software indexes stored results by date. If the date is incorrect, results may not be displayed in the correct order.
Serial Communication Error Message: Serial Communication error occurs because iPAQ has been removed from instrument or cradle, with the software open and the instrument standardized.	This error reflects the temporary loss in communications when the iPAQ was removed. To avoid this problem, always use the **File→Exit** command to exit the software properly. Try simply removing and reseating the iPAQ to solve this problem. If that fails, see steps 1 – 4 below.
Serial communication error on startup, or while testing.	1. If the analysis screen is still open, attempt another test. 2. Verify that the iPAQ is correctly seated in the analyzer by removing and replacing it. 3. Remove the iPAQ and perform a soft reset. Replace iPAQ and restart software. 4. Turn the analyzer off and restart it.
Trigger will not start test.	Reset the instrument. If this fails, call Innov-X Systems Technical Support at 781-938-5005.

Broken Kapton Window	The window is designed as a barrier to dust and dirt. If it is damaged, it should be replaced. To change the window: Turn off the analyzer Remove the screws holding the front plate in place. Remove the old kapton and adhesive, replace with new kapton and replace front plate. **Important Note:** It is very important to avoid getting dirt and sharp objects within the probe, due to the close proximity of the detector. Do not use the analyzer without a kapton window for any length of time. Also, be very careful when removing/replacing screws in face plate so as to not accidentally damage the detector. If the detector is damaged, the instrument will require factory service.

Appendix 4: Guide to Product Registration

Generally, the Innov-X portable XRF system must be registered in the state of usage.   Registration requirements are somewhat state dependent, but there are many similarities.   You may contact Innov-X at 866-4-Innov-X (781-938-5005) to receive specific registration information. Innov-X also maintains sample registrations for every state that we can forward to you. Outside the United States, our local sales agents provide guidance in the proper registration of the analyzer.

Common Registration Features:

Most states require the following for registering an x-ray emitting device that does NOT use radioactive sources:

1. Registration within 30 days of receipt of the analyzer.
2. Annual fee in the $25 to $200 range, depending upon the state.
3. Basic registration form with main information described below.

Common information required on Registration Form, and responses:

Company name, address, phone/fax numbers.

Name of responsible person:	Generally the person designated as the Radiation Safety Officer (RSO).
Name of the manufacturer:	Innov-X Systems, Inc., Woburn, MA
Model of Analyzer:	XT-220 or XT-260.
Tube Operating Parameters:	35 kV, 20 uA current.
Type of Analysis:	Choose Analytical or Industrial
	(as opposed to radiography, medical, dental, veterinarian, etc.)
Utilization Mode:	Portable or Mobile assuming you will carry system to different locations.
	Fixed or stationary ONLY if you will always use the analyzer in the docking station

Appendix 1: Troubleshooting Guide—Soil Analysis

Problem	Possible Solutions
Software won't start: Software will not start when the Innov-X Systems Icon is tapped.	The flash card or the iPAQ may not be correctly seated in the black external sleeve. Remove the flash card and press it firmly into its holder. Press the iPAQ down into the black sleeve.
Software won't start: Software doesn't start when the Innov-X System icon is tapped; instead, the following error message occurs: "Cannot find 'startup' (or one of its components). Make sure the path and filename are correct and all the required libraries are available"	The flash card or the iPAQ may not be correctly seated in the black external sleeve. Remove the flash card and press it firmly into its holder. Press the iPAQ down into the black sleeve.
IPAQ locks up: iPAQ screen "locks up" and doesn't respond when screen is tapped or buttons are pressed	Remove the iPAQ from the analyzer and perform a soft reset by pressing the tip of the stylus into the small indentation found on the bottom of the iPAQ. If the iPAQ is lying flat on a table with the screen facing upwards, the reset button is found to the extreme right of the side containing the power plug and connector. See Page 4 of the Compaq "Getting Started" manual for an illustration showing the location of the reset button.

Analyzer will not standardize	Try again. Choose File -> Standardize to attempt a new standardization. Also be sure the standardization cap is on correctly, and that the solid half is in front of the window. It is OK to try this 2-3 times in the event of a failure. If a repeat attempt fails: Change the battery. In some cases the battery may be too low to provide enough power for tube startup. Follow this procedure: Reset the iPAQ; Turn off the analyzer and remove the battery. Verify that the battery is completely charged. If it is not, replace it with a fresh battery. Even if the battery has been recently recharged, remove it, and replace it in the analyzer. Restart the analyzer and software. Wait several minutes after the software has initialized before attempting standardization.
Results screen doesn't show new readings after a test is completed	Check the date on the iPAQ. The Innov-X Systems software indexes stored results by date. If the date is incorrect, results may not be displayed in the correct order.
Serial Communication Error Message: Serial Communication error occurs because iPAQ has been removed from instrument or cradle, with the software open and the instrument standardized.	This error reflects the temporary loss in communications when the iPAQ was removed. To avoid this problem, always use the **File / Exit** command to exit the software properly. Try simply removing and reseating the iPAQ to solve this problem. If that fails, see steps 1 – 4 below.
Serial communication error on startup, or while testing.	1. If the analysis screen is still open, attempt another test. 2. Verify that the iPAQ is correctly seated in the analyzer by removing and replacing it. 3. Remove the iPAQ and perform a soft reset. Replace iPAQ and restart software. 4. Turn the analyzer off and restart it.

Results take a very long time to display on the first test of the day.	There may be too many readings stored in memory. Erase readings from the results screen by selecting ***File* → *Delete Readings***.
Trigger will not start test.	Verify that the trigger lock is off. Reset the instrument. If this fails, call Innov-X Systems Technical Support at 781-938-5005.
Broken Kapton Window	The window is designed as a barrier to dust and dirt. If it is damaged, it should be replaced. To change the window: Turn off the analyzer Remove the screws holding the front plate in place. Remove the old kapton and adhesive, replace with new kapton and replace front plate. **Important Note:** It is very important to avoid getting dirt and sharp objects within the probe, due to the close proximity of the detector. Do not use the analyzer without a kapton window for any length of time. Also, be very careful when removing/replacing screws in face plate so as to not accidentally damage the detector. If the detector is damaged, the instrument will require factory service.
Results screen shows message "Error in calculation: No Results"	The soil mode calculation is only valid for "soil-like" samples which contain primarily light elements such as carbon, oxygen and silicon. If a dense, highly metallic sample is analyzed, the calculation fails. Make sure the sample being analyzed is a soil sample, if it is and this message occurs repeatedly; call Innov-X technical support.

Appendix 2:

Metals in Soil Analysis Using Field Portable X-ray Fluorescence

A guideline to using portable XRF according to EPA Method 6200, basic overview of the technique of x-ray fluorescence (XRF), appropriate data quality assurance protocols and sample preparation steps for operators analyzing prepared soil samples.

Prepared by:

Innov-X Systems, Inc.
January, 2003

Innov-X Systems
300 Wildwood Ave, Suite 210
Woburn, MA 01801
781-938-5005
781-938-0128 (fax)
info@innov-xsys.com
www.innov-xsys.com

Section 1: Regulatory Status for Field Portable XRF

EPA Reference Method 6200 has been incorporated into SW486 under RCRA, and is now available for field portable XRF analysis of soils and sediments. Please call or email Innov-X Systems for a copy of Method 6200.

Method 6200: Field Portable XRF Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment.

Features of this method:

1. It is a field screening method, for analysis of *in-situ* or bagged samples.
2. The method provides basic quality assurance methods, including calibration verification, determination of instrument precision, accuracy and limit of detection.
3. The method recognizes the some XRF instruments do not require site-specific calibrations by the operator, that is, the factory calibration provides appropriate data quality.
4. The method recommends that a minimum of 5-10% of samples tested by XRF be confirmed by an outside laboratory using a total-digestion EPA analytical reference method.

The purpose of EPA Method 6200 is NOT to replace laboratory analysis. There are two primary sources of error in assessing a site for metal concentration: **Analytical error** and **Sampling error**. Analytical error is the error in the analysis of any one sample by whatever technique is used, for example XRF, ICP, or AA. Sampling error arises when too few samples are collected and tested. In this case an incomplete picture of the extent of metals contamination may be obtained. Although any one sample may be analyzed with very high analytical accuracy, measuring too few samples may result in contamination plumes being mis-judged in size, or depth into the soil. In extreme cases contamination may missed entirely.

EPA Method 6200 was developed to reduce Sampling Errors by increasing the number of samples measured. In general, a large number of screening-level measurements provide a better characterization of contamination than a small number of measurements produced by sample removal and analytical analysis. Portable XRF is an ideal tool to make a large quantity of measurements in a short period of time. A large number of in-situ samples provides detailed data on contamination profiles, depth (provided surface soil is moved aside), and approximate contamination levels. Portable XRF also can provide results with a high degree of analytical accuracy on any given sample. Please see Section 2 “Overview of Field Usage” for this discussion.

Section 2: Overview of Field Usage:

Field portable XRF is generally used in three ways to test for metals in soil:

- **In-situ soil testing:** The XRF is placed directly onto the ground for soil testing. Operators remove any plant growth and foreign objects so that the analyzer probe is flush to the soil.
- **Bagged soil sample testing.** A soil sample is collected in a thin plastic bag (i.e. a "Baggie") and testing directly through the Baggie. Except for a few elements – namely Cr, V and Ba – testing through the thin plastic used for a plastic bag has little effect on the test result. Results for Cr, V and Ba will be lower by 20-30%.
- **Prepared soil sample testing.** Prepared sample testing assures the operator of the maximum possible accuracy. Prepared sample tests require a sample to be collected, dried if necessary, sieved and ground into a powder. The prepared sample is then placed into a baggie or XRF cup for analysis. **A complete Soil Preparation Guide is provided in Appendix 1.**

All analytical methods require a uniform, homogenous sample for the best results. **XRF is no different!** The methods described in EPA Method 6200, namely In-situ and bagged sample testing, are considered *field-screening methods*. Although a field-screening method, in-situ testing is a valuable technique because it generates a great deal of data very quickly. Prepared soil samples generally offer the best accuracy, albeit with several minutes of sample preparation required per sample.

Figure 1. Use of a field portable XRF for in-situ soil testing.

Subsection 2-A: Data Quality Objectives.

The objectives of the testing generally determine the mixture of in-situ versus prepared sample testing. It is important to understand your data quality objectives (DQO) in order to determine the appropriate mix of field screening and prepared sample testing.

In-situ testing usually provides only screening-level data quality. This is because analytical testing always requires a uniform, homogeneous sample matrix. A laboratory achieves this by digesting the sample into a hot acid before analysis. Testing directly on the ground does not ensure uniformity is met. Preparing a sample provides a uniform sample and likely better analytical data quality, although several minutes of testing time is required.

Most portable XRF operators use a mixture of in-situ and prepared sample testing. Several examples are described below. The exact mixture of in-situ and prepared sample testing depends upon the goals of the soil testing. The examples below serve as guidelines. Please contact Innov-X (1-866-4 Innov-X or 866-446-6689) to discuss your specific testing requirements.

Example 1: Initial site investigation to provide detailed contamination data with efficient use of laboratory analysis costs.

Problem: Site needs to be assessed for metals contamination. Little information is available about what metals are present, likely contamination levels or geographic profile of contamination.

The goal of testing is to determine what metals are present at what levels, both in area and in depth into soil. Additionally, testing will locate possible contamination plumes and/or possible sources of contamination.

Recommended Testing Plan: This example uses predominately in-situ testing. The analyst will perform in-situ testing, and gather samples into plastic bags for XRF analysis. A testing grid should be established in two or three dimensions, every several feet. XRF tests can be taken at each location or bagged samples can be collected from each location for later analysis. The in-situ data for each element analyzed may be plotted in a 2-dimensional grid (X, Y coordinates versus elemental concentration) to profile a site. These concentration profiles are ideal for showing contamination patterns, boundaries and plumes. Combining this data with historical use data from the site often allows the operator to deduce sources of contamination. Obtaining this level of geographic data with purely laboratory analysis would produce excessive analytical costs.

Prepared sample analysis should also be done to confirm the regions where in-situ data indicates low or non-detected levels of metal contaminant. There is little need to prepare areas where in-situ testing indicates high concentration levels. Innov-X recommends the same procedure as EPA Method 6200. For locations where in-situ tested indicate low or non-detected concentrations, calculate the total number of in-situ tests, collect 5% of this number of tests from the various locations, and prepare these samples according to Appendix 1. Use these prepared samples to confirm the findings of the in-situ testing. Send a subset of these prepared samples to a laboratory for confirmatory results.

Cost Justification. To adequately characterize a site may require 100-200 samples/acre to be sure the contaminated areas are firmly established. This work may be done with in-situ testing to generate laboratory savings of $5,000 - $10,000/acre depending upon the number of elements being analyzed. The cost reduction in off-site analysis often justifies the price of the XRF.

Example 2: Monitor remediation efforts and assure site meets clearance levels before contractors leave the site.

Goal: Minimize remediation costs by only treating contaminated soil, and obtain immediate verification that various site locations meet clearance objectives.

Recommended Testing Plan: This type of project uses a lot of both in-situ and prepared sample testing. Use in-situ testing to thoroughly delineate contamination regions in both area and depth. To determine depth profiles, test surface soil, remove at least 1-2 inches, and retest. Repeat this step as necessary to profile contamination depth to guide remediation activities. (XRF is a surface technique and only analysis the first few mm of soil sample). As part of clearance, collect several samples from “cleared” area. Prepare samples according to Appendix 1 and test with portable XRF.

If XRF indicates that concentration levels are in excess of clearance requirements, then continue remediation efforts.

If XRF indicates that concentration levels are below clearance requirements, then discontinue remediation efforts, and send a subset of the samples to an analytical laboratory to confirm results. Most operators safely assume that the cleanup requirements have been met for the elements in question, but await final analysis from the laboratory.

If XRF lists concentration levels as non-detected, but the detection level reported exceeds clearance requirements, send samples to a laboratory for final results.

Cost Justification: In-situ results are used to guide remediation efforts, in order to obtain maximum efficiency. Efficiency is produced because contamination boundaries are firmly established, thus avoiding remediation efforts with “clean” soil. Prepared sample testing is used to assure that clearance requirements are met on-site in near real-time (pending laboratory confirmation). Costs savings are generated by avoiding clearance failures. The contractors can leave the site earlier and will not be called back to the site for additional cleanup.

Important Note: Never clear a site based solely on in-situ testing. Always use well-prepared samples to make a clearance decision.

Example 3: Minimize volume of hazardous waste for treatment or disposal.

Goal: For some cleanup projects, the cost of soil disposal in a hazardous waste landfill is much greater than disposal in a standard landfill. Testing soil samples with XRF may minimize the amount of “clean” soil that is inadvertently shipped to a hazardous-waste landfill.

Recommended Testing Plan: This example is almost entirely prepared sample testing. Representative samples are removed from the soil being hauled to landfill. Obtaining an accurate analysis of the samples is crucial for making a hazardous versus non-hazardous determination. For this reason, prepared sample testing is strongly recommended.

Important Note: These types of samples are subject to TCLP procedures for the landfill determination. In general, 20 times the XRF result should be less than the allowable limit for the metal in question. Please contact Innov-X Systems for more details on testing samples versus TCLP regulatory requirements.

Section 3: Quality Assurance.

Quality assurance is detailed for both the proper use of the analyzer (which is also provided in Method 6200) and for verifying the data quality of in-situ testing. All operators should perform the QC procedure, regardless of their data quality objectives. Method 6200 has strict requirements about quality assurance. Additionally, Innov-X recommends that operators verify the data quality of in-situ test results, if they are using in-situ data to guide their reporting or remediation decisions. Procedures are listed below:

3.1: Proper verification of instrument operation

These procedures are taken from EPA Method 6200 and updated to be specific to the Innov-X analyzer. Quality assurance here consists of testing known standards to verify calibration, as well as testing blank standards to determine limits of detection and to check for sample cross-contamination or instrument contamination. EPA Method 6200 provides a detailed procedure, which is provided here in abbreviated form.

Components of instrument QC:

1. An energy calibration check sample at least twice daily
2. An instrument blank for every 20 environmental samples
3. A method blank for every 20 <u>prepared</u> samples
4. A calibration verification check sample for every 20 samples
5. A precision sample at least one per day.
6. A confirmatory sample for every 10 environmental samples

Energy Calibration Check: The Innov-X analyzer performs this automatically; this is the purpose of the standardization check when the analyzer is started. The software does not allow the analyzer to be used if the standardization is not completed.

Instrument Blank: The operator should use the SiO_2 (silicon dioxide) blank provided with the analyzer. The purpose of this test is to verify there is no contamination on the analyzer window or other component that is “seen” by the x-rays. Method 6200 recommends an instrument blank at least once per day, preferably every 20 samples. For either in-situ or prepared-sample testing, the operator should just test the SiO_2 blank to be sure there are no reported contaminant metals.

Method Blank: The purpose of the method blank is to verify that cross-contamination is not introduced into samples during the sample preparation process. Method 6200 recommends following the sample preparation procedures with clean SiO_2 once very 20 prepared samples. This QC step is not required if the operator is not preparing samples.

Calibration Verification: Innov-X provides NIST standard reference samples for calibration check by operator. The operator should perform a 2-minute test on a NIST standard. The difference between the XRF result for an element and the value of the standard should be 20% or less. Calibration Verification should be performed upon instrument startup and periodically during testing. Note: Innov-X recommends a calibration check every 4 hours. EPA Method 6200 recommends a calibration check every 20 samples NIST reference standards are generally applicable for Pb, As, Cr, Cu, Zn. Innov-X provides additional reference standards for other RCRA or Priority Pollutant metals including Cd, Se, Ag, Hg, Ag, Ba, Sn, Sb, and Ni.

This page and the two succeeding pages provide NIST Certified and Noncertified values for SRM2709, SRM2710, and -SRM2711.

SRM2709 San Joaquin Soil

Table 1. Certified Values

Element	Mass Fraction (%)			Element	Mass Fraction (µg/g)		
Aluminum	7.50	±	0.06	Antimony	7.9	±	0.6
Calcium	1.89	±	0.05	Arsenic	17.7	±	0.8
Iron	3.50	±	0.11	Barium	968	±	40
Magnesium	1.51	±	0.05	Cadmium	0.38	±	0.01
Phosphorus	0.062	±	0.005	Chromium	130	±	4
Potassium	2.03	±	0.06	Cobalt	13.4	±	0.7
Silicon	29.66	±	0.23	Copper	34.6	±	0.7
Sodium	1.16	±	0.03	Lead	18.9	±	0.5
Sulfur	0.089	±	0.002	Manganese	538	±	17
Titanium	0.342	±	0.024	Mercury	1.40	±	0.08
				Nickel	88	±	5
				Selenium	1.57	±	0.08
				Silver	0.41	±	0.03
				Strontium	231	±	2
				Thallium	0.74	±	0.05
				Vanadium	112	±	5
				Zinc	106	±	3

Noncertified Values: Noncertified values, shown below, are provided for information only. An element concentration value may not be certified if a bias is suspected in one or more of the methods used for certification, or if two independent methods are not available.

Table 2. Noncertified Values

Element	Mass Fraction (%)	Element	Mass Fraction (µg/g)
Carbon	1.2	Cerium	42
		Cesium	5.3
		Dysprosium	3.5
		Europium	0.9
		Gallium	14
		Gold	0.3
		Hafnium	3.7
		Holmium	0.54
		Iodine	5
		Lanthanum	23
		Molybdenum	2.0
		Neodymium	19
		Rubidium	96
		Samarium	3.8
		Scandium	12
		Thorium	11
		Tungsten	2
		Uranium	3
		Ytterbium	1.6
		Yttrium	18
		Zirconium	160

SRM2710 Montana Soil

Table 1. Certified Values

Element	Mass Fraction (%)			Element	Mass Fraction (mg/kg)		
Aluminum	6.44	±	0.08	Antimony	38.4	±	3
Calcium	1.25	±	0.03	Arsenic	626	±	38
Iron	3.38	±	0.10	Barium	707	±	51
Magnesium	0.853	±	0.042	Cadmium	21.8	±	0.2
Manganese	1.01	±	0.04	Copper	2950	±	130
Phosphorus	0.106	±	0.015	Lead	5532	±	80
Potassium	2.11	±	0.11	Mercury	32.6	±	1.8
Silicon	28.97	±	0.18	Nickel	14.3	±	1.0
Sodium	1.14	±	0.06	Silver	35.3	±	1.5
Sulfur	0.240	±	0.006	Vanadium	76.6	±	2.3
Titanium	0.283	±	0.010	Zinc	6952	±	91

Noncertified Values: Noncertified values are provided for information only. An element concentration value is not certified if a bias is suspected in one or more of the methods used for certification, or if two independent methods are not available.

Table 2. Noncertified Values

Element	Mass Fraction (%)	Element	Mass Fraction (mg/kg)
Carbon	3	Bromine	6
		Cerium	57
		Cesium	107
		Chromium	39
		Cobalt	10
		Dysprosium	5.4
		Europium	1
		Gallium	34
		Gold	0.6
		Hafnium	3.2
		Holmium	0.6
		Indium	5.1
		Lanthanum	34
		Molybdenum	19
		Neodymium	23
		Rubidium	120
		Samarium	7.8
		Scandium	8.7
		Strontium	330
		Thallium	1.3
		Thorium	13
		Tungsten	93
		Uranium	25
		Ytterbium	1.3
		Yttrium	23

SRM2711 Montana Soil

Table 1. Certified Values

Element	Mass Fraction (%)			Element	Mass Fraction (µg/g)		
Aluminum	6.53	±	0.09	Antimony	19.4	±	1.8
Calcium	2.88	±	0.08	Arsenic	105	±	8
Iron	2.89	±	0.06	Barium	726	±	38
Magnesium	1.05	±	0.03	Cadmium	41.70	±	0.25
Phosphorus	0.086	±	0.007	Copper	114	±	2
Potassium	2.45	±	0.08	Lead	1162	±	31
Silicon	30.44	±	0.19	Manganese	638	±	28
Sodium	1.14	±	0.03	Mercury	6.25	±	0.19
Sulfur	0.042	±	0.001	Nickel	20.6	±	1.1
Titanium	0.306	±	0.023	Selenium	1.52	±	0.14
				Silver	4.63	±	0.39
				Strontium	245.3	±	0.7
				Thallium	2.47	±	0.15
				Vanadium	81.6	±	2.9
				Zinc	350.4	±	4.8

Noncertified Values: Noncertified values, shown in parentheses, are provided for information only. An element concentration value may not be certified, if a bias is suspected in one or more of the methods used for certification, or if two independent methods are not available.

Table 2. Noncertified Values

Element	Mass Fraction (%)	Element	Mass Fraction (µg/g)
Carbon	(2)	Bromine	(5)
		Cerium	(69)
		Cesium	(6.1)
		Chromium	(47)
		Cobalt	(10)
		Dysprosium	(5.6)
		Europium	(1.1)
		Gallium	(15)
		Gold	(.03)
		Hafnium	(7.3)
		Holmium	(1)
		Indium	(1.1)
		Iodine	(3)
		Lanthanum	(40)
		Molybdenum	(1.6)
		Neodymium	(31)
		Rubidium	(110)
		Samarium	(5.9)
		Scandium	(9)
		Thorium	(14)
		Tungsten	(3)
		Uranium	(2.6)
		Ytterbium	(2.7)
		Yttrium	(25)
		Zirconium	(230)

Precision Verification: Quoting from EPA "A minimum of one precision sample should be run per day by conducting from 7 to 10 replicate measurements of the sample. The precision is assessed by calculating a relative standard deviation (RSD) of the replicate measurements for the analyte. The RSD values should be less than 20 percent for most analytes, except chromium, for which the value should be less than 30 percent.

Confirmatory Sample: It is recommended that one confirmatory sample is run for every 10 samples collected. According to EPA Method 6200: "Confirmatory samples are collected from the same sample material that is analyzed on site, but are sent to an off-site laboratory for formal analysis. The purpose of a confirmatory sample is to judge the accuracy of the data obtained by analysis on site and to allow corrections, if necessary."

Important Notes about confirmatory samples:

Innov-X always recommends that customers compare prepared-sample results to laboratory results. To do this, collect and prepare a sample following the protocols of Appendix 1. Take a subsample and submit to the laboratory for analysis. The single largest error in XRF analysis is lack of sample preparation. For the best comparison, always use prepared samples.

3.2: Determining data quality of in-situ testing:

For operators relying extensively on in-situ testing, it is important to determine the data quality of this testing at a given site. *This protocol is not intended for every sample, but rather for a small percentage of samples considered representative of the site.* If the operator can demonstrate that quantitative data is achieved with little or no sample preparation, then the site characterization will be completed much more quickly but correctly.

For example, an operator may be able to demonstrate that the XRF result changes considerably when samples are passed through a 2 mm sieve, but that XRF results do NOT change appreciably upon finer sieving. In this case the operator can conclude that good XRF data is achievable with only 2 mm sieving. Sieving only to this level requires far less time than a more robust sample preparation. A protocol to determine the appropriate level of sample preparation is the following:

1. Delineate a region of soil approximately 4" x 4".
2. Perform several in-situ tests in this area, or collect the top (approximately) quarter inch of soil from this region, bag the soil, test through the bag. In either case, average the results.
3. If you did not bag the in-situ test sample, collect the top (approximately) quarter inch of soil from this region and sieve through the 2 mm sieve provided. Otherwise sieve the bagged sample used for the in-situ test. Thoroughly mix the sieved sample, and place some of the sieved material into an XRF cup, and perform a test of this sample.
4. If the results of this prepared sample differ less than 20% with the average in-situ result, this indicates the soil in this region is reasonably homogeneous. The data quality in this case is probably at the semi-quantitative level, rather than just screening data.
5. If the results differ by more than 20%, this indicates the soil is not very homogeneous, and there are serious particle size effects affecting your in-situ measurements.
6. In this case, sieve the sample through the 250 ~m sieve. Mix this sample and place a sub-sample into an XRF cup for testing. If this result differs from the previous by less than 20% then this indicates that at a minimum the 2mm sieving is necessary to achieve higher data quality.

7. If this result differs by more than 20% from the sample sieved through 2 mm, then particle size effects are still affecting the XRF result. In this case samples should be sieved through 125 µm to assure data quality at the quantitative level.

Section 4: Calibration for Innov-X Portable XRF

The Innov-X analyzer may run three different calibration methods, described below. In nearly all cases, customers use the Compton Normalization method. This method (recognized in EPA 6200) offers speed, ease of use, and generally good accuracy for concentration ranges from the ppm level up to 2-3% concentrations. As most field-testing is seeking to remediate or locate environmental contaminants, the upper limit of the calibration (2-3%) is generally not a limitation. If customers do require a calibration up to 100% concentration (i.e. a pure element) then Innov-X recommends they also include the Fundamental Parameters (FP) software module with the analyzer. The FP module may be added at time of purchase or as an upgrade at any later date.

Note: In general customers do not need to calibrate the Innov-X analyzer for soil testing. The analyzer is delivered with a factory calibration, generally based upon the Compton Normalization (CN) method. The CN method has been proven over the past several years to provide a robust calibration generally independent of site-specific soil matrix chemistry. The operator may calibrate the Innov-X system if desired, but calibration is not required to use the analyzer effectively. All customers should follow the QC procedure described in Section 3, which includes a check of the calibration.

The final model is the empirical calibration. In this case, customers run standards to generate calibration curves for various elements in specific soil matrices. Provided the sample is well-prepared, the empirical method generally yields the most accurate result. In our experience, the accuracy gains going from Compton Normalization to Empirical Mode are small and not worth the extra effort in setting up calibration curves. (The greatest source of error for in-field XRF analysis of soil is lack of adequate sample preparation, thus there is little gained in developing a sophisticated empirical calibration if the operator does to grind and homogenize the all measured samples). The empirical calibration module is an optional software package, available for an upgrade fee at the time of purchase, or as an upgrade at any later date.

Calibration Requirements:

The concentration of an element in a soil sample is well-described by the formula:

$$w_i = \frac{k_i}{M(Z,i)} I_i$$

k_i = calibration constant for element "i"

ω_i = concentration of element "i" – the quantity being measured.

I_i = measured x-ray intensity from element "i"

M(Z,I) = Soil matrix value

The factory calibration determines the value of the calibration constants k_i for each element, and a typical value M(Z,I). The calibration method – either CN, fundamental parameters, or empirical – performs the necessary corrections to the value M(Z,I) that are important for the site-specific soil chemistry. The XRF analyzer uses the measured intensity of each element’s fluorescence from the sample, and the calibration data, to produce elemental concentrations.

Compton Normalization:

The Compton Normalization method calibration consists of the analysis of a single, well-characterized standard, such as an SRM or SSCS. The standard data are normalized to the Compton peak. The Compton peak is produced from incoherent backscattering of X-ray radiation from the excitation source and is present in the spectrum of every sample. The matrix affects the way in which source radiation is scattered off the samples. This scatter is directly related to the intensity of the Compton peak. For that reason, normalizing to the Compton peak can reduce problems with matrix effects that vary among samples. Compton normalization is similar to the use of internal standards in analysis for organic analytes.

Fundamental Parameters Calibration:

The fundamental parameters (FP) calibration is a "standardless" calibration. Rather than establishing a unit's calibration curve by measuring its response to standards that contain analytes of known concentrations, FP calibration relies on the known physics of the spectrometer's response to pure elements to set the calibration. Built-in mathematical algorithms are used to adjust the calibration for analysis of soil samples and to compensate for the effects of the soil matrix. The FP calibration is performed by the manufacturer, but the analyst can adjust the calibration curves (slope and y-intercept) on the bases of results of analyses of check samples, such as SRMs which are analyzed in the field.

Empirical Calibration:

The empirical calibration method requires that a number of site-specific calibration standards (SSCS) are used to establish calibration parameters. The instrument response to known analytes is measured and used to create calibration curves. Empirical calibration is effective because the samples used closely match the sample matrix. SSCSs are well-prepared samples collected from the site of interest in which the concentrations of analytes have been determined by inductively coupled plasma (ICP), atomic absorption (AA), or other methods approved by the US Environmental Protection Agency (EPA). The standards should contain all the analytes of interest and interfering analytes. Manufacturers recommend that 10 to 20 calibration samples be used to generate a calibration curve. The empirical method is the least desirable calibration method as it requires that new standards and curves are generated for each site that is analyzed.

Section 5: Effects of Moisture on XRF Results:

Sample moisture has two effects on XRF results:

- It alters the soil chemistry, since water is another chemical compound that comprises the soil matrix.
- Moisture impedes the ability to properly prepare samples.

- Laboratory results are provided on a “dry weight” basis.

Effect on Soil Chemistry:

While the presence of significant moisture does impact the soil chemistry, modern XRF analyzers all perform automatic corrections for variations in soil chemistry from site to site. Indeed, such variations are expected, and that is the reason analyzers use Compton Normalization or fundamental parameters, in order to correct for moisture content changes as well as other differences in soil geochemistry.

EPA Method 6200 states “Moisture content above 20 percent may cause problems, since moisture alters the soil matrix for which the FPXRF has been calibrated.” However, the Compton Normalization or fundamental parameters methods are implemented in order to automatically correct results for changes to the soil matrix. Thus, we believe that soil moisture is not a significant effect on accuracy due to effects of soil matrix, except for the “dilution” effect that can cause discrepancies with laboratory results which is described below.

Sample preparation issues:

The inability to adequately prepare a wet sample is, we believe, the single biggest contributor to errors when testing wet samples. It is very difficult to grind or sieve a wet sample. The highest quality XRF results are generally obtained from prepared samples. If the operator is unwilling to dry the sample to prepare it, comparisons to the laboratory may yield poorer correlation since the samples are not homogeneous.

Laboratory Tests on Dry-Weigh Basis:

Laboratories always dry samples prior to analysis. They report percent weight content based upon a dry sample basis. Portable XRF may often be used to analyze wet samples in the field, and results are thus reported that include the moisture content. Thus, with all other factors the same, the laboratory will report results higher than portable XRF. The results will be higher by the amount of moisture content in the sample. For example laboratory results will be 10% higher compared to XRF results, if the sample contained 10% by weight water when it was tested with XRF. Recall, this applies to samples where other possible sources of error are the same or negligible.

Section 6: Comparing XRF Results to Laboratory Results:

Innov-X strongly recommends that operators compare prepared sample results to laboratory results. This is because prepared-sample results yield the best possible accuracy with portable XRF. Moreover, the most common source of error is due to non-uniform samples. The XRF technique, nor can any analytical technique, properly account for non-uniform sample types.

To perform a comparison between XRF results and laboratory:

1. Collect a sample and prepare it according to the sample preparation guide in Appendix 1.

2. Take a sub-sample (5-10 grams) of the fully-prepared sample, place it into an XRF cup and perform at least a one-minute test on that sample.

3. Send the same sample to the laboratory for wet chemistry analysis.

4. Require the laboratory to use a total-digestion method. If the laboratory does not use a total digestion method, they may not extract all of the elemental metal from the sample. In this case, the lab result will be lower than the XRF result. Incomplete sample digestion is one of the most commons sources of laboratory error, thus it is very important to request a total digestion method.

Example of Error: The operator collects a bag of sample, performs XRF analysis on one part of the bag, and sends the bag, or part of the bag of sample to a laboratory for analysis. The laboratory reports a very different value than the operator obtained with the XRF.

Problem: Since the sample is very non-homogeneous, the operator did not obtain a result that was representative of the entire bag of sample. The lab analyzed a different part of the sample and obtained a very different result due to the non-uniformity of the sample. The solution to this problem is, at a minimum, to test several locations in the bag of sample and report the average value. Also note the differences between the tests, as this is indicative of the non-uniformity of the sample. Operator should send entire bag of sample to the lab, and instruct lab to prepare the sample before removing sub-sample for lab analysis.

Best Practice: The operator should homogenize and prepare the entire bag of sample, and then collect a sub sample for XRF testing. After testing, the same sample should be sent to the lab.

Section 7: Common Interferences:

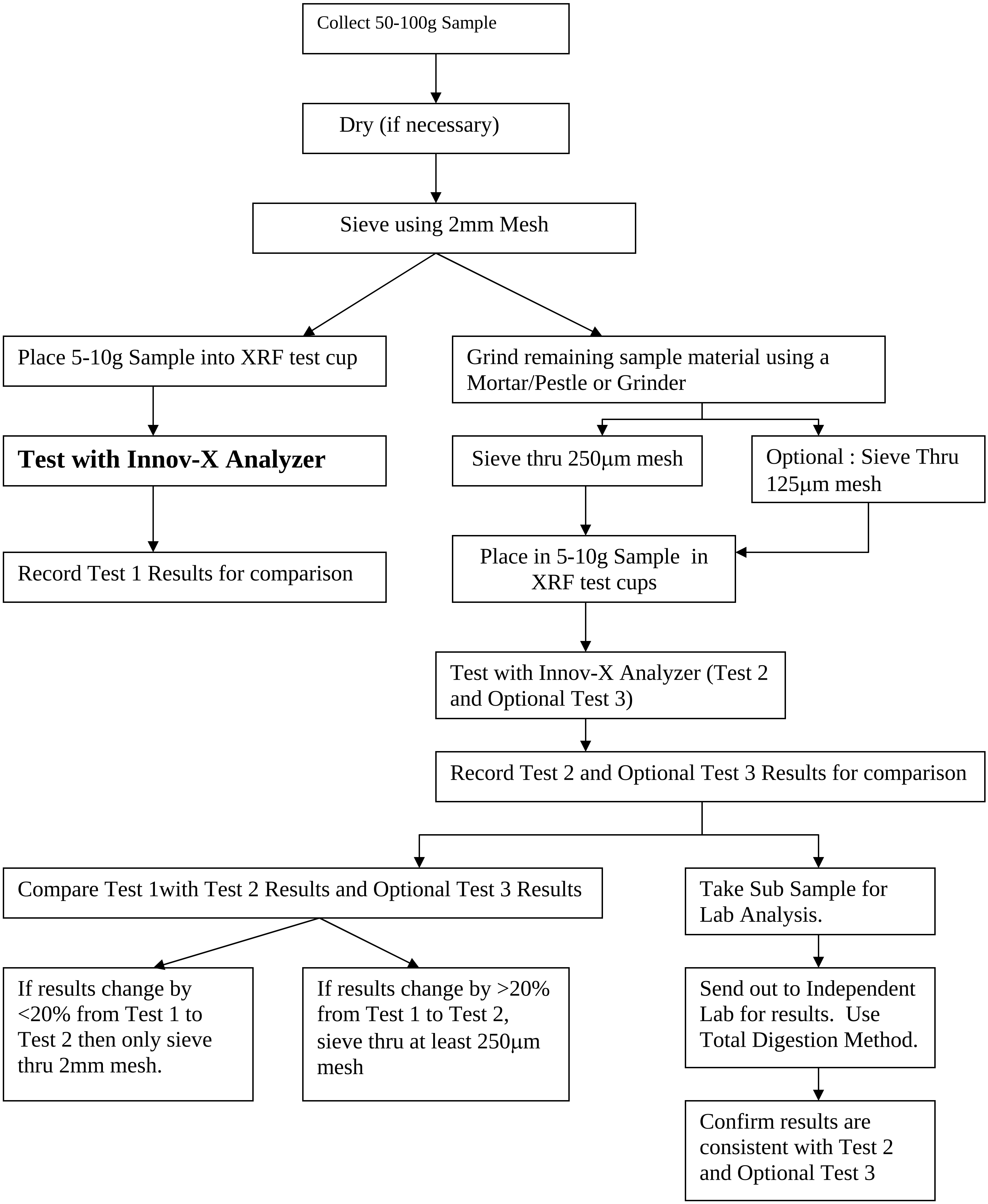
An interference occurs when the spectral peak from one element overlaps either partially or completely with the spectral peak of another. If the XRF is calibrated for both elements (CASE 1) i.e. the one causing the interference and the one being interfered with, it is generally capable of correctly handling the interference. In this case, the element being interfered with may be measured with a poorer detection limit or poorer precision, but the analytical results should still be acceptable for field-portable XRF. If the XRF is not calibrated for the element causing the interference (CASE 2), then the XRF may report the presence of elements not in the sample, or greatly elevated concentrations of elements in or not in the sample.

Example CASE 1: Lead and arsenic. Most XRFs are calibrated for lead and arsenic. Lead interferes with arsenic (not vice-versa though). The net effect is a worsened detection limit for arsenic, and poorer precision. The XRF handles the correction automatically, but the precision is affected. The loss of precision is also reported by the XRF. (Please refer to Innov-X Applications Sheet: *In-field Analysis of Lead and Arsenic in Soil Using Portable XRF* for more detail).

Example CASE 2: Bromine in the sample, but XRF is not calibrated for bromine. Bromine, as a fire retardant, is being seen more and more in soil and other sample types. For this reason, Innov-X analyzers include Br in the calibration data. If Br is not calibrated, but is present in the sample, the analyzer will report highly elevated levels of Pb, Hg and As. The levels will depend upon the concentration of Br in the sample.

Interferences between elements can be broadly categorized into a) Z, Z-1, Z+1 interferences, and b) K/L interferences. Interference type “a” occurs when high levels of an element of atomic number Z are present. This can cause elevated levels of elements with atomic number Z-1 or Z+1. Generally, portable XRFs have good correction methods, so this interference only causes problems with very high levels of the element in question. Example: High concentrations of Fe (Z=26) in excess of 10% may cause elevated levels of Mn or Co (Z=25 or Z=27 respectively).

The type “b” interference occurs when the L-shell line of one element overlaps with the K-shell spectral line of another element. The most common example is the lead/arsenic interference where the L-alpha line of lead is in nearly the exact same location as the K-alpha line of arsenic.



Collect 50-100g Sample
Dry (if necessary)
Sieve using 2mm Mesh
Place 5-10g Sample into XRF test cup
Grind remaining sample material using a Mortar/Pestle or Grinder
Test with Innov-X Analyzer
Sieve thru 250µm mesh
Optional : Sieve Thru 125µm mesh
Record Test 1 Results for comparison
Place in 5-10g Sample in XRF test cups
Test with Innov-X Analyzer (Test 2 and Optional Test 3)
Record Test 2 and Optional Test 3 Results for comparison
Compare Test 1with Test 2 Results and Optional Test 3 Results
Take Sub Sample for Lab Analysis.
If results change by <20% from Test 1 to Test 2 then only sieve thru 2mm mesh.
If results change by >20% from Test 1 to Test 2, sieve thru at least 250µm mesh
Send out to Independent Lab for results. Use Total Digestion Method.
Confirm results are consistent with Test 2 and Optional Test 3

Appendix 3: Guide to Product Registration

Generally, the Innov-X portable XRF system must be registered in the state of usage.   Registration requirements are somewhat state dependent, but there are many similarities.   You may contact Innov-X at 866-4-Innov-X (781-938-5005) to receive specific registration information. Innov-X also maintains sample registrations for every state that we can forward to you.

Common Registration Features:

Most states require the following for registering an x-ray emitting device that does NOT use radioactive sources:

1. Registration within 30 days of receipt of the analyzer.
2. Annual fee ranging from $25 to $100, depending upon the state.
3. Basic registration form with main information described below.

Common information required on Registration Form, and responses:

Company name, address, phone/fax numbers.

Name of responsible person:	Generally the person designated as the Radiation Safety Officer (RSO).
Name of the manufacturer:	Innov-X Systems, Inc., Woburn, MA
Model of Analyzer:	Alpha XXXX
Tube Operating Parameters:	40 kV, 20 uA current.
Type of Analysis:	Choose Analytical or Industrial
	(as opposed to radiography, medical, dental, veterinarian, etc.)
Utilization Mode:	Portable or Mobile assuming you will carry system to different locations.
	Fixed or stationary ONLY if you will always use the analyzer in the docking station

General Appendix 1

Technical Specifications

Description:

Innov-X Systems analyzers are hand-held, battery operated energy dispersive x-ray fluorescence analyzers. They are utilized for the detection and quantification of elements ranging from phosphorus (atomic number 15) though uranium (atomic number 92). Measurable concentrations of elements range from ppm to 100%.

Weight:	2.625 lbs (Base wt.) 3.375 lbs (1.6 kg) with batteries
Excitation Source:	X-ray tube, Ag or W anode, 10-40 kV, 5-50 uA, 5 filter positions
Detector:	Si PiN diode, thermoelectrically cooled, resolution < 280 eV.
Power:	Li-ion batteries, or AC power with Testing Stand
Battery Life:	4-8 hours, depending on duty cycle.
Display:	Color, high-resolution touch screen with variable backlighting on analyzer. Software available for PC/laptop operation also.
Data Storage:	10,000 tests with spectra minimum, expandable to 100,000+ with 1 Gb flash card.
Computer:	HP iPAQ with Intel processor, 64 Mb minimum memory, Windows CE operating system (unless operated from PC).
Optional Accessories:	Bluetooth wireless printing and data transfer, integrated bar-code reader, wireless LAN, other standard PDA accessories.

Operating Conditions

Temp 0 – 40° C
Humidity 10 – 90 % RH, no condensation
Altitude rating 2000 meters

Innov-X Analyzer Limited Warranty

General Terms

EXCEPT AS EXPRESSLY SET FORTH IN THIS LIMITED WARRANTY, INNOVX SYSTEMS, INC. (INNOV-X) MAKES NO OTHER WARRANTIES OR CONDITIONS, EXPRESSED OR IMPLIED, INCLUDING ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. INNOV-X EXPRESSLY DISCLAIMS ALL WARRANTIES AND CONDITIONS NOT STATED IN THIS LIMITED WARRANTY. ANY IMPLIED WARRANTIES THAT MAY BE IMPOSED BY LAW ARE LIMITED IN DURATION TO THE LIMITED WARRANTY PERIOD.

This Limited Warranty applies to Innov-X analyzers sold or leased from Innov-X its affiliates, authorized resellers, or country distributors (collectively referred to in this Limited Warranty as (“Innov-X”)).

Innov-X warrants that the analyzer and all its internal components that you have purchased are free from defects in materials or workmanship under normal use during the Limited Warranty Period. The Limited Warranty Period starts on the date of shipment by Innov-X. You may be required to provide proof of purchase or lease as a condition of receiving warranty service. You are entitled to warranty service according to the terms and conditions of this document if a repair to your Innov-X analyzer is required within the Limited Warranty Period.

During the Limited Warranty Period, Innov-X will repair or replace the defective component parts. All component parts removed under this Limited Warranty become the property of Innov-X. In the unlikely event that your Innov-X analyzer has a recurring failure, Innov-X, at its discretion, may elect to provide you with a replacement unit of Innov-X’s choosing that is at least equivalent to your Innov-X analyzer. This is your exclusive remedy for defective products. The repaired or replacement analyzer is warranted for the remainder of the limited Warranty Period.

YOU SHOULD MAKE PERIODIC BACKUP COPIES OF THE DATA STORED ON YOUR ANALYZER AS A PRECAUTION AGAINST POSSIBLE FAILURES, ALTERATION, OR LOSS OF THE DATA. BEFORE RETURNING ANY UNIT FOR SERVICE, BE SURE TO BACK UP DATA AND REMOVE ANY CONFIDENTIAL, PROPRIETARY, OR PERSONAL INFORMATION. INNOV-X IS NOT RESPONSIBLE FOR DAMAGE TO OR LOSS OF ANY PROGRAMS, OR DATA. INNOV-X IS NOT RESPONSIBLE FOR THE RESTORATION OR REINSTALLATION OF ANY PROGRAMS OR DATA OTHER THAN SOFTWARE INSTALLED BY INNOV-X WHEN THE ANALYZER IS MANUFACTURED. Innov-X does not warrant that the operation of this analyzer will be uninterrupted or error-free. Innov-X is not responsible for damage that occurs as a result of your failure to follow the instructions that came with the Innov-X analyzer.

This Limited Warranty does not apply to expendable parts. This Limited Warranty does not extend to any analyzer from which the serial number has been removed or that has been damaged or rendered defective (A) as a result of accident, misuse, abuse, or other external causes; (b) by operation outside the usage parameters stated in user documentation that shipped with the product; (c) by modification or service by anyone other than (i) Innov-X, or(ii) a Innov-X authorized service provider, (d) installation of software not approved by Innov-X.

These terms and conditions constitute the complete and exclusive warranty agreement between you and Innov-X regarding the Innov-X analyzer you have purchased or leased. These terms and conditions supersede any prior agreements or representations --- including representations made in Innov-X sales literature or advice given to you by Innov-X or any agent or employee of Innov-X --- that may have been made in connection with your purchase or lease of the Innov-X analyzer. No change to the conditions of this Limited Warranty is valid unless it is made in writing and signed by an authorized representative of Innov-X.

Limitation of Liability

IF YOUR INNOV-X ANALYZER FAILS TO WORK AS WARRANTED ABOVE, YOUR SOLE AND EXCLUSIVE REMEDY SHALL BE REPAIR OR REPLACEMENT. INNOV-X’S MAXIMUM LIABILITY UNDER THIS LIMITED WARRANTY IS EXPRESSLY LIMITED TO THE LESSER OF THE PRICE YOU HAVE PAID FOR THE ANALYZER OR THE COST OF REPAIR OR REPLACEMENT OF ANY COMPONENTS THAT MALFUNCTION IN CONDITION OF NORMAL USE.

INNOV-X IS NOT LIABLE FOR ANY DAMAGE CAUSED BY THE PRODUCT OR THE FAILURE OF THE PRODUCT TO PERFORM INCLUDING ANY LOST PROFITS OR SAVINGS OR SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES. INNOV-X IS NOT LIABLE FOR ANY CLAIM MADE BY A THIRD PARTY OR MADE BY YOU FOR A THIRD PARTY.

THIS LIMITATION OF LIABILITY APPLIES WHETHER DAMAGE ARE SOUGHT, OR A CLAIM MADE, UNDER THIS LIMITED WARRATNY OR AS A TORT CLAIM (INCLUDING NEGLIGENCE AND STRICT PRODUCT LIABILITY), A CONTRACT CLAIM, OR ANY OTHER CLAIM. THIS LIMITATION OF LIABILITY CANNOT BE WAIVED OR AMENDED BY ANY PERSON. THIS LIMITATION OF LIABILITY WILL BE EFFECTIVE EVEN IF YOU HAVE ADVISED INNOV-X OR AN AUTHORIZED REPRESENTATIVE OF INNOV-X OF THE POSSIBILITY OF ANY SUCH DAMAGES.

Software

This Limited Warranty does not warrant software products. The Innov-X software installed on your analyzer is covered by the Innov-X Software License.

Warranty Period

The warranty period for a Model XT-245 or Model XT-260 Innov-X analyzer is two years or four thousand hours of use, whichever occurs first. The warranty for all other analyzers is one year or two thousands hours of use whichever occurs first. This warranty does not extend to expendable parts. Extended warranties are available from Innov-X.

Warranty Returns

A Return Material Authorization (RMA) Number must be obtained from the INNOV-X Service Department before any items can be shipped to the factory. Returned goods will not be accepted without an RMA Number. Customer will bear all shipping charges for warranty repairs. All goods returned to the factory for warranty repair should be properly packed to avoid damage and clearly marked with the RMA Number.

Warranty Repairs

Warranty repairs will be done either at the customer's site or at the INNOV-X plant, at our option. All service rendered by INNOV-X will be performed in a professional manner by qualified personnel.

Contacting Innov-X

Be sure to have the following information available before you call Innov-X:

. • Analyzer serial number, model name, and model number
. • Applicable error messages
. • Description of problem
. • Detailed questions

Methods of Contact

. • Phone: 781-938-5005
. • Fax 781-938-0128
. • Email technicalsupport@Innov-Xsys.com
• Mail & Shipping Address:
Innov-X Systems, Inc. 100 Sylvan Rd, Suite 100. Woburn MA 01801

[redacted]

WEARING LATEX GLOVES...

1

...TO PREVENT CONTAMINATING THE KIT...

OPEN THE EL100 PACK...

2

PULL SAMPLE SWAB OUT OF KIT BODY...

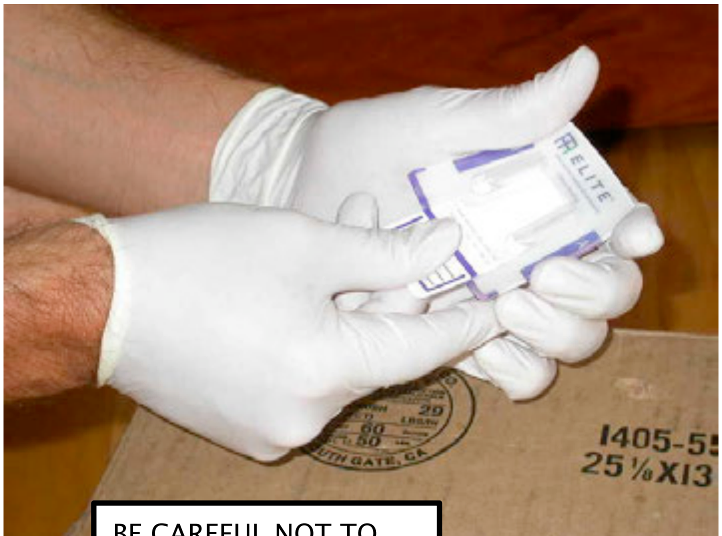
3

RUB SWAB ON SAMPLE SURFACE...

LABEL-SIDE DOWN...

4

INSERT SWAB BACK INTO KIT BODY...



BE CAREFUL NOT TO TOUCH THE SWAB SAMPLE AREA...

5

WITH KIT HORIZONTAL...

CRACK AMPOULE A WITH ONE PUSH OF THUMB...PUSH ONLY ONCE...

6

WAIT ABOUT 20 SECONDS FOR COLOR TO APPEAR...

IF COLOR, STOP & INVESTIGATE...REFER TO COLOR

7

IF NO COLOR OR SLIGHT COLOR...

SLIDE KIT INTO HEATER...

8

SWITCH ON HEATER, KEEP ON FOR 30 SECONDS...

IF COLOR APPEARS DURING HEATING, STOP & INVESTIGATE...

9

IF NO COLOR OR SLIGHT COLOR...

REMOVE FROM HEAT AND CRACK AMPOULE B WITH ONE PUSH OF THUMB...

10

WAIT ABOUT 20 SECONDS FOR COLOR TO APPEAR...

IF COLOR, STOP & INVESTIGATE...

11

IF NO COLOR OR SLIGHT COLOR...

PULL C STRIP AND PLACE STICKY-SIDE DOWN ON SAMPLE SWAB...

12

PRESS TAPE STRIP DOWN ONTO SWAB...

WAIT ABOUT 30 SECONDS FOR COLOR TO APPEAR...

13

IF COLOR STOP & INVESTIGATE...

COLOR INDICATES THE PRESENCE OF NITRATES...

14

IF NITRATES ARE PRESENT THEN COLOR WILL CONTINUE TO INTENSIFY OVER SEVERAL MINUTES...

15

NOTES:

ANY COLOR THAT APPEARS AFTER STEP A AND THROUGH B AND C INDICATES THE PRESENCE OF TARGET (NITROAROMATICS IN A, ALIPHATICS IN B, AND IN STEP C NITRATES)

THE AMOUNT OF COLOR, OR COLOR SATURATION, IS ROUGHLY PROPORTIONAL TO THE AMOUNT OF EXPLOSIVES PRESENT FOR A GIVEN TYPE OF EXPLOSIVE.

THE COLOR CHART DOES NOT LIST ALL THE EXPLOSIVES TO WHICH THE EL100 WILL REACT.

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MODEL EL100 E.L.I.T.E.

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SAP ATTACHMENT 3

CHAIN OF CUSTODY

Attachment 3: Example Chain of Custody

CHAIN OF CUSTODY									
Facility Name: Project No:			Analyses Required / Preservative					Ship to:	
Return Report to: Sampler(s): ______________________________ (Print and Sign)			/	/	/	/	/		
Sample ID: Facility-Location-Type-Number	Grab/Composite	Matrix	No. of containers submitted					Preservative	Remarks:
	G C							Y NA	
	G C							Y NA	
	G C							Y NA	
	G C							Y NA	
	G C							Y NA	
	G C							Y NA	
	G C							Y NA	
	G C							Y NA	
	G C							Y NA	
	G C							Y NA	
Relinquished by: Date/Time: Relinquished by: Date/Time:			Received for Lab by: Date/time: Received for Lab by: Date/time:						Remarks: Airbill No.:
Lab use only: **Temp. on receipt:___________** **Ice present: Yes_______ No_______** **Custody seals: Intact______ Broken_______ NA_______** **Preservation confirmed Yes______ No _______** ***(see remarks)***			Remarks:					Laboratory Project ID: Checked by:	

PART II:

QUALITY ASSURANCE PROJECT PLAN

Culebra Island Site, Puerto Rico

Contract No. W912DY-04-D-0006
Delivery Order No. 0022

February 2011

QAPP_Worksheet_#1
(UFP-QAPP Section 2.1)
Title and Approval Page

Site Name/Project Name: Culebra Island Site
Site Location: Puerto Rico

Document Title: Quality Assurance Project Plan for the Remedial Investigation at the Culebra Island Site, Puerto Rico

Lead Organization: Unites States Army Engineering and Support Center, Huntsville

Preparer's Name and Organizational Affiliation: David Synakorn, USA Environmental, Incorporated

Preparer's Address, Telephone Number, and E-mail Address: 720 Brooker Creek Boulevard, Suite 204, Oldsmar, Florida, Tel: (813) 997-1612, Email: dsynakorn@usatampa.com

Preparation Date (Day/Month/Year): 28/09/2009

Investigative Organization's Project Manager/Date:______________________________
Signature
Printed Name/Organization: Matthew Tucker/USA Environmental, Inc.

Investigative Organization's Project QA Officer/Date:____________________________
Signature
Printed Name/Organization: Robert Crownover/USA Environmental, Inc.

Lead Organization's Project Manager/Date:____________________________________
Signature
Printed Name/Organization: Spencer O'Neal, USAESCH

Approval Signatures/Date: ____
Signature
Printed Name/Title: Teresa Carpenter/Technical Manager

Approval Authority: USAESCH

Other Approval Signatures/Date: ____
Signature
Printed Name/Title:

Document_Control_Numbering_System : ________________________

QAPP Worksheet #2
(UFP-QAPP Section 2.2.4)
QAPP Identifying Information

Site Name/Project Name: Culebra Island Site
Site Location: Puerto Rico
Site Number/Code: I02PR0068
Operable Unit: Not Applicable
Contractor Name: USA Environmental, Inc.
Contractor Number: W912DY-04-D-0006

Title: QAPP for the RI at Culebra
Revision Number: 0
Revision Date: 28 Sep 2009
Page 3 of 64

Contract Title: Munitions Response Services/Other Munitions Response Services
Work Assignment Number: 0022

1. Identify regulatory program: Comprehensive Environmental Response Compensation and Liability Act (CERCLA)

2. Identify approval entity: ~~USACE Jacksonville District~~

3. The QAPP is (select one): ☐Generic ☒Project Specific

4. List dates of scoping sessions that were held: September 15, 2009

5. List dates and titles of QAPP documents written for previous site work, if applicable:
Title
Approval Date

MC Sampling and Analysis Plan for NTCRA at the Municipality of Culebra, Puerto Rico	January 2006

6. List organizational partners (stakeholders) and connection with lead organization:
US Fish and Wildlife Service (FWS) and Puerto Rico Environmental Quality Board (PREQB)
US Environmental Protection Agency (US EPA)

7. List data users:
US Army Engineering and Support Center, Huntsville and USACE Jacksonville District

8. If any required QAPP elements and required information are not applicable to the project, then circle the omitted QAPP elements and required information on the attached table. Provide an explanation for their exclusions below:

WS # 18 is excluded because the sampling program will be based on the result of the MEC data collection and other requirements are identified in the FSP
WS#20is excluded because the smapling program will be based on the result of the MEC data collection and other requirements are identified in the FSP
WS#21is excluded because the field sampling procedures are provided in Section E.1.5 of the FSP

QAPP Worksheet #2
QAPP Identifying Information
(continued)

Identify where each required QAPP element is located in the QAPP (provide section, worksheet, table, or figure number) or other project planning documents (provide complete document title, date, section number, page numbers, and location of the information in the document). Type "NA" for the QAPP elements that are not applicable to the project. Provide an explanation in the QAPP.

Required QAPP Element(s) and Corresponding QAPP Section(s)	**Required Information**	**Crosswalk to Related Documents**
Project Management and Objectives		
2.1 Title and Approval Page	- Title and Approval Page	WS#1
2.2 Document Format and Table of Contents 2.2.1 Document Control Format 2.2.2 Document Control Numbering System 2.2.3 Table of Contents 2.2.4 QAPP Identifying Information	- Table of Contents - QAPP Identifying Information	WS#1, WS#2
Distribution List and Project Personnel Sign-Off Sheet 2.3.1 Distribution List 2.3.2 Project Personnel Sign-Off Sheet	- Distribution List - Project Personnel Sign-Off Sheet	WS#3, WS#4
2.4 Project Organization 2.4.1 Project Organizational Chart 2.4.2 Communication Pathways 2.4.3 Personnel Responsibilities and Qualifications 2.4.4 Special Training Requirements and Certification	- Project Organizational Chart - Communication Pathways - Personnel Responsibilities and Qualifications Table - Special Personnel Training Requirements Table	WS#5, WS#6, WS#7, WS#8
2.5 Project Planning/Problem Definition 2.5.1 Project Planning (Scoping) 2.5.2 Problem Definition, Site History, and Background	- Project Planning Session Documentation (including Data Needs tables) - Project Scoping Session Participants Sheet - Problem Definition, Site History, and Background - Site Maps (historical and present)	WS #9, WS #10
Project Quality Objectives and Measurement Performance Criteria Development of Project Quality Objectives Using the Systematic Planning Process 2.6.2 Measurement Performance Criteria	- Site-Specific PQOs - Measurement Performance Criteria Table	WS #11, WS #12,

QAPP Worksheet #2
QAPP Identifying Information
(continued)

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Documents
2.7 Secondary Data Evaluation	- Sources of Secondary Data and Information - Secondary Data Criteria and Limitations Table	WS #13
2.8 Project Overview and Schedule 2.8.1 Project Overview 2.8.2 Project Schedule	- Summary of Project Tasks - Reference Limits and Evaluation Table - Project Schedule/Timeline Table	WS #14, WS #15, WS #16
Measurement/Data Acquisition		
3.1 Sampling Tasks 3.1.1 Sampling Process Design and Rationale 3.1.2 Sampling Procedures and Requirements 3.1.2.1 Sampling Collection Procedures 3.1.2.2 Sample Containers, Volume, and Preservation 3.1.2.3 Equipment/Sample Containers Cleaning and Decontamination Procedures Field Equipment Calibration, Maintenance, Testing, and Inspection Procedures Supply Inspection and Acceptance Procedures 3.1.2.6 Field Documentation Procedures	- Sampling Design and Rationale - Sample Location Map - Sampling Locations and Methods/SOP Requirements Table - Analytical Methods/SOP Requirements Table - Field Quality Control Sample Summary Table - Sampling SOPs - Project Sampling SOP References Table - Field Equipment Calibration, Maintenance, Testing, and Inspection Table	WS #17, WS #18, WS #19, WS #20, WS #21, WS #22
3.2 Analytical Tasks 3.2.1 Analytical SOPs 3.2.2 Analytical Instrument Calibration Procedures 3.2.3 Analytical Instrument and Equipment Maintenance, Testing, and Inspection Procedures 3.2.4 Analytical Supply Inspection and Acceptance Procedures	- Analytical SOPs - Analytical SOP References Table - Analytical Instrument Calibration Table - Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	WS #23, WS #24, WS #25

QAPP Worksheet #2
QAPP Identifying Information
(continued)

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Required Documents
Sample Collection Documentation, Handling, Tracking, and Custody Procedures 3.3.1 Sample Collection Documentation 3.3.2 Sample Handling and Tracking System 3.3.3 Sample Custody	- Sample Collection Documentation Handling, Tracking, and Custody SOPs - Sample Container Identification - Sample Handling Flow Diagram - Example Chain-of-Custody Form and Seal	WS #26, WS #27
3.4 Quality Control Samples 3.4.1 Sampling Quality Control Samples 3.4.2 Analytical Quality Control Samples	- QC Samples Table - Screening/Confirmatory Analysis Decision Tree	WS #28
3.5 Data Management Tasks 3.5.1 Project Documentation and Records 3.5.2 Data Package Deliverables 3.5.3 Data Reporting Formats 3.5.4 Data Handling and Management 3.5.5 Data Tracking and Control	- Project Documents and Records Table - Analytical Services Table - Data Management SOPs	WS #29, WS #30
Assessment/Oversight		
4.1 Assessments and Response Actions 4.1.1 Planned Assessments Assessment Findings and Corrective Action Responses	- Assessments and Response Actions - Planned Project Assessments Table - Audit Checklists - Assessment Findings and Corrective Action Responses Table	WS #31, WS #32
4.2 QA Management Reports	- QA Management Reports Table	WS #33,
4.3 Final Project Report		

QAPP Worksheet #2
QAPP Identifying Information
(continued)

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Documents
Data Review		
5.1 Overview		
5.2 Data Review Steps 5.2.1 Step I: Verification 5.2.2 Step II: Validation 5.2.2.1 Step IIa Validation Activities 5.2.2.2 Step IIb Validation Activities 5.2.3 Step III: Usability Assessment 5.2.3.1 Data Limitations and Actions from Usability Assessment 5.2.3.2 Activities	- Verification (Step I) Process Table - Validation (Steps IIa and IIb) Process Table - Validation (Steps IIa and IIb) Summary Table - Usability Assessment	WS #34, WS #35, WS #36, WS #37
5.3 Streamlining Data Review 5.3.1 Data Review Steps To Be Streamlined 5.3.2 Criteria for Streamlining Data Review 5.3.3 Amounts and Types of Data Appropriate for Streamlining		

QAPP_Worksheet_#3
(UFP-QAPP Manual Section 2.3.1)
List those entities to whom copies of the approved QAPP, subsequent QAPP revisions, addenda, and amendments will be sent.

☐ Worksheet Not Applicable (State Reason)

Distribution List

QAPP Recipients	Title	Organization	Telephone Number	Fax Number	E-mail Address	Document Control Number
Spencer O'Neal	Project Manager	US Army Engineering & Support Center				
Teresa Carpenter	Technical Manager	US Army Engineering & Support Center				
Charles O'Bryan	Quality Assurance Manager	RTI Laboratories				
Stella Cuenco	Data Validator	Laboratory Data Consultants				
Doug Ralston	Program Manager	USA Environmental, Inc	813-343-6368	813-343-6369	draslton@usatampa.com	
Matthew Tucker	Project Manager	USA Environmental, Inc.	813-343-6370	813-343-6371	mtucker@usatampa.com	
Al Crandall	Geophysicist	USA Environmental, Inc	813-343-6362	813-343-6363	acrandall@usatampa.com	

QAPP_Worksheet_#4

(UFP-QAPP Manual Section 2.3.2)

Have copies of this form signed by key project personnel from each organization to indicate that they have read the applicable sections of the QAPP and will perform the tasks as described. Ask each organization to forward signed sheets to the central project file.

☐ Worksheet Not Applicable (State Reason)

Project Personnel Sign-Off Sheet

Organization: USA Environmental

Project Personnel	Title	Telephone Number	Signature	Date QAPP Read
Matthew Tucker	Project Manager	813-343-6370		
Robert Crownover	Quality Manager	813-343-6364		
Cheryl Nichols	Project Engineer	813-343-6433		
Dan Miller	Site Project Manager/SUXOS	813-695-4389		
Al Crandall	Project Geophysicist	813-343-6362		
Jeff Lewis	GIS Manager	813-343-6376		

Project Personnel Sign-Off Sheet

Organization: TestAmerica Laboratories

Project Personnel	Title	Telephone Number	Signature	Date QAPP Read
Charles O'Bryan	Quality Assurance Manager	734-422-8000		
Elaine Walker	Project Manager	303-736-0156		
Debra Henderer	Customer Service Manager	303-736-0134		

Project Personnel Sign-Off Sheet

Organization: Laboratory Data Consultants

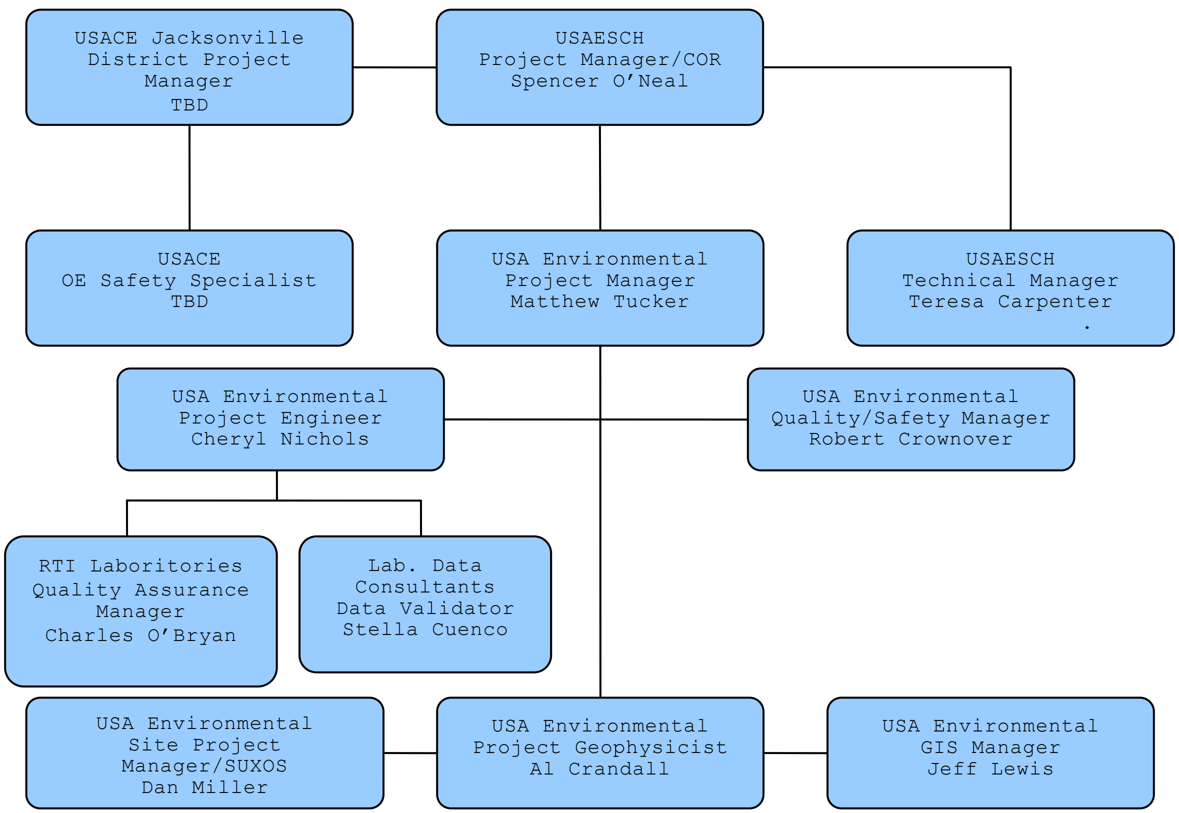
Project Personnel	Title	Telephone Number	Signature	Date QAPP Read
Stella Cuenco	Data Validator	760-634-0437	Stella Cuenco	9/30/09

QAPP Worksheet #5

(UFP-QAPP Manual Section 2.4.1)

Identify reporting relationships between all organizations involved in the project, including the lead organization and all contractor and subcontractor organizations. Identify the organizations providing field sampling, on-site and off-site analysis, and data review services, including the names and telephone numbers of all project managers, project team members, and/or project contacts for each organization.

☐ Worksheet Not Applicable (State Reason)



QAPP_Worksheet_#6
(UFP-QAPP Manual Section 2.4.2)

Describe the communication pathways and modes of communication that will be used during the project, after the QAPP has been approved. Describe the procedures for soliciting and/or obtaining approval between project personnel, between different contractors, and between samplers and laboratory staff. Describe the procedure that will be followed when any project activity originally documented in an approved QAPP requires real-time modifications to achieve project goals or a QAPP amendment is required. Describe the procedures for stopping work and identify who is responsible.

☐ Worksheet Not Applicable (State Reason)

Communication Pathways

Communication_Drivers	Responsible_Entity	Name	Phone Number	Procedure_(Timing,_Pathways,_etc.)
Manages all phases of work	PM, USA Environmental	Matt Tucker	813-343-6368	Serves as the liaison between the USACE and subcontractors.
Major modifications to work plans	PM, USA Environmental	Matt Tucker	813-343-6368	Responsible for changes to the MC SAP and notifies USACE of any work modifications within 24 hours.
Analytical data results	Customer Service Manager, TestAmerica	Debra Henderer	303-736-0134	Submits analytical data to USA and LDC within 30 days.
Validated analytical data	Data Validator, LDC	Stella Cuenco	760-634-0437	Forwards the validated analytical data to USA for reporting to USAESCH.
Release of analytical data	PM, USACE Jacksonville District	Spencer O'Neal	256-895-1574	No analytical data will be released until data validation is complete and USACE Jacksonville District has approved the release.
Notification of delays or changes in fieldwork, or issues affecting sample integrity	Project Chemist, USA Environmental	Teresa Rottero	813-343-6426	Serves as a liaison between the USA PM and the subcontractor. Notifies the USA PM
Laboratory data quality issue	OA Manager, RTI Laboratories	Charles O'Bryan	734-422-8000	All QA/QC issues with project field samples will be reported to the USA PM within 24 hours via telephone or email.

QAPP Worksheet #7

(UFP-QAPP Manual Section 2.4.3)

Identify project personnel associated with each organization, contractor, and subcontractor participating in responsible roles. Include data users, decision-makers, project managers, QA officers, project contacts for organizations involved in the project, project health and safety officers, geotechnical engineers and hydrogeologists, field operation personnel, analytical services, and data reviewers. Identify project team members with an asterisk (*). Attach resume to this worksheet or note the location of the resumes.

☐ Worksheet Not Applicable (State Reason)

Personnel Responsibilities and Qualification Table

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
Doug Ralston	Program Manager	USA Environmental	Provides overall project direction and guidance for development of work plans, execution of project tasks, identification/reporting of problems/non-conformances, and initiation of corrective actions.	Over 30 years of combined EOD and munitions response project management experience.
Teresa Rottero	Project Chemist	USA Environmental	Support in the PM in development of the SAP, direction of the field sampling effort, field documentation, and identification and reporting of problems/non-conformances.	M.S. Environmental Engineering and over 10 years of combined environmental and munitions response project management experience.
Debra Henderer	Customer Service Manager	TestAmerica Laboratories	Manages chemical analysis of samples and generation of analytical data.	
Stella Cuenco	Data Validator	Laboratory Data Consultants	Performs analytical data validation and generates validated electronic data deliverables	B.S. Chemistry and 18 years of combined environmental laboratory and data validation experience.

QAPP_Worksheet_#8
(UFP-QAPP Manual Section 2.4.4)
Provide the following information for those projects requiring personnel with specialized training. Attach training records and/or certificates to the QAPP or note their location.

☐ Worksheet Not Applicable (State Reason)

Special Personnel Training Requirements Table

Project **Function**	Specialized Training – Title or Description of **Course**	**Training Provider**	**Training Date**	**Personnel/Groups Receiving Training**	**Personnel Titles/ Organizational Affiliation**	**Location of Training Records/Certificates**
MEC Operations	EOD	U.S. Navy EOD School and TEEX UXO Tech I School	Various	MEC Personnel	MEC Personnel/USA Environmental	USA Environmental
Field Operations	HAZWOPER	USA Environmental	Various	Field Personnel	Field Personnel	USA Environmental
Field Operations	First Aid and CPR	American Red Cross	Various	Field Personnel	Field Personnel	USA Environmental

QAPP_Worksheet_#9
(UFP-QAPP Manual Section 2.5.1)
Complete this worksheet for each project scoping session held. Identify project team members who are responsible for planning the project.

☐ Worksheet Not Applicable (State Reason)

Project Scoping Session Participants Sheet

Project Name: RI/FS at Culebra Island Sites **Projected Date(s) of Sampling:** TBD **Project Manager:** Matthew Tucker/USA Environmental	**Site Name:** Culebra Island Site **Site Location:** Puerto Rico

Date of Session: 15 September 2009
Scoping Session Purpose: Project Planning

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Spencer O'Neal	OE-DC Project Manager	USAESCH	(256) 895-1574	Spencer.D.Oneal@usace.army.mil	OE-DC Project Manager
Teresa Carpenter	Technical Manager	USAESCH	(256) 895-1659	Teresa.M.Carpenter@usace.army.mil	Technical Manager
William Veith	Facilitator	USAESCH	(256) 895-1592	William.d.veith@usace.army.mil	Facilitator
Jose Mendez	Project Manager	USACE Antilles Office	(787) 729-6893	Jose.M.Mendez@usace.army.mil	Project Manager
Elsa Jimenez	Public Affairs	USACE Antilles Office	(787) 729-6876		Public Affairs
Doug Ralston	Program Manager	USA Environmental. Inc.	(813) 343-6368	Dralston@usatampa.com	Program Manager
Al Crandall	Project Geophysicist	USA Environmental.	(813) 343-6362	acradall@usatampa.com	Project Geophysicist
Matt Tucker	Project Manager	USA Environmental.	(813) 343-6406	dshaw@usatampa.com	Project Manager
Richard Henry	National Technical Liaison ERT	U.S. Fish and Wildlife Service	(732) 906-6987	Richard_Henry@fws.gov	National Technical Liaison ERT
Diane Wehner	Regional Resource Coordinator	NOAA	(240) 338-3411	diane.wehner@noaa.gov	Regional Resource Coordinator
Daniel Rodriguez	Regional Project Manager	US EPA Vieques Field Office	(787) 741-5201	Rodriquez.Daniel@epamail.epa.gov	Regional Project Manager
Ana M. Roman	Refuge Manager Culebra national Wildlife Refuge	U.S. Fish and Wildlife Service	(787) 742-0115	Ana.roman@fws.gov	Refuge Manager Culebra national Wildlife Refuge
Wilmarie Rivera	Federal Facilities Coordinator Puerto Rico Environmental Quality Board	Puerto Rico Environmental Quality Board (PREQB)	(787) 767-8181	wilmarierivera@jca.gobierno.pr	Federal Facilities Coordinator Puerto Rico Environmental Quality Board
Jim Pastorick	President UXO Pro	UXO Pro	(703) 548-5300	Jim@uxopro.com	PREQB Contractor
Felix Lopez	Stakeholder	U.S. Fish and Wildlife Service	(787) 510-5202	Felix_lopez@fws.gov	Stakeholder
Lisamarie Carrubba Ph.D.	Ecologist	NOAA Fisheries	(787) 857-3700	Lisamaria.carrubba@noaa.gov	Ecologist

Project Scoping Session Participants Sheet

Project Name: RI/FS at Culebra Island Sites **Projected Date(s) of Sampling:** TBD **Project Manager:** Matthew Tucker/USA Environmental	**Site Name:** Culebra Island Site **Site Location:** Puerto Rico

Date of Session: 15 September 2009
Scoping Session Purpose: Project Planning

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Robert Matos	DNER-National Reserves Div.	Puerto Rico Department National Environmental Resources (DNER)	(787) 983-7222	Matos_resevas@yahoo.com	
Susan Silander	Project Leader Caribbean Islands NWR complex	U.S. Fish and Wildlife Service	(787) 851-7258 Ext 238	susan_silander@fws.gov	

Comments/Decisions: TPP discussions involved the summary of the sampling and analysis scope as presented in the PWS for all 6 MRSs. This includes: 70 discrete samples for surface soil, 30 discrete samples for subsurface soil, 20 discrete samples for sediment and surface water, 20 discrete background samples for surface and subsurface soil, 10 discrete background samples for sediment and surface water, and 10 each pre- and post-detonation composite samples based on the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) 7-sample wheel approach, Additionally, if deemed necessary by the PDT, USA may increase or decrease the above-listed sample quantity based on the final level of effort determined during the first TPP meeting.

Soil, groundwater, sediment, and surface water samples are analyzed for total metals using SW-846 Method 6010B/7471A. Explosives are analyzed using SW-846 Methods 8330/8332.

Ms. Diana Wehner of (NOAA) asked if the data collection plan included MC sampling for energetic materials and metals from MEC use or from leaking MEC. Diane stated the Superfund values are used for comparison; water is screened for metals (fresh water as well as salt). USA presented the MC sampling that is currently scoped for the project for all 6 MRSs and that it is too early to develop a specific sampling plan. General discussion agreed that the MC sampling plan should be addressed generally in the work plan and that it would be finalized after we have more information for the data collection plan. EPA still expressed concern that insufficient data collection is planned.

USA presented the land and underwater Conceptual Site Models (CSMs). Diana Wehner (NOAA) requested that the Site Inspection MC sampling results be included in the CSMs.

Underwater MC sampling was discussed. Ms. Wehner (NOAA) stated that there are limited laboratory test results on the affects of MC contamination on fish and small vertebrates. There is some data from Vieques on fish and anemones living on/inside MEC that show MC contamination but that the affect stays local and falls off quickly with distance from the open MEC.

Action Items:

Consensus Decisions: No decision on the quantity or specifics for MC sampling until the full extent of MEC both on land and underwater is known

QAPP_Worksheet_#10

(UFP-QAPP Manual Section 2.5.2)

Clearly define the problem and the environmental questions that should be answered for the current investigation and develop the project decision "If…, then…" statements in the QAPP, linking data results with possible actions. The prompts below are meant to help the project team define the problem. They are not comprehensive.

☐ Worksheet Not Applicable (State Reason)

Problem Definition

The problem to be addressed by the project: Past munitions use on Culebra and the surrounding cays may have resulted in human health and ecological risk from MC.
The environmental questions being asked: Is MC present above regulatory criteria in soil, surface water, and sediment at the project sites?
Observations from any site reconnaissance reports: No evidence of munitions use in MRS 08. Site reconnaissance did not identify MEC or MD in MRS 06 or MRS 10 (only a small portion of MRS 10 was visually inspected due to limited ROEs). Site reconnaissance reported MD in MRS 09 (one mortar fin on the beach north of Soldado Point), MRS 11 (one 20mm shell casing), and MRS 13 (seven 5-inch expended projectiles, two 3-inch expended projectiles, a flare cartridge, and a .30-caliber blank cartridge.
A synopsis of secondary data or information from site reports: Groundwater and air pathways incomplete for human and ecological receptors at project sites.
The possible classes of contaminants and the affected matrices: MRS 06 - No explosives detections in soil. Chromium and copper in soil retained for consideration in SLRA. Surface water/sediment may be secondary exposure media. MRS 08 - No explosives detections in sediment or soil. Barium, chromium, copper, lead, mercury, and zinc in sediment retained for consideration in SLRA. Zinc in soil retained for consideration in SLRA. MRS 09 - No explosives detections in soil. Chromium in soil retained for consideration in SLRA. Surface water/sediment may be secondary exposure media. MRS 10 - No explosives detections in soil. Barium, chromium, copper, and zinc in soil retained for consideration in SLRA. Surface water/sediment may be secondary exposure media for ecological receptors. MRS 11 - No MC was detected in soils and soil exposure pathway is incomplete for human and ecological receptors. Since the soil pathway is incomplete, the surface water/sediment (secondary exposure media) is also incomplete. MRS 13 - No explosives detections in soil. Chromium in soil retained for consideration in SLRA. Surface water/sediment may be secondary exposure media for ecological receptors.
The rationale for inclusion of chemical and nonchemical analyses: Metal and explosives constituents of munitions used at the site may have contaminated site media and resulted in human human and ecological risks. Analyses will support evaluation of nature and extent of impact and assessment of risks.
Information concerning various environmental indicators:
Project decision conditions ("If..., then..." statements): If MC is detected below human health and ecological risk levels for an MRS, then the MRS will be recommended for no further action for MC. If MC is detected above human health or ecological risk levels for an MRS, then a risk assessment will be conducted, followed by alternatives development and evaluation to determine the most appropriate response action for the MRS.

QAPP_Worksheet_#11

(UFP-QAPP Manual Section 2.6.1)

Use this worksheet to develop project quality objectives (PQOs) in terms of type, quantity, andquality of data determined using a systematic planning process. Provide a detailed discussion of PQOs in the QAPP. List PQOs in the form of qualitative and quantitative statements. These statements should answer questions such as those listed below. These questions are examples only, however; they are neither inclusive nor appropriate for all projects.

☐ Worksheet Not Applicable (State Reason)

Project_Quality_Objectives /Systematic Planning Process Statements

Who will use the data? USACE Jacksonville District, USAESCH, USA, USFWS, and PREQB
What will the data be used for? To evaluate the nature and extent of human health and ecological risks associated with MC presence resulting from past munitions use at the project sites.
What type of data are needed? (target analytes, analytical groups, field screening, on-site analytical or off-site laboratory techniques, sampling techniques) Field screening will be performed to determine where laboratory analytical samples will be collected. Concentration data (including background concentrations) for targeted metals and explosives analytes.
How "good" do the data need to be in order to support the environmental decision? The data must support a human health and ecological risk assessment and evaluation of remedial alternatives for the site.
How much data are needed? (number of samples for each analytical group, matrix, and concentration) The number of soil, surface water, and sediment samples will be determined after the MEC data collection effort.
Where, when, and how should the data be collected/generated? The scope and schedule of the MC sampling will be determined after the MEC data collection effort. Media samples will be collected by USA Environmental as described in the Field Sampling Plan and sample analysis will be performed by TestAmerica Laboratories.
Who will collect and generate the data? USA Environmental
How will the data be reported? The analytical laboratory will verify, reduce, and report analytical data in accordance with the most current DOD Quality Systems Manual (QSM) for Environmental Laboratories. The analytical data will be reported with full QC deliverables and submitted as both printed and electronic data deliverable (EDD) copies. Analytical data will be sent to LDC for validation and the validated data will be submitted to the Government as a ADR EDD and reported in the RI Report.
How will the data be archived? Laboratory data will be retained for 7 years and all analytical data packages will be stored on CD/DVD and archived in the Administrative Record for the project sites.

QAPP_Worksheet_#12

(UFP-QAPP Manual Section 2.6.2)

Complete this worksheet for each matrix, analytical group, and concentration level. Identify the data quality indicators (DQIs), measurement performance criteria (MPC), and QC sample and/or activity used to assess the measurement performance for both the sampling and analytical measurement systems. Use additional worksheets if necessary. If MPC for a specific DQI vary within an analytical parameter, i.e., MPC are analyte-specific, then provide analyte-specific MPC on an additional worksheet.

☐ Worksheet Not Applicable (State Reason)

Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Metals
Concentration Level	Low

Sampling Procedure[1]	Analytical **Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
Refer to FSP	6010B, 7471A/L-3, L-4	Precision	Laboratory Control Limits	Laboratory Dublicates	S A
Refer to FSP	6010B, 7471A/L-3, L-4	Precision	Laboratory Control Limits	MS/MSD	A
N/A	6010B, 7471A/L-3, L-4	Accuracy/Bias	No target compounds>1/2RL	Equipment Blank	A
N/A	6010B, 7471A/L-3, L-4	Accuracy/Bias	Laboratory Control Limits	LCS	A
Refer to FSP	6010B, 7471A/L-3, L-4	Accuracy/Bias	Laboratory Control Limits	MS/MSD	A
N/A	6010B, 7471A/L-3, L-4	Sensitivity	<reporting limit	Method Blank	A
N/A	6010B, 7471A/L-3,L-4	Completeness	90%; valid data:total data	Analytical results	A

References: Attachment 1, Laboratory SOP L1, L3, Quality Assurance Manual Attachment 4, and Attachment 2 DoD, Environmental Data Quality Workgroup "Development of of DoD Laboratory Control Sample Control Limits" May 2004.

Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Explosives
Concentration Level	Low

Sampling Procedure[1]	Analytical **Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
Refer to FSP	8330B/L-8	Precision	Laboratory Control Limits	Laboratory Duplicates	S A
Refer to FSP	8330B/L-8	Precision	Laboratory Control Limits	MS/MSD	A
N/A	8330B/L-8	Accuracy/Bias	No target compounds>1/2RL	Equipment Blank	A
N/A	8330B/L-8	Accuracy/Bias	Laboratory Control Limits	LCS	A
Refer to FSP	8330B/L-8	Accuracy/Bias	Laboratory Control Limits	MS/MSD	A
N/A	8330B/L-8	Accuracy/Bias	Laboratory Control Limits	Surrogates (organics)	A
N/A	8330B/L-8	Sensitivity	-< reporting limit	Method Blank	A
N/A	8330B/L-8	Completeness	90%; valid data:total data	Analytical results	A

References: Attachment 1, Laboratory SOP L7, L8, and Quality Assurance Manual Attachment 4

Measurement Performance Criteria Table

Matrix	Surface Water
Analytical Group	Metals
Concentration Level	Low

Sampling Procedure[1]	Analytical **Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
Refer to FSP	6010B, 7470A/L-3, L-5	Precision	Laboratory Control Limits	Laboratory Duplicates	S A
Refer to FSP	6010B, 7470A/L-3, L-5	Precision	Laboratory Control Limits	MS/MSD	A
N/A	6010B, 7470A/L-3, L-5	Accuracy/Bias	No target compounds>1/2RL	Equipment Blank	A
N/A	6010B, 7470A/L-3, L-5	Accuracy/Bias	Laboratory Control Limits	LCS	A
Refer to FSP	6010B, 7470A/L-3, L-5	Accuracy/Bias	Laboratory Control Limits	MS/MSD	A
N/A	6010B, 7470A/L-3, L-5	Sensitivity	< reporting limit	Method Blank	A
N/A	6010B, 7471A/L-3,L-4	Completeness	90%; valid data:total data	Analytical results	A

References: Attachment 1, Laboratory SOP L1, L3, and Quality Assurance Manual Attachment 4

Measurement Performance Criteria Table

Matrix	Surface Water
Analytical Group	Explosives
Concentration Level	Low

Sampling Procedure[1]	Analytical **Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
Refer to FSP	8330B/ L-8	Precision	Laboratory Control Limits	Field Duplicates	S A
Refer to FSP	8330B/ L-8	Precision	Laboratory Control Limits	MS/MSD	A
N/A	8330B/ L-8	Accuracy/Bias	No target compounds>1/2RL	Instrument Blank	A
N/A	8330B/ L-8	Accuracy/Bias	Laboratory Control Limits	LCS	A
Refer to FSP	8330B/ L-8	Accuracy/Bias	Laboratory Control Limits	MS/MSD	A
N/A	8330B/ L-8	Accuracy/Bias	Laboratory Control Limits	Surrogates (organics)	A
N/A	8330B/ L-8	Sensitivity	< reporting limit	Method Blank	A
N/A	8330B/L-8	Completeness	90%; valid data:total data	Analytical results	A

[1]Reference number from QAPP_Worksheet_#21 (see Section 3.1.2).
[2]Reference number from QAPP_Worksheet_#23 (see Section 3.2).
References: Attachment 1, Laboratory SOP L7, L8, and Quality Assurance Manual Attachment 4

QAPP_Worksheet_#13

(UFP-QAPP Manual Section 2.7)

Identify all secondary data and information that will be used for the project and their originating sources. Specify how the secondary data will be used and the limitations on their use.

☐ Worksheet Not Applicable (State Reason)

Secondary Data Criteria and Limitations Table

Secondary Data	**Data Source (Originating Organization, Report Title, and Date)**	**Data Generator(s) (Originating Org., Data Types, Data Generation/ Collection Dates)**	**How Data Will Be Used**	**Limitations on Data Use**
Property description and history, previous investigations, data on receptors and exposure pathways, MEC and MC sampling data, and screening-level risk assessment data.	Parsons, Site Inspection Report, Culebra Island Site, Puerto Rico, September 2007	USACE/USAESCH, Parsons, SI Report, September 2007	Site history information; focus the RI, identifies areas for survey, intrusive investigation, and MC sampling; supplement data collected during the RI.	Very few soil and sediment samples were collected during the SI. No surface water samples were collected.

QAPP_Worksheet_#14

(UFP-QAPP Manual Section 2.8.1)

Provide a brief overview of the listed project activities.

☐ Worksheet Not Applicable (State Reason)

Summary of Project Tasks

Sampling Tasks: Sampling and analysis program will be approved of by the project team prior to completing MEC data collection efforts. MC sampling will be performed concurrent to MEC investigation. Following the MEC data collection efforts, USA will propose the sampling and analysis program for project team approval. Once the sampling program is approved, USA will mark the GPS location of each sample point, perform sampling in accordance with the FSP with oversight of a UXO Technician II/III, and ship the samples to the analytical laboratory.
Analysis Tasks: The analytical laboratory will process, prepare, and analyze the samples for the analytical groups identified in Worksheet #12.
Quality Control Tasks: Field personnel will adhere to the sample collection and handling procedures in the FSP. The analytical laboratory will follow analytical SOPs. QC samples are described in Worksheet #26.
Secondary Data: See Worksheet #13.
Data Management Tasks: The analytical laboratory will provide the analytical data to USA and the data validating firm in hard copy and EDD. The analytical laboratory will retain analytical data for 7 years.
Documentation and Records: Field logbooks will be maintained at the site at all times during field work and will be used to document the field activities. All sampling locations will be documented in the field logbook. Chain-of-custody forms and air freight bills will be used to track and document the shipment of soil samples to the analytical laboratory. A copy of the work plan containing this SAP will be available onsite at all times during field work activities. Analytical data packages will be in accordance with the current DoD QSM and will be submitted in hard copy and EDD. Records will be retained for 5 years. Analytical results will be reported in the RI Report, which will be placed in the Adminstrative Record for the project site along with the analytical data package.
Assessment/Audit Tasks: Laboratory audits, if necessary, will be performed by USAESCH. Results of any field audits will be maintained with the project files.
Data Review Tasks: The analytical laboratory will verify that all data are complete for samples received. All data packages deliverables requirements will be met. LDC will perform analytical data validation. Achievement of performance criterial specified in the QAPP and data validation criteria will be evaluated during the Tier II data validation, and analytical measurement error will be assessed. Data usability will be assessed by the project team. The USA Project Chemist and Engineer will review the field logs/records and validated data for reporting in the RI Report. The USA Team will perform a peer review of the RI Report prior to submittal.

QAPP_Worksheet_#15

(UFP-QAPP Manual Section 2.8.1)

Complete this worksheet for each matrix, analytical group, and concentration level. Identify the target analytes/contaminants of concern and project-required action limits. Next, determine the quantitation limits (QLs) that must be met to achieve the project quality objectives. Finally, list the published and achievable detection and quantitation limits for each analyte.

☐ Worksheet Not Applicable (State Reason)

Reference Limits and Evaluation Table

Matrix: Soil

Analytical Group: Metals

Concentration Level: Low

Analyte	**CAS Number**	**Project Action Limit (mg/kg)**	**Project Quantitation Limit (mg/kg)**	**Analytical Method**		Achievable Laboratory Limits	
		Human/Ecological		**MDLs**	**Method QLs**	**MDLs**	**QLs**
Aluminum	7429-90-5	77000/50	50	1.55	50	1.55	50
Antimony	7440-36-0	31/3.5	2.0	0.38	2.0	0.38	2.0
Barium	7440-39-3	15000/165	2.0	0.076	2.0	0.076	2.0
Chromium (VI)	7440-47-3	230/0.4	3.5	0.058	3.5	0.058	3.5
Copper	7440-50-8	3100/40	5	0.217	5	0.217	5
Iron	7439-89-6	55000/200	80	3.8	80	3.8	80
Lead	7439-92-1	400/50	0.9	0.27	0.9	0.27	0.9
Mercury (elemental)	7439-97-6	5.6/0.1	0.033	0.00553	0.033	0.00553	0.033
Zinc	7440-66-6	23000/50	8.0	0.398	8.0	0.398	8.0

Reference: USEPA Regional Screening Levels for human health, USEPA Region 4 Waste Management Division Ecological Soil Screening Values for Hazardous Waste Sites, and Puerto Rico Environmental Quality Bureau

Reference Limits and Evaluation Table

Matrix: Sediment

Analytical Group: Metals

Concentration Level: Low

Analyte	**CAS Number**	**Project Action Limit** **Human (mg/kg)/Ecological (ppm)**	**Project Quantitation Limit (mg/kg)**	**Analytical Method**		Achievable Laboratory Limits	
				MDLs	**Method QLs**	**MDLs**	**QLs**
Aluminum	7429-90-5	7700/NA	50	1.55	50	1.55	50
Antimony	7440-36-0	3.1/12	2.0	0.38	2.0	0.38	2.0
Barium	7440-39-3	1500/NA	2.0	0.076	2.0	0.076	2.0
Chromium (VI)	18540-29-9	28/52.3	3.5	0.058	3.5	0.058	3.5
Copper	7440-50-8	310/18.7	5	0.217	5	0.217	5
Iron	7439-89-6	5500/200	80	3.8	80	3.8	80
Lead	7439-92-1	40/30.2	0.9	0.27	0.9	0.27	0.9
Mercury (elemental)	7439-97-6	0.43/0.13	0.033	0.00553	0.033	0.00553	0.033
Zinc	7440-66-6	2300/124	8.0	0.398	8.0	0.398	8.0

Reference: USEPA Regional Screening Levels for human health, USEPA Region 4 Waste Management Division Ecological Screening Values for Hazardous Waste Sites, and Puerto Rico Environmental Quality Bureau

Reference Limits and Evaluation Table

Matrix: Surface Water

Analytical Group: Metals

Concentration Level: Low

Analyte	**CAS Number**	**Project_Action Limit (ug/L)**	**Project Quantitation_Limit (ug/L)**	**Analytical_Method**		Achievable_Laboratory_Limits	
		Human/Ecological		**MDLs**	**Method QLs**	**MDLs**	**QLs**
Aluminum	7429-90-5	37000/750	300	18	300	18	300
Antimony	7440-36-0	15/1300	15	3.14	20	3.14	20
Barium	7440-39-3	7300/NA	10	0.576	10	0.576	10
Chromium (VI)	18540-29-9	110/16	15	0.663	15	0.663	15
Copper	7440-50-8	1500/9.22	9.22	1.36	15	1.36	15
Iron	7439-89-6	26000/NA	100	22.0	100	22.0	100
Lead	7439-92-1	15/33.78	15	2.61	15	2.61	15
Mercury (elemental)	7439-97-6	2.0/2.40	0.2	0.0272	0.2	0.0272	0.2
Zinc	7440-66-6	11000/65.04	65.04	4.53	150	4.53	150

Reference: USEPA Regional Screening Levels for human health, tap water (Nov 2010), USEPA Region 4 Waste Management Division Ecological Surface Water Screening Values for Hazardous Waste Sites, and Puerto Rico Environmental Quality Bureau

Reference Limits and Evaluation Table

Matrix: Soil/Sediment

Analytical Group: Explosives

Concentration Level: Low

Analyte	CAS Number	Project_Action Limit (mg/kg) Human/Ecological	Project Quantitation_Limit (mg/kg)	Analytical_Method		Achievable_Laboratory_Limits	
				MDLs	Method QLs	MDLs	QLs
2-Amino-4,6-dinitrotoluene	35572-78-2	150/NA	0.25	0.0455	0.25	0.0455	0.25
4-Amino-2,6-dinitrotoluene	19406-51-0	150/NA	0.25	0.0391	0.25	0.0391	0.25
1,3-Dinitrobenzene	99-65-0	6.1/NA	0.25	0.0611	0.25	0.0611	0.25
2,4-Dinitrotoluene	121-14-2	120/NA	0.25	0.0498	0.25	0.0498	0.25
2,6-Dinitrotoluene	606-20-2	61/NA	0.25	0.0542	0.25	0.0542	0.25
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	230/NA	0.26	0.0854	0.26	0.0854	0.26
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	240/NA	0.50	0.0548	0.50	0.0548	0.50
Nitrobenzene	98-95-3	130/NA	0.25	0.0614	0.25	0.0614	0.25
Nitroglycerin	55-63-0	6.1/NA	5.1	0.1928	5.1	0.1928	5.1
2-Nitrotoluene	88-72-2	70/NA	0.25	0.0841	0.25	0.0841	0.25
3-Nitrotoluene	99-08-1	6.1/NA	0.50	0.0548	0.50	0.0548	0.50
4-Nitrotoluene	99-99-0	240/NA	0.40	0.109	0.40	0.109	0.40
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	3800/NA	0.25	0.0776	0.25	0.0776	0.25
Pentaerythritol tetranitrate (PETN)	78-11-5	NA/NA	NA/NA	0.8730	4.0	0.8730	4.0
1,3,5-Trinitrobenzene	99-35-4	2200/NA	0.25	0.0712	0.25	0.0712	0.25
2,4,6-Trinitrotoluene	118-96-7	36/NA	0.25	0.0578	0.25	0.0578	0.25

Reference: USEPA Regional Screening Levels for human health, USEPA Region 4 Waste Management Division Ecological Soil Screening Values for Hazardous Waste Sites, and Puerto Rico Environmental Quality Bureau

Reference Limits and Evaluation Table

Matrix: Surface Water

Analytical Group: Explosives

Concentration Level: Low

Analyte	**CAS Number**	**Project_Action Limit (ug/L)**	**Project Quantitation_Limit (ug/L)**	**Analytical_Method**		Achievable_Laboratory_Limits	
		Human/Ecological		**MDLs**	**Method QLs**	**MDLs**	**QLs**
2-Amino-4,6-dinitrotoluene	35572-78-2	73/NA	0.2	0.0507	0.2	0.0507	0.2
4-Amino-2,6-dinitrotoluene	19406-51-0	73/NA	0.2	0.0577	0.2	0.0577	0.2
1,3-Dinitrobenzene	99-65-0	3.7/NA	0.4	0.0887	0.4	0.0887	0.4
2,4-Dinitrotoluene	121-14-2	73/NA	0.4	0.0838	0.4	0.0838	0.4
2,6-Dinitrotoluene	606-20-2	37/NA	0.2	0.0645	0.2	0.0645	0.2
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	110/NA	0.2	0.0523	0.2	0.0523	0.2
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	150/NA	0.24	0.0793	0.24	0.0793	0.24
Nitrobenzene	98-95-3	15/NA	0.4	0.0910	0.4	0.0910	0.4
Nitroglycerin	55-63-0	3.7/NA	3.0	0.921	3.0	0.921	3.0
2-Nitrotoluene	88-72-2	33/NA	0.31	0.0855	0.4	0.0855	0.4
3-Nitrotoluene	99-08-1	3.7/NA	0.4	0.0834	0.4	0.0834	0.4
4-Nitrotoluene	99-99-0	150/NA	1.0	0.20	1.0	0.20	1.0
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	1800/NA	0.4	0.0876	0.4	0.0876	0.4
Pentaerythritol tetranitrate (PETN)	78-11-5	NA/NA	2.0	0.416	2.0	0.416	2.0
1,3,5-Trinitrobenzene	99-35-4	1100/NA	1.0	0.20	1.0	0.20	1.0
2,4,6-Trinitrotoluene	118-96-7	18/NA	0.4	0.0724	0.4	0.0724	0.4

Reference: USEPA Regional Screening Levels for human health, tap water (Nov 2010) USEPA Region 4 Ecological Screening Values, and Puerto Rico Environmental Quality Bureau

QAPP_Worksheet_#16
(UFP-QAPP Manual Section 2.8.2)
List all project activities as well as the QA assessments that will be performed during the course of the project. Include the anticipated start and completion dates.

☐ Worksheet Not Applicable (State Reason)

Project Schedule Timeline Table

Activities	Organization	Dates (MM/DD/YY) Anticipated Date(s) of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Task Order Award	USA	6/30/09	10/12/09	none	
Technical Project Planning Meeting 1	USA/USACE/PRDEPB	9/1/09	9/15/09	none	
Draft & Draft Final WP	USA	9/16/09	11/20/09	Draft Final WP Submittal	11/20/09
TPP Memorandum	USA	12/7/09	12/25/09	Final TPP Memorandum Submittal	12/25/09
Submittal of GIS on CD/DVD	USA	10/23/09	10/23/09	CD/DVD	10/23/09
Public Involvement Planning	USA	9/16/09	11/27/09	Final PIP Submittal	11/27/09
Technical Project Planning Meeting 2	USA/USACE/PRDEPB	11/23/09	12/4/09	none	
Final WP	USA	12/7/09	12/18/09	Final WP Submittal	12/18/09
Notice to Proceed	USACE	12/21/09	12/21/09	Notice to Proceed	12/21/09
RI/FS field activities	USA	12/22/09	6/14/10	Analytical data	7/27/10
Draft and Draft Final RI Report	USA	6/15/10	9/29/10	Draft Final RI Report Submittal	9/29/10
TPP Meeting 3	USA/USACE/PREPB	9/30/10	10/6/10	none	
Final RI Report	USA	10/7/10	10/20/10	Final RI Submittal	10/20/10
Feasibility Study Report	USA	10/21/10	2/2/11	Final FS Report Submittal	2/2/11

Project Schedule Timeline Table

Activities	Organization	Dates (MM/DD/YY) Anticipated Date(s) of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Proposed Plan	USA	2/3/11	4/29/11	Final Proposed Plan Submittal	4/29/11
Decision Document	USA	5/2/11	7/6/11	Final DD Submittal	7/6/11
Administrative Record	USA	7/7/11	7/13/11	Final record placement & submittal	7/13/10
Electronic Laboratory Data Submittal	USA	7/14/10	7/14/10	Electronic Laboratory Data Submittal	7/14/10
Task Order Close out	USA	8/12/10	8/12/10	none	

QAPP_Worksheet_#17

(UFP-QAPP Section 3.1.1)

Describe the project sampling approach. Provide the rationale for selecting sample locations and matrices for each analytical group and concentration level.

☐ Worksheet Not Applicable (State Reason)

Sampling Design and Rationale

Describe and provide a rationale for choosing the sampling approach (e.g., grid system, biased statistical approach):
Describe the sampling design and rationale in terms of what matrices will be sampled, what analytical groups will be analyzed and at what concentration levels, the sampling locations (including QC, critical, and background samples), the number of samples to be taken, and the sampling frequency (including seasonal considerations) [May refer to map or Worksheet #18 for details]:

Function	Sample Type	No. of Samples	Laboratory Analyses		
			8330B (explosives)	6010B (metals no mercury)	7470A/7471A (mercury)
MC Sampling	discrete surface soil	TBD[1]	x	x	x
	discrete subsurface soil	TBD[1]	x	x	x
	discrete surface water	TBD[1]	x	x	x
	discrete sediment	TBD[1]	x	x	x
	background samples	TBD[1]	x	x	x
pre-detonation	Composite soil sample	TBD[1]	x	x	x
post detonation	Composite soil sample	TBD[1]	x	x	x

Notes:

1. Number of samples will be dependent on amount of MEC encountered

QAPP_Worksheet_#18

(UFP-QAPP Manual Section 3.1.1)

List all site locations that will be sampled and include sample/ID number, if available. (Provide a range of sampling locations or ID numbers if a site has a large number.) Specify matrix and, if applicable, depth at which samples will be taken. Only a short reference for the sampling location rationale is necessary for the table. The text of the QAPP should clearly identify the detailed rationale associated with each reference. Complete all required information, using additional worksheets if necessary.

☑ Worksheet Not Applicable (State Reason) The sampling and analysis program will be based on the result of the MEC data collection, which the project team will use to determine the location and number of soil, surface water, and sediments samples (including background and QC samples). The sample depths are discussed in Section E.1.5 and sample numbering is discussed in Section E.1.6. of the FSP, Part I of this MC SAP.

Sampling Locations and Methods/SOP Requirements Table

Sampling Location/ID Number	**Matrix**	**Depth ( )**	Analytical Group	**Concentration Level**	**Number of Samples (identify field duplicates**	**Sampling SOP Reference[1]**	**Rationale for Sampling Location**

[1]Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet_#21).

QAPP_Worksheet_#19

(UFP-QAPP Manual Section 3.1.1)

For each matrix, analytical group, and concentration level, list the analytical and preparation method/SOP and associated sample volume, container specifications, preservation requirements, and maximum holding time.

☐ Worksheet Not Applicable (State Reason)

Analytical SOP Requirements Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method/SOP Reference [1]	Sample Volume	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Soil/Sediment	Metals	Low	SW6010B/L-3, L-2	200g (minimum)	16oz glass or polyethylene container	Storage at 4°C	6 months
Soil/Sediment	Mercury	Low	SW7471A/L-4	200g (minimum)	16oz glass or polyethylene container	Storage at 4°C	28 days
Surface Water	Metals	Low	SW6010B/L-3, L-1	100mL (minimum)	1L glass or polyethylene container	HNO3, Storage at 4°C	6 months
Surface Water	Mercury	Low	SW7470A/L-5	100mL (minimum)	1L glass or polyethylene container	HNO3, Storage at 4°C	28 days
Soil/Sediment	Explosives	Low	SW8330B/L-8, L-7	10g (minimum)	8oz glass wide-mouth container w/ Teflon lined lid	Storage at 4°C	14 days to extraction/40 days from extraction to analysis
Surface Water	Explosives	Low	SW8330B/L-8, L-6	1L (minimum)	2 – L 1L amber glass container w/ Teflon lined lid	Storage at 4°C	7 days to extraction/40 days from extraction to analysis

[1]Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet_#23).

QAPP_Worksheet_#20
(UFP-QAPP Manual Section 3.1.1)
Summarize by matrix, analytical group, and concentration level the number of field QC samples that will be collected and sent to the laboratory.

☑ Worksheet Not Applicable (State Reason) The sampling and analysis program will be based on the result of the MEC data collection, which the project team will use to determine the location and number of soil, surface water, and sediments samples (including background and QC samples). The type and frequency of field QC samples are discussed in Section E.1.3.2.5. of the FSP, Part I of this MC SAP.

Field Quality Control Sample Summary Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation SOP Reference[1]	No. of Sampling Locations	No. of Field Duplicate Pairs	Inorganic No. of MS	No. of Field Blanks	No. of Equip. Blanks	No. of PT Samples	Total No. of Samples to Lab

[1]Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet_#23).

QAPP_Worksheet_#21

(UFP-QAPP Manual Section 3.1.2)

List all SOPs associated with project sampling including, but not limited to, sample collection, sample preservation, equipment cleaning and decontamination, equipment testing, inspection and maintenance, supply inspection and acceptance, and sample handling and custody. Include copies of the SOPs as attachments or reference all in the QAPP. Sequentially number sampling SOP references in the Reference Number column. The reference number can be used throughout the QAPP to refer to a specific SOP.

☑ Worksheet Not Applicable (State Reason) No specific Standard Operating Procedures are used. See FSP.

Project Sampling SOP References Table

Reference Number	**Title, Revision Date and/or Number**	**Originating Organization**	**Equipment Type**	**Modified for** Project Work? **(Check if yes)**	Comments
				☐	
				☐	

QAPP_Worksheet_#22

(UFP-QAPP Manual Section 3.1.2.4)

Identify all field equipment and instruments (other than analytical instrumentation) that require calibration, maintenance, testing, or inspection and provide the SOP reference number for each type of equipment. In addition, document the frequency of activity, acceptance criteria, and corrective action requirements on the worksheet.

☐ Worksheet Not Applicable (State Reason)

Field Equipment Calibration, Maintenance, Testing, and Inspection Table [2]

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
Innov-X	factory calibrated	as needed	none	as needed	as needed	n/a	n/a	factory/field sampler	n/a

[1]Specify the appropriate reference letter or number from the Project Sampling SOP References table (Worksheet_#21).

[2] Field equipment table will be completed as applicable in accordance with the User Manual upon initiation of field activities.

QAPP_Worksheet_#23

(UFP-QAPP Manual Section 3.2.1)

List all SOPs that will be used to perform on-site or off-site analysis. Indicate whether the procedure produces screening or definitive data. Sequentially number analytical SOP reference in the Reference Number column. Include copies of the SOPs as attachments or reference in the QAPP. The reference number can be used throughout the QAPP to refer to a specific SOP. SOPs are included in Attachment 1 to this QAPP.

☐ Worksheet Not Applicable (State Reason)

Analytical SOP References Table

Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
L-1	Acid Digestion of Aqueous Samples, DV-IP-0010, Rev. 4.3	Definitive	Metals	Digestion	TestAmerica Laboratories	☐
L-2	Acid Digestion of Solids, DV-IP-0015, Rev. 3.3	Definitive	Metals	Digestion	TestAmerica Laboratories	☐
L-3	ICP Analysis for Trace Elements by SW-846 Method 6010B, DV-MT-0019, Rev. 1	Definitive	Metals	ICP	TestAmerica Laboratories	☐
L-4	Mercury in Solids by Cold Vapor Atomic Absorption, DV-MT-0016, Rev. 2.2	Definitive	Mercury	CVAA	TestAmerica Laboratories	☐
L-5	Mercury in Water by Cold Vapor Atomic Absorption, DV-MT-0017, Rev. 0.2	Definitive	Mercury	CVAA	TestAmerica Laboratories	☐
L-6	Solid Phase Extraction of Nitroaromatic and Nitroamine Explosive Compounds and Picric Acid from Water Samples, DV-OP-0017, Rev. 0	Definitive	Explosives	Extraction	TestAmerica Laboratories	☐

Analytical SOP References Table

Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
L-7	Extraction of Nitroaromatic and Nitroamine Explosive Compounds and Picric Acid from Soil Samples, DV-OP-0018, Rev. 1	Definitive	Explosives	Extraction	TestAmerica Laboratories	☐
L-8	Nitroaromatic and Nitroamine Explosive Compounds by High Performance Liquid Chromatography (HPLC), DV-LC-0002, Rev. 11	Definitive	Explosives	HPLC	TestAmerica Laboratories	☐

QAPP_Worksheet_#24

(UFP-QAPP Manual Section 3.2.2)

Identify all analytical instrumentation that requires calibration and provide the SOP reference number for each. In addition, document the frequency, acceptance criteria, and corrective action requirements on the worksheet.

☐ Worksheet Not Applicable (State Reason)

Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
ICP/AES	Initial calibration - minimum one high standard and a calibration blank	Daily initial calibration prior to sample analyses	No acceptance criteria unless more than one standard is used, in which case r≥0.995	Correct problem and repeat initial calibration	Analyst	DoD QSM Version 3 and L-3
	Initial Calibration Verification (ICV) -	Each Calibration	Value of all analytes within 5% of expected value	Correct problem then repeat initial calibration	Analyst	TAL Denver QAM, Appendix 4
	Continuing Calibration Verification (CCV) -	Befire sample analysis, after every 10 samples, and at the end of the analysis sequence	All analytes within 10%	Repeat calibration and re-analyze all samples since last successful calibration	Analyst	TAL Denver QAM, Appendix 4
	High-level Calibration Verification (HLCV) -		Result of standard must be within 10% of the expected value	Single reanalysis attempted without modification to the instrument operating conditions. Otherwise, analysis should be terminated, problem corrected, instrument recalibrated and the calibration re-verified.	Analyst	

Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
CVAA	Initial calibration - minimum 5 standards and a calibration blank	Daily initial calibration prior to sample analyses	r≥0.995	Correct problem and repeat initial calibration	Analyst	DoD QSM Version 3 and L-4
	Initial Calibration Verification (ICV) -	Immediately following initial daily calibration	Analytes within 10% of expected value	Correct problem then repeat initial calibraton. If calibration fails again, re-digest the entire digestion batch	Analyst	TAL Denver QAM, Appendix 4
	Continuing Calibration Verification (CCV) -	Before sample analysis, after every 10 samples, and at the end of the analysis sequence	Analytes within 20% of expected value	Correct problem then repeat all QC and samples since last successful calibration. If the CCV fails again upon reanalysis, reprep the entire digestion batch	Analyts	TAL Denver QAM, Appendix 4
HPLC	Initial calibration - minimum 5 point initial calibration for all analytes	Initial calibration prior to sample analyses	Option 1: RSD for each analyte ≤ 20% Option 2: linear least squares regression, r≥0.995 Option 3: non-linear regression r2≥0.99 (6 points shall be used for second order)	Correct problem and repeat initial calibration	Analyst	DoD QSM Version 3 and L-8
	Initial Calibration Verification (ICV) -	Immediately following initial calibration	All analytes within 15% of expected value	Correct problem then repeat initial calibration	Analyst	TAL Denver QAM Appendix 4
	Continuing Calibration Verification (CCV) -	Before sample analysis and at the end of the analysis sequence	All analytes within 15% of expected value	Correct problem then repeat initial CCV and re-analyze all samples since last successful CCF	Analyst	TAL Denver QAM Appendix 4

[1]Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet_#23).

QAPP_Worksheet_#25
(UFP-QAPP Manual Section 3.2.3)
Identify all analytical instruments that require maintenance, testing, or inspection and provide the SOP reference number for each. In addition, document the frequency, acceptance criteria, and corrective action requirements on the worksheet. SOPs are included in Attachment 1 to this QAPP.

☐ Worksheet Not Applicable (State Reason)

Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
ICP/AES - TJA 61E Trace	1) Check pump tubing 2) Check fluid level in waste container 3) Clean air filter 4) Check torch for residue 5) Check nebulizer flow 6) Fill rinse solution/ IS solution 7) Replace capillary tubing/ sipper probe 8) Check internal fluid reservoir	SW-846 Method 6010B	1) Visual inspection for wear 2) Visual inspection of waste level 3) Visual inspection of filter 4) Visual inspection for residue 5) Visual inspection of backflow via meter 6) Visual inspection of level 7) Visual inspection of sample flow 8) Visual inspections of fluid level	1) Daily 2) Weekly 3) Daily 4) As needed 5) Daily 6) Daily 7) As needed 8) Daily	Passing calibration	1) Replace pump tubing 2) Empty waste container 3) Clean air filter 4) Clean torch 5) Clean or replace nebulizer 6) Replenish solutions 7) Clean or replace tubing 8) Replenish solutions	Analyst	TestAmerica Quality Assurance Manual

Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
CVAA - Cetac CVAA M-7500	1) Check silica gel in drying tube 2) Change lamp 3) Clean cell and aspirator in aqua regia 4) Check pump tubing and pump flow 5) Check waste container 6) Fill reductant bottle with 10% stannous chloride and check acid reagent	SW846 Method SW7471A	verify instrument performance 2) Monitor lamp voltage 3) Verify instrument performance 4) Visual inspection of flow 5) Visual inspection of waste level 6) Visual inspection of level	1) As needed 2) As needed 3) Monthly 4) Daily 5) Daily 6) Daily	Passing calibration	1) Replace silica gel and drying tube unit 2) Replace lamp 3) Clean cell and aspirator 4) Clean or replace tubing 5) Empty container 6) Fill container	Analyst	TestAmerica Quality Assurance Manual

Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
HPLC - Agilent Technologies 1100 Multiple Wavelength UV / Fluorescence Detectors	1) Check level of eluent vessels 2) Check gas supply 3) Change pump seals 4) Change the column frit 5) Change fuses in power supply 6) Filter all samples 7) Change autosampler rotor or oil autosampler slides 8) Change or backflush columns	SW846 Method SW8330B	1) Visual inspection of level 2) Read pressure gauge 3) Verify instrument performance 4) Verify instrument performance 5) Verify instrument performance 6) Verify instrument performance 7) Verify instrument performance 8) Verify instrument performance	1) Daily 2) Daily 3) Semi-annually or as required 4) As needed 5) As needed 6) Daily 7) As needed 8) As needed	Passing calibration	1) Fill container 2) Replace gas tank 3) Replace pump seal 4) Replace column frit 5) eplace fuse 6) Replace filter 7) Replace parts 8) Replace column	Analyst	TestAmerica Quality Assurance Manual

[1]Specify the appropriate reference letter or number from Analytical SOP References table (Worksheet_#23).

QAPP_Worksheet_#26
(UFP-QAPP Manual Appendix A)

Use this worksheet to identify components of the project-specific sample handling system. Record personnel, and their organizational affiliations, who are primarily responsible for ensuring proper handling, custody, and storage of field samples from the time of collection, to laboratory delivery, to final sample disposal. Indicate the number of days field samples and their extracts/digestates will be archived prior to disposal.

☐ Worksheet Not Applicable (State Reason)

Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): TBD/USA Environmental
Sample Packaging (Personnel/Organization): TBD/USA Environmental
Coordination of Shipment (Personnel/Organization): TBD/USA Environmental
Type of Shipment/Carrier: Air/FedEx
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Aaron Bindel/TestAmerica Denver
Sample Custody and Storage (Personnel/Organization): Aaron Bindel/TestAmerica Denver
Sample Preparation (Personnel/Organization): Erma Potruff and Doug Gomer/TestAmerica Denver
Sample Determinative Analysis (Personnel/Organization): Susan Decker and Richard Clinkscales/TestAmerica Denver
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): 1
Sample Extract/Digestate Storage (No. of days from extraction/digestion): 1
Biological Sample Storage (No. of days from sample collection): 0
SAMPLE DISPOSAL
Personnel/Organization: Adam Alban/TestAmerica Denver
Number of Days from Analysis: 5

QAPP_Worksheet_#27
(UFP-QAPP Manual Section 3.3.3)
Describe the procedures that will be used to maintain sample custody and integrity. Include examples of chain-of-custody forms, traffic reports, sample identification, custody seals, laboratory sample receipt forms, and laboratory sample transfer forms. Attach or reference applicable SOPs.

☐ Worksheet Not Applicable (State Reason)

Sample Custody Requirements

Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory): Sample kits will be received from laboratory in sealed containers. Seals will not be broken before use. Sample containers will be verified prior to use. Upon collection of samples, containers will be sealed and include seal labels to ensure integrity of seal. Shipping will be same day as collection including tracking information. Delivery to lab will be at earliest time (next day is actually 2 days)
Laboratory Sample Custody Procedures (receipt of samples, archiving, disposal): Chain of custody documentation will be completed. The chain of custody will be sealed within the containers with samples. Upon receipt by the lab, they will document receipt.
Sample Identification Procedures: Every sample will contain an individual label indicating the date, location, sample type, sampler, analysis and other pertinent information to properly identify the sample.
Chain-of-custody Procedures: See Laboratory Sample Custody Procedures

QAPP_Worksheet_#28

(UFP-QAPP Manual Section 3.4)

Complete a separate worksheet for each sampling technique, analytical method/SOP, matrix, analytical group, and concentration level. If method/SOP QC acceptance limits exceed the measurement performance criteria, the data obtained may be unusable for making project decisions.

☐ Worksheet Not Applicable (State Reason)

QC Samples Table

Matrix	Soil, Sediment, and Surfa
Analytical Group	Explosives
Concentration Level	Low
Sampling SOP	Refer to FSP
Analytical Method/ SOP Reference	8330B/8332/L-8
Sampler's Name	TBD
Field Sampling Organization	USA Environmental
Analytical Organization	TestAmerica Denver
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per prep batch (no > 20 samples per batch)	must be less than RL for analytes of interest or less than 10% of the analyte concentration found in associated samples, whichever is higher. (note: some programs require max blank concentration be less than ½ RL or less than 10% of lowest sample concentration.	if target analytes in blank exceed acceptance limits, samples must be re-extracted and re-analyzed. If MB acceptance criteria are not met and repreparation and reanalysis are nto possible, the sample data must be qualified.	Analyst / Section Supervisor	Quantitation Limits	No target compounds>1/2RL; no common lab contaminants >RL.
Instrument Blank	1 per 12 hours if method blank is not run	No target compounds>1/2RL; no common lab contaminants >RL.	If sufficient sample is available, reanalyze samples. Qualify data as needed. Report results if sample results >20x blank result or sample results ND.	Analyst / Section Supervisor	Accuracy/Bias	No target compounds>1/2RL; no common lab contaminants >RL.

QC Samples Table

Matrix	Soil, Sediment, and Surfa
Analytical Group	Explosives
Concentration Level	Low
Sampling SOP	Refer to FSP
Analytical Method/ SOP Reference	8330B/8332/L-8
Sampler's Name	TBD
Field Sampling Organization	USA Environmental
Analytical Organization	TestAmerica Denver
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
LCS	1 per batch (20 samples)	Refer to Attachment 1 for LCS control limits.	Outside of est. control limits, system is out of control and corrective action must occur. If above upper control limit, data may be reported w/ qualifiers. Other: batch must be re-prepared and re-analyzed.	Analyst / Section Supervisor	Accuracy/Bias	Laboratory % Recovery Control Limits
MS/MSD	1 per batch (20 samples)	Refer to Attachment 1 for MS control limits.	Determine root cause; flag MS/MSD data; discuss in narrative.	Analyst / Section Supervisor	Accuracy/Bias/Preci	Laboratory % Recovery / RPD Control Limits
Surrogate	Every sample, spike, standard, and blank	Control limits in LIMS or Clouseau	Check system, re-inject, re-extract	Analyst	Accuracy/bias	Laboratory % recovery control limits

QC Samples Table

Matrix	Soil, Sediment, and Surfa
Analytical Group	Explosives
Concentration Level	Low
Sampling SOP	Refer to FSP
Analytical Method/ SOP Reference	8330B/8332/L-8
Sampler's Name	TBD
Field Sampling Organization	USA Environmental
Analytical Organization	TestAmerica Denver
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Second-Column Confirmation	Every sample	RPD between confirmed results should agree within 40%	If interference exists between the two columns, use data from column w/o interference. If both columns have interference, report lower of 2 results with flags.	Analyst	Accuracy	RPD between confirmed results should agree within 40%

Refferences: Attachment 1, Laboratory SOP L7, L8, and Quality Assurance Manual Attachment 4

QC Samples Table

Matrix	Soil, Sediment, and Surfa
Analytical Group	Metals
Concentration Level	Low
Sampling SOP	Refer to FSP
Analytical Method/ SOP Reference	3010A/6010B
Sampler's Name	TBD
Field Sampling Organization	USA Environmental
Analytical Organization	TestAmerica Denver
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	**Data Quality Indicator (DQI)**	**Measurement Performance Criteria**
Method Blank	1 per batch (20 samples)	Should not contain any analyte of interest at or above the RL or at or above 10% of measured concentration of that analyte in associated samples	Blank and all associated samples in batch must be re-digested and reanalyzed	Analyst / Section Supervisor	Quantitation Limits	No target compounds>1/2RL; no common lab contaminants >RL.
Interference check solution	At the beginning of an analytical run	Within 20% of expected value	Terminate analysis; correct problem; reanalyze ICS; reanalyze all affected samples	Analyst	Accuracy	Interference check solution
Instrument Blank	1 per 12 hours if method blank is not run	No target compounds>1/2RL; no common lab contaminants >RL.	If sufficient sample is available, reanalyze samples. Qualify data as needed. Report results if sample results >20x blank result or sample results ND.	Analyst / Section Supervisor	Accuracy/Bias	No target compounds>1/2RL; no common lab contaminants >RL.

QC Samples Table

Matrix	Soil, Sediment, and Surfa
Analytical Group	Metals
Concentration Level	Low
Sampling SOP	Refer to FSP
Analytical Method/ SOP Reference	3010A/6010B
Sampler's Name	TBD
Field Sampling Organization	USA Environmental
Analytical Organization	TestAmerica Denver
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	**Data Quality Indicator (DQI)**	**Measurement Performance Criteria**
LCS	1 per batch (20 samples)	Refer to Attachment 1 for LCS control limits.	If LCS % recovery falls outside of control limits for any analyte, analyte is judged to be out of control. All samples must be reprocessed.	Analyst / Section Supervisor	Accuracy/Bias	Laboratory % Recovery Control Limits
RL Verification						
Serial Dilution	Each batch of samples	Analyte concentration is sufficiently high, analysis of a 1+4 dilution must agree within +/- 10% of the original determination	If 2 results do not agree within +/- 10%, interference is suspected. Qualifier flag is assigned	Analyst	Accurancy	none

QC Samples Table

Matrix	Soil, Sediment, and Surfa
Analytical Group	Metals
Concentration Level	Low
Sampling SOP	Refer to FSP
Analytical Method/ SOP Reference	3010A/6010B
Sampler's Name	TBD
Field Sampling Organization	USA Environmental
Analytical Organization	TestAmerica Denver
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Post Digestion spike	New or unusual sample matrix is encountered	Spike added should be recovered to within 75-125% of method 6010.	If spike is not recovered within limits, matrix effect is confirmed.	Analyst	Accuracy	none
Interference check	At beginning of run	Results must fall within 80-120% of true value	Reason documented. Data canot be accepted.	Analyst	Accuracy	none
Internal standards	Added to every solution tested	Falls within +/- 30% of counts observed	Samples must be diluted and reanalyzed; IS concentration raised, or different standard used	Analyst	Accuracy	none
MS/MSD	1 per batch (20 samples)	Refer to Attachment 1 for MS control limits.	Determine root cause; flag MS/MSD data; discuss in narrative.	Analyst / Section Supervisor	Accuracy/Bias/Precis	Laboratory % Recovery / RPD Control Limits
Post Digestion Spike Addition	When dilution test fails	Recovery within 25% of expected results	Correct problem then re-analyze post digestion spike addition	Analyst		

References: Attachment 1, Laboratory SOP L1, L3, and Quality Assurance Manual Attachment 4

QC Samples Table

Matrix	Soil, Sediment, and Surfa
Analytical Group	Mercury
Concentration Level	Low
Sampling SOP	Refer to FSP
Analytical Method/ SOP Reference	7470A
Sampler's Name	TBD
Field Sampling Organization	USA Environmental
Analytical Organization	TestAmerica Denver
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per batch (20 samples)	No target compounds>1/2RL; no common lab contaminants >RL.	If sufficient sample is available, reanalyze samples. Qualify data as needed. Report results if sample results >20x blank result or sample results ND.	Analyst / Section Supervisor	Quantitation Limits	No target compounds>1/2RL; no common lab contaminants >RL.
Instrument Blank	1 per 12 hours if method blank is not run	No target compounds>1/2RL; no common lab contaminants >RL.	If sufficient sample is available, reanalyze samples. Qualify data as needed. Report results if sample results >20x blank result or sample results ND.	Analyst / Section Supervisor	Accuracy/Bias	No target compounds>1/2RL; no common lab contaminants >RL.
LCS	1 per batch (20 samples)	Refer to Attachment 1 for LCS control limits.	If sufficient sample is available, reanalyze samples. Qualify data as needed.	Analyst / Section Supervisor	Accuracy/Bias	Laboratory % Recovery Control Limits

QC Samples Table

Matrix	Soil, Sediment, and Surfa
Analytical Group	Mercury
Concentration Level	Low
Sampling SOP	Refer to FSP
Analytical Method/ SOP Reference	7470A
Sampler's Name	TBD
Field Sampling Organization	USA Environmental
Analytical Organization	TestAmerica Denver
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
MS/MSD	1 per batch (20 samples)	Refer to Attachment 1 for MS control limits.	Determine root cause; flag MS/MSD data; discuss in narrative.	Analyst / Section Supervisor	Accuracy/Bias/Precis	Laboratory % Recovery / RPD Control Limits

References: Attachment 1, Laboratory SOP L4, L5, and Quality Assurance Manual Attachment 4

QAPP_Worksheet_#29

(UFP-QAPP Manual Section 3.5.1)

Identify the documents and records that will be generated for all aspects of the project including, but not limited to, sample collection and field measurement, on-site and off-site analysis, and data assessment.

☐ Worksheet Not Applicable (State Reason)

Project Documents and Records Table

Sample Collection Documents and Records	On-site Analysis Documents and Records	Off-site Analysis Documents and Records	Data Assessment Documents and Records	Other
Field Notes Chain-of-Custody Records Airbills Custody Seals Telephone Logs Corrective Action Forms	N/A	Sample Receipt, Custody, and Tracking Records Standard Traceability Logs Equipment Calibration Logs Sample Prep Logs Run Logs Equipment Maintenance, Testing, and Inspection Logs Corrective Action Forms Reported Results for Standards, QC Checks, and QC Samples Data Package Completeness Checklists Sample Disposal Records Telephone Logs Extraction/Clean-up Records Raw Data (stored on CD/DVD)	Field Sampling Audit Checklists Fixed Laboratory Audit Checklists Data Validation Reports Corrective Action Forms Telephone Logs	

QAPP_Worksheet_#30
(UFP-QAPP Manual Section 3.5.2.3)
Complete this worksheet for each matrix, analytical group, and concentration level. Identify all laboratories or organizations that will provide analytical services for the project, including on-site screening, on-site definitive, and off-site laboratory analytical work. If applicable, identify the subcontractor laboratories and backup laboratory or organization that will be used if the primary laboratory or organizations cannot be used.

☐ Worksheet Not Applicable (State Reason)

Analytical Services Table

Matrix	Analytical Group	Concentration Level	Sample Location/ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization (Name and Address, Contact Person and Telephone Number)	Backup Laboratory/Organization (Name and Address, Contact Person and Telephone Number
Soil/Sediment	Metals/Explosives	Low	TBD	L-3, L-4, L-8	28 calendar days	TestAmerica Laboratories, Debra Henderer, 4955 Yarrow Street, Arvada, CO 80002, (303) 736-0134	N/A
Surface Water	Metals/Explosives	Low	TBD	L-3, L-5, L-8	28 calendar days	TestAmerica Laboratories, Debra Henderer, 4955 Yarrow Street, Arvada, CO 80002, (303) 736-0134	N/A

QAPP_Worksheet_#31
(UFP-QAPP Manual Section 4.1.1)
Identify the type, frequency, and responsible parties of planned assessment activities that will be preformed for the project.

☐ Worksheet Not Applicable (State Reason)

Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (Title and Organizational Affiliation)	Person(s) Responsible for Responding to Assessment Findings (Title and Organizational Affiliation)	Person(s) Responsible for Identifying and Implementing Corrective Actions (CA) (Title and Organizational Affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (Title and Organizational Affiliation)
Laboratory Technical Systems Audit (if necessary)	Once, prior to sampling startup	Ext.	USAESCH	TBD, Project Chemsit, USAESCH	Debra Henderer, Customer Services Manager, TestAmerica	Debra Henderer, Customer Services Manager, TestAmerica	TBD, Project Chemsit, USAESCH
Field Sampling Technical Systems Audit	Once, at sampling startup	Int.	USA Environmental	TBD, UXOQCS, USA Environmental	TBD, Field Sampling Team Leader, USA Environmental	TBD, Field Sampling Team Leader, USA Environmental	TBD, UXOQCS, USA Environmental

QAPP_Worksheet_#32

(UFP-QAPP Manual Section 4.1.2)

For each type of assessment describe procedures for handling QAPP and project deviations encountered during the planned project assessments.

☐ Worksheet Not Applicable (State Reason)

Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Organization)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Name, Title, Org.)	Timeframe for Response
Laboratory Technical Systems Audit (if necessary)	Written Audit Report	Charles O'Bryan, QA manager, RTI Laboratories	48 hours after audit	Letter	David Howell, Director, Federal Programs, RTI Laboratories	3 days after notification
Field Sampling Technical Systems Audit	Written Audit Report	Doug Ralston, Project Manager, USA Environmental	24 hours after audit	Letter	Teresa Rottero, Project Chemist, USA Environmental	24 hours after notification

QAPP_Worksheet_#33

(UFP-QAPP Manual Section 4.2)

Identify the frequency and type of planned QA Management Reports, the projected delivery date, the personnel responsible for report preparation, and the report recipients.

☐ Worksheet Not Applicable (State Reason)

QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Laboratory Technical Systems Audit Report (if necessary)	Once, prior to sampling startup	TBD	Robert Crownover, Quality Manager, USA Environmental	Doug Ralston, Project Manager, USA Environmental; Spencer O'Neal, Project Manager, USAESCH
Field Sampling Technical Systems Audit Report	Once, at start of sampling	TBD	Robert Crownover, Quality Manager, USA Environmental	Spencer O'Neal, Project Manager, USAESCH
Data Usability Assessment Report	Once, after all data are generated and validated	TBD	Doug Ralston, Project Manager, USA Environmental	Spencer O'Neal, Project Manager, USAESCH
Final RI/FS Report	Once, after completion of risk assessment	TBD	Doug Ralston, Project Manager, USA Environmental	Spencer O'Neal, Project Manager, USAESCH; Daphne Ross, Project Manager, USACE Jacksonville District

QAPP_Worksheet_#34

(UFP-QAPP Manual Section 5.2.1)

Describe the processes that will be followed to verify project data. Verification inputs include items such as those listed in Table 9 of the UFP-QAPP Manual (Section 5.1). Describe how each item will be verified, when the activity will occur, and what documentation is necessary, and identify the persons responsible. *Internal* or *external* is in relation to the data generator.

☐ Worksheet Not Applicable (State Reason)

Verification (Step I) Process Table

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
Chain-of-custody and shipping forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain-of-custody should be initialed by the reviewer, a copy of the chain-of-custody retained in the site file, and the original and remaining copies taped inside the cooler for shipment.	Int.	UXOQCS, USA Environmental
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If corrective actions are required, a copy of the documented corrective action taken will be attached to the appropriate audit report in the site file. At the beginning of each week, and at the completion of the site work, site file audit reports will be reviewed internally to ensure that all appropriate corrective actions have been taken and that corrective action reports are attached. If corrective actions have not been taken, the SUXOS will be notified to ensure action is taken.	Int.	UXOQCS, USA Environmental
Field Notes	field notes will be reviewed internally and placed in the site file. A copy of the field notes will be attached to the final report.	Int.	UXOQCS, USA Environmental
Laboratory Data	All laboratory data packages will be verified by the laboratory performing the work for completeness and technical accuracy prior to submittal.	Ext.	Karen Kuoppala, TestAmerica Laboratories
Laboratory Data	All laboratory data packages will be verified externally according to the data validation procedures specified Worksheets #35 and #36.	Ext.	Stella Cuenco, Laboratory Data Consultants

QAPP_Worksheet_#35

(UFP-QAPP Manual Section 5.2.2)

Describe the processes that will be followed to validate project data. Validation inputs include items such as those listed in Table 9 of the UFP-QAPP Manual (Section 5.1). Describe how each item will be validated, when the activity will occur, and what documentation is necessary and identify the person responsible. Differentiate between steps IIa and IIb of validation.

☐ Worksheet Not Applicable (State Reason)

Validation (Steps IIa and IIb) Process Table

Step IIa/IIb	Validation Input	**Description**	**Responsible for Validation (Name, Organization)**
IIa	SOPs	Ensure that all sampling and analytical SOPs are followed.	Stella Cuenco, Laboratory Data Consultants
IIa	Documentation of Method QC Results	Establish that all method required QC samples were run and met required limits.	Stella Cuenco, Laboratory Data Consultants
IIa	Raw Data	10% review of raw data to confirm laboratory calculations.	Stella Cuenco, Laboratory Data Consultants
IIb	Documentation of QAPP QC Sample Results	Establish that all QAPP required QC samples were run and met required limits.	Stella Cuenco, Laboratory Data Consultants
IIb	Project Quantitation Limits	All sample results met the project quantitation limit specified in the QAPP	Stella Cuenco, Laboratory Data Consultants

QAPP_Worksheet_#36

(UFP-QAPP Manual Section 5.2.2)

Identify the matrices, analytical groups, and concentration levels that each entity performing validation will be responsible for, as well as criteria that will be used to validate those data.

☐ Worksheet Not Applicable (State Reason)

Validation (Steps IIa and IIb) Summary Table

Step IIa/IIb	**Matrix**	**Analytical Group**	Concentration Level	**Validation Criteria**	**Data Validator (title and organizational affiliation)**
IIa	All	Metals/Explosives	Low	Check compliance with methods and procedures in the MC SAP.	Stella Cuenco, Laboratory Data Consultants
IIb	All	Metals/Explosives	Low	Worksheets #12 and #15 DoD QSM (Current Version) for any gaps in the QAPP. USACE 200-1-10, Guidance for Evaluation Performance Based Data (June 2005) National Functional Guidelines for Inorganic Data Review (EPA, 2004) National Functional and Guidelines for Organic Data Review (EPA, 2008) for application of professional judgement.	Stella Cuenco, Laboratory Data Consultants

QAPP_Worksheet_#37

(UFP-QAPP Manual Section 5.2.3)

Describe the procedures/methods/activities that will be used to determine whether data are of the right type, quality, and quantity to support environmental decision-making for the project. Describe how data quality issues will be addressed and how limitations of the use of the data will be handled.

☐ Worksheet Not Applicable (State Reason)

Usability_Assessment

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used: The Usability Assessment will involve examination of each of the Project Quality Objectives (PQOs) presented on Worksheet #12 to determine if the objective was met. This examination will include a combined overall assessment of the results of each analysis pertinent to an objective. Each analysis will first be evaluated separately in terms of the major impacts observed from the Data Validation, Data Quality Indicators, and measurement performance criteria assessments. Based on the results of these assessments, the quality of the data will be determined. Based on the quality determined, the usability of the data for each analysis will be determined. Based on the combined usability of the data from all analyses for an objective, it will be determined if the PQO was met and whether project action limits were exceeded.
Describe the evaluative procedures used to assess overall measurement error associated with the project: The following items will be assessed and conclusions drawn based on their results: Precision – For each duplicate pair, the relative percent difference (RPD) will be calculated for each analyte whose original and duplicate values are both greater than or equal to the quantitation limit. The RPDs will be checked against the measurement performance criteria presented on Worksheet #12. The RPDs exceeding criteria will be identified on the tables. Additionally, the RPD of each analyte will be averaged across all duplicate pairs whose original and duplicate values are both greater than or equal to the quantitation limit, and the combined overall average RPD for each analysis will be calculated for the laboratory duplicates. A discussion will follow summarizing the results of the laboratory precision. Any conclusions about the precision of the analyses will be drawn and any limitations on the use of the data will be described. Accuracy/Bias – Results for all laboratory blanks, spikes, controls, and surrogates will be checked against the measurement performance criteria presented on Worksheet #12. Results for analytes that exceed criteria will be identified on the tables. A discussion will follow summarizing the results of the laboratory accuracy/bias. Any conclusions about the accuracy/bias of the analyses will be drawn and any limitations on the use of the data will be described. Sensitivity – Results for all laboratory fortified blanks will be checked against the measurement performance criteria presented on Worksheet #12 and cross-checked against the quantitation limits presented on Worksheet #15. Results for analytes that exceed criteria will be identified on the tables. A discussion will follow summarizing the results of the laboratory sensitivity. Any conclusions about the sensitivity of the analyses will be drawn and any limitations on the use of the data will be described.
Identify the personnel responsible for performing the usability assessment: A team of management and technical personnel from USA Environmental, including the PM, Project Chemist, Project Engineer, Risk Assessor, GIS Manager, and Quality Manager.
Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies: A summary of the results of the usability assessment will be presented in the final RI/FS Report.

Department of Defense
Environmental Data Quality Workgroup

DEVELOPMENT OF DEPARTMENT OF DEFENSE LABORATORY CONTROL SAMPLE CONTROL LIMITS

Final
May 2004

Acknowledgments

The study was overseen by the Quality Assurance Authors/Task Action Team (QAA/TAT) of the Department of Defense (DoD) Environmental Data Quality Workgroup (EDQW), which was composed of environmental chemists from each of the three DoD components (represented by Naval Sea Systems Command [NAVSEA], Air Force Center for Environmental Excellence [AFCEE], and the Army Corps of Engineers [USACE]). The study was performed with the cooperation of the American Council of Independent Laboratories (ACIL). The study team was composed of the QAA/TAT, ACIL members from the environmental testing laboratory community, and a contractor support team from Versar, Inc.

ACIL solicited and collected data from over 20 laboratories, then provided the data volunteered by the laboratories to DoD. DoD made all final decisions; however, ACIL provided input on the methodology and policy for setting and applying limits. This study would not have been possible without their support. In particular, the QAA/TAT would like to thank Richard Burrows, Charles Carter, Jack Farrell, Debra Henderer, Deb Loring, Tony Pagliaro, Jerry Parr, Michael Shepherd, John Webb, and Chuck Wibby

Representatives from EPA, DoD, and ACIL membership conducted an informal peer review on the LCS Study.

DoD LCS Study Team

Quality Assurance Authors/Task Action Team (current members):

William H. Batschelet, Ph.D., AFCEE
Chung-Rei Mao, Ph.D., U.S. Army Corps of Engineers
Fred McLean, NAVSEA
Pati Moreno, Naval Facilities Engineering Service Center
Jackie Sample, NAVSEA

Quality Assurance Authors/Task Action Team (former members):

Cheryl Groenjes, U.S. Army Corps of Engineers
Maj. W. Kevin Kuhn, AFCEE

Versar, Inc. (support team):

Sharon McCarthy, Ph.D.
Clem Rastatter
Nicole Weymouth

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EXECUTIVE SUMMARY

In 1999 the Department of Defense (DoD) Environmental Data Quality Workgroup (EDQW) initiated a study of laboratory control samples (LCSs) from commercial environmental laboratories that have shown good performance on work done for DoD.

The objectives of the study were twofold:

- To develop and publish LCS control limits (LCS-CLs) based on empirical data, which must be used by laboratories doing work for DoD.
- To establish objective benchmarks for analytical method performance to assist in evaluating the suitability of alternative methods.

The DoD LCS study focused on nine different analytical methods published in *Test Methods for Evaluating Solid Waste* (SW-846): semivolatiles 8270C, volatiles 8260B, herbicides 8151A, polynuclear aromatic hydrocarbons (PAHs) 8310, explosives 8330, pesticides 8081A, polychlorinated biphenyls (PCBs) 8082, metals 6010B, and mercury 7470A/7471A.

This report presents the outcome of the study and is organized into four major sections:

1. Purpose (Section 1.0): Briefly identifies the reasons DoD initiated the LCS study.
2. Background (Section 2.0): Describes the current use of LCSs in laboratories and DoD's goals and requirements for the study.
3. DoD LCS-CLs Development (Section 3.0): Presents the process DoD went through in developing the LCS-CLs, including a detailed description of the methodology, study findings, and analysis of policy issues.
4. DoD LCS-CLs Implementation (Section 4.0): Describes the final LCS-CL policy developed by DoD and presents the data tables. These tables are also published as quality requirements in the *Quality Systems Manual for Environmental Laboratories* (QSM) Version 2 (June 2002).

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DEVELOPMENT OF DEPARTMENT OF DEFENSE LABORATORY CONTROL SAMPLE CONTROL LIMITS

1.0 PURPOSE

As part of its charter to develop and coordinate environmental sampling and testing policy for the Department of Defense (DoD), the DoD Environmental Data Quality Workgroup (EDQW) developed the *DoD Quality Systems Manual for Environmental Laboratories* (QSM), of which Version 1 (October 2000) and Version 2 (June 2002) have now been published. As part of that work, the EDQW recognized the need for minimum objective standards against which laboratory and analytical method performance can be judged. They focused on the use of a particular quality control sample, the laboratory control sample (LCS), to provide a measure of analytical performance. DoD wished to set realistic and scientifically defensible targets for LCS recoveries based on the routine performance of commonly used methods. Their objectives were twofold:

- To develop and publish LCS control limits (LCS-CLs) based on empirical data, which must be used by laboratories doing work for DoD.
- To establish objective benchmarks for analytical method performance to assist in evaluating the suitability of alternative methods.

2.0 BACKGROUND

LCSs are used as quality control (QC) measures to establish and track intra-laboratory performance of the analytical system. The percent recovery of each spiked compound is compared with a range of acceptable recoveries (control limits) that are typically statistically calculated. Laboratories should establish in-house LCS-CLs annually. The control limits capture both systematic and random errors and serve as benchmarks against which analyst and instrument performance are measured. If the LCS recovery for any analyte in a particular batch of samples is outside the established limits for that analyte and method, then the batch results may be considered unacceptable, triggering corrective action as appropriate (e.g., reanalysis may be required). Unacceptable LCS recovery (i.e., LCS failure) is of great concern to both laboratories and DoD because of the cost and time associated with reanalysis. As currently implemented, the failure of a single compound in an LCS can constitute failure of the entire analytical batch.

> **Laboratory Control Samples** are clean matrices (e.g., reagent water or a clean solid such as sand, glass beads, or sodium sulfate) that have been spiked with a known quantity of a compound or group of compounds and are processed with every analytical batch of environmental samples. The percentage of the compound that is recovered in the analysis provides a measure of method accuracy. When analysis of the LCS is repeated, the standard deviation provides a measure of analytical precision.

2.1 Calculation of LCS Control Limits

According to the widely used *Test Methods for Evaluating Solid Waste* (SW-846 methods, Chapter 1, Section 4.4.2), analyte-specific control limits are calculated as 3 standard deviations around the mean.

$$CL = \overline{\chi} \quad \pm \quad 3SD$$

where:

CL = control limit

$\overline{\chi}$ = mean recovery of data set

SD = standard deviation of data set

Method 8000B of SW-846, *Determinative Chromatographic Separations*, suggests that the control limits should be generated from an LCS data set consisting of at least 15 to 20 data points for each analyte.

Prior to the DoD LCS study, laboratories generally either set their own control limits or met limits published in the *AFCEE Quality Assurance Project Plan* or in the method. Since most of the AFCEE QAPP limits and the method limits are based on a limited amount of data from a single laboratory, some laboratories voiced concerns that the limits do not reflect the true capabilities of the methods to recover analytes. Failure to meet these limits was costly to the laboratories (due to reanalysis) and to DoD (due to increased costs from laboratories for reanalysis and time delays).

2.2 DoD Goals and Data Requirements for the Study

DoD's goal when initiating the LCS study was to establish a consistent set of default LCS control limits to be used DoD-wide, in the absence of project-specific requirements. Key criteria for *developing* the LCS-CLs were that the limits be:

- Scientifically valid and statistically defensible.
- Based on actual laboratory data from laboratories that performed satisfactory work for DoD.
- Able to accommodate the variability that exists in the ways laboratories execute the methods.
- Based on SW-846 methods, since those methods are commonly used by DoD for the two largest programs that require the collection of analytical data — the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Resource Conservation and Recovery Act (RCRA).

Key requirements for *implementing* the LCS-CLs included the following:

- The default LCS-CLs would not take the place of project-specific limits that were based on site-specific information.
- The use of SW-846 methods as the basis for this study would not limit the use of alternative analytical methods, as appropriate. Instead, the LCS-CLs would provide objective benchmarks against which the adequacy of an alternative method could, in part, be evaluated.
- The complexity of implementation by the laboratories would be taken into account (e.g., no requirement for the bench chemist to manage multiple sets of limits that vary by analyte).

The DoD LCS study purposely included data from multiple laboratories. This approach was considered necessary in order to calculate control limits that encompassed the method-allowed variations in procedures routinely used by different laboratories. The goal was to establish LCS-

CLs that reflected routine performance by laboratories that performed well according to method specifications. Environmental laboratories that had passed an audit by one or more of the DoD components within the past 18 to 24 months were deemed to be “good performing,” and data submitted by those laboratories were considered to reflect routine method performance for good laboratories.

3.0 DoD LCS-CLs DEVELOPMENT

Development of DoD LCS-CLs involved establishing the statistical methodology, analyzing the results, and evaluating the policy implications.

3.1 Methodology

The study was conducted in two phases. During the pilot study, or Phase I, two different statistical methodologies for generating control limits were tested using multi-laboratory data for a single analytical method (SW-846 Method 8270C for semivolatile organic compounds). During Phase II, the selected statistical methodology was applied to multi-laboratory data for eight other SW-846 analytical methods, including volatile organic compounds 8260B, chlorinated herbicides 8151A, polynuclear aromatic hydrocarbons (PAHs) 8310, explosives 8330, organochlorine pesticides 8081A, polychlorinated biphenyls (PCBs) 8082, metals 6010B, and mercury 7470A/7471A.

Laboratories voluntarily provided data for the study according to data submittal instructions placed on the DoD DENIX website and distributed by ACIL (see Attachments 1 and 2 of Appendix A). Data were requested for target analytes routinely reported for DoD compliance and restoration programs (target analyte lists are found in the DoD QSM Version 2, Appendix DoD-C). Information submitted by each laboratory included the LCS sample ID number, analyte name, matrix type (solid or water), preparation/extraction methods, spike concentrations, and percent recovery.

For Phase I, 17 laboratories submitted data for 77 semivolatile target analytes. Data sets ranged from 74 to 435 data points per analyte. For Phase II, 16 laboratories submitted data for at least one of the eight methods. Data sets for the 162 total analytes ranged from 91 to 396 data points per analyte.

During Phase I of the study, the team divided the data into two groups, by laboratory: a test group, which went through every step of the proposed methodologies, and a control group. After the statistical methodology was selected, the data sets from both the test group and the control group were then compared with the control limits generated from the test group data. The comparisons demonstrated that overall failure rates were similar, without significant differences between the control group data and test group data. Therefore, the EDQW decided to use consolidated data sets and generate a single set of LCS-CLs for each analyte using the selected statistical methodology for both the 8270C method and the Phase II analytical methods.

The final statistical methodology used by the study team included analysis of variances (ANOVA) between different method-specific parameters, identification of outliers, calculation of mean and standard deviation, and calculation of control limits. Figure 1 presents a flow chart of the general methodology. The methodology is described in detail in Appendix A to this report; Attachment 3 to Appendix A presents the original methodology strategy for the study.

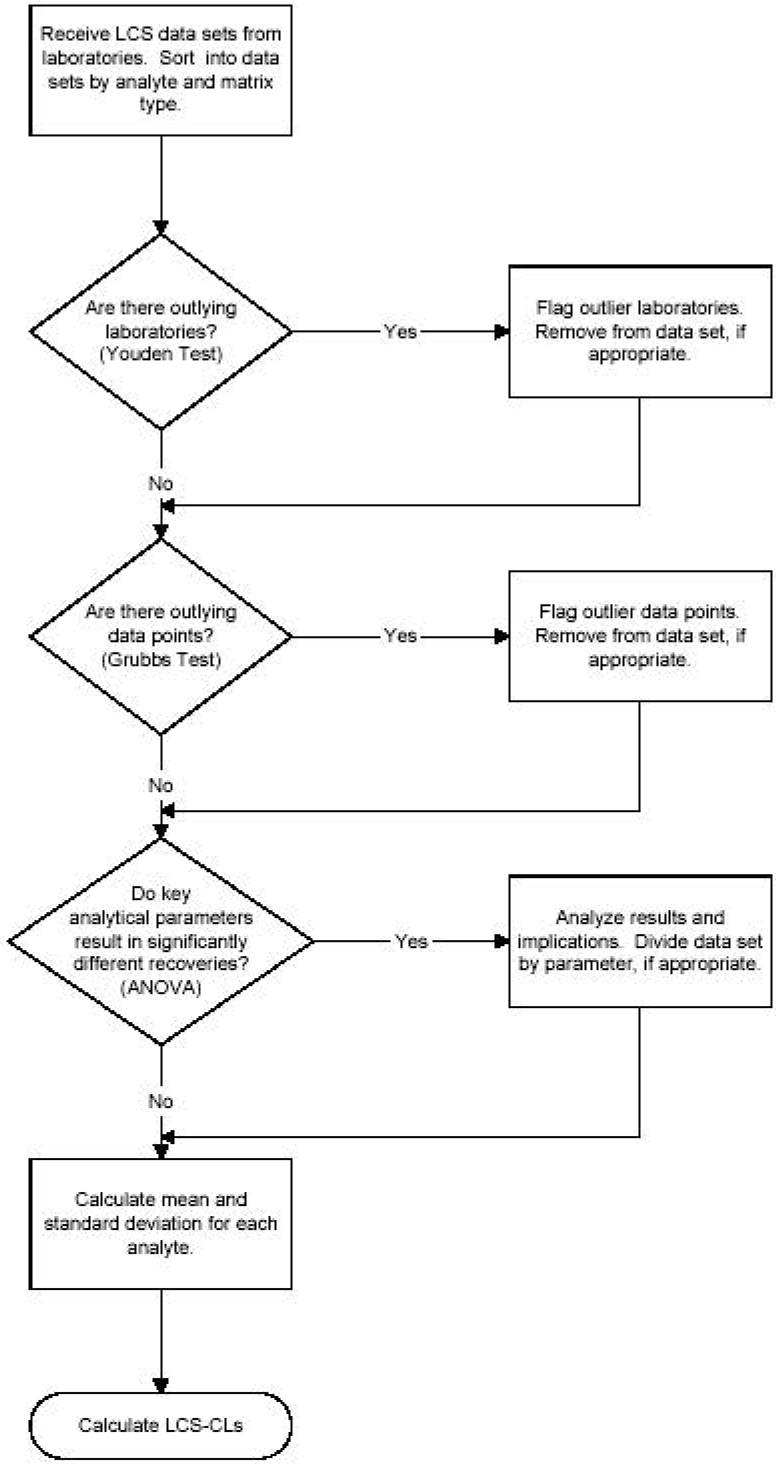

Figure 1. Statistical Methodology Flow Chart

3.2 Findings

This section presents the results of the primary study analyses and an evaluation of the effects of applying the calculated control limits to the data.

3.2.1 Summary of Findings

The study involved nine analytical methods, for both solid and water matrices, which resulted in more than 450 different analyte data sets. (Note: Data for solid and water matrices for the same analyte are counted as two different data sets.) The following is a summary of the limits generated using the selected methodology and an analysis of quantitative results:

- In general, mean recoveries were high, greater than 70% recovery for the majority (93%) of 454 total analytes.
- For organics, LCS recoveries were more variable, yielding higher standard deviations and, therefore, a high level of uncertainty.
- Not surprisingly, inorganics produced much better results. Means were near 100% with low standard deviations.

Figures 2 and 3 present the range of means, across analytes, for each of the nine analytical methods (solid and water matrix data, respectively). Mean recoveries are typically between 70 and 100%. The relative standard deviation (RSD) charts (Figures 4 and 5) demonstrate the varied precisions of the different methods across analytes. (Note: For the purposes of this report, high precision is defined by low RSD.) The figures use bar graphs that represent all of the data for a given method. The graphs are color-coded to show the percentage of compounds within that method that have low, medium, or high precision. Metals (methods 6010B and 7470A/7471A) have low RSD and high levels of precision, and herbicides (method 8151A) have medium to high RSD, therefore less precision. The mean, standard deviation, and lower and upper control limits for each analyte can be found in the tables at the end of this report.

General findings from further analysis of the data and methodology include the following:

- The outlier methodology (Youden/Grubbs), in almost all cases, lowered the standard deviation. In addition, outliers were typically biased high. Therefore, removing outliers lowered the resulting upper control limit by lowering both the mean and the standard deviation.
- Occasionally, significant differences were identified by the ANOVA test; however, the differences did not have a material effect on the calculation of the LCS-CLs with the exception of explosives method 8330 in water. In some cases, not enough data were available to conduct ANOVA, since many laboratories use the same parameter (e.g., extraction methods).
- The analysis of certain analytes by a specific analytical method resulted in such inconsistent performance that high standard deviations established lower control limits at or below 10%. These compounds were defined as poor performing analytes by DoD.
- The LCS-CLs were evaluated by comparing them with existing acceptance limits from alternative sources (benchmarks; see Section 3.2.5). This comparison demonstrated that the limits calculated in the study were comparable to or more stringent than most existing limits.

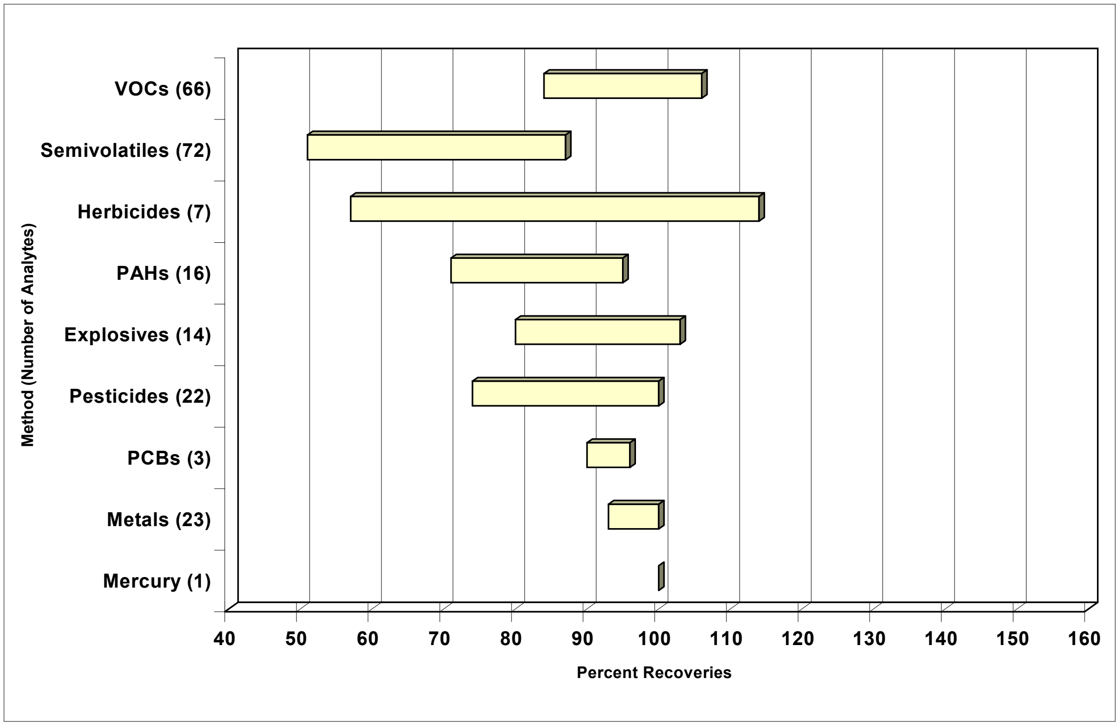

Figure 2. Range of Mean Recoveries in Solid*

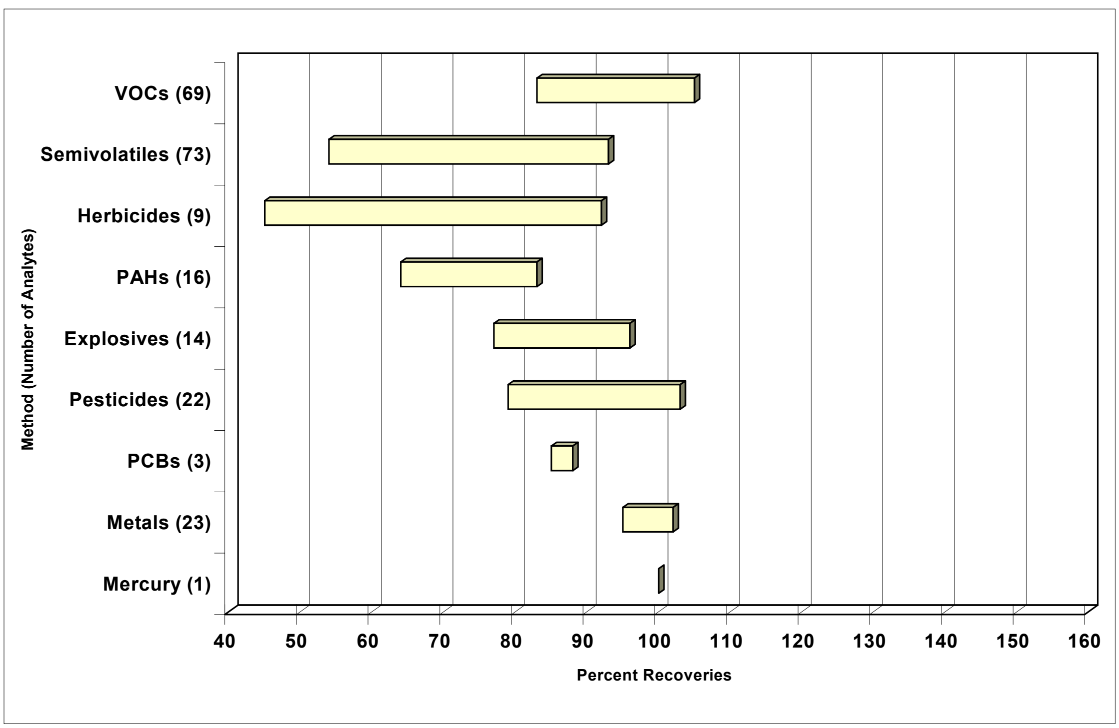

Figure 3. Range of Mean Recoveries in Water*

* The number of analytes varies between the solid and water matrices because of differences in the amount of data received from laboratories.

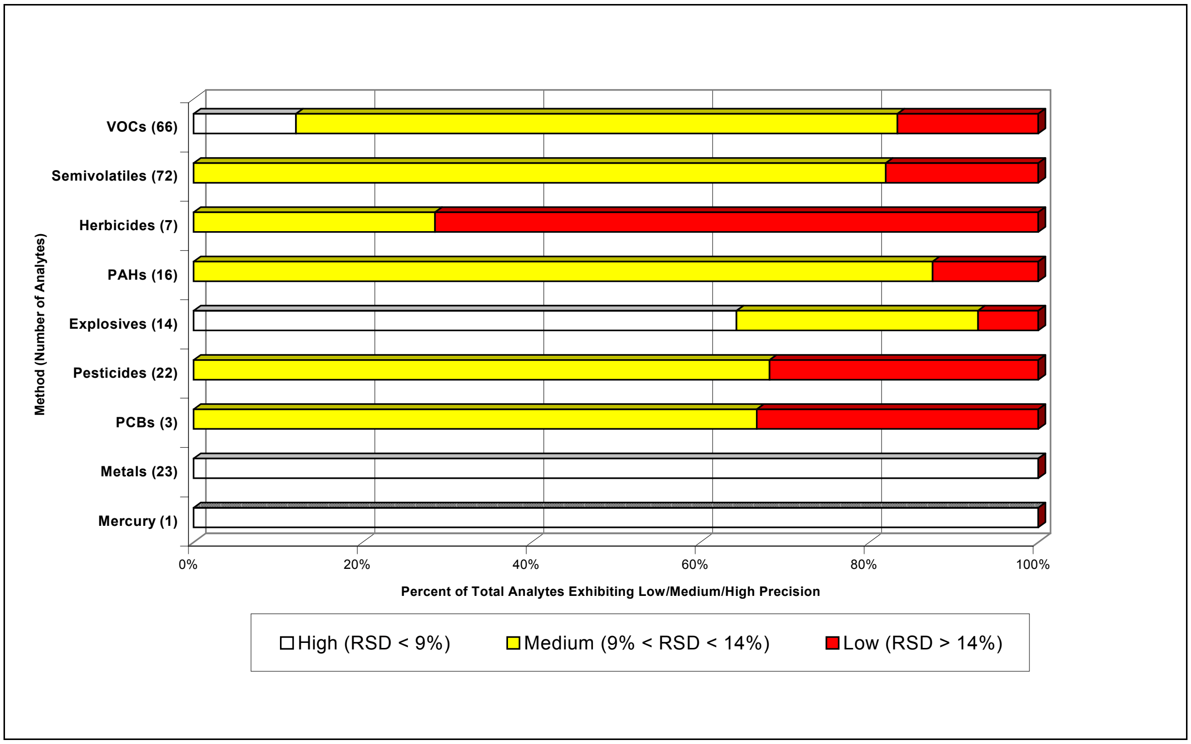

Figure 4. Precision of Methods in Solid*

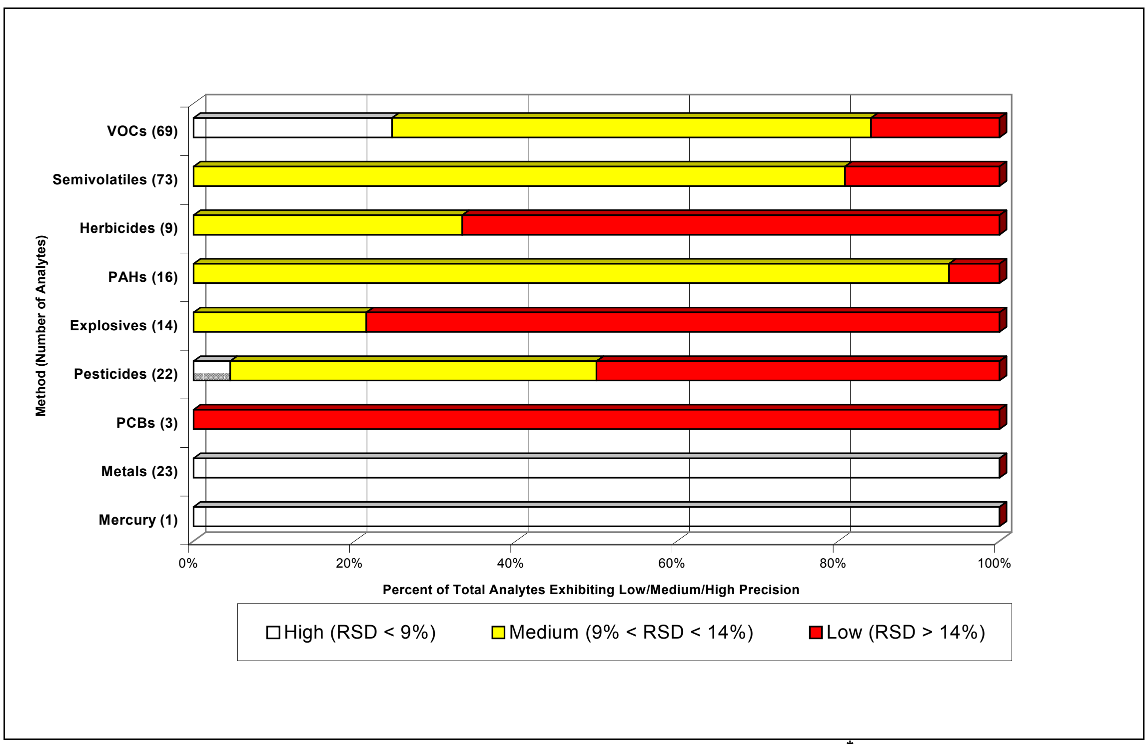

Figure 5. Precision of Methods in Water*

* The number of analytes varies between the solid and water matrices because of differences in the amount of data received from laboratories.

- Calculation of estimated failure rates where one or more of the analytes were outside the LCS-CLs demonstrated that failure was more likely at the upper limit.
- Estimated failure rates showed that LCS failure is statistically more likely with longer lists of analytes.

3.2.2 Effects of Outlier Removal

The selected methodology called for identification of outliers using the Youden test and the Grubbs test. Most outliers were identified using the Youden test. Because the Youden test excluded data for a particular analyte from an entire laboratory, often the study identified a large number of data points as outliers. A laboratory's data set was identified as a Youden outlier for various reasons. In some cases the outlier laboratories had consistently higher or lower recoveries than the other laboratories. In other cases the outlier laboratories' recoveries were more tightly clustered than the other laboratories'.

Analysis of the effect of outlier removal on the LCS-CLs led to the conclusion that lower standard deviations were usually achieved when outliers were removed. In two-thirds of the cases, a lower mean also resulted (often only one or two points). However, the effect on control limits of a change in standard deviation was 6 times as great as a change in mean (i.e., the standard deviation is multiplied by 3 on both the upper and lower ends). Therefore, the slightly lower means were considered acceptable by DoD, since the overall effect of outlier removal was tighter control limits.

3.2.3 ANOVA Results

Analysis of the variance in method parameters could result in several outcomes:

- Multiple sets of LCS-CLs based on a particular parameter (e.g., spiking level, preparation/extraction method).
- LCS-CLs based only on the parameter that produced a "better" result (e.g., higher and tighter recoveries).
- LCS-CLs based on all data if no significant difference in recoveries was identified.

As the ANOVA results were being reviewed, it became apparent that compelling evidence was needed to justify the creation of multiple control limits for the same analyte. First of all, LCS recoveries may not be indicative of the performance of the parameter in environmental samples. Second, multiple sets of control limits for a single analytical method would be too confusing for laboratories to manage at the bench. Third, the methods allow laboratories to make choices in implementation. These choices may have cost and time implications or may be appropriate for achieving the level of data quality necessary for decision-making (e.g., selection of a particular preparation method). Finally, the identification of significant differences in ANOVA results may not always lead to significant differences in the generated LCS-CLs. DoD did not want to limit its or the laboratory's choices unless there was a significant benefit; therefore, although the use of different parameters resulted in some findings of statistically different recoveries, the LCS-CLs were calculated using entire data sets. The only exception was for explosives method 8330 in water.

For explosives method 8330, water matrix only, the ANOVA results demonstrated that there was a significant difference in recovery depending on the extraction method used. Solid phase extraction (SPE) using acetonitrile elution produced higher mean recoveries and considerably lower standard deviations than those of the alternative salting out extraction method. In addition, SPE is less expensive, cumbersome, and time and labor intensive than the alternative. As a result, the EDQW chose to set LCS-CLs for method 8330 (water matrix) using SPE data only. Because of the small number of laboratories in that data set (approximately 4, depending on the analyte), no outliers were removed prior to calculating the limits. This approach ensured that a reasonably sized, representative data set was used to generate the control limits. (Note: Laboratories may use any extraction method they feel is appropriate; however, the LCS recoveries must fall within the LCS-CLs generated with the SPE data.)

3.2.4 Poor Performing Analytes

After running all the data through the statistical methodology, the study team identified analytes that did not perform well with specific methods. DoD felt those analytes needed to be addressed because of the high level of uncertainty in their results. DoD defined those poor performing analytes as analytes with lower LCS-CLs of 10% or less. They typically have low mean recoveries and high standard deviations, resulting in wide LCS-CLs. (Note: Although the term "poor performing analytes" is used, DoD is aware that this is a reflection of the analytical system as routinely implemented and not an indictment of the laboratories' performance.)

The EDQW discussed extensively the options for defining poor performing analytes (e.g., lower limit less than 10 or 20%, mean less than 70%). They looked at scatter plots and found that the poor performing analytes had high variability both within a given laboratory as well as across laboratories. As described in Section 3.2.6, estimation of failure rates after various adjustments to the limits demonstrated that raising lower limits above 10% increased failure rates (sometimes significantly). Raising the cutoff to 20% or higher would significantly increase the number of poor performing analytes, thereby eliminating from regular evaluation compounds frequently found at DoD sites. Eventually, a compromise was reached, and poor performing analytes were defined as those analytes with a statistically generated lower control limit of 10% or less.

The decision to use 10% was a means of letting the data speak for themselves and not accepting extremely low recoveries. The purpose of the LCS study was to evaluate routinely achievable performance, not optimize performance for a particular problematic analyte or group of analytes. DoD did not want to penalize the laboratories or itself for the poor performance of the methods. In many cases the lower limit published in the SW-846 methods for the poor performing analytes was lower than 10% (sometimes nondetect or zero). However, DoD did not feel that extremely low recoveries should be considered acceptable and felt the issue should be addressed in some way.

Table 1 presents the poor performing analytes, as identified by a lower control limit of 10% or less. See Section 4.3 for an explanation of DoD's policy on addressing poor performing analytes.

Table 1. Poor Performing Analytes

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
8270C Water:				
4-Nitrophenol	54.3	23.0	0	123
Benzoic acid	54.9	24.0	0	127
Phenol	55.9	19.9	0	116
Phenol-d5/d6 (surrogate)	62.6	18.0	9	117
8270C Solid:				
3,3'-Dichlorobenzidine	68.9	19.6	10	128
4-Chloroaniline	51.0	14.2	8	94
Benzoic acid	55.7	18.7	0	112
8151A Solid:				
Dinoseb	57.3	50.9	0	210
8330 Solid:				
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	80.2	23.3	10	150

3.2.5 Comparison with Benchmarks

One step in analyzing the effects of the methodology on the calculated control limits was to compare the LCS-CLs that were statistically generated in this study with a variety of benchmarks, including the following:

- The laboratory's in-house limits (as provided by the laboratories that submitted data for the study)
- The method limits (when available)
- AFCEE published limits
- Proficiency testing (PT) acceptance limits for water (calculated using regression constants from EPA's National Standards for Water Proficiency Testing Studies)
- Limits from the USACE Quality Assurance Laboratory in Omaha, Nebraska

The findings of this comparison varied by method, but in the majority of cases the upper control limits generated in this study were more stringent (i.e., lower) than the benchmark upper limits. The comparison of lower control limits produced mixed results. For the most part, the lower limits in this study were more stringent than the PT limits; however, in only half the cases were they more stringent than the limits published in the methods. Since method limits were calculated using extremely limited data (i.e., from a single laboratory), the LCS study data was considered more typical of laboratory performance and therefore more appropriate to use.

3.2.6 Estimation of Failure Rates

The EDQW was concerned about the effects of the new control limits on laboratory LCS failure rates. They approached the study with an understanding that several key factors drive the capabilities of the analytical system:

- The methods themselves are far from perfect. As documented in many of the published methods, the anticipated lower control limits for LCS recoveries of certain analytes approach zero percent.
- LCS failure can occur as a result of both random and systematic problems. When analyzing a list of analytes, there is a statistical probability that one or more of the

analytes will fail to meet acceptance criteria due to random errors that are beyond the control of the laboratory. Although they raise a level of concern, these random failures do not reflect the laboratory's implementation of the method.
- A significant increase in the failure rate beyond what already occurs under the existing approaches to LCSs would have negative cost implications for both the laboratory and DoD.

To test the limits' effect on laboratory LCS failures, the LCS-CLs were applied to the individual LCS results submitted for the study. If one or more analytes exceeded the LCS-CLs (less than the lower limit or greater than the upper limit), the LCS failed and corrective action would be required for the batch of environmental samples. Estimated failure rates were first calculated using the limits generated in the study and the definition of failure described above. Table 2 presents total failure rates for all laboratories, as well as failure rates when the lower and upper limits were considered separately. (Note: It is possible for a single LCS to fail as a result of separate analytes failing the lower limit and the upper limit. Consequently, the sum of the lower limit and upper limit failures may be greater than the total number of failures.)

Table 2. Baseline LCS Failure Rates

	Failure Rates – Solid Matrix			Failure Rates – Water Matrix		
Method	**Total (%)**	**Lower Limit (%)**	**Upper Limit (%)**	**Total (%)**	**Lower Limit (%)**	**Upper Limit (%)**
Semivolatiles (8270C)	18	4	15	28	14	14
Volatiles (8260B)	22	6	19	15	6	10
Herbicides (8151A)	24	6	19	16	6	10
PAHs (8310)	28	5	23	9	2	8
Explosives (8330)	13	9	6	14	7	6
Pesticides (8081A)	24	14	14	18	11	8
PCBs (8082)	9	6	3	5	3	2
Metals (6010B)	21	8	15	11	7	4
Mercury (7470A/7471A)	2	1	1	1	0	1

Analysis of the baseline failure rates demonstrated that more LCS failures were caused by exceedance of the upper control limits than exceedance of the lower control limits and therefore are more likely to result in unnecessary actions (false positives) than in not enough action. Failure rates sometimes varied significantly by laboratory. For some methods, only a handful of laboratories accounted for most of the failures. Failure rates for in-house control limits (each laboratory's data compared with the in-house limits it provided for the study) showed that laboratories were generally less likely to fail using their own limits than using the limits generated by the study. This is not surprising considering that the in-house limits should be generated using historical data from that laboratory. Laboratories having more variability in LCS recoveries generate wide limits within which their data could fall. However, not all laboratories that submitted data for the study generated in-house limits using historical data. Some laboratories appear to have adopted AFCEE published limits or arbitrarily set limits, such as 80 to 120% for all analytes.

After determining the baseline failure rates, the study team performed numerous additional analyses to evaluate the effects of modifying the manner in which LCS limits were set and applied. This analysis varied (1) the manner in which the LCS limits were set (e.g., lower limits raised to 10 or 20%) and (2) the manner in which LCS limits were applied (e.g., the definition of failure of an LCS to allow for sporadic marginal exceedances of limits).

Some of the adjustments of the limits included raising the lower limits (to 10, 20, and 50%), raising the upper limits (to 100, 110, and 120%), and setting limits at 2 standard deviations around the mean instead of three. Adjusting the definition of failure included multiple variations of the marginal exceedance approach (allowing a certain number of analytes to marginally exceed the LCS-CLs based on the total number of analytes spiked in the LCS). Failure rates increased when raising the lower limit and decreased when raising the upper limit. Adjusting the upper limit usually had less effect on failure rates than adjusting the lower limit, since failures of the upper limit tended to be by larger amounts (i.e., greater than 120%). However, adjusting the upper limits affected more compounds. Modifying the definition of failure always decreased failure rates from the baseline, since more than one failed analyte was allowed. The amount of change in failure rates varied depending on the number of allowances. Section 4.0 discusses adjustments in how the limits were set and the final approach for determining failures.

3.3 Establishing DoD LCS-CLs

When DoD initiated the project to establish LCS-CLs, it determined that any decisions to come out of the study would be based on sound science. However, since these final decisions represent DoD-wide policy, they had to be tempered with scientific insight. With that in mind, once the statistically generated limits were determined, a number of issues were considered as to how the LCS-CLs would be both set and applied. These factors reflect the following considerations:

- The LCS-CLs should be used to identify blunders and generally not to penalize laboratories for random out-of-control events.
- Given the variability within the laboratory community and the fact that the data reflect analytical practice at a given point in time, the study results are not necessarily predictive of future laboratory performance. However, understanding potential LCS and analytical batch failure rates is critically important to policy development. Unwarranted increases in failure rates (i.e., those associated with random failures) could lead to excessively penalizing the laboratory and DoD for factors out of their control.
- Failure rates based on the application of LCS-CLs to default lists of analytes may be different from those resulting from the application of LCS-CLs to individual analytes identified as project-specific target analytes.
- High levels of variability (as measured by wide standard deviations) can be associated with entire methods or specific analytes.
- Implementation of the DoD-wide LCS-CLs by commercial laboratories should minimize complexity.
- The LCS policy should encourage laboratories to maintain or improve performance beyond the default limits.

3.3.1 <u>Statistical Probabilities of Random and Nonrandom Failures</u>

Random error during laboratory analysis is inevitable. Given the complexity of the analytical methods, there is a finite probability that an LCS result will fall outside the LCS-CLs as a result of random error. By spiking multiple analytes in a single LCS, the probability of LCS failures due to random error is compounded, and the chance that one or more of the analytes will not meet acceptance criteria increases. DoD does not accept the results of an analytical batch when its associated LCS has failed; however, DoD does not want to penalize laboratories for random events beyond their control. At the same time it seeks to minimize the acceptance of LCSs that reflect systematic problems over which the laboratory should have control. This issue can be framed by two questions:

1. What is the likelihood that failure of the LCS is due to the random occurrences that are out of the laboratory's control?
2. What is the likelihood that failure is due to nonrandom events (e.g., systematic errors or blunders) that the laboratory does have some control over?

Probability theory using a binomial distribution indicates that the chance for a random event increases as the number of trials increases. For an LCS with multiple analytes, each analyte would be considered a separate trial. The Army Corps of Engineers has a system in place for allowing a certain number of analytes to fail based on the number of analytes in the LCS. The EDQW agreed with the concept and performed multiple statistical analyses to determine the maximum allowable number of failed analytes.

After analyzing the results, DoD chose to set the allowable number of failures at 5% of the total number of analytes. This is a straightforward yet still conservative approach that is based on professional judgment. Table 4 in Section 4.2 presents the final number of allowable failures versus the number of analytes in the LCS.

3.3.2 Evaluation of Adjustments to Limits and Application

As described in Section 3.2.6, the study team calculated LCS failure rates for a baseline scenario (statistically generated limits using the standard definition of failure) as well as for a variety of scenarios involving modifications to how the limits were set and how failure was defined.

3.3.2.1 Setting the Limits

Adjustments to the limits reflected the following concerns:

- Excessively low lower control limits could result in a low bias and lead to false negatives (and potential risks to human health and the environment). This concern was addressed by the poor performing analyte concept discussed in Section 3.2.4.
- Excessively high upper control limits could allow a high bias and lead to false positives (and thus unnecessary expense to DoD); however, high bias was generally not a problem in this study.
- Control limits in which the upper limit was less than 100% could in effect penalize laboratories for good performance. Producing the correct recovery (100%) would result in failure of the LCS.
- There was no benefit in requiring laboratories to achieve LCS acceptance criteria that were more stringent than method-defined acceptance criteria, if the method limits were already sufficiently stringent.

The EDQW discussed the advantages and disadvantages of adjusting the statistically generated limits. They considered whether the limits should be arbitrarily modified or whether the data should be allowed to speak for themselves, thereby identifying where improvements in the methods need to be made. Ultimately the EDQW struck a balance by:

- Generally keeping the LCS-CLs close to those generated by the statistical methodology; allowing exceptions only if supported by sound scientific rationale.

- Noting that if a project-specific analyte of concern has a level of variability and resulting LCS-CLs that are inadequate for the use of the data, the client should be contacted about the need for potential method optimization.
- Identifying certain analytes that are poor performing analytes, and noting that the client should be contacted about method optimization if data suggest that those analytes may be present at the site.

For herbicides method 8151A (both water and solid matrix) the intra-laboratory variability in recoveries was large for almost every analyte. The standard deviations were high, resulting in extremely wide control limits. Scatter plots for every compound were reviewed to confirm this variability. The EDQW chose to set control limits for method 8151A using nonparametric statistics. The control limits were based on 5th and 95th percentiles for each analyte (no outliers were removed). As described in Section 3.2.3, LCS-CLs for explosives method 8330 in water were based only on data that used solid phase extraction (SPE).

The EDQW decided to define poor performers as analytes with lower control limits of 10% or less and treat those analytes separately on a project-specific basis. They felt that it was inappropriate to control batch acceptance on analytes with lower control limits of 10% or less. However, artificially raising the lower limits from the statistically generated level did not address the problems of a method that produced extremely low or variable recoveries.

For inorganic compounds, the limits were adjusted to be at least 80 to 120%, consistent with the allowable acceptance criteria in proposed method 6010C.

All limits were rounded to the nearest 5% for ease of implementation.

3.3.2.2 Applying the Limits: Sporadic Marginal Exceedances

The study team also considered options for applying the LCS-CLs (i.e., defining LCS failure), recognizing that larger lists of analytes result in higher rates of random failures. Simple probability calculations (binomial statistics) predict that there is a finite chance that random errors will cause an analyte to fall outside the LCS-CLs, and that the chance will increase with the number of analytes. Thus, laboratories that include a long list of analytes in the LCS spike can be penalized in terms of higher LCS failure rates and the associated costs of repreparing and reanalyzing the samples. After evaluating the failure rates, the study team developed a marginal exceedance approach for calculating failure for methods with longer lists of analytes (see Section 4.2 for a complete explanation).

Allowing a certain number of analytes to exceed the control limits on the basis of analyte list length lessens the likelihood that laboratories will fail an LCS because of random error, while still maintaining acceptable data quality. Calculating failure rates using this approach resulted in lower failure rates than with the standard approach, with the greatest effect being on the methods with long lists of analytes (e.g., methods 8270C and 8260B). Table 3 summarizes the failure rates for each method using the final limits and final definition of failure: rounding the limits to the nearest 5%, adjusting limits to be at least as wide as 80 to 120% for inorganics, applying the marginal exceedance approach, and excluding poor performing analytes. (Note: The final policy specifies that project-specific requirements supersede all DoD-specified limits. In addition, the marginal exceedance policy cannot be used for any analytes specifically identified as project-specific analytes of concern.)

Table 3. LCS Failure Rates Using Final LCS Policy

Method	Failure Rates – Solid Matrix			Failure Rates – Water Matrix		
	Total (%)	Lower Limit (%)	Upper Limit (%)	Total (%)	Lower Limit (%)	Upper Limit (%)
Semivolatiles (8270C)	9	2	7	18	10	8
Volatiles (8260B)	13	2	11	8	4	5
Herbicides (8151A)	28	14	15	34	19	16
PAHs (8310)	19	4	15	5	1	4
Explosives (8330)	13	9	5	3*	3*	0*
Pesticides (8081A)	20	12	11	10	7	5
PCBs (8082)	9	6	3	5	3	2
Metals (6010B)	6	3	3	1	1	0
Mercury (7470A/7471A)	0	0	0	0	0	0

* Included only laboratories that used SPE preparatory method.

A comparison of the final failure rates with the baseline failure rates found that the total rate of expected failures decreased between 0 and 15 percentage points under the final policy, depending on the method. The one exception to this decrease was herbicides method 8151A, in which a nonparametric methodology was used to generate limits. The nonparametric methodology produced more stringent control limits than the standard methodology; therefore, it was more likely that recoveries would fall outside the limits (see Section 3.3.2.1). Failure rates actually increased from the baseline by 4 percentage points for solid and 18 percentage points for water. There was no change in failure rate for PCBs method 8082 because short analyte lists do not benefit from the marginal exceedance allowance, and failure rates for mercury method 7470A/7471A decreased only 2 and 1 percentage points (solid and water matrix, respectively) because of the widening of the limits to 80 to 120%.

Failure rates for in-house laboratory limits were generally comparable to the final policy rates. The most significant exception was for herbicides, where failure rates increased significantly under the final policy as a result of the more stringent limits from the nonparametric methodology.

4.0 DoD LCS-CLs IMPLEMENTATION

The EDQW developed a final approach regarding the setting and applying of LCS-CLs after substantial input from a variety of stakeholders. This approach is described in Appendix DoD-D of the QSM Version 2 and is summarized in this section.

4.1 Setting the Limits

The general approach to setting the control limits used 3 standard deviations around the mean, calculated after outliers had been removed. Limits were then rounded to the nearest 5% for ease of use. LCS-CLs for metals method 6010B and mercury methods 7470A/7471A were set at 80 to 120% if the statistically generated limits were within that range. If the statistically generated limits were outside 80 to 120% (e.g., silver in the solid matrix has a lower LCS-CL of 75%), the control limit remained at the statistically generated value. These values are consistent with the allowable LCS acceptance criteria in proposed method 6010C.

4.2 Applying the Limits: Allowance for Sporadic Marginal Exceedances

DoD redefined LCS failure in order to allow a number of sporadic marginal exceedances of the LCS-CLs. This policy reflects DoD's desire to not penalize laboratories for small random errors, while still identifying significant systematic errors. The number of exceedances is based on the total number of analytes spiked in the LCS. The number of allowable marginal exceedances is based on a policy decision that no more than 5% of the total number of analytes spiked in the LCS may exceed the DoD limits. This is a simple and conservative approach. Table 4 presents the allowable number of marginal exceedances for a given number of analytes in the LCS. The marginal exceedance limits were set at 4 standard deviations around the mean with a lower limit of at least 10%.

Table 4. Number of Marginal Exceedances

Number of Analytes in LCS	Allowable Number of Marginal Exceedances of LCS-CLs
> 90	5
71 – 90	4
51 – 70	3
31 – 50	2
11 – 30	1
< 11	0

A *marginal exceedance* is defined as beyond the LCS-CL but still within the marginal exceedance limits of 4 standard deviations around the mean. This outside boundary prevents a grossly out-of-control LCS from passing. Marginal exceedances are not allowed for analytes that are project-specific analytes of concern. DoD also requires that the marginal exceedances be sporadic (i.e., random). If the same analyte repeatedly exceeds the LCS-CL (e.g., 2 out of 3 consecutive LCSs), that is an indication that the problem is systematic and something is wrong with the measurement system. The source of error should be located and the appropriate corrective action taken.

Under this policy, failure of the LCS can occur several ways:

- Exceedance of an LCS-CL by any project-specific analyte of concern
- Marginal exceedance of the LCS-CLs by more than the allowable number of analytes
- Exceedance of the marginal exceedance limits by one or more analytes

4.3 Addressing Poor Performing Analytes

Laboratories are required to include all target analytes in the calibration standards, including the poor performing analytes. However, they should not apply LCS-CLs to the poor performing analytes when determining LCS acceptance. If one of the poor performing analytes identified in Table 1 is a project-specific analyte of concern, or if it is detected in the project samples, the laboratory should contact the client (DoD), who will then work with the laboratory on an appropriate course of action. Ideally, DoD and the laboratory will use an alternative method to test for the analyte (one that is known to produce higher recoveries) or else modify the original method to optimize conditions for the poor performing analyte. The lower control limit for alternative or modified methods must be greater than 10% to be considered acceptable. The LCS-CLs for the poor performing analytes generated in this study are provided as a benchmark against which laboratories may measure the effectiveness of alternative methods or modifications to the current methods.

4.4 Maintaining In-house LCS Limits

In keeping with current, accepted practices, laboratories should continue to maintain their own in-house LCS limits. These in-house limits must be consistent with the limits produced in the LCS study, where available. The laboratory should calculate in-house limits from its historical LCS data and monitor its performance through the use of control charts.

The laboratory's in-house limits should be used for several purposes:

- As part of the laboratory's quality control system, to evaluate trends and monitor and improve performance.
- To evaluate the effects of laboratory performance on environmental data quality, on a batch-specific basis. When a laboratory's in-house limits are outside the DoD control limits (upper or lower), the laboratory must include its in-house limits in the laboratory report, even if the LCS associated with the batch was within the DoD limits.
- To enable DoD to determine acceptability of a laboratory's overall performance. DoD may review the laboratory in-house limits and the associated trends reflected in control charts. If DoD deems the performance unacceptable, they may use the in-house limits as a basis for deciding to not use the laboratory until substantial improvement has occurred.

4.5 LCS-CLs

The LCS study used real-world data to demonstrate current method performance by environmental laboratories. The EDQW expects that laboratories will be able to routinely achieve the LCS-CLs. Project managers should incorporate the LCS-CLs in their quality assurance project plans, and laboratories can use the limits to benchmark alternative methods as part of a performance-based approach.

Tables 5 through 20 present the mean (or median), standard deviation, and control limits as generated by the DoD LCS policy (excluding rounding to the nearest 5%). Refer to Appendix DoD-D of the QSM Version 2 for the rounded LCS-CLs and marginal exceedance limits.

Table 5. LCS Control Limits for Volatile Organic Compounds
SW-846 Method 8260B Water Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
1,1,1,2-Tetrachloroethane	104.7	8.0	81	129
1,1,1-Trichloroethane	99.7	10.8	67	132
1,1,2,2-Tetrachloroethane	95.6	10.7	63	128
1,1,2-Trichloroethane	100.0	8.4	75	125
1,1-Dichloroethane	100.8	10.7	69	133
1,1-Dichloroethene	98.6	10.3	68	130
1,1-Dichloropropene	102.3	9.9	73	132
1,2,3-Trichlorobenzene	99.3	14.1	57	142
1,2,3-Trichloropropane	98.2	8.5	73	124
1,2,4-Trichlorobenzene	99.9	11.4	66	134
1,2,4-Trimethylbenzene	102.9	9.7	74	132
1,2-Dibromo-3-chloropropane	91.3	13.7	50	132
1,2-Dibromoethane	100.4	6.7	80	121
1,2-Dichlorobenzene	96.5	8.5	71	122
1,2-Dichloroethane	100.1	10.5	69	132
1,2-Dichloroethane-d4 (surrogate)	95.2	7.8	72	119
1,2-Dichloropropane	100.2	8.3	75	125
1,3,5-Trimethylbenzene	102.3	9.5	74	131
1,3-Dichlorobenzene	99.6	8.1	75	124
1,3-Dichloropropane	99.6	8.9	73	126
1,4-Dichlorobenzene	98.8	8.1	74	123
2,2-Dichloropropane	102.9	11.2	69	137
2-Butanone	91.0	19.7	32	150
2-Chlorotoluene	99.5	9.0	73	126
2-Hexanone	92.4	12.0	56	128
4-Bromofluorobenzene (surrogate)	97.6	7.1	76	119
4-Chlorotoluene	101.0	8.9	74	128
4-Methyl-2-pentanone	96.0	12.7	58	134
Acetone	90.7	17.2	39	142
Benzene	101.7	6.9	81	122
Bromobenzene	100.0	7.9	76	124
Bromochloromethane	97.3	10.6	65	129
Bromodichloromethane	98.2	7.5	76	121
Bromoform	98.6	9.9	69	128
Bromomethane	88.0	19.5	30	146
Carbon disulfide	99.7	20.8	37	162
Carbon tetrachloride	101.9	12.0	66	138
Chlorobenzene	101.8	6.9	81	122
Chlorodibromomethane	95.7	12.5	58	133
Chloroethane	98.6	12.1	62	135
Chloroform	99.6	12.2	63	136
Chloromethane	83.2	14.6	39	127

Table 5. LCS Control Limits for Volatile Organic Compounds SW-846 Method 8260B Water Matrix (continued)

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
cis-1,2-Dichloroethene	98.6	9.0	72	126
cis-1,3-Dichloropropene	100.3	10.3	69	131
Dibromofluoromethane (surrogate)	99.9	5.1	85	115
Dibromomethane	100.6	8.3	76	125
Dichlorodifluoromethane	93.0	20.6	31	155
Ethylbenzene	100.2	9.1	73	127
Hexachlorobutadiene	96.9	15.2	51	142
Isopropylbenzene	101.1	8.8	75	127
m,p-Xylene	102.3	8.7	76	128
Methyl tert-butyl ether	94.0	9.7	65	123
Methylene chloride	96.4	14.4	53	140
Naphthalene	96.1	14.0	54	138
n-Butylbenzene	102.6	11.3	69	137
n-Propylbenzene	100.5	9.4	72	129
o-Xylene	100.3	6.8	80	121
p-Isopropyltoluene	101.7	9.7	73	131
sec-Butylbenzene	99.6	9.2	72	127
Styrene	99.8	11.5	65	134
tert-Butylbenzene	99.4	9.8	70	129
Tetrachloroethene	96.3	17.6	44	149
Toluene	99.8	7.5	77	122
Toluene-d8 (surrogate)	101.6	6.1	83	120
trans-1,2-Dichloroethene	99.3	13.3	60	139
trans-1,3-Dichloropropene	97.7	14.8	53	142
Trichloroethene	98.7	9.4	70	127
Trichlorofluoromethane	102.7	14.6	59	146
Vinyl chloride	98.9	16.1	50	147

Table 6. LCS Control Limits for Volatile Organic Compounds
SW-846 Method 8260B Solid Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
1,1,1,2-Tetrachloroethane	99.7	8.6	74	125
1,1,1-Trichloroethane	100.5	10.9	68	133
1,1,2,2-Tetrachloroethane	92.5	13.0	54	131
1,1,2-Trichloroethane	94.9	10.9	62	127
1,1-Dichloroethane	99.0	8.7	73	125
1,1-Dichloroethene	100.2	11.8	65	136
1,1-Dichloropropene	102.2	10.8	70	135
1,2,3-Trichlorobenzene	97.5	11.7	62	133
1,2,3-Trichloropropane	96.7	11.2	63	130
1,2,4-Trichlorobenzene	97.6	11.0	65	131
1,2,4-Trimethylbenzene	100.0	11.8	65	135
1,2-Dibromo-3-chloropropane	87.4	15.7	40	135
1,2-Dibromoethane	97.1	9.1	70	124
1,2-Dichlorobenzene	96.6	7.4	74	119
1,2-Dichloroethane	104.3	10.8	72	137
1,2-Dichloropropane	95.0	8.1	71	119
1,3,5-Trimethylbenzene	98.9	11.4	65	133
1,3-Dichlorobenzene	98.1	8.7	72	124
1,3-Dichloropropane	99.8	7.8	76	123
1,4-Dichlorobenzene	98.5	8.9	72	125
2,2-Dichloropropane	100.6	11.3	67	134
2-Butanone	94.0	21.6	29	159
2-Chlorotoluene	98.5	9.9	69	128
2-Hexanone	96.7	16.4	47	146
4-Bromofluorobenzene (surrogate)	101.3	5.6	84	118
4-Chlorotoluene	99.8	8.8	73	126
4-Methyl-2-pentanone	97.2	16.6	47	147
Acetone	88.2	23.1	19	158
Benzene	99.4	8.8	73	126
Bromobenzene*	93.4	9.3	66	121
Bromochloromethane	99.4	9.3	71	127
Bromodichloromethane	99.8	9.4	72	128
Bromoform	96.5	13.4	56	137
Bromomethane	95.0	21.3	31	159
Carbon disulfide	102.7	18.7	47	159
Carbon tetrachloride	99.7	11.0	67	133
Chlorobenzene	98.9	8.1	75	123
Chlorodibromomethane	98.0	10.5	66	130
Chloroethane	98.3	19.6	39	157
Chloroform	98.0	8.7	72	124
Chloromethane	89.8	13.0	51	129

*Provisional limits – outlier analyses during the LCS study resulted in LCS-CLs generated with data from fewer than four laboratories.

Table 6. LCS Control Limits for Volatile Organic Compounds
SW-846 Method 8260B Solid Matrix (continued)

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
cis-1,2-Dichloroethene	96.2	9.7	67	125
cis-1,3-Dichloropropene	98.8	8.9	72	126
Dibromomethane	100.4	9.2	73	128
Dichlorodifluoromethane*	84.7	17.0	34	136
Ethylbenzene	100.5	8.8	74	127
Hexachlorobutadiene	97.8	14.9	53	142
Isopropylbenzene	103.0	8.8	77	129
m,p-Xylene	102.4	7.9	79	126
Methylene chloride	97.4	14.4	54	141
Naphthalene	83.5	14.4	40	127
n-Butylbenzene	101.1	12.2	65	138
n-Propylbenzene	99.0	11.9	63	135
o-Xylene	101.4	8.0	77	125
p-Isopropyltoluene	103.6	9.6	75	133
sec-Butylbenzene	97.2	11.5	63	132
Styrene	100.7	9.1	74	128
tert-Butylbenzene	98.8	11.1	65	132
Tetrachloroethene	103.0	11.9	67	139
Toluene	98.9	9.2	71	127
Toluene-d8 (surrogate)	100.3	5.3	84	116
trans-1,2-Dichloroethene	100.1	11.3	65	135
trans-1,3-Dichloropropene	95.8	10.4	65	125
Trichloroethene	100.5	7.8	77	124
Trichlorofluoromethane	105.6	26.9	25	186
Vinyl chloride	92.1	11.4	58	126

*Provisional limits – outlier analyses during the LCS study resulted in LCS-CLs generated with data from fewer than four laboratories.

Table 7. LCS Control Limits for Semivolatile Organic Compounds
SW-846 Method 8270C Water Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
1,2,4-Trichlorobenzene	71.7	11.6	37	107
1,2-Dichlorobenzene	67.3	11.4	33	102
1,2-Diphenylhydrazine	84.8	9.4	57	113
1,3-Dichlorobenzene	64.8	10.9	32	98
1,4-Dichlorobenzene	64.8	10.9	32	98
2,4,5-Trichlorophenol	79.7	10.3	49	111
2,4,6-Tribromophenol (surrogate)	82.9	13.6	42	124
2,4,6-Trichlorophenol	80.7	10.7	49	113
2,4-Dichlorophenol	76.3	9.6	48	105
2,4-Dimethylphenol	68.8	13.5	28	109
2,4-Dinitrophenol	75.8	20.6	14	138
2,4-Dinitrotoluene	84.3	11.2	51	118
2,6-Dinitrotoluene	82.7	11.3	49	117
2-Chloronaphthalene	76.5	9.3	49	104
2-Chlorophenol	71.3	11.4	37	106
2-Fluorobiphenyl (surrogate)	79.9	10.6	48	112
2-Fluorophenol (surrogate)	63.7	14.8	19	108
2-Methylnaphthalene	75.0	9.5	46	104
2-Methylphenol	73.3	11.7	38	109
2-Nitroaniline	81.8	11.2	48	115
2-Nitrophenol	75.8	12.4	39	113
3,3'-Dichlorobenzidine	65.2	15.3	19	111
3-Methylphenol/4-Methylphenol	71.3	13.0	32	110
3-Nitroaniline	72.6	17.7	19	126
4,6-Dinitro-2-methylphenol	84.9	15.0	40	130
4-Bromophenyl phenyl ether	82.9	10.2	52	113
4-Chloro-3-methylphenol	78.6	10.7	47	111
4-Chloroaniline	62.2	15.6	15	109
4-Chlorophenyl phenyl ether	80.6	10.3	50	111
4-Nitroaniline	77.2	13.7	36	118
Acenaphthene	77.6	10.1	47	108
Acenaphthylene	78.5	9.4	50	107
Anthracene	83.0	9.7	54	112
Benz(a)anthracene	82.7	8.9	56	109
Benzo(a)pyrene	81.3	9.5	53	110
Benzo(b)fluoranthene	81.8	12.1	45	118
Benzo(g,h,i)perylene	80.5	14.1	38	123
Benzo(k)fluoranthene	84.6	13.2	45	124
Benzyl alcohol	71.0	13.8	30	112
Bis(2-chlorethoxy)methane	76.2	10.2	46	107
Bis(2-chloroethyl)ether	73.3	12.3	37	110

Table 7. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270C Water Matrix (continued)

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
Bis(2-chloroisopropyl) ether	78.2	17.5	26	131
Bis(2-ethylhexyl) phthalate	84.2	14.0	42	126
Butyl benzyl phthalate	81.1	11.7	46	116
Carbazole	82.5	11.4	48	117
Chrysene	82.1	8.9	55	109
Dibenz(a,h)anthracene	84.7	14.1	42	127
Dibenzofuran	80.3	8.8	54	107
Diethyl phthalate	79.2	12.9	41	118
Dimethyl phthalate	75.9	16.9	25	127
Di-n-butyl phthalate	84.8	10.3	54	116
Di-n-octyl phthalate	87.4	16.6	37	137
Fluoranthene	85.2	10.4	54	116
Fluorene	80.6	10.3	50	112
Hexachlorobenzene	82.3	10.0	52	112
Hexachlorobutadiene	65.2	12.6	27	103
Hexachloroethane	60.9	11.1	28	94
Indeno(1,2,3-cd)pyrene	84.3	13.6	43	125
Isophorone	81.0	10.5	50	112
Naphthalene	70.8	10.5	39	102
Nitrobenzene	76.8	10.8	44	109
Nitrobenzene-d5 (surrogate)	76.0	11.8	41	111
N-Nitrosodimethylamine	67.9	14.1	26	110
N-Nitrosodi-n-propylamine	80.9	15.7	34	128
N-Nitrosodiphenylamine	79.6	10.6	48	111
Pentachlorophenol	77.6	13.3	38	117
Phenanthrene	84.0	11.0	51	117
Pyrene	88.6	13.2	49	128
Terphenyl-d14 (surrogate)	92.7	14.0	51	135

Table 8. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270C Solid Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
1,2,4-Trichlorobenzene	77.4	11.2	44	111
1,2-Dichlorobenzene	70.9	8.7	45	97
1,3-Dichlorobenzene	69.7	10.3	39	100
1,4-Dichlorobenzene	69.0	11.4	35	103
2,4,5-Trichlorophenol	80.1	10.4	49	111
2,4,6-Tribromophenol (surrogate)	80.9	15.1	36	126
2,4,6-Trichlorophenol	76.3	11.0	43	109
2,4-Dichlorophenol	77.2	10.9	45	110
2,4-Dimethylphenol	67.3	11.9	32	103
2,4-Dinitrophenol	72.6	20.0	13	132
2,4-Dinitrotoluene	82.0	11.4	48	116
2,6-Dinitrotoluene	80.2	10.7	48	112
2-Chloronaphthalene	75.2	9.9	45	105
2-Chlorophenol	74.7	10.3	44	106
2-Fluorobiphenyl (surrogate)	72.8	10.0	43	103
2-Fluorophenol (surrogate)	70.6	11.1	37	104
2-Methylnaphthalene	77.3	10.0	47	107
2-Methylphenol	71.7	10.6	40	104
2-Nitroaniline	81.0	12.2	44	118
2-Nitrophenol	76.2	11.5	42	111
3-Methylphenol/4-Methylphenol	73.9	10.9	41	107
3-Nitroaniline	68.8	13.8	27	110
4,6-Dinitro-2-methylphenol	83.1	18.0	29	137
4-Bromophenyl phenyl ether	81.7	11.8	46	117
4-Chloro-3-methylphenol	79.5	11.1	46	113
4-Chlorophenyl phenyl ether	79.6	10.7	47	112
4-Nitroaniline	73.6	13.1	34	113
4-Nitrophenol	77.0	20.2	17	138
Acenaphthene	77.3	10.3	46	108
Acenaphthylene	75.7	10.4	44	107
Anthracene	79.9	9.0	53	107
Benz(a)anthracene	81.6	9.8	52	111
Benzo(a)pyrene	80.7	10.3	50	111
Benzo(b)fluoranthene	79.7	11.4	45	114
Benzo(g,h,i)perylene	81.8	14.7	38	126
Benzo(k)fluoranthene	83.8	12.9	45	123
Benzyl alcohol	70.9	17.4	19	123
Bis(2-chlorethoxy)methane	75.5	10.9	43	108
Bis(2-chloroethyl) ether	71.1	11.2	38	105
Bis(2-chloroisopropyl) ether	68.4	15.7	21	115
Bis(2-ethylhexyl) phthalate	87.4	13.3	47	127
Butyl benzyl phthalate	86.4	12.3	49	123

Table 8. LCS Control Limits for Semivolatile Organic Compounds SW-846 Method 8270C Solid Matrix (continued)

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
Carbazole	80.4	12.3	44	117
Chrysene	82.6	9.9	53	112
Dibenz(a,h)anthracene	82.9	13.9	41	125
Dibenzofuran	77.1	8.8	51	103
Diethyl phthalate	82.2	10.6	50	114
Dimethyl phthalate	79.6	10.2	49	110
Di-n-butyl phthalate	83.2	9.1	56	110
Di-n-octyl phthalate	86.4	15.2	41	132
Fluoranthene	83.9	10.1	54	114
Fluorene	78.3	9.8	49	108
Hexachlorobenzene	82.5	11.7	47	118
Hexachlorobutadiene	78.2	12.9	40	117
Hexachloroethane	71.9	12.6	34	110
Indeno(1,2,3-cd)pyrene	79.7	13.8	38	121
Isophorone	77.0	11.4	43	111
Naphthalene	73.4	11.1	40	107
Nitrobenzene	77.2	11.9	41	113
Nitrobenzene-d5 (surrogate)	69.5	10.7	37	102
N-Nitrosodimethylamine	66.1	15.9	18	114
N-Nitrosodi-n-propylamine	76.8	12.3	40	114
N-Nitrosodiphenylamine	82.4	11.1	49	116
Pentachlorophenol	71.9	15.6	25	119
Phenanthrene	80.1	10.0	50	110
Phenol	69.7	10.2	39	100
Phenol-d5/d6 (surrogate)	71.0	10.2	40	102
Pyrene	84.4	12.8	46	123
Terphenyl-d14 (surrogate)	78.8	15.5	32	125

Table 9. LCS Control Limits for Chlorinated Herbicides SW-846 Method 8151A Water Matrix*

Analyte	Median	Lower Control Limit	Upper Control Limit
2,4-D	88	35	113
2,4-DB	99	44	132
2,4,5-T	83	34	112
2,4,5-TP (Silvex)	87	49	116
Dalapon	62	40	108
Dicamba	86	60	112
Dichloroprop	91	68	122
Dinoseb	65	21	97
MCPA	93	62	144

*LCS-CLs were generated using nonparametric statistics (see Section 3.3.2.1 for further explanation).

Table 10. LCS Control Limits for Chlorinated Herbicides SW-846 Method 8151A Solid Matrix*

Analyte	Median	Lower Control Limit	Upper Control Limit
2,4-D	88	36	144
2,4-DB	108	52	157
2,4,5-T	86	43	137
2,4,5-TP (Silvex)	90	46	125
Dicamba	90	56	110
Dichloroprop	99	77	138

*LCS-CLs were generated using nonparametric statistics (see Section 3.3.2.1 for further explanation).

Table 11. LCS Control Limits for Polynuclear Aromatic Hydrocarbons SW-846 Method 8310 Water Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
Acenaphthene	69.5	11.5	35	104
Acenaphthylene	73.7	13.2	34	113
Anthracene	76.9	11.8	41	112
Benzo(a)anthracene	80.7	10.5	49	112
Benzo(a)pyrene	79.4	11.3	45	113
Benzo(b)fluoranthene	81.6	10.3	51	112
Benzo(g,h,i)perylene	76.6	14.1	34	119
Benzo(k)fluoranthene	79.3	10.4	48	110
Chrysene	83.3	10.9	50	116
Dibenzo(a,h)anthracene	64.2	15.5	18	111
Fluoranthene	82.1	11.3	48	116
Fluorene	69.1	11.3	35	103
Indeno(1,2,3-cd)pyrene	79.6	10.8	47	112
Naphthalene	68.1	11.8	33	104
Phenanthrene	80.2	13.4	40	120
Pyrene	80.0	9.3	52	108

Table 12. LCS Control Limits for Polynuclear Aromatic Hydrocarbons SW-846 Method 8310 Solid Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
Acenaphthene	70.6	12.4	33	108
Acenaphthylene	72.8	13.4	33	113
Anthracene	86.1	13.0	47	125
Benzo(a)anthracene	78.0	9.3	50	106
Benzo(a)pyrene	86.5	15.4	40	133
Benzo(b)fluoranthene	89.3	10.7	57	121
Benzo(g,h,i)perylene*	84.6	10.4	53	116
Benzo(k)fluoranthene	84.5	12.2	48	121
Chrysene	87.0	10.7	55	119
Dibenzo(a,h)anthracene	80.8	11.4	47	115
Fluoranthene	88.2	15.6	41	135
Fluorene	76.4	10.1	46	107
Indeno(1,2,3-cd)pyrene	94.9	13.0	56	134
Naphthalene	79.9	10.5	48	111
Phenanthrene	91.2	11.5	57	126
Pyrene	82.3	11.0	49	115

* Provisional limits – outlier analyses during LCS study resulted in LCS-CLs generated with data from fewer than four laboratories.

Table 13. LCS Control Limits for Explosives
SW-846 Method 8330 Water Matrix*

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
1,3,5-Trinitrobenzene	101.5	12.6	64	139
1,3-Dinitrobenzene	102.5	18.4	47	158
2,4-Dinitrotoluene	97.6	12.3	61	135
2,6-Dinitrotoluene	98.5	12.7	60	137
2,4,6-Trinitrotoluene (TNT)	97.8	15.2	52	143
2-Amino-4,6-dinitrotoluene**	101.2	17.1	50	153
2-Nitrotoluene	88.1	15.0	43	133
3-Nitrotoluene	89.9	14.1	48	132
4-Amino-2,6-dinitrotoluene**	104.3	16.5	55	154
4-Nitrotoluene	90.2	14.0	48	132
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	106.3	18.3	51	161
Methyl-2,4,6-trinitrophyenylnitramine (Tetryl)**	97.9	25.2	22	174
Nitrobenzene	93.6	14.7	49	138
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	98.8	5.8	81	116

*LCS-CLs were generated with data using solid phase extraction with acetonitrile only, without removing outliers from the data set (see Section 3.2.3 for further explanation).
**Provisional limits – LCS-CLs were generated with data from fewer than four laboratories.

Table 14. LCS Control Limits for Explosives
SW-846 Method 8330 Solid Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
1,3,5-Trinitrobenzene	99.0	8.5	73	125
1,3-Dinitrobenzene	102.3	7.8	79	126
2,4-Dinitrotoluene	101.9	7.3	80	124
2,6-Dinitrotoluene	100.2	7.3	78	122
2,4,6-Trinitrotoluene (TNT)	98.5	13.8	57	140
2-Amino-4,6-dinitrotoluene	102.0	7.0	80	124
2-Nitrotoluene	101.2	7.2	80	123
3-Nitrotoluene	99.9	7.5	77	122
4-Amino-2,6-dinitrotoluene	101.0	7.0	79	124
4-Nitrotoluene	100.6	8.1	76	125
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	103.0	10.0	72	134
Nitrobenzene	100.4	7.8	77	124
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	100.0	9.0	74	126

Table 15. LCS Control Limits for Organochlorine Pesticides
SW-846 Method 8081A Water Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
4,4'-DDD	88.1	20.4	27	149
4,4'-DDE	86.7	17.8	33	140
4,4'-DDT	92.5	15.0	47	138
Aldrin	82.8	18.6	27	138
alpha-BHC	94.1	11.4	60	128
alpha-Chlordane	93.1	10.0	63	123
beta-BHC	96.1	10.0	66	126
Decachlorobiphenyl (surrogate)	83.3	17.2	32	135
delta-BHC	90.9	15.0	46	136
Dieldrin	95.5	11.0	62	129
Endosulfan I*	80.1	10.4	49	111
Endosulfan II	79.2	17.1	28	130
Endosulfan sulfate	95.8	13.9	54	137
Endrin	95.2	13.0	56	134
Endrin aldehyde	96.4	13.6	56	137
Endrin ketone	102.1	8.2	77	127
gamma-BHC	81.9	18.3	27	137
gamma-Chlordane	93.8	10.7	62	126
Heptachlor	86.6	14.8	42	131
Heptachlor epoxide	96.4	11.5	62	131
Methoxychlor	103.0	15.5	56	150
TCMX (surrogate)	81.4	18.8	25	138

*Provisional limits – outlier analyses during the LCS study resulted in LCS-CLs generated with data from fewer than four laboratories.

Table 16. LCS Control Limits for Organochlorine Pesticides SW-846 Method 8081A Solid Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
4,4'-DDD	81.3	17.9	28	135
4,4'-DDE	97.1	9.7	68	126
4,4'-DDT	92.3	15.8	45	140
Aldrin	93.3	15.6	47	140
alpha-BHC	93.4	10.5	62	125
alpha-Chlordane	92.1	9.7	63	121
beta-BHC	94.5	10.7	62	127
Decachlorobiphenyl (surrogate)	93.9	12.6	56	132
delta-BHC	93.6	12.3	57	130
Dieldrin	96.0	9.7	67	125
Endosulfan I	73.7	19.8	14	133
Endosulfan II	88.9	17.3	37	141
Endosulfan sulfate	98.6	12.2	62	135
Endrin	96.9	12.1	61	133
Endrin aldehyde	92.0	18.4	37	147
Endrin ketone	99.7	11.3	66	134
Gamma-BHC	90.5	10.7	59	123
Gamma-Chlordane	96.4	10.0	66	126
Heptachlor	95.6	14.9	51	140
Heptachlor epoxide	98.0	10.6	66	130
Methoxychlor	100.0	14.2	57	143
TCMX (surrogate)	96.6	9.1	69	124

Table 17. LCS Control Limits for Polychlorinated Biphenyls SW-846 Method 8082 Water Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
Aroclor 1016	84.6	19.8	25	144
Aroclor 1260	87.5	19.2	30	145
Decachlorobiphenyl (surrogate)	87.5	15.1	42	133

Table 18. LCS Control Limits for Polychlorinated Biphenyls SW-846 Method 8082 Solid Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
Aroclor 1016	89.5	16.1	41	138
Aroclor 1260	96.0	11.6	61	131
Decachlorobiphenyl (surrogate)	91.4	11.2	58	125

Table 19. LCS Control Limits for Metals SW-846 Methods 6010B and 7470A Water Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
Aluminum	97.2	4.6	83	111
Antimony	98.0	4.1	86	110
Arsenic	97.9	4.3	85	111
Barium	99.4	3.8	88	111
Beryllium	99.2	4.0	87	111
Cadmium	99.5	4.2	87	112
Calcium	98.4	3.8	87	110
Chromium	99.9	4.1	88	112
Cobalt	98.7	3.1	89	108
Copper	99.0	3.4	89	109
Iron	101.6	4.0	90	113
Lead	98.9	4.0	87	111
Magnesium	98.4	3.6	88	109
Manganese	100.1	3.9	88	112
Mercury	100.2	5.0	85	115
Molybdenum	94.9	5.2	79	111
Nickel	100.2	4.4	87	113
Potassium	97.7	4.3	85	111
Selenium	98.1	6.0	80	116
Silver	97.3	5.3	82	113
Sodium	99.1	4.0	87	111
Thallium	97.1	3.8	86	109
Vanadium	99.4	4.0	88	111
Zinc	99.7	4.5	86	113

Table 20. LCS Control Limits for Metals
SW-846 Methods 6010B and 7471A Solid Matrix

Analyte	Mean	Standard Deviation	Lower Control Limit	Upper Control Limit
Aluminum	95.1	5.5	79	112
Antimony	96.1	4.7	82	110
Arsenic	95.1	3.9	84	107
Barium	98.4	3.4	88	108
Beryllium	99.1	3.5	89	110
Cadmium	96.8	4.4	83	110
Calcium	96.6	4.1	84	109
Chromium	98.7	4.5	85	112
Cobalt	97.8	4.1	86	110
Copper	96.9	3.1	88	106
Iron	100.3	4.2	88	113
Lead	94.9	4.1	83	107
Magnesium	96.5	3.3	87	106
Manganese	97.4	4.0	85	109
Mercury	100.3	5.9	83	118
Molybdenum	95.5	5.2	80	111
Nickel	97.5	3.9	86	109
Potassium	95.7	4.1	83	108
Selenium	92.8	4.3	80	106
Silver	96.4	7.2	75	118
Sodium	95.6	4.4	82	109
Thallium	94.5	4.2	82	107
Vanadium	98.7	3.4	89	109
Zinc	95.2	5.1	80	110

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Appendix A
Statistical Approach Used to Develop DoD LCS-CLs

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Appendix A: Statistical Approach Used to Develop DoD LCS-CLs

1.0 Introduction

The DoD Environmental Data Quality Workgroup (EDQW) established DoD-wide control limits for laboratory control samples (LCS-CLs) using empirical data from commercial laboratories that perform work for DoD. The EDQW consulted chemists, statisticians, laboratory representatives, and quality assurance personnel to establish a statistical methodology that would produce reasonable and defensible results. The strategy developed for the study included two phases: In the pilot phase the study team tested the methodology; in the second phase the study team incorporated professional judgment and cost and time implications to arrive at the final outcome. This appendix provides details on the statistical methodology and the initial raw data results.

2.0 Description of the Data Set

The LCS study depended on commercial laboratories to voluntarily submit LCS data to DoD. The American Council of Independent Laboratories (ACIL) assisted in efforts to collect data (see Attachments 1 and 2 for data submittal instructions provided to the laboratories). Ultimately 17 laboratories submitted data for the Phase I analyte group (semivolatiles using SW-846 method 8270C), and 16 laboratories submitted data for at least one analyte group in Phase II. Table A-1 presents the number of laboratories that submitted data for each Phase II analyte group, by matrix.

Table A-1. Phase II Data Received

Analyte Group (SW-846 method)	Number of Laboratories	
	Water	Solid
Volatile Organic Compounds (8260B)	15	13
Chlorinated Herbicides (8151A)	12	9
Polynuclear Aromatic Hydrocarbons (8310)	10	10
Explosives (8330)	10	10
Organochlorine Pesticides (8081A)	15	15
Polychlorinated Biphenyls (8082)	12	12
Metals (6010B)	12	11
Mercury (7470A/7471A)	10	10

Laboratories do not necessarily perform all of the nine methods analyzed in the study for both solid and water matrices. In addition, the analyte list for a given method will likely vary slightly by laboratory. As a result the number of available data points in the LCS study varied by analyte – from a minimum of 91 points submitted for dichloroprop using chlorinated herbicides method 8151A in solid matrix to a maximum of 396 data points for benzene using volatiles method 8260B in water. Section 4.0 of this appendix provides a detailed summary of all the data received.

3.0 Description of Approach

This section describes the assumptions of the statistical approach for establishing the LCS-CLs, followed by a detailed description of each step of the approach.

3.1 Assumptions

The study approach used the following primary assumptions to develop the LCS-CLs:

- *The laboratories responding to the request for data are a representative sample of the population of "good performing" laboratories.* At the time the study began, a total of 81 laboratories met the criteria for good performing laboratories (i.e., passed an audit by one or more of the DoD components within the past 18 to 24 months). Seventeen laboratories responded to Phase I, and 16 laboratories responded to Phase II.

- *The LCS data submitted by the laboratories was the result of analytical processes that were "in control."* This assumption was met by requiring that LCS data be from batches that passed both initial calibration verification and continuing calibration verification tests.

- *The LCS-CLs developed for each analyte/matrix combination were calculated from data sets that were representative of the capabilities of good performing laboratories.* This assumption was met, first, by requiring that data for an analyte/matrix combination be available from a minimum of five laboratories before the LCS-CL would be calculated. Data sets were tested for the presence of outlying laboratories and individual data points. Analysis of variance (ANOVA) was performed to determine whether differences in laboratory execution of the subject methods (e.g., differences in extraction methods used) resulted in significantly different performance. Finally, the resulting LCS-CLs were benchmarked against in-house control limits from individual laboratories.

3.2 LCS-CL Development Process

During Phase I of the study, the team tested and finalized the process used to develop the DoD LCS-CLs. The study team divided the data set into a test group and a control group. They applied control group data to the control limits that were generated using the test group data to analyze the effect on failure rates. In addition, the team compared two different outlier methodologies and performed extensive analysis of variance and carefully assessed the results. The original study strategy is presented in Attachment 3 to this appendix.

During Phase II of the study, the methodology consisted of identifying outlier laboratories using the Youden test, identifying outlier data points using the Grubbs test, determining significantly different recoveries between key parameters in the analytical method using ANOVA, and calculating the mean and standard deviation of the final data set. The LCS-CLs were calculated at 3 times the standard deviation around the mean. The statistical methodologies used for each step are described below.

3.2.1 <u>Test for Outlying Laboratories</u>

A rank-sum test, called the Youden test (Taylor, 1987), was used to check each analyte data set for outlying laboratories. The test was implemented as follows:

1. The data set was sorted by laboratory.
2. If more than 15 laboratories submitted data for the analyte, the analyte data set was divided into two groups, with laboratories randomly assigned to each group.
3. Fifteen data points were randomly selected for each laboratory.

4. The first data points selected for the laboratories were assigned ranks based on their relative magnitudes, with the largest value assigned a rank of 1, the next largest a rank of 2, etc.
5. Step 4 was repeated for each of the 15 data points.
6. The 15 ranks for each laboratory were summed, and those scores were compared with reference values based on the number of laboratories and number of data points being tested. Laboratories with scores outside of the range of reference values were flagged as possible outliers.
7. Steps 2 through 6 were repeated two more times, to mitigate the possibility that test results were biased either by the division of the laboratories into two groups, or by the 15 randomly selected data points. Laboratories that were flagged as outliers all three times were then identified as potential outliers for the analyte.

The reference values used for the Youden test provide a 95% confidence that non-outlying laboratories will be correctly identified as such (in other words, there is a 5% chance that the test will identify a laboratory as an outlier when it is not). The test assumes that the sources of variation within the data for each laboratory are the same, although it is possible that individual laboratories implemented the analytical methods in different ways. Therefore, the results of the Youden test were examined in conjunction with the results for the ANOVA before a decision was made to exclude a flagged laboratory from the analyte data set.

The Youden test identified at least one laboratory as an outlier for almost all analyte data sets. In most cases DoD chose to remove the Youden outlier data (except in cases where their removal left fewer than four laboratories for a given data set). Since each laboratory had approximately 15 data points per analyte, the removal of Youden outliers had a significant impact on the results. DoD reviewed scatter plots for many data sets to understand how the outlier data points were distributed compared with the rest of the data. The Youden test identified as outliers those laboratories that had consistently higher or lower recoveries than the other laboratories or those with more tightly clustered recoveries.

3.2.2 Test for Outlying Data Points

The Grubbs test was applied to each data set to identify outlier data points. In the Grubbs test, the mean and standard deviation of the entire data set were calculated and the minimum and maximum data points in the data set were identified. Next, the T-values for the minimum and maximum data points were calculated as follows:

$$T = (X_{av} - X_{min})/S \qquad \text{or} \qquad T = (X_{max} - X_{av})/S$$

X_{av} = mean of the data set
X_{min} = minimum value of the data set
X_{max} = maximum value of the data set
S = standard deviation of the data set

The T-values were compared with reference values (Taylor, 1987) using a 5% false rejection rate. This means that there is a 5% chance that a non-outlier would be falsely rejected as an outlier. The reference values depend on both the risk factor and size of the data set. If the T-value is larger than the reference value, the maximum or minimum data point is identified as an outlier. For this study, the Grubbs test was applied to a maximum of 100 data points. If a data set consisted of more than 100 data points for a particular analyte, the program randomly divided the data set into the appropriate number of groups, each with 100 points or less. The Grubbs test was then performed on each group.

The Grubbs test identified outlier data points at both the low and high end equally. Since the test identified only single data points as outliers, the removal had little effect on the results (except in cases in which the outlier was an order of magnitude higher than the rest of the data).

3.2.3 Analysis of Variance

The analytical methods published in SW-846 allow for variations in their implementation. For example, specific methods may allow variations in the following parameters:

- LCS spike concentrations
- Type of extraction or preparatory method
- LCS matrix
- Sample cleanup method
- Type of chromatography column
- Injection volume

The study used one-way ANOVA to evaluate the effect of these variations on mean LCS recovery results. The ANOVA identified statistically significant differences in mean LCS recoveries for data using opposing method-allowed parameters. The effects of specific variations were evaluated only if the laboratories provided sufficient data to make a valid comparison. For ANOVA results to be considered valid in this study, each parameter (e.g., extraction method) had to have data from at least two different laboratories and a total of more than 30 data points. The amount of data often varied from analyte to analyte within a given method; therefore, ANOVA was not conducted in all cases.

The ANOVA tests were applied both with and without the outliers removed. The ANOVA results were examined in conjunction with the Youden test results and the scientific basis of differing results were considered. The team used the results to decided whether to exclude outlying laboratories or divide the analyte data set by parameter.

When evaluating the ANOVA results and their implications for each method, there were indications that the data should not be divided according to the parameter of interest. In one case, although there was a statistically significant difference in the means, the difference was not enough to have a real effect on the limits (i.e., no practical difference in absolute numbers). For example, the ANOVA on data for metals method 6010B in water showed significant difference in recoveries between extraction methods 3005 and 3010. However, the difference in the means was often less than 4 percentage points. Because the calculation of control limits is driven by the standard deviation (it is multiplied by 3 for both the lower and upper limits), a minor difference in means did not result in significantly different limits.

Another circumstance showed a lack of consistency across analytes in a given method. For the 22 analytes analyzed using method 8081A in water, 8 showed significantly higher recoveries using a *narrow-bore* GC column; however, another 8 showed significantly higher recoveries using a *wide-bore* GC column. The remaining 6 analytes showed no significant difference based on column width. The absence of a consistent trend in results represented a problem with implementation, since it would require two variations in methodology when analyzing a single LCS.

If only one laboratory submitted data for a particular parameter, ANOVA was not performed within the given method. It was not reasonable to make assessments about the effects of certain parameters on an analytical method when the data for one parameter came from a single laboratory. In such a case there could be no certainty whether the differences were truly significant or were due to an outlier laboratory. For instance, PAH method 8310 and semivolatile method 8270C (both solid and water matrices) had only one laboratory that performed a cleanup method. All others did not indicate that cleanup was performed. Similarly, data for volatile method 8260B in water indicated that all but one laboratory used the same extraction method (5030) and same purge temperature (ambient). No ANOVA was performed on these data sets.

In several circumstances, an appropriate amount of data demonstrated noticeable trends; however, after much discussion the EDQW chose to keep the LCS-CLs as they were and not separate the data set by parameters. For example, in Phase I of the study for method 8270C in water, ANOVA tests indicated that extraction method 3520 produced significantly higher recoveries than extraction method 3510. The DoD chemists involved in the study felt that LCS recoveries may not be indicative of the quality of performance of the extraction methods on environmental samples. Opposite trends concerning those same extraction methods were observed in Phase II of the study for PAH method 8310 in water and pesticide method 8081A in water (3510 produced higher recoveries than 3520), but these differences were not pursued for the same reasons.

For several methods in the solid matrix, differences in means were observed between matrix materials (e.g., Ottawa sand and sodium sulfate). However, since they are all clean matrices, none of the materials can truly predict the performance of the analytical method on environmental samples. Although means were often higher using sodium sulfate, DoD chose not to indicate a preference for matrix material by modifying the control limits. Similarly, differences in mean recovery based on spiking concentration did not result in generation of alternative control limits. ANOVA indicated that in some cases, higher spiking concentrations produced higher means; however, the choice of spiking concentration is often a project-specific decision and should not be broadly dictated.

DoD did choose to set LCS-CLs based on ANOVA results for explosives method 8330 in water. There were higher mean recoveries and lower standard deviations for LCS using solid phase extraction (SPE) with acetonitrile elution than for those using the salting out extraction method.

4.0 Raw Data Results

The following tables provide information on the data received (number of laboratories and data points) and the effects of the outlier and ANOVA tests, on an analyte-by-analyte basis.

Results for Method 8260B – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
1,1,1,2-Tetrachloroethane	9	219	103.5	11.7	178	104.7	8.0	
1,1,1-Trichloroethane	10	257	101.3	12.9	175	99.7	10.8	Injection volume 5 mL > 25 mL
1,1,2,2-Tetrachloroethane	10	236	96.4	13.8	173	95.6	10.7	Injection volume 5 mL > 25 mL
1,1,2-Trichloroethane	10	257	97.5	14.5	235	100.0	8.4	
1,1-Dichloroethane	10	257	100.1	12.9	255	100.8	10.7	
1,1-Dichloroethene	14	343	101.2	12.2	247	98.6	10.3	Injection volume 5 mL > 25 mL
1,1-Dichloropropene	9	211	103.6	13.9	189	102.3	9.9	Injection volume 5 mL > 25 mL
1,2,3-Trichlorobenzene	9	208	100.3	16.0	192	99.3	14.1	
1,2,3-Trichloropropane	9	222	98.8	18.5	220	98.2	8.5	Injection volume 5 mL > 25 mL
1,2,4-Trichlorobenzene	9	210	100.6	14.2	188	99.9	11.4	
1,2,4-Trimethylbenzene	9	209	102.8	12.2	187	102.9	9.7	Injection volume 5 mL > 25 mL
1,2-Dibromo-3-chloropropane	9	207	94.1	13.1	147	91.3	13.7	Injection volume 5 mL > 25 mL
1,2-Dibromoethane	9	232	101.0	10.4	170	100.4	6.7	Injection volume 5 mL > 25 mL
1,2-Dichlorobenzene	9	203	99.3	10.4	81	96.5	8.5	Injection volume 5 mL > 25 mL
1,2-Dichloroethane	11	297	98.2	15.8	252	100.1	10.5	
1,2-Dichloroethane-d4 (surrogate)	4	100	99.8	14.1	79	95.2	7.8	
1,2-Dichloropropane	10	257	98.5	12.1	235	100.2	8.3	
1,3,5-Trimethylbenzene	9	209	102.0	12.0	184	102.3	9.5	Injection volume 5 mL > 25 mL
1,3-Dichlorobenzene	9	203	99.6	10.7	161	99.6	8.1	Injection volume 5 mL > 25 mL
1,3-Dichloropropane	8	188	99.7	12.0	168	99.6	8.9	Injection volume 5 mL > 25 mL
1,4-Dichlorobenzene	10	203	99.0	10.4	138	98.8	8.1	Injection volume 5 mL > 25 mL
2,2-Dichloropropane	9	211	103.2	15.9	206	102.9	11.2	Injection volume 5 mL > 25 mL
2-Butanone	9	244	92.3	21.4	222	91.0	19.7	
2-Chlorotoluene	9	206	99.6	11.7	184	99.5	9.0	Injection volume 5 mL > 25 mL
2-Hexanone	9	236	96.9	24.4	192	92.4	12.0	
4-Bromofluorobenzene (surrogate)	7	160	100.9	11.3	140	97.6	7.1	
4-Chlorotoluene	9	206	100.9	11.5	184	101.0	8.9	Injection volume 5 mL > 25 mL
4-Methyl-2-pentanone	9	204	93.7	20.3	162	96.0	12.7	

Results for Method 8260B – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Acetone	9	236	91.4	24.7	194	90.7	17.2	
Benzene	14	356	101.0	8.6	335	101.7	6.9	
Bromobenzene	9	210	99.7	10.7	188	100.0	7.9	Injection volume 5 mL > 25 mL
Bromochloromethane	10	229	97.5	13.1	207	97.3	10.6	
Bromodichloromethane	9	227	100.4	11.6	165	98.2	7.5	Injection volume 5 mL > 25 mL
Bromoform	10	256	97.2	16.4	174	98.6	9.9	
Bromomethane	10	247	93.1	20.6	167	88.0	19.5	
Carbon disulfide	9	237	99.6	20.5	176	99.7	20.8	High spiking > low
Carbon tetrachloride	11	279	100.5	16.2	234	101.9	12.0	
Chlorobenzene	14	352	101.1	10.0	251	101.8	6.9	
Chlorodibromomethane	9	227	100.3	16.1	125	95.7	12.5	Injection volume 5 mL > 25 mL
Chloroethane	10	257	94.7	14.5	201	98.6	12.1	Low spiking > high
Chloroform	11	277	98.7	15.2	274	99.6	12.2	
Chloromethane	10	247	93.4	21.6	147	83.2	14.6	
cis-1,2-Dichloroethene	10	194	98.7	13.7	128	98.6	9.0	Injection volume 5 mL > 25 mL
cis-1,3-Dichloropropene	10	216	99.3	14.9	173	100.3	10.3	
Dibromofluoromethane (surrogate)	5	100	103.1	11.5	60	99.9	5.1	
Dibromomethane	9	208	100.3	11.0	166	100.6	8.3	Injection volume 5 mL > 25 mL
Dichlorodifluoromethane	8	201	90.3	24.1	140	93.0	20.6	
Ethylbenzene	11	252	101.1	12.0	197	100.2	9.1	
Hexachlorobutadiene	9	207	96.8	17.7	203	96.9	15.2	
Isopropylbenzene	9	210	101.5	11.9	172	101.1	8.8	High spiking > low; Injection vol 5 mL > 25 mL
m,p-Xylene	8	113	102.3	8.7	113	102.3	8.7	High spiking > low; Injection vol 5 mL > 25 mL
Methyl tert-butyl ether	4	92	95.5	9.6	72	94.0	9.7	
Methylene chloride	10	250	98.4	17.0	192	96.4	14.4	
Naphthalene	9	210	98.1	15.7	169	96.1	14.0	Injection volume 5 mL > 25 mL
n-Butylbenzene	9	172	102.4	14.0	150	102.6	11.3	
n-Propylbenzene	9	172	100.5	12.4	147	100.5	9.4	Injection volume 5 mL > 25 mL

Results for Method 8260B – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
o-Xylene	10	169	101.0	12.5	131	100.3	6.8	Injection volume 5 mL > 25 mL
p-Isopropyltoluene	9	176	100.8	12.6	174	101.7	9.7	Injection volume 5 mL > 25 mL
sec-Butylbenzene	9	169	100.6	13.1	147	99.6	9.2	Injection volume 5 mL > 25 mL
Styrene	10	249	100.8	13.2	207	99.8	11.5	
tert-Butylbenzene	9	169	100.2	12.7	131	99.4	9.8	Injection volume 5 mL > 25 mL
Tetrachloroethene	11	260	101.4	15.9	132	96.3	17.6	Injection volume 5 mL > 25 mL
Toluene	14	349	101.3	9.1	268	99.8	7.5	
Toluene-d8 (surrogate)	6	140	104.0	11.5	100	101.6	6.1	
trans-1,2-Dichloroethene	10	187	100.1	14.8	165	99.3	13.3	Injection volume 5 mL > 25 mL
trans-1,3-Dichloropropene	10	196	97.5	17.6	173	97.7	14.8	
Trichloroethene	14	343	100.9	9.8	188	98.7	9.4	Injection vol 5 mL > 25 mL; Purge temp 40 deg C > ambient
Trichlorofluoroethane	10	257	97.2	19.3	202	102.7	14.6	
Vinyl chloride	11	277	94.6	17.8	222	98.9	16.1	

Results for Method 8260B – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
1,1,1,2-Tetrachloroethane	6	143	99.1	8.9	105	99.7	8.6	
1,1,1-Trichloroethane	8	180	100.5	10.9	180	100.5	10.9	
1,1,2,2-Tetrachloroethane	8	180	94.5	14.3	158	92.5	13.0	
1,1,2-Trichloroethane	8	180	96.1	10.6	113	94.9	10.9	
1,1-Dichloroethane	8	181	100.5	10.1	114	99.0	8.7	
1,1-Dichloroethene	13	362	101.0	50.6	294	100.2	11.8	Low spiking > high
1,1-Dichloropropene	6	143	101.1	10.7	105	102.2	10.8	
1,2,3-Trichlorobenzene	6	143	94.8	15.4	122	97.5	11.7	

Results for Method 8260B – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
1,2,3-Trichloropropane	6	143	93.4	14.3	123	96.7	11.2	
1,2,4-Trichlorobenzene	6	143	96.4	14.5	103	97.6	11.0	
1,2,4-Trimethylbenzene	6	143	100.0	11.8	143	100.0	11.8	
1,2-Dibromo-3-chloropropane	6	133	89.7	15.7	113	87.4	15.7	
1,2-Dibromoethane	7	138	97.1	9.1	138	97.1	9.1	
1,2-Dichlorobenzene	6	133	95.7	9.9	93	96.6	7.4	
1,2-Dichloroethane	9	232	101.2	12.9	194	104.3	10.8	Ambient purge temp > 40 deg C
1,2-Dichloropropane	8	180	98.0	9.3	131	95.0	8.1	
1,3,5-Trimethylbenzene	6	143	98.9	11.4	143	98.9	11.4	
1,3-Dichlorobenzene	6	133	96.9	10.7	93	98.1	8.7	
1,3-Dichloropropane	6	143	97.7	9.5	125	99.8	7.8	
1,4-Dichlorobenzene	8	182	96.7	10.5	162	98.5	8.9	
2,2-Dichloropropane	6	143	101.6	13.7	105	100.6	11.3	
2-Butanone	9	179	116.2	86.4	159	94.0	21.6	
2-Chlorotoluene		143	97.2	11.0	103	98.5	9.9	
2-Hexanone	8	169	96.7	19.0	167	96.7	16.4	
4-Bromofluorobenzene (surrogate)	6	173	101.1	5.9	172	101.3	5.6	
4-Chlorotoluene	6	143	97.7	10.7	123	99.8	8.8	
4-Methyl-2-pentanone	8	157	96.7	17.7	156	97.2	16.6	
Acetone	8	175	92.9	24.2	125	88.2	23.1	
Benzene	13	360	105.0	97.8	289	99.4	8.8	
Bromobenzene	6	144	96.5	10.5	55	93.4	9.3	
Bromochloromethane	7	163	97.7	10.4	145	99.4	9.3	
Bromodichloromethane	7	151	99.8	9.4	151	99.8	9.4	
Bromoform	8	181	95.8	13.5	143	96.5	13.4	
Bromomethane	8	170	96.3	25.2	100	95.0	21.3	
Carbon disulfide	8	177	111.6	35.0	138	102.7	18.7	
Carbon tetrachloride	9	232	101.2	12.2	212	99.7	11.0	
Chlorobenzene	13	364	104.4	92.4	323	98.9	8.1	

Results for Method 8260B – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Chlorodibromomethane	8	175	98.0	10.5	175	98.0	10.5	
Chloroethane	8	180	98.8	21.7	134	98.3	19.6	
Chloroform	9	232	102.5	59.2	212	98.0	8.7	
Chloromethane	8	170	92.3	15.4	149	89.8	13.0	
cis-1,2-Dichloroethene	7	162	99.3	10.2	113	96.2	9.7	
cis-1,3-Dichloropropene	8	176	97.3	10.5	138	98.8	8.9	
Dibromomethane	6	142	100.4	9.2	142	100.4	9.2	
Dichlorodifluoromethane	6	142	90.3	28.7	55	84.7	17.0	
Ethylbenzene	9	202	101.4	9.1	182	100.5	8.8	
Hexachlorobutadiene	6	143	95.2	16.5	123	97.8	14.9	
Isopropylbenzene	6	144	101.4	9.9	124	103.0	8.8	
m,p-Xylene	7	160	100.9	9.2	140	102.4	7.9	
Methylene chloride	8	181	100.9	14.8	131	97.4	14.4	
Naphthalene	7	146	92.6	14.9	56	83.5	14.4	
n-Butylbenzene	6	143	100.2	13.4	103	101.1	12.2	
n-Propylbenzene	6	143	99.0	11.9	143	99.0	11.9	
o-Xylene	7	164	100.9	8.9	124	101.4	8.0	
p-Isopropyltoluene	5	127	100.9	11.8	107	103.6	9.6	
sec-Butylbenzene	6	144	98.8	12.6	125	97.2	11.5	
Styrene	8	192	100.7	9.1	192	100.7	9.1	
tert-Butylbenzene	6	143	98.8	11.1	143	98.8	11.1	
Tetrachloroethene	9	209	100.6	13.0	168	103.0	11.9	Low spiking > high
Toluene	13	380	103.3	86.5	379	98.9	9.2	
Toluene-d8 (surrogate)	5	147	100.8	5.2	127	100.3	5.3	
trans-1,2-Dichloroethene	7	162	100.1	11.3	162	100.1	11.3	
trans-1,3-Dichloropropene	8	177	95.6	10.6	138	95.8	10.4	
Trichloroethene	13	362	105.9	97.0	321	100.5	7.8	
Trichlorofluoromethane	7	172	106.3	28.7	171	105.6	26.9	
Vinyl chloride	9	227	93.6	12.3	207	92.1	11.4	Low spiking > high

Results for Method 8270C – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
1,2,4-Trichlorobenzene	17	418	73.6	16.1	274	71.7	11.6	Extraction 3520 > 3510*
1,2-Dichlorobenzene	11	302	70.8	16.8	215	67.3	11.4	
1,2-Diphenylhydrazine	6	115	86.6	11.9	70	84.8	9.4	
1,3-Dichlorobenzene	11	301	69.2	18.5	213	64.8	10.9	
1,4-Dichlorobenzene	16	401	69.5	16.8	294	64.8	10.9	Extraction 3520 > 3510*
2,4,5-Trichlorophenol	11	291	84.8	14.8	185	79.7	10.3	Extraction 3520 > 3510*
2,4,6-Tribromophenol (surrogate)	7	207	89.4	16.6	139	82.9	13.6	Extraction 3520 > 3510*; High spiking > low**
2,4,6-Trichlorophenol	12	318	85.0	15.1	187	80.7	10.7	
2,4-Dichlorophenol	12	318	81.4	15.0	167	76.3	9.6	Extraction 3520 > 3510*
2,4-Dimethylphenol	12	320	66.9	17.6	255	68.8	13.5	
2,4-Dinitrophenol	12	318	82.6	25.1	231	75.8	20.6	Extraction 3520 > 3510*
2,4-Dinitrotoluene	17	434	88.1	15.6	344	84.3	11.2	Extraction 3520 > 3510*
2,6-Dinitrotoluene	11	297	87.8	13.6	206	82.7	11.3	Extraction 3520 > 3510*
2-Chloronaphthalene	12	314	80.8	14.3	203	76.5	9.3	Extraction 3520 > 3510*
2-Chlorophenol	17	411	76.3	17.2	261	71.3	11.4	Extraction 3520 > 3510*
2-Fluorobiphenyl (surrogate)	7	230	82.4	13.7	142	79.9	10.6	Extraction 3520 > 3510*
2-Fluorophenol (surrogate)	7	208	67.7	22.7	61	63.7	14.8	High spiking > low**
2-Methylnaphthalene	11	291	78.9	16.2	164	75.0	9.5	Extraction 3520 > 3510*
2-Methylphenol	10	281	74.3	16.8	167	73.3	11.7	Extraction 3520 > 3510*; High spiking > low**
2-Nitroaniline	10	292	87.0	14.9	225	81.8	11.2	Extraction 3520 > 3510*
2-Nitrophenol	11	301	81.7	18.6	189	75.8	12.4	Extraction 3520 > 3510*
3,3'-Dichlorobenzidine	12	312	75.7	26.6	184	65.2	15.3	High spiking > low**
3-Methylphenol/4-Methylphenol	10	284	75.5	21.0	150	71.3	13.0	Extraction 3520 > 3510*
3-Nitroaniline	9	259	79.4	20.4	192	72.6	17.7	
4,6-Dinitro-2-methylphenol	11	301	90.3	20.6	213	84.9	15.0	
4-Bromophenyl phenyl ether	12	313	86.0	13.5	154	82.9	10.2	

Results for Method 8270C – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
4-Chloro-3-methylphenol	16	403	82.2	14.9	274	78.6	10.7	Extraction 3520 > 3510*
4-Chloroaniline	10	276	69.9	18.5	189	62.2	15.6	
4-Chlorophenyl phenyl ether	12	313	84.6	12.4	203	80.6	10.3	Extraction 3520 > 3510*
4-Nitroaniline	10	278	81.1	15.1	211	77.2	13.7	High spiking > low**
4-Nitrophenol	17	417	64.3	29.9	291	54.3	23.0	Extraction 3520 > 3510*
Acenaphthene	17	436	80.3	12.3	331	77.6	10.1	Extraction 3520 > 3510*
Acenaphthylene	12	334	80.8	12.3	202	78.5	9.4	Extraction 3520 > 3510*; High spiking > low**
Anthracene	12	333	83.7	10.2	308	83.0	9.7	Extraction 3520 > 3510*; High spiking > low**
Benz(a)anthracene	11	325	86.4	11.1	233	82.7	8.9	Extraction 3520 > 3510*; High spiking > low**
Benzo(a)pyrene	12	337	85.6	12.2	245	81.3	9.5	Extraction 3520 > 3510*
Benzo(b)fluoranthene	12	334	84.9	13.3	266	81.8	12.1	
Benzo(g,h,i)perylene	12	323	87.3	16.8	232	80.5	14.1	
Benzo(k)fluoranthene	12	330	87.0	13.0	220	84.6	13.2	Extraction 3520 > 3510*; High spiking > low**
Benzoic acid	10	234	59.5	36.2	108	54.9	24.1	Extraction 3520 > 3510*
Benzyl alcohol	10	248	77.0	21.7	123	71.0	13.8	Extraction 3520 > 3510*
Bis(2-chlorethoxy)methane	12	312	82.9	16.3	201	76.2	10.2	Extraction 3520 > 3510*; High spiking > low**
Bis(2-chloroethyl) ether	12	312	77.6	14.6	202	73.3	12.3	Extraction 3520 > 3510*
Bis(2-chloroisopropyl) ether	10	290	82.1	20.5	177	78.2	17.5	
Bis(2-ethylhexyl) phthalate	12	320	90.6	27.0	231	84.2	14.0	
Butyl benzyl phthalate	12	313	87.0	15.3	226	81.1	11.7	Extraction 3520 > 3510*; High spiking > low**
Carbazole	8	174	84.8	14.5	153	82.5	11.4	High spiking > low**
Chrysene	12	334	86.3	11.3	243	82.1	8.9	Extraction 3520 > 3510*; High spiking > low**
Dibenz(a,h)anthracene	11	323	87.6	14.8	236	84.7	14.1	
Dibenzofuran	11	287	82.4	12.0	180	80.3	8.8	Extraction 3520 > 3510*
Diethyl phthalate	12	314	82.5	14.4	246	79.2	12.9	Extraction 3520 > 3510*; High spiking > low**
Dimethyl phthalate	12	314	77.6	21.5	183	75.9	16.9	High spiking > low**
Di-n-butyl phthalate	11	304	84.8	10.3	304	84.8	10.3	High spiking > low**
Di-n-octyl phthalate	12	314	89.0	18.6	288	87.4	16.6	High spiking > low**
Fluoranthene	12	331	85.8	10.7	306	85.2	10.4	Extraction 3520 > 3510*; High spiking > low**
Fluorene	12	331	84.3	11.4	241	80.6	10.3	Extraction 3520 > 3510*; High spiking > low**

Results for Method 8270C – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Hexachlorobenzene	12	314	85.6	11.9	203	82.3	10.0	Extraction 3520 > 3510*
Hexachlorobutadiene	12	313	70.7	18.8	206	65.2	12.6	Extraction 3520 > 3510*
Hexachloroethane	12	311	67.8	19.9	203	60.9	11.1	Extraction 3520 > 3510*
Indeno(1,2,3-cd)pyrene	12	334	86.1	15.4	225	84.3	13.6	
Isophorone	11	293	83.4	13.5	197	81.0	10.5	Extraction 3520 > 3510*
Naphthalene	12	328	74.9	14.3	218	70.8	10.5	Extraction 3520 > 3510*
Nitrobenzene	12	315	80.3	15.5	175	76.8	10.8	Extraction 3520 > 3510*
Nitrobenzene-d5 (surrogate)	7	229	81.9	16.2	142	76.0	11.8	Extraction 3520 > 3510*
N-Nitrosodimethylamine	9	238	73.6	27.0	132	67.9	14.1	Extraction 3520 > 3510*
N-Nitrosodi-n-propylamine	17	418	80.4	16.0	360	80.9	15.7	Extraction 3520 > 3510*
N-Nitrosodiphenylamine	9	198	81.3	12.0	173	79.6	10.6	
Pentachlorophenol	17	410	81.3	18.3	322	77.6	13.3	Extraction 3520 > 3510*
Phenanthrene	12	331	84.8	11.1	307	84.0	11.0	Extraction 3520 > 3510*; High spiking > low**
Phenol	17	416	62.2	27.1	234	55.9	19.9	Extraction 3520 > 3510*
Phenol-d5/d6 (surrogate)	7	209	65.6	29.0	77	62.6	18.0	High spiking > low**
Pyrene	17	431	88.2	14.2	409	88.6	13.2	
Terphenyl-d14 (surrogate)	7	227	88.8	23.1	180	92.7	14.0	Extraction 3510 > 3520*; High spiking > low**

* Controlled for higher spiking level.
** Controlled for extraction method 3520.

Results for Method 8270C – Solid Matrix								
			All Data		Outliers Removed			
Analyte	# of Labs	Total # of points	Mean	Std Dev.	Total # of points	Mean	Std Dev.	ANOVA
1,2,4-Trichlorobenzene	17	408	76.6	12.6	312	77.4	11.2	Extraction 3540 > 3550 (SS)
1,2-Dichlorobenzene	11	261	73.2	12.6	131	70.9	8.7	Extraction 3540 > 3550 (SS)
1,3-Dichlorobenzene	10	259	72.4	13.8	166	69.7	10.3	Extraction 3540 > 3550 (SS)
1,4-Dichlorobenzene	16	435	70.9	13.2	398	69.0	11.4	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550 (SS)
2,4,5-Trichlorophenol	11	258	82.3	13.1	154	80.1	10.4	Extraction 3540 > 3550
2,4,6-Tribromophenol (surrogate)	7	189	85.1	17.1	152	80.9	15.1	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550 (SS); Extraction 3550 > 3540 (Ottawa)
2,4,6-Trichlorophenol	12	282	80.9	13.2	177	76.3	11.0	Extraction 3540 > 3550 (SS)
2,4-Dichlorophenol	12	281	79.1	12.8	185	77.2	10.9	Extraction 3540 > 3550 (SS)
2,4-Dimethylphenol	11	272	67.6	14.2	184	67.3	11.9	SS > Ottawa (extraction 3550)*; Extraction 3550 > 3540 (Ottawa)
2,4-Dinitrophenol	12	282	74.1	24.6	173	72.6	20.0	Extraction 3540 > 3550 (SS)
2,4-Dinitrotoluene	17	409	84.0	15.3	297	82.0	11.4	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550 (SS)
2,6-Dinitrotoluene	11	271	83.1	12.3	197	80.2	10.7	Extraction 3540 > 3550 (SS)
2-Chloronaphthalene	11	271	78.2	12.1	197	75.2	9.9	Extraction 3540 > 3550 (SS)
2-Chlorophenol	17	409	75.2	12.6	313	74.7	10.3	Extraction 3540 > 3550 (SS)
2-Fluorobiphenyl (surrogate)	7	203	76.2	11.9	167	72.8	10.0	Extraction 3540 > 3550 (SS)
2-Fluorophenol (surrogate)	7	193	73.1	13.6	135	70.6	11.1	Extraction 3540 > 3550 (SS); Extraction 3550 > 3540 (Ottawa)
2-Methylnaphthalene	11	256	78.8	13.2	135	77.3	10.0	Extraction 3540 > 3550
2-Methylphenol	10	251	74.0	11.5	215	71.7	10.6	Extraction 3540 > 3550 (SS)
2-Nitroaniline	9	240	83.0	13.5	168	81.0	12.2	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550
2-Nitrophenol	10	259	77.8	14.1	146	76.2	11.5	Extraction 3540 > 3550 (SS)
3,3'-Dichlorobenzidine	11	270	70.7	22.2	166	68.9	19.6	SS > Ottawa (extraction 3550)*; Extraction 3540 > 3550 (SS)
3-Methylphenol/4-Methylphenol	10	249	76.3	13.1	196	73.9	10.9	Extraction 3540 > 3550 (SS)
3-Nitroaniline	9	240	71.5	17.8	156	68.8	13.8	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550 (SS)
4,6-Dinitro-2-methylphenol	10	259	85.0	21.2	186	83.1	18.0	SS > Ottawa (extraction 3550)*; Extraction 3540 > 3550 (SS)
4-Bromophenyl phenyl ether	11	271	83.7	13.1	170	81.7	11.8	Extraction 3540 > 3550 (SS)
4-Chloro-3-methylphenol	16	400	81.9	12.2	304	79.5	11.1	Extraction 3540 > 3550
4-Chloroaniline	9	239	58.3	20.7	155	51.0	14.2	Extraction 3540 > 3550
4-Chlorophenyl phenyl ether	11	271	81.9	11.4	190	79.6	10.7	Extraction 3540 > 3550

Results for Method 8270C – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of points	Mean	Std Dev.	Total # of points	Mean	Std Dev.	ANOVA
4-Nitroaniline	9	240	77.3	15.0	204	73.6	13.1	Extraction 3540 > 3550
4-Nitrophenol	17	409	81.3	21.8	353	77.0	20.2	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550
Acenaphthene	17	422	78.5	10.7	386	77.3	10.3	Extraction 3540 > 3550
Acenaphthylene	12	290	78.2	10.9	209	75.7	10.4	Extraction 3540 > 3550
Anthracene	12	290	81.4	9.4	241	79.9	9.0	Extraction 3540 > 3550
Benz(a)anthracene	11	282	83.8	10.5	201	81.6	9.8	Extraction 3540 > 3550 (SS)
Benzo(a)pyrene	12	293	83.8	11.6	233	80.7	10.3	Extraction 3540 > 3550 (SS)
Benzo(b)fluoranthene	12	293	83.0	12.4	229	79.7	11.4	Extraction 3540 > 3550 (SS)
Benzo(g,h,i)perylene	12	281	84.4	16.7	230	81.8	14.7	Extraction 3540 > 3550 (SS)
Benzo(k)fluoranthene	11	280	85.5	13.0	244	83.8	12.9	Extraction 3540 > 3550 (SS)
Benzoic acid	8	177	58.2	24.7	140	55.7	18.7	SS > Ottawa (extraction 3550)*; Extraction 3550 > 3540
Benzyl alcohol	8	187	78.7	22.0	117	70.9	17.4	
Bis(2-chlorethoxy)methane	11	270	77.7	14.5	197	75.5	10.9	Extraction 3540 > 3550 (SS)
Bis(2-chloroethyl) ether	11	271	73.5	12.7	196	71.1	11.2	Extraction 3540 > 3550 (SS)
Bis(2-chloroisopropyl) ether	10	254	73.1	21.7	178	68.4	15.7	Extraction 3540 > 3550 (SS); Extraction 3550 > 3540 (Ottawa)
Bis(2-ethylhexyl) phthalate	11	274	86.5	13.6	257	87.4	13.3	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550 (SS)
Butyl benzyl phthalate	11	271	86.1	13.5	186	86.4	12.3	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550 (SS)
Carbazole	8	184	81.6	12.9	167	80.4	12.3	Extraction 3540 > 3550 (Ottawa)
Chrysene	12	293	83.8	10.9	238	82.6	9.9	Extraction 3540 > 3550 (SS)
Dibenz(a,h)anthracene	11	285	84.9	14.2	249	82.9	13.9	Extraction 3540 > 3550 (SS)
Dibenzofuran	11	253	78.6	12.6	155	77.1	8.8	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550
Diethyl phthalate	11	274	83.7	11.2	165	82.2	10.6	Extraction 3540 > 3550
Dimethyl phthalate	11	271	81.7	11.3	197	79.6	10.2	Extraction 3540 > 3550 (SS)
Di-n-butyl phthalate	11	265	84.3	10.3	198	83.2	9.1	Extraction 3540 > 3550 (SS)
Di-n-octyl phthalate	11	271	87.8	16.1	249	86.4	15.2	Extraction 3540 > 3550 (SS)
Fluoranthene	12	290	83.0	10.4	271	83.9	10.1	Extraction 3540 > 3550
Fluorene	12	289	81.1	10.7	195	78.3	9.8	Extraction 3540 > 3550
Hexachlorobenzene	11	275	83.2	11.8	222	82.5	11.7	Extraction 3540 > 3550 (SS)
Hexachlorobutadiene	11	275	78.0	14.9	162	78.2	12.9	Extraction 3540 > 3550

Results for Method 8270C – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of points	Mean	Std Dev.	Total # of points	Mean	Std Dev.	ANOVA
Hexachloroethane	11	272	73.3	15.0	199	71.9	12.6	Extraction 3540 > 3550 (SS)
Indeno(1,2,3-cd)pyrene	12	293	83.9	15.2	229	79.7	13.8	Extraction 3540 > 3550
Isophorone	11	271	78.5	13.8	158	77.0	11.4	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550 (SS)
Naphthalene	12	293	74.7	11.8	237	73.4	11.1	Extraction 3540 > 3550
Nitrobenzene	11	273	76.1	14.0	168	77.2	11.9	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550 (SS)
Nitrobenzene-d5 (surrogate)	7	202	74.6	14.7	166	69.5	10.7	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550
N-Nitrosodimethylamine	7	177	74.7	22.8	140	66.1	15.9	
N-Nitrosodi-n-propylamine	17	409	77.1	15.2	301	76.8	12.3	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550
N-Nitrosodiphenylamine	9	192	83.7	12.3	170	82.4	11.1	SS > Ottawa (extraction 3550)*
Pentachlorophenol	17	412	75.5	19.3	322	71.9	15.6	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550 (SS)
Phenanthrene	12	292	82.0	10.1	211	80.1	10.0	Extraction 3540 > 3550
Phenol	17	408	73.8	13.3	330	69.7	10.2	Extraction 3540 > 3550 (SS)
Phenol-d5/d6 (surrogate)	7	193	75.4	14.4	155	71.0	10.2	Extraction 3540 > 3550 (SS)
Pyrene	17	420	85.0	13.1	400	84.4	12.8	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550 (SS)
Terphenyl-d14 (surrogate)	7	206	83.9	18.0	129	78.8	15.5	Ottawa > SS (extraction 3550)*; Extraction 3540 > 3550 (SS); Extraction 3550 > 3540 (Ottawa)

Notes: Ottawa = Ottawa sand; SS = sodium sulfate
* Controlled for lower spiking level.

Results for Method 8151A – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
2,4,5-T	10	215	81.9	21.7	174	83.0	17.4	Low spiking > high
2,4,5-TP	11	222	86.4	22.9	122	84.4	16.5	Narrow GC column > wide; Low spiking > high
2,4-D	11	235	81.4	23.8	135	80.3	18.6	
2,4-DB	8	160	95.6	26.5	140	91.6	25.7	No cleanup > method 8151
Dichloroprop	7	140	91.5	18.6	98	92.0	11.9	Narrow GC column > wide; No cleanup > method 8151
Dalapon	7	138	68.5	29.2	77	59.6	12.6	No cleanup > method 8151

Results for Method 8151A – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Dicamba	8	153	85.2	17.7	112	86.6	12.9	
Dinoseb	8	150	62.4	24.3	70	44.8	16.3	No cleanup > method 8151
MCPA	7	138	97.7	25.8	78	89.8	15.7	No cleanup > method 8151

Results for Method 8151A – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
2,4,5-T	8	191	85.0	31.8	105	95.1	21.7	Wide GC column > narrow
2,4,5-TP	8	196	88.1	26.2	136	92.5	15.7	Wide GC column > narrow
2,4-D	8	188	88.5	35.0	108	86.3	24.0	
2,4-DB	6	105	112.6	61.9	86	114.0	31.7	Wide GC column > narrow
Dicamba	6	111	88.0	16.4	91	92.7	12.5	High spiking > low
Dichloroprop	5	91	103.1	18.2	52	93.1	12.3	Wide GC column > narrow
Dinoseb	6	115	71.2	62.5	53	57.3	50.9	Wide GC column > narrow

Results for Method 8310 – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Acenaphthene	7	135	73.4	15.8	103	69.5	11.5	Extraction 3510 > 3520
Acenaphthylene	7	135	76.6	13.2	104	73.7	13.2	Extraction 3510 > 3520
Anthracene	8	155	84.3	13.3	91	76.9	11.8	Extraction 3510 > 3520
Benzo(g,h,i)perylene	6	115	82.5	14.4	71	76.6	14.1	Low spiking > high
Benzo(b)fluoranthene	7	135	89.3	14.0	71	81.6	10.3	Extraction 3510 > 3520
Benzo(k)fluoranthene	8	155	87.0	11.4	71	79.3	10.4	Extraction 3510 > 3520; Low injection vol > high*

Results for Method 8310 – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Benzo(a)anthracene	8	145	88.6	11.5	61	80.7	10.5	Extraction 3510 > 3520
Benzo(a)pyrene	8	155	82.1	12.6	131	79.4	11.3	Low injection vol > high*
Chrysene	8	155	88.9	11.4	91	83.3	10.9	
Dibenzo(a,h)anthracene	7	135	74.0	19.8	91	64.2	15.5	
Fluoranthene	7	135	88.1	13.3	91	82.1	11.3	Extraction 3510 > 3520
Fluorene	7	135	77.1	14.4	80	69.1	11.3	
Indeno(1,2,3-cd)pyrene	8	155	87.1	12.0	71	79.6	10.8	
Naphthalene	7	135	70.4	13.5	103	68.1	11.8	Low spiking > high
Phenanthrene	8	155	85.5	13.7	100	80.2	13.4	Extraction 3510 > 3520
Pyrene	8	155	84.9	11.4	111	80.0	9.3	

* Injection volume: Low = 0.01 – 0.06 mL; High = 5 – 20 mL

Results for Method 8310 – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Acenaphthene	8	150	90.0	80.0	94	70.6	12.4	SS > Ottawa; High spiking > medium*
Acenaphthylene	8	150	83.0	19.6	94	72.8	13.4	High spiking > medium; Low spiking > medium*
Anthracene	8	158	85.8	17.9	74	86.1	13.0	
Benzo(g,h,i)perylene	8	158	86.2	17.7	55	84.6	10.4	
Benzo(b)fluoranthene	8	158	89.8	14.6	75	89.3	10.7	
Benzo(k)fluoranthene	8	158	88.0	16.7	93	84.5	12.2	
Benzo(a)anthracene	8	148	89.2	16.9	64	78.0	9.3	
Benzo(a)pyrene	8	158	82.8	19.3	94	86.5	15.4	
Chrysene	8	158	90.3	14.7	94	87.0	10.7	
Dibenzo(a,h)anthracene	8	158	83.9	18.3	95	80.8	11.4	
Fluoranthene	8	158	90.4	17.9	114	88.2	15.6	

Results for Method 8310 – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Fluorene	8	158	82.4	19.8	94	76.4	10.1	
Indeno(1,2,3-cd)pyrene	8	158	90.7	16.7	121	94.9	13.0	SS > Ottawa
Naphthalene	8	153	82.4	23.3	74	79.9	10.5	High spiking > medium*
Phenanthrene	8	158	89.5	17.3	94	91.2	11.5	
Pyrene	8	158	86.8	15.8	94	82.3	11.0	Medium spiking > low*

Notes: Ottawa = Ottawa sand; SS = sodium sulfate
* Spiking level: High = 1,330 – 10,050 ug/kg; Medium = 100 – 999 ug/kg; Low = 3.33 – 99 ug/kg

Results for Method 8330 – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
1,3,5-Trinitrobenzene	9	158	86.8	29.0	131	82.2	29.1	SPE > Salting out; High spiking > low
1,3-Dinitrobenzene	9	157	86.1	29.3	125	81.1	25.6	SPE > Salting out; High spiking > low
2,4,6-Trinitrotoluene (TNT)	9	158	85.9	27.1	108	77.4	28.8	SPE > Salting out; High spiking > low
2,4-Dinitrotoluene	9	157	86.7	25.6	118	83.0	23.6	SPE > Salting out; High spiking > low
2,6-Dinitrotoluene	9	157	86.8	26.2	127	82.2	26.8	
2-Amino-4,6-dinitrotoluene	7	105	95.6	14.5	48	86.7	9.3	High spiking > low
2-Nitrotoluene	9	154	83.9	21.9	104	76.6	22.2	High spiking > low
3-Nitrotoluene	9	153	85.7	21.7	117	80.4	21.8	High spiking > low
4-Amino-2,6,-dinitroluene	7	109	98.9	18.1	92	96.3	13.6	
4-Nitrotoluene	9	153	84.9	21.2	117	79.8	21.2	SPE > Salting out; High spiking > low
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	8	137	93.1	23.5	108	88.1	16.0	SPE > Salting out
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	7	123	89.2	24.4	107	85.1	22.8	
Nitrobenzene	9	161	83.9	23.6	132	79.5	23.5	High spiking > low
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	8	136	91.7	17.0	87	89.4	14.0	

Results for Method 8330 – Solid Matrix								
		All Data			Outliers Removed			
Analyte	**# of Labs**	**Total # of Points**	**Mean**	**Std Dev.**	**Total # of Points**	**Mean**	**Std Dev.**	**ANOVA**
1,3,5-Trinitrobenzene	8	212	94.9	22.2	169	95.1	20.3	
1,3-Dinitrobenzene	8	209	96.6	22.6	159	101.5	7.6	SS > Ottawa
2,4-Dinitrotoluene	8	212	98.6	23.5	169	98.4	20.8	
2,6-Dinitrotoluene	8	207	96.6	23.9	157	99.8	7.4	
2,4,6-Trinitrotoluene (TNT)	8	212	94.6	24.8	192	95.1	25.9	Acetonitrile extraction > ultrasonic
2-Amino-4,6-dinitrotoluene	8	169	101.3	10.1	134	101.7	7.3	SS > Ottawa
2-Nitrotoluene	8	208	95.5	21.5	185	97.2	19.5	
3-Nitrotoluene	8	206	94.5	22.9	204	95.4	21.1	Acetonitrile extraction > ultrasonic; SS > Ottawa
4-Amino-2,6-dinitrotoluene	8	166	102.7	14.0	113	101.5	7.4	
4-Nitrotoluene	8	207	96.0	21.9	197	100.6	7.8	
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	8	175	100.3	14.0	154	103.2	10.3	
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	8	171	79.7	24.0	170	80.2	23.3	
Nitrobenzene	8	211	94.5	21.9	167	96.3	19.2	Acetonitrile extraction > ultrasonic
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	8	172	101.2	11.1	132	100.0	8.5	

Note: Ottawa = Ottawa sand; SS = sodium sulfate

Results for Method 8081A – Water Matrix								
		All Data			Outliers Removed			
Analyte	**# of Labs**	**Total # of Points**	**Mean**	**Std Dev.**	**Total # of Points**	**Mean**	**Std Dev.**	**ANOVA**
4,4'-DDD	11	215	92.5	20.3	137	88.1	20.4	Narrow GC column > wide
4,4'-DDE	11	215	90.5	21.3	176	86.7	17.8	
4,4'-DDT	14	278	94.6	16.4	186	92.5	15.0	
Aldrin	14	288	84.4	18.9	268	82.8	18.6	Extraction 3520 > 3510; Narrow GC column > wide; High spiking > low
alpha-BHC	11	223	90.2	20.3	140	94.1	11.4	

Results for Method 8081A – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
alpha-Chlordane	9	185	92.5	13.3	142	93.1	10.0	Extraction 3510 > 3520
beta-BHC	11	223	92.4	22.3	160	96.1	10.0	Extraction 3510 > 3520
Decachlorbiphenyl (surrogate)	8	170	76.9	23.1	109	83.3	17.2	
delta-BHC	11	223	90.5	22.4	122	90.9	15.0	
Dieldrin	14	288	95.0	17.6	186	95.5	11.0	Extraction 3510 > 3520
Endosulfan I	9	186	81.5	20.8	58	80.1	10.4	
Endosulfan II	10	206	85.2	20.8	93	79.2	17.1	
Endosulfan sulfate	9	186	94.2	21.5	93	95.8	13.9	Extraction 3510 > 3520
Endrin	14	288	97.5	22.1	184	95.2	13.0	
Endrin aldehyde	10	206	89.7	20.1	164	96.4	13.6	
Endrin ketone	7	150	97.4	16.3	79	102.1	8.2	Extraction 3510 > 3520; Wide GC column > narrow
gamma-BHC	13	258	86.7	19.6	168	81.9	18.3	
gamma-Chlordane	3	186	91.5	12.8	165	93.8	10.7	
Heptachlor	14	288	85.7	16.7	247	86.6	14.8	Narrow GC column > wide
Heptachlor epoxide	10	208	92.5	17.6	145	96.4	11.5	Extraction 3510 > 3520
Methoxychlor	10	208	100.6	17.9	187	103.0	15.5	Extraction 3510 > 3520; Wide GC column > narrow
TCMX (surrogate)	9	190	78.8	23.5	130	81.4	18.8	Narrow GC column > wide; High spiking > low

Results for Method 8081A – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
4,4'-DDD	11	238	94.6	19.4	89	81.3	17.9	
4,4'-DDE	11	237	93.4	19.8	167	97.1	9.7	
4,4'-DDT	14	295	95.7	18.1	222	92.3	15.8	Narrow GC column > wide
Aldrin	14	303	95.3	21.3	182	93.3	15.6	
alpha-BHC	11	248	91.7	17.8	159	93.4	10.5	
alpha-Chlordane	8	188	97.3	16.3	89	92.1	9.7	

Results for Method 8081A – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
beta-BHC	11	248	93.7	18.9	159	94.5	10.7	
Decachlorobiphenyl (surrogate)	8	191	114.8	77.8	150	93.9	12.6	
delta-BHC	11	248	91.2	23.8	158	93.6	12.3	
Dieldrin	13	283	94.0	19.3	191	96.0	9.7	
Endosulfan I	9	208	85.2	26.1	109	73.7	19.8	
Endosulfan II	10	227	87.1	24.0	158	88.9	17.3	High spiking > low
Endosulfan sulfate	9	207	96.2	19.9	138	98.6	12.2	High spiking > low
Endrin	14	303	96.6	21.3	191	96.9	12.1	Low spiking > high
Endrin aldehyde	10	228	88.4	24.8	138	92.0	18.4	
Endrin ketone	7	178	98.4	15.5	129	99.7	11.3	
gamma-BHC	13	274	89.5	17.6	183	90.5	10.7	
gamma-Chlordane	2	188	96.4	14.8	139	96.4	10.0	
Heptachlor epoxide	10	227	95.1	18.4	157	98.0	10.6	High spiking > low
Heptachlor	14	305	93.8	18.4	234	95.6	14.9	Sodium sulfate > Ottawa sand; High spiking > low
Methoxychlor	9	207	102.6	22.6	158	100.0	14.2	
TCMX (surrogate)	9	210	106.6	48.5	150	96.6	9.1	Low spiking > high

Results for Method 8082 – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Aroclor 1016	12	241	88.1	21.4	181	84.6	19.8	
Aroclor 1260	13	261	90.6	19.8	180	87.5	19.2	
Decachlorobiphenyl (surrogate)	6	121	82.2	27.5	99	87.5	15.1	

Results for Method 8082 – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Aroclor 1016	12	236	92.2	21.0	174	89.5	16.1	
Aroclor 1260	13	256	97.6	56.6	194	96.0	11.6	
Decachlorobiphenyl (surrogate)	6	121	87.7	17.5	81	91.4	11.2	

Results for Methods 6010B and 7470A – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Aluminum	12	248	98.3	5.6	206	97.2	4.6	Extraction 3010 > 3005
Antimony	11	227	98.3	4.1	207	98.0	4.1	
Arsenic	13	259	99.4	5.0	205	97.9	4.3	High spiking > low
Barium	13	265	99.7	4.4	204	99.4	3.8	
Beryllium	12	246	100.1	4.4	207	99.2	4.0	Extraction 3005 > 3010
Cadmium	13	259	100.1	4.5	227	99.5	4.2	
Calcium	13	260	99.8	4.9	189	98.4	3.8	
Chromium	13	266	100.3	4.5	206	99.9	4.1	
Cobalt	12	240	99.3	3.8	198	98.7	3.1	
Copper	13	265	98.6	3.7	243	99.0	3.4	
Iron	13	263	102.3	7.3	188	101.6	4.0	Extraction 3010 > 3005
Lead	12	247	99.9	4.6	209	98.9	4.0	High spiking > low
Magnesium	13	258	99.3	3.9	208	98.4	3.6	
Manganese	12	247	100.2	4.0	167	100.1	3.9	
Mercury	12	224	100.5	5.4	210	100.2	5.0	
Molybdenum	10	192	97.4	5.4	118	94.9	5.2	Extraction 3005 > 3010
Nickel	13	264	100.6	4.5	244	100.2	4.4	High spiking > low
Potassium	13	261	96.7	11.0	171	97.7	4.3	
Selenium	13	260	99.6	6.2	206	98.1	6.0	High spiking > low; Extraction 3005 > 3010
Silver	13	266	97.1	9.8	149	97.3	5.3	

Results for Methods 6010B and 7470A – Water Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Sodium	13	261	102.0	47.3	259	99.1	4.0	
Thallium	12	223	98.0	4.3	167	97.1	3.8	High spiking > low
Vanadium	11	230	99.6	4.0	170	99.4	4.0	
Zinc	13	266	100.5	6.2	168	99.7	4.5	

Results for Methods 6010B and 7471A – Solid Matrix								
		All Data			Outliers Removed			
Analyte	# of Labs	Total # of Points	Mean	Std Dev.	Total # of Points	Mean	Std Dev.	ANOVA
Aluminum	12	216	96.4	5.6	155	95.1	5.5	
Antimony	11	230	96.7	7.2	189	96.1	4.7	
Arsenic	12	253	96.3	6.3	188	95.1	3.9	
Barium	12	250	100.1	6.8	138	98.4	3.4	
Beryllium	11	231	98.6	4.8	169	99.1	3.5	
Cadmium	12	252	96.9	5.5	202	96.8	4.4	
Calcium	11	204	98.1	5.3	160	96.6	4.1	Low spiking > high
Chromium	12	250	100.0	5.3	180	98.7	4.5	
Cobalt	11	231	97.7	4.3	191	97.8	4.1	
Copper	12	244	98.3	5.0	158	96.9	3.1	
Iron	12	227	102.2	8.4	142	100.3	4.2	Low spiking > high
Lead	11	233	96.0	4.4	183	94.9	4.1	Low spiking > high; Extraction 3050 > 3051
Magnesium	11	212	97.2	4.0	141	96.5	3.3	
Manganese	11	213	99.6	4.9	130	97.4	4.0	
Mercury	12	240	100.3	6.2	238	100.3	5.9	
Molybdenum	9	140	96.8	5.2	103	95.5	5.2	
Nickel	12	241	98.7	4.4	170	97.5	3.9	Low spiking > high
Potassium	10	181	93.8	6.8	94	95.7	4.1	
Selenium	12	249	93.2	8.0	139	92.8	4.3	Extraction 3051 > 3050

Results for Methods 6010B and 7471A – Solid Matrix								
		All Data			Outliers Removed			
Analyte	**# of Labs**	**Total # of Points**	**Mean**	**Std Dev.**	**Total # of Points**	**Mean**	**Std Dev.**	**ANOVA**
Silver	12	250	95.4	10.6	168	96.4	7.2	Low spiking > high
Sodium	11	199	97.5	5.3	149	95.6	4.4	Low spiking > high
Thallium	11	220	95.1	4.6	190	94.5	4.2	
Vanadium	11	231	99.3	4.6	141	98.7	3.4	
Zinc	12	244	98.6	7.1	133	95.2	5.1	

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ATTACHMENT 1
PILOT STUDY DATA COLLECTION INSTRUCTIONS

Department of Defense
Environmental Data Quality Workgroup
Laboratory Control Sample (LCS) Study Data Submittal Instructions

Please submit electronically all the LCS results for **SW-846 Method 8270C** (see target analyte list below) from the most recent **thirty days, with a minimum of 20 results**. If your lab generates less than 20 results in a month, please extend the time period until 20 data sets can be retrieved. Equivalent data sets are requested for **both solid and water matrices**.

LCS samples must be from batches that passed initial calibration verification (ICV) and continuing calibration verification (CCV) tests. The LCS sample should still be provided if it passed the ICV and CCV tests but is outside your laboratory's LCS limits.

The following is the information required from those who wish to contribute to the LCS study. All the fields are required and most fields are either followed by the required format of the data or a list of acceptable values to be chosen from. If an option for a field is not listed, enter a value in the same form or format as the listed values. The lab-specific information is only required once while the detail file must be repeated for the entire analyte list for every data set being submitted.

Data may be submitted as a Microsoft Excel file or a text delimited file. A variable field length separated by the vertical bar is preferred over comma delimited since many analyte names contain commas.

<u>Lab-Specific</u>
1) Lab Name
2) Small Business (yes or no)
3) SIC Code (if a small business)
4) Were outlier data points removed? (yes or no)

<u>Detail File:</u>
1) Sample Number (if not unique within the data set, please include Time Analyzed (6))
2) SW-846 Method (only **8270C** for this initial pilot study)
3) Matrix (solid or water) (may also submit two separate files, if clearly identified)
4) Date Extracted (**/**/1999)
5) Date Analyzed (**/**/1999)
6) Time Analyzed (**:**) (hour:min)
7) LCS Matrix Material:
   - teflon chips;
   - quartz beads;
   - glass beads;

- sodium sulfate;
- in-house purified solids;
- Ottawa sand; or
- water.

8) Extraction Method:
   - 3540;
   - 3541;
   - 3545;
   - 3550;
   - 3560/3561;
   - 3510;
   - 3520; or
   - 3535.
9) Cleanup Method:
   - 3610;
   - 3611;
   - 3620;
   - 3630;
   - 3640;
   - 3650;
   - 3660; or
   - 3665.
10) Type of Instrument Used (i.e., GC/MS)
11) Lab-specific Instrument ID
12) Analyte Name (see target list)
13) CAS Number or PAR Label (**data will be sorted by this field, please include**)
14) Spiking Level
15) Spiking Level Units
16) Lower In-house LCS Acceptance Limit (%)
17) Upper In-house LCS Acceptance Limit (%)
18) Measured Concentration
19) Measured Concentration Units
20) Actual Recovery (%)

ATTACHMENT 2
PHASE II DATA COLLECTION INSTRUCTIONS

Department of Defense
Environmental Data Quality Workgroup
Laboratory Control Sample (LCS) Study Data Submittal Instructions

Please submit electronically **the most recent 20 LCS results** for each of the following **SW-846 Methods: 8260B, 6010B, 7470A/7471A, 8310, 8081A, 8082, 8330, and 8151A** (see target analyte list). Equivalent data sets are requested for **both soil and water matrices**.

LCSs must be from batches that passed initial calibration verification (ICV) and continuing calibration verification (CCV) tests. The LCS should still be provided if it passed the ICV and CCV tests but is outside your laboratory's LCS limits. Do not exclude outlier data points.

The following is the information required from those who wish to contribute to the LCS study. All the fields are required and most fields are either followed by the required format of the data or a list of acceptable values to be chosen from. If an option for a field is not listed, enter a value in the same form or format as the listed values. The lab-specific information is only required once while the detail file must be repeated for the entire analyte list for every data set being submitted.

Data may be submitted as a Microsoft Excel file or a text delimited file. A variable field length separated by the vertical bar is preferred over comma delimited since many analyte names contain commas.

<u>Lab-Specific</u>
1) Lab Name
2) Small Business (yes or no)
3) SIC Code (if a small business)
4) Were outlier data points removed? (yes or no)

<u>Detail File:</u>
1) Sample Number (if not unique within the data set, please include Time Analyzed [5])
2) SW-846 Method
3) Matrix (soil or water) (may also submit two separate files, if clearly dentified)
4) Date Analyzed (**/**/2000)
5) Time Analyzed (**:**) (hour:min)
6) LCS Matrix Material:
    - teflon chips;
    - quartz beads;
    - glass beads;
    - sodium sulfate;
    - in-house purified soils;

- Ottawa sand; or water.

7) Preparation (Extraction or Digestion) Method:

Analytical Method:	6010B	7470A/ 7471A	8260B	8081A	8082	8151A	8310	8330
Preparation Method:	3005 3010 3015 3020 3050 3051 3052	7470A 7471A 7471A alt.- autoclave	5030 5035 Direct injection	3510 3520 3535 3540 3541 3545 3550	3510 3520 3535 3540 3545 3550	Ultrasonic Shaker Separatory funnel	3510 3520 3540 3541 3545 3550 3561	8330: Salting out (*filtered or unfiltered*) Direct injection (*Acetonitrile or Methanol*) Acetonitrile extraction

8) Extraction Solvent
8081/8082 - solids:
- Hexane:acetone
- Methylene chloride:acetone

9) Is alkaline hydrolysis required? (yes or no) (for 8151A only)

10) Type of esterification? (for 8151A only):
- Diazomethane
- Pentafluorobenzyl Bromide

11) Cleanup Method:

Analytical Method:	6010B	7470A/ 7471A	8260B	8081A	8082	8151A	8310	8330
Cleanup Method:	None specified	None specified	Not applicable	3610 3620 3630 3640 3660	3620 3630 3640 3660 3665	8151	3610 3611 3630 3640 3650	None specified

12) Type of Instrument Used (i.e., GC/MS, HPLC, ICP, etc.)

13) Instrument Configuration (for 8151A, 8081A, and 8082 only)
- primary column with confirmation column
- dual column

14) Type of GC Column (for 8151A, 8081A, and 8082 only)
- Narrow bore
- Wide bore

15) Injection volume (for 8310 and 8260B only)
8260B:
- 5 mL
- 25 mL

16) Purge temperature (for 8260B only):
- ambient
- 40 degrees C
- Other

17) Analyte Name (see attached target analyte list)
18) CAS Number (**data will be sorted by this field, please include**)
19) Spiking Level
20) Spiking Level Units
21) Lower In-house LCS Acceptance Limit (%)
22) Upper In-house LCS Acceptance Limit (%)
23) Actual Recovery (%)

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ATTACHMENT 3

METHDOLOGY FOR ESTABLISHING DOD-WIDE LABORATORY CONTROL SAMPLE TARGET ACCEPTANCE LIMITS (OCTOBER 1999)

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FINAL

METHODOLOGY FOR ESTABLISHING DOD-WIDE LABORATORY CONTROL SAMPLE TARGET ACCEPTANCE LIMITS

Submitted to:

DOD Quality Assurance Authors Task Action Team
Environmental Data Quality Workgroup

Submitted by:

Versar, Inc.
6850 Versar Center
Springfield, Virginia 22151

Under Contract No.:
N00174-96-D-0001/0065
Subcontract C048-98-D-18
Delivery Order 3

October 13, 1999

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METHODOLOGY FOR ESTABLISHING DOD-WIDE LABORATORY CONTROL SAMPLE TARGET ACCEPTANCE LIMITS

1.0 Purpose

This paper describes the strategy to develop standardized DOD-wide method specific acceptance limits for laboratory control sample (LCS) recoveries. These limits will be used to identify quantitative target windows that analytical batches processed for the U.S. Department of Defense (DOD) will be expected to achieve. These LCS acceptance limits will be included in an appendix to the Laboratory Quality Systems Manual now under development by a Quality Assurance subgroup of the Environmental Data Quality Workgroup.[1]

The purpose of this paper is to document the methodology for development of acceptance limits for LCS and foster dialogue on the approach with interested parties.

2.0 Overview

The purpose of this study is to establish standardized, routinely achievable, method-specific acceptance limits for LCS recoveries that will ensure high data quality and be applicable DOD-wide. In determining the DOD-wide LCS acceptance limits, both the measurement variability inherent in an analytical method and the inter-laboratory variability must be considered. In this study, the DOD-wide LCS acceptance limits will be determined based on the statistical confidence interval generated from the LCS data sets obtained from multiple laboratories.

The study strategy consists of three elements:

- Obtaining data sets from laboratories for each method (listed in Section 5.1), and variables within the method, for which a Target Acceptance Limit for LCS samples will be established;
- Establishment of the Target Acceptance Limit for the method (or variable within the method) using accepted statistical methodologies, including outlier analyses; and
- Reality testing of the results through comparison to method recommendations, the laboratories' own LCS limits, and experience with recoveries in proficiency testing.

A number of policy issues are posed that are not addressed by this study. Some of these policy issues concern whether the generated LCS limits will be mandatory, how data that is outside the DOD limits but within the laboratories' own limits will be viewed, and the nature of corrective actions required. These and other policy issues will be addressed at later stages in the project. This paper focuses solely on the methodology for developing DOD-wide limits.

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[1] The Environmental Data Quality Workgroup (EDQW) is a four service workgroup established by Sherri Wasserman Goodman under the leadership of the U.S. Navy. The EDQW is charged with establishing policies and procedures to improve the management of environmental data throughout DOD.

3.0 Study Phases

The work will be conducted in three phases:

- Phase 1 – Exploration of the methodology and testing of the data collection approach;
- Phase 2 – Pilot testing of the full methodology on one method (SW-846 method 8270C); and
- Phase 3 – Expansion of the study project to additional methods (listed in Section 5.1).

Information from each phase will feed the subsequent phases.

Phase 1 of the project will include:

- Exploring potential sources of LCS data that may have been collected by others and will fit the needs of the project;
- Conducting exploratory discussions to ascertain interest of laboratories in contributing data;
- Creating a database for storage of data from multiple laboratories (further detail presented in Section 6.0);
- Pilot testing statistical methodologies for merging data from multiple laboratories; and
- Finalizing the information collection strategy.

Phase 2 of the project will include:

- Obtaining data from laboratories on the pilot study method (SW-846, method 8270C);
- Developing sample acceptance limits for that method; and
- Examining the generated acceptance limits, and comparison of these limits to other published limits (including method specific limits and recoveries that may have been generated for that method in association with PE samples).

Phase 3:

Phase 3 of the project will include developing LCS levels for the remaining methods. The details of Phase 3 are not spelled out here, because they are so dependent on the outcomes of Phases 1 and 2. The purpose of Phase 3 is to implement a data collection strategy based on the results of the previous two phases.

4.0 Background

The LCS acceptance limits are a statistical measure for the analytic uncertainty resulting from uncontrollable systematic and random errors inherent in an analytic method. They are used to screen measurements for avoidable human errors and instrumental failures during sample analysis. A LCS consists of an aliquot of a clean (control) matrix similar to the sample matrix spiked with standards for selected analytes. The LCS is used to verify that the laboratory can perform the indicated method in a clean matrix.

LCSs measure the percent of a known quantity of chemical injected into a clean matrix that can be seen by the analytical instrument. Typically, a laboratory establishes LCS limits annually, as a range (plus or minus a percent recovery that reflects the mean and standard deviation around that mean) of the amount of the chemical that is identified. At least one LCS is run per analytical batch after the calibration, but before the samples are run. The percent recovery for each batch is benchmarked against the pre-established limits. If the LCS recovery for a particular batch is outside the established limits for that method, then the batch results may be considered to be unacceptable, triggering corrective action as appropriate (e.g., reanalysis may be required).

According to the widely used SW-846 methods, the LCS acceptance limits are defined as the mean recovery ± 3 * the standard deviation, with the mean recovery and standard deviation generated from an LCS data set consisting of 20 data points. A common protocol for establishing laboratory-specific acceptance limits is to take the first 20 consecutive LCS sample results at the beginning of 1 year and calculate the mean recovery and standard deviation of the LCS for each analyte in the sample (U.S. EPA, 1995). The LCS acceptance limits determined are used to control the quality of sample analysis for the whole year. However, in some laboratories, the LCS acceptance limits are continuously updated whenever another set of 20 LCS samples has been analyzed. In still other laboratories, the mean and standard deviation may be calculated with an entire year's worth of data to establish the LCS limits for the following year.

5.0 Study Design

The study design addresses a variety of issues, including the methods for which DOD will calculate LCS limits, the universe of laboratories from which data will be sought, the data required from the laboratories, and the nature of the information about the LCS data sets that will be sought.

5.1 Methods of Concern

The methods for which LCS limits will initially be developed include the following SW-846 methods: 8260B (volatile organics), 8081A (pesticides), 8082 (polychlorinated biphenyls), 8151A (herbicides), 8270C (semivolatile organics), 8330 (explosives), 6010B (metals), 8310 (PAHs), and 7470/7471 (Mercury).

5.2 Obtaining data from laboratories

LCS limits will be set using recent actual LCS data from laboratories working on DOD projects that have demonstrated quality work. The initial strategy will involve providing opportunities for laboratories to voluntarily offer data for participation in the study. Data collection instructions and a description of desired data will be placed on the EDQW web-site. In addition, trade associations such as the American Council of Independent Laboratories (ACIL) will be notified that the EDQW will be accepting historic data from laboratories that perform work for DOD.

In order to provide a clear record of the quality status of the laboratories who are voluntarily contributing to the study, a list has been prepared of laboratories that represent the universe of laboratories currently in good standing for performing work for at least one of the DOD components overseeing this study. In addition to performing the methods that are the subject of this study, the laboratories on this list have passed a laboratory quality audit within the last 18 to 24 months with one of the following agencies: U.S. Navy, U.S. Air Force, U.S. Army (and U.S. Army Corps of Engineers), and Defense Logistics Agency. A total of 81 laboratories have been identified that meet the criteria for the methods that are the subject of this study.

In using the data submitted by the laboratories, the study team will first identify those laboratories that meet the criteria listed above and flag that data in the database that is created. In the data analysis methodology described in Section 7.0, those laboratories will be identified as "Group A" and will provide an initial benchmark against which LCS limits will be developed. A few of these laboratories will also be put into the control group ("Group B"). In addition, the distribution of the laboratories within the population of laboratories that meet the criteria above will be analyzed. If an insufficient data set is obtained from laboratories that meet the criteria, then additional data may be directly solicited from up to nine laboratories selected at random from that portion of the set of 81 laboratories that did not respond.

5.3 Data Required From Laboratories

The DOD workgroup is preparing a Target Analyte List (TAL). This TAL will be listed in the DOD Quality Systems for Laboratories Manual and will be used for a variety of purposes. For the purpose of this study, the TAL will define the specific analytes for a given method that will be the subject of the LCS study. Historic LCS data will be sought from laboratories only for those analytes. However, if the laboratory has gathered historical data on a broader array of analytes, then the study team will accept the full array of data provided by the laboratory to ACIL.[2]

The generation of a statistical confidence interval requires that the mean and standard deviation used must be derived from a data set consisting of a **minimum** of 15 data points for each variable involved so that the whole population of possible LCS values can be well represented (Taylor, 1987). A data set of 20 data points is commonly used in environmental laboratories to determine in house acceptance limits.[3]

As described in Section 4.0, however, laboratories vary in the way they set LCS limits. In order to ensure uniformity, each LCS limit set by this study will use data sets consisting of LCS results from **consecutive analytical runs from the most recent 30 days, with a minimum**

[2] The TAL list is intended to make data collection easier, not harder. The laboratory will be invited to supply data for the list of analytes that is easiest for them.

[3] SW-846 specifies that the average percent recovery and standard deviation(s) for each matrix spike compound are calculated after analysis of 15-20 matrix spike samples of the same matrix. In Quality Assurance of Chemical Measurement (Taylor, 1987), an F test is recommended for calculation of control limits. "It is recommended that each of the s values in question be based on at least 14 degrees of freedom." Fifteen are the minimum number of data points required. SW-846 recommends 15 to 20 data points.

of 20 data points, from each laboratory.[4] If a laboratory performs less than 20 analytical runs in the 30-day period, that lab would extend the time period until 20 LCS results are compiled. The LCS data submitted will be for those recent, consecutive batches that have passed initial calibration (ICV) and continuing calibration verification (CCV) tests. This will ensure that the batches represented in the study are "in control," even if individual LCS values are not within the laboratory's limits. The final LCS acceptance limits for each analyte will then be estimated based on the combined LCS data sets from many laboratories. This final data set may represent hundreds of data points depending on the total number of laboratories participating in the study and the number of LCS results submitted by each lab (e.g., X labs times 20+ data points per analyte).

Because all methods of interest are applicable to both soils and water matrices, at least two sets of acceptance limits, one for soils and the other for water, will be determined. The laboratories will be requested to submit their last 30 days worth of LCS runs for each matrix.

5.4 Information about LCS Data Sets

It is hypothesized that there may be certain variables that affect the final recovery value for the LCS. Such variables include the type of solid matrix, specific preparatory method, or spiking level. If different laboratories address these variables differently, this can lead to significantly different results.

Therefore, for each set of LCS acceptance limits to be determined, the following information on a given analytical method will be requested from the environmental laboratories along with the LCS data set:

- A full list of analytes addressed in the batch;
- Preparatory methods used;
- Description of the material used as a soil blank;
- Spiking levels of analytes in laboratory control samples;
- Cleanup methods used;
- Instruments used to generate LCS data; and
- The LCS acceptance criteria in use by the laboratory for the method and matrix associated with the LCS run supplied.

Statistical tests (described below) will be used to decide if the variables identified above significantly affect the magnitude of the LCS data points provided by the laboratories. Depending on the outcome of this analysis, the study team will determine if additional LCS limits (or collection of additional data sets) are necessary.

[4] Although some laboratories may use a year's worth of data to set in-house LCS limits, use of all of their data could bias the study toward those laboratories' results. If the combined data sets using 30 days worth of data are still dominated by a few laboratories, a weighted adjustment or a random selection of individual data sets will be used to ensure that data from a few laboratories do not dictate results.

6.0 Database

The study team is evaluating the use of a database in StatSoft's STATISTICA statistical analysis software (or MS-Access, if that is not possible) to process the LCS data requested from laboratories. Every effort will be made to collect the data from the laboratories in a common format. This database will be composed of the following three components:

- An input spreadsheet in MS-Excel whose main function is to ensure the electronic data from laboratories is consistent;

- Statistical analysis software (STATISTICA) used to compare and consolidate the data sets for a given analytic method, evaluate the quality of the LCS data, determine the nature of data distribution, and calculate the LCS recovery acceptance limits; and

- An output file for storing the calculated LCS recovery acceptance limits in both numeric and graphical form.

7.0 Pilot Study Work Plan

A pilot study will be performed using data gathered from the complete universe of laboratories identified on only one analytical method (SW-846, method 8270C). This will serve as a way to test the data quality evaluation steps that are proposed before beginning a full-scale study. A flow chart, attached to this document (Figure 1), presents the following methodology. In the following discussion the term 'data set' refers to a set of LCS values for a specific analyte from an individual laboratory.

The objectives of the pilot study are two fold: first, to determine if the chosen software tools are appropriate, and second, to determine if the approach yields the desired outcome. The first objective will be evaluated by the Project Team staff and modifications recommended for the full study as needed. The second objective will be achieved in two ways. First, the laboratories will be divided into two groups: a larger group (group A) to be taken through every step of the data quality evaluation and a smaller group (group B) to be set aside and used as a control. The data sets from group B will then be compared to the pilot study acceptance limits generated from group A. Next, a small peer-review team will be assembled as an outside check on the study methodology and the reasonableness of the acceptance limits. As part of this step, an alternative method to calculating acceptance limits, the biweight approach, will also be used. Thus two sets of acceptance limits will be generated and compared in this phase.

Three different statistical tests will be used to generate the final data set from which the acceptance limits will be calculated. Initially, analysis of variance (ANOVA) will be used to determine if LCS recoveries vary according to any of the descriptor variables (e.g., preparatory method, spiking level). If significant differences are identified, each data set will be tested for outlier data points using the Grubbs test (Section 8.3) as a way to double check that the ANOVA results were not driven by extreme values. Then the data will be subdivided into groups based on common descriptor variables. Next, the Youden test (Section 8.4) will be used to identify outlier laboratories within any of the subgroups. Data from outlier laboratories will be flagged and not included in the final data set. Lastly, the entire data set will be tested for outlier data points using the Grubbs test. Data points not meeting the test requirements will be flagged and not included in calculation of the acceptance criteria from the final data set.

The LCS acceptance criteria will be based on the 99 percent (%) confidence interval for each analyte calculated using the mean and standard deviation of the final data set (Section 9.0), assuming the final data set is approximately normally distributed. At this point, the data sets in control group B will be tested against the resulting confidence intervals. If 95% of the data sets in group B are within the calculated acceptance criteria, then the group B data sets will go through the previously described steps of data quality evaluation. The data remaining in group B after the evaluation is complete will be integrated with the group A data, and a new overall confidence interval calculated. If 95% of the group B data sets are not within the calculated acceptance criteria, all steps of the statistical analysis should be reviewed and potentially revised.

For the pilot study, the biweight approach to calculate an estimate of the central tendency and spread of the distribution, developed by Karen Kafadar (Kafadar, 1982, 1983), will be run in parallel with the tests mentioned above (Section 8.5). Two of the advantages of this approach are that it does not require the identification and removal of outliers and it does not require the data to be normally distributed. The disadvantage is that computationally it is extremely complex and it is not available in commercial software. The effectiveness of the two approaches will be evaluated by comparing the acceptance criteria by both approaches.

Finally, the acceptance criteria by both approaches will be compared to participating laboratory LCS limits, PE sample LCS limits, or any other source of comparison. If the calculated LCS limits are reasonable, a decision will be made regarding the technique (biweight or traditional) to be used for the entire study. If the results are not reasonable, the entire process will be reviewed and alternative methods developed.

8.0 Data Quality Evaluation

Section 7.0 and the attached flowchart describe the overall approach to data quality evaluation that will be used in the pilot study. This approach may be adjusted as appropriate and as the methodology is proven. The basic approach is to first evaluate the shape of the data sets (e.g., testing the data points for normal distribution) and then combine the data sets if ANOVA indicates that there is no significant difference among them. Second, analyze for outlier laboratories and then outlier data points in the set of data for each analyte. Finally, the combined data set, after being tested again for normality, will be used to calculate the LCS acceptance criteria. These steps and the biweight approach are discussed below.

8.1 Distribution of Data

LCS acceptance limits will be generated based on 99% confidence intervals. This requires that each LCS data set exhibit a normal distribution. In this study, a two-step procedure will be used to test the normality of data for each LCS data set. Distribution tests will be performed using the Statistica software. This software provides several techniques for distribution fitting. These include skewness and kurtosis as well as two goodness-of-fit tests (Kolmogorov-Smirnov and Chi-square). In addition, the ANOVA procedure includes a test for homogeneity of variance, which is analogous to a distribution-fitting test.

After the outlier tests have been performed, the normality of the final data set will be tested using the procedure just described.

8.2 One Way ANOVA Analysis

Each data set will contain not only the LCS values but also coded information pertaining to the different parameters described in Section 5.4 (e.g., preparatory method, spiking level). The data sets will be evaluated to determine if those parameters affect the LCS recovery values using one-way Analysis of Variance (ANOVA). If a significant difference is observed between data sets due to a certain parameter, the data sets will be sorted according to that parameter, and the LCS recovery limits generated separately for each parameter. For example, one set of LCS acceptance limits might need development for the spiking level of 50 parts per billion (ppb) and another set for the spiking level of 200 ppb. If a majority of the data sets are found to be non-normal, a non-parametric test can be used as an alternative to ANOVA.

8.3 Grubbs Test for Outlying Data Points

The Grubbs test will be conducted on the subgroups identified by the ANOVA analysis (if any) to determine if extreme values are driving ANOVA results. It will be used again on the entire LCS data set (after the Youden test) to identify and flag outlying data points, using the following procedure:

1. Calculate the mean and standard deviation of each LCS data set;
2. Identify minimum and maximum data points in the data set; and
3. Calculate the appropriate values of T for minimum and maximum data points:

$$T = (X_{av} - X_{min})/S \qquad \text{or} \qquad T = (X_{max} - X_{av})/S$$

Where:

X_{av}	=	Mean of the LCS data set
X_{min}	=	Minimum of the LCS data set
X_{max}	=	Maximum of the LCS data set
S	=	Standard deviation of the LCS data set

4. Select the risk factor for false rejection (e.g., 1 or 5%); and
5. Compare T with values tabulated in Appendix B (from Taylor, 1987), depending on the size of LCS data set and acceptable risk. If T is larger than the tabulated values, maximum or minimum data points will be rejected as outliers.

Dixon’s Test could also be used as an alternate approach to determine outlier data points but this is more complex and will only be considered if the Grubbs test is not adequate for our purposes.

8.4 Youden Test for Outlying Laboratories

The Youden Test will be conducted to identify LCS data sets or laboratories that consistently report high or low LCS recoveries. The test ranks each data point in LCS data sets, as shown in the following tables. The rankings for all data points in each data set will be summed as cumulative scores. The cumulative scores are compared to the statistical ranges listed in Appendix A (Taylor, 1987). If the scores are not within the range, then the LCS data set is an outlier, consistently lower or higher than other LCS data sets, and should not be used in generating LCS limits. In the example below, seven laboratories reported on five samples; the range is expected to be between 8 to 32, with 95% confidence. Laboratory A is considered to provide results consistently higher than other members of the group and is an outlier.

Youden Test Example: Data Sets Collected from Seven Laboratories

	Data Points				
Laboratory	**1**	**2**	**3**	**4**	**5**
A	10.5	14.2	20.0	18.1	12.3
B	9.9	13.7	19.7	18.2	11.7
C	10.2	14.1	19.9	17.8	12.0
D	9.7	13.9	19.5	17.9	12.2
E	10.4	14.0	19.7	17.5	11.6
F	10.0	13.6	19.4	17.6	11.9
G	10.1	13.8	19.6	17.7	12.1

Youden Test Example: Rankings and Cumulative Scores for Each Laboratory

	Rankings of Data Points					Cumulative Score
Laboratory	**Data Point 1**	**Data Point 2**	**Data Point 3**	**Data Point 4**	**Data Point 5**	
A	1	1	1	2	1	6
B	6	6	3	1	6	22
C	3	2	2	4	4	15
D	7	4	6	3	2	22
E	2	3	4	7	7	23
F	5	7	7	6	5	30
G	4	5	5	5	3	22

The Youden test can only be used when the number of observations for each laboratory is equal. This may not always be the case for this project. Therefore, if a laboratory submits more than the minimum number of 20 LCS data points, 20 points will be randomly selected for the sole purpose of testing for outlier laboratories. All submitted LCS data will be used in the calculation of the acceptance criteria.

8.5 Alternative Pilot Test: Biweight Approach

The biweight approach to identifying outliers is an alternative technique to calculating the central tendency of a population and the variability of the population around the central tendency measure. The approach assigns a zero weight to very extreme values and very small weights (e.g., 0.1) to samples that are not quite as extreme. Therefore, it does not require the removal of outliers. It utilizes a rather complex iterative approach to calculate the central tendency value starting from the median. These steps have already been programmed by an outside source) and the pilot study data will be processed by that source for this stage of the parallel evaluation.

The biweight approach is effectively a substitute for the two outlier tests described above, and, since the approach does not require a normal distribution, the normality tests are no longer necessary. The one-way ANOVA analysis is still required, however, and will be conducted for this approach in the same manner described in Section 8.2. The LCS recovery acceptance limits for this alternative approach will be generated by the central tendency and variability calculated by the biweight approach.

9.0 Generation of LCS Recovery Acceptance Limits

In this study (for the main statistical approach), to be consistent with common practice, the confidence interval rather than tolerance intervals or other statistical intervals will be used to generate LCS acceptance limits. The acceptance limits will be based on a 99% confidence interval

After the quality of LCS data sets has been examined, the final LCS data sets will be generated based on the ANOVA results (e.g., combined as one data set or split into subgroups). The mean recovery and standard deviation for the final data set (containing potentially hundreds of data points) will be calculated and used to generate LCS acceptance limits according to the following two-sided 99% confidence interval:

$$LCS\ Recovery\ Acceptance\ Limits = Mean\ Recovery \pm t * S\tan dardDeviation$$

The value for t will depend on the level of confidence desired and the number of degrees of freedom (the number of data points minus one) associated with the estimation of the standard deviation. The values for t are provided in Appendix C (Taylor, 1987). If it is determined that data has been collected from the entire population of labs that meet the defined criteria for the population, then the z (or standard normal curve) rather than the t-distribution will be used.

10.0 Assessment of Results of LCS Recovery Acceptance Limits

The LCS Recovery Acceptance Limits generated by both statistical approaches will be compared to one another. Only one final approach and methodology will be used to analyze the remaining methods.

Prior to finalizing the LCS limits that result from the chosen approach, it is desirable to compare these results to standard measures for a "reality check." Several types of standard measures can be used:

- In-house LCS acceptance limits established by and obtained from the selected laboratories;

- LCS limits established by PE providers who may cooperate in the study;
- Comparison of results from available data bases of PE samples; and
- Single or multiple laboratory method performance data published along with the method(s).

The DOD study team will review the various benchmark comparisons, as well as comments from the analytical community to establish final LCS limits.

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Figure 1
Overview of Pilot Study Methodology

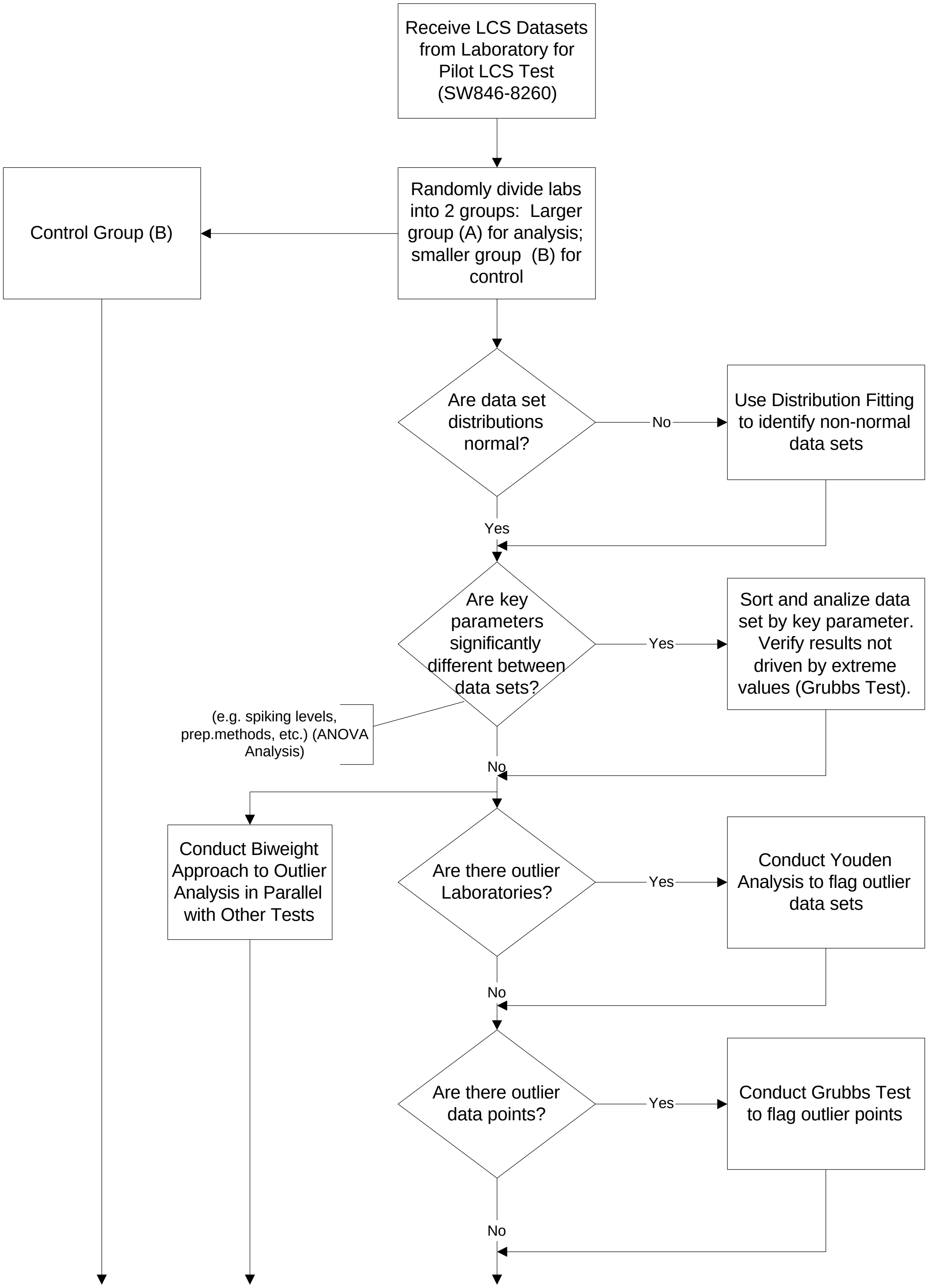
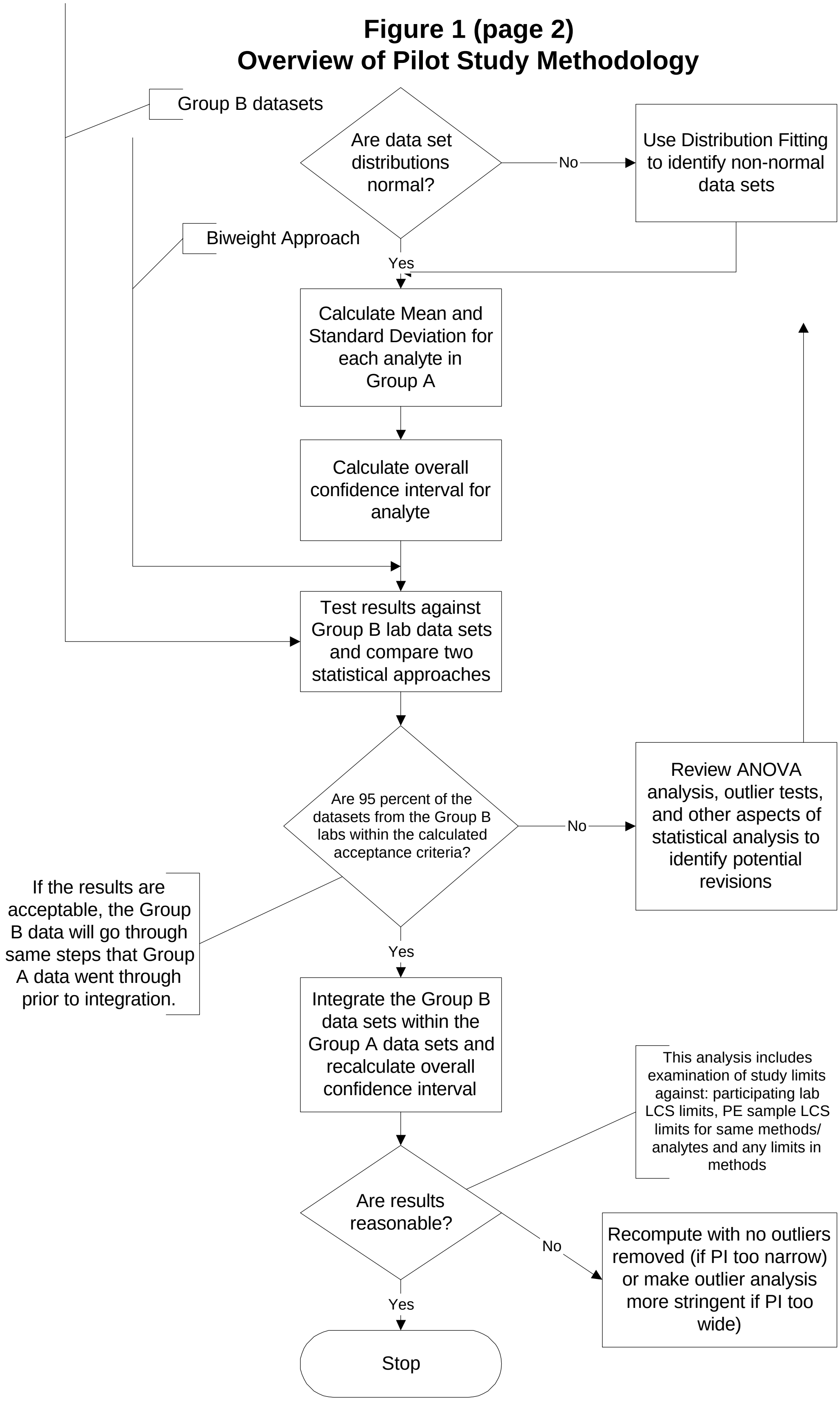


Figure 1 (page 2)
Overview of Pilot Study Methodology



APPENDIX F. FORMS

This appendix contains the following project forms:

- Accident Investigation Report (ENG Form 3394)
- Accident/Illness/Near Miss Report
- Daily Operations Summary
- Daily Quality Control Report
- DD Form 626 (Motor Vehicle Inspection)
- DD Form 1348-1A (Munitions Debris and Range Related Debris)
- DD Form 1348-1A (Munitions Debris)
- Emergency Notification Information
- Employee Emergency Information
- Employee Injury Report
- Explosive Usage Record
- Grid Record
- Hazard Assessment
- Heat Stress Alert
- Heat Stress Monitoring Log
- Magazine Data Card
- Record of Safety Violation or Non-Compliance
- Safety Inspection Form for MEC Operations.
- Safety Inspection Report
- Safety Meeting/Training Record
- Site Visitor Log
- Tailgate Safety Briefing
- Analog Operations Prep Initial and Followup
- Demobilization Prep Initial and Followup
- DGM Operations Prep Initial and Followup
- Explosives Management Prep Initial and Followup
- Intrusive Operations Prep Initial and Followup
- Mobilization and Site Training Prep Initial and Followup
- MPPEH Mgmt Prep Initial and Followup
- Personnel Qualification Verification Form
- Project Reporting and Submittals Prep Initial and Followup
- Test Strip Set Up Prep Initial and Followup
- Underwater Visual Investigation Prep Initial and Followup
- Vegetation Removal Prep Initial and Followup
- Work and Staging Areas Prep Initial and Followup.

(For Safety Staff only)	REPORT NO.	EROC CODE	UNITED STATES ARMY CORPS OF ENGINEERS ACCIDENT INVESTIGATION REPORT (For Use of this Form See Help Menu and USACE Suppl to AR 385-40)	REQUIREMENT CONTROL SYMBOL: CEEC-S-8(R2)

1. ACCIDENT CLASSIFICATION

PERSONNEL CLASSIFICATION	INJURY/ILLNESS/FATAL	PROPERTY DAMAGE	MOTOR VEHICLE INVOLVED	DIVING
GOVERNMENT ☐ CIVILIAN ☐ MILITARY	☐	☐ FIRE INVOLVED ☐ OTHER	☐	☐
☐ CONTRACTOR	☐	☐ FIRE INVOLVED ☐ OTHER	☐	☐
☐ PUBLIC	☐ FATAL ☐ OTHER		☐	

2. PERSONAL DATA

a. Name *(Last, First, MI)*	b. AGE	c. SEX ☐ MALE ☐ FEMALE	d. SOCIAL SECURITY NUMBER	e. GRADE

f. JOB SERIES/TITLE	g. DUTY STATUS AT TIME OF ACCIDENT	h. EMPLOYMENT STATUS AT TIME OF ACCIDENT
	☐ ON DUTY ☐ TDY ☐ OFF DUTY	☐ ARMY ACTIVE ☐ ARMY RESERVE ☐ VOLUNTEER ☐ PERMANENT ☐ FOREIGN NATIONAL ☐ SEASONAL ☐ TEMPORARY ☐ STUDENT ☐ OTHER *(Specify)* ______

3. GENERAL INFORMATION

a. DATE OF ACCIDENT *(month/day/year)*	b. TIME OF ACCIDENT *(Military time)* hrs	c. EXACT LOCATION OF ACCIDENT	d. CONTRACTOR'S NAME (1) PRIME:

e. CONTRACT NUMBER	f. TYPE OF CONTRACT	g. HAZARDOUS/TOXIC WASTE ACTIVITY	
______ ☐ CIVIL WORKS ☐ MILITARY ☐ OTHER *(Specify)* ______	☐ CONSTRUCTION ☐ SERVICE ☐ A/E ☐ DREDGE ☐ OTHER *(Specify)* ______	☐ SUPERFUND ☐ DERP ☐ IRP ☐ OTHER *(Specify)* ______	(2) SUBCONTRACTOR:

4. CONSTRUCTION ACTIVITIES ONLY *(Fill in line and corresponding code number in box from list - see help menu)*

a. CONSTRUCTION ACTIVITY	(CODE) #	b. TYPE OF CONSTRUCTION EQUIPMENT	(CODE) #

5. INJURY/ILLNESS INFORMATION *(Include name on line and corresponding code number in box for items e, f & g - see help menu)*

a. SEVERITY OF ILLNESS/INJURY	(CODE) #	b. ESTIMATED DAYS LOST	c. ESTIMATED DAYS HOSPITALIZED	d. ESTIMATED DAYS RESTRICTED DUTY

e. BODY PART AFFECTED	(CODE)	g. TYPE AND SOURCE OF INJURY/ILLNESS	(CODE)
PRIMARY ______	#	TYPE ______	#
SECONDARY ______	#	SOURCE ______	#
f. NATURE OF ILLNESS/INJURY ______	(CODE) #		

6. PUBLIC FATALITY *(Fill in line and correspondence code number in box - see help menu)*

a. ACTIVITY AT TIME OF ACCIDENT	(CODE) #	b. PERSONAL FLOATATION DEVICE USED? ☐ YES ☐ NO ☐ N/A

7. MOTOR VEHICLE ACCIDENT

a. TYPE OF VEHICLE	b. TYPE OF COLLISION	c. SEAT BELTS	USED	NOT USED	NOT AVAILABLE
☐ PICKUP/VAN ☐ AUTOMOBILE	☐ SIDE SWIPE ☐ HEAD ON ☐ REAR END	(1) FRONT SEAT			
☐ TRUCK ☐ OTHER *(Specify)* ______	☐ BROADSIDE ☐ ROLL OVER ☐ BACKING ☐ OTHER *(Specify)* ______	(2) REAR SEAT			

8. PROPERTY/MATERIAL INVOLVED

a. NAME OF ITEM	b. OWNERSHIP	c. $ AMOUNT OF DAMAGE
(1)		
(2)		
(3)		

9. VESSEL/FLOATING PLANT ACCIDENT *(Fill in line and correspondence code number in box from list - see help menu)*

a. TYPE OF VESSEL/FLOATING PLANT	(CODE) #	b. TYPE OF COLLISION/MISHAP	(CODE) #

10. ACCIDENT DESCRIPTION *(Use additional paper, if necessary)*

11. **CAUSAL FACTOR(S)** *(Read Instruction Before Completing)*

a. (Explain YES answers in item 13)

	YES	NO
DESIGN: Was design of facility, workplace or equipment a factor?	☐	☐
INSPECTION/MAINTENANCE: Were inspection & maintenance procedures a factor?	☐	☐
PERSON'S PHYSICAL CONDITION: In your opinion, was the physical condition of the person a factor?	☐	☐
OPERATING PROCEDURES: Were operating procedures a factor?	☐	☐
JOB PRACTICES: Were any job safety/health practices not followed when the accident occurred?	☐	☐
HUMAN FACTORS: Did any human factors such as, size or strength of person, etc., contribute to accident?	☐	☐
ENVIRONMENTAL FACTORS: Did heat, cold, dust, sun, glare, etc., contribute to the accident?	☐	☐

a. *(CONTINUED)*

	YES	NO
CHEMICAL AND PHYSICAL AGENT FACTORS: Did exposure to chemical agents, such as dust, fumes, mists, vapors or physical agents, such as, noise, radiation, etc., contribute to accident?	☐	☐
OFFICE FACTORS: Did office setting such as, lifting office furniture, carrying, stooping, etc., contribute to the accident?	☐	☐
SUPPORT FACTORS: Were inappropriate tools/resources provided to properly perform the activity/task?	☐	☐
PERSONAL PROTECTIVE EQUIPMENT: Did the improper selection, use or maintenance of personal protective equipment contribute to the accident?	☐	☐
DRUGS/ALCOHOL: In your opinion, was drugs or alcohol a factor to the accident	☐	☐

b. WAS A WRITTEN JOB/ACTIVITY HAZARD ANALYSIS COMPLETED FOR TASK BEING PERFORMED AT TIME OF ACCIDENT?

☐ YES *(If yes, attach a copy.)* ☐ NO

12. **TRAINING**

a. WAS PERSON TRAINED TO PERFORM ACTIVITY/TASK?	b. TYPE OF TRAINING.	c. DATE OF MOST RECENT FORMAL TRAINING.
☐ YES ☐ NO	☐ CLASSROOM ☐ ON JOB	(Month) (Day) (Year)

13. **FULLY EXPLAIN WHAT ALLOWED OR CAUSED THE ACCIDENT; INCLUDE DIRECT AND INDIRECT CAUSES** *(See instruction for definition of direct and indirect causes.) (Use additional paper, if necessary)*

a. DIRECT CAUSE

b. INDIRECT CAUSE(S)

14. **ACTION(S) TAKEN, ANTICIPATED OR RECOMMENDED TO ELIMINATE CAUSE(S).**

DESCRIBE FULLY:

15. **DATES FOR ACTIONS IDENTIFIED IN BLOCK 14.**

a. BEGINNING (Month/Day/Year)	b. ANTICIPATED COMPLETION (Month/Day/Year)

c. SIGNATURE AND TITLE OF SUPERVISOR COMPLETING REPORT	d. DATE *(Mo/Da/Yr)*	e. ORGANIZATION IDENTIFIER *(Div, Br, Sect)*	f. OFFICE SYMBOL
CORPS ____________ CONTRACTOR ____________			

16. **MANAGEMENT REVIEW** *(1st)*

a. ☐ CONCUR b. ☐ NON CONCUR c. COMMENTS

SIGNATURE	TITLE	DATE

17. **MANAGEMENT REVIEW** *(2nd - Chief Operations, Construction, Engineering, etc.)*

a. ☐ CONCUR b. ☐ NON CONCUR c. COMMENTS

SIGNATURE	TITLE	DATE

18. **SAFETY AND OCCUPATIONAL HEALTH OFFICE REVIEW**

a. ☐ CONCUR b. ☐ NON CONCUR c. ADDITIONAL ACTIONS/COMMENTS

SIGNATURE	TITLE	DATE

19. **COMMAND APPROVAL**

COMMENTS

COMMANDER SIGNATURE	DATE

*U.S. GOVERNMENT PRINTING OFFICE: 1993-0-791-757

10. **ACCIDENT DESCRIPTION** *(Continuation)*

13a. **DIRECT CAUSE** *(Continuation)*

Page 3 of 4 pages

13b. INDIRECT CAUSES *(Continuation)*

14. ACTION(S) TAKEN, ANTICIPATED, OR RECOMMENDED TO ELIMINATE CAUSE(S) *(Continuation)*

ACCIDENT/ILLNESS/NEAR MISS REPORT

SECTION 1 - GENERAL INFORMATION

Name:	**SSN:**		
Job Title:	**D.O.B.:**	**Sex:**	**Age:**
Site Name:	**UXOSO:**		
Date of Report:	**Date of Incident:**	**Time of Incident:**	
Task/Operation Being Conducted:			
PPE Worn:			

SITE CONDITIONS AT TIME OF INCIDENT

Temperature: ________________ **Humidity:** ________________
Wind Speed: ________ **Direction:** **Cloud Cover:** ________________
Precipitation: ________________ **Other:** ________________

Type of Incident: ☐ **Personal Injury** ☐ **Personal Illness** ☐ **Chemical Exposure**
☐ **Motor Vehicle** ☐ **Property Damage** ☐ **Near Miss**

If chemical exposure, what material(s) was(were) involved: ________________
What was the nature of exposure (contact, inhalation, etc.): ________________

Other Individual(s) Involved: ________________

SECTION 2 - PERSONAL INJURY/ILLNESS INFORMATION

Nature/Type of Injury/Illness (laceration, strain, etc.): ________________

Cause of Injury/Illness: ________________

Body Part(s) Affected: Primary: ________________ **Secondary:** ________________

Injury/Illness Required: ☐ **On Site First Aid Treatment** ☐ **Emergency Room Treatment** ☐ **Hospitalization**

Injury/Illness Resulted In: ☐ **Loss of Work Time** ☐ **Limitation of Duties** ☐ **Fatality**
☐ **Other: (Explain):** ________________

Status at Time of Report: ☐ **Returned to Work: (Date: ________)** ☐ **Hospitalized: (Anticipated Stay: ________)**
☐ **Convalescing: (Anticipated Length of Convalescence: ________)**
☐ **Other:** ________________

On Site First Aid Treatment Given: ________________

Off Site Medical Treatment (attach documentation, including Physician statement): ________________

ACCIDENT/ILLNESS/NEAR MISS REPORT (cont.)

SECTION 3 - MOTOR VEHICLE ACCIDENT

Type of Vehicle/Equipment	Type of Collision	Seat Belt Use
☐ Automobile ☐ Van/Truck ☐ Bush Hog ☐ Other:	☐ Side Swipe ☐ Rear End ☐ Backing ☐ Head on ☐ Broadside ☐ Roll	Front Seat ☐ Yes ☐ No Back Seat ☐ Yes ☐ No

Property/Material/Items Involved

Name of Item	Owner	$ Amount of Damage

Accident Description (Use additional paper if needed)

SECTION 4 - POST ACCIDENT/INJURY/ILLNESS REVIEW

Has the Corporate Office been notified? ☐ **Yes** ☐ **No, If Yes, When?** **By Whom?**

Were operations conducted using approved USAE SOP or a APP/SSHP?
☐ **Yes Reference:**
☐ **No Explain:**

UXOSO/SSO's Comments:

Employee Comments:

Witnesses

Name	Organization	Phone Number

Employee Signature: **Date:**

UXOSO/SSO Signature: **Date:**

Actions Completed By: **Date:**

Corporate Review By: **Date:**

DAILY OPERATIONS SUMMARY

DATE: ____/____/____ **PAGE 1 OF 5 PAGES**

SITE / LOCATION: ____

1. WORK SUMMARY

a. Work Accomplished:	**Number Completed**	**Total Remaining**
(1) Survey	_______	_______
(2) Preparation	_______	_______
(3) Mag & Flag	_______	_______
(4) Geophysical	_______	_______
(5) Intrusive	_______	_______
(6) Quality Control	_______	_______
(7) Quality Assurance	_______	_______

b. Discrepancies: ____
____
____
____

c. Inspection Results:	**Pass**	**Fail**
(1) Quality Control	_______	_______
(2) Quality Assurance	_______	_______
(3) Safety	_______	_______

2. INSTRUCTIONS RECEIVED FROM CUSTOMER REPRESENTATIVE: __________
____
____
____
____

OPS-1 Form

Daily Operations Summary Con't. **PAGE 2 OF 5 PAGES**

3. UXO SUMMARY

a. UXO Located:

Type:	Quantity:	Live/Prac.:	Remarks:

OPS-1 Form

Daily Operations Summary Con't. **PAGE 3 of 5 PAGES**

b. Demolition Supplies Expended:

Type:	Quantity:	Remarks:

c. Scrap Generation / Deposition:

Type:	Quantity:	Weight:	Remarks:

OPS-1 Form

Daily Operations Summary Con't. **PAGE 4 of 5 PAGES**

4. **Utilization**

   a. **Daily Man-hours:**

Labor Category:	Task #	M/H Today:	M/H 0% :	M/H 4%	M/H 8%
Site Manager					
SUXOS					
UXO Technician III					
UXO Technician II					
UXO Technician I					
Laborer					
UXOSO					
UXOQCS					
Admin Personnel					
Visitor					
Sub-Contractor Personnel (List by Category)					

OPS-1 Form

Daily Operations Summary Con't. **PAGE 5 of 5 PAGES**

b. Daily Equipment:

Description:	Task:	Hours Used:	Hours Remaining:	% Hours Remaining:	Remarks:

5. Operational Remarks:

____
____
____
____
____
____

6. Signature / Date:

______________________________________ **Date: ____/____/____**

SUXOS

OPS-1 Form

USA Environmental, Inc.

DAILY QUALITY CONTROL REPORT

Date: ____/____/____ Contract #: _______________ Task Order #: ________

Site/Location : __________________________________

Weather: __________________ Temperature: _______ Rainfall: _________

1. Preparatory Inspection: ____

Results: ____

2. QC Audits Performed

a. Operations: ____

Results: ____

b. Safety: ____

Results: ____

c. Administrative: ____

Results: ____

d. Equipment: ____

Results: ____

Page 1 of 2

Daily Quality Control Report Con't:

3. QC Performed (Grids)

Number of Grids QC'd: __________ Results: _______ # Pass _______ # Fail

Comments: ____
____
____
____

4. Follow Up Inspections and Results

Section(s): ____
____
____
Results: ____

5. Instructions Received: ____
____
____
____
____

Remarks: ____
____
____
____

QC Signature: ___________________________________ **Date:** ____/____/____

Printed Name: ___________________________________

Page 2 of 2

MOTOR VEHICLE INSPECTION (TRANSPORTING HAZARDOUS MATERIALS)

(Read Instructions before completing this form.)

This form applies to all vehicles which must be marked or placarded in accordance with Title 49 CFR.	1. BILL OF LADING/TRANSPORTATION CONTROL NUMBER

SECTION 1 - DOCUMENTATION	ORIGIN a.	DESTINATION b.
2. CARRIER/GOVERNMENT ORGANIZATION		
3. DATE/TIME OF INSPECTION		
4. LOCATION OF INSPECTION		
5. OPERATOR(S) NAME(S)		
6. OPERATOR(S) LICENSE NUMBER(S)		
7. MEDICAL EXAMINER'S CERTIFICATE*		

8. *(X if satisfactory at origin)*				9. CVSA DECAL DISPLAYED ON COMMERCIAL EQUIPMENT*	YES	NO
a. MILITARY HAZMAT ENDORSEMENT		d. ERG OR EQUIVALENT COMMERCIAL: YES / NO				
b. VALID LEASE*		e. DRIVER'S VEHICLE INSPECTION REPORT*		a. TRUCK/TRACTOR		
c. ROUTE PLAN		f. COPY OF 49 CFR PART 397		b. TRAILER		

SECTION II - MECHANICAL INSPECTION

All items shall be checked on empty equipment prior to loading. Items with an asterisk shall be checked on all incoming loaded equipment.

10. TYPE OF VEHICLE(S)	11. VEHICLE NUMBER(S)

12. PART INSPECTED *(X as applicable)*	ORIGIN (1) SAT	ORIGIN (1) UNSAT	DESTINATION (2) SAT	DESTINATION (2) UNSAT		ORIGIN (1) SAT	ORIGIN (1) UNSAT	DESTINATION (2) SAT	DESTINATION (2) UNSAT	COMMENTS (3)
a. SPARE ELECTRICAL FUSES					k. EXHAUST SYSTEM					
b. HORN OPERATIVE					l. BRAKE SYSTEM*					
c. STEERING SYSTEM					m. SUSPENSION					
d. WINDSHIELD/WIPERS					n. COUPLING DEVICES					
e. MIRRORS					o. CARGO SPACE					
f. WARNING EQUIPMENT					p. LANDING GEAR*					
g. FIRE EXTINGUISHER*					q. TIRES, WHEELS, RIMS					
h. ELECTRICAL WIRING					r. TAILGATE/DOORS*					
i. LIGHTS AND REFLECTORS					s. TARPAULIN*					
j. FUEL SYSTEM*					t. OTHER *(Specify)*					

13. INSPECTION RESULTS *(X one)* ACCEPTED ☐ REJECTED ☐
(If rejected give reason under "Remarks". Equipment will be approved if deficiencies are corrected prior to loading.)

14. SATELLITE MOTOR SURVEILLANCE SYSTEM: *(X one)* ACCEPTED ☐ REJECTED ☐

15. REMARKS

16. INSPECTOR SIGNATURE *(Origin)*	17. INSPECTOR SIGNATURE *(Destination)*

SECTION III - POST LOADING INSPECTION

This section applies to Commercial and Government/Military vehicles. All items will be checked prior to release of loaded equipment and shall be checked on all incoming loaded equipment.

	ORIGIN (1) SAT	ORIGIN (1) UNSAT	DESTINATION (2) SAT	DESTINATION (2) UNSAT	COMMENTS (3)
18. LOADED IAW APPLICABLE SEGREGATION/COMPATIBILITY TABLE OF 49 CFR					
19. LOAD PROPERLY SECURED TO PREVENT MOVEMENT					
20. SEALS APPLIED TO CLOSED VEHICLE; TARPAULIN APPLIED ON OPEN EQUIPMENT					
21. PROPER PLACARDS APPLIED					
22. SHIPPING PAPERS/DD FORM 836 FOR GOVERNMENT VEHICLE SHIPMENTS					
23. COPY OF DD FORM 626 FOR DRIVER					
24. SHIPPED UNDER DOT SPECIAL PERMIT 868					

25. INSPECTOR SIGNATURE *(Origin)*	26. DRIVER(S) SIGNATURE *(Origin)*
27. INSPECTOR SIGNATURE *(Destination)*	28. DRIVER(S) SIGNATURE *(Destination)*

DD FORM 626, MAR 2007 PREVIOUS EDITION IS OBSOLETE. Page 1 of 3 Pages
Adobe Professional 7.0

INSTRUCTIONS

SECTION I - DOCUMENTATION

General Instructions.

All items (2 through 9) will be checked at origin prior to loading. Items with an asterisk (*) apply to commercial operators or equipment only. Only Items 2 through 7 are required to be checked at destination.

Items 1 through 5. Self explanatory.

Item 6. Enter operator's Commercial Driver's License (CDL) number or Military OF-346 License Number. CDL and OF-346 must have the HAZMAT and other appropriate endorsements IAW 49 CFR 383.

Item 7. *Enter the expiration date listed on the Medical Examiner's Certificate.

Item 8.a. APPLIES TO MILITARY OPERATORS ONLY. Military Hazardous Materials Certification. In accordance with applicable service regulations, ensure operator has been certified to transport hazardous materials.

b. *Valid Lease. Shipper will ensure a copy of the appropriate contract or lease is carried in all leased vehicles and is available for inspection. (49 CFR 376.12 and 376.11(c)(2)).

c. Route Plan. Prior to loading any Hazard Class/Division 1.1, 1.2, or 1.3 (Explosives) for shipment, ensure that the operator possesses a written route plan in accordance with 49 CFR Part 397. Route Plan requirements for Hazard Class 7 (Radioactive) materials are found in 49 CFR 397.101.

d. Emergency Response Guidebook (ERG) or Equivalent. Commercial operators must be in possession of an ERG or equivalent document. Shipper will provide applicable ERG page(s) to military operators.

e. *Driver's Vehicle Inspection Report. Review the operator's Vehicle Inspection Report. Ensure that there are no defects listed on the report that would affect the safe operation of the vehicle.

f. Copy of 49 CFR Part 397. Operators are required by regulation to have in their possession a copy of 49 CFR Part 397 (Transportation of Hazardous Materials Driving and Parking Rules). If military operators do not possess this document, shipper will provide a copy to operator.

Item 9. *Commercial Vehicle Safety Alliance (CVSA) Decal. Check to see if equipment has a current CVSA decal and mark applicable box. Vehicles without CVSA, check documentation of the last vehicle periodic inspection and perform DD Form 626 inspection.

SECTION II - MECHANICAL INSPECTION

General Instructions.

All items (12.a. through 12.t.) will be checked on all incoming empty equipment prior to loading. All UNSATISFACTORY conditions must be corrected prior to loading. Items with an asterisk (*) shall be checked on all incoming loaded equipment. Unsatisfactory conditions that would affect the safe off-loading of the equipment must be corrected prior to unloading.

SECTION II *(Continued)*

Item 12.a. Spare Electrical Fuses. Check to ensure that at least one spare fuse for each type of installed fuse is carried on the vehicle as a spare or vehicle is equipped with an overload protection device (circuit breaker). (49 CFR 393.95)

b. Horn Operative. Ensure that horn is securely mounted and of sufficient volume to serve purpose. (49 CFR 393.81)

c. Steering System. The steering wheel shall be secure and must not have any spokes cracked through or missing. The steering column must be securely fastened. Universal joints shall not be worn, faulty or repaired by welding. The steering gear box shall not have loose or missing mounting bolts or cracks in the gear box mounting brackets. The pitman arm on the steering gear output shaft shall not be loose. Steering wheel shall turn freely through the limit of travel in both directions. All components of a power steering system must be in operating condition. No parts shall be loose or broken. Belts shall not be frayed, cracked or slipping. The power steering system shall not be leaking. (49 CFR 396 Appendix G)

d. Windshield/Wipers. Inspect to ensure that windshield is free from breaks, cracks or defects that would make operation of the vehicle unsafe; that the view of the driver is not obscured and that the windshield wipers are operational and wiper blades are in serviceable condition. Defroster must be operative when conditions require. (49 CFR 393.60, 393.78 and 393.79)

e. Mirrors. Every vehicle must be equipped with two rear vision mirrors located so as to reflect to the driver a view of the highway to the rear along both sides of the vehicle. Mirrors shall not be cracked or dirty. (49 CFR 393.80)

f. Warning Equipment. Equipment must include three bidirectional emergency reflective triangles that conform to the requirements of FMVSS No. 125. FLAME PRODUCING DEVICES ARE PROHIBITED. (49 CFR 393.95)

g. Fire Extinguisher. Military vehicles must be equipped with two serviceable fire extinguishers with an Underwriters Laboratories rating of 10 BC or more. (Commercial motor vehicles must be equipped with one serviceable 10 BC Fire Extinguisher). Fire extinguisher(s) must be located so that it is readily accessible for use and securely mounted on the vehicle. The fire extinguisher must be designed, constructed and maintained to permit visual determination of whether it is fully charged. (49 CFR 393.95)

h. Electrical Wiring: Electrical wiring must be clean and properly secured. Insulation must not be frayed, cracked or otherwise in poor condition. There shall be no uninsulated wires, improper splices or connections. Wires and electrical fixtures inside the cargo area must be protected from the lading. (49 CFR 393.28, 393.32, 393.33)

INSTRUCTIONS

SECTION II *(Continued)*

i. Lights/Reflectors. (Head, tail, turn signal, brake, clearance, marker and identification lights, Emergency Flashers). Inspect to see that all lighting devices and reflectors required are operable, of proper color and properly mounted. Ensure that lights and reflectors are not obscured by dirt or grease or have broken lenses. High/Low beam switch must be operative. Emergency Flashers must be operative on both the front and rear of vehicle. (49 CFR 393.24, 25, and 26)

j. Fuel System. Inspect fuel tank and lines to ensure that they are in serviceable condition, free from leaks, or evidence of leakage and securely mounted. Ensure that fuel tank filler cap is not missing. Examine cap for defective gasket or plugged vent. Inspect filler necks to see that they are in completely serviceable condition and not leaking at joints. (49 CFR 393.83)

k. Exhaust System. Exhaust system shall discharge to the atmosphere at a location to the rear of the cab or if the exhaust projects above the cab, at a location near the rear of the cab. Exhaust system shall not be leaking at a point forward of or directly below the driver compartment. No part of the exhaust system shall be located where it will burn, char or damage electrical wiring, fuel system or any other part of the vehicle. No part of the exhaust system shall be temporarily repaired with wrap or patches. (49 CFR 393.83)

l. Brake System (to include hand brakes, parking brakes and Low Air Warning devices). Check to ensure that brakes are operational and properly adjusted. Check for audible air leaks around air brake components and air lines. Check for fluid leaks, cracked or damaged lines in hydraulic brake systems. Ensure that parking brake is operational and properly adjusted. Low Air Warning devices must be operative. (49 CFR 393.40, 41, 42, 43, 44, 45, 47, 48, 49, 50, 51, 52, 53, and 55)

m. Suspension. Inspect for indications of misaligned, shifted or cracked springs, loosened shackles, missing bolts, spring hangers unsecured at frame and cracked or loose U-bolts. Inspect for any unsecured axle positioning parts, and sign of axle misalignment, broken torsion bar springs (if so equipped). (49 CFR 393.207)

n. Coupling Devices (Inspect without uncoupling). Fifth Wheels: Inspect for unsecured mounting to frame or any missing or damaged parts. Inspect for any visible space between upper and lower fifth wheel plates. Ensure that the locking jaws are around the shank and not the head of the kingpin. Ensure that the release lever is seated properly and safety latch is engaged. Pintle Hook, Drawbar, Towbar Eye and Tongue and Safety Devices: Inspect for unsecured mounting, cracks, missing or ineffective fasteners (welded repairs to pintle hook is prohibited). Ensure safety devices (chains, hooks, cables) are in serviceable condition and properly attached. (49 CFR 393.70 and 71)

o. Cargo Space. Inspect to ensure that cargo space is clean and free from exposed bolts, nuts, screws, nails or inwardly projecting parts that could damage the lading. Check floor to ensure it is tight and free from holes. Floor shall not be permeated with oil or other substances. (49 CFR 393.84)

p. Landing Gear. Inspect to ensure that landing gear and assembly are in serviceable condition, correctly assembled, adequately lubricated and properly mounted.

SECTION II *(Continued)*

q. Tires, Wheels and Rims: Inspect to ensure that tires are properly inflated. Flat or leaking tires are unacceptable. Inspect tires for cuts, bruises, breaks and blisters. Tires with cuts that extend into the cord body are unacceptable. Thread depth shall not be less than: 4/32 inches for tires on a steering axle of a power unit, and 2/32 inches for all other tires. Mixing bias and radial on the steering axle is prohibited. Inspect wheels and rims for cracks, unseated locking rings, broken, loose, damaged or missing lug nuts or elongated stud holes. (49 CFR 393.75)

r. Tailgate/Doors. Inspect to see that all hinges are tight in body. Check for broken latches and safety chains. Doors must close securely. (49 CFR 177.835(h))

s. Tarpaulin. If shipment is made on open equipment, ensure that lading is properly covered with fire and water resistant tarpaulin. (49 CFR 177.835(h))

t. Other Unsatisfactory Condition. Note any other condition which would prohibit the vehicle from being loaded with hazardous materials.

Item 14. For AA&E and other shipments requiring satellite surveillance, ensure that the Satellite Motor Surveillance System is operable. The DTTS Message Display Unit, when operative, will display the signal "DTTS ON". The munitions carrier driver, when practical, will position the DTTS message display unit in a manner that allows the shipping inspector or other designated shipping personnel to observe the "DTTS ON" message without climbing aboard the cab of the motor vehicle.

SECTION III - POST LOADING INSPECTION

General Instructions.

All items will be checked prior to the release of loaded equipment. Shipment will not be released until deficiencies are corrected. All items will be checked on incoming loaded equipment. Deficiencies will be reported in accordance with applicable service regulations.

Item 18. Check to ensure shipment is loaded in accordance with 49 CFR Part 177.848 and the applicable Segregation or Compatibility Table of 49 CFR 177.848.

Item 19. Check to ensure the load is secured from movement in accordance with applicable service outload drawings.

Item 20. Check to ensure seal(s) have been applied to closed equipment; fire and water resistant tarpaulin applied on open equipment.

Item 21. Check to ensure each transport vehicle has been properly placarded in accordance with 49 CFR 172.504.

Item 22. Check to ensure operator has been provided shipping papers that comply with 49 CFR 172.201 and 202. For shipments transported by Government vehicle, shipping paper will be DD Form 836.

Item 23. Ensure operator(s) sign DD Form 626, are given a copy and understand the hazards associated with the shipment.

Item 24. Applies to Commercial Shipments Only. If shipment is made under DOT Special Permit 868, ensure that shipping papers are properly annotated and copy of Special Permit 868 is with shipping papers.

DD FORM 626, MAR 2007 Page 3 of 3 Pages

DD FORM 1348-1A, JUL 91 (EG) ISSUE RELEASE/RECEIPT DOCUMENT

1 2 3 DOC I D E N T	4 5 6 RI FROM	7 M & S	23 24 UNIT I S S	25–29 QUANTITY	45 SER	46–50 SUPPLEMENTARY ADDRESS	51 SIG	52 FUND	53–55 DISTRIBUTION	56–59 PROJECT	60–61 PRI	62–64 REQD DEL DATE	65–66 ADV	67–69 RI	70 O/P	71 COND	72 MGT	73–80 UNIT PRICE DOLLARS CTS	1. TOTAL PRICE DOLLARS CTS	2. SHIP FROM	3. SHIP TO

4. MARK FOR

5. DOC DATE	6. NMFC	7. FRT RATE	8. TYPE CARGO	9. PS

10. QTY. REC'D	11.UP	12. UNIT WEIGHT	13. UNIT CUBE	14. UFC	15. SL

16. FREIGHT CLASSIFICATION NOMENCLATURE

17. ITEM NOMENCLATURE

18. TY CONT	19. NO CONT	20. TOTAL WEIGHT	21. TOTAL CUBE

22. RECEIVED BY	23. DATE RECEIVED

24. DOCUMENT NUMBER & SUFFIX (30-44)

Basic Material Content: ____

Estimate Weight (lbs): ____________

Container ID No.: ____________________ Seal ID No.: ____________________

25. NATIONAL STOCK NO. & ADD (8-22)

Site Address: ____

Site Telephone No.: ____

____

26. RIC (4-6) UI (23-24) QTY (25-29) CON CODE (71) DIST (55-56) UP (74-80)

This certifies and verifies that the material listed has been100 percent inspected and to the best of our knowledge and belief, are inert and/or free of explosives or related materials.

27. ADDITIONAL DATA

Certify By:

Date:______________

____

Senior UXO Supervisor / Team Leader

Verify By:

_________________________________ Date: ______________

USACE OE Safety Specialist

USA Environmental, Inc., 720 Brooker Creek Boulevard, Suite 204, Oldsmar, Florida 34677, Telephone: 813.343.6336, Fax: 813.343.637

PREVIOUS EDITION MAY BE USED

PerFORM (DLA)

DD FORM 1348-1A, JUL 91 (EG) ISSUE RELEASE/RECEIPT DOCUMENT

1 2 3 4 5 6 7 23 24 25 26 27 28 29 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

DOC IDENT | RI FROM | M&S | UNIT | ISS | QUANTITY | SER | SUPPLEMENTARY ADDRESS | SIG | FUND | DISTRIBUTION | PROJECT | PRI | REQD DATE | DEL DATE | ADV | RI | O/P | COND | MGT | UNIT PRICE DOLLARS CTS

1. TOTAL PRICE DOLLARS CTS

2. SHIP FROM

3. SHIP TO

4. MARK FOR

5. DOC DATE

6. NMFC

7. FRT RATE

8. TYPE CARGO

9. PS

10. QTY. REC'D

11.UP

12. UNIT WEIGHT

13. UNIT CUBE

14. UFC

15. SL

16. FREIGHT CLASSIFICATION NOMENCLATURE

17. ITEM NOMENCLATURE

18. TY CONT

19. NO CONT

20. TOTAL WEIGHT

21. TOTAL CUBE

22. RECEIVED BY

23. DATE RECEIVED

24. DOCUMENT NUMBER & SUFFIX (30-44)

25. NATIONAL STOCK NO. & ADD (8-22)

26. RIC (4-6) UI (23-24) QTY (25-29) CON CODE (71) DIST (55-56) UP (74-80)

27. ADDITIONAL DATA

Basic Material Content: ______________________________

Estimate Weight (lbs): ____________

Container ID No.: ____________________ Seal ID No.: ____________________

Site Address: ______________________________

Site Telephone No.: ______________________________

____

This certifies that the material listed has been 100 percent properly inspected and, to the best of our knowledge and belief, are free of explosive hazards, engine fluids, illuminating dials and other visible liquid HTWR materials.

Certify By: Verify By:

Date:______________ ______________________________ Date: ______________

USACE OE Safety Specialist

USA Environmental, Inc., 720 Brooker Creek Boulevard, Suite 204, Oldsmar, Florida 34677, Telephone: 813.343.6336, Fax: 813.343.637

____

Senior UXO Supervisor / Team Leader

PREVIOUS EDITION MAY BE USED

PerFORM (DLA)

EMERGENCY NOTIFICATION INFORMATION

Employee's Name:____

Date:______/______/______

IN CASE OF EMERGENCY, PLEASE NOTIFY:

Name:____ Relationship:_______________________

Telephone: (______) ______-_________ or (______) ______-________

Address:____

City:_____________________________ State:_______________ Zip:_________

AND / OR

Name:____ Relationship:_______________________

Telephone: (______) ______-_________ or (______) ______-________

Address:____

City:_____________________________ State:_______________ Zip:_________

Additional Information:____
____
____
____

Employee Signature:____

Date:_____/_____/_____

DO NOT RELEASE INFORMATION TO A 3RD PARTY.

EMPLOYEE EMERGENCY INFORMATION

Employee's Name:____

Date of Birth:_____/_____/_____ SSN:________-________-________

Blood Type:_________________

Allergic To:____

____

Current Medications:____

____

Medical Conditions:____

____

Local Address:____

City:________________________ State:_______________ Zip:____________

Telephone : (_______) _______-_______ or (_______) _______-________

Employee Signature:____

Date:______/______/______

Reviewed or Updated On:______/______/______

<u>DO NOT RELEASE THIS INFORMATION TO ANY 3RD PARTY.</u>

USA Environmental, Inc. Employee Injury Report

Site/Location: __________________ **Control Number**: _________________

This is an official document to be initiated by USA supervisors. Be accurate, thorough, and answer all questions.

BACKGROUND DATA

Todays Date: ____/____/____ Date of Accident: ____/____/____ Time: ______ AM PM

Day of Accident: S M T W T F S Weather Conditions: Sunny Clear Rain Fog Overcast

Temperature: 0-32 32-50 50-70 70-85 85 + Wind Conditions: Still Moderate High None

Location of Accident: _______________________ Time Accident was Reported: _______ AM PM

____ Reported to Whom: ______________________

PERSONAL DATA

Name: Last ____________________________ First ___________________________ MI __________

Sex: F M DOB: ____/____/____ Place of Birth: ___________________________

SSAN: _____-_____-_____ DOH: ____/____/____ Position: _________________________

Address: _____________________________________ City: __________________ State: ____

Telephone Number: (______) ______-______ Zip: ___________

ACCIDENT DATA

Nature of Accident: Near Miss ___ 1st Aid ___ Dr Visit ___ Ambul ___ Hospitalized ___ Fatality ___

If Fatality, Name of Agency Notified: ____________________ Type of Injury: ___________________

Did Employee Leave the Work Site: Yes ___ No ___ If Yes, Time Departed: __________ AM PM

Name of Medical Facility: __________________________ Telephone Number: (____) ____-_____

Address: _______________________________ City: ___________________ State: ___ Zip: _______

Description of Accident: ____

Activity at Time of Accident: ____

Employee Injury Report Con't.

WITNESS DATA

Witness Name: Last ______________________________ First ______________________ MI _______

Address: __________________________________ City: ____________________ State: ____ Zip: ______

Telephone Number: (____) _____-______ Employed By: ___________________________________

Statement Attached: Yes ___ No ___ Telephone Number: (____) _____-______

ACCIDENT ACTIONS/ANALYSIS

Accident Cause(s):____

____

____

Lack of Safety Equipment a Factor: Yes ___ No ___ If Yes, Explain: ______________________________

____

Safety Regulations or Guidance Violated: Yes ___ No ___ If Yes, Explain: ________________________

____

Photographs Taken: Yes ___ No ___ If Yes, Located at: ____

Regulatory Agencies Notified: Yes ___ No ___ If Yes, which: _____________________________________

Point of Contact: ___________________________ Date and Time: ____/____/____ _________ AM PM

Corrective Actions Taken or Recommended: ____

____

____

Report Prepared By: ______________________________ Signature: _______________________________

SUXO/PROJECT MANAGER

Corrective Actions/Recommendations: ____

SUXO Signature: ____ Date: ____/____/____

Concur With Actions Taken: Yes ___ No ___ Remarks: _______________________________________

Project Manager Signature: _______________________________ Date: ____/____/____

Is ENG Form 3394 to be submitted: Yes______ No____ If Yes, Dated: ___/___/_______

EXPLOSIVE USAGE RECORD

Contract Number: ____________

Team Number: ________ *Date:* ________ *Project Name:* ____________

Team Leader: ____________ *Work area/Grid Number:* ____________

EXPLOSIVES	LOT NUMBER	QUANTITIES						Signatures	
		Issued	*Initials*	*Used*	*Initials*	*Returned*	*Initials*	*Team Leader*	*Checker*

Reviewed and Accepted: ____________ **Date:** ____________

Senior UXO Supervisor

USA Environmental, Inc.

Page 1of 1 Pages

USA Environmental, Inc. Grid Record

Date: ____/____/____ Grid Number: __________ Supervisor Name: ____________________

Type of Operation:_______________________ Number of Personnel: ___________________

Start Time: ________ AM PM Stop Time: ________ AM PM

SW Corner of Grid

Remarks:____

____

____

____

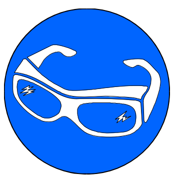
Supervisor Signature: ____

1 of 1

HAZARD ASSESSMENT FORM PAGE 1

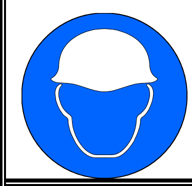
I am reviewing (check the appropriate box):	❑ A worksite	Specify location:
	❑ A single employee's job description	Name of employee:
		Working title of position:
		Position Number:
	❑ A job description for a class of employees	Working title of positions:
		Position Number(s):

Your name:	**DEPARTMENT:**	**Date:**



EYE HAZARDS (Appendix B). Tasks that can cause eye injury include: working with chemicals or acids; chipping, sanding, or grinding; welding; furnace operations; and, metal and wood working.

Check the appropriate box for each hazard:			*Description of hazard(s):*	*Based upon the hazard assessment, the following PPE is required:*
Chemical Exposure	Yes ❑	No ❑		
High Heat/Cold	Yes ❑	No ❑		
Dust/Flying Debris	Yes ❑	No ❑		
Impact	Yes ❑	No ❑		
Light/Radiation	Yes ❑	No ❑		



HEAD HAZARDS (Appendix C). Tasks that can cause head injury include: working below other workers who are using tools or materials that could fall; working on energized electrical equipment or utilities; and, working in trenches or confined spaces.

Check the appropriate box for each hazard:			*Description of hazard(s):*	*Based upon the hazard assessment, the following PPE is required:*
Impact	Yes ❑	No ❑		
Electrical Shock	Yes ❑	No ❑		

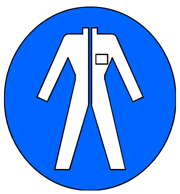
FOOT HAZARDS (Appendix D). Tasks that can cause foot injury include: exposure to chemicals or acids; welding or cutting; foundry operations; materials handling; renovation or construction; electrical work; and, spray finishing or other work with flammable or explosive materials.

Check the appropriate box for each hazard:			*Description of hazard(s):*	*Based upon the hazard assessment, the following PPE is required:*
Chemical Exposure	Yes ❑	No ❑		
High Heat/Cold	Yes ❑	No ❑		
Impact/Compression	Yes ❑	No ❑		
Slips/Trips	Yes ❑	No ❑		
Puncture	Yes ❑	No ❑		
Slippery/Wet Surfaces	Yes ❑	No ❑		
Explosive/Flammable Atmospheres	Yes ❑	No ❑		
Electrical	Yes ❑	No ❑		

HAZARD ASSESSMENT FORM PAGE 2

HAND HAZARDS (Appendix E). Hand injury can be caused by: work with chemicals or acids; exposure to cut or abrasion hazards (for example, during demolition, renovation, or woodworking); and, work with very hot or cold objects or materials. BLOODBORNE PATHOGENS – ADDITIONAL TRAINING/MONITORING IS REQUIRED!

Check the appropriate box for each hazard:			*Description of hazard(s):*	*Based upon the hazard assessment, the following PPE is required:*
Chemical Exposure	Yes ❑	No ❑		
High Heat or Cold	Yes ❑	No ❑		
Cuts/Abrasion	Yes ❑	No ❑		
Puncture	Yes ❑	No ❑		
Electrical Shock	Yes ❑	No ❑		
Bloodborne Pathogens (see Appendix E)	Yes ❑	No ❑		



BODY/TORSO HAZARDS (Appendix F). Injury of the body or torso occur during: exposure to chemicals, acids, or other hazardous materials; abrasive blasting; welding, cutting, brazing; chipping, sanding, or grinding; use of chainsaws or similar equipment; foundry operations; and, work around electrical arcs.

Check the appropriate box for each hazard:			*Description of hazard(s):*	*Based upon the hazard assessment, the following PPE is required:*
Chemical Exposure	Yes ❑	No ❑		
Extreme Heat/Cold	Yes ❑	No ❑		
Abrasion	Yes ❑	No ❑		
Impact	Yes ❑	No ❑		
Electrical Arc	Yes ❑	No ❑		

FALL HAZARDS (Appendix G). Personnel may be exposed to fall hazards when performing work on a surface with an unprotected side or edge that is 6 feet or more above a lower level, or 10 feet or more on scaffolds. Fall protection may also be required when using vehicle manlifts, elevated platforms, tree trimming, performing work on poles, roofs, or fixed ladders. ADDITIONAL TRAINING/MONITORING IS REQUIRED!

Check the appropriate box for each hazard:			*Description of hazard(s):*	*Based upon the hazard assessment, the following PPE is required:*
Fall hazard	Yes ❑	No ❑		

NOISE HAZARDS (Appendix G). Personnel may be exposed to noise hazards when machining, grinding, sanding, using pneumatic equipment, generators, motors, jackhammers, or similar equipment. ADDITIONAL TRAINING/MONITORING IS REQUIRED!

Check the appropriate box for each hazard:			*Description of hazard(s):*	*Based upon the hazard assessment, the following PPE is required:*
Noise hazard	Yes ❑	No ❑		

RESPIRATORY HAZARDS (Appendix G). Personnel may be exposed to respiratory hazards that require the use of respirators: when using certain chemicals outside of chemical fume hood; when applying paints or chemicals in confined spaces; when welding, cutting, or brazing on certain metals; and, when disturbing asbestos, lead, silica, or other particulate hazards. ADDITIONAL TRAINING/MONITORING IS REQUIRED!

Check the appropriate box for each hazard:			*Description of hazard(s):*	*Based upon the hazard assessment, the following PPE is required:*
Chemical exposure	Yes ❑	No ❑		
Confined space work	Yes ❑	No ❑		
Particulate exposure	Yes ❑	No ❑		
Welding/related hazard	Yes ❑	No ❑		

I certify that the above inspection was performed to the best of my knowledge and ability, based on the hazards present on this date (signature)

____

HEAT STRESS ALERT **Field Monitoring and Alert Checklist**					
DATE:			SURVEYOR(S):		
I. AREA INFORMATION					
LOCATION:					
SOURCE:					
ENGINEERING CONTROLS:					
II. SURVEY INSTRUMENT INFORMATION					
INSTRUMENT:	MODEL:		SERIAL #:		
FACTORY CALIBRATION DATE:	PRE-CAL: BY:		POST-CAL: BY:		
III. SAMPLING INFORMATION AND RESULTS					
HAZARD: Heat Stress	UNITS: °F (°C) WBGT		CORRECTIONAL FACTOR:		
See attached printout or record below.					

TIME	**WBGT-OUT (°F)**	**WB**	**DB**	**GL**	**COMMENTS**

HEAT STRESS MONITORING LOG

Date:_________________________ Site Name:_________________________________ Conditions: ________________________________

UXOSO:_____________________________________Location:____

Name	Organization	Start Time	Pulse Rate	Time	Pulse Rate	Time	Pulse Rate	Time	Pulse Rate

Remarks:

Magazine Data Card

Nomenclature:

Lot Number:

Hazard Div.

Unit Of Issue:

Date	Name	Received	Issue	Balance	Checker's Initials

The signatures in each section of this document indicate that the items listed were in fact issued, expended, or returned to storage and that all quantities listed were verified through a physical count.

RECORD
OF
SAFETY VIOLATION OR NON-COMPLIANCE

Employee Name: ____________________________ Position: _____________________

Site / Location: ___________________________ Date: ____/____/____

Type of Violation: ____ PPE ____ Procedural ____ Explosive _____ Equipment ____ Other

Type of Non-Compliance: ____ Policy ____ Procedural ____ Directive _____ Contract
____ Other

Description of Violation or Non-Compliance:

____
____

Document Reference (Specify document, page, paragraph, etc. as applicable):

____
____
____

Corrective Action(s) to be taken:

____
____
____
____

Employee or Company Response and Comments:

____
____
____

Notification made to:

Manager: ____ Yes ____ No Date:

SUXOS: ____ Yes ____ No Date:

Supervisor: ____ Yes ____ No Date:

Corrective Actions Inspection Required: ____ Yes ____ No

If Yes, Date of Inspection: ____/____/___

Signature:_______________________________ Signature: __________________________________
Safety Officer Employee/Company Representative

USAE
Safety Inspection Form
FOR MEC OPERATIONS

DATE:	**TIME:**	**LOG NO.:**
CONTRACT NO.:	**TASK ORDER NO.:**	
SITE NAME AND LOCATION:		
TEAM OR NAME OF INSPECTED:		
INSPECTED ITEMS OR OPERATIONS: (List by task, item or other specific identifier)		

II. INSPECTION RESULTS

Item Description	Pass	Item Description	Pass
1. PPE (A, B,C,D)	Y / N	9. MEC/UXO Disposal Operations:	Y / N
2. Compliance with Approved SOP's	Y / N	10. Motor Vehicles / MHE Inspections	Y / N
3. Compliance with Approved Safety Plans	Y / N	11. First Aid / Trauma Kit:	Y / N
4. Safety / Support Equipment	Y / N	12. Other (list):	Y / N
5. On- and Off-Site Communications	Y / N	13. Other (list):	Y / N
6. Explosives / Ordnance Reference Material	Y / N	14. Other (list):	Y / N
7. MSDSs and Container Labeling per APP or SOP	Y / N	15. Other (list):	Y / N
8 MEC/UXO Precautions Observed	Y / N	16. Other (list):	Y / N

SUMMARY OF DEFICIENCIES NOTED: (If Required)

CORRECTIVE ACTIONS RECOMMENDED: (If required)

REINSPECTION RESULTS: (If required)

VI. SIGNATURES:

I acknowledge that I have been briefed on the results of this inspection and will take corrective actions (if necessary)

UXOSO / SSO	Sr. UXO Supervisor / Site Manager

Note: Safety Inspections are to be conducted each day and documented on this form. This form will also be used to document the present status of the site/site operations, personnel, and will also be used to note the current status of deficiencies noted during daily inspections. Any daily inspection forms where deficiencies have been noted will be forwarded to the Site Manager/SUXOS and a CC to the USAE Safety Manager.

SAFETY INSPECTION REPORT

Site / Location: ___________________________ Date: ____/____/____

Type of Inspection: ____ Daily ____ Weekly ____ Re-Inspection ____ Other

Type of Operation Inspected:

____

____

Equipment Inspected: (Specify if Safety or Operational in Nature)

____

____

____

____

____

Comments:

____

____

____

____

____

Deficiencies Found or Noted:

____

____

____

Corrective Action:

____

____

____

Re-Inspection Required: ____ Yes ____ No If Yes, Date of Re-Inspection: ____/____/___

Signature:_______________________________ ___________________________________

Site Safety Officer SUXO / Project Manager

* Copy to Supervisor if Deficiencies or Corrective Action were found, noted or deemed necessary.

USA Environmental, Inc.

SAFETY MEETING/TRAINING RECORD

DATE: _____/_____/_____ **TIME: _________ AM/PM**

LOCATION/SITE: ___________________________________

1. Reason for Meeting/Training: (Check all that apply)	
	Daily Safety Meeting/Training
	Initial Site Safety Meeting/Training
	New Task Briefing
	Periodic Safety Meeting/Training
	New Site Procedures
	New Site Information
	Periodic Review of Site Information
	Other (Explain):

2. Personnel Attending Meeting/Training:

Name	Signature	Company

Page 1 of 2 Pages

USA Environmental Inc.

Safety Meeting/Training Record Cont:

3. Topics Covered (Check all that apply)			
	Site Safety Personnel		**Decontamination Procedures**
	Site/Work Area Description		**Emergency Response Plan**
	Site Characterization		**Hazard Communication**
	Biological Hazard(s)		**On-Site Emergency**
	Chemical Hazard(s)		**On-Site Injuries/Illnesses**
	Physical Hazard(s)		**Evacuation Procedures**
	Heat Stress		**Rally Point(s)**
	Cold Stress		**Emergency Communication**
	Site Control		**Directions to Medical Facility**
	Work and Support Zones		**Drug and Alcohol Policies**
	PPE		**Medical Monitoring Program**
	Air monitoring		**Specific Task Training**
	Safe Work Practices		**Confined Spaces**
	Engineering Controls and Equipment		**Heavy Equipment**
	Spill Containment Procedures		**Other: (Specify)**
	MEC Hazard(s)		
4. Remarks:			

5. Verification:

I certify that the personnel listed above on this record received the Information and/or Training described as indicated. Personnel not attending this meeting/training will receive said information/training prior to commencing their assigned duties.

____

Site Safety Officer **Date: ____/____/____**

Page 2 of 2 Pages

SITE VISITOR LOG

DATE:	NAME:	TITLE:	COMPANY:	SAFETY BRIEF:	TIME: IN	OUT	ESCORTED BY:	SITE:	REMARKS:

USA Environmental, Inc.

Tailgate Safety Briefing

Date: _____/_____/_____ **Location:**______________________

Time: _____________ **AM PM** **Team #:** _______________________

1. Reason for Briefing:			
	Daily Safety Briefing		New Site Procedure
	Initial Safety Briefing		New Site Information
	New Task Briefing		Review of Site Information
	Periodic Safety Meeting		Other: (Specify)

2. Personnel Attending:

Name	Signature	Position

Briefing Given By:

Name	Signature	Position

3. Topics: (Check All That Apply)			
	Site Safety Personnel		Decontamination Procedures
	Site/Work Area Description		Emergency Response/Equipment
	Physical Hazards		On-Site Injuries/Illnesses
	Chemical/Biological Hazards		Reporting Procedures
	Heat/Cold Stress		Directions to Medical Facility
	Work/Support Zones		Drug and Alcohol Policies
	PPE		Medical Monitoring
	Safe Work Practices		Evacuation/Egress Procedures
	Air Monitoring		Communications
	Task Training		Confined Spaces
	MEC Precautions		Other:

4. Remarks:

PREPARATORY, INITIAL, FOLLOW-UP QC SURVEILLANCE FORM
W912DY-04-D-0006, TO #0022, Culebra RI/FS
ANALOG OPERATIONS

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): ***Preparatory (P); Initial (I); Follow-Up (F)***		

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
1	**PWS, Table 7-2**	Instrument Functionality: Did all analog instrument operators detect on a daily basis, the items in the test strip prior to commencing analog operations?				Document deficiency and report to the SUXOS for resolution and follow-up to verify compliance
2	**WP Section 3.6**	Was an EZ established by the SUXOS prior to beginning analog operations?				Same as above
3	**APP**	Have all personnel read and signed all AHAs associated with analog operations?				Same as above
4	**WP Section 3.6**	Have onsite and offsite communications channels been established prior to commencing analog operations?				Same as above
5	**APP & SOP OPS-14**	Has the Team Leader conducted the Tail Gate Safety Briefing before beginning analog operations?				Same as above
6	**PWS, Table 7-2**	Dynamic Repeatability (transects used only for density estimates): Was a segment of transect repeated and were the number of counts repeated within the greater of ±20% or ±8 digs/flags?				Same as above
7	**PWS, Table**	Dynamic Repeatability (transects with digging): Was a				Same as above

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
	7-2	segment of transect repeated and were the number of extra flags/digs not greater than the greater of 20% or 8 flags/digs?				
8	**PWS, Table 7-2**	Were all DSI/ISOs included on the analog dig list?				Identify BSI/ISOs not included on dig list
9	**PWS, Table 7-2**	Detection and Recovery: BSI/ISOs included on dig list/recovered - 80% if MEC, 100% if no MEC found?				Record unrecovered BSI/ISOs location and identification number. Report to the SUXOS for resolution.
10	**PWS, Table 7-2**	Anomaly Resolution: Were the following confidence levels achieved – If MEC, 70% confidence that < 10% unresolved; or if no MEC, 90% confidence that < 5% unresolved?				Document deficiency and report to the SUXOS for resolution and follow-up to verify compliance
11	**PWS, Table 7-2**	Geodetic Equipment Functionality: Is geodetic equipment position offset of known/temporary control point within the expected range as listed in the WP?				Same as above

FINDINGS	
Item	**Comments**

Conducted By: __________________________ Reviewed By: _______________________________

PREPARATORY, INITIAL, FOLLOW-UP QC SURVEILLANCE FORM
W912DY-04-D-0006, TO #0022, Culebra RI/FS
DEMOBILIZATION

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): *Preparatory (P); Initial (I); Follow-Up (F)*		

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
1	**WP Section 2.0**	Have all project support agreements been terminated?				Document deficiency and report to the SUXOS for resolution and follow-up to verify compliance
2	**WP Section 2.0**	Has all equipment and project files been packaged and shipped back to the corporate headquarters?				Same as above
3	**WP Section 2.0**	Have all leased/rented equipment been returned and taken off lease/rental?				Same as above
4	**WP Section 2.0**	Has a walkthrough of the project area been conducted to ensure all excavations have been backfilled and no equipment remains onsite?				Same as above

FINDINGS	
Item	**Comments**

Conducted By: __________________________ Reviewed By: _______________________________

PREPARATORY, INITIAL, FOLLOW-UP QC SURVEILLANCE FORM
W912DY-04-D-0006, TO #0022, Culebra RI/FS
DGM OPERATIONS

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): ***Preparatory (P); Initial (I); Follow-Up (F)***		

CHECKLIST

Item	Ref.	Inspection Point	Yes	No	N/A	Comments
1	**WP Section 7.2.3.1**	Has the biologist performed morning beach surveys prior to and during the nesting season, before DGM survey activities commence?				Document deficiency and report to the SUXOS for resolution and follow-up for compliance
2	**WP Sections 3.4 & SOP OPS-05**	Were daily instrument checks performed prior to conducting DGM field activities (e.g. EM61-MK2 and positioning system)?				Enter specific comments or deficiencies in the Findings Section below. Report to Site Geophysicist for resolution and follow-up for compliance
3	**PWS, Table 7-1**	Equipment Functionality - Static Repeatability: Does the response (mean static spike minus mean static background) meet the PWS requirements?				Same as above
4	**APP**	Have all personnel read and signed all AHAs associated with analog operations?				Document deficiency and report to the SUXOS for resolution and follow-up for compliance
5	**WP Section 3.6**	Have onsite and offsite communications channels been				Same as above

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
		established prior to commencing analog operations?				
6	**APP**	Has the Team Leader conducted the Tail Gate Safety Briefing before beginning analog operations?				Same as above
7	**PWS, Table 7-1**	Along Line Measurement Spacing: Is 98% ≤ 25cm along line?				Enter specific comments or deficiencies in the Findings Section below. Report to Site Geophysicist for resolution and follow-up for compliance
8	**PWS, Table 7-1**	Coverage: Is > 90% coverage at 2.5-ft line spacing?				Same as above
9	**PWS, Table 7-1**	Dynamic Detection Repeatability (Grids): Are the test item anomaly characteristics (peak response and size) repeatable within the allowable variation, ±25%?				Same as above
10	**PWS, Table 7-1**	Dynamic Detection Repeatability (Transects): a. The number of anomalies on repeat segment within ±20% or ±8 of original or within of adjacent sections?				Same as above
11	**SOP OPS-04**	Target Selection: Are all dig list targets selected according to the project design?				Same as above
12	**PWS, Table 7-1**	Anomaly Resolution: Were the following confidence levels achieved – If MEC, 70% confidence that < 10% unresolved; or if no MEC, 90% confidence that < 5% unresolved?				Same as above
13	**PWS, Table 7-1**	Geodetic Equipment Functionality: Is geodetic equipment position offset of known/temporary control point within the expected range as listed in the WP?				Same as above

FINDINGS	
Item	**Comments**

Conducted By: ___________________________ **Reviewed By:** _________________________________

PREPARATORY, INITIAL, FOLLOW-UP QC SURVEILLANCE FORM

W912DY-04-D-0006, TO #0022, Culebra RI/FS

EXPLOSIVES MANAGEMENT

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): ***Preparatory (P); Initial (I); Follow-Up (F)***		

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
1	**WP Section 5.4 & SOP OPS-07**	Is the Type II magazine properly grounded in accordance with the National Fire Protection Association requirements and, is the lightning protection systems in place and functioning?				Document deficiency and report to the SUXOS for resolution and follow-up for compliance
2	**WP Section 5.5 and SOP OPS-08**	Are explosives transported in accordance with DOT regulations?				Same as above
3	**WP Section 5.4 & SOP OPS-07**	Are the proper fire extinguishers in the magazine area and is the area surrounding the magazine(s) clear of combustible materials for a distance of at least 50-ft?				Same as above
4	**WP Section 5.3 & SOP OPS-07**	Does the cargo manifest reflect the correct type and amount of explosives ordered and received?				Same as above
5	**WP Section 5.5 & SOP OPS-08**	Is the established explosives route used to/from the storage magazine(s)?				Same as above
6	**WP Section 5.4 & SOP OPS-07**	Are explosives stored in accordance with the applicable ATF&E regulations?				Same as above
7	**WP Section 5.7 & SOP**	Are stock control and inventory procedures				Same as above

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
	OPS-07	followed?				
8	**WP Section 3.7.10 & SOP OPS-03**	Are Demolition procedures followed during demolition operations?				Same as above

FINDINGS	
Item	**Comments**

Conducted By: ___________________________ **Reviewed By:** ________________________________

PREPARATORY, INITIAL, FOLLOW-UP QC SURVEILLANCE FORM

W912DY-04-D-0006, TO #0022, Culebra RI/FS

INTRUSIVE OPERATIONS

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): *Preparatory (P); Initial (I); Follow-Up (F)*		

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
1	**WP Section 7.2.3.1**	Has the biologist performed morning beach surveys prior to and during the nesting season, before intrusive activities commence?				Document deficiency and report to the SUXOS for resolution and follow-up to verify compliance
2	**WP Section 3.7 & SSHP**	Have the site security features and EZ been established around beaches been erected and maintained during intrusive operations?				Same as above
3	**SSHP**	Are all supplies and health and safety equipment on hand and complete, and are all personnel aware of their location in the operational area?				Same as above
4	**SOPs OPS-04 & OPS-14**	Are the TSD established and adhered to?				Same as above
5	**APP**	Are all team members properly outfitted with the appropriate PPE?				Same as above
6	**APP**	Have all personnel read and signed all AHAs associated with the intrusive operations?				Same as above
7	**WP Section 3.7**	Have onsite and offsite communications channels been established prior to commencing intrusive				Same as above

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
		investigation?				
8	**APP, SOPs OPS-04 & OPS-14**	Has the Team Leader conducted the Tail Gate Safety Briefing before beginning the intrusive investigation?				Same as above
9	**SOP OPS-14**	Are MEC team members swinging the analog detector back and forth to maintain the instrument tip within 6 inches of the ground and complete coverage of the lane?				Same as above
10	**SOP OPS-14**	Are all subsurface anomalous features removed from the hole prior to moving forward?				Same as above
11	**WP Section 3.7 & SOPs OPS-04 & OPS-14**	Are all recovered materials properly inspected, further classified and segregated in accordance with the listed reference?				Same as above
12	**SOP OPS-14**	Are MEC items properly identified, marked and their location recorded for future disposal?				Same as above
13	**WP Section 3.7 & SOP OPS-14**	Is the Team Leader completing all entries on the PDA or his portion of the Clearance Data and Munitions Accountability Log?				Same as above
14	**SSHP**	Are personal hygiene and decontamination procedures followed?				Same as above
15	**EPP**	Are Best Management Practices and good housekeeping procedures followed to mitigate impacts to the project site?				Same as above

FINDINGS	
Item	**Comments**

Conducted By: ___________________________ **Reviewed By:** ________________________________

PREPARATORY, INITIAL, FOLLOW-UP QC SURVEILLANCE FORM

W912DY-04-D-0006, TO #0022, Culebra RI/FS

MOBILIZATION AND SITE TRAINING

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): ***Preparatory (P); Initial (I); Follow-Up (F)***		

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
1	**WP Sections 2.2.4 & 3.6.3**	Do all personnel meet the requirements and qualifications for the positions assigned or have waivers from the USAESCH?				Complete a Personnel Qualifications Form for each employee onsite to verify qualifications and training. Document and report any deficiencies to the SUXOS for resolution and follow-up for compliance
2	**WP Sections 2.2.4 & 3.6.3**	Are all personnel trained and certified as necessary to operate equipment and machinery?				Document deficiencies and report to the SUXOS for resolution and follow-up for compliance
3	**WP & APP**	Have all field personnel reviewed the Work Plan and Accident Prevention Plan?				Same as above
4	**APP**	Have all personnel signed the Employee Sign-off Forms for the Site Safety and Health Plan, the Certificate of PPE Training and all Activity Hazard Analyses Forms?				Same as above

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
5	**APP**	Are all personnel familiar with the MSDS and know where they are located?				Same as above
6	**WP Section 2.6 & Project Schedule**	Is equipment received on island as needed to support the project schedule?				Same as above
7	**WP Section 3.1.2**	Is all required equipment functional, properly calibrated and in compliance with contract specifications?				Same as above
8	**WP Section 2.2**	Has coordination been conducted with personnel on Culebra, FWS, DNER, PREQB, the U.S. Coast Guard, FAA and USAESCH?				Same as above
9	**WP Section 5 & Puerto Rico Explosives Law**	Has transportation support been coordinated prior to scheduling movement of hazardous cargo in accordance with dangerous cargo regulations?				Same as above

FINDINGS	
Item	**Comments**

Conducted By: ___________________________ Reviewed By: ________________________________

PREPARATORY, INITIAL, FOLLOW-UP QC SURVEILLANCE FORM
W912DY-04-D-0006, TO #0022 Culebra RI/FS
MPPEH MANAGEMENT

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): ***Preparatory (P); Initial (I); Follow-Up (F)***		

CHECKLIST

Item	Ref.	Inspection Point	Yes	No	N/A	Comments
1	**SOPs 13 Workers' Statement**	Have all MEC Team Members reviewed SOP 13, MPPEH Management?				Document deficiency and report to the SUXOS for resolution and follow-up for compliance
2	**SOP-13**	Has all recovered MPPEH undergone a 100% inspection and an independent 100% re-inspection?				Same as above
3	**SOP-13**	Was Material Inspection Release Form completed to document the two independent 100% inspections?				Same as above
4	**SOP-13**	Were inspected items properly classified as munitions debris or MPPEH, as verified through random sampling by the UXOQCS?				Same as above
5	**SOP-13**	Has the Team Leader ensured no co-mingling of munitions debris and MPPEH?				Same as above
6	**SOP-13**	Are containers secured to prevent co-mingling of MPPEH and munitions debris?				Same as above
7	**SOP-13**	Has the SUXOS conducted random checks of munitions debris and range related debris to ensure there are no explosives				Same as above

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
		hazards?				
8	**SOP-13**	Has all MPPEH been demil/demo/de-fluid as necessary to remove any hazards?				Same as above
9	**SOP-13**	Once demil/demo/de-fluid as required, were materials 100% inspected and 100% re-inspected in order to classify as free from explosives hazard?				Same as above
10	**SOP-13**	Has all properly inspected debris been secured in sequentially numbered, labeled containers?				Same as above
11	**SOP-13 & Attach. 3**	Are container labels properly filled-out?				Same as above
12	**SOP-13 & Attach. 1**	Is the appropriate statement used to certify that materials are free from explosives or other hazards incorporated on the DD Form 1348-1A for each container?				Same as above

FINDINGS	
Item	**Comments**

Conducted By: ___________________________ **Reviewed By:** ________________________________

PERSONNEL QUALIFICATION VERIFICATION FORM

NAME: ________________________________ POSITION ______________________

CONTRACT:

REVIEW ITEMS		QUALIFICATIONS	VERIFIED BY/DATE
EXPERIENCE	REQUIRED:		
	ACTUAL:		
EDUCATION	REQUIRED:		
	ACTUAL:		
CERTIFICATIONS & QUALIFICATIONS	REQUIRED:		
	ACTUAL:		
TRAINING	REQUIRED:		
	ACTUAL:		
OTHER	REQUIRED:		
	ACTUAL:		

PREPARATORY, INITIAL, FOLLOW-UP CHECKLIST and QC SURVEILLANCE
W912DY-04-D-0006, TO #0022, Culebra RI/FS
PROJECT REPORTING AND SUBMITTALS

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): *Preparatory (P); Initial (I); Follow-Up (F)*		

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
1	**WP Section 2.5 and the PWS**	Are Project Status Reports prepared in accordance with DID MR-085 and include additional items required specifically by the PWS?				Document and report deficiency to the PM and follow-up for compliance
2	**WP Section 2.5 and the PWS**	Are records of telephone conversations, written correspondence concerning this Task Order and meeting minutes in accordance with DID MR-045 and MR-055 attached to the Project Status Report?				Same as above

FINDINGS	
Item	**Comments**

Conducted By: ________________________ **Reviewed By:** ______________________________

PREPARATORY, INITIAL, FOLLOW-UP QC SURVEILLANCE FORM
W912DY-04-D-0006, TO #0022, Culebra RI/FS
TEST STRIP SET-UP

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): ***Preparatory (P); Initial (I); Follow-Up (F)***		

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
1	**WP Section 7.2.3.1**	Has the biologist performed morning beach surveys prior to and during the nesting season, before Test Strip set-up activities commence?				Document deficiency and report to the SUXOS for resolution and follow-up for compliance
2	**WP Section 3.3.1**	Does test strip location represent the actual MRS conditions (e.g. terrain, geology, vegetation, background noise, etc.) as closely as possible?				Same as above
3	**WP Section 3.3.1**	Has the test strip been seeded with four ISOs (two small and two large), two horizontal at depths 3 and 7 times the ISO diameters, and two vertical at the same 3 and 7 times diameter depth?				Same as above
4	**WP Section 3.3.1 & DQO for operational parameters for survey and investigation equipment**	Have the capabilities and limitations of each sensor and positioning system to detect the seed items in the test strip been established and documented?				Enter specific comments or deficiencies in the Findings Section below, report to the SOXOS and Site Geophysicist for resolution and follow-up for compliance

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
5	**WP Section 3.5 and DQOs for Data Collection and Management**	Have data transfer, processing analysis and reacquisition tasks been conducted in accordance with the references?				Same as above
6	**WP Section 3.4 and DQO for Detector Team Performance Evaluation**	Have the background noise, sample density, MEC detection, false positives, position accuracy, reacquisition, anomaly selection, and data management been established or refined in accordance with the references?				Same as above

FINDINGS	
Item	**Comments**

Conducted By: ___________________________ Reviewed By: ________________________________

PREPARATORY, INITIAL, FOLLOW-UP QC SURVEILLANCE FORM
W912DY-04-D-0006, TO #0022, Culebra RI/FS
UNDERWATER VISUAL INVESTIGATION

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): ***Preparatory (P); Initial (I); Follow-Up (F)***		

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
1	**WP Section 3.5 & SOP DOPS-08**	Were pre-operations checks performed on the ROV, pole camera and related equipment?				Document deficiency and report to the SUXOS for resolution and follow-up for compliance
2	**WP Section 3.5 and SOP DOPS-08**	Were expanded surveys conducted on discovered MEC-like items using the ROV?				Same as above
3	**WP Section 3.5 SOP DOPS-08**	Were post-operations checks performed on the ROV, pole camera and related equipment?				Same as above

FINDINGS	
Item	**Comments**

Conducted By: ___________________________ **Reviewed By:** ________________________________

PREPARATORY, INITIAL, FOLLOW-UP QC SURVEILLANCE FORM

W912DY-04-D-0006, TO #0022, Culebra RI/FS

VEGETATION CLEARANCE

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): ***Preparatory (P); Initial (I); Follow-Up (F)***		

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
1	**WP Section 7.2.3.1**	Has the biologist performed morning beach surveys prior to and during the nesting season, before vegetation clearance activities commence?				Document deficiency and report to the SUXOS for resolution and follow-up for compliance
2	**SOP-21**	Are all Vegetation Removal Team Members trained and qualified to operate removal equipment?				
3	**SOP-21**	Is the PPE serviceable and properly worn by all team members?				
4	**EPP**	Are all team members familiar with the Environmental Protection Plan restoration requirements?				
5	**WP Section 3.4.1**	Was ground vegetation trimmed to a height of 6-inches or less for DGM transects and grids?				
6	**WP Section 3.4.1**	Was overhead vegetation to at least 6-ft above the ground, but not more than 10-ft?				
7	**WP Section 3.4.1**	Were transects placed along the “least path of resistance” to minimize the amount of vegetation cut or trimmed?				
8	**WP**	Were transects cut to a width of				

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
	Section 3.4.1	one meter?				
9	**WP Section 3.4.1**	Were transects marked with survey tape, approximately every 100-ft?				

FINDINGS	
Item	**Comments**

Conducted By: ___________________________ **Reviewed By:** ________________________________

PREPARATORY, INITIAL, FOLLOW-UP QC SURVEILLANCE FORM
W912DY-04-D-0006, TO #0022, Culebra RI/FS
WORK & STAGING AREA PREPARATION

TEAM INFORMATION		
Team:	**Location:**	**Date:**
Team Leader:		
Personnel Present:		
Phase of Inspection (Circle): ***Preparatory (P); Initial (I); Follow-Up (F)***		

CHECKLIST						
Item	**Ref.**	**Inspection Point**	**Yes**	**No**	**N/A**	**Comments**
1	**WP Section 2.10**	Has coordination with support facilities been conducted?				Document and report deficiency to SUXOs for resolution, follow-up for compliance
2	**SSHP**	Are work zones, exclusion zones and team separation distances been established and briefed to site personnel?				Same as above
3	**SSHP**	Have break and rest areas been established in accordance with the reference?				Same as above
4	**SSHP**	Have toilet facilities been established in accordance with EM 385-1-1, Table 2-1?				Same as above

FINDINGS	
Item	**Comments**

Conducted By: __________________________ Reviewed By: _______________________________

APPENDIX G. MSD CALCULATION SHEETS

This appendix contains the following MSD Calculation Sheets:

- 75mm projectile, MKI
- 4.2” M3A1
- 100lb bomb, AN-M30A1
- Buried Explosion Module, 100lb AN-M30A1
- 37mm projectile, MK II
- 81mm mortar, M45
- 81mm mortar, M362A1
- 81mm mortar, M43
- 3” Common projectile, MK 3 Mod 7
- 5” projectile MK 41
- 5in Mk 1 HVAR (warhead only).

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
Munition:	75 mm HE Mk I
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Projectile
Munition Case Classification:	Robust

DODIC:	
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	3/8/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	1.64
Diameter (in):	2.9528
Maximum Fragment Weight (Intentional) (lb):	0.2135
Design Fragment Weight (95%) (Unintentional) (lb):	0.0392
Critical Fragment Velocity (fps):	3468

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	1.640
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	21
Public Traffic Route Distance (2.3 psi); K24 Distance:	28
Inhabited Building Distance (1.2 psi), K40 Distance:	47
Intentional MSD (0.0655 psi), K328 Distance:	387

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	1.640
Kinetic Energy 10^6 (lb-ft²/s²):	1.2839
Required Wall & Roof Sandbag Thickness (in)	24
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	239
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1873
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1425

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	7.22	3.71
Mild Steel:	1.40	0.72
Hard Steel:	1.15	0.59
Aluminum:	2.77	1.47
LEXAN:	7.36	4.86
Plexi-glass:	5.75	3.32
Bullet Resist Glass:	5.02	2.73

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	1.640
Kinetic Energy 106 (lb-ft²/s²):	1.2839
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
Munition:	4.2 in M3A1
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Robust

DODIC:	
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	2/16/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	8.17
Diameter (in):	4.2000
Maximum Fragment Weight (Intentional) (lb):	0.0864
Design Fragment Weight (95%) (Unintentional) (lb):	0.0119
Critical Fragment Velocity (fps):	6538

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	8.170
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	36
Public Traffic Route Distance (2.3 psi); K24 Distance:	48
Inhabited Building Distance (1.2 psi), K40 Distance:	81
Intentional MSD (0.0655 psi), K328 Distance:	661

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	8.170
Kinetic Energy 10^6 (lb-ft²/s²):	1.8466
Required Wall & Roof Sandbag Thickness (in)	24
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	316
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1670
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1326

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	11.03	4.85
Mild Steel:	1.97	0.90
Hard Steel:	1.62	0.74
Aluminum:	3.98	1.90
LEXAN:	8.37	5.15
Plexi-glass:	6.80	3.57
Bullet Resist Glass:	5.87	2.87

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	8.170
Kinetic Energy 106 (lb-ft²/s²):	1.8466
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	275

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Air-Launched HE Rounds
DODIC:	
Munition:	100 lb AN-M30A1
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Bomb
Munition Case Classification:	Non-Robust

Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	12/23/2009
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	Tritonal (TNT/Al=80/20)
Explosive Weight (lb):	62
Diameter (in):	8.1800
Maximum Fragment Weight (Intentional) (lb):	0.1001
Design Fragment Weight (95%) (Unintentional) (lb):	0.0106
Critical Fragment Velocity (fps):	8410

Overpressure Distances

TNT Equivalent (Pressure):	1.07
TNT Equivalent Weight - Pressure (lbs):	66.340
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	73
Public Traffic Route Distance (2.3 psi); K24 Distance:	97
Inhabited Building Distance (1.2 psi), K40 Distance:	162
Intentional MSD (0.0655 psi), K328 Distance:	1328

Required Sandbag Thickness

TNT Equivalent (Impulse):	0.9600
TNT Equivalent Weight - Impulse (lbs):	59.520
Kinetic Energy 10^6 (lb-ft²/s²):	3.5399
Required Wall & Roof Sandbag Thickness (in)	N/A
Expected Maximum Sandbag Throw Distance (ft):	N/A
Minimum Separation Distance (ft):	N/A

Distribution authorized to the Department of Defense and U.S. DoD contractors only for Administrative-Operational Use (17 October 2002). Other requests shall be referred to the Chairman, Department of Defense Explosives Safety Board, Room 856C, Hoffman Building I, 2461 Eisenhower Avenue, Alexandria, VA 22331-0600.

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	413
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1833
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1469

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	17.09	6.66
Mild Steel:	2.76	1.13
Hard Steel:	2.26	0.93
Aluminum:	5.55	2.41
LEXAN:	9.97	5.76
Plexi-glass:	8.56	4.13
Bullet Resist Glass:	7.50	3.34

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	0.9600
TNT Equivalent Weight - Impulse (lbs):	59.520
Kinetic Energy 106 (lb-ft²/s²):	3.5399
Water Containment System:	N/A
Minimum Separation Distance (ft):	N/A

Item Notes

BURIED EXPLOSION MODULE

(Version 6.2)

Based on DDESB Technical Paper 16 Revision 3, EARTHEX software, and NSWCDD/TR-92/196

(ENGLISH UNITS)

SELECT BURIAL MEDIUM Soil

SELECT SOIL TYPE Dry Sand

(See TP 16, Revision 3 for soil details)

SELECT ITEM DESCRIPTION 100 lb AN-M30A1

ENTER TOTAL NUMBER OF ITEMS	1
ENTER TOTAL WEIGHT OF ALL DONOR CHARGES (lbs)	1.00
SINGLE ITEM NEW (lbs)	62.00
SINGLE ITEM MAXIMUM FRAGMENT WEIGHT (lbs)	0.0997
FRAGMENT WEIGHT USED IN CALCULATIONS (lbs)	0.0997
SINGLE ITEM MAXIMUM FRAGMENT VELOCITY (ft/s)	8,414
FRAGMENT VELOCITY USED IN CALCULATIONS (ft/s)	8,414
TOTAL TNT WEIGHT USED (lbs)	67.34
ENTER DEPTH OF BURIAL (ft)	4.00
ENTER HORIZONTAL RANGE (for pressure calculation) (ft)	600

CRATER OR CAMOUFLET?
CRATER

TRUE CRATER RADIUS (ft)	9.22
MAXIMUM SOIL EJECTA DISTANCE (ft)	472

FRAGMENT EXIT VELOCITY (ft/s)	105.6	**FRAGMENT LAUNCH ANGLE (°)**	23.5

MAXIMUM FRAGMENT DISTANCE (ft)	248.1

***Distance at which pressure is 0.066 psi=**

Open Air Withdrawal Distance, K328 (ft)	1,334.4

Blast Withdrawal Distance (buried/undex) (ft)*		351.5
Fragment Hazard Distance (ft)		471.9
Pressure at Fragment Hazard Distance	(psi)	0.0469
	(dB)	144.2
Pressure at Range Entered	(psi)	0.0357
	(dB)	141.8

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
Munition:	37 mm Mk II
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Projectile
Munition Case Classification:	Extremely Heavy Case

DODIC:	
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	1/11/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	0.053
Diameter (in):	1.4567
Maximum Fragment Weight (Intentional) (lb):	0.0305
Design Fragment Weight (95%) (Unintentional) (lb):	0.0213
Critical Fragment Velocity (fps):	3307

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	0.053
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	7
Public Traffic Route Distance (2.3 psi); K24 Distance:	9
Inhabited Building Distance (1.2 psi), K40 Distance:	15
Intentional MSD (0.0655 psi), K328 Distance:	123

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	0.053
Kinetic Energy 10^6 (lb-ft²/s²):	0.1668
Required Wall & Roof Sandbag Thickness (in)	12
Expected Maximum Sandbag Throw Distance (ft):	25
Minimum Separation Distance (ft):	200

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Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	90
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	982
MFD-V [Maximum Fragment Distance, Vertical] (ft):	756

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	2.96	1.95
Mild Steel:	0.57	0.37
Hard Steel:	0.46	0.30
Aluminum:	1.18	0.79
LEXAN:	4.23	3.25
Plexi-glass:	2.76	1.94
Bullet Resist Glass:	2.23	1.51

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	0.053
Kinetic Energy 106 (lb-ft²/s²):	0.1668
Water Containment System:	5 gal carboys/ inflatable pool
Minimum Separation Distance (ft):	200/200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
DODIC:	
Munition:	81 mm M45
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Non-Robust
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	3/2/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	4.48
Diameter (in):	3.1890
Maximum Fragment Weight (Intentional) (lb):	0.0265
Design Fragment Weight (95%) (Unintentional) (lb):	0.0034
Critical Fragment Velocity (fps):	7384

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	4.480
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	30
Public Traffic Route Distance (2.3 psi); K24 Distance:	40
Inhabited Building Distance (1.2 psi), K40 Distance:	66
Intentional MSD (0.0655 psi), K328 Distance:	541

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	4.480
Kinetic Energy 10^6 (lb-ft²/s²):	0.7224
Required Wall & Roof Sandbag Thickness (in)	24
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	242
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1199
MFD-V [Maximum Fragment Distance, Vertical] (ft):	963

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	8.05	3.43
Mild Steel:	1.41	0.63
Hard Steel:	1.16	0.51
Aluminum:	2.93	1.37
LEXAN:	6.71	4.06
Plexi-glass:	5.06	2.60
Bullet Resist Glass:	4.21	2.01

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	4.480
Kinetic Energy 106 (lb-ft²/s²):	0.7224
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
Munition:	81 mm M362A1
Case Material:	Iron, Pure
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Robust

DODIC:	C222
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	2/18/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	Composition B
Explosive Weight (lb):	2.1
Diameter (in):	3.1890
Maximum Fragment Weight (Intentional) (lb):	0.0441
Design Fragment Weight (95%) (Unintentional) (lb):	0.0071
Critical Fragment Velocity (fps):	5990

Overpressure Distances

TNT Equivalent (Pressure):	1.16
TNT Equivalent Weight - Pressure (lbs):	2.436
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	24
Public Traffic Route Distance (2.3 psi); K24 Distance:	32
Inhabited Building Distance (1.2 psi), K40 Distance:	54
Intentional MSD (0.0655 psi), K328 Distance:	441

Required Sandbag Thickness

TNT Equivalent (Impulse):	1.16
TNT Equivalent Weight - Impulse (lbs):	2.436
Kinetic Energy 10^6 (lb-ft²/s²):	0.7912
Required Wall & Roof Sandbag Thickness (in)	24
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

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Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	247
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1342
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1066

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	7.51	3.55
Mild Steel:	1.40	0.68
Hard Steel:	1.15	0.56
Aluminum:	2.87	1.45
LEXAN:	6.91	4.42
Plexi-glass:	5.23	2.89
Bullet Resist Glass:	4.40	2.28

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1.16
TNT Equivalent Weight - Impulse (lbs):	2.436
Kinetic Energy 106 (lb-ft²/s²):	0.7912
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
Munition:	81 mm M43
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Robust

DODIC:	C225
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	3/10/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	1.23
Diameter (in):	3.1890
Maximum Fragment Weight (Intentional) (lb):	0.1096
Design Fragment Weight (95%) (Unintentional) (lb):	0.0377
Critical Fragment Velocity (fps):	3776

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	1.230
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	19
Public Traffic Route Distance (2.3 psi); K24 Distance:	26
Inhabited Building Distance (1.2 psi), K40 Distance:	43
Intentional MSD (0.0655 psi), K328 Distance:	351

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	1.230
Kinetic Energy 10^6 (lb-ft²/s²):	0.7813
Required Wall & Roof Sandbag Thickness (in)	24
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	209
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1579
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1215

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	6.61	3.98
Mild Steel:	1.27	0.77
Hard Steel:	1.04	0.63
Aluminum:	2.59	1.60
LEXAN:	6.62	5.05
Plexi-glass:	4.99	3.49
Bullet Resist Glass:	4.22	2.87

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	1.230
Kinetic Energy 106 (lb-ft²/s²):	0.7813
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds	DODIC:	
Munition:	3 in Common Mk 3 Mod 7		
Case Material:	Steel, Mild	Date Record Created:	6/2/2008
		Record Created By:	MC
Fragmentation Method:	Naturally Fragmenting	Last Date Record Updated:	3/25/2010
Secondary Database Category:	Projectile	Individual Last Updated Record:	SDH
Munition Case Classification:	Extremely Heavy Case	Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT & Black Powder
Explosive Weight (lb):	0.28
Diameter (in):	3.0000
Maximum Fragment Weight (Intentional) (lb):	0.1949
Design Fragment Weight (95%) (Unintentional) (lb):	0.0628
Critical Fragment Velocity (fps):	2720

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	126
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1700
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1271

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	0.280
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	12
Public Traffic Route Distance (2.3 psi); K24 Distance:	16
Inhabited Building Distance (1.2 psi), K40 Distance:	26
Intentional MSD (0.0655 psi), K328 Distance:	215

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	5.55	3.60
Mild Steel:	1.03	0.66
Hard Steel:	0.85	0.54
Aluminum:	2.05	1.34
LEXAN:	6.29	4.77
Plexi-glass:	4.68	3.24
Bullet Resist Glass:	4.04	2.69

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	0.280
Kinetic Energy 10^6 (lb-ft²/s²):	0.7208
Required Wall & Roof Sandbag Thickness (in)	20
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	0.280
Kinetic Energy 106 (lb-ft²/s²):	0.7208
Water Containment System:	5 gal carboys/ inflatable pool
Minimum Separation Distance (ft):	264/200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
Munition:	5 in Mk 41
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Projectile
Munition Case Classification:	Robust

DODIC:	D320
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	2/17/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	Explosive D
Explosive Weight (lb):	7.38
Diameter (in):	5.0000
Maximum Fragment Weight (Intentional) (lb):	0.6726
Design Fragment Weight (95%) (Unintentional) (lb):	0.1367
Critical Fragment Velocity (fps):	2538

Overpressure Distances

TNT Equivalent (Pressure):	0.85
TNT Equivalent Weight - Pressure (lbs):	6.273
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	33
Public Traffic Route Distance (2.3 psi); K24 Distance:	44
Inhabited Building Distance (1.2 psi), K40 Distance:	74
Intentional MSD (0.0655 psi), K328 Distance:	605

Required Sandbag Thickness

TNT Equivalent (Impulse):	0.85
TNT Equivalent Weight - Impulse (lbs):	6.273
Kinetic Energy 10^6 (lb-ft²/s²):	2.1663
Required Wall & Roof Sandbag Thickness (in)	36
Expected Maximum Sandbag Throw Distance (ft):	220
Minimum Separation Distance (ft):	220

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Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	359
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	2377
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1748

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	9.17	4.80
Mild Steel:	1.77	0.92
Hard Steel:	1.45	0.75
Aluminum:	3.43	1.86
LEXAN:	8.58	5.73
Plexi-glass:	7.05	4.13
Bullet Resist Glass:	6.32	3.49

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	0.85
TNT Equivalent Weight - Impulse (lbs):	6.273
Kinetic Energy 106 (lb-ft²/s²):	2.1663
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	275

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
Munition:	5 in Mk 1 HVAR (warhead only)
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Rocket
Munition Case Classification:	Robust

DODIC:	
Date Record Created:	12/3/2010
Record Created By:	SDH
Last Date Record Updated:	
Individual Last Updated Record:	
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	8.6
Diameter (in):	4.9700
Maximum Fragment Weight (Intentional) (lb):	0.4056
Design Fragment Weight (95%) (Unintentional) (lb):	0.0948
Critical Fragment Velocity (fps):	4534

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	8.600
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	37
Public Traffic Route Distance (2.3 psi); K24 Distance:	49
Inhabited Building Distance (1.2 psi), K40 Distance:	82
Intentional MSD (0.0655 psi), K328 Distance:	672

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	8.600
Kinetic Energy 10^6 (lb-ft²/s²):	3.5532
Required Wall & Roof Sandbag Thickness (in)	36
Expected Maximum Sandbag Throw Distance (ft):	220
Minimum Separation Distance (ft):	220

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Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	349
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	2328
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1804

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	11.91	6.05
Mild Steel:	2.28	1.17
Hard Steel:	1.87	0.96
Aluminum:	4.45	2.39
LEXAN:	9.59	6.38
Plexi-glass:	8.16	4.75
Bullet Resist Glass:	7.33	4.01

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	8.600
Kinetic Energy 106 (lb-ft²/s²):	3.5532
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	275

Item Notes

APPENDIX H. RESUMES

This appendix contains resumes for the following USA personnel:

- Crandall, A.
- Crownover, R.
- Lewis, J.
- Nichols, C.
- Ralston, D.
- Tucker, M.

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ALAN L. CRANDALL SENIOR GEOPHYSICIST

B.S. ELECTRICAL ENGINEERING, LOWELL TECHNOLOGICAL INSTITUTE

OTHER PERTINENT TRAINING: HAZWOPER 40 HOUR JUN 1991; CURRENT 8 HOUR REFRESHER

Jul 73 – Aug 86 **Naval Explosive Ordnance Disposal Technology Division, Indianhead, MD**.

Project Manager. Set up and performed underwater technical evaluations for the Point Search System (PSS) that provides bomb disposal crew with a hand held underwater ordnance locator. Trained military operators for operational evaluation conducted by the military. Provided system maintenance. *Result*: PSS was approved for service use and successfully transitioned to production.

Technical Support. Operated and maintained equipment for Area Point Search System development. Trained military personnel in use of towed ordnance locator system using side scan sonar and integrated microwave positioning. Deployed the developed system on more than 10 different surveys and port breakout exercises.

Technical Director. Designed, developed and operationally tested Remotely Operated Vehicles for explosive ordnance disposal. Deployed an ROV on a successful downed F-16 recovery project.

Project Manager. Designed, developed and tested a towed, Underwater Magnetometer Search system to detect and survey underwater unexploded ordnance.

Sep 86 – Jun 01 **Geo-Centers, Inc., Newton Center, MA.**

Geophysical Project Manager. Designed, developed and tested integrated geophysical systems. Managed team of electronic design engineers and developed design specifications with other team leaders. Collaborated with mechanical and software engineering groups to ensure successful system integration. Reviewed designs throughout project cycle against design specifications. Implemented and tested vehicular and portable designs. Patented system providing commercial UXO detection and mapping services. Commercially deployed Geo-Centers' geophysical systems to detect, map and identify UXO at over 30 sites.

Jul 01 - Present USA Environmental, Inc., Tampa, FL.

Senior Geophysicist. Manages USA's geophysical capabilities including in-house resources and geophysical subcontractors.

Project Manager for: Digital Geophysical Surveys to detect, map, and locate UXO and landfill extent at two sites at the Naval Surface Warfare Center, Dahlgren, VA.; OE Construction Support at Wagner Range, Fort Benning, GA; the Geophysical Meandering Path Technology Demonstration at former Fort Ord, California; UXO Detection Survey at the Picatinny Arsenal Proposed Outdoor Range Facility, Picatinny, NJ; the Expanded OE Time-Critical Removal Action at the Fort Sam Houston Junior High School Site, Fort Sam Houston, San Antonio, TX; the Non-Time Critical OE Removal Action at the Former Armstrong Air-to-Air Gunnery Range, SD; a towed magnetometer array survey of a 100-acre housing development area in North Myrtle Beach, SC; digital geophysical mapping to support the site investigations at the Jackson Park Elementary School, Earlands Apartment Complex, the Kitsap County Health District, NAD Marine Park, and the NAD Soroptimist Park in Bremerton, WA; Geophysical Survey and UXO Removal at Camp Blanding, Clay County, FL and Odyssey Middle School Project, Orlando, FL; Established the geophysical test strip for the Remedial Investigation/Feasibility Study (RI/FS) for the Former Popoki Target Area, Island of Hawaii, HI. Project Manager on three technology development Task Orders: The Development of Automated Tools on Handheld PC for OE Field Operations and Quality Control, Option 2; The Development of a Quality Assurance Instrument for OE Safety Specialists, The Development of a Remote Excavator for Heavily Contaminated UXO Sites (Range Master).

Project Geophysicist for four Engineering Evaluation/Cost Analysis (EE/CA) Task Orders: Former Frankford Arsenal, Philadelphia, PA; Williams Field Target Range #6, Pinal County, AZ, FUDS Portion of Camp Chaffee, Fort Smith, AR, Former Waikoloa Maneuver Area, Phase III, Island of Hawaii, HI.

Provide Technical Engineering and Field Support to Geo-Centers, Inc. for an ESTCP/USAESCH contract to develop and demonstrate a Combined EM and Magnetometer Data Acquisition and Processing System. Demonstrated the developed system at the Standardized UXO Test Site, Aberdeen, MD and Yuma, AZ, and at two surveys at the Former Lowery Bombing Range, CO, and the Portland International Air Port, Portland, OR.

ROBERT D. CROWNOVER CORPORATE SAFETY AND QC MANAGER

Date Completed Basic EOD School: August 1978

OTHER PERTINENT TRAINING: HAZWOPER 40 HOUR, AUG 1995; CURRENT 8 HOUR SUPERVISOR/REFRESHER

MILITARY EOD ASSIGNMENTS:

Aug 78 - Apr 80	EOD Technician, 45th EOD, Ft. Polk, LA. Team member who assisted in locating, identifying, removal & destruction of munitions. Member of range clearance team. Assisted in classroom & practical instruction.
Apr 80 - Jun 83	EOD Technician, 72nd EOD, Bremerhaven, Germany. Team member who assisted in determining and implementing render safe & disposal procedures. Range safety NCO. Assisted in training EOD and non-EOD personnel.
Jun 83 - Sep 87	EOD Supervisor, 60th EOD, Ft. Dix, NJ. Assumed command of an EOD Team. Determined render safe and disposal procedures. Performed administrative functions. Supervised other EOD personnel. Conducted range operations.
Sep 87 - May 90	EOD Instructor, EOD Tng. Det #1, Eglin AFB, Florida. Taught courses in ordnance recovery, protection of personnel and property safety, ORD. ID, and access and recovery. Testing of applied instructions. Drafting, finalizing and implementing testing criteria.
May 90 - Sep 90	EOD Supervisor, 52nd EOD, Pine Bluff, AR. Team leader during EOD operations. Range Safety NCO. Conducted training in EOD related matters. Conducted range operations. Performed administrative functions.
Sep 90 - May 91	EOD Supervisor, 16th EOD, Camp Darby, IT. Team leader during EOD operations. Assisted in determining and implementing policy. Range NCO. Safety NCO. Training of other EOD & non-EOD personnel. Regulated administrative functions.
May 91 - Dec 91	EOD Supervisor, 137th EOD, Ft. Sam, Houston, TX. Assumed command of an EOD team. Conducted range safety classes. Conducted training in EOD related matters. Determined render safe and disposal procedures security functions.

CIVILIAN UXO EXPERIENCE:

Mar 93 - Sep 94	UXO Supervisor, CMSI, Kuwait. Team member on minefield team. Conducted sweep, demolition and bunker operations. Field supervisor for 213 Third Country Nationals (TCN) and four EOD technicians. Conducted training for TCN. Supervised disposal operations.
Aug 95 – Jun 96	UXO Specialist, CMS Environmental, Inc., Fort Ord, CA. UXO Team member of a BRAC clearance and removal action.
Jun 96 – Sep 96	UXO Supervisor, CMS Environmental, Inc., Ft. Ord, CA. Sampling and removal of OE.
Sep 96 – Jul 98	Site Safety Officer, CMS Environmental, Inc., Ft. Ord, CA. Responsible for the overall safety of the project personnel and compliance with the Site Safety and Health Plan.
Jul 98 – Nov 99	Site Safety Officer, USA Environmental, Inc., Ft. Ord, CA. Responsible for the overall safety of the project personnel and compliance with the Site Safety and Health Plan.
Nov 99 – Present	Corporate Safety & Health Manager/Quality Control Manager, USA Environmental, Inc., Oldsmar, FL. Responsible for the development and

implementation of USA's Safety and Quality Control programs and plans for all USA job sites to include: Pinecastle TCRA, Orlando, FL; Vieques, PR JN01; Iraq Mobile Teams; CWM and IPBC, Ft. Benning, GA; RI/FS Popoki, HI; RI/FS, Adak, AK; MEC Reconnaissance & Avoidance, Former Koon-Ni Range, Korea; CMC, Iraq; and EE/CA Camp Chaffee, AR. Reviews draft and final work plans for accuracy, completeness, and content. Interfaces with external agencies on safety, quality control and health issues at the corporate or job site levels, and performs project site inspections, audits and on-site safety and quality control support to ensure compliance with requirements and standards. Traveled to Iraq on several occasions during the Army Corps of Engineers' Captured Enemy Ammunition (CEA) and Coalition Munitions Clearance (CMC) Contracts to provide training, management and audits of its safety and quality control personnel for the USA mobile teams and depot operations.

JEFFERY A. LEWIS GIS MANAGER

B.S. DEGREE IN ENVIRONMENTAL SCIENCE/ GEOGRAPHIC INFORMATION SYSTEMS, SAMFORD UNIVERSITY, BIRMINGHAM, AL

OTHER PERTINENT TRAINING: HAZWOPER 40 HOUR, NOVEMBER 2001; CURRENT 8 HOUR REFRESHER

Sep 98 – May 00	GIS Assistant, Jefferson County Alabama Information Services, GIS Department, Birmingham, AL. Worked with ArcView and Arc/Info producing maps and coverages. Updated street maps and county tax maps for the Birmingham and Jefferson County area. Developed custom ArcView software for the Jefferson County Emergency Management Association using Avenue Programming.
Mar 01 – Oct 01	GIS Analyst, Dynamic Drafting and Design (Consulting for IMC Phosphates), Ft. Lonesome, FL. Created and maintained GIS coverages using ArcView and Arc/Info. Used GIS to support the management of over 150,000 acres of company owned land. Produced maps used in permit applications and the permitting process. Supported engineers and biologists with graphics and maps used in reports. Analyzed GIS data for use in decision-making. Generated tables using ArcView and Excel.
Nov 01 - Present	GIS Manager, USA Environmental, Inc., Oldsmar, FL. Oversees project GIS and data management functions for USA MEC characterization and remediation projects using ESRI ArcMap and various databse software applications. Mr. Lewis supports the project teams from development of CSM graphics through management of collected field data and the development of maps and graphics for work plans and reports. Mr. Lewis was directly involved in data management and GIS applications for performance of AF MRP CSE Phase 1 project and numerous projects under the Navy MRC contract. Produced final maps for the following USA projects: Adak, AK RI/FS; Dahlgren, VA; Camp Pendleton, CA; Ft. Wingate, NM and others. Produced maps and coverages used in the planning process for work at the Former Camp Chaffee, AR; Removal Construction Support, Ft. Hood, TX; TCRA Armstrong, SD; and TCRA Pinecastle, FL, etc. Generated maps for USA field personnel and managed all intrusive data for the Removal Action at the Badlands Bombing Range, SD. Supported EE/CA planning (conceptual site model) and work being performed at the Former Frankford Arsenal, Philadelphia, PA. Supported the project manager during the TPP process at Williams Field, Florence, AZ. Was in charge of GPS data collection and integration at the Williams Field Site visit. In charge of acquiring and integrating relevant base map data and production of shapefiles, coverages and metadata for use in project GIS. Uses Microstation and AutoCAD data for inclusion into GIS. Creates, organizes and manages associated database files. Manages GPS survey data either sent to, or collected at project sites. Supports project managers with analysis, field maps and final maps. Supports geophysical operations with maps and fieldwork. In charge of creating and managing project web site including Internet GIS applications.

CHERYL-ANNE NICHOLS PROJECT ENGINEER
M.E.V.E., ENVIRONMENTAL ENGINEERING, UNIVERSITY OF SOUTH FLORIDA
B.S., CHEMICAL ENGINEERING, FLORIDA INSTITUTE OF TECHNOLOGY
OTHER PERTINENT TRAINING: HAZWOPER 40 HOUR MAY 03; CURRENT 8 HOUR REFRESHER; PROFESSIONAL ENGINEER (PE), FL LICENSE 71530

Jan 03 – Dec 03 **Staff Engineer**, OES Environmental, Inc., Orlando, FL. Performed work under Florida Department of Environmental Protection (FDEP) Petroleum Preapproval Program. Prepared proposals to conduct assessment work. Developed plans and conducted pilot tests of remediation technologies. Implemented remedial action plans to conduct full-scale remediation. Coordinated fieldwork events including scheduling, sampling, etc. Completed reports and submittals for remediation equipment operation.

Jan 04 – Sep 10 **Project Engineer,** Enviro-Logical Solutions, Inc./Environmental Compliance Services, Tampa, FL. Managed approximately 10-15 projects simultaneously. Coordinated schedules to ensure projects were completed on time. Facilitated communications between FDEP representatives and clients to ensure work was moving forward as anticipated by all parties. Performed work under FDEP Petroleum Preapproval Program. Prepared proposals and plans. Performed assessment work and pilot test. Coordinated well installation events and oversaw installation. Coordinated site monitoring schedules, operations and maintenance schedules and work, and performed field work. Prepared remedial action plans to conduct full-scale remediation. Prepared construction drawings. Prepared remedial action specifications and purchased remedial systems. Implemented construction projects and oversaw work, including remediation system installation and soil excavations from proposal preparation to closure. Prepared reports and submittals for remediation equipment operation, natural attenuation monitoring and site closure. Prepared site invoices and maintained project budgets. Performed storm water audits for private clients. **Assistant Health and Safety Manager** (Aug 06 – May 09). Coordinated company training programs and performed onsite health and safety audits. Prepared site specific health and safety plans and purchased equipment necessary for onsite work (PPE, mechanical equipment).

Sep 10 – Present **Project Manager/Project Engineer,** USA Environmental, Inc., Oldsmar, FL. Provides project management, technical and analytical project support, and report writing support to various environmental projects under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA), supporting Department of Defense initiatives at unexploded ordnance and chemical warfare materiel sites. Responsibilities include technical guidance, quality assurance, project coordination, and cost management.

DOUGLAS D. RALSTON **PROGRAM/PROJECT MANAGER**
Date Completed Basic EOD School: August 1971
OTHER PERTINENT TRAINING: HAZWOPER 40 HOUR OCTOBER 1995; CURRENT 8 HOUR SUPERVISOR/REFRESHER.

MILITARY EOD ASSIGNMENTS:

Sep 71 - Feb 72	EOD Specialist, 53d Ord Det EOD, Vancouver, WA. Learned basic EOD Operations and how to be a team member. First Range clearance at Yakima Firing range.
Mar 72 - Apr 73	EOD Specialist; 510th Ord Det EOD, Northern Greece. Learned nuclear operations in this unit. PPE monitoring hotline for nuclear contamination and work on nuclear weapons.
Apr 73 - Mar 74	EOD Specialist; 142D Ord Det EOD, Ft McClellan, AL. Participated in "Peacetime" chemical disposal of all Agents when the Chemical Schools closed. Learned the trade conventional response & range work.
Mar 74 - Aug 78	EOD Supervisor; 547th Ord Det EODCT, Ft Gillem, GA. Staff position involving training of subordinate EOD units, funding, operations, and security. Participated in incident responses at Ft Bragg, NC and Ft McClellan, AL.
Aug 78 - Aug 81	EOD Supervisor; 13th Ord Det EOD, Ft. Gillem, GA; Responding to several hundred incidents as team leader. Taught classes for safety and was involved in production of the EOD Range Clearance movie.
Nov 81 - Aug 84	EOD Supervisor; 72d Ord Det EOD, Bremerhaven, Germany; Typical work in dark world of Northern Germany. Extensive work for 3 years at Grafenwoehr the largest training area in Germany.
Aug 84 - Aug 85	EOD Supervisor; 2d Ord Det EOD, Grafenwoehr, Germany; Responded to chemicals located at Grafenwoehr. Responsible within unit for over 400 EOD incidents and the destruction of 12,000 tons of DEMO 2 and small range work at Grafenwoehr.
Oct 85 - Aug 87	EOD Supervisor; 87th Ord Det EOD, San Francisco, CA; Detachment NCO; Supervised 18 personnel, directed and performed the EOD mission of 150 EOD incidents per year in Northern California along with range work at Ft. Ord & Camp Roberts.
Sep 87 - Aug 93	EOD Supervisor, Operations NCO E-8; 168th Ord Det EODCT, Mannheim, Germany; Written command directives on safety in EOD Opns involving ACRs and Range Clearances. Involved directly in EOD Operations; chemical, nuclear and conventional.
Aug 93 - Oct 94	EOD Supervisor, 17th Ord Det EOD, Ft. Campbell, KY; Detachment NCO supervised 27 personnel; performed EOD operations in TN and KY. Responded to incidents at FUDS in KY and directed small range clearance Opns at Ft. Campbell. RETIRED.

CIVILIAN UXO EXPERIENCE:

May 95 - Aug 95	UXO Supervisor, UXB International, Raritan Arsenal, NJ. In charge of a brush crew that cleared 31 acres of swamp and location of ordnance items: 37mm HE, adapter boosters, U.S. and French hand grenades.
Aug. 95 - Apr. 96	UXO Supervisor, CMS, Environmental, Inc., Fort Ord, CA. Team leader in charge of a brush crew that cleared 314 grids without any OE accidents. Also responsible for the location and identification of ordnance items

	which included 22mm and 14.5mm subcaliber rounds, rockets, and mortars.
Apr. 96 - Aug. 96	Project Manager, CMS Environmental, Inc., George Air Force Base (AFB), Victorville, CA. Managed an ordnance remediation job site at George AFB. Successfully cleared three areas consisting of 318 100x100 feet grids, including a 40mm grenade range, with no lost time accidents. Managed a workforce of 14 UXO technicians. Responsible for a $490,000 programmed budget, including per diem and purchased and/or leases of supplies and equipment. Responsible for producing daily, weekly, and monthly reports and coordination with the BRAC office, Bureau of Prisons, and the Victorville Economic Development Agency. Safely completed all task order objectives two weeks ahead of schedule and under projected cost estimates. All work was accepted by the US Army Corps of Engineer's site representative on the first inspection.
Aug. 96 - Dec. 96	Project Manager, CMS Environmental, Inc., Camp Elliott, East Elliott, CA. Successfully completed an EE/CA project consisting of 101 sampling grids within a 3,200 acre FUDS site, ahead of schedule, under projected cost estimates, and with no lost time accidents. Managed a workforce of 14 UXO technicians, five laborers, and one clerk typist. Responsible for producing daily, weekly, and monthly reports.
Jan 97 – Jul 98	Project Manager, CMS Environmental, Inc., Fort Ord, CA. Managed an ordnance remediation project of 29.5 million dollars. The work involved the preparation of monthly Cost and Schedule Status Reports. During the performance of the contract no accidents occurred in the performance of work with explosives or vehicles. Participated in weekly and monthly meetings with the Corps of Engineers and the Installation to make decisions on the progress of the work and future sampling and removal actions this included public meetings to brief on the status of the contract.
Jul 98 – Dec 00	Project Manager, USA Environmental, Inc., Fort Ord, CA. Managed an ordnance remediation project of 29.5 million dollars. The work involved the preparation of monthly Cost and Schedule Status Reports. During the performance of the contract no accidents occurred in the performance of work with explosives or vehicles. Participated in weekly and monthly meetings with the Corps of Engineers and the Installation to make decisions on the progress of the work and future sampling and removal actions this included public meetings to brief on the status of the contract.
Jan 01 – Apr 04	Project Manager, USA Environmental, Inc., Tampa, FL. Responsible for the planning, scheduling, oversight and cost estimating of UXO support operations at the former Fort Ord, CA, Fort McClellan, AL, Benicia, CA, and Sioux Army Ammunition Depot, NE. Project Manager for the Frankford Arsenal EE/CA in Philadelphia, PA a small (110 acres) but complex EE/CA being performed in the City of Philadelphia and the States of Pennsylvania and New Jersey. Assisted USA Environmental Marketing in preparing responses to requests for proposal from US Army Corps of Engineers, AFCEE and NavFAC. Prepared and presented presentations on UXO operations at the former Fort Ord, California for the 2000 UXO Forum and the 2001 Louisville Corps of Engineers District Ordnance and Explosives Conference.
Apr 04 – Aug 04	Site Manager, USA Environmental, Inc. Overseas Operations, Captured Enemy Ammunition, Iraq. Managed former Iraqi Ammunition Supply Point including retrieval, receipt, inventory, storage, packaging, transport and disposal of captured Iraqi munitions. Duties included administrative oversight of all reports and finances; operational oversight of munitions,

	EOD, security, medical and logistics activities. Managed more than 120 personnel in all aspects of ASP operations.
Aug 04 – Oct 04	Operations Manager/Task Order Manager for Overseas Operations, USA Environmental, Inc., Mobile Teams Task Order, Iraq. Managed task order with multiple teams conducting clearance activities of Captured Enemy Ammunition (CEA) and UXO at various remote locations in Iraq in support of the CEA program.
Oct 04 – Mar 06	Project Manager for Overseas Operations, USA Environmental, Inc., Coalition Munitions Clearance (CMC), Iraq. Managed all facets of the CMC project including mobile teams, remote teams and depot operations for USA Environmental. Worked closely with representatives of the Corps of Engineers and other contractor management personnel as needed. Prepared and submitted final reports for the depots and mobile teams to the Army Corps of Engineers at the completion of the project.
Mar 06 - Present	Program/Project Manager, USA Environmental, Inc., Oldsmar, FL. Responsible for the planning, scheduling, oversight and cost estimating of UXO support operations for multiple projects to include Vieques, PR, Culebra, PR, Pinecastle TCRA, Orlando, FL, and Okinawa, Japan. Assists USA Environmental Marketing in preparing responses to requests for proposal from US Army Corps of Engineers, AFCEE and NavFAC. Knowledge of applicable federal, state, and local laws, regulations, and guidance.

MATTHEW TUCKER PROJECT MANAGER

B.S. ENGINEERING GEOLOGY, UNIVERSITY OF TENNESSEE

OTHER PERTINENT TRAINING: HAZWOPER 40 HOUR JUL 09; CURRENT 8 HOUR REFRESHER; PROFESSIONAL GEOLOGIST (PG), TN LICENSE 00005219

Jan 99 – May 07	**Engineer/Project Manager**, City of Chattanooga, Chattanooga, TN – Public Works Department. Performed and/or managed in-house and out-sourced design-build activities. Conducted activities involved in planning, concepts, engineering design, and specifications involved with roadway, streetscape, sanitary sewer, storm sewer, environmental, municipal solid waste facilities, buildings, facilities, and site projects ranging from \$2 to \$10 million in value. Oversight and support in the development of engineered systems (i.e., pavement construction materials, erosion control, geotechnical engineering; infrastructure management systems, etc.). Procurement and technical oversight of professional consulting services. Procurement, coordination and oversight of contract bidding (general contractor and/or subcontractors) and awarding processes. Contract administration, scheduling management, coordination of progress meetings, and quality assurance of construction projects. Coordinated and/or oversaw work coordination with utility companies and/or other city departments/divisions. Technical expertise for implementation and support of engineering projects and/or systems within technical specialties noted above.
May 07 – Nov 07	**Construction Project Manager,** Dillard Construction, Inc., Dayton, TN. Project management of build-build projects for the following types of building construction: commercial warehouse/distribution centers (\$5-20 million); industrial and pharmaceutical manufacturing facilities (\$10-30 million); residential-commercial mixed use developments (\$5-25 million); residential developments (\$1-5 million); infrastructure and site developments (\$2-\$15 million). Involved in preconstruction management and construction management. Preconstruction activities included but were not limited to: design coordination, construction document QA-QC reviews, building preliminary project schedules, obtaining building and environmental permits, creating/reviewing project cost estimates and bids, providing value engineering alternatives, bid coordination and proposal evaluation and negotiating contract agreements. Construction activities included but were not limited to: maintaining positive working relationships with clients/subcontractors, project budgeting and document tracking, subcontractor coordination, project scheduling, establishing job site management organization and job site procedures, and carrying out project close-out procedures.
Dec 07 – Jul 09	**Sr. Transportation Planning Coordinator,** North Georgia Regional Development Center, Dalton, GA. Program management of transportation planning services for the Dalton-Whitfield County metropolitan planning organization (MPO). Major duties included, but were not limited to: developing and administrating unified planning work program for the MPO; monitoring and administering FHWA/FTA and GDOT service contracts; providing preliminary transportation engineering and construction cost estimates for the roadway improvement plan; maintaining and processing amendments made to the adopted long range transportation plan (LRTP) and transportation improvement program (TIP); serving as a technical advisor for three standing MPO committees; serving on the Whitfield county comprehensive planning technical advisory committee; conducting facility needs assessments and corridor studies; preparing and reviewing quarterly and annual progress reports; conducting public involvement meetings and presentations; and overseeing GPS/GIS data collection activities.

Dec 05 – Jul 09	**Project/Construction Management,** Tucker Consulting, Chattanooga, TN. Self-employed consultant providing coordination and management services to multi-party groups involved in the following types of projects: federal and state superfund sites (RCRA, CERCLA, etc.); closing and decommissioning of major industrial and commercial facilities; DOD/UXO decommissioning projects (VAAP, Chattanooga, TN); state-mandated site remediation; voluntary site remediation to allow for property sale or redevelopment (brownfields); and non-environmental site development. Services provided to clients included: Phase I/Phase II reviews; coordination of multi-site auditing, assessment and remediation programs; regulatory agency negotiation support; peer review and assessment of technical reports, plans and specifications; value-engineering/constructability reviews; remedial strategy development (CERCLA); waste stream recycling programs; cost estimating/evaluation/reserve analysis; development of consultant/contractor work scopes; management of services procurement (RFP, bidding/selection, contracting); oversight of remedial construction/construction management; file reviews/environmental executive summaries; and operation and maintenance of remedial systems.
Jul 09 – Present	**Project Manager,** USA Environmental, Inc., Oldsmar, FL. Responsible for the planning, scheduling, technical guidance, quality assurance, project coordination and oversight, and cost estimating and management of munitions response operations for multiple projects, including various RI/FSs and RAs at Camp Lejeune, NC; an RI/FS effort at Sierra Army Depot, CA; a RI/FS at Milan Army Ammunition Plant; and UXO support at Rock Island, IL; provides CERCLA, RCRA and other regulatory guidance.

APPENDIX I. MINUTES OF THE TECHNICAL PROJECT PLANNING MEETING

15 SEPTEMBER 2009

MINUTES OF THE TECHNICAL PROJECT PLANNING MEETING

Date: 29 January 2010

Subject: Final Culebra RI/FS Technical Project Planning Meeting, 15 September 2009

Contract Number: W912DY-04-D-0006

Task Order: 0022

Administrative Data: The meeting was convened at the direction of USA Environmental and the USAESCH Project Manager to discuss the RI/FS for Culebra, Puerto Rico.

Date and Location: The meeting was held on 15 September 2009 at the USACE office in San Juan, Puerto Rico.

Attendees/Organization:

Spencer O'Neal	OE-DC Project Manager – USAESCH
Teresa Carpenter	Technical Manager – USAESCH
William Veith	Facilitator – OECX, Huntsville
Jose Mendez	Project Manager – USACE, Puerto Rico (PR)
Elsa Jimenez	Public Affairs – USACE, PR
Doug Ralston	Program Manager – USA
Al Crandall	Project Geophysicist – USA
Don Shaw	Project Manager – USA
Richard Henry	National Technical Liaison ERT – U.S. Fish and Wildlife Service (USFWS)
Diane Wehner	Regional Resource Coordinator – National Oceanic and Atmospheric Administration (NOAA)
Daniel Rodriguez	Regional Project Manager – Environmental Protection Administration (EPA)
Ana M. Roman	Refuge Manager Culebra National Wildlife Refuge (NWR)
Wilmarie Rivera	Federal Facilities Coordinator Puerto Rico Environmental Quality Board – (PREQB)
Jim Pastorick	President UXO Pro (Consultant to PREQB)
Felix Lopez	USFWS, Contaminants Specialist for PR and the USVI
Lisamarie Carrubba, PhD	National Oceanographic and Atmospheric Administration (NOAA), Ecologist
Robert Matos	Department of Natural and Environmental Resources (DNER) – National Reserves Division
Susan Silander	Project Leader Caribbean Islands NWR complex

Note: A copy of the sign-in sheet is included at the end of this document.

1.0 INTRODUCTION

The objective of the meeting is to implement the Technical Project Planning (TPP) IAW EM 200-1-2 and the USAESCH Implementation of TPP for FUDS Interim Guidance Document (undated).

This memorandum is a record of the TPP for six Munitions Response Sites (MRSs) on Culebra Island Site, which was conducted on 15 September 2009 in San Juan, Puerto Rico.

The Technical Approach to the RI/FS is based on award of Task Order 0022 and available site information to include the 1991 Inventory Project Report (INPTR), 1995 Archives Search Report (ASR) and 1997 Engineering Evaluation/Cost Analysis (EE/CA), 2004 ASR Supplement, 2005 INPR, 2005

Supplemental ASR. The decisions and agreements from this meeting will be used to finalize the development of the RI/FS Work Plan.

2.0 AGENDA

- Project Team
- Site Description
- Remedial Investigation/Feasibility Study (RI/FS)
- Current Guidance Documents for Field Operations
- Funding of In-depth Site Visit
- Funded Field Operations Luis Pena Island
- Decisions Required
  - Vegetation Removal (Meandering Path)
  - Underwater Work Access
  - Timely Anomaly Selection (Next Day)
  - Inaccessible Anomalies (Beach/Water Intrusion)

3.0 INTRODUCTION OF THE TPP

A TPP meeting was held at the San Juan, PR, USACE conference room on Tuesday, 15 September 2009.

The objective of the meeting was for the project team to agree on the data collection program outlined during the meeting, for the purposes of developing the project Work Plan that will lead to a decision document for MRS 13, Cayo De Luis Pena (one of six MRSs that is currently funded as a top priority). A map of data collection planned for MRS 13 was displayed during the opening of the meeting, and introductions and a hard copy of the map and TPP presentation were provided to each attendee.

Mr. Jose Mendez, Project Manager, USACE, PR, opened the meeting at 10:00 AM. Mr. Mendez welcomed everyone and introduced his Deputy District Engineer, Mr. Jose M. Rosado.

Mr. Rosado acknowledged the importance of the MMRP at Culebra and thanked all attendees for their best efforts to help make Culebra a safer place.

Following the Deputy Director's welcome, Mr. Mendez invited attendees to introduce themselves, and then introduced Mr. William Veith from USACE, Huntsville, who officially opened the meeting.

4.0 GENERAL DISCUSSION ITEMS/DECISIONS/ACTION ITEMS

4.1 DOCUMENT DISTRIBUTION AND COMMENT REVIEW

USA began the TPP presentation with the history of Luis Pena, the current data collection plan, and an overview about the current project scope, which includes two land demolition shots and one underwater demolition shot to dispose of discovered MEC. A unit cost per demolition shot was provided in case additional MEC disposal is required. (Refer to Enclosure 2 , Chart 20, Transects for Luis Pena.)

There was general discussion between the EPA and USACE about document reviews and feedback on response to EPA comments prior to final document delivery. It was suggested that a response to comment be provided via email to each commenter as the desired feedback, prior to release of the final document. Mr. Mendez agreed on the distribution of PDF response to comments and, to speed the review process, to have USA send hard copies of the documents directly to the agencies. (See Project Issue #1, Paragraph 4.15, below.)

4.2 HISTORY OF LUIS PENA

Mr. Veith introduced Mr. Doug Ralston, Program Manager for USA Environmental, Inc. (USA), who made the TPP presentation. Mr. Ralston's briefing included a physical display of the VideoRay underwater ROV and the Vulcan explosive tool, designed to "low-order" munitions. (Refer to Enclosure 2, Chart 7.)

- Site Location -- Culebra Island, Puerto Rico
  - MRS 13 Cayo Luis Pena Impact Areas
  - MRS 10 Defensive Firing Area No. 1 (Optional)
  - MRS 11 Defensive Firing Area No. 2 (Optional)
  - MRS 06 Artillery Firing Area (Optional)
  - MRS 09 Soldado Point Mortar and Bombing Area (Optional)
  - MRS 08 Cayo Norte Impact Area (Optional)
- Current Usage -- Culebra National Refuge (Luis Pena) Culebra FWS, DNER, and development
- Former Military Usage (1902 – 1975):
  - Bombing target (30lb Frag, 100lb, 1000lb Bombs)
  - Firing Positions (37mm, 75mm, 155mm, 3", 5", 6" Projectiles)
  - Marine Landings.

Daniel Rodriquez of the EPA commented that the proposed data collection plan looked more like a demonstration project than an RI/FS. USACE commented that lessons learned on past RI/FS projects are being folded into new RI/FS projects in an attempt to optimize each project.

General discussion focused around the fact that the historical review did not indicate that Cay De Luis Pena was used as a Military target area, except for a 1924 map that showed that the northern peninsula was designated as a target area for shore batteries located on Culebra, MRS 11. It was also noted that the data collection plan being presented represented a starting point and that additional data may be needed as the project team learns more.

4.3 UNDERWATER REMOTE OPERATING VEHICLE (ROV)

USA tabled the topic of underwater access, both in terms of collecting data with the ROV and divers and performing any necessary underwater excavation and disposal of discovered MEC.

This is a topic that is overseen by USFWS, NOAA, and DNER. NOAA stated that the current data collection plan map does not include the entire critical habitat for sea turtles that extends 3 miles around Culebra or coral that extends out to 30 meters of water. The data collection map needs to better detail exactly where critical habitat areas are, including coral colony boundaries, within the MRS work areas. (See Paragraph 4.16, Issue #5.)

Figure 1: USA ROV

4.4 LOW ORDER DETONATION OF MUNITIONS (VULCAN)/SECTION 7 CONSULTATION ESA

NOAA clearly stated that a formal consultation would be required for any underwater excavation/disposal, regardless of whether it was a blow in place (BIP) or a Vulcan low-order attempt to address and minimize any adverse modifications of any designated critical habitat or species. The formal consultation requires 180 days to complete, following receipt of a complete application package for consultation. An informal consultation is required for boat, ROV, and Diver operations during the data collection task because they are not likely to affect critical habitat, as long as the required precautionary procedures are followed. The data collection plan does need to include a detailed mapping of underwater MEC, coral, and critical habitat areas within the MRS work area. Following the data collection activities, a formal consultation could be reopened for excavation/disposal of underwater MEC, if needed to support the FS. The consultation would impose strict engineering controls to minimize blast effects (sediment, shock and noise control) and would require underwater soil and water samples be tested for energetics and MEC metals as well as site restoration. DNER stated they would prefer that all underwater MEC encountered that was determined acceptable to move, both from an MEC perspective and an environmental perspective, be removed from the water. NOAA stated that any MEC discovered in a critical habitat does not necessarily need a subsequent removal action, as NOAA would prefer no follow-on action in identified critical habitat. (See Paragraph 4.15, Decision #2, regarding “Formal Section 7 Consultation to ESA.”)

The source for the 100-yard MRS boundary, seaward from mean high water, was questioned. USACE responded that the 100-yard boundary came from a DERP requirement in order to allocate funding.

4.5 BEACH MONITORING

Turtle issues were discussed, including a turtle nesting beach monitoring program prior to and throughout field activities. The team acknowledged that there are turtle avoidance procedures for in water and on land encounters, and that turtle nests and hatchlings will be avoided.

USA stated the procedures outlined in the Final SOP for Endangered Species Conservation and their habitat on DERP-FUDS Project No. I02PR006802, Culebra, PR. for 75 days of beach monitoring will be followed before operations commence on Luis Pena or other MRS. (See Enclosure 2, Chart 35.) See Paragraph 4.14 for details on the Issue of Procedures on Turtle Nest (MEC).

Figure 2: Turtle Hatchlings

4.6 PWS AUTHORIZED MRS

The following information is from Chart 12 in Enclosure 2.

- MRS 13 Cayo Luis Pena Impact Areas
- MRS 10 Defensive Firing Area No. 1 (Optional)
- MRS 11 Defensive Firing Area No. 2 (Optional)
- MRS 06 Artillery Firing Area (Optional)
- MRS 09 Soldado Point Mortar and Bombing Area (Optional)
- MRS 08 Cayo Norte Impact Area (Optional)

All six MRSs were reviewed. These will be addressed generally in the Work Plan, with specific details for data collection at each MRS added as they are funded. USFWS noted that a British 2000 pound bomb was found during the Military clean up. They also noted that there is one endangered spineless cactus on Culebra that will need to be included in the Work Plan.

Mr. Spencer O’Neal (USACE) asked the project team what their priorities were for subsequent MRS investigations. The consensus was to move to MRS 09, MRS 10, and then MRS 11, as funding becomes available.

4.7 PHASE II TPP HOW MUCH DATA IS SUFFICIENT:

The following information is from the presentation in Enclosure 2, Chart 16, as a discussion point on the adequacy of data for the RI/FS:

- Who will use the data?
- What will the data be used for?
- What type of data is needed?
- How good do the data need to be?
- How much data are needed?
- Where, When, and How should the data be Collected/Generated?
- Who will collect and generate the data?
- How will the data be reported?
- How will the data be archived?

A general discussion was held to talk about the authorized/funded field work for land and underwater. Huntsville made the point that the RI will not evaluate 100% of the site whether it is land or water.

PREQB asked how we deal with the limited data collection. Their major concern is that if no MEC is found, will there be sufficient data to justify a decision for No Further Action? After some discussion, it was agreed that we could augment the RI with additional data while working on the FS, if necessary. USACE tabled the possibility that if no MEC is found on land, on the beaches, or on the sea floor, then there probably is sufficient data to make a No DoD Action Indicated (NDAI) decision for that area. Determining where MEC is located is critical for the RI; MEC disposal can be addressed differently.

Messrs. Veith, O'Neal, and Pastorick (Consultant for PREQB) agreed for additional data by Huntsville if the regulators say we don't have sufficient data to support a NDAI (No Further Action).

The EPA representative, Mr. Danny Rodriquez, commented that if he feels we don't have sufficient data it may only be an "interim measure". He explained that if he did not believe the level of effort to be sufficient to support a decision that USAESCH may need to come back and gather additional data, this would be especially important on the south side of the island if no MEC was found. Messrs. Veith, O'Neal, and Pastorick agreed to additional data by USAESCH if the regulators say the data collected is not sufficient.

The question was discussed on why the underwater survey is limited to 100 yards off mean high tide. The DERP FUDS manual prescribes this limitation.

Dr. Lisamarie Carrubba discussed the USA map of Luis Pena, saying that it does not have all critical habitat identified. She talked about additional data on critical habitat that will be placed on the maps. She wants the USA sampling around Luis Pena to identify critical habitat while using the ROV. (See Paragraph 4.16, Action Item #5.)

4.8 PWS MC SAMPLING

The following data is from Chart 30 of the presentation showing the amount of MC sampling funded for the RI/FS. The Collection Team consists of one Site Chemist and one UXOTII.

- 70 discrete samples for surface soil,
- 30 discrete samples for subsurface soil,
- 20 discrete samples for sediment and surface water,
- 20 discrete background samples for surface and subsurface soil,
- 10 discrete background samples for sediment and surface water, and
- 10 each pre- and post-detonation composite samples based on the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) 7-sample wheel approach

Additionally, if deemed necessary by the PDT, USA may increase or decrease the above-listed sample quantity based on the final level of effort determined during the first TPP meeting.

Soil, groundwater, sediment, and surface water samples are analyzed for total metals using SW-846 Method 6010B/7471A.

Explosives are analyzed using SW-846 Methods 8330/8332.

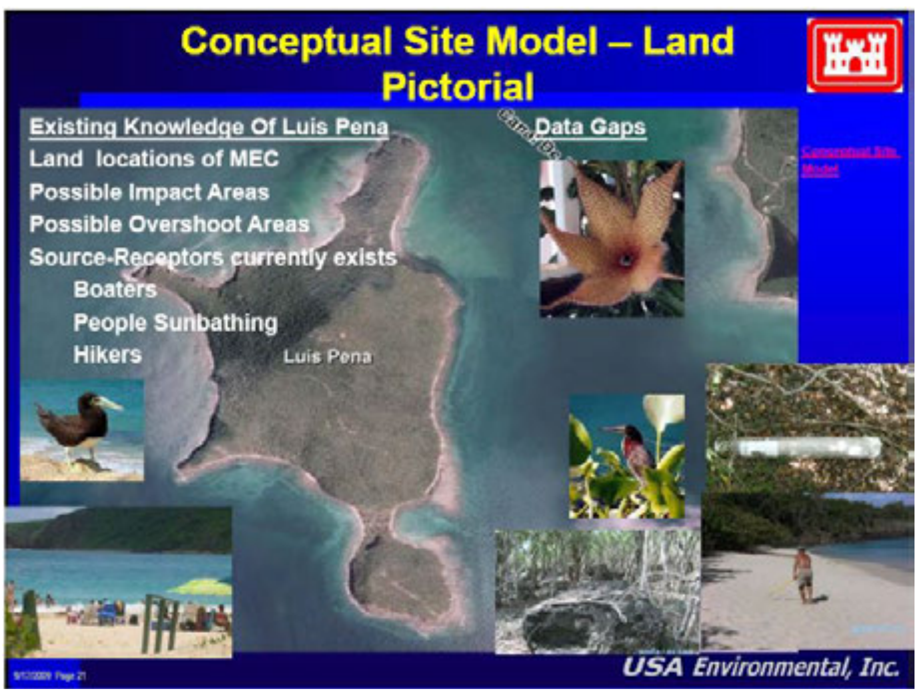
Ms. Diana Wehner of NOAA asked if the data collection plan included MC sampling for energetics materials and metals from MEC use or from leaking MEC. Ms. Wehner stated the Superfund values are used for comparison; water is screened for metals (fresh water as well as salt water). USA presented the MC sampling that is currently scoped for the project for all six MRSs and that it is too early to develop a specific sampling plan. General discussion followed, and the parties agreed that the MC sampling plan should be addressed generally in the Work Plan and that it would be finalized after we have more information for the data collection plan. EPA still expressed concern that insufficient data collection is planned.

USA presented the land and underwater Conceptual Site Models (CSMs). Ms. Wehner requested that the Site Inspection MC sampling results be included in the CSMs.

Underwater MC sampling was discussed. Ms. Wehner stated that there are limited laboratory test results on the effects of MC contamination on fish and small vertebrates. There is some data from Vieques on fish and anemones living on/inside MEC that show MC contamination but that the effect stays local and falls off quickly with distance from the open MEC.

4.9 CONCEPTUAL SITE MODEL: LAND AND WATER (ATTACHED TO THE MEMORANDUM)

The following chart is an example of CSM from the presentation.



CSM: Land transects will require limited devegetation to allow meandering along transects. Mr. Robert Matos (DNER) requested that we add Fishermen as potential receptors on the underwater CSM.

4.10 UNDERWATER DEMOLITION/SECTION 7 CONSULTATION FOR ENDANGERED SPECIES ACT (ESA)

A general discussion followed lunch about the focus of the RI/FS. A decision was reached that the RI/FS should concentrate on collecting data to map surface land and underwater MEC and potential subsurface land and underwater MEC, and that there will be no explosive underwater MEC disposal during the initial data collection field activities. With the surface and potential subsurface MEC mapped, an application for formal consultation with NOAA may be filed. The informal consultation will address all six MRSs. Each formal consultation will need to be MRS-specific. However, a letter request to reopen a consultation can be used to address each MRS that has underwater issues.

Figure 3: Example of Vulcan on Bomb

Any underwater demolition will require USFWS and DNER to be notified, prior to any approved underwater demolition, in addition to the current notifications. NOAA has US Navy consults regarding underwater BIP that include additional engineering controls (e.g., bubble curtains to minimize acoustic disturbances).

At this meeting, no agreement was reached regarding any additional engineering controls. This will be an issue with the Formal Section 7 Consultation.

4.11 PHASE II TPP USER OF DATA COLLECTED

The following data is Chart 36 of the presentation which shows users of the data.

- Who Will Use the Data: USAESCH, NOAA, FWS, DNER, and Puerto Rico EQB.
- What Will the Data be Used For: RI/FS Characterize Luis Pena
- What Type of Data: Geophysical (Digital, Analog) (Water/Land) MC
- Good Data to Support Decision: Sufficient definitive data with adequate QC
- How Much Data are Needed: MEC 4 acres transects, 2 acres grids, Investigate 350 anomalies, 3 demo shots, 100 yards in sea
- Data Collected/Generated: Luis Pena, Schedule, IAW DQOs and SOPs
- Collects /Generates Data: SUXOS, Quality Control, GIS Manager, Site and Project Geophysicist
- Reporting: Daily/Weekly/Monthly/Final Report
- Data Archive: Admin Record/IAW DID

DNER needs to be added to the “Who will use the RI/FS data?” PREQB noted that the authorized data collection may not be sufficient to make a MRS decision. USACE acknowledged that there is a possibility that additional data may be collected under this RI, if needed to reach a defensible decision point. It was also acknowledged that the 100-yard off-shore boundary limit may need to be expanded, if data indicates that MEC or MC contamination extends beyond that boundary. The DERP FUDS Manual dated July 1996 Chapter 3, Section 3-2b (l) states “clean-up of off-shore ordnance properties, beyond 100 yards of mean high tide, will not be eligible, except -in special cases where a public exposure pathway exists."

USAESCH stated the 100-yard limit was from the DERP FUDS manual for underwater investigation.

Need to add VideoRay GPS-positioned video of surface underwater MEC, critical habitat, and coral colonies to what type of data.

A photograph of a potential underwater 5" rocket caused some discussion about the CSM. The most likely scenario is that if it is a 5" rocket warhead, it is an overshoot from the Culebra NW peninsula.

Biting insects and poisonous vegetation need to be added to the things affecting data collection. Data formats should include PDF.

4.12 DATA QUALITY OBJECTIVES

USA introduced the project DQOs used during the SI (see Chart 39 in Enclosure 2)… "determine the nature and extent of MEC and MC". There are no uniform transect spacings to base a DQO on.

- The RI data needs to establish if MRS 13 (Cayo de Luis Pena) was used as a military target or not.
- The southern portion of the island (e.g., south of the Observation Post) data collection is SI-style where we need to determine the presence or absence of MEC/MC.
- If there is MEC in the southern portion of Luis Pena, then more data and more DQOs will be needed to establish the full nature and extent of contamination.

The EPA and PREQB discussed that since parallel transects based on a known impact area are not being placed on the island, the northern portion of Luis Pena does need DQOs that determine the nature and extent of possible MEC and the southern portion needs a DQO to determine the absence or presence of MEC or MC. The southern section may need additional transects if no MEC is found during the RI to support a NOFA decision. (See Paragraph 4.16, Action Items #3 and #4.)

4.13 ISSUES FOR DEVELOPMENT OF THE RI/FS WORK PLAN

USA finished the presentation with a list of issues that will be addressed in the Work Plan and the agency most responsible for each issue.

- The land and underwater results will drive the MC sampling design.
- Underwater MC sampling needs to test for MEC metals and energetic materials. NOAA has some underwater screening levels for MC.
- Land devegetation is a concern for USFWS and DNER, particularly for land grids (50' x 50'). Huntsville should consider converting grid acreage into additional transect miles. USA will check with USACE project geophysicists.

All issues that identify USFWS as the primary agency need to include DNER. Schedule the post-award site visit with USFWS, NOAA, and DNER.

4.14 SUMMARY OF ISSUES DISCUSSED DURING TPP

The following table is a summary of the issues discussed during the TPP.

Issue	Comments	Responsible Agency
Vegetation Removal	USA will limit vegetation removal on Luis Pena during collection of data on transects. USA requested to change the authorized grids to additional transects to reduce the long-term impact on the vegetation.	FWS and DNER
Underwater Access	USA has been restricted from performing any underwater DGM or underwater excavation/demolition until a formal Section 7 Consultation to the Endangered Species Act has been approved, which will not be submitted until Site Visit ROV investigation of the location for critical habitat and MEC has been documented.	NOAA
Timely Anomaly Selection Review	USA is working with USAESCH on the anomaly selection for DGM transects. Analog (All Metals) sweeps of beaches will be performed with excavations of selected anomalies on the same day.	USAESCH
Inaccessible Anomalies (Beach)	Anomalies selected on a beach with water intrusion will not be pursued and another anomaly will be selected. No additional efforts will be made to remove the water.	USAESCH
Procedures on Diving Coral Reef	Informal consultation can be provided by NOAA before the formal Section 7 Consultation is submitted.	NOAA
Decision on Underwater Demo	No underwater demolition is authorized until after receiving the formal Section 7 response from NOAA.	NOAA
Procedures on Turtle Nest (MEC)	USA will follow the procedures listed in the SOP for Endangered Species Conservation and their habitat on DERP-FUDS Project No. I02PR006802, Culebra, PR. 75 days for beach monitoring for Turtle nests/hatchlings. No anomalies will be investigated within established radius from identified nests.	FWS
Updated Boating Instructions	USA will use the published guidance in the SOP for Endangered Species Conservation and their habitat on DERP-FUDS Project No. I02PR006802, Culebra, PR.	NOAA
GPO or Daily Detection Tests	Agreement with USAESCH on performance of an Instrument Test Plot.	USAESCH
GPS Accuracy	Use of a handheld GPS with external antenna is proposed to position DGM transect data.	USAESCH
EM61-MK2 Orientation	Agreement with USAESCH on orientation of the EM61-MK2 0.5 meter edge forward.	USAESCH
SOP's VideoRay, Diving, Underwater Demo, Underwater Intrusive Investigation	USA has developed SOPs for ROV, Underwater Demolition, and Intrusive Investigation. USA will develop DQOs for MC Sampling and Underwater Geophysics for the RI/FS Work Plan.	USA

4.15 DECISIONS ON PROJECT ISSUES

#	Issue	Decision
1	Distribution of Documents and Response to Comments	FTP will be available for document access by project team. Once accepted by USAESCH, documents with incorporated response to comments will be converted to PDF and delivered directly to the reviewers. Response to comments will be distributed prior to final document distribution.
2	Underwater Geophysical Transects Formal Section 7 Consultation to ESA.	No underwater geophysical transects or underwater demolition until approval of the Formal Section 7 Consultation with the Endangered Species Act (ESA). Additional data on location of MEC underwater and the location of critical habitat after the site visit may have sufficient data to submit a Formal Section 7 Consultation.
3	MC Sampling	No decision on the quantity or specifics for MC sampling until the full extent of the MEC both on land and underwater is known.

4.16 ACTION ITEMS

#	Action Item	Responsible	Comment
1	Distribution of Documents for Review and Response to Comments	USA and USAESCH	Agencies were asked to identify which required a copy of a published document and which required a PDF of response to comments.
2	MC Sampling	USA	Diane Wehner (NOAA) wants existing data for MC sampling and a description of how the data is screened.
3	DQO MC Sampling	USA	Develop a DQO for the collection of samples both on land and underwater (Insert Work Plan)
4	DQO MEC (Luis Pena)	USA	Develop a DQO for the North side of Luis Pena "Determine the nature and extent of MEC on north side of Luis Pena" Develop a DQO for the South side of Luis Pena "Determine the presence or absence of MEC on the south side of Luis Pena.
5>	Identification of Critical Habitat around Luis Pena	USA	NOAA will supply website to download known critical habitat to be added to RI/FS maps. USA GIS Manager to add data.

4.17 USA RI/FS PROJECT PERSONNEL CONTACT INFORMATION

Al Crandall	Project Geophysicist	(813) 343-6362	acrandall@usatampa.com
Jeff Lewis	GIS Manager	(813) 343-6376	jlewis@usatampa.com
Brian Skubin	Underwater PM	(813) 343-6384	bskubin@usatampa.com
Joe Blue	Contracts Manager	(813) 343-6400	jblue@usatampa.com
Doug Ralston	Program Manager	(813) 343-6368 (813) 500-1099 Cell	dralston@usatampa.com

ENCLOSURE 1: DISTRIBUTION OF RI/FS DOCUMENTS

Type of Plan/ Report/ Documents	USAEXCH	CESAJ	CE Antilles	FWS Rich Henry	FWS Felix Lopez	PR EQB	NOAA Diane Wehner	NOAA Lisamarie Carrubba	FWS Ana Roman	DNER Robert Matos	FWS Susan Silander	Admin Record	Comments
AAPP Draft	4	4											14 days prior to site visit
AAPP Final	4	4											
Explosive Siting Plan Draft	4	4											Separate MACOM approval before intentional physical contact with MEC
PDF Response to Comments	XX	XX											
Explosive Siting Plan Final	4	2	1	1	1	1	1	1	1	1	1	1	
Schedule Monthly	XX	XX											
Advanced TPP Package & CSM	4	2	1	1	1	1	1	1	1	1	1	1	14 days before 1st TPP
Draft Public Involvement Plan	4	2	1	1	1	1	1	1	1	1	1	1	TBD (Not funded)
PDF Response to Comments	X	X	X	X	X	X	X	X	X	X	X	X	
Final Public Involvement Plan	4	2	1	1	1	1	1	1	1	1	1	1	14 days after receipt of comments
Draft Work Plan	4	2											21 days after DQO's are determined (TPP) **6 Oct 09**
PDF Response to Comments	X	X											14 days after on board Review
Draft Final Work Plan	4	2	1	1	1	1	1	1	1	1	1	1	14 days after on board Review
Draft RI Report w/GIS on DVD	4	2	1	1	1	1	1	1	1	1	1	1	60 days after completion of field work

Type of Plan/ Report/ Documents	USAEXCH	CESAJ	CE Antilles	FWS Rich Henry	FWS Felix Lopez	PR EQB	NOAA Diane Wehner	NOAA Lisamarie Carrubba	FWS Ana Roman	DNER Robert Matos	FWS Susan Silander	Admin Record	Comments
Draft Final RI Report	4	2	1	1	1	1	1	1	1	1	1	1	14 days after receipt of comments
PDF Response to Comments	X		X	X	X	X	X	X	X	X	X	X	
Final RI Report	4	2	1	1	1	1	1	1	1	1	1	1	14 days after on board Review
Draft FS Report	4	12											TBD
PDF Response to Comments	X	X	X	X	X	X	X	X	X	X	X	X	
Draft Final FS Report	4	2	1	1	1	1	1	1	1	1	1	1	14 days after receipt of comments
PDF Response to Comments			X	X	X	X	X	X	X	X	X	X	
Final FS Report	4	2	1	1	1	1	1	1	1	1	1	1	14 days after on board Review
Draft Proposed Plan	4	2	1	1	1	1	1	1	1	1	1	1	14 days after receipt of acceptance of the FS Report
PDF Response to Comments			X	X	X	X	X	X	X	X	X	X	
Final Proposed Plan	4	2	1	1	1	1	1	1	1	1	1	1	7 days after receipt of comments
PP Meeting Transcripts	4	2	1	1	1	1	1	1	1	1	1	1	With final Proposed Plan
Responsive Summary	4	2	1	1	1	1	1	1	1	1	1	1	With Decision Documents
Draft Decision Document	4	12											
Draft Final Decision Document	4	2	1	1	1	1	1	1	1	1	1	1	14 days after acceptance of Proposed Plan

Type of Plan/ Report/ Documents	USAEXCH	CESAJ	CE Antilles	FWS Rich Henry	FWS Felix Lopez	PR EQB	NOAA Diane Wehner	NOAA Lisamarie Carrubba	FWS Ana Roman	DNER Robert Matos	FWS Susan Silander	Admin Record	Comments
PDF Response to Comments			X	X	X	X	X	X	X	X	X	X	7 days after receipt of comments
Final Decision Document	4	2	1	1	1	1	1	1	1	1	1	1	7 days after receipt of comments
Final Administrative Record (DVD)	4	2	1	1	1	1	1	1	1	1	1	1	Upon completion of the Record
Daily QC Report for Environmental Sampling	XX	XX											Daily during Environmental Sampling Activities
Analytical Data Submittal for QA Evaluation	XX	XX											30 days after completion of field work
Electronic Laboratory Data Submittal	XX	XX											45 days after completion of field work
Final GIS Files on CD	4	2	1	1	1	1	1	1	1	1	1	1	End of Project

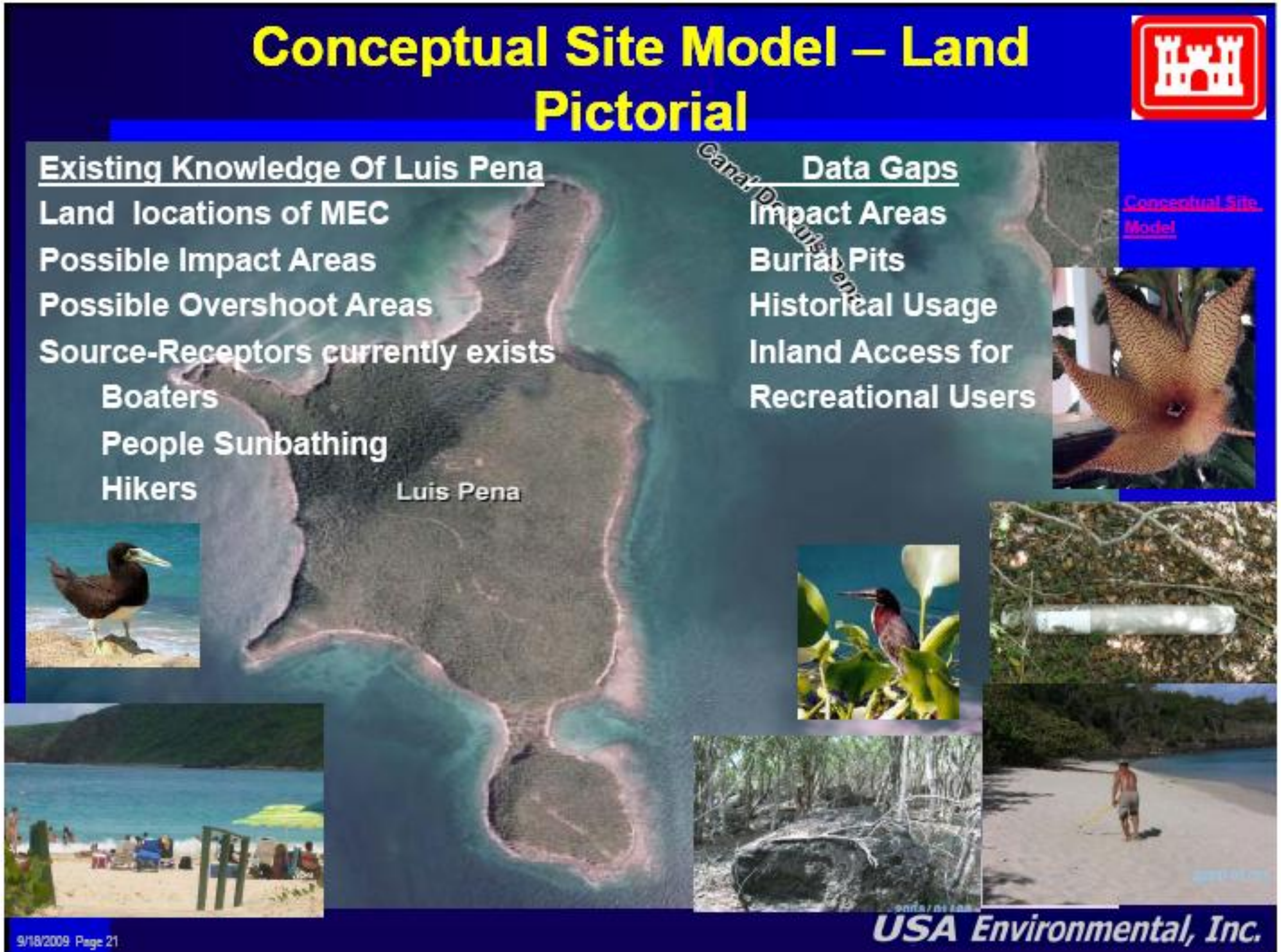
- Fish and Wildlife Rich Henry National Technical Liaison ERT, is the official channel for response to comments
- FWS copies need to go directly to all offices Rich Henry, Susan Silander and Felix are in the same location, and Ana Roman,
- NOAA Diane Wehner and Dr Lisamarie Carrubba get documents for review. Both will submit comments to USACE.
- EPA copy directly to Daniel Rodriquez. Comments to USACE.
- DNER copy to Robert Matos. Comments to USACE.
- PREQB copies to Wilmarie Rivera she will distribute to UXO Pro. Comments to USACE.

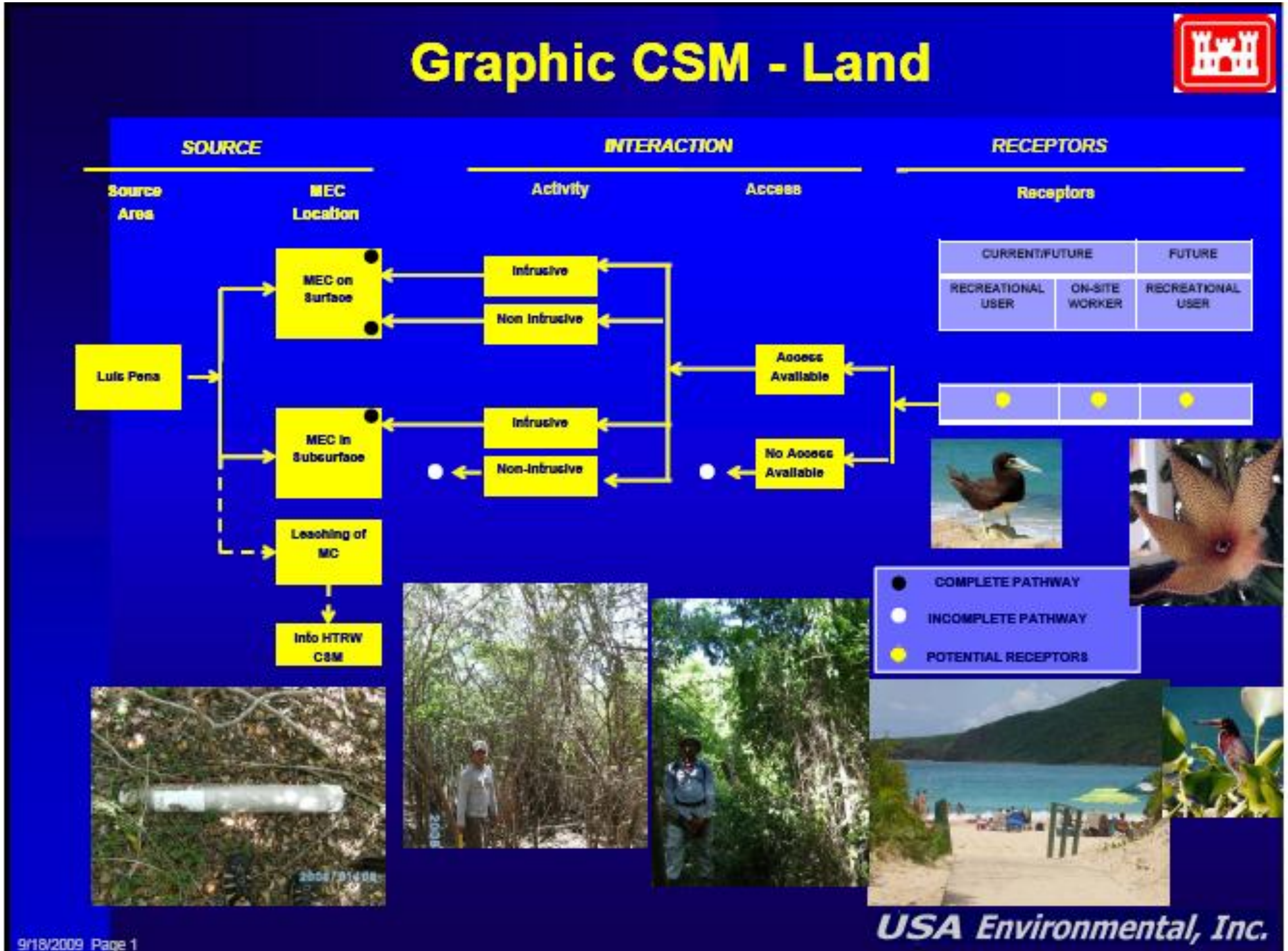
Note: XX indicates copies to USACE only

ENCLOSURE 2: TECHNICAL PROJECT PLANNING PRESENTATION (15 SEP 09)

ENCLOSURE 3: TECHNICAL PROJECT PLANNING PHASE 1 MEMORANDUM AND PROJECT OBJECTIVES

ENCLOSURE 4: CONCEPTUAL SITE MODEL (LAND) GRAPHIC AND PICTORIAL


Conceptual Site Model – Land Pictorial
Existing Knowledge Of Luis Pena
Land locations of MEC
Possible Impact Areas
Possible Overshoot Areas
Source-Receptors currently exists
Boaters
People Sunbathing
Hikers
Luis Pena
Data Gaps
Impact Areas
Burial Pits
Historical Usage
Inland Access for
Recreational Users
Conceptual Site Model
9/18/2009 Page 21
USA Environmental, Inc.


Graphic CSM - Land
SOURCE
INTERACTION
RECEPTORS
Source Area
MEC Location
Activity
Access
Receptors
CURRENT/FUTURE
FUTURE
RECREATIONAL USER
ON-SITE WORKER
RECREATIONAL USER
Luis Pena
MEC on Surface
MEC in Subsurface
Leaching of MC
Into HTRW CSM
Intrusive
Non Intrusive
Intrusive
Non-Intrusive
Access Available
No Access Available
COMPLETE PATHWAY
INCOMPLETE PATHWAY
POTENTIAL RECEPTORS
USA Environmental, Inc.
9/18/2009 Page 1

ENCLOSURE 5: CONCEPTUAL SITE MODEL (UNDERWATER) GRAPHIC AND PICTORIAL

Conceptual Site Model – Underwater Pictorial

Existing Knowledge Of Luis Pena

Underwater locations of MEC

Unmapped locations of Critical Habitat

Source-Receptors currently exists

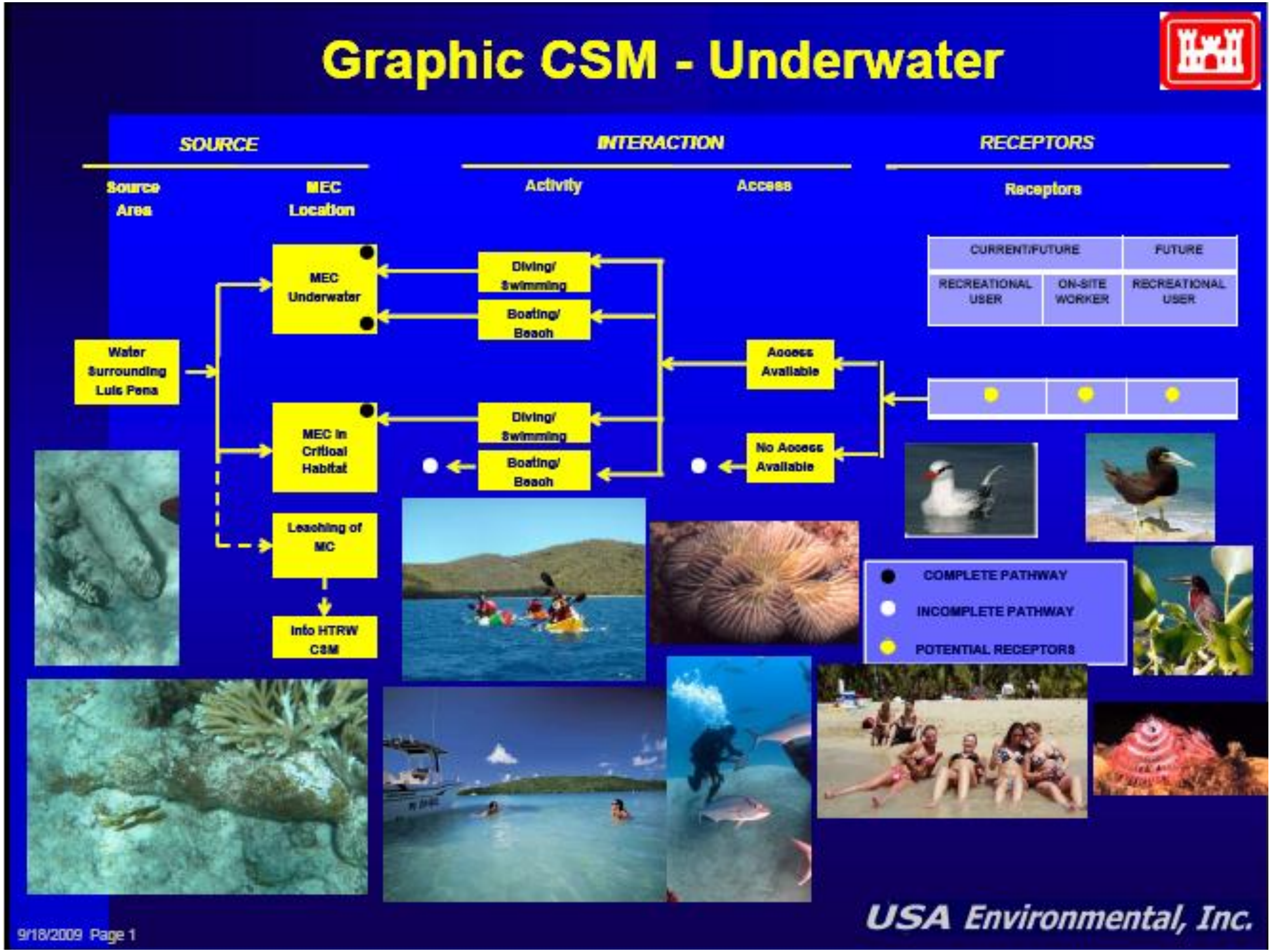
- Boaters
- Swimmers
- Snorkelers
- Divers
- Coral
- Fish
- Fishermen

Data Gaps

- Impact Areas
- Historical Usage
- MPPEH/UXO
- Critical Habitat

Conceptual Site Model Graphic - Underwater

USA Environmental, Inc.


Graphic CSM - Underwater
SOURCE
INTERACTION
RECEPTORS
Source Area
MEC Location
Activity
Access
Receptors
CURRENT/FUTURE
FUTURE
RECREATIONAL USER
ON-SITE WORKER
RECREATIONAL USER
Water Surrounding Luis Pena
MEC Underwater
MEC in Critical Habitat
Leaching of MC
Into HTRW CSM
Diving/ Swimming
Boating/ Beach
Diving/ Swimming
Boating/ Beach
Access Available
No Access Available
COMPLETE PATHWAY
INCOMPLETE PATHWAY
POTENTIAL RECEPTORS
USA Environmental, Inc.
9/18/2009 Page 1

ENCLOSURE 6: LIST OF ATTENDEES AND SIGN-IN SHEET

Name	Title	Organization	Email and Telephone
Spencer O'Neal	OE-DC Project Manager	U.S. Army Corps of Engineers Support Center Huntsville (USAESCH) CEHNC-DC-MM	**Spencer.D.Oneal@usace.army.mil** Office (256) 895-1574 Cell (256) 655-1067
Teresa Carpenter	Technical Manager	U.S. Army Corps of Engineers Support Center Huntsville (USAESCH) CEHNC-DC-MM	**Teresa.M.Carpenter@usace.army.mil** Office (256) 895-1659
William Veith	Facilitator	U.S. Army Corps of Engineers Support Center Huntsville (USAESCH) CENHC-CX-MM	**William.d.veith@usace.army.mil** Office (256) 895-1592
Jose Mendez	Project Manager	U.S. Army Corps of Engineers Antilles Office 400 Fernadez Juncos, San Juan, Puerto Rico 00901-3299	**Jose.M.Mendez@usace.army.mil** (787) 729-6893, 6895, Ext 3099 (787) 370-8928
Elsa Jimenez	Public Affairs	U.S. Army Corps of Engineers Antilles Office 400 Fernadez Juncos San Juan, Puerto Rico 00901-3299	(787) 729-6876
Doug Ralston	Program Manager	USA Environmental. Inc. 720 Brooker Creek Blvd., Suite 204 Oldsmar, FL 34677	**Dralston@usatampa.com** Office (813) 343-6368 Cell (813) 500-1099
Al Crandall	Project Geophysicist	USA Environmental. Inc. 720 Brooker Creek Blvd., Suite 204 Oldsmar, FL 34677	**acradall@usatampa.com** Office (813) 343-6362 Cell (813) 927-2975
Don Shaw	Project Manager	USA Environmental. Inc. 720 Brooker Creek Blvd, Suite 204 Oldsmar, FL 34677	**dshaw@usatampa.com** Office (813) 343-6406 Cell (813) 846-9138
Richard Henry	National Technical Liaison ERT	US FWS 2890 Woodbridge Ave. Edison, NJ 08837	**Richard_Henry@fws.gov** Office (732) 906-6987 Cell (973) 204-5825
Diane Wehner	Regional Resource Coordinator	NOAA 85 Central Ave. New Providence, NJ 07974	**diane.wehner@noaa.gov** (240) 338-3411
Daniel Rodriguez	Regional Project Manager	US EPA Vieques Field Office Carr 200 km 0.4 Vieques, PR 00765	**Rodriguez.Daniel@epamail.epa.gov** Office (787) 741-5201 Cell: (787) 741-5017
Ana M. Roman	Refuge Manager Culebra National Wildlife Refuge	U.S. Fish and Wildlife Service P.O. Box 190 Culebra, PR 00775	**Ana.roman@fws.gov** Office (787) 742-0115 Cell (787) 306-1389

Name	Title	Organization	Email and Telephone
Wilmarie Rivera	Federal Facilities Coordinator Puerto Rico Environmental Quality Board	Puerto Rico Environmental Quality Board (PREQB) P.O. Box 11488 San Juan, PR 00910	**wilmarierivera@jca.gobierno.pr** Office (787) 767-8181 Ext 6141 Cell (787) 365-5873
Jim Pastorick	President UXO Pro	UXO Pro 811 Duke St. Alexandria, VA 22314	**Jim@uxopro.com** **www.uxopro.com** (703) 548-5300
Felix Lopez		U.S. Fish and Wildlife Service (USFWS) P.O. Box 491 Boqueron, PR 00910	Felix_lopez@fws.gov (787) 510-5202
Lisamarie Carrubba Ph.D.	Ecologist	National marine Fisheries Service (USFWS) National Wildlife Refuge PR 301 km 5.1 P.O. Box 1310 Boqueron, PR 00622	**Lisamaria.carrubba@noaa.gov** Office (787) 857-3700 Cell (787) 455-0007
Robert Matos	DNER-National Reserves Div.	Puerto Rico Department National Environmental Resources (DNER) P.O. Box 11488, San Juan, PR 00910	Matos_resevas@yahoo.com (787) 983-7222
Susan Silander	Project Leader Caribbean Islands NWR Complex	U.S. Fish and Wildlife Service	**susan_silander@fws.gov** (787) 851-7258 Ext 238

Sign in Sheet

NAME	ORGANIZATION	E-MAIL	PHONE
Alan Crandall	USA Environmental, Inc.	acrandall@usatampa.com	813-927-2975
Spencer [illegible]	USACE	spencer.j.[illegible]@usace.army.mil	256-895-1574
Teresa Carpenter	USACE	teresa.m.carpenter@usace.army.mil	256-895-4459
Bill Veith	USACE	william.b.veith@usace.army.mil	256 895-1592
Richard Henry *	FWS	richard_henry@fws.gov	732-906-6987
Diane Wehner *	NOAA	diane.wehner@noaa.gov	240-338-3411
Daniel Rodriguez *	EPA	rodriguez.daniel@epa.gov	787-741-5201
Wilmarie Rivera	PR EQB	wilmarierivera@jca.gobierno.pr	(787)767-8181
Jim Pastorick	EQB/UXO Pro	Jim@UXOPro.com	703 548 5300
Felix Lopez *	USFWS	felix_lopez@fws.gov	787-570-520[illegible]
Lisamarie Carrubba *	NOAA Fisheries	lisamarie.carrubba@noaa.gov	787-851-3[illegible]
Ana M. Roman *	USFWS-CNWR (Culebra)	ana_roman@fws.gov	(787) 306-1389
Robert Matos	DNER - Nat. Reserves Div	rmatos@drna.gobierno.pr	(787) 999-2200 x2113
Susan Silander	FWS	susan_silander@fws.gov	787/851-7258
Donald Shaw	USA Environmental, Inc.	dshaw@usatampa.com	(813) 846 9178
Jose Mendez	Corps of Eng	jose.M.Mendez@usace.army.mil	787 370-8926
Doug Ralston	USA	dralston@usatampa.com	813 393-6368

28 SEPTEMBER 2010

MINUTES OF THE TECHNICAL PROJECT PLANNING MEETING

Culebra RI/FS Technical Project Planning Meeting; 28 September 2010

Contract Number: W912DY-04-D-0006

Task Order: 0022

Administrative Data: The meeting was convened at the direction of USA Environmental and the USAESCH Project Manager to discuss the RI/FS Work Plan issues and December 2009 Site Visit for Culebra, Puerto Rico.

This memorandum is a record of the Technical Project Planning (TPP) for six MRS's on Culebra Island site conducted on 28 September 2010 in San Juan, Puerto Rico.

The Technical Approach to the RI/FS is based on award of Task Order 22 and available site information to include the 1991 Inventory Project Report (INPR), 1995 Archives Search Report (ASR), 1997 Evaluation/Cost Analysis (EE/CA), 2004 ASR Supplement, 2005 INPR, and 2005 Supplemental ASR. The decisions and agreements from this meeting will be used to finalize the development of the Draft Final RI/FS Work Plan.

Attendees:

Spencer O'Neal	OE-DC Project Manager (USAESCH)
Teresa Carpenter	Technical Manager (USAESCH)
Kelly Enriquez	Project Geophysicist (USAESCH)
Thomas Freeman	Facilitator (USACE St Louis District)
Terry Walker	Risk Assessor (USACE EMCX)
Jose Mendez	Project Manager (USACE)
Javier Cortes	Environmental Engineer (USACE)
Alexis Alejando	Realty Specialist (USACE)
Ivan Acosta	Chief Special Projects
Doug Ralston	USA Program Manager
Al Crandall	USA Project Geophysicist
Matt Tucker	USA Project Manager P.G.
Cheryl Nichols	USA Environmental Engineer P.E.
Richard Henry	National Technical Liaison ERT
Diane Wehner	Regional Resource Coordinator
Daniel Rodriguez	Regional Project Manager
Ana M. Roman	Refuge Manager Culebra national Wildlife Refuge (USFWS)
Wilmarie Rivera	Federal Facilities Coordinator Puerto Rico Environmental Quality Board
Jim Pastorick	President UXO Pro (Consultant PREQB)
Katarina Rutkowski	TRC Environmental (Consultant PREQB)
Felix Lopez	Contamination Specialist (USFWS)
Lisamarie Carrubba	NOAA Fisheries Caribbean Field Office PhD Ecologist
Robert Matos	DNER-National Reserves Div.

Note: Sign In sheet is attached (Enclosure 5)

Agenda:

- Welcome
- Review Technical Project Planning Memorandum
- Discussion Topics
- Data Quality Objectives
  - Tools needed
  - Data Amount
- Munitions Constituents (MC) Sampling
- Digital Geophysical Transects
- Analog Geophysical Transects
- Work Plan Comments
- Schedule

Introduction of the TPP:

A TPP meeting was held at the San Juan, PR Corps of Engineers conference room on Tuesday, 28 September 2010.

The object for the meeting was for the project team to agree on the data collection program outlined during the meeting, for the purposes of developing the project work plan that will lead to a decision document for the six MRS on Culebra that are currently funded as a top priority. A copy of the TPP Phase 1 Memorandum, Presentation and MRS maps with proposed transects was provided to each agency.

Jose Mendez opened the meeting at 10:00 AM welcoming everyone. Following the welcome, Jose started a round-robin self introduction and then introduced Thomas Freeman from USACE, St Louis, who officially opened the meeting.

General Discussion Items (TPP Presentation):

1. Review of Phase I TPP Memorandum from the September 2009 meeting

There was general discussion between the EPA and USACE about document reviews and feedback on response to EPA comments prior to final document delivery. It was suggested that a response to comment be provided via email to each commenter as to the desired feedback, prior to release of the final document. Jose Mendez agrees on the distribution of PDF response to comments, and to speed the review process have USA send hard copies of the documents directly to the agencies. (See Action Item #1 below)

- Doug Ralston began power point presentation covering the first TPP memorandum covering the Phase I items and indicated the recent funding of additional MRSs (6, 8, 9, 10, and 11).
- Terry Walker (Risk Assessor, USACE, Omaha) was not comfortable with statement in the slide saying" As safe as possible" and suggested saying, "Will be protective of human health"
- Doug reviewed TPP objectives for the land portions and revisions that will be made to the CSM modeling MRS 13 CSM. The updated CSM will depict exposure pathways three-dimensionally for both MEC and MC.
- Doug said RTCs will be incorporated into the WP in the November timeframe. Turtle monitoring would begin upon approval of final WP and last for 75 days at the beaches in the MRSs. Field work will begin after the monitoring is complete.
- Jim Pastorick (EQB UXO consultant) asked if the Phase I memorandum had been sent out prior to the meeting. Several PDT members confirmed that it had been sent out Terry Walker Doug/Spencer said that it will be on the project website.

2. Review of MRS:

- Culebra Island, Puerto Rico

  - MRS 13 Cayo Luis Pena Impact Areas
  - MRS 10 Defensive Firing Area No. 1
  - MRS 11 Defensive Firing Area No. 2
  - MRS 06 Artillery Firing Area
  - MRS 09 Soldado Point Mortar and Bombing Area
  - MRS 08 Cayo Norte Impact Area

- Current Usage: - Culebra National Refuge (Luis Pena) MRS 13 Culebra FWS, DNER, and development in MRS 06, 08, 09, 10, and 11.
- Doug reviewed the MRS 13 CSM for MEC (MC CSM was not included) Doug mentioned that this was an illumination round overshoot area.
- Doug went over the list of data needs (DQOs) for the newly funded MRSs (6, 8, 9, 10, and 11).
- MRS 6- Doug reviewed history. No indications of MEC impact areas historically, direct fire was to Culebrita and MRS 8 from fixed locations.
- MRS 8- Doug reviewed history. Private owner planning to develop. ROE pending; unclear as to ownership status according to Jose. Zoning allows up to 10 structures. Dock planned as well.
- MRS 9- Doug reviewed the history. ROEs in progress. Noted that there are squatters living along the beach areas in the inlet areas. FWS noted that there are identified endangered species (plants) that will need to be marked to avoid damage during deveg ops. Lagoons are present, they will be sampled for MC along the land's edge but will not be intrusively investigated (NOAA). Lagoon areas to the north are used heavily by the public.
- MRS 10- Doug reviewed the history. FWS said note endangered cactus presents during deveg ops. A large residential/mixed use development is planned in the near future. Will need to consider the plans in the RI field work efforts. Some roads access the sites. Planning board should have plans to share. Spencer said this will rank high in prioritizing the MRSs.
- MRS 11- Doug reviewed the history. Access beaches by land mostly. Lisamarie (NOAA) mentioned that some access by water will need to be coordinated and the need for site specific SOPs. Matt will coordinate SOPS for all sites planned for water access. EQB wants CSM to show all sampling location types. Doug mentioned 3D CSMs. (See Enclosure 3)

General discussion focused around the fact that the historical review did not indicate that Cayo Luis Pena was used as a military target area, except for a 1924 map (from ASR) that showed that the northern peninsula was designated as a target area for shore batteries located on Culebra, MRS11 and that the data collection plan presented represented a starting point and that additional data may be needed as the project team learns more.

3. PWS Authorized MRS:

- MRS 13 Cayo Luis Pena Impact Areas
- MRS 10 Defensive Firing Area No. 1 (Optional)
- MRS 11 Defensive Firing Area No. 2 (Optional)
- MRS 06 Artillery Firing Area (Optional)
- MRS 09 Soldado Point Mortar and Bombing Area (Optional)
- MRS 08 Cayo Norte Impact Area (Optional)

All 6 MRSs were reviewed. These will be addressed generally in the work plan with specific details for data collection at each MRS added as they are funded. USFWS noted that a British 2000 pound bomb was found during the military clean up. They also noted that there is one endangered spineless cactus on Culebra that will need to be included in the work plan.

Spencer O'Neal (USACE) asked the project team what their priorities were for subsequent MRSs. The consensus was to move to MRS 09, MRS 10, and then MRS 11, as funding becomes available.

4. Beach Monitoring:

Doug reviewed sensitive habitat mitigation. Lisamarie mentioned SOPS dealing with turtle nests. SOPs will be coordinated in the WP.

Turtle issues were discussed, including a turtle nesting beach monitoring program prior to and throughout field activities. The team acknowledged that there are turtle avoidance procedures for in water and on land encounters, and that turtle nests and hatchlings will be avoided.

USA stated the procedures outlined in the Final SOP for 75 days of beach monitoring will be followed before operations commence on Luis Pena or other MRS.

5. PWS MC Sampling:

Collection Team: One Site Chemist and one UXOTII,

MC sampling will be conducted in accordance with (IAW) the approved sampling and analysis plan (SAP). The SAP will incorporate a qualitative and quantitative MC sampling DQO to ensure adequate data is obtained in order to support the RI.

Sampling called out in the PWS:

- 70 discrete samples for surface soil
- 30 discrete samples for subsurface soil,
- 20 discrete samples for sediment and surface water
- 20 discrete background samples for surface and subsurface soil
- 10 discrete background samples for sediment and surface water
- 10 each pre- and post-detonation composite samples based on the U.S. Army

Cold Regions Research and Engineering Laboratory (CRREL) 7-sample wheel approach will be used for BIP pre/post sampling.

Additionally, if deemed necessary by the PDT, USA may increase or decrease the above listed sample quantity based on the final level of effort determined during the first TPP meeting.

Soil, sediment, and surface water samples are analyzed for total metals using SW-846 Method 6010B/6020B7471A.

Explosives are analyzed using SW-846 Methods 8330B.

General Discussion:

There was a general discussion on the number and amount of samples to be taken during the RI/FS field work. The basis for sampling is dependent on the locations of MEC which cannot be determined before the field effort. USA's view is the MC sampling is part of the investigative work under the RI and should stay in the WP.

A general discussion of background sampling was conducted by PREQB consultants, EPA, and NOAA. USA is currently scoped to perform limited discrete background samples. This subject will be discussed with PREQB and their consultants to arrive at a consensus on the number and types of samples that would be requested. This should be conducted before 15 Nov 2010.

FWS, NOAA and PREQB discussed the development of CSM (3D) to show the environmental impacts and run off collection areas that may be sampled during the RI/FS

A discussion between FWS, NOAA, USACE Risk Assessor, and PREQB discussed sampling surface soils at the 2" level or to sample at depths 6" to 12". PREQB stated that if no MC is found within the first 2" then it will not be at a greater depth. PREQB wants USA to recommend background samples based on soil type. It was debated as to utilizing a background for all sampling locations or to keep them to each MRS. Various methods were discussed.

Sampling Depth was issue between EQB (0-2) and FWS/NOAA (0-12). Both agreed to discuss and get back to the PDT. NOAA suggested 2 soil horizons, but MIS is not desired.

EPA was questioning the need for a pre and post detonation sample. General discussion in which NOAA feels the pre-detonation sample is good for risk assessment. The PDT concurred.

MC Sampling Topics Discussed TPP 1 Sep 2009

Superfund values are used for comparison, surface water is screened for metals (fresh water as well as salt). General discussion agreed that the MC sampling plan should be addressed generally in the work plan and that it would be finalized after we have more information for the data collection plan. EPA still expressed concern that insufficient data collection is planned. USA is to provide MC DQOs to ensure sufficient data collection in support of the RI.

Underwater MC sampling was discussed. Diana Wehner (NOAA) stated that there are limited laboratory test results on the affects of MC contamination of fish and small vertebrates. There is some data from Vieques on fish and anemones living on/inside of MEC that show MC contamination but that the affect stays local and falls off quickly with distance from the open MEC.

6. Data collection Tools

Doug reviewed the tools that collect data. ROV was mentioned for future water portions of MRSs.

7. Review of December 2009 Site Visit

December 09 site visit info – Luis Pena – Doug reviewed what was found were Illuminations/case/projectiles rusting away.

MRS 13 55 Munition Debris items located during the site visit. No indication of any MEC items. Only one location #19 indicated large amount of subsurface anomalies. USA did locate MEC in the coral on the north side of the island.

MRS 08 Only one historical reference in 1924 to a possible target area but not confirmed. Records indicate ordnance may be in the water on the east side of the island.

MRS 06 All records show this was a firing position to shoot at MRS 08, 07, 02 and the water target near Mosquito Bay and a Beach Defensive Area on the south side of the MRS.

MRS 09 Several separate targets, Defensive Firing Area on north side, 37mm water target on east side, bombing target on southeast side, and a mortar boat firing area on the south side.

MRS 10 Defensive Firing Area near the city of Dewey, historical records indicate mortar firing from the heights to the beaches, and possible landing area.

MRS 11 Defensive Firing Area which encompasses a large section of the City of Dewey, historical records indicate mortar firing from the heights to the beaches, mortar boat firing to the beaches, and possible landing area.

CSM. Land transects will require limited de-vegetation to allow meandering along transects. Robert Matos (DNER) requested that we add Fishermen as potential receptors on the underwater

7. Data Quality Objectives:

USA introduced the project DQOs used during the SI "determine the nature and extent of MEC and MC". There are no uniform transect spacing's to base a DQO on.

- The RI data needs to establish if MRS 13 (Cayo De Luis Pena) was used as a military target or not.
- The southern portion of the island (e.g. south of the Observation Post) data collection is SI-style where we need to determine the presence or absence of MEC/MC.
- If there is MEC in the southern portion of Luis Pena, then more data collection and appropriate DQOs will be needed to establish the full nature and extent of contamination.

EPA and PREQB discussed that since parallel transects based on a known impact area are not being placed on the island the northern portion of Luis Pena does need a DQO that determines the nature and extent of possible MEC and the southern portion needs a DQO to determine the absence or presence of MEC. The southern section may need additional transects if no MEC is found during the RI.

8. Project Issues and Action Items:

The following table reflects Decisions on Project Issues and Action Items for the meeting.

Follow On Meeting: Schedule for USA to submit RTC to Huntsville by 15 Oct 2010 for distribution to the regulatory agencies for review and a telephone conference call on or about 15 Nov 2010 to discuss any issues with the Final RI/FS WP.

1. **Decisions on Project Issues:**

#	Issue	Decision
1	Distribution of Documents and Response to Comments	ftp will be available for document access by regulatory agencies Once accepted by USAESCH documents with incorporated response to comments will be PDF to the reviewers
2	Prioritize MRS 08,09, and 10	Development is being conducted or considered for these MRS.
3	Maps to reflect historical data and water access issues.	
4	Telephone conference for WP Response to Comments	PREQB telephone conference in Nov to discuss the response to comments for the Draft Work Plan

2. Action Items:

#	Issue	Responsible	Comment
1	Access to ftp	USA	Agencies asked for user names and password to gain access to the USA ftp. This allows downloading of electronic data.
2	DQOs for MEC/MC	USA	USA will provide project MEC DQOS and will also be using task specific DQOs in Appendix O as the MEC DQO and will develop separate MC DQOs for the RI/FS
3	Response to comments for Draft Final Work Plan	USA	15 Oct 2010 for all RTC to Huntsville.
4	Previous MC Sampling	USA	Diane Wehner (NOAA) wants existing data for MC sampling from the SI and a description of how the data is screened be included on maps.. EQB wants overlays on maps to show soils types, ecological, and deposition areas (CSM) to base location selection on

USA RI/FS Project Personnel Contact Information:

Al Crandall	Project Geophysicist	(813) 343-6362 acrandall@usatampa.com
Jeff Lewis	GIS Manager	(813) 343-6376 jlewis@usatampa.com
Brian Skubin	Underwater PM	(813) 343-6384 bskubin@usatampa.com
Joe Blue	Contracts Manager	(813) 343-6400 jblue@usatampa.com
Cheryl Nichols	Environmental Engineer	(813) 343-6433 cnichols@usatampa.com
Mathew Tucker	Project Manager	(813) 343-6370 mtucker@usatampa.com

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ENCLOSURE 1
DISTRIBUTION OF RI/FS DOCUMENTS

Type of Plan/ Report/ Documents	USAEXCH	CESAJ	CE Antilles	FWS Rich Henry	FWS Felix Lopez	PR EQB	NOAA Diane Wehner	NOAA Lisemarie Carrubba	FWS Ana Roman	DNER Robert Matos	FWS Susan Silander	Admin Record	Comments
AAPP Draft	4	4											14 days prior to site visit
AAPP Final	4	4											
Explosive Siting Plan Draft	4	4											Separate MACOM approval before intentional physical contact with MEC
PDF Response to Comments	X	X											
Explosive Siting Plan Final	4	2	1	1	1	1	1	1	1	1	1	1	
Schedule Monthly	X	X											
Advanced TPP Package & CSM	4	2	1	1	1	1	1	1	1	1	1	1	14 days before 1st TPP
Draft Public Involvement Plan	4	2	1	1	1	1	1	1	1	1	1	1	TBD
PDF Response to Comments	X	X	X	X	X	X	X	X	X	X	X	X	
Final Public Involvement Plan	4	2	1	1	1	1	1	1	1	1	1	1	14 days after receipt of comments
Draft Work Plan	4	2	1	1	1	1	1	1	1	1	1	1	21 days after DQO's are determined (TPP) **6 Oct 09**
PDF Response to Comments	X	X	X	X	X	X	X	X	X	X	X	X	14 days after on board Review
Draft Final Work Plan	4	2	1	1	1	1	1	1	1	1	1	1	14 days after on board Review
Draft RI Report w/GIS on DVD	4	2	1	1	1	1	1	1	1	1	1	1	60 days after completion of field work
Draft Final RI Report	4	2	1	1	1	1	1	1	1	1	1	1	14 days after receipt of comments
PDF Response to Comments	X		X	X	X	X	X	X	X	X	X	X	
Final RI Report	4	2	1	1	1	1	1	1	1	1	1	1	14 days after on board Review
Draft FS Report	4	12											TBD
PDF Response to Comments	X	X	X	X	X	X	X	X	X	X	X	X	
Draft Final FS Report	4	2	1	1	1	1	1	1	1	1	1	1	14 days after receipt of comments
PDF Response to Comments			X	X	X	X	X	X	X	X	X	X	
Final FS Report	4	2	1	1	1	1	1	1	1	1	1	1	14 days after on board Review
Draft Proposed Plan	4	2	1	1	1	1	1	1	1	1	1	1	14 days after receipt of acceptance of the FS Report
PDF Response to Comments			X	X	X	X	X	X	X	X	X	X	
Final Proposed Plan	4	2	1	1	1	1	1	1	1	1	1	1	7 days after receipt of comments
TPP Meeting	4	2	1	1	1	1	1	1	1	1	1	1	With final Proposed Plan

Contract Number: W912DY-04-D-0006
Task Order: 0022

Type of Plan/ Report/ Documents	USAEXCH	CESAJ	CE Antilles	FWS Rich Henry	FWS Felix Lopez	PR EQB	NOAA Diane Wehner	NOAA Lisemarie Carrubba	FWS Ana Roman	DNER Robert Matos	FWS Susan Silander	Admin Record	Comments
Transcripts													
Responsive Summary	4	2	1	1	1	1	1	1	1	1	1	1	With Decision Documents
Draft Decision Document	4	12											
Draft Final Decision Document	4	2	1	1	1	1	1	1	1	1	1	1	14 days after acceptance of Proposed Plan
PDF Response to Comments			X	X	X	X	X	X	X	X	X	X	7 days after receipt of comments
Final Decision Document	4	2	1	1	1	1	1	1	1	1	1	1	7 days after receipt of comments
Final Administrative Record (DVD)	4	2	1	1	1	1	1	1	1	1	1	1	Upon completion of the Record
Daily QC Report for Environmental Sampling	X	X											Daily during Environmental Sampling Activities
Analytical Data Submittal for QA Evaluation	X	X											30 days after completion of field work
Electronic Laboratory Data Submittal	X	X											45 days after completion of field work
Final GIS Files on CD	4	2	1	1	1	1	1	1	1	1	1	1	End of Project

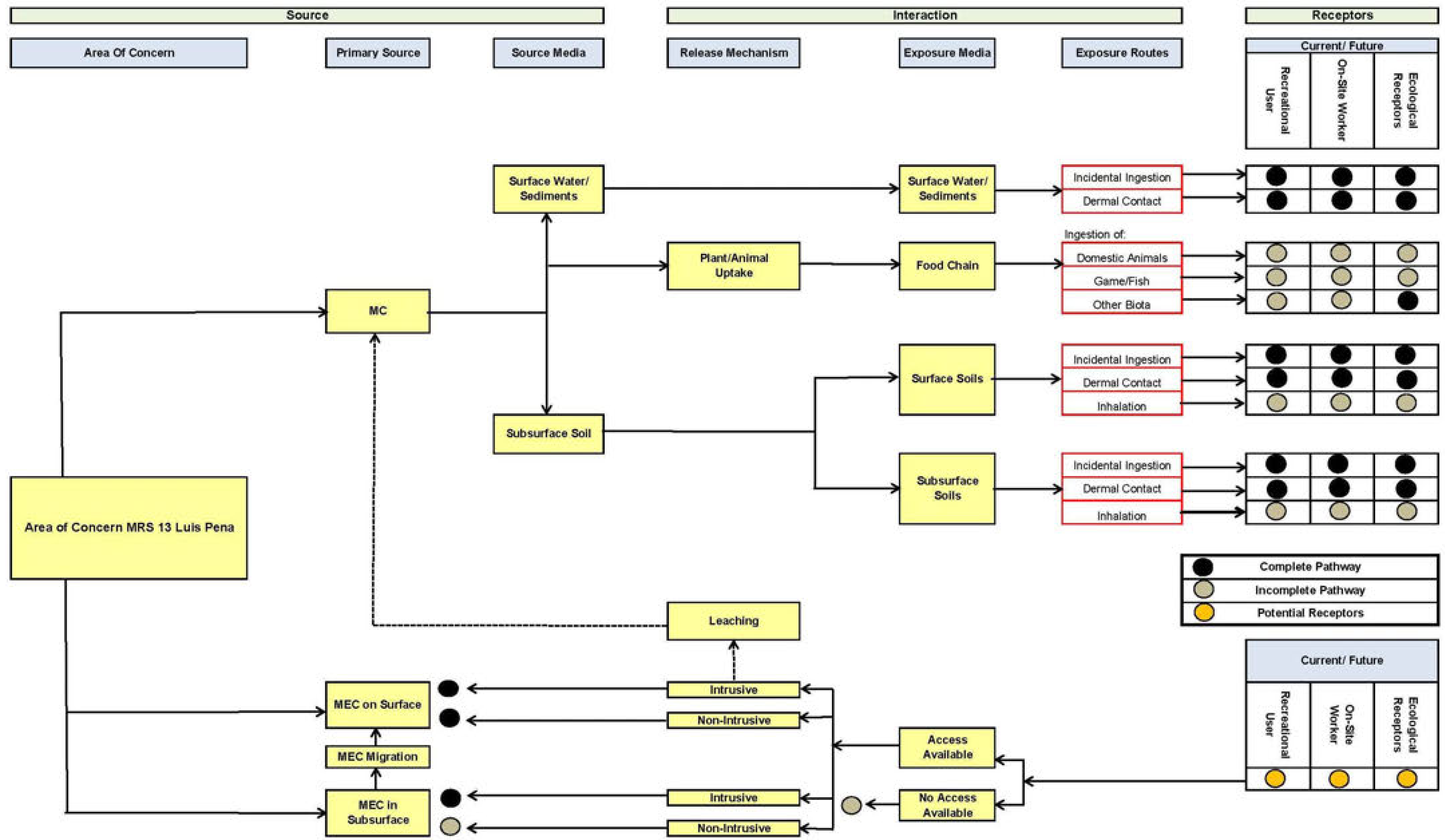
- Fish and Wildlife Rich Henry National Technical Liaison ERT, is the official channel for response to comments
- FWS copies need to go directly to all offices Rich Henry, Susan Silander and Felix are in the same location, and Ana Roman,
- NOAA Diane Wehner and Lisemaria Carrubba get documents for review. Both will submit comments to USACE.
- EPA copy directly to Daniel Rodriquez. Comments to USACE.
- DNER copy to Robert Matos. Comments to USACE.
- PREQB copies to Wilemarie Riveria she will distribute to UXO Pro. Comments to USACE.

Note: X indicates copies to USACE only

ENCLOSURE 2
TECHNICAL PROJECT PLANNING PRESENTATION
28 SEPTEMBER 2010

Contract Number: W912DY-04-D-0006
Task Order: 0022

ENCLOSURE 3
EXAMPLE OF CONCEPTUAL SITE MODEL (LAND)
GRAPHIC AND 3D



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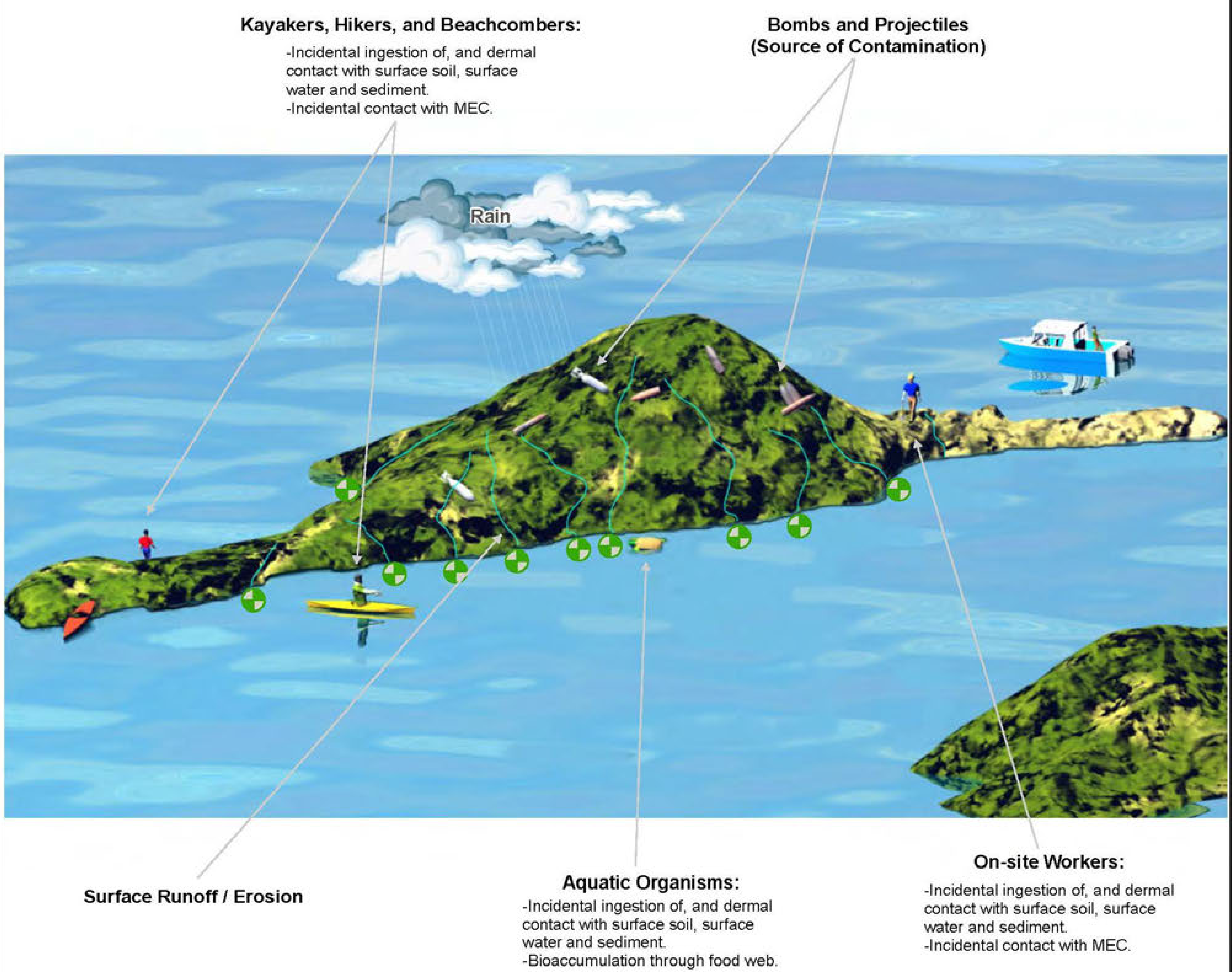

N

Not To Scale

Remedial Action/ Feasibility Study

Figure B-17

MRS 13 - Cayo Luis Pena Impact Areas

Conceptual Site Model

Culebra Island Site, Puerto Rico

Legend

Ephemeral Streams

Depositional Areas

USA Environmental, Inc.

US Army Engineering And Support Center Huntsville, Alabama

Drawn By:	JAL	Scale:	Not To Scale	Rev:	
Checked By:	MT	Date Drawn:	9-15-2010		
Submitted By:	DR	Revision Date:			

Path: S:\Culebra\RIFS 2009\Work Plan B-12 MRS 9 Transect Map.mxd

Contract Number: W912DY-04-D-0006
Task Order: 0022

ENCLOSURE 4
EXAMPLE OF DQO FOR GEOPHYSICAL EQUIPMENT PERFORMANCE

DQO FOR GEOPHYSICAL EQUIPMENT PERFORMANCE

A. State the Problem

1. Identify performance criteria for geophysical equipment which will result in data of sufficient quality to support remedial investigation/feasibility study (RI/FS).

2. Identify methodologies with which to measure geophysical equipment (analog and digital) performance. Transect data sufficient to cover each MRS in accordance with the PWS and approved work plan. Anomalies identified along transects, as well as any/all historic or observed surface MEC are used to generate anomaly density maps for each MRS. 100% coverage grids (50' x 50' or equivalent rectangular area) are used to establish the nature and extent of anomalies (potential MEC) in each high density area (anomaly density > 5 to 6 times the background density). Certain physical constraints, such as slopes greater than 30 degrees, vegetation removal constraints, such as endangered species and critical habitat, as well as rights of entry (ROE), will limit data collection.

B. Identify the Decision

1. Determine appropriate performance criteria for the geophysical equipment and operator to be used in the RI/FS field work.

2. Determine appropriate methods for measurement of equipment performance.

3. Determine if selected equipment and operator meet the performance standard.

C. Identify Inputs to the Decision

1. Data requirements for the RI/FS.

2. Contractual Requirements.

3. Environmental factors influencing equipment operation, including vegetation.

4. Characteristic MEC present or suspected of being present at Culebra MRSs.

D. Define the Study Boundaries

1. MEC of interest.

2. Sampling density for the EM61-MK2 EM data.

3. Soil/geology.

4. Site environmental factors.

5. Vegetation removal to permit acceptable DGM operations (surface vegetation cut to a height of no more than 12 inches, tree limbs removed to a height of 6 ft (1.83 m) above ground level, and 3 ft (0.91 m) of additional devegetation outside grids to allow for turns and overlap). Transects in MRS 13 (Luis Pena) need to be a minimum of 2.5-ft wide. Transects on all other MRSs need to be a minimum of 4-ft wide.

E. Develop a Decision Rule

1. Primary Target Acquisition Equipment

This equipment must be man portable in rolling and vegetated terrain and must remain operational in inclement weather, including periods of rainfall and winds. Other factors that may be evaluated in the performance of equipment include the relative influence of magnetic geological features on the equipment performance and ease of operation.

This equipment must achieve a probability of detection (Pd) of 100% as determined in accordance with the approved test strip for this project.

Area coverage by Geophysics is 100% of planned survey area. Area not so covered will be explained and justified.

2. Target Reacquisition Equipment

This equipment must achieve a Pd of 100% with a confidence of 95% as determined in accordance with the approved test strip for this project. Reacquisition must be repeatable within 2m, or as finalized in the initial test strip report.

This equipment must be man portable in rolling and vegetated terrain and must remain operational in inclement weather, including periods of rainfall and winds.

F. Specify Limits to Decision Errors – Equipment found to be functioning improperly or outside of the stated performance criteria will not be utilized until it has been reset, re-calibrated, repaired, or otherwise modified to correct noted inconsistencies in performance or operation.

a. Static Repeatability: Response (mean static spike minus mean static background) +-10% of original value on all channels

b. Along Line Measurement Spacing: 98% <=25cm along line

c. Speed: 95% within max project design speed of <= 3.4mph

d. Grid Coverage: >90% coverage at project design line spacing (2.5 feet).

e. Dynamic Detection Repeatability – Grids: Test item anomaly characteristics (peak response and size) repeatable with allowable variation +/-25%.

f. Dynamic Detection Repeatability – Transects: Test item (in test strip or on transect) anomaly characteristics (peak response and size) repeatable with allowable variation +/-25%. Or Fit coefficient over test strip is acceptable.

g. Static Positioning Accuracy: The coordinates being obtained from the positioning system are at a sufficient accuracy to allow for appropriate relocation of MEC for intrusive investigation. Measurement performance criteria: The error from a known location does not exceed +/- 2m from a known location from the reoccupation test.

h. Dynamic Positioning Repeatability, Grids: Position offset of Test item target <=35cm + 1/2 line spacing[11] (<=50cm + 1/2 line spacing for fiducially positioned data).

i. Dynamic Positioning Repeatability, Transects with reacquisition/digging: Test item anomaly characteristics (peak response and size) repeatable with allowable variation +/-25% and position offset <=2m.

j. Target Selection: The systems reliably detect the required MEC, as specified in the PWS, or to their typical maximum detection depth (11 times diameter rule of thumb). The daily test strip will document actual detection capabilities of ISO object responses fall within published response curves. In MRSs with grid surveys, additional test strip data is acquired to simulate grid surveys. Additional anomaly classification analysis will be performed. Geosoft's Signal to Noise Ratio (SNR) utility will be used to help classify anomalies as MEC like or not MEC like. All selected anomalies will be screened for proper time gate decay.

G. Optimize the Design for Obtaining Data – Design elements of this process will be evaluated on a continuing basis with field data for review, analysis, design improvement, acceptance, and implementation. All initial DGM metrics will be documented, including:

- Dynamic background noise levels for each time gate.
- DGM sample density.
  - Along track sample density (sample rate and survey speed)
  - Across track sample density (line spacing) for grids
- Anomaly selection methodology.
  - MEC like
  - Not MEC like
- Anomaly location accuracy.

ENCLOSURE 5
LISTING OF ATTENDEES AND SIGN IN SHEET

Name	Title	Organization	Email and Telephone
Spencer O'Neal	OE-DC Project Manager	U.S. Army Corps of Engineers Support Center Huntsville (USAESCH) CEHNC-DC-MM	Spencer.D.Oneal@usace.army.mil Office (256) 895-1574 Cell (256) 655-1067
Teresa Carpenter	Technical Manager	U.S. Army Corps of Engineers Support Center Huntsville (USAESCH) CEHNC-DC-MM	Teresa.M.Carpenter@usace.army.mil Office (256) 895-1659
Kelly Enriquez	Project Geophysicist	U.S. Army Corps of Engineers Support Center Huntsville (USAESCH) CENHC-CX-MM	Kelly.d.enriquez@usace.army.mil
Terry Walker	Risk Assessor	U.S. army Corps of Engineers Omaha District 106 S. 15th Street, Omaha, NE	mailto:terry.l.walker@usace.army.mil
Thomas Freeman PE	Facilitator	U.S. Army Corps of Engineers St Louis District1222 Spruce St., St. Louis, MO 63103-2833 CEMVS-EC-P	Tom.freeman@usace.army.mil Office (314) 331-8785
Jose Mendez	Project Manager	U.S. Army Corps of Engineers Antilles Office 400 Fernadez Juncos, San Juan, Puerto Rico 00901-3299	Jose.M.Mendez@usace.army.mil (787) 729-6893, 6895, Ext 3099 (787) 370-8928
Javier Cortes	Environmental Engineer (USACE)	U.S. Army Corps of Engineers Antilles Office 400 Fernadez Juncos, San Juan, Puerto Rico 00901-3299	Javier.cortes@usace.army.mil
Ivan Acosta	Chief Special Projects	U.S. Army Corps of Engineers Antilles Office 400 Fernadez Juncos, San Juan, Puerto Rico 00901-3299	Ivan.acosta@usace.army.mil
Alexis Alejando	Realty Specialist (USACE)	U.S. Army Corps of Engineers Antilles Office 400 Fernadez Juncos, San Juan, Puerto Rico 00901-3299	Alexis.alejando@usace.army.mil
Doug Ralston	Program Manager	USA Environmental. Inc. 720 Brooker Creek Blvd, Suite 204, Oldsmar, FL 34677	Dralston@usatampa.com Office (813) 343-6368 Cell (813) 500-1099
Al Crandall	Project Geophysicist	USA Environmental. Inc. 720 Brooker Creek Blvd, Suite 204, Oldsmar, FL 34677	acradall@usatampa.com Office (813) 343-6362 Cell (813) 927-2975
Mathew Tucker	Project Manager	USA Environmental. Inc. 720 Brooker Creek Blvd, Suite 204, Oldsmar, FL 34677	mtucker@usatampa.com Office (813) 343-6370 Cell (813) 426-2426
Cheryl Nichols	Environmental Engineer	USA Environmental. Inc. 720 Brooker Creek Blvd, Suite 204, Oldsmar, FL 34677	cnichols@usatampa.com Office (813) 343-6433 Cell (813) 748-1492

Name	Title	Organization	Email and Telephone
Richard Henry	National Technical Liaison ERT	US FWS 2890 Woodbridge Ave. Edison, NJ 08837	Richard_Henry@fws.gov Office (732) 906-6987 Cell (973) 204-5825
Diane Wehner	Regional Resource Coordinator	NOAA 85 Central Ave. New Providence, NJ 07974	diane.wehner@noaa.gov (240) 338-3411
Daniel Rodriguez	Regional Project Manager	US EPA Vieques Field Office Carr 200 km 0.4 Vieques, PR 00765	Rodriquez.Daniel@epamail.epa.gov Office (787) 741-5201 Cell: (787) 741-5017
Ana M. Roman	Refuge Manager Culebra national Wildlife Refuge	U.S. Fish and Wildlife Service P.O. Box 190 Culebra, PR 00775	Ana.roman@fws.gov Office (787) 742-0115 Cell (787) 306-1389
Wilmarie Rivera	Federal Facilities Coordinator Puerto Rico Environmental Quality Board	Puerto Rico Environmental Quality Board (PREQB) P.O. Box 11488 San Juan, Pr 00910	wilmarierivera@jca.gobierno.pr Office (787) 767-8181 Ext 6141 Cell (787) 365-5873
Jim Pastorick	President UXO Pro	UXO Pro 811 Duke St. Alexandria, VA 22314	Jim@uxopro.com www.uxopro.com (703) 548-5300
Katarina Rutkowski	Consultant	TRC Environmental	Krutkowski@trcsolutions.com (860) 305-4339
Felix Lopez	Contamination Specialist	U.S. Fish and Wildlife Service (USFWS) P.O. Box 491 Boqueron, PR 00910	Felix_lopez@fws.gov (787) 510-5202
Lisamarie Carrubba Ph.D.	Ecologist	National marine Fisheries Service (USFWS) National Wildlife Refuge PR 301 km 5.1 P.O. Box 1310 Boqueron, PR 00622	Lisamaria.carrubba@noaa.gov Office (787) 857-3700 Cell (787) 455-0007
Robert Matos	DNER-National Reserves Div.	Puerto Rico Department National Environmental Resources (DNER) P.O. Box 11488, PR 00910	Matos_resevas@yahoo.com (787) 983-7222
Susan Silander	Project Leader Caribbean Islands NWR complex	U.S. Fish and Wildlife Service	susan_silander@fws.gov (787) 851-7258 Ext 238

Name	Title	Organization	Email and Telephone	28 Sep 2010 Sign In
Spencer O'Neal	OE-DC Project Manager	U.S. Army Corps of Engineers Support Center Huntsville (USAESCH) CEHNC-DC-MM	Spencer.D.Oneal@usace.army.mil Office (256) 895-1574 Cell (256) 655-1067	
Teresa Carpenter	Technical Manager	U.S. Army Corps of Engineers Support Center Huntsville (USAESCH) CEHNC-DC-MM	Teresa.M.Carpenter@usace.army.mil Office (256) 895-1659	
William Veith	Facilitator	U.S. Army Corps of Engineers Support Center Huntsville (USAESCH) CENHC-CX-MM	William.d.veith@usace.army.mil Office (256) 895-1592	
Jose Mendez	Project Manager	U.S. Army Corps of Engineers Antilles Office 400 Fernadez Juncos, San Juan, Puerto Rico 00901-3299	Jose.M.Mendez@usace.army.mil (787) 729-6893, 6895, Ext 3099 (787) 370-8928	
Elsa Jimenez	Public Affairs	U.S. Army Corps of Engineers Antilles Office 400 Fernadez Juncos, San Juan, Puerto Rico 00901-3299	(787) 729-6876	
Doug Ralston	Program Manager	USA Environmental. Inc. 720 Brooker Creek Blvd, Suite 204, Oldsmar, FL 34677	Dralston@usatampa.com Office (813) 343-6368 Cell (813) 500-1099	
Al Crandall	Project Geophysicist	USA Environmental. Inc. 720 Brooker Creek Blvd, Suite 204, Oldsmar, FL 34677	acrandall@usatampa.com Office (813) 343-6362 Cell (813) 927-2975	
Matt Tucker	Project Manager, PG	USA Environmental. Inc. 720 Brooker Creek Blvd, Suite 204, Oldsmar, FL 34677	mtucker@usatampa.com Office (813) 343-6370 Cell (813) 426-2426	
Cheryl Nichols	Environmental Engineer, P.E.	USA Environmental. Inc. 720 Brooker Creek Blvd, Suite 204, Oldsmar, FL 34677	cnichols@usatampa.com Office (813) 343-6433 Cell (813) 748-1492	

Contract Number: W912DY-04-D-0006
Task Order: 0022

Name	Title	Organization	Email and Telephone	28 Sep 2010 Sign In
Richard Henry	National Technical Liaison ERT	US FWS 2890 Woodbridge Ave. Edison, NJ 08837	Richard_Henry@fws.gov Office (732) 906-6987 Cell (973) 204-5825	
Diane Wehner	Regional Resource Coordinator	NOAA 85 Central Ave. New Providence, NJ 07974	diane.wehner@noaa.gov (240) 338-3411	
Daniel Rodriguez	Regional Project Manager	US EPA Vieques Field Office Carr 200 km 0.4 Vieques, PR 00765	Rodriguez.Daniel@epa.gov Office (787) 741-5201 Cell: (787) 741-5017	
JIM PASTORICK	CONSULTANT TO ERB	UXO PRO, INC	JIM@UXOPRO.COM 703 548-5300	
Katarina Rutkowski	Consultant ERB	TRC Environmental	Krutkowski@trcsolutions.com 860 305 4339	
Kelly Enriquez	Project Geophysicist	CEHNC	Kelly.d.enriquez@usace.army.mil	
TERRY WALKER	RISK ASSESSOR	EMCX	terry.l.walker@usace.army.mil	
JAVIER CORTES	ENV. ENG	USACE-PD-EP	JAVIER.CORTES@USACE.ARMY.MIL	

Contract Number: W912DY-04-D-0006
Task Order: 0022

Name	Title	Organization	Email and Telephone	28 Sep 2010 Sign In
Ivan ACOSTA	Chief Special Projects	CESAJ-PD-EP	ivan.acosta@usace.army.mil	
Alexis Alejandro	Realty Specialist	CESAJ-RE	alexis.alejandro@usace.army.mil	
ROBERT MATOS	Chief NATURAL Reserves & Wildlife Division	PRDNER	rmatos@drna.gobierno.pr	
Wilmarie Rivera	RPM	PREQB	wilmarierivera@jca.gobierno.pr	
TOM FREEMAN		CEMVS-EC-P	tom.freeman@usace.army.mil	
Felix Lopez		USFWS	felix_lopez@fws.gov	
Ana M. Román	Culebra Refuge Manager	USFWS	ana_roman@fws.gov	
Lisamarie Carrubba		NOAA Fisheries Caribbean Field Office	lisamarie.carrubba@noaa.gov	

Contract Number: W912DY-04-D-0006
Task Order: 0022

APPENDIX J. PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Task Order Award**	**70 days**	**Mon 9/14/09**	**Fri 12/18/09**
2	Planning Site Visit	6 days	Mon 11/2/09	Fri 12/18/09
3	Coordination and Planning	56 days	Mon 9/14/09	Mon 11/30/09
4	Abbr. APP Submittal	1 day	Tue 11/24/09	Tue 11/24/09
5	Site Visit	6 days	Wed 12/9/09	Wed 12/16/09
6	**Technical Project Planning Meeting 1**	**11 days**	**Mon 8/31/09**	**Mon 9/14/09**
7	Advance TPP package and CSM Submittal	1 day	Mon 8/31/09	Mon 8/31/09
8	Coordination and Planning	9 days	Tue 9/1/09	Fri 9/11/09
9	Meeting	1 day	Mon 9/14/09	Mon 9/14/09
10	**TPP Memorandum**	**99 days**	**Tue 10/6/09**	**Fri 2/19/10**
11	Draft TPP Memorandum Submittal	1 day	Tue 10/6/09	Tue 10/6/09
12	Government Review Period	9 days	Wed 10/7/09	Mon 10/19/09
13	Revision Period	4 days	Mon 2/15/10	Thu 2/18/10
14	Final TPP Memorandum Submittal	1 day	Fri 2/19/10	Fri 2/19/10
15	**Draft and Draft Final Work Plan (WP)**	**416 days**	**Tue 6/30/09**	**Tue 2/1/11**
16	Draft WP Development	14 days	Wed 9/16/09	Mon 10/5/09
17	Draft WP Submittal	1 day	Tue 10/6/09	Tue 10/6/09
18	Government Review Period	31 days	Fri 2/5/10	Fri 3/19/10
19	Revision Period	226 days	Mon 3/22/10	Mon 1/31/11
20	Draft Final WP Submittal	1 day	Tue 2/1/11	Tue 2/1/11
21	**Funding of Tasks 1a, 5, 9, 10, 11, 12, 12a, 12b, 12d, 12e**	1 day	Tue 6/30/09	Tue 6/30/09
22	**Submittal of GIS on CD/DVD**	**1 day**	**Fri 10/23/09**	**Fri 10/23/09**
23	**Public Involvement Plan (PIP)**	**276 days**	**Mon 10/12/09**	**Mon 11/1/10**
24	Draft PIP Development	19 days	Mon 10/12/09	Thu 11/5/09
25	Draft PIP Submittal	1 day	Fri 11/6/09	Fri 11/6/09
26	Government Review Period	23 days	Mon 11/9/09	Wed 12/9/09
27	Revision Period	19 days	Thu 12/10/09	Fri 10/29/10
28	Final PIP Submittal	1 day	Mon 11/1/10	Mon 11/1/10
29	**Technical Project Planning Meeting 2**	**9 days**	**Mon 9/13/10**	**Thu 9/23/10**
30	Cordniation of Meeting	9 days	Mon 9/13/10	Thu 9/23/10
31	Meeting	1 day	Mon 9/13/10	Mon 9/13/10
32	**Technical Project Planning Meeting 3 (Additional)**	**28 days?**	**Mon 1/17/11**	**Wed 2/23/11**
33	Coordination and Planning	25 days?	Mon 1/17/11	Fri 2/18/11
34	Meeting	1 day?	Wed 2/23/11	Wed 2/23/11
35	**Final WP**	**10 days**	**Tue 3/1/11**	**Mon 3/14/11**
36	Revision Period	9 days	Tue 3/1/11	Fri 3/11/11
37	Final WP Submittal	1 day	Mon 3/14/11	Mon 3/14/11
38	**Receipt of Notice to Proceed (NTP)**	**1 day**	**Tue 3/15/11**	**Tue 3/15/11**
39	**Receipt of NTP for Turtle Monitoring**	1 day	Mon 1/24/11	Mon 1/24/11
40	**RI/FS Field Activities**	**96 days**	**Tue 1/25/11**	**Tue 6/7/11**
41	Turtle Monitoring	75 days	Tue 1/25/11	Mon 5/9/11
42	Coordination and Planning	15 days	Tue 2/15/11	Mon 3/7/11
43	Window for RI/FS Field Activities	60 days	Wed 3/16/11	Tue 6/7/11
44	**Analytical Data Submittal for QA**	**1 day**	**Fri 7/8/11**	**Fri 7/8/11**
45	**Electronic Laboratory Data Submittal**	**1 day**	**Fri 7/22/11**	**Fri 7/22/11**
46	**Draft and Draft Final RI Report**	**65 days**	**Wed 6/8/11**	**Tue 9/6/11**
47	Draft RI Report Development	30 days	Wed 6/8/11	Tue 7/19/11
48	Draft RI Report Submittal	1 day	Wed 7/20/11	Wed 7/20/11
49	Government Review Period	23 days	Thu 7/21/11	Mon 8/22/11
50	On-Board Review Teleconference	1 day	Tue 8/23/11	Tue 8/23/11
51	Revision Period	9 days	Wed 8/24/11	Mon 9/5/11

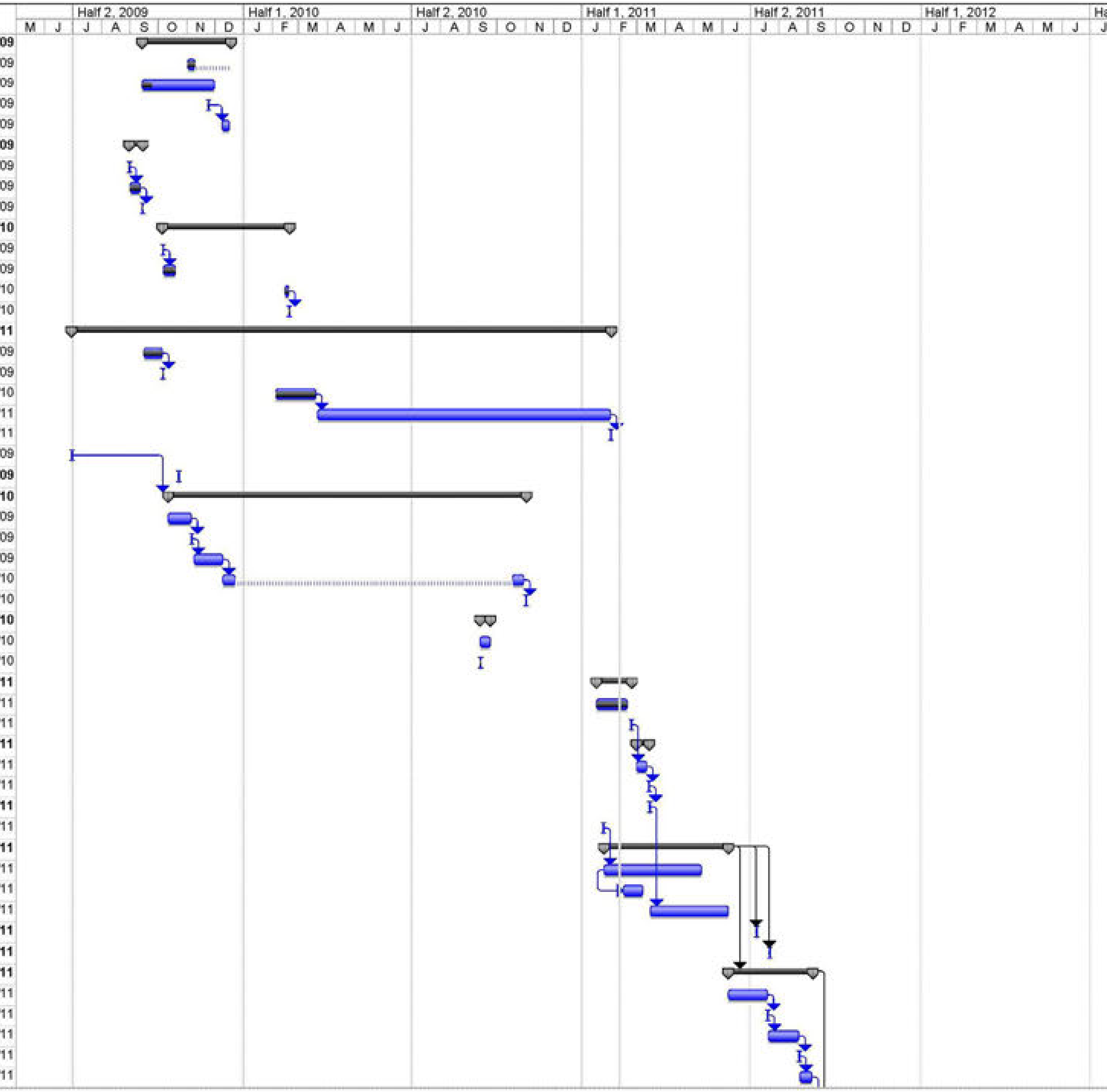

Exhibit 1: Project Schedule for Culebra RI/FS
Date: Thu 2/10/11

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

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Project Schedule (Sheet 1 of 2)

ID	Task Name	Duration	Start	Finish
52	Draft Final RI Report Submittal	1 day	Tue 9/6/11	Tue 9/6/11
53	**Technical Project Planning Meeting 4**	**5 days**	**Wed 9/7/11**	**Tue 9/13/11**
54	Coordination and Planning	4 days	Wed 9/7/11	Mon 9/12/11
55	Meeting	1 day	Tue 9/13/11	Tue 9/13/11
56	**Final RI Report**	**10 days**	**Wed 9/14/11**	**Tue 9/27/11**
57	Revision Period	9 days	Wed 9/14/11	Mon 9/26/11
58	Final RI Report Submittal	1 day	Tue 9/27/11	Tue 9/27/11
59	**Feasibility Study (FS) Report**	**75 days**	**Wed 9/28/11**	**Tue 1/10/12**
60	Draft FS Report Development	29 days	Wed 9/28/11	Mon 11/7/11
61	Draft FS Report Submittal	1 day	Tue 11/8/11	Tue 11/8/11
62	Government Review PeFSod	24 days	Wed 11/9/11	Mon 12/12/11
63	On-Board Review Teleconference	1 day	Tue 12/13/11	Tue 12/13/11
64	Revision Period	9 days	Wed 12/14/11	Mon 12/26/11
65	Draft Final FS Report Submittal	1 day	Tue 12/27/11	Tue 12/27/11
66	Final FS Report Development	9 days	Wed 12/28/11	Mon 1/9/12
67	Final FS Report Submittal	1 day	Tue 1/10/12	Tue 1/10/12
68	**Proposed Plan**	**62 days**	**Wed 1/11/12**	**Thu 4/5/12**
69	Draft Proposed Plan Development	9 days	Wed 1/11/12	Mon 1/23/12
70	Draft Proposed Plan Submittal	1 day	Tue 1/24/12	Tue 1/24/12
71	Government Review Period	23 days	Wed 1/25/12	Fri 2/24/12
72	Public Availability Meeting	1 day	Mon 2/27/12	Mon 2/27/12
73	30-Day Public Comment Period	23 days	Tue 2/28/12	Thu 3/29/12
74	Revision Period	4 days	Fri 3/30/12	Wed 4/4/12
75	Final Proposed Plan Submittal	1 day	Thu 4/5/12	Thu 4/5/12
76	**Decision Document (DD)**	**48 days**	**Fri 4/6/12**	**Tue 6/12/12**
77	Draft DD Development	9 days	Fri 4/6/12	Wed 4/18/12
78	Draft DD Submittal	1 day	Thu 4/19/12	Thu 4/19/12
79	Government Review Period	14 days	Fri 4/20/12	Wed 5/9/12
80	Revision Period	4 days	Thu 5/10/12	Tue 5/15/12
81	Draft Final DD Submittal	1 day	Wed 5/16/12	Wed 5/16/12
82	Government Review Period	14 days	Thu 5/17/12	Tue 6/5/12
83	Revision Period	4 days	Wed 6/6/12	Mon 6/11/12
84	Final DD Submittal	1 day	Tue 6/12/12	Tue 6/12/12
85	**Administrative Record**	**5 days**	**Wed 6/13/12**	**Tue 6/19/12**
86	Coordination and Compilation	4 days	Wed 6/13/12	Mon 6/18/12
87	Final Record Placement and Submittal	1 day	Tue 6/19/12	Tue 6/19/12
88	**Task Order Close-Out**	**1 day**	**Thu 7/19/12**	**Thu 7/19/12**

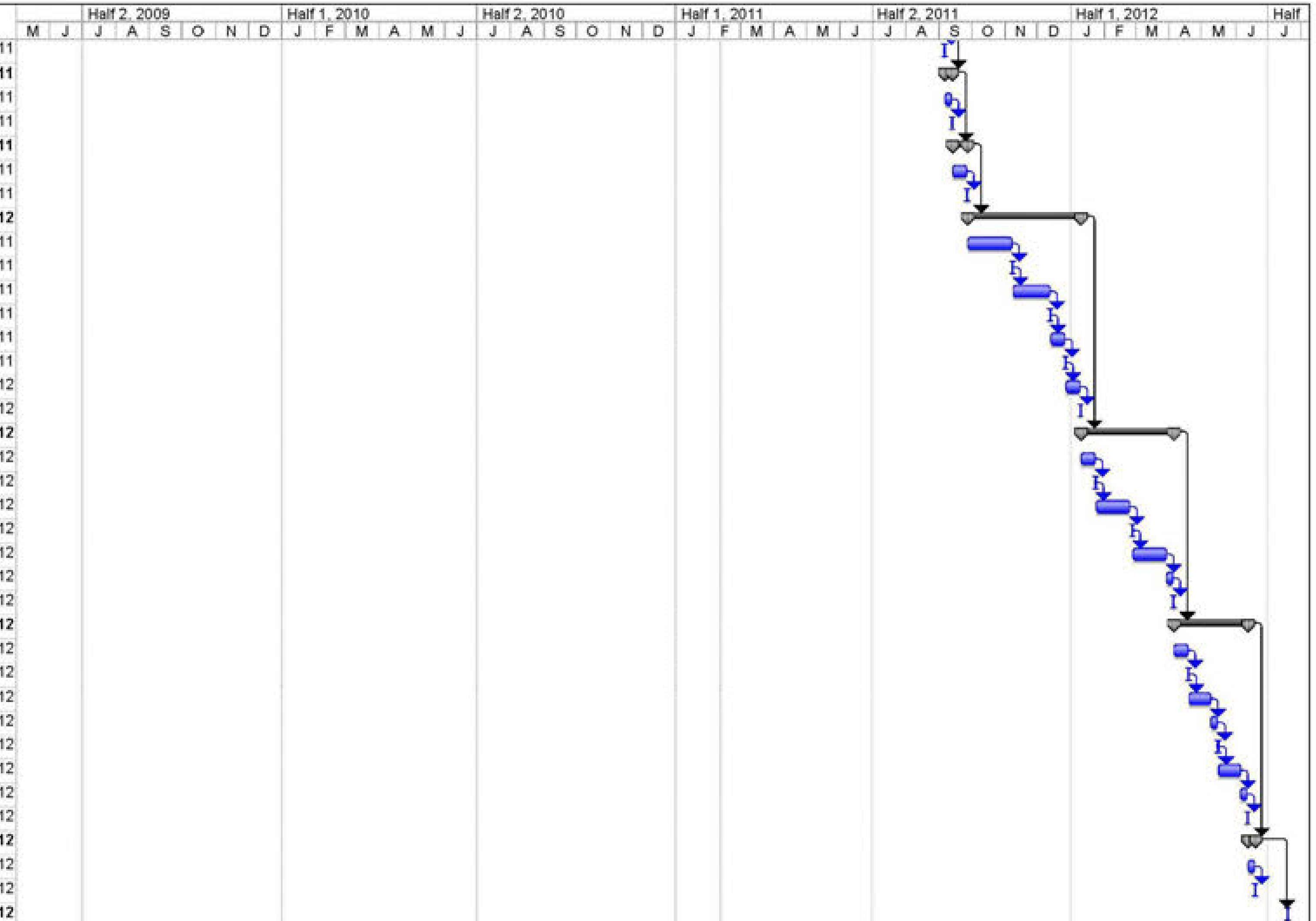

Exhibit 1: Project Schedule for Culebra RI/FS
Date: Thu 2/10/11

Task — Progress — Summary — External Tasks — Deadline
Split — Milestone — Project Summary — External Milestone

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Project Schedule (Sheet 2 of 2)

APPENDIX K. STANDARD OPERATING PROCEDURES (SOPS)

This appendix contains the following SOPs related to the RI/FS project at the Culebra Island Site:

- HSP-01, Accident Reporting
- HSP-23, Weather Emergencies
- OPS-01, Backhoe Operation
- OPS-02, Miniature Open Front Barricades and Enclosed Barricades
- OPS-03, Demolition/Disposal Operations
- OPS-04, DGM Anomaly Investigations
- OPS-05, Digital Geophysical Mapping
- OPS-07, Explosives Storage and Accountability
- OPS-08, Explosives and Ammunition Transportation
- OPS-09, Forklift Operation
- OPS-11, Hand and Power Tool Operation
- OPS-12, Heavy Equipment Operation
- OPS-13, MPPEH Management
- OPS-14, MEC Analog Detection and Removal Actions
- OPS-15, UXO/MEC Avoidance
- OPS-19, Site Rules and Prohibited Practices
- OPS-21, Vegetation Removal Operations
- OPS-23, Leased and Rental Vehicles
- OPS-25, Field Procedure Document Change Protocol
- OPS-29, Explosives Transportation via Open Water Vessels
- DSOP-08, Remotely Operated Vehicle Operations.

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STANDARD OPERATING PROCEDURE
HSP-01 – ACCIDENT REPORTING

1.0 BACKGROUND

Accident forms are used to document and record injuries, illnesses, and damage to equipment that occur on USA Environmental, Inc. (USA) project sites. Injuries, illnesses, and damaged equipment meeting the reporting requirements of Federal, State, and contractual directives will be submitted in a complete and timely manner per the reporting instructions, directives, and policies.

2.0 SCOPE

This Standard Operating Procedure (SOP) contains information for completing, submitting, and tracking Accident Reporting Forms. It may also require the addition of policies and publications relevant to updating, correcting, or changing information pertaining to accidents and investigations. It is incumbent upon all designated personnel who are responsible for completing, signing, submitting, or tracking Accident Reporting Forms and to familiarize themselves with this SOP and its accompanying documents, and to periodically review the material in an effort to remain current with procedures.

3.0 OPERATIONS

USA employees who work on project sites are required to immediately report all accidents, injuries, illnesses, and damaged equipment to their Supervisor and/or Safety personnel. Corrective action is to be taken to eliminate or mitigate the potential for hazardous or dangerous conditions on the project site, which may result in accidents, injuries, illnesses, or damaged equipment. Documentation is a key element in operations.

4.0 RESPONSIBILITIES

The following personnel, by position, are responsible for the completion, review, signing, and submitting of Accident Reporting Forms:

- USA Unexploded Ordnance Safety Officer (UXOSO)/Site Safety and Health Officer (SSHO): responsible for compiling and submitting the initial form(s) in accordance with form instructions and guidance. Making the initial notification of reportable accidents to the USA Corporate Office and performing an investigation into the accident.
- USA Occupational Safety Manager (OSM): responsible for reviewing, completing, signing, and sending the accident form(s) with attachments to the USA Corporate Office in Oldsmar, FL. Following up on the notification made from the project site and ensuring updated information is received and personnel are medically tracked to completion.
- USA Corporate Safety and Health Manager: responsible for the corporate implementation and enforcement of the USA Safety Program and for reviewing and signing the accident from(s) for submittal. Follows up notification from the project site and tracks personnel medically when the USA Occupational Safety Manager is not available.
- USA Project Manager: responsible for implementation of policies and procedures. May be required to perform in the capacity of the Site Manager in his/her absence for reviewing, completing, signing, and submitting accident form(s).
- Human Resources Administrator: responsible for the mailing (FedEx) and tracking of the form(s) to the appropriate agencies or personnel. Generating copies of required documents. Other duties as assigned by the USA Human Resources Director.

- USA Corporate Office: responsible for reviewing and physically submitting the form(s) and attachments to the Workers Compensation Insurance Carrier. Confirming to program and project personnel that receipt and submission has been completed.

5.0 REPORTING REQUIREMENTS AND PROCESS

The following reporting requirements will be observed when preparing, signing, and submitting Accident Reporting Form(s):

- Only the authorized USA forms will be submitted. For an example, see the attached blank copy of the Accident Investigation Report located in the Accident Prevention Plan/Site Safety and Health Plan.
- Signature blocks will be signed by safety personnel or designated representative.
- Activity Hazards Analysis (AHA) Sheet(s) will be submitted with the Accident Reporting Form. Tasks that do not have an AHA at the time of the accident will have them generated for approval.

Upon completion of the Accident Reporting Form, attachment of the AHA, as applicable, and any other supporting documents (statements, photographs, drawings) the packet will be sent by FedEx to the USA Corporate Office in Oldsmar, FL, addressed to the Corporate Safety and Health Manager. There, it will be placed into the appropriate reporting system.

Projects requiring Accident Reporting Forms from sources other than USA will follow those specific requirements as directed. Forms, instructions, and reporting requirements will be supplied on a project by project basis.

6.0 SUMMARY

This SOP is designed for USA personnel who have the responsibility of preparing, signing, and submitting Accident Reporting Forms for work related injuries, illnesses, damaged equipment, and accidents meeting the reporting requirements and guidance provided by Federal, State, and company directives and policies. The information contained within this SOP is not all inclusive, it requires the responsible personnel to follow the referenced material and submit the Accident Reporting Forms in a timely manner.

7.0 REFERENCES

- Occupational Safety and Health Administration
- U.S. Army Corps of Engineers, Engineer Manual 385-1-1
- USA Corporate Safety and Health Program

STANDARD OPERATING PROCEDURE
HSP-23 – WEATHER EMERGENCIES

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide the minimum safety and health requirements, procedures, and practices applicable to the conduct of operations during weather emergencies. These procedures outline the rules, guidance, policies, and general information that will be used during operations.

2.0 SCOPE

This SOP applies to all site personnel, to include contractor and subcontractor personnel, who are involved in operations in the exclusion zone (EZ), contamination reduction zone (CRZ), and support zone (SZ). The procedures outlined here are required to help ensure the safety and health of all site personnel. This SOP is not intended to contain all requirements needed to ensure that every weather emergency is covered but to ensure a range of knowledge and information is available so informed decision making takes place. Consult the documents listed in Section 3.0 of this SOP for reference material.

3.0 REFERENCES

The following references were used to contribute information contained within this SOP and develop requirements that apply to the conduct of operations associated with this project. In the event that other hazards are identified outside the scope of this SOP, review and implementation of additional SOPs and references may be needed:

- OSHA General Industry Standard 29 CFR, Part 1910.120.
- USACE Engineer Manual 385-1-1.
- USA Safety and Health Program.
- National Weather Service.
- American Red Cross.

4.0 RESPONSIBILITIES

4.1 OCCUPATIONAL SAFETY MANAGER (OSM)

The OSM will be responsible for ensuring the availability of the resources needed to implement this SOP, and will also ensure that this SOP is incorporated into plans, procedures, and training for sites where this SOP is to be implemented.

4.2 SENIOR UXO SUPERVISOR

The Senior UXO Supervisor (SUXOS) will ensure that this SOP is implemented by all operations during weather emergencies. The SUXOS will also ensure that relevant sections of this SOP are discussed in the tailgate safety briefings, and that information related to its daily implementation is documented in the Site Operational Log.

4.3 UXO TECHNICIAN III (UXOTIII)

The UXOT III will be responsible for the field implementation of this SOP and the safety and health requirements outlined in Section 5.0 of this SOP. In the absence of a SUXOS, the UXOT III will be responsible for implementing the SUXOS's responsibilities outlined in Paragraph4.2.

4.4 UXO SAFETY OFFICER/SITE SAFETY AND HEALTH OFFICER (UXOSO/SSHO)

The UXO Safety Officer (UXOSO)/Site Safety and Health Officer (SSHO) will be responsible for ensuring that the safety and health hazards and control techniques associated with this SOP are discussed during the initial site hazard training and the daily tailgate safety briefings. The UXOSO/SSHO will also be responsible for daily inspection of site operations and conditions to ensure their initial and continued compliance with applicable SOPs and other guidelines.

5.0 PROCEDURE

All site personnel, including contractor and subcontractor personnel, involved in any site operation will be familiar with the contents of this SOP. Since the safety and health of all site personnel, the environment, and the general population is of paramount importance, all personnel will be expected to follow the procedures at all times. Violation of these procedures, or those imposed by the UXOSO/SSHO, may lead to personal injury or property damage, and may be grounds for positive disciplinary action.

5.1 INFORMATION REQUIREMENTS

5.1.1 Information Requirements for the Site

Daily weather conditions will be a part of the daily briefing. Many people incur injuries or are killed as a result of misinformation and/or inappropriate behavior during severe weather. During severe weather project personnel will seek shelter in an appropriate location (e.g., building or vehicle).

Generally speaking, identify and seek shelter that is appropriate for the type of severe weather you are encountering. Proper shelter will always include sound structure and remove you from the elements.

When available, pay attention to weather warning devices such as the National Oceanic & Atmospheric Administration (NOAA) weather radio, commercial radio, and/or credible weather detection systems; however, do not let this information override good common sense.

Remember: The individual is ultimately responsible for his/her personal safety and has the right to take appropriate action when threatened by severe weather.

The information listed below will be followed at all times by on-site personnel conducting operations in any location of the site:

- The Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP), Corporate Safety and Health Program, and all other required safety and health guidelines will be met at all times.
- All necessary, and feasible, precautions will be taken to prevent injury to personnel.
- Potentially harmful situations will be immediately reported to the UXOSO/SSHO.
- All personal injuries, no matter how minor, will be reported to the UXOSO/SSHO.
- Buddy system procedures will be enforced during all site operations.
- The number of personnel in the SZ or EZ will be the minimum number necessary to perform work tasks in a safe and efficient manner.

- Site personnel will check in with the UXOSO/SSHO prior to leaving the site, and again upon returning to the site.
- Site visitors are to be escorted by UXO-qualified personnel at all times, and site operations will cease if non-UXO-qualified personnel enter an area where UXO operations are being conducted.
- Site personnel will remain aware of site conditions at all times and will alert the UXOSO/SSHO to any changes that could pose additional hazards.

5.1.2 Information Requirements for Thunderstorms

Thunderstorms affect relatively small areas when compared with hurricanes and winter storms. The typical thunderstorm is only 15 miles in diameter; however, despite their small size, ALL thunderstorms are dangerous! Thunderstorms last an average of 30 minutes. Of the estimated 100,000 thunderstorms that occur each year in the United States, about 10 percent are classified as severe.

No place is absolutely safe from severe weather; however, some places are safer than others. The information listed below will be briefed to on-site personnel conducting operations at the project site.

Before Lightning Strikes:

- Keep an eye on the sky. Look for darkening skies, flashes of light, or increasing wind. Listen for the sound of thunder.
- If you can hear thunder, you are close enough to the storm to be struck by lightning. Go to safe shelter immediately.
- Listen to NOAA Weather Radio or commercial radio for the latest weather forecasts and storm information.

When a Storm Approaches:

- Find shelter in a building or car. Large enclosed structures (substantially constructed buildings) tend to be much safer than smaller or open structures. In general, fully enclosed metal vehicles such as cars, trucks, buses, vans, etc. with the windows rolled up provide good shelter from many weather conditions.
- The risk for lightning injury depends on whether the structure incorporates lightning protection, construction materials used, and the size of the structure.
- Avoid being in or near high places, open fields, isolated trees, rain or picnic shelters, communications towers, flagpoles, light poles, bleachers (metal or wood), metal fences, water (lakes, streams, rivers, etc.).
- Avoid use of the telephone, washing your hands, or any contact with conductive surfaces with exposure to the outside such as metal door or window frames, electrical wiring, telephone wiring, cable TV wiring, plumbing, etc., if lightning is a factor.

After the Storm Passes:

- Stay away from storm-damaged areas.
- Listen to the radio for information and instructions.
- Do not resume work until the “all clear” has been given by the UXOSO/SSHO.

If Someone is Struck by Lightning:

- Initiate the site EMS response system.
- Render First Aid and CPR, as necessary.

5.1.3 Information Requirements for Tornados

Although tornadoes occur in many parts of the world, they are found most frequently in the United States. In an average year, 1,200 tornadoes cause 70 fatalities and 1,500 injuries nationwide.

Tornadoes can occur at any time of the year. Tornadoes have occurred in every state, but they are most frequent east of the Rocky Mountains during the spring and summer months. In the southern states, peak tornado occurrence is March through May.

The information listed below will be briefed to on-site personnel conducting operations at the project site:

When Tornado Producing Storms are in the Area:

- Ensure all site personnel are briefed on the location(s) of tornado shelters.
- Keep an eye on the sky. Look for darkening skies, flashes of light, or increasing wind.
- Listen to NOAA Weather Radio or commercial radio for the latest weather forecasts and storm information concerning tornado watches and warnings.
- When weather conditions are such that a tornado is likely, prepare to move to safety.
- If a tornado is sighted or warning is given, move to the nearest shelter as quickly as possible.

During a Tornado:

- Remain in the shelter.
- Do not open doors or windows.
- Stay within the strongest portion of the shelter.

After the Tornado Passes:

- Stay away from damaged areas.
- Listen to the radio for information and instructions.
- Re-enter buildings with extreme caution.
- Be alert to fire hazards such as broken electrical wires or damaged electrical equipment, gas or oil leaks, and downed power lines.
- Report broken utilities to the appropriate authorities.
- Do not resume work until the “all clear” has been given by the UXOSO/SSHO.

If Someone is Injured:

- Initiate the site EMS response system.
- Render First Aid and CPR as necessary.

5.1.4 Information Requirements for Floods

When a Storm Approaches:

- Keep an eye on the sky. Look for darkening skies, flashes of light, or increasing wind. Listen for the sound of thunder.
- Listen to NOAA Weather Radio or commercial radio for the latest weather forecasts and storm information concerning flood watches and warnings.
- Move out of and away from low lying areas that may flood.
- If you are in a flood zone, move to higher ground away from rivers, streams, creeks, and storm drains.
- Find shelter in a building. Large enclosed structures (substantially constructed buildings) tend to be much safer than smaller or open structures.

During a Flood

- Remain in the shelter.
- Do not open doors or windows.
- Do not drive around warning barricades.
- Do not attempt to drive or wade through flooded areas.
- Stay away from storm-damaged areas.
- Listen to the radio for information and instructions.
- If your vehicle stalls in rapidly rising waters, abandon it immediately and climb to higher ground.
- Do not resume work until the "all clear" has been given by the UXOSO/SSHO.

If Someone is Injured:

- Initiate the site EMS response system.
- Render First Aid and CPR as necessary.

5.1.5 Information Requirements for Hurricanes

Although hurricanes (a type of tropical cyclone) may occur in many parts of the world, they are generally products of the tropical ocean. Hurricane season in the Atlantic starts on 1 June and officially extends through November.

Tropical Cyclones are classified as follows:

- Tropical Depression (sustained winds of 38 mph or less)
- Tropical Storm (sustained winds of 39-73 mph)
- Hurricane (sustained winds of 74 mph or greater)

The information listed below will be briefed to on-site personnel conducting operations at the project site.

When weather formations produce a Tropical Depression, Tropical Storm, or Hurricane (hereafter referred to as a storm) in the area:

- Ensure all site personnel are briefed on the location of storm shelters.
- Be prepared for evacuation of the work site.
- Have a personal bag/backpack/suitcase, etc., ready at the first indication of an approaching storm.
- Review working conditions of emergency equipment.
- Review (if available) the community safety plans.
- Allow enough time to accomplish preparation activities.
- Listen to NOAA Weather Radio or commercial radio for the latest weather forecasts and storm information concerning watches and warnings.
- When weather conditions are such that a storm is likely to strike, prepare to take shelter.

During a Storm:

- Remain in the shelter.
- Listen to NOAA Weather Radio or commercial radio for the latest weather forecasts and storm information concerning watches and warnings.
- Follow instructions issued by authorities.
- Do not open doors or windows.
- Stay away from windows and doors.
- Close all interior doors.
- If in a multi-story building, go to the upper levels.
- Stay within the strongest portion of the shelter.

After the Storm Passes:

- Stay away from damaged areas.
- Listen to the radio for information and instructions.
- Re-enter buildings with extreme caution.
- Be alert to hazards such as broken electrical wires or damaged electrical equipment, gas or oil leaks, downed power lines, deep pools of standing water, or fast-moving water.
- Report broken utilities to the appropriate authorities.
- Do not cook or drink tap water until informed by authorities it is safe to do so.
- Do not resume work until the all clear has been given by the proper authority.

If Someone is Injured:

- Initiate the site EMS response system.
- Render First Aid and CPR as necessary.

5.2 SAFETY AND PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS

Site personnel will at all times comply with safety precautions, safe work practices, and PPE requirements detailed in the APP/SSHP for the project. The continued wearing of PPE may be appropriate during weather emergencies. The use of work clothing, gloves, safety glasses, and boots can help in reducing injury during severe weather conditions.

STANDARD OPERATING PROCEDURE – OPS-01
BACKHOE OPERATION

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide all USA Environmental, Inc. (USAE) employees and subcontractors the minimum safety and health requirements and procedures applicable to the operation of a backhoe.

2.0 SCOPE

Backhoes may be used to excavate during investigation of subsurface magnetic anomalies, during clearing of rodent nests, and for minor road repair to facilitate site access and egress. This SOP contains information specific to backhoe operations. It may also include manuals and publications relevant to backhoes that may be leased, purchased, or otherwise employed on the site. It is incumbent upon all designated operators to familiarize themselves with this SOP and to periodically review it an effort to remain current with safe, productive backhoe procedures.

3.0 OPERATIONS

USAE employees who operate backhoes on the project site will be qualified through on-the-job training (OJT). Equivalent OJT will be documented through previous employment or experience or through documented formal training. When engaged in backhoe operations the operator will perform daily inspection and maintenance functions and operate the backhoe as directed. The operator will also conduct OJT of other operators at the Senior Unexploded Ordnance Supervisor (SUXOS) or Team Leader's discretion.

3.1 PERSONNEL PROTECTIVE EQUIPMENT

Level D personal protective equipment (PPE) will be required for personnel engaged in backhoe operations and will include:

- Coveralls or work clothing as prescribed
- Work gloves, leather or canvas, as appropriate
- Safety glasses - as wind conditions and airborne particulate matter dictates
- Hardhats
- Work Boots: Sturdy and of sufficient height to aid in ankle support
- Hearing Protection: Noise Attenuating Helmet or earplugs will be worn by anyone within 25 feet of the backhoe while it is operating
- Dust Masks - as wind conditions and airborne particulate matter dictates

3.2 GENERAL SAFETY PRECAUTIONS

The following lateral distances will be maintained when operating a backhoe on a UXO site:

- Personnel will conform to the approved safe separation distance for the task being performed by other personnel and/or will maintain a distance of 200 feet from other UXO personnel conducting manual, intrusive operations.

- Personnel will know and observe all applicable MEC/UXO safety precautions.
- Personnel will know and use appropriate hand signals.

These distances may be reduced or extended by the U.S. Army Corps of Engineers (USACE) OE Safety Specialist or UXO Safety Officer, based on an assessment of site history, expected MEC/UXO, terrain features or other such factors that may apply. The backhoe will not be operated without a spotter. This includes using the front and rear attachments, and backing of the tractor. Prior to starting an excavation, a safety arc will be etched in the ground with the rear boom, fully extended. If operating on a hard surface, the safety arc will be marked with bright spray paint, traffic cones, and/or other identifier. Prior to anyone entering the safety arc, the operators will:

- Swing the boom arm fully to one side
- Lower the bucket to the ground
- Return the engine to idle speed
- Hold his hands clear of the controls or in the "Hands Up" position

3.3 EQUIPMENT SAFETY PRECAUTIONS

See the Operator's Manual.

3.4 TEAM COMPOSITION

The Team Leader will serve as a safety observer and director for other team personnel and all members of the backhoe team will be UXO qualified. The minimum team make-up will be:

- One operator
- One Team Leader/SUXOS

3.5 GROUND PERSONNEL

Team members working on a backhoe team will be qualified through OJT and/or formal training and will perform such tasks as magnetometer checks, manual excavation, and checks of the hole as appropriate.

3.6 TRAINING

Training will be documented in Team Leaders field notebooks and in USAE on-site records.

3.7 GENERAL OPERATIONAL PROCEDURES

The operator will have a radio in place so he can monitor radio transmissions while driving the backhoe to and from excavation sites. Prior to shutting off the tractor engine, the operator should let the engine run at idle speed for a few minutes to allow the engine to cool.

Prior to excavation operations the SUXOS shall establish/review hand signals with all members of the team. The backhoe will not be used to excavate closer than 12 inches from any MEC/UXO. Removed dirt will be placed at least 2 feet from the expected edge of the excavation, and on the uphill side when working on a slope.

Excavations will not be deeper than 4 feet without authorization from the USACE OE Safety Specialist. Such excavations require the UXO Safety Officer/competent person to determine step/slope requirements.

4.0 ATTACHMENTS

- Backhoe Operational Procedures
- Backhoe Safety Checklist

BACKHOE OPERATIONAL PROCEDURES

BEFORE USING THE MACHINE

- Read the owner's manual to learn the characteristics of your machine.
- For your personal protection you will need to wear some or all of the following:
    - sturdy pants and shirt
    - safety shoes
    - hard hat
    - safety goggles or glasses
    - gloves
    - hearing protection
    - respirator for dusty conditions
- Sunscreen protection is vital in bright sunshine if not under a roof.
- Check the loader/backhoe for the presence of the following safety devices in good working order:
    - rollover protective structure (ROPS)
    - seat belt (if ROPS equipped)
    - guards
    - shields
    - backup warning system
    - lights, and mirrors
- Fill the fuel tank while engine is off and cool. Never fill inside a building. Do not smoke. Wipe up any spills immediately.
- Check the machine daily for broken, missing, or damaged parts. Make the necessary repairs or replacements.
- Keep the machine clean -- especially steps, hand rails, pedals, grab irons, and floor of the cab. Slippery surfaces are very hazardous.
- Remove or secure loose items in the cab that could interfere with operating the controls.
- Check the work area for hidden holes, obstacles, drop-offs, etc. Clear children, pets, and bystanders from the area.
- Check overhead for utility lines, roofs, and other obstacles.
- Request Blue Stake service to locate underground cables, gas lines, water, and sewer lines before digging. You need to request this service in advance.
- Always use the hand rails, ladders, and steps provided when mounting the machine; never grab controls or the steering wheel.
- The cab was designed for one person -- allow no riders, especially children.

OPERATING THE LOADER

- Adjust the seat, fasten the seat belt, set the brake, and place transmission in park or neutral before starting the engine.
- If machine is in a garage be sure ventilation is adequate. CARBON MONOXIDE KILLS!
- Start the engine and check all controls for proper function. Check horn and backup alarm. Do not use if anything is faulty.
- If the backhoe is still attached, be sure to use chains and locks to prevent it from swinging.
- If the backhoe is removed, you may have to use counterweights. Check your owner's manual.
- Keep the working area as level and clean as possible. Use the bucket to grade the area frequently.
- Always carry the bucket low for good visibility and maximum stability.
- Use extreme caution when backfilling to avoid collapsing the wall of the trench.
- When undercutting high banks or material piles be alert for falling rocks and/or cave-ins.

OPERATING THE BACKHOE

- Keep the loader bucket on the ground.
- Level the machine for maximum stability.
- Operate the backhoe only from the seat.
- Never swing the bucket over a truck cab.
- Dump the bucket uphill if possible when operating on a slope. If you must dump downhill swing slowly to avoid tipping the machine.
- If using the backhoe as a hoist, do so with the weight over the back of the machine -- NEVER THE SIDE -- to avoid tipping.
- Be sure the load you are lifting is balanced, and move the boom slowly to avoid swaying the load.

SAFE STOPPING PROCEDURE

- Park the machine on level ground if possible and set the parking brake. Place transmission in park if so equipped.
- Lower the loader and backhoe buckets to the ground.
- Stop the engine and remove the key.
- Work the hydraulic controls to relieve pressure.
- Wait until all motion has stopped and then dismount carefully using steps and safety holds. Do not jump from the machine.

BACKHOE SAFETY CHECKLIST

Site/Location: ______________________________ Date: ______________

Backhoe Characteristics:

- ☐ Labeled for operating rated capacity.
- ☐ Steps and grab handles.
- ☐ Seat belts / ROPS.
- ☐ Protective shields or guards.
- ☐ Correct bucket size.
- ☐ Proper lighting and signals.
- ☐ Operating handles easy to reach for operator with full view of work area from all positions.
- ☐ Brake system.
- ☐ Appropriate type of fire extinguisher readily available.

Backhoe Operators:

- ☐ Trained and designated to use the equipment.
- ☐ Never exceed the equipment's rated capacity.
- ☐ Use warning signal to alert others in the work area to problems.
- ☐ Allow proper clearance, including overhead.
- ☐ Select correct size of bucket.
- ☐ Ensure area to be dug has been marked. Observe the area and contact the utilities company(s) for locations of utilities. Request "blue stake" service in advance of operations.
- ☐ Tighten sling without hands or fingers between sling and load.
- ☐ Know maximum depth capability.
- ☐ Ensure stop locks or barricades are placed near the excavation.
- ☐ Balance loads placed in buckets.

- [ ] Wear correct personal protective equipment while operating backhoe.
- [ ] Remove and secure loose clothing, tools, equipment, etc., out of operating area in cab.
- [ ] Never operate boom or bucket in an unsafe manner.
- [ ] Use equipment smoothly, avoiding sudden starts and stops.

Bucket Characteristics:

- [ ] Select by rated capacity and job requirements for model being operated.

Backhoe Inspection:

Operators are to check, observe, correct, and ensure the following at a minimum:

- [ ] Observe warnings, cautions, precautions, and recommendations in the operators manual.
- [ ] Operating mechanism: check all controls and throttle.
- [ ] Hydraulic system: Check hoses, lines, and connections or fittings
- [ ] Proper fluid levels: Check all fluid levels, use only approved fluid replacements.
- [ ] Hoses and lines: Check for cuts, excessive wear, or leaks.
- [ ] Air filter system: Check for cleanliness and in place.
- [ ] Frame-lock lever: Check lever and lock stop for damage.
- [ ] Lighting and mirrors: Check for serviceability.
- [ ] Frame, steps, and grab handles: Check for damage.
- [ ] Brakes: Check for stopping ability on and off road.
- [ ] Backup warning alarm: Check for serviceability.
- [ ] Seatbelts/ROPS: Check for cuts or missing/inoperable componets.
- [ ] Exhaust system: Check for leaks or missing componets.
- [ ] Check for fluid leaks: Check for any fluid leaks, use spill control methods until repaired.
- [ ] Tires: Check for proper inflation, tread wear and damage to rims.

☐ Grease fittings: Check fittings and grease every 8 hours of use, ensure correct type and amount is utilized.

☐ Inspect work area: Check for stop blocks or barricades, collapsed walls, unauthorized personnel in area, obstacles, or other hazardous or dangerous conditions/situations.

☐ Conduct repair/maintenance outside of populated work area. Turn equipment off, lower buckets, display warning signs.

Completed By:

____________________________ ____________________________

Name Position

STANDARD OPERATING PROCEDURES – OPS-02
MINIATURE OPEN FRONT BARRICADES AND ENCLOSED BARRICADES

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) is for use by USA Environmental, Inc. (USAE) personnel who are trained and assigned the task of using the miniature open front barricade (MOFB) or enclosed barricade (EB) in the performance of their duties. This SOP makes provisions for the use, storage, and inspection of this equipment. It is the responsibility of the assigned personnel using this equipment to know and follow all applicable requirements, guidance, and directives associated with this equipment and its intended use. This SOP is not a stand-alone document and is to be used with other applicable reference material.

2.0 PURPOSE

The MOFB and the EB are designed to defeat the primary fragments of selected ordnance at munitions and explosives of concern (MEC) removal sites. The MOFB and the EB are intended to be used as engineering controls during intrusive operations to defeat primary fragments due to an accidental/unintentional detonation. The MOFB consists of an aluminum frame with aluminum plates on three sides and the roof. The enclosed barricade consists of an aluminum frame with aluminum panels on three sides, roof, canopy and front barricade. Since the MOFB is open at the front, it defeats primary fragments in three directions while the EB is fully enclosed and defeats primary fragments in all directions. The MOFB and the EB are not designed for use as engineering controls for an intentional detonation, and are not designed to mitigate effects from blast overpressure and noise. In addition, the MOFB and the EB are not intended for reuse after an incident.

3.0 WARNINGS AND PRECAUTIONS

All personnel to ensure safe and proper use of this equipment will adhere to the following warnings and precautions:

- Only trained and authorized personnel will utilize this equipment.
- Safe separation distances will be observed at all times.
- Site control measures will be instituted and maintained at all times during operations.
- Operations will cease upon entry by any unauthorized personnel.
- Violations will be reported immediately for correction.
- All appropriate ordnance and explosive safety precautions will be observed at all times.
- The MOFB or EB is not intended to mitigate overpressure or noise from an unintentional detonation.
- The MOFB or EB will not be used for intentional detonations.
- The MOFB or EB will not be reused after a detonation.
- The MOFB will NOT be used within 200 feet of non-essential personnel or occupied structures.
- The EB will NOT be used within 300 feet of non-essential personnel or occupied structures.
- Only one person will occupy the MOFB or EB during excavations and/or investigations.
- Exercise care when entering and exiting the MOFB or EB.

4.0 PERSONNEL PROTECTIVE EQUIPMENT

Personnel while using the MOFB or EB will wear level “D” personal protective equipment (PPE). The PPE will be in accordance with the SSHP and additional requirements may be directed by appropriate authority.

5.0 INSPECTION

The MOFB or EB will be inspected for completeness and serviceability prior to and following each use. Missing or unserviceable components will be reported to the Senior UXO Supervisor or the UXO Safety Officer for repair or replacement.

6.0 STORAGE

The MOFB or EB will be stored as a complete unit with all plates available to facilitate ease of inspection and accountability of components. The MOFB or EB should be placed on a wooden pallet or other suitable material, and should be transported by the most appropriate method available.

7.0 OPERATIONS

USAE personnel who employ the MOFB will be trained in its proper use. The MOFB or EB will be used to investigate suspected ordnance items in areas where the observation of the established Exclusion Zone is not possible.

- Follow all precautions associated with ordnance and explosives.
- Observe safe work practices and procedures.
- Install all plates prior to investigating and/or excavating the anomaly.
- Plates will be installed one at a time during setup operations.
- Plates will be placed into the MOFB or EB, never dropped in place.
- Extreme caution will be used when installing plates, as severe injury to forgers could result.
- When using the MOFB:
    - The MOFB will be placed with the anomaly located a minimum of 6 inches inside the open front.
    - The rear of the MOFB will face the area to be protected.
    - Use of the MOFB is based on the munition with the greatest fragmentation distance, the largest.
    - The MOFB will not be used for munitions with a TNT-equivalent, net explosive weight exceeding 2.3 pounds.
    - The MOFB should not be used for munitions larger than an 81mm M374 mortar.

"CEASE ALL OPERATIONS IN THE EVENT OF ENTRY BY UNAUTHORIZED PERSONNEL INSIDE THE EXCLUSION ZONE. DO NOT RESUME OPERATIONS UNTIL SITUATION HAS BEEN CORRECTED. "

7.1 SANDBAGS

Sandbags may be used to provide a level surface for the open front (OFB) or the enclosed barricade (EB). In the event that there is a gap between the ground surface and the bottom of the OFB or the EB, this gap must be covered by the appropriate thickness of sandbags.

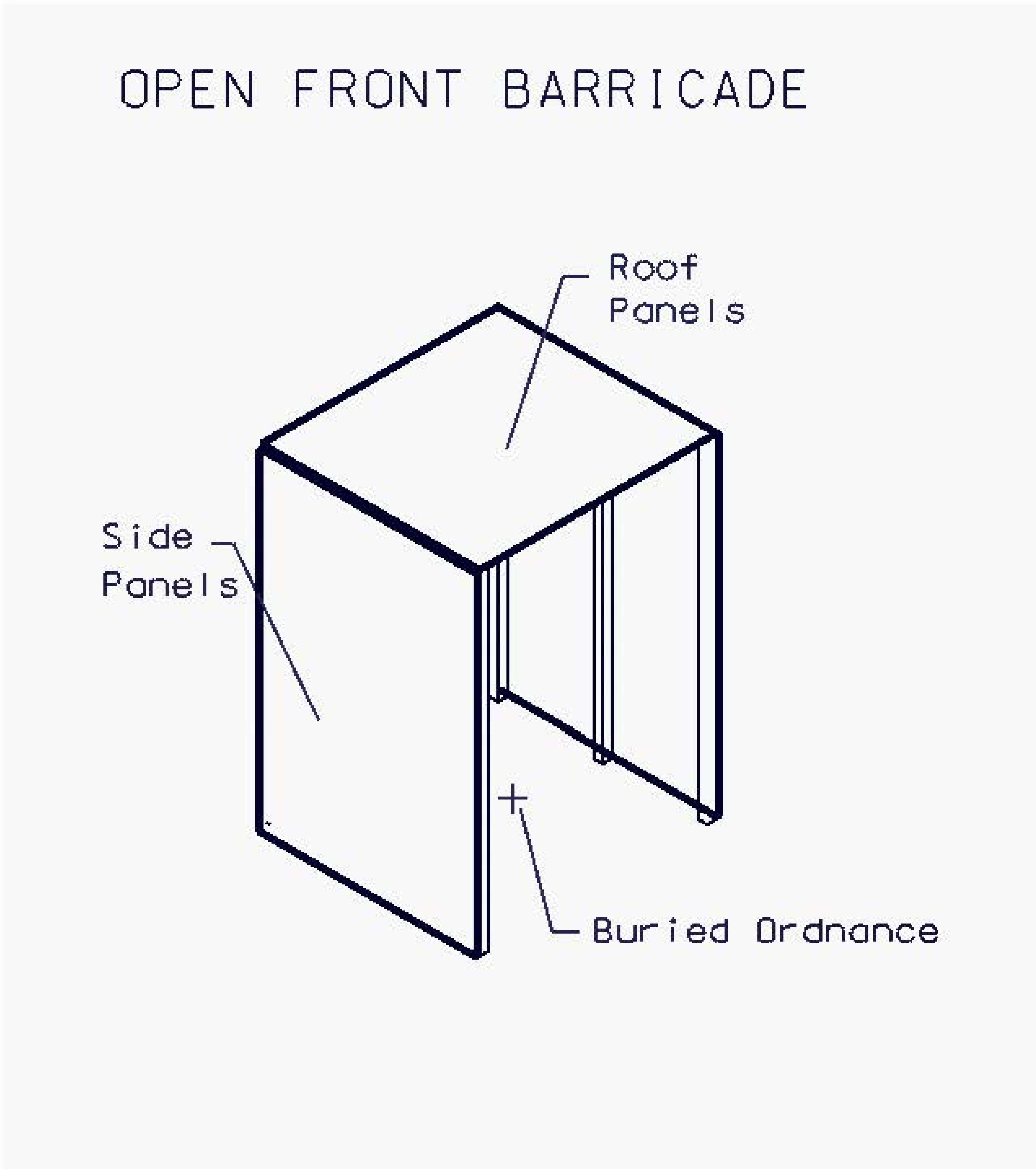
8.0 SUMMARY

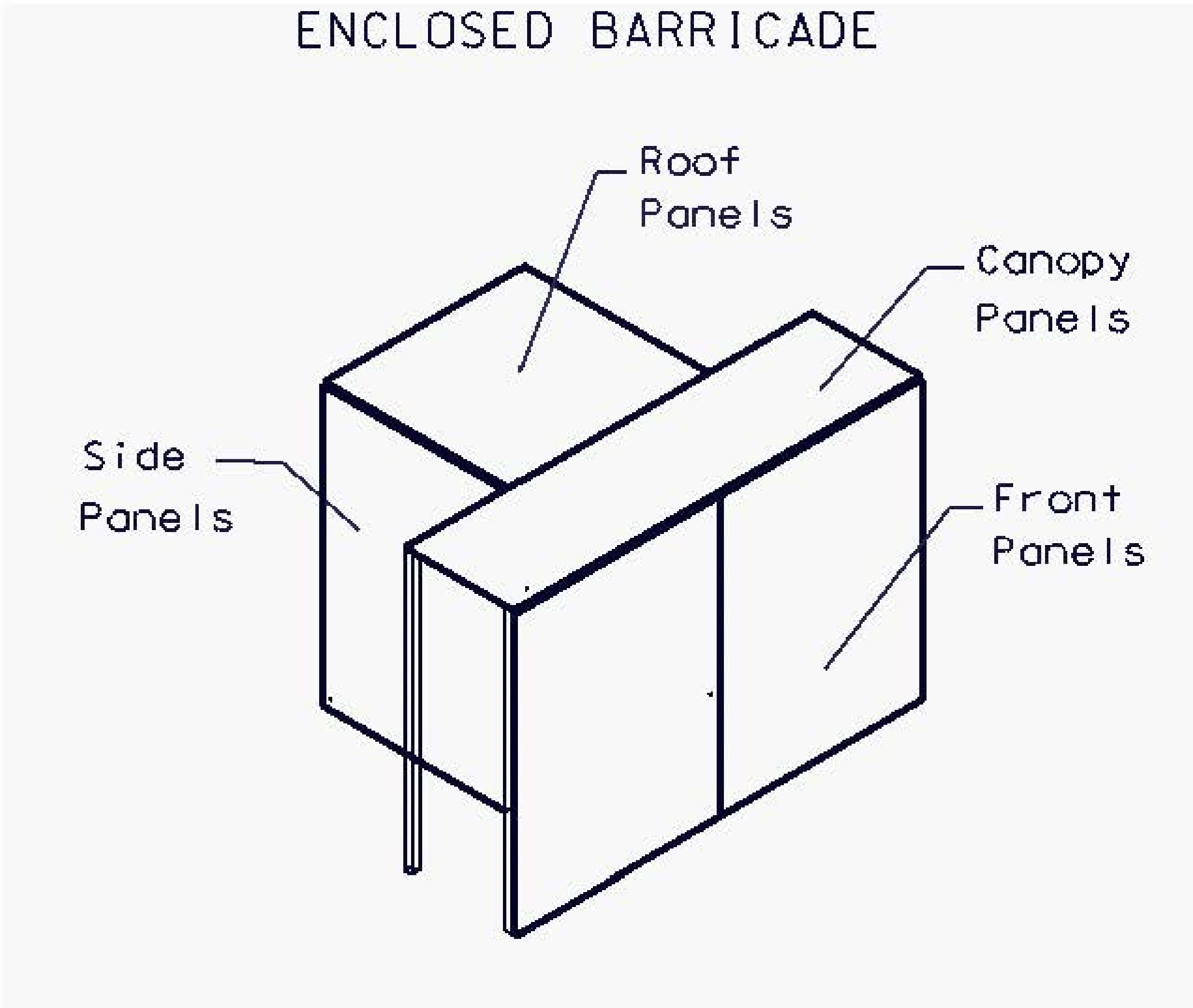
This SOP will be followed by those personnel whose duties include the use of the MOFB. This SOP establishes guidance and procedures to minimize the potential hazards associated with the investigation and/or excavations of suspected ordnance items. Personnel will adhere to the use of Safe Work Practices and Procedures during operations.

9.0 REFERENCES

This SOP was prepared using the following reference material:

- HNC-ED-CS-99-1, Open Front and Enclosed Barricades, March 1999 (Terminology Update March 2000)
- CEHNC-OE-CX Interim Guidance Document 00-01 Determination of Appropriate Safety Distances on OE Sites
- EP 385-1-95a Basic Safety Concepts and Considerations for Ordnance and Explosives Operations
- Technical Manual 60A-1-1-31
- Technical Manual 60A-1-1-22
- Technical Manual 5-1300, Structures to Resist the Effects of Accidental Explosions


OPEN FRONT BARRICADE
Roof Panels
Side Panels
Buried Ordnance


ENCLOSED BARRICADE
Roof Panels
Canopy Panels
Side Panels
Front Panels

STANDARD OPERATING PROCEDURE – OPS-03
DEMOLITION/DISPOSAL OPERATIONS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide the minimum procedures and safety and health requirements applicable to the conduct of demolition/disposal operations on sites contaminated with unexploded ordnance (UXO) or munitions and explosives of concern (MEC).

2.0 SCOPE

This SOP applies to all USA Environmental, Inc. (USA) site personnel, including contractor and subcontractor personnel, involved in the conduct of MEC/UXO demolition/disposal operations on a MEC/UXO contaminated site. This SOP is not intended to contain all of the requirements needed to ensure complete compliance, and should be used in conjunction with approved project plans and applicable referenced regulations. Consult the documents listed in Section 11.0 of this SOP for additional compliance issues.

3.0 RESPONSIBILITIES

3.1 PROJECT MANAGER

The Project Manager (PM) will be responsible for ensuring the availability of the resources needed to implement this SOP, and will also ensure that this SOP is incorporated into plans, procedures, and training for sites where this SOP is to be implemented. In those instances were a State Licensed Blaster is required, the PM will ensure one is available on site during demolition operations.

3.2 SENIOR UXO SUPERVISOR

The Senior UXO Supervisor (SUXOS) will be responsible for assuring that adequate safety measures and housekeeping are performed during all phases of site operations, to include demolition activities, and will visit site demolition locations, as deemed necessary, to ensure that demolition operations are carried out in a safe, clean, efficient, and economic manner. The demolition activities will then be conducted under the direct control of the SUXOS, who will have the responsibility of supervising all demolition operations within the area.

The SUXOS will be responsible for training all on-site UXO personnel regarding the nature of the materials handled, the hazards involved, and the precautions necessary. The SUXOS will also ensure that the Daily Operational Log, MEC Accountability Log, USA Demolition Shot Records, and inventory records are properly filled out and accurately depict the demolition events and demolition material consumption for each day's operations. The SUXOS will be present during all demolition operations or designate a competent, qualified person to be in charge during any absences.

3.3 UXO SAFETY OFFICER

The UXO Safety Officer (UXOSO) for the site is responsible for ensuring that all demolition operations are being conducted in a safe and healthful manner, and is required to be present during all MEC demolition operations. The UXOSO will ensure the compliance of the demolition team with the referenced documents in Section 11.0 that are applicable to the particular task being performed.

3.4 UXO QUALITY CONTROL SPECIALIST

The UXO Quality Control Specialist (UXOQCS) is responsible for ensuring the completeness of demolition operations records and for weekly inspection of the Ordnance Accountability Log, the Daily Operational Log, the USA Demolition Shot Record, and the inventory of MEC and demolition material. The UXOQCS, assisted by demolition team personnel, will inspect each demolition pit and an area of appropriate radius after each demolition shot, in accordance with the approved explosive siting plan, to ensure that there are no kick-outs, hazardous MEC/UXO components, or other hazardous items. In addition, the pit may be checked with a magnetometer and large metal fragments, and any hazardous debris, will be removed on a per use basis in accordance with the SOW/PWS. Any MEC/UXO discovered during the QC check will be properly disposed of using the demolition procedures in the WP. Extreme caution must be exercised when handling MEC/UXO, which has been exposed to the forces of detonation. Personnel must adhere to acceptable safe practices and procedures when determining the condition of munitions and fuzes that have not been consumed in the disposal process.

4.0 GENERAL OPERATIONAL AND SAFETY PROCEDURE

All personnel, including contractor and subcontractor personnel, involved in operations on MEC/UXO-contaminated sites will be familiar with the potential safety and health hazards associated with the conduct of demolition/disposal operations, and with the work practices and control techniques used to reduce or eliminate these hazards. During demolition operations, the general safety provisions listed below will be followed by all demolition personnel, at all times. Noncompliance with the general safety provisions listed below will result in disciplinary action, which may include termination of employment:

All safety regulations applicable to demolition range activities and demolition and MEC materials involved will be complied with.

- Demolition of any kind is prohibited without an approved siting plan.
- The quantity of MEC to be destroyed will be determined by the range limit, fragmentation and K-Factor distance calculations.
- In the event of an electrical storm, dust storm, or other hazardous meteorological conditions, immediate action will be taken to cease all demolition range operations and evacuate the area.
- In the event of a fire, which does not include explosives or energetic material, put out the fire using the firefighting equipment located at the site; if unable to do so, notify the fire department and evacuate the area. If injuries are involved, remove the victims from danger, administer first aid, and seek medical attention.
- The UXOSO is responsible for reporting all injuries and accidents that occur.
- Personnel will not tamper with any safety devices or protective equipment.
- Any defect or unusual condition noted that is not covered by this SOP will be reported immediately to the SUXOS or UXOSO for evaluation and/or correction.
- Methods of demolition will be conducted in accordance with this SOP and approved changes or revisions thereafter
- Adequate fire protection and first aid equipment will be provided at all times.
- All personnel engaged in the destruction of MEC will wear clothing made of natural fiber, close-weave clothes, such as cotton. Synthetic material such as nylon is not authorized unless treated with anti-static material.
- Care will be taken to minimize exposure to the smallest number of personnel, for the shortest time, to the least amount of hazard, consistent with safe and efficient operations.
- Work locations will be maintained in a neat and orderly condition.
- All hand tools will be maintained in a good state of repair.

- Each heavy equipment and/or vehicle operator will have a valid operator's permit or license for the equipment being operated as prescribed by law.
- Equipment and other lifting devices designed and used for lifting will have the load rating and date of next inspection marked on them. The load rating will not be exceeded and the equipment will not be used without a current inspection date.
- Leather or leather-palmed gloves will be worn when handling wooden boxes, munitions, or MEC/UXO.
- Lifting and carrying require care. Improper methods cause unnecessary strains. Observe the following preliminaries before attempting to lift or carry:
  - When lifting, keep your arms and back as straight as possible, bend your knees and lift with your leg muscles.
  - Be sure you have good footing and hold, and lift with a smooth, even motion.
- The demolition range will be provided with two forms of communication, capable of contacting appropriate personnel or agencies (i.e., medical response, police, and fire).
- Motor vehicles and material handling equipment (MHE) used for transporting MEC or demolition materials must meet the following requirements:
  - Exhaust systems will be kept in good mechanical repair at all times.
  - Lighting systems will be an integral part of the vehicle.
  - One Class 10B:C rated, portable fire extinguisher will, if possible, be mounted on the vehicle outside of the cab on the driver's side, and one Class 10B:C fire extinguisher will be mounted inside the cab. MHE (e.g., forklifts) require only one extinguisher while motor vehicles (e.g., trucks) require 2 extinguishers.
  - Wheels of carriers must be chocked and brakes set during loading and unloading.
  - No demolition material or MEC will be loaded into or unloaded from, motor vehicles while the motors are running.
- Motor vehicles and MHE used to transport demolition material and MEC will be inspected prior to use to determine that:
  - Fire extinguishers are filled and in good working order.
  - Electrical wiring is in good condition and properly attached.
  - Fuel tank and piping are secure and not leaking.
  - Brakes, steering, and safety equipment are in good working condition.
  - The exhaust system is not exposed to accumulations of grease, oil, gasoline, or other fuels, and has ample clearance from fuel lines and other combustible materials.
- Employees are required to wear leather, or rubber, gloves when handling demolition materials. The type of glove worn is dependent on the type of demolition material.
- A red warning flag, such as a “Active Range Flag” or a wind sock, will be displayed at the entrance to the sited demolition range during demolition operations when required by local authority. If applicable, the entrance gate will be locked or manned when demolition work is in progress.

- Unless otherwise directed or authorized by the explosive siting plan, all demolition shots will be tamped with an appropriate amount of earth/dirt/sandbags.
- An observer will be stationed at a location where there is a good view of the air and surface approaches to the demolition range, before material is detonated. It will be the responsibility of the observer to order the SUXOS to suspend firing if any aircraft, vehicles, or personnel are sighted approaching the general demolition area.
- Radios/push-to-talk phones will not be operated in close proximity of the demolition range while the pit is electrically primed or during the electrical priming process. Transmissions and explosives will be separated by a minimum of 25 feet during electrical procedures.
- No Demolition operation will be left unattended during the active portion of the operation (i.e., during the burn or once any explosives or MEC/UXO are brought to the range).
- A minimum radius (determined by size and location of the shot) around the demolition pit will be cleared of dry grass, leaves, and other extraneous combustible materials around the demolition pit area.
- No demolition activities will be conducted if there is less than a 2,000-foot ceiling (AGL) or if wind velocity is in excess of 20 mph.
- Demolition shots must be fired during daylight hours (minimum time for sunrise and sunset is determined by the firing procedure used (i.e., electric, non-electric, shock tube 30/60/60).
- Notification of the local authorities will be made in accordance with the site requirements.
- No more than two persons will ride in a truck transporting demolition material or MEC, and no person will be allowed to ride in the trailer/bed.
- Vehicles will not be refueled when carrying demolition material or MEC, and must be 100 feet from magazines or trailers containing such items before refueling.
- All explosive vehicles will be cleaned of visible explosive and other contamination, before releasing the vehicles for other tasks.
- Prior to conducting any other task, personnel will wash their face and hands after handling demolition material or MEC.
- Demolition pits will be spaced a safe distance apart, with no more than 10 pits prepared for a series of shots at any one time and NEW may not exceed the range limit.

5.0 SPECIAL REQUIREMENTS FOR DEMOLITION ACTIVITIES

The following safety and operational requirements will be followed during demolition range operations. Any deviations from this procedure will be allowed only after receipt of written approval from the PM and the client. Failure to adhere to the requirements and procedures listed in the paragraphs below could result in serious injury or death; therefore, complete compliance with these requirements and procedures will be strictly enforced. Personnel performing demolition operations will follow applicable safety precautions for the method and materials selected.

5.1 GENERAL REQUIREMENTS

The general demolition range requirements listed below will be followed at all times for the demolition method being used:

- The CEHNC "Procedures for Demolition of Multiple Rounds (Consolidated Shots) on Munitions and Explosives of Concern (MEC) Sites," will be followed when destroying multiple munitions by detonation on site. This document will be present on site during site operations.
- White Phosphorus and propellant will only be disposed of in an approved manner and following the guidance for maximum temperature exposure (90 degrees Fahrenheit).
- Material awaiting destruction will be stored at not less than intra-line distance, based on the largest quantity involved, from adjacent explosive materials and from explosives being destroyed. The material will be protected against accidental ignition or explosion from fragments, grass fires, burning embers, or detonating impulses originating in materials being destroyed.
- MEC/UXO or bulk explosives to be destroyed by detonation should be detonated in a pit, preferably not less than 3 feet deep and covered with earth which protrudes not less than 2 feet above existing ground level or the required number of sandbags as determined by DDESB/CEHNC calculations. Requirements may be found in the explosive siting plan. The components should be placed on their sides or in a position to expose the largest area to the influence of the demolition material. The demolition material should be placed in intimate contact with the item to be detonated and held in place by tape or earth packed over the demolition materials. The total quantity to be destroyed below ground at one time will not exceed the range limit.
- Detonations will be counted to ensure detonation of all pits. After each series of detonations, a search will be made of the surrounding area for MEC/UXO. Items such as lumps of explosives or unfuzed ammunition may be picked up and prepared for the next shot. Fuzed ammunition, or items that may have internally damaged components, will be detonated in place, if possible.
- Prevailing weather condition information can be obtained from the local weather service, or other acceptable source and the data logged in the Demolition Shot Log/Briefing Sheet before each shot or round of shots.
- All shots will be dual primed when applicable and based on the method of disposal/venting being performed.
- Whenever possible, during excavation of the demolition pits contour the ground so that runoff water is channeled away from the pits. If demolition operations are discontinued for more than two weeks, the pits should be backfilled until operations resume.
- Upon completion of the project, all disturbed demolition areas will be thoroughly inspected for MEC/UXO. Depending upon contract requirements, the site may have to be backfilled and leveled. If necessary, this will be coordinated with the contractor representative.
- Prior to and after each shot, the USA Demolition Shot Record is to be filled out by the SUXOS with all applicable information. This record will be kept with the MEC Accountability Log and reflect each shot.

5.2 ELECTRIC DETONATOR USE

The following requirements are necessary when using electric detonators and blasting circuits. If utilized, refer to 5.6 for connection to and use of the Remote Firing Device

- Electric detonators and electric blasting circuits may be energized to dangerous levels from outside sources such as static electricity, induced electric currents, and radio communication equipment. Safety precautions will be taken to reduce the possibility of a premature detonation of the electric detonator and explosive charges of which they form a part. Radios or cell phones will not be operated within 25 feet while the pit/shot is primed or during the priming process.

- The shunt will not be removed from the leg wires of the detonator until the continuity check of the detonator is to be performed.

- When uncoiling, or straightening, the detonator leg wires, keep the explosive end of the detonator pointing away from the body and away from other personnel. When straightening the leg wires, do not hold the detonator itself; rather hold the detonator leg wires approximately 1 inch from the detonator body. Straighten the leg wires by hand; do not throw or wave the wires through the air to loosen them.

- Prior to use, the detonators will be tested for continuity. To conduct the test, place the detonators in a pre-bored hole in the ground or place them in a sand bag, and walk facing away from the detonators and stretch the wires to their full length, being sure to not pull the detonators from the hole or sand bag. With the leg wires stretched to their fullest length, test the continuity of the detonators one at a time by un-shunting the leg wires and attaching them to the galvanometer and checking for continuity. After the test, re-shunt the wires by twisting the two ends together. Repeat this process for each detonator until all detonators have been tested. This process will be accomplished at least 50 feet from and downwind of any MEC or demolition materials and out of the demolition range personnel and vehicle traffic flow pattern. In addition, all personnel on the demolition range will be alerted prior to the test being conducted.

  NOTE: When testing the detonator, prior to connecting the detonator to the firing circuit, the leg wires of the detonator must be shunted by twisting the bare ends of the wires together immediately after testing. The wires will remain short circuited until time to connect them to the firing line or RFD receiver.

- At the power source end of the blasting circuit, the ends of the wires will be shorted or twisted together (shunted) at all times, except when actually testing the circuit or firing the charge. The connection between the detonator and the circuit firing wires must not be made, unless the power end of the firing wires are shorted and grounded or the firing panel is off and locked.

- The firing line will be checked using pre-arranged hand signals or through the use of two-way radios, if the demolition pit is not visible from the firing point. If radios/push-to-talk phones are used, communication will be accomplished a minimum of 25 feet from the demolition pit/shot and electrical detonators. The firing line will be checked for electrical continuity in both the open and closed positions, and will be closed/shunted after the check is completed.

- MEC/UXO to be detonated will be placed in the demolition pit and the demolition material placed/attached in such a manner as to ensure the total detonation of the MEC/UXO. Once the MEC/UXO and demolition material are in place and the shot has been tamped, the detonators will be connected to the detonating cord. Prior to handling any detonators that are connected to the firing line or RDF, personnel will ensure that they are grounded. The detonators will then be carried to the demolition pit with the end of the detonators pointed away from the individual. The detonators are then connected to the detonation cord, shock tube, etc., ensuring that the detonator is not covered with tamping material to allow for ease of recovery/investigation in the event of a misfire.

- Prior to making electrical connections to the blasting machine or RFD Transmitter, the entire firing circuit will be tested for electrical continuity and ohms resistance, or transmitting power (as applicable), to ensure the blasting machine or RFD Transmitter (distance) has the capacity to initiate the shot.

- The individual assigned to make the connections at the blasting machine or transmitter will not complete the circuit at the blasting machine or transmitter, and will not give the signal for detonation, until satisfied that all personnel in the vicinity have been evacuated to a safe distance. When in use, the blasting machine, key to transmitter, or its actuating device will be in the blaster's possession at all times. When using the RFD, the power key must be locked out until ready to fire, and the single key (as applicable by RFD system) must be in the blaster's possession.

- Prior to initiating a demolition shot(s), a warning will be given; the type and duration of such warning will be determined by the project requirements and prevailing conditions at the demolition site. At a minimum, this should be an audible signal using a siren, air horn, or megaphone, which is sounded for duration of one minute, five minutes prior to the shot and again one minute prior to the shot. A verbal “Fire in the Hole” will be made 3 times prior to initiation of the shot.

5.2.1 MISFIRE PROCEDURES - ELECTRIC

To prevent electric misfires, one technician will be responsible for all electrical wiring in the circuit. If a misfire does occur, it must be cleared with extreme caution, and the responsible technician will investigate and correct the situation, using the steps outlined below:

- Check firing line and blasting machine connections, and make a second initiation attempt.

- If unsuccessful, disconnect and connect to another blasting machine (if available), and attempt to initiate a charge.

- If unsuccessful, commence a 30-minute wait period.

- After the maximum delay predicted for any part of the shot has passed, the designated technician will proceed down range to inspect the firing system, and a safety observer must watch from a protected area.

- Disconnect and shunt the detonator wires, connect a new detonator to the firing circuit, check the replacement detonator for continuity, and prime the charge without disturbing the original detonator.

- Follow normal procedures for effecting initiation of the charge.

5.3 NON-EL USE (SHOCK TUBE)

The following general requirements are to be followed when using NON-EL (Shock Tube) systems. If utilized, refer to 5.6 for connection to and use of the Remote Firing Device.

- After cutting a piece of shock tube, either immediately tie a tight overhand knot in one or both cut ends or splice one exposed end and tie of the other.

- Always use a sharp knife or razor blade to cut shock tube so as to prevent the tube from being pinched or otherwise obstructed.

- Always cut shock tube squarely across and make sure the cut is clean.

- Use only the splicing tubes provided by the manufacturer to make splices.

- Every splice in the shock tube reduces the reliability of the priming system; therefore keep the number of splices to a minimum.

- Always dispose of all short cut-off pieces in accordance with local laws as they relate to flammable material.

The shock tube system is a thin plastic tube of extruded polymer with a layer of PETN coated on its interior surface. The PETN propagates a shock wave, which is normally contained within the plastic tubing. The shock tube offers the controlled instantaneous action of electric initiation without the risk of premature initiation of the detonator by radio transmissions, high-tension power lines or by static electricity discharge. The NON-EL system uses detonators in the bunch blocks and in the detonator assembly, which are to be, handled in accordance with approved procedures.

The high reliability of the shock tube initiating system is due to the fact that all of the components are sealed and unlike standard non-electric priming components, cannot be easily degraded by moisture. Cutting the shock tube makes the open end vulnerable to moisture and foreign contamination, therefore care must be taken to prevent moisture and foreign matter from getting in the shock tubes exposed ends.

5.3.1 SHOCK TUBE DEMOLITION PROCEDURES 1 AND 2

WARNING
Although the detonation along the shock tube is normally contained within the plastic tubing, burns may occur if the shock tube is held.

(1) SHOCK TUBE ASSEMBLY (NON-PRECUT - OPEN SPOOL LENGTHS)

- Spool out the desired length of shock tube from firing point to demolition site and cut it off with a sharp knife, razor blade, or shock tube cutter. Weight down the lose end of trunk line.

- Immediately seal off the shock tube remaining on the spool by tying a tight overhand knot in the cut off end or use a push-over sealer.

- Using a sharp knife, razor blade, or shock tube cutter cut the sealed end off of the detonator assembly.

- Push one of the shock tube ends to be spliced firmly into one of the pre-cut splicing tubes provided by the manufacturer at least ¼ inch. Push the other shock tube end firmly into the other end of the splicing tube at least ¼ inch. Secure splice with tape if needed, see Figure 1.

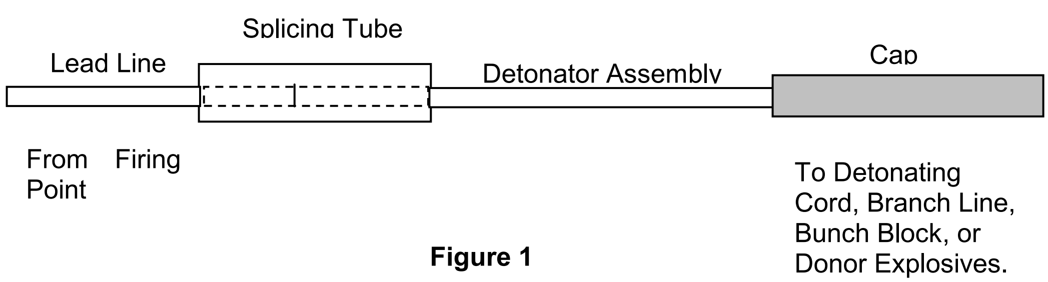


Figure 1

(2) SHOCK TUBE ASSEMBLY (PRE-CUT LENGTHS)

- Place cap under sandbag until ready for connection to remaining demolition components.
- Spool out the manufactured pre-cut length (i.e., 500', 1,000', 2,000', etc.) of shock tube from demolition site to the firing point. See Figure 2.

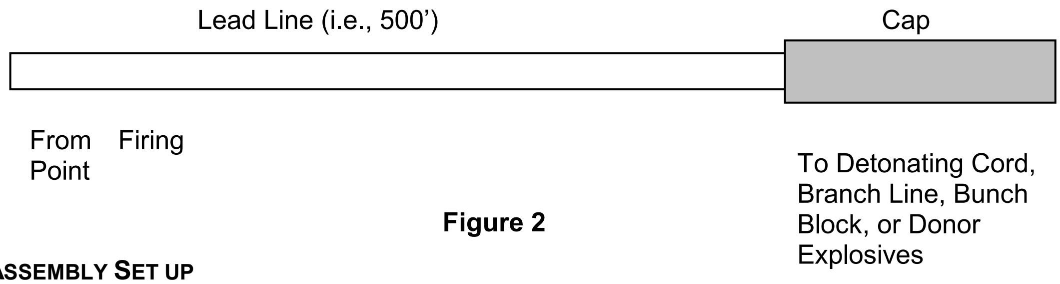


Figure 2

FIRING ASSEMBLY SET UP

- If there are multiple items to be destroyed using bunch block(s), supplied by the manufacturer, lay out branch lines at demo site to the shot(s) and secure the bunch block with a sandbag, or some other item which will keep it from moving.

Note: No more than six leads may be used from any one bunch block.

- If the detonator assembly has not been attached yet then using the splicing tube, splice the detonator assembly to the shock tube lead line as explained in the splicing instructions in above (1).
- If the detonator assembly is a manufactured pre-cut length (i.e., 16', 20', 30'), assemble into the bunch block.
- If this is a non-tamped shot place the detonator assembly into the demolition material. If the shot is to be tamped with loose soil then prepare the demolition material with a detonating cord lead long enough to stick out of the tamping at least 6 foot.
- Attach the detonator assembly with cap to the detonating cord, perforator, etc. as shown in Figure 3.

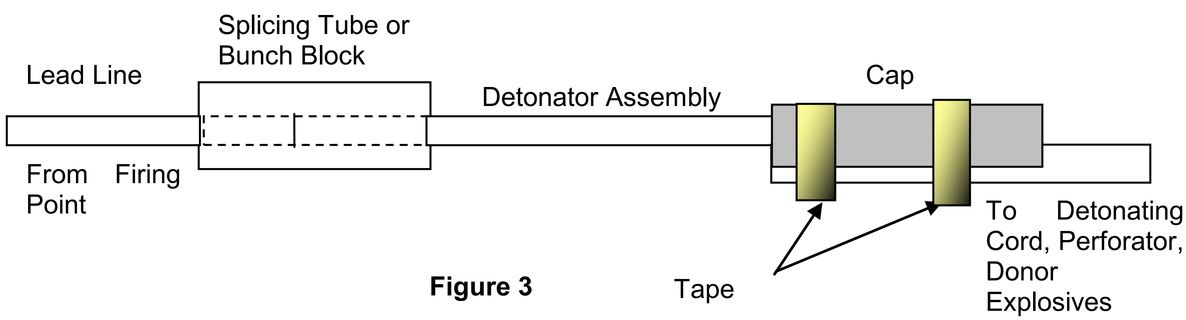


Figure 3

- Return to the firing position.
- Cut off the sealed end of shock tube using a sharp knife, razor, or shock tube cutter; proceed to the directions listed in Step 7. If you are using a previously cut piece of shock

tube, cut approximately 18 inches from the previously cut end, whether or not it was knotted in accordance with the above guidance.

- Insert a primer into the firing device (if mechanical) and connect the shock tube lead line to the firing device ensuring that the shock tube is properly seated in the firing device. **-Or-**
- Insert shock tube into the firing tip for non-mechanical firing devices.
- Take cover.
- Signal **"Fire in the hole"** three times and initiate charge IAW the firing device instructions.
- Observe a 5-minute wait time after the detonation.
- Remain in designated safe area until Demolition Supervisor announces **"All Clear".**

5.3.2 MISFIRE PROCEDURES – NON-EL MISFIRE (SHOCK TUBE)

The use of a shock tube for blast initiation can present misfires, which require the following actions:

- If charge fails to detonate, it could be the result of the shock tube not firing. Visually inspect the shock tube; if it is not discolored (i.e., slightly black), it has not fired.
- If it has not fired, cut a 1 foot piece off the end of the tube, re-insert the tube into the firing device, and attempt to fire again.
- If the device still does not fire, wait 60 minutes and proceed down range and replace the shock tube per the instructions outlined below.
- If the tube is slightly black, then a "Black Tube" misfire has occurred, and the shock tube will have to be replaced, do not cut and reattempt to fire. Observe a 60 minute wait time and replace the shock tube per the instructions outlined below.

Instructions:

1). When replacing the shock tube, be sure to remove the tube with the detonator in place.

"Do not remove the detonator from the end of the tube, dispose of by demolition"

3). If bunch blocks are used, open and remove the misfired lead line from the bunch block and replace entire initiating or firing system.

4.) If detonating cord is used, disconnect the misfired lead line and replace.

5.4 TIME/SAFETY FUSE USE

The following procedures are required when using a time/safety fuse:

- Prior to each daily use, the burn rate for the time/safety fuse must be tested to ensure the accurate determination of the length of time/safety fuse needed to achieve the minimum burn time of five minutes needed to conduct demolition operations.
- To ensure both ends of the time/safety fuse are moisture free, use approved crimpers to cut 6 inches off the end of the time/safety fuse roll, and place the 6 inch piece in the time/safety fuse container.

- If quantity allows, accurately measure and cut off a 6 foot long piece of the time/safety fuse from the roll.
- Take the 6 foot section out of the magazine, and attach a fuse igniter.
- In a safe location, removed from demolition materials and MEC/UXO, ignite the time/safety fuse, measure the burn time from the point of initiation to the "spit" at the end, and record the burn time in the SUXOS's Log or other appropriate log.
- To measure the burn time, use a watch with a second hand or chronograph.
- To calculate the burn rate in seconds per foot, divide the total burn time (in seconds) by the length (in feet) of the test fuse.
- When using time/safety fuse for demolition operations, the minimum amount of fuse to be used for each shot will be the amount needed to permit a minimum burn time of five minutes.

5.4.1 MISFIRE PROCEDURES – TIME/SAFETY FUSE

Working on a non-electric misfire is the most hazardous of all operations. Occasionally, despite all painstaking efforts, a misfire will occur. Investigation and corrective action should be undertaken only by the technician that placed the charge, using the following procedure:

- If charge fails to detonate at the determined time, initiate a 60-minute wait period plus the time of the safety fuse, i.e., 5-minute safety fuse plus 60 minutes for a total of 65 minutes.
- After the wait period has expired, a designated technician will proceed down range to inspect the firing system. A safety observer must watch from a protected area.
- Prime the shot with a new non-electric firing system, and install a new fuse igniter.
- Follow normal procedures for initiation of the charge.

5.5 DETONATING CORD USE

The following procedures are required when using detonating cord:

- Detonating cord should be cut using approved crimpers or cutters, and only the amount required should be removed from inventory.
- When cutting detonation cord, the task should be performed outside the magazine.
- For ease of inventory control, only remove detonating cord in 1-foot increments.
- Detonating cord should not be placed in clothing pockets or around the neck, arm, or waist, and should be transported to the demolition location in either an approved “day box”, original container, or a cloth satchel, depending upon the magazine location and proximity to the demolition area.
- Detonating cord should be placed at least 50 feet away from detonators and demolition materials until ready for use. To ensure consistent safe handling, each classification of demolition material will be separated by at least 25 feet until ready for use.
- When ready to “tie in” either the detonating cord to demolition materials, or detonating cord to detonator, the detonating cord will be connected to the demolition material and secured to the MEC/UXO. The detonating cord is then strung out of the hole and secured in place with soil, or

filled sandbags, being sure to leave a minimum of 6 feet of detonating cord exposed outside the hole.

- Once the hole is filled, make a loop in the detonating cord large enough to accommodate the detonator, place the detonator in the loop, and secure it with tape. The detonators explosive end will face down the detonating cord toward the demolition material or parallel to the main line.
- In all cases, ensure that there is a minimum of 6 feet of detonating cord extending out of the hole to allow for ease of detonator attachment and detonator inspection/replacement should a misfire occur.
- If the detonating cord detonators are electric, they will be checked, tied in to the firing line, and shunted prior to being taped to the loop. If the detonating cord detonators are non-electric, the time/safety fuse will be prepared with the igniter in place prior to taping the detonators to the detonating cord loop. If the detonating cord detonators are Non-El, simply tape the detonators into the loop as described above.
- In the event that a time/safety fuse is used, an igniter is not available, and a field expedient initiation system is used (i.e., matches), do not split the safety fuse until the detonator is taped into the detonating cord loop.

5.5.1 MISFIRE PROCEDURE – DETONATING CORD

USA uses detonating cord to tie in multiple demolition shots, and to ensure that electric detonators are not buried. Since detonating cord initiation will be either electrical, shock tube, or non-electrical, the procedures presented in Paragraphs 5.2, 5.3, or 5.4, as appropriate to the type of detonator used, will be used to clear a detonating cord misfire. In addition, the following will be conducted:

- If there is no problem with the initiating system, wait the prescribed amount of time, and inspect the initiator to the cord connection to ensure it is properly connected. If it was a bad connection, simply attach a new initiator, and follow the appropriate procedures in Paragraphs 5.2, 5.3, or 5.4 above.
- If the initiator detonated and the cord did not, inspect the cord to ensure that it is detonating cord and not time fuze. Also, check to ensure that there is PETN in the cord at the connection to the initiator.
- It may be necessary to uncover the detonating cord and replace it. This must be accomplished carefully, to ensure that the demolition charge and the MEC item are not disturbed.

5.6 REMOTE FIRING DEVICE USE

The remote firing device (RFD) may be used to initiate electrical or non-el (shock tube) firing systems. Each RFD make and model may contain different procedures so close adherence to the operators manual is required. Only personnel familiar with the RFD should attempt to use the system. The procedures contained below are for use of the Rothenbuhler Engineering Model 1670 Remote Firing Device. For special operation modes, maintenance, or basic trouble shooting in the field please refer to the 1670 RFD Operation Manual.

SAFETY WARNINGS

- Never rely on this equipment or any equipment totally for your safety. All mechanical and electronic equipment can fail. Always have a safety procedure that will protect you and minimize hazards of such nature.
- High power radio transmissions can cause electric blasting caps to detonate. Keep the high powered controller 25 feet (8 meters) or more from electric detonators.
- The Shock Tube Initiator on the Remote Unit can develop up to 3,000 Volts. Do not touch this tip or tip jacks while arming the unit.
- Do not connect electric detonators or shock tube to the Remote Unit unless the GREEN READY light is on, the RED ARMED light is off, and the BATTERY light is on steady.
- Do not use the system if any of the units show damage to the point that failure is suspected. Thoroughly test the system prior to use.
- Never approach the Remote Unit if it is attached to live explosives unless you have a confirmed READY status back to the controller AND you have waited at least 2 minutes for the automatic disarm AND you have followed proper safety wait times.

5.6.1 SET-UP PROCEDURE

1.) Ensure the Controller Unit is sufficiently charged and tested according to the Operation Manual.

2.) Install the Controller's Antenna. Ensure the Controller's Key is removed.

"Do not turn on the Controller near blasting caps".

3.) Ensure the Remote Unit is sufficiently charged and tested according to the Operation Manual.

4.) Position the Remote at a safe location, but close to the blast area.

5.) Install the Remote's Antenna.

6.) Turn the switch on the Remote to the POWER ON position. Observe the yellow battery light is on and is not flashing.

7.) Press and hold the PRESS TO TEST switch. Ensure the battery reads at least **12.0V**.

8.) Select the fire circuit to be used. Observe that the red ARMED light is off, and the green READY light is on.

9.) Connect electric detonator wires to the binding posts, or the non-electric shock tube to the firing tip and install the tip into the jacks on the left side of the Remote Unit.

10.) Insert the Key into the Remote Unit. The yellow light next to the Key begins flashing to show the key is active.

11.) Close and fasten the lid. Repeat procedures 3-10 for each additional Remote Unit to be fired.

Firing the Device -

12.) Activate the Controller Unit by pressing the On Switch. The yellow POWER light comes on.

13.) The BATTERY indicator should read 40% or higher.

14.) Press the SELECT switches (1-8) to select the Remote Units to be fired. The yellow lights light for selected units will light.

15.) Note: Always hold all switches until the audible indicator goes out.

16.) Press the STATUS switch to perform a status request of all selected Remote Units.

17.) After a short time, the green READY lights for all selected Remotes will turn on steady to show the Controller is communicating bidirectionally with the Remotes.

18.) The steady green READY light means the Controller has received message from Unit #3 that it is disarmed or Ready.

19.) The steady yellow BATTERY light means Unit #3 does not have a low battery.

20.) Wait for the appropriate warning sirens. About 30 seconds from firing, install the Controller's key and Press and hold the ARM switch for ½ second. The red ARMED lights will blink for 15 seconds and come on steady.

21.) If any of the ARMED lights remain blinking, those Remote Units are not within 2-way range of the Controller and may not fire.

22.) Before 2-minutes have expired, press the two fire switches at the same time and hold for ½ second. Shot initiation should be detected.

Checking Status -

23.) The green READY lights for the selected Remotes should flash for a short time and come on steady.

24.) **Ensure the READY lights are on steady (not flashing) before approaching the Remotes.**

25.) You may perform a manual status check at any time by pressing the STATUS switch. After a short time, the results will be shown on the display panel.

26.) You may disarm any selected Remote by pressing the DISARM switch at any time. After a short time, the results will be shown on the display panel.

27.) In a panic situation, you may disarm all Remotes within 3 seconds by removing the Controller's Key.

28.) When all Remotes are disarmed and confirmed READY on the Controller panel, turn off the Controller by pressing the OFF switch.

29.) Remove the Controller's Key.

30.) You may approach and retrieve the Remote Units. Restore all antenna, firing tips, and keys to the storage pouches.

31.) If the units are wet, store them inside with the lids open. If the batteries are low, recharge them. Inspect the units for damage. Do not ever use a Remote Firing Device that is not working properly or is damaged.

5.7 DEMOLITION RANGE INSPECTION SCHEDULE

The schedule for the demolition range inspection will be followed when demolition operations are being conducted. This inspection will be conducted by the UXOSO or UXOQCS and will be documented in the Site Safety or QC Log. If any deficiencies are noted, demolition operations will be suspended and the deficiency reported to the SUXOS. Once the deficiencies are corrected, demolition operations may be resumed.

6.0 METEOROLOGICAL CONDITIONS

In order to control the effects of demolition operations and to ensure the safety of site personnel, the following meteorological limitations and requirements will apply to demolition operations:

- Demolition operations will not be conducted during electrical storms or thunderstorms.
- No demolition operations will be conducted if the surface wind speed is greater than 20 miles per hour.
- Demolition operations will not be conducted during periods of visibility of less than one mile caused by, but not limited to, dense fog, blowing snow, rain, sand storms, or dust storms.
- Demolition will not be carried out on extremely cloudy days, defined as overcast (more than 80% cloud cover) with a ceiling of less than 2,000 feet (AGL).
- Demolition operations will not be initiated until an appropriate time after sunrise (minimum 30 minutes), and will be secured at an appropriate time prior to sunset (minimum 30 minutes)(see Section 5.0).

7.0 PRE-DEMOLITION/DISPOSAL PROCEDURES

7.1 PRE-DEMOLITION/DISPOSAL OPERATIONAL BRIEFING

It is the belief of USA that the success of any operation is dependent upon a thorough brief, covering all phases of the task, which is presented to all affected personnel. The USA Demolition Operations Briefing/Checklist will be completed for each demolition operation. The SUXOS will brief all personnel involved in range operations in the following areas:

- Type of MEC/UXO being destroyed.
- Type, placement, and quantity of demolition material being used.
- Method of initiation (electric, non-electric, or NON-EL.
- Means of transporting and packaging MEC.
- Route to the disposal site.
- Equipment being used (e.g., galvanometer, blasting machine, firing wire, etc.).
- Misfire procedures.
- Post shot clean up of range.

7.2 PRE-DEMOLITION/DISPOSAL SAFETY BRIEFING

The USA SUXOS, Team Leader, or UXOSO will conduct a safety brief for all personnel involved in range operations in the following areas at a minimum:

- Care and handling of explosive materials.
- Personal hygiene.
- Two man rule, and approved exceptions.
- Personnel rolls and responsibilities.
- Potential trip/fall hazards.
- Horse play on the range.
- Stay alert for any explosive hazards on the range.
- Calling a safety stop for hazardous conditions.
- Location of emergency shelter (if available).
- Parking area for vehicles (vehicles must be positioned for immediate departure, with the keys in the ignition.
- Location of range emergency vehicle.
- Location of the assigned Paramedic.
- Wind direction (to assess potential toxic fumes).
- Locations of first aid kit and fire extinguisher.
- Route to nearest hospital or emergency aid station.
- Type of communications in event of an emergency.
- Storage location of demolition materials and MEC awaiting disposal.
- Demolition schedule.

7.3 TASK ASSIGNMENTS

Individuals with assigned tasks will report the completion of the task to the SUXOS. The types of tasks that may be required are:

- Contact local military authorities, fire personnel, and get air clearance, as required.
- Contact hospital/emergency response/medevac personnel, if applicable.
- Secure all access roads to the range area.
- Visually check range for any unauthorized personnel.
- Check firing wire for continuity and shunt.

- Prepare designated pits as required.
- Check continuity of detonators.
- Check time/safety fuse and its burn rate.
- Designate a custodian of the blasting machine; fuse igniters, or Non-El initiator.
- Secure detonators in a safe location.
- Place MEC/UXO in pit, and place charge in desired location.

7.4 PREPARING EXPLOSIVE CHARGE FOR INITIATION

To prepare the explosive charge for initiation, the procedures listed below will be followed:

- Insure firing wire is shunted.
- Connect detonator to the firing wire.
- Isolate or insulate all connections.
- Prime the demolition charge.
- Place demolition charge on MEC/UXO.
- Depart to firing point (if using non electric firing system, obtain head count, pull igniters, and depart to designated safe area).
- Obtain a head count.
- Give one minute warning signal, using a bullhorn or siren, five minutes prior to detonation, and again at one minute prior to detonation.
- Check the firing circuit.
- Signal **"fire in the hole"** three times (or an equivalent warning), and take cover.
- If using electric firing system, connect firing wires to blasting machine, and initiate charge.
- Remove firing wires from blasting machine and shunt or turn off RFD transmitter.
- Remain in designated safe area until SUXOS announces **"All Clear**." This will occur after a post-shot waiting period of 5 minutes and the SUXOS has and inspected the pit(s).

8.0 POST DEMOLITION/DISPOSAL PROCEDURES

Do not approach a smoking hole or allow personnel out of the designated safe area until cleared to do so, and follow the procedures listed below:

- After the **"All Clear"** signal, check pit for low orders or kick outs.
- Examine pit, and remove any large fragmentation as needed.
- Back fill hole, as necessary.

- Police all equipment.
- Notify military authorities, fire, etc. that the operation is complete.

9.0 RECORD KEEPING REQUIREMENT

To document the demolition operations procedures and the completeness of the demolition of MEC, the following record keeping requirements will be met:

- USA (as required) will obtain and maintain all required permits.
- The SUXOS will ensure the accurate completion of the logs, and the SUXOS and UXOQCS will monitor the entries in the log for completeness, accuracy, and compliance with meteorological conditions.
- The SUXOS will enter the appropriate data on the MEC Accountability Log and the Demolition Shot Record, to reflect the MEC destroyed, and will complete the appropriate information on the Explosives Accountability Log (a.k.a. the Magazine Data Card) which indicates the demolition materials used to destroy the MEC.
- The quantities of MEC recovered must also be the quantities of MEC destroyed or disposed.
- USA will retain a permanent file of all demolition records, including permits; magazine data cards; training and inspection records; waste manifests, if applicable; and operating logs.
- Copies of ATF License and any required permits must be on hand.

10.0 SAFETY AND PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS

The following safety measures and personal protective equipment (PPE) will be used in preventing or reducing exposure to the hazards associated with MEC/UXO demolition/disposal operations. These requirements will be implemented unless superseded by site-specific requirements stated in the SSHP.

- Hard hats are required only when working around heavy equipment or when an overhead or head impact hazard exists.
- Steel toe/shank boots are not required during surface/subsurface location of anomalies, unless a serious toe hazard exists, whereupon a composite safety toe will be used.
- Safety glasses will be required whenever an eye hazard exists, for example, when working around flying dirt/debris, using hand tools, etc. Safety glasses will provide protection from impact hazards and, if necessary, ultraviolet radiation (i.e., sunlight).
- Positive means will be required to secure the PPE and prevent it from falling and causing an accidental detonation.

11.0 REFERENCES

Applicable sections and paragraphs in the documents listed below will be used as references for the conduct of UXO demolition/disposal operations:

- USA Corporate Safety and Health Program.
- USA Standard Operating Procedures.
- USA Activity Hazard Analysis.

- OSHA General Industry Standards, 29 CFR 1910.
- OSHA Construction Standards, 29 CFR 1926.
- Basic Safety Concepts and Considerations for Ordnance and Explosives Operations, EP 385-1-95a.
- USACE EM 385-1-1, Safety and Health Requirements Manual.
- TP-16, Methodology for Calculation of Fragmentation Characteristics.
- DoD 4160.21-M, Defense Reutilization and Marketing Manual.
- DoD 6055.9-STD, DoD Ammunition and Explosives Safety Standards.
- AR 385-64, U.S. Army Explosives Safety Program.
- AR 385-10, Army Safety Program.
- DA PAM 385-64, U.S. Army Explosives Safety Program.
- TM 9-1300-200, Ammunition General.
- TM 9-1300-214, Military Explosives.
- Applicable TM 60 Series Publications.
- AR 190-11, Physical Security of Arms, Ammunition, and Explosives.
- ATF 5400.7, Alcohol, Tobacco, and Firearms Explosives Laws and Regulations.
- Applicable sections of DOT, 49 CFR, Parts 100 to 199, Transportation.
- Applicable sections of EPA, 40 CFR Parts 260 to 299, Protection of Environment.
- AR 385-40 w/ USACE Supplement 1, Accident Reporting & Records.

STANDARD OPERATING PROCEDURE – OPS-04
DGM ANOMALY INVESTIGATIONS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide USA Environmental, Inc. (USAE) employees and subcontractors with the minimum procedures and safety and health requirements applicable to the conduct of digital geophysical mapping (DGM) anomaly investigation operations on sites contaminated with unexploded ordnance (UXO) or munitions and explosives of concern (MEC).

2.0 SCOPE

This SOP applies to all USAE site personnel, including contractor and subcontractor personnel, involved in the conduct of DGM operations on a UXO/MEC contaminated site. The following USAE policies and procedures are not all inclusive nor are they applicable in all situations. This SOP is not a stand-alone document and is to be used together with Work Plans, other USAE SOPs, the USAE Site Safety and Health Plan (SSHP), applicable Federal, State, and local regulations, and contract restrictions and guidance. Consult the documents listed in Section 5.0 of this SOP for additional compliance issues.

3.0 INTRUSIVE INVESTIGATION OPERATIONS

All intrusive operations at MEC sites will be under the supervision of UXO qualified personnel. Non-UXO qualified personnel will not be allowed in the exclusion zone (EZ) during intrusive operations. The EZ will encompass an area large enough to protect personnel from fragmentation by an unplanned detonation. In addition, if non-UXO qualified personnel require access to the EZ, all work will stop while they are in the EZ. During operations, USAE personnel will strictly adhere to the SSHP and the following general safety practices:

- Operations will be conducted during daylight hours only.
- Access to operating areas will be limited to only those personnel necessary to accomplish the specific operation.
- UXO will only be handled by qualified UXO Technicians.
- During UXO operations the minimum separation distance (MSD) between UXO and non-UXO operations is the munition with the greatest fragmentation distance (MGFD), as stated in the Work Plan.
- MEC Teams will adhere to the team separation distance as established in the WP.
- During demolition operations personnel remaining on site will be limited to those personnel needed to safely and efficiently prepare the item/s for destruction.
- All personnel will attend the daily safety briefing (tailgate safety briefing) prior to entering the operating area.
- Anyone can stop operations for an unsafe act or situation.
- Safety violations and/or unsafe acts will be immediately reported to the UXO Safety Officer (UXOSO).
- Failure to comply with safety rules/procedures may result in termination of employment.

3.1 DETECTION AND REMOVAL PROCEDURES

3.1.1 GRID LAYOUT

A registered Land Surveyor will survey each of the clearance areas, accompanied by a UXO escort. Surveying activities will consist of locating clearance area boundaries, establishing permanent survey monuments, and establishing grids for geophysical investigation activities within the clearance areas.

Grids will be laid out by the survey team in the approximate size of 100 feet (ft) x 100 ft or 200 ft x 200 ft, depending on the terrain. These grids will be geophysical surveyed and the data gathered and evaluated to determine which anomalies will be selected for intrusive investigation. Dig sheets will be developed that prioritize the anomalies. These prioritized anomalies will be re-acquired to an exact location using the highly accurate Real Time Kinematic-Differential Global Positioning System (RTK-DGPS) and a Schonstedt GA-52CX magnetometer.

3.1.2 ANOMALY REACQUISITION AND MARKING

The DGM personnel will reacquire all geophysical anomalies identified for excavation on the tracking sheets using the reacquisition method tested during the geophysical prove-out (GPO). Using a polyvinylchloride (PVC) flag with the unique identifier number recorded in indelible ink, the actual field location of each reacquired anomaly shown on the tracking sheet will be flagged. Such reacquisition will be carried out concurrently with other site activities, taking into account proper explosive safety quantity distance (ESQD) requirements related to adjoining work and off-site personnel.

3.1.3 INTRUSIVE INVESTIGATION OF ANOMALIES

3.1.3.1 Intrusive Teams

Intrusive investigation teams usually consist of a Team Leader (UXO Technician III) and at least one UXO Technician II or I. During Intrusive operations UXO Technicians I will operate under the supervision of UXO Technicians II or III. Only qualified UXO technicians will perform UXO operations, which are defined as:

- MEC identification
- Access procedures such as excavation, either by hand or using heavy equipment
- Handling of MEC, explosives or explosive items
- Disposal, including movement, transportation, and final disposal of MEC

The UXO Team will be assigned a set of anomalies. Using the Dig Sheets provided, the dig team(s) will excavate each of the selected target anomalies. Site-specific conditions (e.g., a larger ordnance item found than was anticipated) may warrant modification of the EZ/MSD and removal procedures described herein. As necessary, any changes will be prepared and submitted separately for approval prior to initiation of further activities on site.

3.1.3.2 Manual Excavations

Excavations for individual anomalies will be conducted using Schonstedt GA-52CX (ferrous metal) and/or White's XLT or Minelab's Explorer II (all metals) detector to assist the team in determining the location and orientation of the target item. The personnel excavating an anomaly shall initially remove no more than a 6-inch layer of soil at the location of the anomaly. A visual and electronic search of the excavation shall then be made. This process shall be repeated until the audible signal from the magnetometer indicates the object is close to the surface. Once this determination has been made, soil will be removed by hand until the source of the anomaly is located. Excavations on individual anomalies greater than 4 ft below the ground surface (bgs) will not be made without prior approval of the U.S. Army Corps of Engineers (USACE) OE Safety Specialist.

3.1.3.3 Mechanical Handling Equipment

Mechanical handling equipment (MHE) may be used to excavate large anomalies (e.g., pits) or those deeper than 4 ft bgs if required (e.g., to confirm the anomaly is not a MEC). Any decision to use mechanized equipment to excavate these anomalies will be made by the Senior UXO Supervisor (SUXOS) and the USACE OE Safety Specialist. Excavations will proceed slowly to ensure the MHE does not broach the item. If the excavated material is considered to be an MEC, it shall be uncovered sufficiently by hand to obtain a positive identification of the item. If the item is identified as UXO/MEC, a determination will subsequently be made as to whether it is fuzed or not.

While excavating with MHE, a UXO technician will be stationed in a position that is out of the reach of the excavation equipment but affords a view of the excavation site. This observer will ensure that the next lift is visually free of UXO. The excavated material will be placed onto the ground within a screening area that has been surface swept and the boundaries recorded. The soil spoils will be spread across the screening area using the excavator bucket. The excavated material will be screened for range related debris, material potentially presenting an explosive hazard (MPPEH), munitions debris (MD), and UXO/MEC items. UXO technicians will recover all pieces of munitions debris or range related debris and any ordnance items. After screening, the soil spoils will be stockpiled to the side of the screening area.

3.1.3.4 Disposal Pits

Excavations for disposal pits using MHE will be performed in a similar manner as specified in Section 3.1.3.2. However, because individual anomalies cannot be discerned within the disposal pits, material from the disposal pit will be excavated carefully in 2-foot lifts.

3.2 ANOMALY EXCAVATION REPORTING

The MEC Subcontractor will excavate and identify the sources of the reacquired anomalies in the field. Data to be recorded for each item discovered during anomaly excavation will include the following (as applicable):

- Type (e.g., MD, MPPEH, MEC, and UXO)
- Description (e.g., “20mm projectile, MK105 practice bomb, 40mm hand grenade” and “base, coupling, firing device”)
- Initial Condition (e.g., expended, inert, live, and to be determined [TBD])
- Approximate length
- Approximate width
- Depth
- Approximate weight
- Approximate inclination (per Figure 1-1)
- Approximate orientation (Azimuth per Figure 1-1)
- Approximate distance from flag

- Approximate orientation from flag
- Found in a pit?
- Piece of fragmentation?
  - Initial disposition (e.g., left in place or removed to scrap pile)
  - Requires demolition?

All data will be turned into the Site Geophysicist at the end of the day.

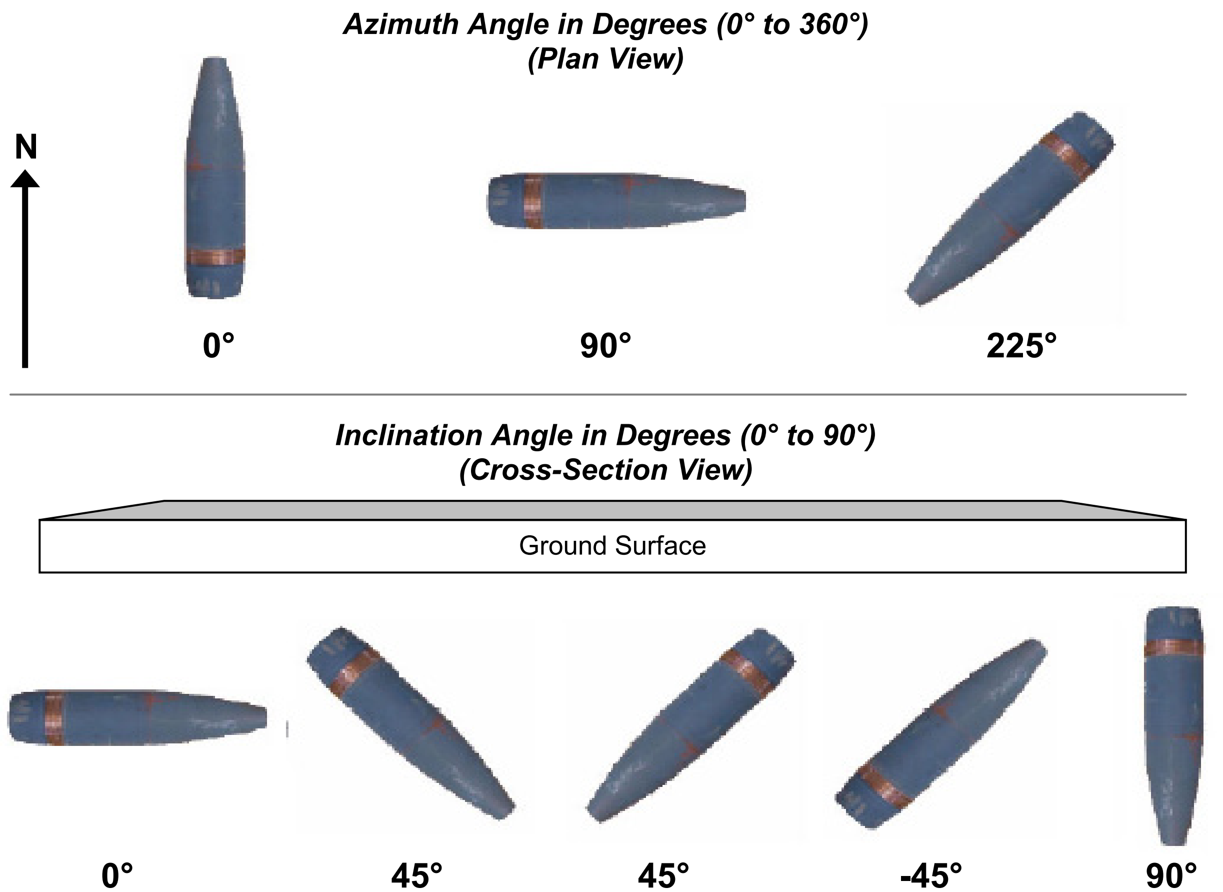


Figure 1-1: Azimuth and Inclination Examples

4.0 DISPOSAL OPERATIONS

Fuzed UXO/MEC items will be blown in place (BIP), and un-fuzed UXO/MEC items will be consolidated whenever possible in accordance with USACE Engineer Pamphlet (EP) 1110-1-17, *Establishing a Temporary Open Burn and Open Detonation Site for Conventional Ordnance and Explosives Projects*, dated 16 July 1999, Appendix D. In no case shall the SUXOS authorize or undertake destruction of UXO/MEC when there is sufficient reason to believe that the disposal action will result in personnel casualties or property damage. The USACE OE Safety Specialist will be consulted for guidance in the event that there is sufficient reason to believe that the disposal action will result in personnel casualties or property damage.

5.0 REFERENCES

- USACE Safety Considerations for UXO/MEC
- USAE Corporate Safety and Health Program (CSHP)
- OSHA, 29 CFR 1910, Occupational Safety and Health Standards
- OSHA, 29 CFR 1926, Construction Standards
- Applicable sections of EPA, 40 CFR Parts 260 to 299, Protection of Environment
- Applicable sections of DOT, 49 CFR Parts 100 to 199, Transportation
- USACE EM 385-1-1, Safety and Health Requirements Manual
- USACE ER 385-1-92, Safety and Occupational Health Document Requirements for Hazardous Waste Remedial Actions
- DOD 4145.26-M, Contractors' Safety Manual for Ammunition and Explosives
- DOD 6055.9-STD, DOD Ammunition and Explosives Safety Standards
- DOD 4160.21-M, Defense Reutilization and Marketing Manual
- DA PAM 385-64, Ammunition and Explosives Safety Standards
- AR 385-64, Ammunition and Explosives Safety Standards
- AR 200-1, Environmental Protection and Enhancement
- AR 385-10, The Army Safety Program
- AR 385-16, System Safety Engineering and Management
- AR 385-40 w/USACE supplement, Accident Reporting and Records
- TM 9-1300-200, Ammunition General
- TM 9-1300-214, Military Explosives
- TM 60 Series Publications

STANDARD OPERATING PROCEDURE AND CHECKLISTS – OPS-05
DIGITAL GEOPHYSICAL MAPPING

1.0 CHECKLIST FOR GEOPHYSICAL TEST STRIP LOCATION AND DESIGN

Project Name: ______________________________

Project Location: ______________________________

USACE POC: ______________________________

Reviewer's Name and Title: ______________________________

Date of Review: ______________________________

	Y	N	N/A
Objectives			
a. Have survey objectives been determined, clarified, and documented?	____	____	____
b. Has EM-1110-1-4009 been consulted to ensure that all objectives mentioned therein will be met?	____	____	____
c. Will the prove-out be available during the project for the evaluation of suspected instrument malfunctions?	____	____	____
d. Will the prove-out be available during the project for the evaluation of new equipment and operators?	____	____	____
e. Is the contractor prepared to demonstrate target reacquisition techniques in the prove-out area?	____	____	____
Site Selection			
1. Has the proposed prove-out site been evaluated for the following criteria:			
• Easy access for project personnel?	____	____	____
• Restricted access for non-project personnel?	____	____	____
2. Is the prove-out located in close proximity to the survey area?	____	____	____
3. Does the prove-out have geophysical noise conditions similar to those expected in the survey area?	____	____	____
4. Does the prove-out have terrain and vegetation conditions similar to those of the survey area?	____	____	____
5. Has a backup prove-out site been identified?	____	____	____
Site Preparation			
6. Has surface clearance been performed?	____	____	____
7. Have the following steps been executed in preparing three areas within the prove-out:			

Site Preparation (continued)	Y	N	N/A
• Geophysically map entire area prior to burial?	____	____	____
• Remove non geologic sources of anomalous response from two-thirds of the area? (optimal situation)	____	____	____

Seeding Test Strip

8. Have all available sources been consulted to determine appropriate seeded items and orientations?	____	____	____
9. Have DQO's been established and documented?	____	____	____
10. Have appropriate burial depths been determined for the seeded items?	____	____	____
11. Have the DQO's been consulted to determine the number of seeded items?	____	____	____
12. Have the seeded items been spaced a minimum of 3 meters apart?	____	____	____
13. Has a list been made to document the range of burial depths for different MEC items?	____	____	____
14. Have the following steps been taken to ensure accurate locations for the seeded items:	____	____	____
• Specify location requirements in x,y,z?	____	____	____
• Measure depth to top and center of mass of each object?	____	____	____
• Thorough notes taken on each item's burial?	____	____	____
• GPS or a land surveyor employed to record the position of each item?	____	____	____

Seeding Survey Areas

15. Have items been seeded near the boundaries of the survey areas?	____	____	____
16. Has a list been made of number and type of items buried, the range burial depths for different MEC items, and percentage of area seeded?	____	____	____
17. Will target threshold be reevaluated based on results of seeded items in the survey areas?	____	____	____
18. Have the positional accuracy standards used during the prove-out been applied to seeded items in the survey areas?	____	____	____

2.0 CHECKLIST FOR OUT OF BOX EQUIPMENT TESTS

Project Name: ____________________

Project Location: ____________________

USACE POC: ____________________

Equipment Source: ____________________

Equipment Serial Numbers: ____________________

____

Reviewer's Name and Title: ____________________

Date of Review: ____________________

	Y	N	N/A
1. Has the equipment been inventoried and inspected for damage or wear?	____	____	____
2. Has the cable shake test been performed? (Replace any faulty components if necessary)	____	____	____
3. Has the instrument (EM only) been nulled?	____	____	____
4. Has a nearby, noise-free site been selected for static background and static response tests?	____	____	____
5. Have the following instrument function tests been successfully performed:	____	____	____
• Static background test demonstrating <20% deviation in response for at least 3 minutes?	____	____	____

Background values: TG1__________, TG2___________, TG3____________, TG4____________

	Y	N	N/A
• Instrument response test demonstrating <20% deviation in response from test to test?	____	____	____

Response values: TG1__________, TG2___________, TG3____________, TG4____________

3.0 CHECKLIST FOR INITIAL INSTRUMENT TESTS

Project Name: ____________________

Project Location: ____________________

USACE POC: ____________________

Equipment Source: ____________________

Equipment Serial Numbers: ____________________

____

Reviewer's Name and Title: ____________________

Date of Review: ____________________

	Y	N	N/A
6. Has the six-line test been utilized to evaluate the following factors:			
• Heading effects?	____	____	____
• Repeatability of the response amplitude?	____	____	____
• Positional accuracy?	____	____	____
• Latency?	____	____	____
7. If magnetics data are to be collected, have the following steps been taken in the performance of the azimuthal test:	____	____	____
• Selected an area free of geophysical noise?	____	____	____
• Fixed sensor head position?	____	____	____
• Marked four cardinal directions on ground?	____	____	____
• Collected data using a variety of sensor head orientations?	____	____	____
8. If magnetics data is to be collected, has the octant test been performed and documented?	____	____	____
9. Has the optimum sensor height for each instrument been determined?	____	____	____
10. Has the pull-away test been performed and successfully demonstrated no influence for navigational or towing equipment?	____	____	____

4.0 CHECKLIST FOR DAILY INSTRUMENT QC CHECKS

Project Name: ____________________

Project Location: ____________________

USACE POC: ____________________

Equipment Source: ____________________

Equipment Serial Numbers: ____________________

____

Reviewer's Name and Title: ____________________

Date of Review: ____________________

	Y	N	N/A
1. Has the cable shake test been performed? (Replace faulty components if necessary)	____	____	____
2. Has instrument (EM only) been nulled?	____	____	____
3. Has a static background test been performed and demonstrated <20% deviation in response over at least 3 minutes:			
• Start of day?	____	____	____
Background values: TG1__________, TG2___________, TG3____________, TG4____________			
• End of day?	____	____	____
Background values: TG1__________, TG2___________, TG3____________, TG4____________			
4. Has instrument response test been performed and demonstrated <20% deviation in response from test to test:			
• Start of day?	____	____	____
Response values: TG1__________, TG2___________, TG3____________, TG4____________			
• End of day?	____	____	____
Response values: TG1__________, TG2___________, TG3____________, TG4____________			
5. Has the operator been thoroughly examined with the geophysical instrument for any sources of response that may not be readily apparent?	____	____	____
6. Has the repeat data or "clover-leaf" tests been utilized to evaluate the following factors:			
• Repeatability of response amplitude?	____	____	____
• Proper Lag Correction Applied?	____	____	____
• Positional accuracy?	____	____	____

Has there been an equipment or DQO metric failure?

Document any failure:

Document any corrective action (repair/retest)

Has corrective action solved failure?

5.0 SURVEY AREA REPORT FORM

☐ QC checked by _____________ Date: __________ ☐ QA checked by __________ Date: ________

Project Name: ____________________________________ **Project Location:** ____________________________________

Geophysical Contractor: ___________________________ **Design Center POC:** _________________________________

Project Geophysicist: ______________________________ **Site Geophysicist:** ____________________________________

Prove-out Area ID: ___________ **Date:** ______________ **Field Team:** ____

Survey Type: ☐Grid ☐Meandering Path ☐Transect ☐Other ______________

Coordinate System: ☐UTM ☐State Plane NAD ______ ☐Local ☐Other ______________ **Unit of Measure:** ☐ meters☐ feet

Sketch of Survey Area: **Approx. Scale:** _____________ **North Arrow:** ________

Terrain: ☐Level ☐Moderate Slope ☐Steep ☐Rolling ☐Ruts ☐Gullies ☐Rocky ☐Swampy ☐Dangerous

Tree Cover: **Tree Height:** ____☐None ☐Light ☐Medium ☐Thick

Brush: ☐None ☐Light ☐Medium ☐Thick

Weather: ☐Sunny ☐Cloudy ☐Drizzle ☐Rain ☐Thunderstorms ☐Hail ☐Fog ☐Humid ☐Snow

Grid Corner Coordinates: UTM/State Plane Local

Battery Voltage: Start _____ End _____

SW ___________, ___________ ___________, ___________ **Static Background Value:** File Name _____ _____ _____, _______

NW ___________, ___________ ___________, ___________

Static Response Value: _____ _____ _______, _______

NE ___________, ___________ ___________, ___________ *SE* ___________, ___________ ___________, ___________

Instrument Clock Drift: ____________

Raw Data File Name: _______________________________

Repeat Data File Name: _______________________________

Geophysical Instrumentation: ____

Serial Number: _________________

Sensor Separation (if applicable)**:** _____________________

Source (rental agency, contractor, etc.)**:** _________________________

Base Station: ______________________________________ **Source:** _________________ **Serial Number:** _________________

Navigation Method: ________________________________ **Source:** _________________ **Serial Number:** _________________

Additional Comments:

____

____

____

6.0 CHECKLIST FOR DATA STORAGE AND TRANSFER

Project Name: ______________________

Project Location: ______________________

USACE POC: ______________________

Reviewer's Name and Title: ______________________

Date of Review: ______________________

	Y	N	N/A
a. Has the transfer medium been approved by USACE?	____	____	____
b. Are all files in USACE approved formats?	____	____	____
c. Have all of the following been included in the transfer packet:			
• "Readme" file detailing contents?	____	____	____
• Raw data files?	____	____	____
• Edited data files?	____	____	____
• GPS positioning files (if separate)?	____	____	____
• Completed geophysical maps?	____	____	____
• Prioritized target lists?	____	____	____
• Data File Log / Spreadsheet of Delivered Data Files with Dates Sent?	____	____	____
d. Have the required number of copies, per USACE, been included in the transfer packet?	____	____	____

7.0 CHECKLIST FOR FIELD EDITING

Project Name: ______________________________

Project Location: ______________________________

USACE POC: ______________________________

Reviewer's Name and Title: ______________________________

Date of Review: ______________________________

	Y	N	N/A
1. Have the following items been evaluated for correctness and edited if necessary:			
• Line numbers?	____	____	____
• Start and end points?	____	____	____
• Line direction?	____	____	____
• Fiducial locations?	____	____	____
2. Has the data been examined in profile and evaluated for geophysical noise? Enter background noise value and compare with Test Strip background:_______________ vs. ______________	____	____	____
3. Has the data been examined for the presence of drop-outs and spikes?	____	____	____
4. Has the presence of metal on the operator been eliminated as a possible source of geophysical noise?	____	____	____
5. Has the edited data been converted to the appropriate .xyz format?	____	____	____
6. If using magnetics, have the following steps been taken:			
• Examined base station data for any problems?	____	____	____
• Performed diurnal correction to field magnetometer data?	____	____	____
7. Has the positional data been evaluated for accuracy and completeness?	____	____	____

8.0 CHECKLIST FOR DATA PROCESSING

			FILENAMES:
Site:	______________	Raw:	______________
Location:	______________	Edited:	______________
Contractor:	______________	Processed:	______________
Sector:	______________	Contour Map:	______________
Grid:	______________	Target List:	______________
Processor(s):	______________	Target Map:	______________

	Y	N	N/A
Preprocessing			
1. Coordinate Conversion PROJECTED COORDINATE SYSTEM ______________	____	____	____
2. Removal of Drift and Leveling	____	____	____
Record Corrections:			
3. Removal of Heading	____	____	____
Record Corrections:			
4. Lag and Offset	____	____	____
Record Corrections:			
Processing			
5. Initial Gridding	____	____	____
Record Parameters:			
6. Calculation of 3D Analytic Signal	____	____	____
7. Digital Filtering and Enhancement ☐ Low Pass ☐ High Pass ☐ Non Linear ☐ 3x3 Convolution ☐ Difference ☐ Other ______________	____	____	____
8. Threshold Selection Threshold value ______________	____	____	____
9. Anomaly Selection Number of targets ______________	____	____	____

DGPS AND EM61-MK2 SOP

NMEA GGA and GSA strings are used as inputs to the Geonics EM61-MK2 data logger to position sensor data in DGM operations. For applications in wooded areas or wherever RTK DGPS does not provide sufficient coverage AND the acceptable sensor positioning accuracy is less than normal (e.g. to support reconnaissance operations), Trimble's GeoExplorer 2005 (GeoXH or equivalent) can be configured to output the required NMEA position strings. The ability to tailor the output strings in necessary, because the default output of all NMEA strings clogs up the EM61-MK2 data logger too severely.

1. Attach GeoXH, or equivalent to EM61-MK2 handle,
2. Mount external antenna over EM61-MK2 coil center,
3. Attach the serial clip to get access to the GeoXH, or equivalent, COM1 port;
4. Turn ON the GPS and once it boots, Tap START, SETTINGS, and then the CONNECTIONS tab;
5. Open *GPS CONNECT*;
6. COM2 NMEA (GPS CONNECT) should be routed to COM1 and COM3 & COM4 should be (Available). Note the very bottom message "NMEA output on COM1 at 9600-8-1-N." You're good to go;
    a. If this is not the case, tap Setup;
        i. Set NMEA Output to External – COM1:
        ii. Using the tool wrench next to the NMEA Output:
        iii. Set Port Configuration to Custom (top menu option);
        iv. Set Baud Rate to 9600;
        v. Set Data Bits to 8;
        vi. Set Stop Bits to 1; and
        vii. Set Parity to None;
        viii. Tap OK.
    b. Check that TSIP is set to Internal – COM3; and
    c. Real-Time is set to None;
    d. Tap OK;
    e. The bottom message should read "NMEA output on COM1 at 9600-8-1-N";

NOTE: GPS Connector needs to stay running, so *DO NOT tap OK*, simply tap the Windows Flag, Programs, and open GPS Controller.

7. For Surveys in wooded areas, set the precision slide all the way *left* for maximum productivity;
8. Tap the wrench to open GPS Settings;
    a. GPS Receiver Port should be set to COM3: TSIP Serial Port;
    b. The precision slider should be all the way left;
    c. Max PDOP: should be 20;
    d. Min SNR: should be 33.0 (scroll down);
    e. Min Elevation: should be 5 degrees;
    f. Velocity Filter: should be Auto;
    g. NMEA Output: Should be On;
    h. Tap the wrench next to NMEA Output:
        i. Output Interval: should be 1s;
        ii. Baud Rate: should be 9600;
        iii. Data Bits: should be 8;
        iv. Stop Bits: should be 1;
        v. Parity: should be None;
        vi. Only the GGA box needs to be checked. Adding additional NMEA stings will only slow the EM61-MK2 data logger down. Scroll down to verify;

vii. Tap OK.

i. Tap OK.

9. In the upper left hand corner of the frame, open the menu and select "Real-time." On the next bar down, click on the menu and select "Summary."

   a. If everything is working correctly you should notice the following categories and their respective status:
      i. Integrated SBAS: In Use;
      ii. System: ;
      iii. Satellite ID: ;
      iv. SNR: _._ dB;
      v. Last correction: .
10. **If under "Summary" the categories above do not appear,** the settings are incorrect. Go back to the upper left hand menu (in GPS Correct) and select "Setup". Click on "Real-Time Settings" and choose:
    a. Choice 1: Integrated SBAS;
    b. Choice 2: Use uncorrected GPS;
    c. Real Time Age Limit: 4 min.
11. Verify the NMEA GGA output is being accepted by the EM61-MK2 data logger and periodically check DGPS status and number of satellites.
12. Periodically monitor GPS Controller for position accuracy, including number of satellites, PDOP, and Differential status.

Rover DGPS Equipment

1. Rover DGPS receiver with integrated and external antenna box
2. Rover Antenna telescoping range pole – in tripod box
3. Rover charger – in yellow box Rover serial cable – in yellow box (DB9 to DB9)
4. Rover Range Pole Bracket – in yellow box

Support Equipment

1. Battery chargers and data transfer link to PC – in yellow boxes
2. VAC power cable for chargers – in yellow box
3. Serial data transfer cable – in yellow box
4. Laptop PC with Trimble Geomatics Office software

Rover DGPS set up for Reacquisition:

1. Charge rover DGPS
2. Setup Telescoping Range Pole and attach Rover external antenna
3. Attach Rover bracket to range pole and Rover DGPS to bracket
4. Power ON the receiver and start TerraSync
5. Select Stakeout for Reacquisition
6. Select points from list or from map
7. Add all points, if necessary
8. Select anomaly point [e.g. A1-12842]
9. Follow rover guidance to anomaly location.
10. Extend range pole above tree canopy, if necessary
11. When delta values fall below 2m, mark location with flag labeled with the point name. Verify point reacquired with flag label
12. Measure location and accept to mark anomaly as reacquired
13. Select next point … etc.
14. When done, exit TerraSync and power down the rover DGPS
15. Remove DGPS from Range Pole
16. Store Rover
17. Store Range Pole
18. Charge Rover batteries overnight

Rover DGPS Position Reoccupation QC Test:

1. Position rover DGPS antenna over a known location
2. Verify rover position Differential
3. Record Easting (X), and Northing (Y) location
4. Compare measured location to known location
5. If location offset exceeds 2m, combined,
    a. Check satellite planning software

EM61-MK2 Setup:

1. Assemble coil assemblies
2. Attach wheels and handle (or stretcher)
3. Attach rover GPS antenna mount and mount rover GPS
4. connect upper coil to lower coil connector or attach shorting plug for bottom coil only
5. Attach battery to backpack
6. Connect coil cable to backpack
7. Connect data cable to backpack and Data Logger COM1
8. Connect GPS to EM Data Logger COM2
9. Move to an electromagnetically clean area
    a. Set the EM61-MK2 Mode Switch to:
        i. 4 – for logging four (4) bottom coil time gates
    b. Set the Master/Slave Switch to M for single sensor operation
    c. Push In the Circuit Breaker on the EM61-MK2 backpack and warm up for at least 5 minutes.
    d. Turn on Rover GPS
    e. Push the ON/OFF button to turn on the Data Logger
        i. Set Antenna Coil Size (e.g. Standard 1 x .5 m)
        ii. Set Up Logger
            1. Date
            2. Time
            3. Units (e.g. feet)
            4. COM port (e.g. COM1)
            5. Audio
            6. Pause Key: (e.g. Alt F1 or any key)
            7. Display (e.g. Text or Graphic)
        iii. Set GPS Port
            1. GPS Input: (Enabled)
            2. COM Port (COM2)
            3. Baud Rate: (9600)
            4. Parity: (No)
            5. Data Bits: 8
            6. Stop Bits: 1
            7. Can monitor GPS data in terminal mode (F3)
        iv. Set Output Port – Not used unless logging data to external PC
    f. Monitor/Null Coils – After 5 minute warm-up, null EM61-MK2 – all channels should be close to 0 +/- 1
    g. Acquire Data:
        i. Create File (F1 for default name, F3, Enter, F1 for other file name)
        ii. Survey Setup
            1. Mode: Auto
            2. Wheel Inc: N/A
            3. Reading/s: 10.00 or 16
            4. Surv Line: (e.g. 0)
            5. Line Incr: (e.g. 1 for instrument checks or 2.5 for survey)
            6. Sequence: (e.g. Alternate)
            7. Direction: (e.g. North
            8. Start Stn: (e.g. 0)
            9. Stn Incr: (e.g. Positive)
        iii. LOG DATA
            1. Wait for data display (0 to 100% internal calibration)
            2. Observe time gate values

3. Observe DGPS input (observe toggle bar and correction status for letter D, letter A is unusable GPS)
4. Enter to log data– System is ready to log data. Move to start of survey line.

h. When coil is centered over start point, press ENTER again. Display will show “logging” on the top display line. Observe coil readings. Observe Station Number (STN). Note any unusual recordings on Field Survey Sheet.

i. Walk along survey line slowly (about 2 to 3.5 miles per hour). Periodically observe Data Logger display. Note any unusual recordings, any deviations from the survey line, or any observed metal objects. Escort should log these observations and marks the outer coil edge with marking paint or plastic pin flags to insure sensor overlap on a return transect.

(If fiducial marks are available, press thumb button when coil is centered over mark for 1 second)

j. Press Pause Key (e.g. Any Key) when coil is centered over the line end to stop logging EM61-MK2 data.

(If in the Auto mode, simply continue to next line and keep moving until survey session is complete or manually set new lines with the F1 key)

k. When survey is complete, press F5 then the letter Y to exit logging. Enter a new file name to continue surveying, or return to main menu to transfer data.

l. Data Transfer using a cable:
   i. Turn OFF the Data Logger by holding the ON/OFF key
   ii. Disconnect Data Logger from EM61-MK2 backpack.
   iii. Change EM61-MK2 Backpack battery, if required
   iv. Connect Data Logger to Field Lap Top PC
   v. Power PC
   vi. Run DAT61MK2
   vii. Select “Data Transfer”
   viii. Verify serial port settings (COM1, Baud Rate: Auto)
   ix. Run the Data Logger program File Manager
      1. Upload Files.
   x. Select “List Files” and select the file names. (Check the Field Survey Form).
   xi. Select “Download” and observe PC and Data Logger to monitor data transfer status. Log any transfer problems on Field Survey Sheet.
   xii. Data Transfer using Memory Card:
      1. Exit DAT61 program to DOS c: prompt
      2. Use up arrow to find (or type) copy *.r61 d:
      3. Hit enter (files get copied from c: to Memory Card)
      4. Turn data logger OFF and eject Memory Card
      5. Insert Memory Card into PC and copy files to appropriate folder
      6. In DAT61 for Windows, convert all files from raw to ASCII (from *.r61 to *.m61)

m. Combine EM and GPS data in EM61MK2 using the “GPS Positioning” tool (or position with line and marker data).
   i. Select input file name
   ii. Enter output file name and location, enter file name on Survey Sheet.
   iii. Select the channels to position (e.g. STD D or STD 4 (all 4 bottom coil time gates))
   iv. Set the GPS Time Gap (e.g. 3 seconds)
   v. Select file format (e.g. Geosoft)
   vi. Set the GPS System (e.g. Geodetic or UTM)
   vii. Set Units to meters
   viii. Set GPS corrections to Raw GPS or Differential RTK

ix. Click “Apply” to export GPS integrated ASCII data file
n. From the File tool, select “Open XYZ File” and select the one just created. Display should show the survey tracks.
o. Data is ready for Processing and Analysis.

10. Data Management in Data Logger
    a. Once data transfer is complete and data has been positioned, exported (*.xyz file), and processed successfully, clear the data logger memory
        i. From the Main Menu, select “File Manager”
        ii. Select “Delete File”
            1. Scroll to select a file to be deleted
            2. Hit F1 key to delete
            3. Hit the “Y” key to confirm delete

File should have been removed from list

Daily EM61 Static Check

1. Setup as above
2. In a quiet area, log static EM61 background data for 1 minute (observe meter readings near 0, +/- 2-3 mV)
3. Press Enter to Pause and increment line (F1)
4. Place a “know object (e.g. a Standard Static Test Bar with steel bolt)” on the coil and log data (Enter) for 1 minute (observe meter readings #> 0, +/- 2-3 mV)
5. Press Enter to Pause, remove target, and increment line (F1)
6. Log static background data (Enter) for 1 more minute (observe meter readings near 0 +/- 2-3 mV)
7. Press Enter to Pause, and increment line
8. Log static data for 30 seconds while all system cables are shaken (observe meter readings near 0 +/- 2-3 mV – no jumps or spikes),
9. Press Enter to Pause, and increment line
10. Log static data for 30 seconds while operator kicks towards coil, twists left/right, and bends up/down (observe meter readings near 0 +/- 2-3 mV).
11. QC checks:
    a. Look for near zero readings during lines 0, 2, 3, and 4 – re-null coil or replace battery as necessary
    b. Check for consistent target readings +/-20% on line 1 from previous readings. Replace battery as necessary

Daily Latency Check

1. Setup as above
2. Find a quiet area at least 50 feet long
3. Place a known object in the center of this line (e.g. 2” Tow Ball)
4. Acquire line 0 from start (0,0) to end (0,50) directly over the object (0,25)
5. Increment the line number and acquire line 1 from end (0,50) to start (0,0) directly over the object (0,25)
6. Use this data to help determine data processing latency parameter needed to get the peak to line up in both directions.

EM Reacquisition

1. Setup as above
2. Position coil (push and pull) over flagged location in several directions while monitoring the display (e.g. SUM Channel).
3. Try to match or exceed the reported mV value on the Dig Sheet within 5 to 7m of each flag along cleared and marked transect
4. Move the flag to coil center over refined peak location
5. Log reacquired mV peak on Dig Sheet. If necessary, log refined location offset distance and direction on Dig List
6. Move to next flag

PC – Pathfinder Office, or equivalent

1. New Project
2. Enter new project name (e.g. Luis Pena)
3. Make sure Template: is using project coordinate system and units
4. Set Coordinate System correctly (e.g. US State Plane 1983, Colorado Central 0502, NAD 1983, Geoid (none) … click Finish … click Apply … click OK
5. Import points, select Custom [format] … select Name, East, North, Elevation … OK
6. Find *.csv file to load (e.g. My Documents/DRI/DRI_Sector_D.csv). Points should load and be displayed. Verify!

GPS Data Transfer from PC to Rover DGPS

1. Run Trimble Pathfinder Office, or equivalent, software on PC
2. Open Project and verify project coordinate system and units (e.g. Luis Pena, UTM, 19N, meters)
3. Import or verify target waypoints are shown
4. Connect Rover DGPS to PC (USB or Serial) a power ON Rover (machines should connect thru ActiveSync)
5. Export target waypoints to rover DGPS
6. Verify on rover DGPS:
7. Select the job
8. Select Review current job and verify points and point order. You can also map the points for the job

1. Charge all GPS and EM61-MK2 batteries overnight.

9.0 WEEKLY DGM QC REPORT:

Project Name: ______________________________

Report Week: ______________________________

9.1 INSTRUMENT LATENCY TEST

Metric is no zig-zag or chevron effects visible.

Describe latency correction performed ____________________

Document critical latency correction parameter(s) ____________________

Attach a representative data image map for each survey day documenting proper latency correction.

9.2 INSTRUMENT NOISE

Metric based on approved GPO results (e.g. < +/- 1.3 mV on time gate 1).

Report the weekly summary of all static background noise levels from each static test.

Report the dynamic noise levels for each survey file.

9.3 INSTRUMENT RESPONSE TEST RESULTS

Metric +/- 20 % from day to day.

Report the weekly summary of all static instrument response tests.

9.4 MAGNETOMETER HEADING CORRECTION

If used, magnetometer data will be corrected for heading errors such that there is no visible heading affects in the data displayed at the amplitude range used for detection and analysis.

Describe magnetometer heading correction performed ____________________

Document specific heading correction values ____________________

Attach a representative data image map for each survey day documenting proper heading correction.

9.5 DATA LEVELING AND/OR FILTERING

Metric is leveling and/or filtering utilities do not adversely alter the nature of the original measured response by more than 5%.

Describe data leveling and/or filtering used ____________________

Document critical leveling and/or filtering parameters used ____________________

Attach example of data profile before and after leveling and/or filtering

9.6 REOCCUPATION ACCURACY

Metric is not to exceed +/- 2m from a known location.

Describe the reoccupation point ____________________

Record the known location X = ______________, Y = ______________

Summarize the location offsets from each reoccupation test.

9.7 DATA SAMPLING DENSITY

Metric is along-track density will not exceed 0.5 feet.

Use Oasis QC tools to assess data sampling density.

Check if all data sets pass metric ______________.

Attach QC maps to document any failures.

9.8 ACROSS-TRACK LINE SPACING FOR GRIDS

Metric is 90% of line spacing will not exceed 2.5 feet.

Use Oasis QC tools to assess the across-track line spacing for each grid survey.

Check if all data sets pass metric ________________.

Attach QC maps to document any failures.

9.9 DYNAMIC REPEATABILITY

Dynamic DGM detection metric for grids is: Test item characteristics (peak response and size) repeatable with allowable variation of +/-25%.

Dynamic DGM detection metric for transects is: Test item in test strip anomaly characteristics (peak response and size) repeatable with allowable variation +/-25%.

Dynamic DGM positioning metric for grids is: Position offset of test item target <=35cm + ½ line spacing (e.g. <=2.4 ft for 2.5 ft line spacing) or <=50cm + ½ line spacing (e.g. <=2.9 ft for 2.5 ft line spacing) for fiducially positioned data.

Dynamic DGM positioning metric for transects is: Test item position offset <=2m.

Dynamic Analog detection repeatability metric is: Repeat a segment transect and show extra flags not greater than the greater of 20% or 8 flags, or within range of adjacent segment.

9.10 REACQUISITION ACCURACY

Metric is not to exceed 2 meters from to refined location.

Document all refined location offsets on dig list

Include updated dig list with this report

9.11 REFINED LOCATION ACCURACY

Metric is not to exceed 30 cm from refined location.

Document all discovered location offsets from refined location on Dig List

Include updated dig list with this report.

9.12 DGM FALSE NEGATIVES

Metric is no false negatives.

Document all false negative discoveries

Provide failure ID and photograph (attached to this report)

Provide failure location X = ________________, Y = ________________

Document corrective action taken ______________________________

9.13 INTRUSIVE ANOMALY RESOLUTION

Metric is for all intrusive results resolved with DGM data.

UXOQCS and Project Geophysicist will initial all dig results

Each discrepancy and final resolution will be documented

Final weekly dig list is attached to this report

Site Geophysicist Signature and Date ______________________________

UXOSO/UXOQCS Signature and Date ______________________________

STANDARD OPERATING PROCEDURE
OPS-07 – EXPLOSIVES STORAGE AND ACCOUNTABILITY

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide the minimum procedures and safety and health requirements applicable to the acquisition, storage, and accountability of explosives and unexploded ordnance (UXO) or munitions and explosives of concern (MEC).

The following USA Environmental, Inc. (USA) policies are not all inclusive nor are they applicable in all situations. This SOP is not a stand-alone document and is to be used together with the Work Plan, Site Safety and Health Plan, applicable Federal, State, and local regulations, and contract restrictions and guidance.

2.0 SCOPE

This SOP applies to all site personnel, including contractor and subcontractor personnel, involved in the conduct of operations on a site with UXO/MEC contamination. This SOP is not intended to contain all of the requirements needed to ensure compliance. Consult the documents listed in Section 8.0 of this SOP for additional compliance issues.

3.0 RESPONSIBILITIES

3.1 PROJECT MANAGER

The Project Manager (PM), in conjunction with the Senior UXO Supervisor (SUXOS), is responsible for the initial quantity and type of demolition material ordered. The initial requisition should be of sufficient quantity to support the project for a 90-day period. In the event that the project is scheduled to run for less than 90 days, only one requisition will be made, if possible.

3.2 SENIOR UXO SUPERVISOR

The Senior UXO Supervisor (SUXOS) will be responsible for all subsequent requisitions for demolition materials. He will accomplish this by submitting a purchase order (PO) request through the PM, who approves it and forwards it to Accounting for the preparation of a PO. Accounting then forwards the PO to the Program Manager for action.

4.0 REQUISITION PROCEDURES

The requisition of explosives will be in accordance with USA's policy, which requires that whenever possible three quotes be obtained to ensure the best possible price for the task. Of paramount importance in this process is the determination of the location of the supplier(s). Generally, response time to requisitions is better for those suppliers closest to the site. Additionally, there is the possibility of leasing explosives magazines from the supplier.

5.0 LICENSES/PERMITS

5.1 FEDERAL LICENSE

In order to requisition explosives, USA will maintain a valid Bureau of Alcohol, Tobacco, and Firearms (BATF) license/permit on hand, to include an Explosives Purchase/Receipt Authorization List for the receipt of explosives. These two documents must be on file at the USA Corporate Office, and at the project site, and each explosives supplier must also have a copy of each in order to sell to USA.

5.2 STATE BLASTER'S LICENSE

If required by the state in which a project is being conducted, USA personnel will obtain a state blaster's license. This will usually be accomplished by contacting the State Fire Marshall or State Safety Office to determine the requirements and schedule for the test. Only those individuals licensed by the State may actually shoot the shot. The PM and SUXOS will be responsible for identifying the need to obtain a blaster's license for a given project and for scheduling the personnel resources needed to obtain the requisite license.

5.3 STATE/COUNTY PERMITS

In some instances, it is necessary to obtain a state or county permit to conduct open burn/open detonation. This is accomplished by contacting the State Fire Marshall or County Fire Department for instructions.

6.0 EXPLOSIVES RECEIPT

Only those individuals named on the authorization list may sign for explosives from the shipper. In order to ensure that the quantity shipped is the same as the quantity listed on the shipping documents, two USA personnel will inventory the shipment prior to signing receipts.

6.1 SHIPPING DOCUMENTS

Explosive shipments generally are accompanied by the explosive supplier's Bill of Lading (B/L) and the freight company's shipping document. The initial inventory will include reconciling the two documents with the actual shipment and creating an on-site record that includes these documents and the inventory records. Regardless of the outcome of the initial inventory, one copy of the B/L and the freight company's shipping document will be attached to a copy of the PO request and the PO. One copy of each of the four documents will be filed on site, and one complete set will be forwarded to the Corporate Office.

6.2 RECEIPT DISCREPANCIES

In the event that there is a discrepancy between the amount shipped and the amount received, the SUXOS will immediately contact the PM and explosives supplier and inform the supplier of the discrepancy. It is then the responsibility of the supplier and shipper to rectify the situation and inform USA of the results. The supplier and/or shipper must then correct their documents and forward the corrected documents to the site. In all cases, only the amount received will be entered on the Explosives Accountability Record/Magazine Data Card, as shown in Figure 1.

7.0 STORAGE AND ACCOUNTABILITY

Demolition operations require the availability and storage of explosive materials. To the maximum extent possible, local government facilities will be used.

7.1 STORAGE

Demolition operations require the availability and storage of explosive demolition materials. To the maximum extent possible, local government or existing facilities will be used. Existing facilities are desirable because of their low cost and pre-approval, negating transport and set up. USA will comply with local storage criteria and procedures when using Government facilities. When required to provide explosives storage, USA will:

- Use portable approved BATF Type 2 structures or existing Government-furnished magazines.
- Locate, install, and maintain the magazines to comply with the magazine criteria and quantity distance requirements established in DOD 6055.9-STD, DoD Ammunition and Explosives Safety Standards.

- Install sufficient magazines to comply with explosive compatibility requirements, (i.e., bulk explosives, initiating explosives, and MEC).
- Establish security, such as fencing and/or guards, to prevent unauthorized access and/or theft.

7.1.1 Type 2 Outdoor Magazines

A Type 2 magazine is a box, trailer, semi-trailer, or other mobile facility.

7.1.1.1 General

Outdoor magazines will be bullet-resistant, fire-resistant, weather-resistant, theft-resistant, and ventilated. They will be supported to prevent direct contact with the ground and, if less than 1 cubic yard in size, will be securely fastened to a fixed object. The ground around outdoor magazines must slope away for drainage or other adequate drainage provided. When unattended, vehicular magazines must have wheels removed or otherwise effectively immobilized by kingpin locking devices or other methods.

7.1.1.2 Exterior Construction

The exterior and doors are to be of not less than ¼-inch steel and lined with at least 2 inches of hardwood. Magazines with top openings will have lids with water-resistant seals or which overlap the sides by at least one inch when in a closed position.

7.1.1.3 Hinges and Hasps

Hinges and hasps will be attached to doors by welding, riveting, or bolting (nuts on inside of door). Hinges and hasps will be installed so they cannot be removed when the doors are closed and locked.

7.1.1.4 Locks

Each door will be equipped with two padlocks fastened in separate hasps and staples. Padlocks must have at least five tumblers and a case-hardened shackle of at least 3/8-inch diameter. Padlocks will be protected with not less than ¼-inch steel hoods constructed so as to prevent sawing or lever action on the locks, hasps, and staples.

7.1.2 Signs and Placards

The BATF and the DoD require that all magazines be appropriately posted to indicate the hazard class of the contents, the fire fighting hazards, and the emergency notification list. Magazines will be placarded in accordance with DOD 6055.9-STD. This will require that the magazine area be posted for the most hazardous items stored in the magazine area. For example, a Fire Division Class 1 is needed for recovered UXO, and a Fire Division Class 3 for the demolition material, excluding detonators, which are Fire Division Class 4. In the event that there are two fire division or hazard class items in the same magazine, use the higher hazard division/class placard.

7.1.3 Lightning Protection

Appropriate lightning protection will be installed in accordance with Chapter 7 of DOD 6055.9 and/or the National Fire Protection Association (NFPA) requirements. For sites where existing storage facilities are typically not available, lightning protection is not required if the following criteria are met:

- The magazine is constructed of metal that is 3/16-inch steel or larger (reference Appendix L of NFPA 780).
- The magazine is grounded in accordance with NFPA requirements.
- All parts of the magazine are located at least 6.5 feet from the nearest fence.

7.1.4 Emergency Notification List

An emergency notification list containing the names, telephone numbers, and local addresses of the individuals to be notified in the event of an emergency, will be posted on the outside and inside of the magazine door. These individuals should be the same individuals authorized to sign for explosives.

7.1.5 Compatibility

Explosive compatibility will be maintained. Table 1 lists the various storage compatibility groups and Table 2 is the compatibility chart. In certain instances, it may be necessary to store incompatible items in the same magazine. If this should occur, a barricade, such as sandbags, within the magazine will physically separate the incompatible items. This situation should be an interim occurrence to be avoided and, if needed, approved by the client prior to implementation.

7.1.6 Key Control

Magazines will remain locked except when receipts and issues are being made. The two locks on the magazines will require two different keys to unlock. One key will be kept by the SUXOS and the second key by the Ordnance Accountability Officer (OAO). This procedure ensures that access to the magazines cannot be made without obtaining the two keys and no one individual can gain access to the magazines.

7.2 ACCOUNTABILITY

USA will employ the following procedures to account for explosive materials:

- Control of and access to explosive magazines will be strictly controlled by the SUXOS. All issues and turn-ins of explosives will be properly documented and verified, though physical count, by a UXO Quality Control Specialist (UXOQCS).
- On receipt, the type, quantity, and lot number of each explosive item is recorded in the magazine data card and the original receipt documents will be maintained on file by the SUXOS or Site Manager.
- All requests for explosives, from the individual operating sites, will be reviewed by the SUXOS. Only sufficient explosives for the day's operations are issued.
- Issues of explosives are recorded on explosives usage records (Figure 2) and deducted from the magazine data card(s) (Figure 1). This procedure will ensure that the quantities of explosives on-the-floor in the magazine reflect the quantities listed on the magazine data card, and that issued explosives are accounted for while they are in the possession of individual users.
- Entries made on the explosive usage records and magazine data cards will be verified through physical count by the UXO Team Leader drawing or turning-in the explosives and the UXOQCS.
- All unused explosives are turned in at the end of each day, re-entered on the magazine data card, and recorded on the explosives usage record.
- At the end of each day the SUXOS and the UXO Team Leader reconcile the entries on each explosives usage record, and will turn these records over to the Project Manager.
- Weekly, the Site Manager will direct that the UXOQCS perform a 100 percent inventory of all explosives on hand. These inspections will include a physical count of the explosives and a comparison of this amount with the amount listed on the individual magazine data cards. Discrepancies and the results of these inventories will be recorded and reported to the Site Manager.

7.2.1 USAGE INVENTORY

Following each occurrence of a receipt or issue of explosive material, the OAO will conduct a joint inventory in conjunction with the demolition team leader, drawing out or returning the explosives. Only those items issued/returned will be inventoried. The OAO will appropriately annotate the two sets of magazine data cards and the explosives usage record (Figure 2).

7.2.2 WEEKLY INVENTORY

The last day of each work week, the SUXOS, the OAO, and a third individual (who will be changed each week) will conduct an inventory and record results on the two sets of magazine data cards.

7.2.3 DISCREPANCIES

In the event that there is a discrepancy during any inventory, the item will be recounted a minimum of two additional times. If a discrepancy still exists, the PM, the Customer's Contracting Officer (or the Contracting Officer's Representative) and the BATF will be notified. All actions from this point will be dictated by the BATF.

7.3 SUMMARY

The procedures contained in this SOP ensure that explosive materials are properly stored, accounted for, and issued. These procedures will be strictly followed and violations of these policies may result in an employee's immediate dismissal.

8.0 REFERENCES

Procedures and information contained in this document were obtained from the below listed references:

- USA Safety and Health Program (SHP)
- DOD 4145.26-M, Contractors' Safety Manual for Ammunition and Explosives
- DOD 6055.9-STD, Department of Defense (DoD) Ammunition and Explosives Safety Standards
- DOD 4160.21-M, Defense Reutilization and Marketing Manual
- DA PAM 385-64, Ammunition and Explosives Safety Standards
- AR 385-64, Ammunition and Explosives Safety Standards
- AR 200-1, Environmental Protection and Enhancement
- AR 385-10, The Army Safety Program
- AR 385-16, System Safety Engineering and Management
- AR 385-40 w/USACE supplement, Accident Reporting and Records
- TM 9-1300-200, Ammunition General
- TM 9-1300-214, Military Explosives
- TM 60 Series Publications
- OSHA, 29 CFR 1910, Occupational Safety and Health Standards
- OSHA, 29 CFR 1926, Construction Standards
- EPA, 40 CFR Parts 260 to 299, Protection of Environment (applicable sections)
- DOT, 49 CFR Parts 100 to 199, Transportation (applicable sections)

- BATF P 5400.7, BATF-Explosives Law and Regulations
- USACE EM 385-1-1, Safety and Health Requirements Manual
- USACE ER 385-1-92, Safety and Occupational Health Document Requirements for Hazardous Waste Remedial Actions
- EP 385-1-95a Basic Safety Concepts and Considerations for Ordnance and Explosives Operations

Table 1: Storage Compatibility Groups for Explosives and Ammunition

GROUP A	
Cyclonite (RDX), dry	Mercury fulminate, wet
HMX, dry	PETN, dry
Lead azide, wet	RDX (cyclonite), dry
Lead styphnate, wet	Tetracene, wet
GROUP B	
Fuses (except chemically actuated fuses containing ampules which may initiate, directly or indirectly, explosives and explosives-loaded components which are assembled in the conventional manner to form the finished explosive fuse).	Detonators
	Mines, practice, AP, M17
	Percussion elements
	Primer detonators
GROUP C	
Ammunition, blank and saluting, cannon	Cartridge, 90mm, canister, AP
Ammunition, .50 caliber, except API/incendiary	Cartridges, practice, over 40mm
Ammunition, 20mm, practice and high pressure test	Catapults, aircraft ejection seat, M3A1, M4A1, M5
Ammunition, 25mm, with inert projectile	Charge, propelling, not assembled to projectiles EC powder
Ammunition, 27mm, caseless	Detonating cord (primacord)
Ammunition, 30mm, ball and high pressure test	Nitrocellulose
Ammunition, 30mm, practice and training	Fuel (solid), emergency power unit
Ammunition, 37mm and 40mm, TP and AP	Propellant
Ammunition, 40mm, practice, M407A1, M382, and M385	Rockets, practice, 3.5-inch
Benite	Rocket motors, M3, M5, M6, M10, M13, M26, M30, M37, M42, M53, M66; Pershing 1st and 2nd stages; Spartan 1st, 2nd, and 3rd stages
Boron potassium nitrate	
GROUP D	
Adapter booster	Explosive D
Ammonium nitrate, except in original shipping container or equivalent	Explosives, cratering
Ammonium perchlorate, except when particle size is over 15 microns and in original shipping container or equivalent	Grenades, rifle, AT (except pentolite loaded)
Ammonium picrate (Explosive D)	HMX, wet
Bangalore torpedoes	Mine, APERS, MN, M14 (w/integral fuse)
Baratol	Mines, antipersonnel (bounding type
Black powder, bulk	Mines, antipersonnel (cast iron block)
Bombs, demolition	Mines, HEAT Nitrocellulose wet 8-30% water exposed to detonation hazards at less than intra line distance
Bombs, fragmentation	Nitroguanidine

Bombs, general purpose	Nitrostarch Octol
Boosters	PBX
Boosters, auxiliary	pentolite
Bursters	PETN, wet
Charge, demolition, snake	Picratol
Charge, springing earth rod, blast driven	Picric acid
Charge, supplementary, HE	Projectiles, HE, fuzed or unfuzed
Compositions A, A-2, A-3, A-4, B, B-3, C, C-2, C-3, and C-4	RDX (Cyclonite), wet
Cutter, cable M1	Rocket heads, HE and HEAT (except pentolite loaded) w/o motors
Cyclonite (RDX), wet	Shaped charges
Cyclotol	Tetranitrocarbazole (TNC)
Demolition Blocks	Tetryl
Destructor, HE, M10	Tetrytol
Detonating cord (primacord) exposed to detonation hazard at less than intra line distance	TNT
Dynamite	Tritonal
Ednatol	Torpex
GROUP E	
Ammunition, HEP	Ammunition, fixed and semi-fixed, 90mm through 106mm, loaded with ammonal, amatol, Explosive D, composition B or TNT
Ammunition, 20mm, HE, HEI and functional packs containing HE and HEI	Cartridge, heavy mortar, over 81mm (including 81mm M56), except chemical loaded
Ammunition, 30mm, HEDP	Cartridge, light mortar, 81mm or less (excluding 81mm M56), except chemical loaded
Ammunition, 37mm, HE	Redeye guided missiles, packaged 3 complete rounds w/launcher
Ammunition, 40mm, HE, RDX loaded	
Ammunition, 40mm, HE, M406, M386, M441, and M463	Rockets, HEAT, 3.5-inch, complete round
Ammunition, 57mm through 81mm, except White Phosphorous smoke, HEP and blank	Rockets, HE, 2.75-inch (in LAU-3/A rocket launcher)
GROUP F	
Grenades, hand offensive	Grenades, fragmentation
GROUP G	
Ammunition, .50 caliber API and incendiary	Grenades, hand, CN1, ABC, M25A1, w/fuse C12
Ammunition, 20mm, API	Grenades, hand, CM1, ABC, M25A2, w/fuse C12
Ammunition, 20mm, incendiary and functional packs containing incendiary, except those containing HE or HEI	Grenades, illuminating and incendiary

Ammunition, 40mm, riot control and pyrotechnic loaded, except White Phosphorous smoke	Grenades, practice, w/spotting charge
Bombs, photoflash	Grenades, rifle, smoke, XM48E1 and M22 and M23
Cartridge, igniter, M2	Grenades, smoke (except White Phosphorous and PWP)
Cartridge, illuminating	Grenades, riot control, CS1, M25A2
Cartridge, photoflash	Igniter, spotting charge
Cartridge cases, primer (w/o propellant)	Igniters for rocket motors (e.g., M12, M18, M20 and M29)
Charge, igniter assembly, for practice hand grenades	Ignition cartridge for trench mortar ammunition
Charge, spotting, APR practice, M8	Illuminating compositions (consolidated in final press operations)
Chemical ammunition, Group B, tear or smoke producing, w/explosive components, over 40mm	Mines, practice, w/spotting charge and/or fuse
Chemical ammunition, Group B, tear or smoke producing, w/o explosive components	Nuclear fire marker device 11-F2
Chemical ammunition, Group D, containing flammable solids, except for TEA or TPA, w/o explosive components	Photoflash powder
Chemical ammunition, Group D, fixed or semi-fixed rounds, containing flammable solids, except for TEA or TPA	Primers, artillery and cannon, percussion and electric
Clusters, incendiary bomb, M31 and M32 (w/o fuzing components)	Projectiles, illuminating
Destroyer, file, M4	Rocket, riot control agent, CS, 2.75-inch FFAR, MX99
Detonation, simulator, explosive M80	Simulators, M110, M115, M116, M117, M118, M119 and XM142
Grenade, hand, smoke, HC, M8	Smoke pots
Grenades, hand, CN, M7A1, w/fuse M201A1	Spotting charges (cartridge for miniature practice bombs)
Grenades, hand, CS, M7A3, w/fuse M210A1	
GROUP H	
Chemical ammunition, Group C	Grenade rifle, White Phosphorous, M19
Grenades, White Phosphorous	
GROUP J	
Chemical ammunition, Group D, containing flammable liquids or gels, with or w/o explosive components	Chemical ammunition, Group D, fixed and semi-fixed rounds, containing flammable liquids or gels with or without explosive components
GROUP K	
Chemical ammunition, Group A, with or without explosive components	Chemical ammunition, Group B, with or without explosive components, designed for toxic or incapacitating effects greater than lachrymation
Rockets, toxic chemical agents, complete rounds	

GROUP L	
Aluminum powder	Fuzes, chemically actuated, containing ampoules which may initiate directly or indirectly, explosives and explosives loaded components which are assembled in the conventional manner to form the finished explosive fuse
Ammonium nitrate	Magnesium powder
Ammonium perchlorate	Grenades, rifle, AT (pentolite loaded)
Ammunition, pentolite loaded	Nitrates (inorganic), except ammonium nitrate (in original shipping container or equivalent)
Chemical Ammunition, Group A, without explosive components	Perchlorates
Chemical ammunition, Group B, without explosive components, designed for toxic or incapacitating effects more severe than lachrymation	Peroxides, solid
Chemical ammunition, Group D, TEA or TPA components	Rocket heads, pentolite loaded, w/o motors
Chlorates	Zirconium (types I and II, spec. FED 1665)
DNT	
GROUP S	
Ammunition, 40mm, canister and multiple projectile	Fuse lighters
Ammunition, small arms, less than .50 caliber	Fuse safety
Explosive bellows	Squibs commercial
Firing devices	

Table 2: Storage Compatibility Chart

GROUPS	A	B	C	D	E	F	G	H	J	K	L	S
A	X	Z										Z
B	Z	X										X
C			X	Z	Z		Z					X
D			Z	X	X							X
E			Z	X	X							X
F						X						X
G			Z				X					X
H								X				X
J									X			X
K										X	U	
L										U		
S	Z	X	X	X	X	X	X	X	X			X

Notes:

1. The marking AX@ at an intersection of the above chart indicates that these groups may be combined in storage. Otherwise, mixing is either prohibited or restricted per Note 2 below.
2. The marking AZ@ at an intersection of the above chart indicates that, when warranted by operational considerations or magazine non-availability, and when safety is not sacrificed, these groups may be combined in storage.
3. Equal numbers of separately packaged components of complete rounds of any single type of ammunition may be stored together. When so stored, compatibility is that of the assembled rounds; i.e., White Phosphorous Filler in Group H, HE Filler in Groups D, E, or F, as appropriate.
4. Group K required not only separate storage from other groups, but also requires that munitions having different toxic chemical agent fillers be stored separately from each other.
5. The marking AU@ on above chart indicates that leaking toxic chemical munitions of one agent type, i.e., GB, with or without explosive components, may be stored together in one magazine specifically designated for storage of leakers of that agent type.
6. Ammunition designated APRACTICE@ by NSN and nomenclature may be stored with the fully loaded ammunition it simulates.

Magazine Data Card

Nomenclature:

Lot Number: Unit Of Issue:

Date	Name	Received	Issued	Balance	Checkers Initials

Figure 1: Magazine Data Card

Explosives Usage Record

Contract Number:

Team Number: Date: Project Name:

Team Leader: Work Areas & Grid Numbers:

Explosives Issued Signature Of Team Leader:

Item	Quantity	Lot Number	Checkers Initials

Explosives Expended Signature Of Team Leader

Item	Quantity	Lot Number	Checkers Initials

Explosives Returned Signature Of QC Officer:

Item	Quantity	Lot Number	Checkers Initials

The signatures in each section of this document indicate that the items listed in that section were in fact issued, expended, or returned to storage and that the quantities listed were verified through a physical count.

Figure 2: Explosives Usage Record

STANDARD OPERATING PROCEDURE
OPS-08 – EXPLOSIVES AND AMMUNITION TRANSPORTATION

1.0 PURPOSE

The purpose of this Explosives and Ammunition Transportation Standard Operating Procedure (SOP) is to provide the minimum procedures and safety and health requirements applicable to the transportation of explosives and unexploded ordnance (UXO) or munitions and explosives of concern (MEC).

The following USA Environmental, Inc. (USA) policies are not all inclusive nor are they applicable in all situations. This SOP is not a stand-alone document and is to be used together with the Work Plan, Site Safety and Health Plan, applicable Federal, State, and local regulations, and contract restrictions and guidance.

2.0 SCOPE

This SOP applies to all site personnel, including contractor and subcontractor personnel, involved in the conduct of operations on a site with UXO/MEC contamination. This SOP is not intended to contain all of the requirements needed to ensure compliance. Consult the documents listed in Section 6.0 of this SOP for additional compliance issues.

3.0 TRANSPORTATION REQUIREMENTS FOR EXPLOSIVES AND MEC

Transportation of munitions and explosives of concern (MEC) and explosives will comply with all Federal, State, and local regulations. Permits are not required under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for on-site or on Federal Installation transportation of explosives or MEC. Off-site shipment of MEC will be made using commercial carriers approved to transport ammunition and explosives (Hazard Class A and B). For off-site shipment:

- MEC will be packaged in accordance with 49 CFR part 173.
- Drivers will be provided with DD Form 836 (Special Instructions for Motor Vehicle Drivers).
- Vehicles will be inspected using DD Form 626, Motor Vehicle Inspection, and be properly placarded.
- Compatibility requirements will be observed.
- The load will be well braced and, except when in closed vans, covered with a fire-resistant tarpaulin.

4.0 FEDERAL INSTALLATIONS/ON SITE

USA will transport explosives in an on site vehicle and Institute of Makers of Explosives (IME) -22 containers for transportation of explosives to the disposal sites while using public access roads When transporting explosives personnel will comply with the following:

- Initiating explosives, such as blasting caps, will remain separated at all times. Blasting caps may be transported in the same vehicle as long as they are in a separate IME-22 container (49 CFR 173.63) and secured away from other items;
- Vehicles will be inspected using DD Form 626, Motor Vehicle Inspection or USA inspection form at attachment 1, and be properly placarded.
- Compatibility requirements will be observed;

- Only UXO Technicians III and above may be issued and transport explosive materials. The receiving party shall sign the receipt documents for accountability;
- Operators transporting Hazard Division (49 CFR 173.50) 1.1 explosives will have a valid drivers license;
- Drivers will comply with posted speed limits but will not exceed a safe and reasonable speed for conditions. Vehicles transporting explosives off-road will not exceed 25 miles per hour and will be properly equipped; and
- Personnel will not ride in the cargo compartment with explosives or MEC

5.0 SUMMARY

Transportation of explosives presents risks to both the vehicle operator and the surrounding populace. The procedures contained in this SOP are designed to eliminate and/or mitigate these risks. Personnel engaged in these activities will strictly comply with these procedures and those contained in the referenced documents.

6.0 REFERENCES

Procedures and information contained in this document were obtained from the references listed below:

- USA Corporate Safety and Health Program (CSHP)
- DOD 4145.26-M, Contractors' Safety Manual for Ammunition and Explosives
- DOD 6055.9-STD, Department of Defense (DoD) Ammunition and Explosives Safety Standards
- DOD 4160.21-M, Defense Reutilization and Marketing Manual
- DOT, 49 CFR Parts 100 to 199, Transportation (applicable sections)
- 27 CFR Part 55, Commerce in Explosives
- 29 CFR 1910, Occupational Safety and Health Standards
- 29 CFR 1926, Construction Standards
- EPA, 40 CFR Parts 260 to 299, Protection of Environment (applicable sections)
- BATF 5400.7, Bureau of Alcohol, Tobacco, and Firearms Explosives Laws and Regulations
- USACE EM 385-1-1, Safety and Health Requirements Manual
- TM 9-1300-200, Ammunition General
- TM 9-1300-214, Military Explosives
- TM 60 Series Publications

ATTACHMENT 1

Explosive Vehicle Inspection, ON-SITE

This form must be filled out for any vehicle carrying explosives, prior to loading.
This form is for use on site only, if traveling on public highways use DD Form 626

DRIVERS NAME _______ LICENSE NUMBER _______
COMPANY _______
TYPE OF VEHICLE _______ VEHICLE NUMBER _______
INSPECTION DATE/TIME _______ INSPECTOR _______

PART INSPECTED	SAT.	UNSAT.	COMMENT
HORN			
STEERING SYSTEM			
WIPERS			
MIRRORS			
FIRE EXTINGUISHERS (10 ABC, 2 EACH)			
REFLECTORS			
EMERGENCY FLASHERS			
LIGHTS			
ELECTRIC WIRING			
FUEL SYSTEM			
EXHAUST SYSTEM			
BRAKE SYSTEM			
SUSPENSION			
CARGO SPACE			
TIRES, WHEELS, RIMS			
TAILGATE			
TARPAULIN			

INSPECTION RESULTS (INSPECTOR INITIAL) ACCEPTED _______

REJECTED _______

REMARKS _______________________________________

DRIVERS SIGNATURE/DATE _______ INSPECTORS SIGNATURE/DATE _______

STANDARD OPERATING PROCEDURE – OPS-09
FORKLIFT OPERATION

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide all USA Environmental, Inc. (USAE) employees and subcontractors the minimum safety and health requirements and procedures applicable to the operation of a forklift.

2.0 SCOPE

This SOP contains information specific to forklift operations. It may also include manuals and publications relevant to forklifts that may be leased, purchased, or otherwise employed on the site. It is incumbent upon all designated operators to familiarize themselves with this SOP and to periodically review it an effort to remain current with safe, productive forklift procedures.

3.0 OPERATIONS

USAE employees who operate forklifts on the project site will be qualified through classroom and practical training. When engaged in forklift operations the operator will perform daily inspection and maintenance functions and operate the forklift as directed. They may also conduct OJT of other operators at the Senior UXO Supervisor (SUXOS) discretion.

3.1 PERSONNEL PROTECTIVE EQUIPMENT

Level D personal protective equipment (PPE) will be required for personnel engaged in forklift operations. Minimum PPE items will include:

- Coveralls or work clothing as prescribed
- Work gloves, leather or canvas, as appropriate
- Safety glasses - as wind conditions and airborne particulate matter dictates
- Hardhats
- Work Boots: Sturdy and of sufficient height to aid in ankle support with safety toe
- Hearing Protection: Noise Attenuating Helmet or earplugs will be worn by anyone within 25 feet of the forklift while it is operating
- Dust Mask (P100) - as wind conditions and airborne particulate matter dictates

The level of PPE may be modified or increased if additional hazards are anticipated or encountered due to task or environmental changes.

3.2 GENERAL SAFETY PRECAUTIONS

The following safety precautions and distances will be observed when operating a forklift on the project site:

- Personnel will conform to the approved safe separation distance for the task being performed by other personnel and/or will maintain 50 feet from other UXO personnel conducting manual operations.

- Personnel will know and observe all applicable MEC/UXO safety precautions.
- Personnel will know and use appropriate hand signals.

The distances provided above may be reduced or extended by the U.S. Army Corps of Engineers (USACE) OE Safety Specialist or UXO Safety Officer, based on an assessment of site history, expected MEC/UXO, terrain features or other such factors that may apply. The forklift will not be operated without a spotter. This includes movement of the tines, sling, or drum attachments, and backing of the forklift. Prior to anyone entering the forklift work area, the operator will:

1. Acknowledge the persons presence
2. Ensure a safe distance and speed is maintained
3. Stop the forklift and return the engine to idle speed
4. Hold his/her hands clear of the controls or in the "Hands Up" position if personnel enter within the work area of the forklift without permission

3.3 EQUIPMENT SAFETY PRECAUTIONS AND CHECKLIST

Review the Operator's Manual for specific equipment precautions, Review the Checklist-Forklift General listed below for operational guidance. Complete the Operational Checklist prior to commencing operations.

3.4 TEAM COMPOSITION

The UXO Technician III will serve as a safety observer and director for other team personnel during forklift operations. All members of the work team will be UXO qualified. The minimum team make-up will include:

- One Operator
- One UXO Technician III

3.5 GROUND PERSONNEL

Team members working on a forklift operation will be briefed on all tasks related to the operation and will perform such tasks in a safe, competent, and vigilant manner.

3.6 TRAINING

Only qualified personnel will operate equipment on the project site. USAE employees who operate forklifts on the project site will be qualified through classroom and practical training. This documented training may be through USAE or through previous employment. Training will be documented on appropriate forms, certificates issued, and copies maintained for inspection and review.

3.7 GENERAL OPERATIONAL PROCEDURES

The operator will have a radio in place so he/she can communicate/monitor radio transmissions while driving the forklift to and from various locations on site. Prior to shutting off the forklift engine the operator should let the engine run at idle speed for a few minutes to allow the engine to cool.

Prior to forklift operations the UXO Technician III shall establish/review hand signals with all members of the team. The forklift shall not be used in a manner not consistent with safe operations, manufacturer's intent, or beyond equipment capabilities.

Operators will follow safe work practices when engaged in starting, loading, moving, unloading, parking, and refueling the forklift.

Operators will ensure that attachments are designed for the forklift in use, are safe to use, and have been properly installed.

Containers must be properly opened, inspected, closed, labeled, and placed on a serviceable pallet and banded before placement or loading for off-site shipment.

Movement of containers will only occur after:

- The containers have been inspected by competent authority
- The containers new location has been determined
- There are no un-authorized personnel or activities in the area
- The spotter is available and communications have been established
- Permission has been received from the UXO Technician III to begin movement

4.0 SUMMARY

This SOP is designed for USAE personnel who have the responsibility of operating a forklift on project sites. The information contained within this SOP is not all inclusive. It requires personnel to follow safe work practices, observe safety precautions, maintain levels of PPE, be trained in forklift operations, and follow the requirements found within the manufacturer's and operator's manuals.

5.0 ATTACHMENTS

- Forklift Checklist

FORKLIFT CHECKLIST

Before Starting a Forklift:

- Check that brakes, controls, gauges, and other mechanisms work properly.
- Check for leaks.
- Check that forks aren't bent, damaged, or cracked.
- Report any problems so that they can be handled by trained, authorized mechanics.
- Check load capacity-and stay within it.
- Be sure that truck is rated for planned use and area.
- Check planned route for adequate lighting and headroom.
- Note any floor-surface problems or possible obstructions in planned route. Remove if possible; otherwise, proceed with extra caution.

General Safety Precautions:

- Operate a forklift only if you're trained and authorized.
- Always use seat belts.
- Wear hard hats and any other required protective gear.
- Keep arms, hands, and legs inside the forklift.
- Never indulge in horseplay or stunt-driving.
- Never allow an unauthorized person on a forklift.
- Don't allow anyone to stand or pass under the elevated portion of a truck, even if it's empty.
- Never drive a truck up to a person standing in front of a fixed object.

Loading a Forklift:

- Be sure load is within truck's rated capacity.
- Set forks high and wide to go under load.
- Drive into loading position and place load squarely on forks.
- Drive under load until it touches carriage slightly.
- Be sure load is stable and centered.
- Stack and/or tie loose or uneven loads.
- Tilt mast back and lift the load; tilt mast back a little more before traveling.

Operating a Forklift:

- Obey plant speed limits and all other traffic regulations.
- Drive in designated lanes.
- Keep a three-truck distance from other vehicles.
- Keep a clear view of route; if load blocks view, drive in reverse (except up a slope).

- Drive loaded truck with forks 6 to 8 inches above the ground, and the load low and tilted back.
- Don't raise or lower loads while moving.
- Don't carry anything on the overhead guard.
- Slow down, stop, and sound the horn at intersections or any place you can't see well.
- Use vehicle, wall, and ceiling mirrors to help see around corners.
- Yield right-of-way to pedestrians and emergency vehicles, and stay out of pedestrian lanes.
- Don't pass vehicles at intersections, blind spots, or other dangerous locations.
- Keep a safe distance from the edge of elevated ramps or platforms.
- Slow down on wet, slippery, or uneven surfaces and before making turns.
- Avoid sharp turns that could tip the truck.
- Avoid driving over loose objects.
- Try to cross railroad trucks diagonally.
- Drive slowly and carefully over dockboards and bridgeplates, and only when load doesn't exceed their rated capacity.
- Slow down on slopes and point load uphill if the grade is more than 10 percent. Raise load only enough to clear the surface.

Unloading a Forklift:

- Turn forklift slowly into position.
- Go straight into trailers or railcars.
- If unloading onto stakebed, flat bed, or box trailer, be sure the rear wheels are chocked, brakes locked on, and dock plate secure. Then position load, tilt it forward, and release it.
- If unloading onto rack or stack, check maximum safe stack height. Then raise and position load to correct height and move it slowly into position. Tilt load forward, lower onto rack or stack, pull forks back slowly. Then back out slowly, looking over your shoulder.

Parking a Forklift:

- Select flat parking surface, away from traffic and not blocking aisles, doors, exits, etc.
- When leaving truck unattended (or if you'll be 25 or more feet from it):
- Fully lower load-engaging means, neutralize controls, shut off power, set brakes, remove key.
- Block wheels if parked on an incline.

Refueling a Forklift:

- Turn off engine.
- Refuel in assigned, ventilated area containing nothing that could cause fire or explosion.
- Have fire extinguishers and cleanup materials available.
- Don't smoke!
- Use acid-resistant material-handling equipment and wear corrosion-resistant personal protective clothing and equipment during battery changing.
- Remove battery cap slowly and leave open.
- Pour acid into water, not water into acid.
- Follow manufacturer's instructions for gasoline or propane fueling.
- Don't use open flame to check fuel level.
- Try to prevent spills, clean any spills promptly, and replace cap on tank before starting truck.

STANDARD OPERATING PROCEDURE – OPS-11
HAND AND POWER TOOL OPERATION

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide all USA Environmental, Inc. (USAE) employees and subcontractors with the minimum safety and health requirements and procedures applicable to the conduct of operations involving the use of power and hand tools.

2.0 SCOPE

This SOP applies to all site personnel, to include contractor and subcontractor personnel, involved in the conduct of operations that require the use of power and hand tools. This SOP is not intended to contain all the requirements needed to ensure regulatory compliance. Consult the documents listed in Section 5.0 of this SOP for additional compliance issues.

3.0 RESPONSIBILITIES

3.1 PROJECT MANAGER

The Project Manager (PM) shall be responsible for ensuring the availability of the resources needed to implement this SOP, and shall also ensure that this SOP is incorporated into plans, procedures, and training for sites where this SOP is to be implemented.

3.2 SENIOR UXO SUPERVISOR

The Senior Unexploded Ordnance Supervisor (SUXOS) will ensure that this SOP is trained and implemented for power and hand tool operations. The SUXOS will also ensure that relevant sections of this SOP are discussed in the tailgate safety briefings, and that information related to its daily implementation is documented in the Site Daily Operational Log.

3.3 UXO TECHNICIAN III

The UXO Technician III (UXOTIII) shall be responsible for the field implementation of this SOP and for implementing the safety and health requirements outlined in section 4.0 of this SOP. In the absence of a SUXOS, the UXOTIII shall be responsible for implementing the SUXOS'S responsibilities.

3.4 UXO SAFETY OFFICER

The UXO Safety Officer (UXOSO) will be responsible for ensuring that the safety and health hazards and control techniques associated with this SOP are discussed during the initial site hazard training and the daily tailgate safety briefings. The UXOSO will also be responsible for daily inspection of site operations and conditions to ensure their initial and continued compliance with this SOP and other regulatory guidelines.

4.0 PROCEDURE

All personnel, including contractor and subcontractor personnel, involved in power and hand tool operations shall be familiar with the potential safety and health hazards associated with their usage, and with the work practices and control techniques to be used to reduce or eliminate those hazards.

4.1 SAFETY AND HEALTH OPERATIONAL CONTROL TECHNIQUES

4.1.1 POWER TOOLS

Power tools have great capability for inflicting serious injury upon personnel, if they are not used and maintained properly. To control the hazards associated with power tool operation, the safe work practices listed below shall be observed when using power tools:

- Operation of power tools shall be conducted by authorized personnel familiar with the tool, its operation, and the manufacturer's recommended safety precautions.
- Power tools shall be inspected prior to use, and defective equipment shall be removed from service until repaired.
- Power tools designed to accommodate guards shall have such guards properly in place.
- Loose fitting clothing or long hair shall not be permitted around moving parts.
- Hands, feet, and other appendages shall be kept away from all moving parts.
- Maintenance and/or adjustments to equipment shall not be conducted while it is in operation or connected to a power source.
- An adequate operating area shall be provided, allowing sufficient clearance for operation.
- Good housekeeping practices shall be followed at all times.

4.1.2 HAND TOOLS

Use of improper or defective tools can contribute significantly to the occurrence of accidents on site. Therefore, the work practices listed below shall be observed when using hand tools:

- Hand tools shall be inspected for defects prior to each use.
- Defective hand tools shall be removed from service and repaired or properly discarded.
- Tools shall be selected and used in the manner for which they were designed.
- Be sure of footing and grip before using any tool.
- Do not use tools that have split handles, mushroom heads, worn jaws, or other defects.
- Gloves shall be worn to increase gripping ability and/or if cut, laceration, or puncture hazards exist during the use of the tool.
- Safety glasses or a face shield shall be used, if the use of tools presents an eye/face hazard.
- Do not use makeshift tools or other improper tools.
- When working overhead, tools shall be secured to prevent them from falling.
- Use non-sparking tools in the presence of explosive vapors, gases, or residue.
- If hand tools become contaminated, they must be properly decontaminated, bagged, marked, and held for disposition by the UXOSO.
- Tools used in the exclusion zone that have porous surfaces, such as wooden or rubber coated handles, shall be discarded as contaminated upon termination of site activities, unless testing can prove the absence of contamination.

4.2 SAFETY AND PERSONAL PROTECTIVE EQUIPMENT (PPE) REQUIREMENTS

In accordance with the personal protective equipment (PPE) SOP, the following safety measures and PPE shall be used in preventing or reducing exposures associated with power and hand tool operations. These requirements will be implemented, unless superseded by specific requirements stated in the Site Safety and Health Plan (SSHP).

- Hard hat and safety boots shall be worn when working with power or hand tools.
- Safety glasses with side shields shall be worn at all times when operating, servicing, or working around hand or power tools.
- Hearing protection shall be worn if hand/power tool operation has the potential for noise exposures greater than 85 dBA Time Weighted Average.
- Leather, or other protective, gloves shall be worn when using hand/power tools.
- Protective face shields shall be worn for all operations that have the potential for generating flying fragments, objects, chips, particles, or similar.

5.0 REFERENCES

The following Occupational Safety and Health Administration (OSHA) standards and U.S. Army Corps of Engineers (USACE) requirements directly apply to the conduct of operations associated with this SOP. In the event that other hazards are associated with the conduct of this SOP, consultation of other SOPs and regulatory references may be needed:

- OSHA Construction Standard 29 CFR, Part 1910, Subpart O
- OSHA General Industry Standard 29 CFR, Part 1926, Subpart I
- USACE Engineer Manual 385-1-1, Section 13

STANDARD OPERATING PROCEDURE
OPS-12 – HEAVY EQUIPMENT OPERATION

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide all USA Environmental, Inc. (USA) employees and subcontractors with the minimum safety and health requirements and procedures applicable to the conduct of operations involving the use of heavy equipment.

2.0 SCOPE

This SOP applies to all site personnel, to include contractor and subcontractor personnel, and operations involved in the conduct of heavy equipment operations. This SOP is not intended to contain all requirements needed to ensure regulatory compliance. Consult the documents listed in Section 5.0 of this SOP for additional compliance issues.

3.0 RESPONSIBILITIES

3.1 PROJECT MANAGER

The Project Manager (PM) will be responsible for ensuring the availability of the resources needed to implement this SOP, and will also ensure that this SOP is incorporated into plans, procedures, and training for sites where this SOP is to be implemented.

3.2 SENIOR UXO SUPERVISOR

The Senior Unexploded Ordnance Supervisor (SUXOS) will ensure that this SOP is implemented for heavy equipment operations. The SUXOS will also ensure that relevant sections of this SOP are discussed in the tailgate safety briefings, and that information related to its daily implementation is documented in the Site Operational Log.

3.3 UXO TECHNICIAN III

The UXO Technician III (UXOTIII) will be responsible for the field implementation, of this SOP and for implementing the safety and health requirements outlined in Section 4.0 of this SOP. In the absence of a SUXOS, the UXOTIII will be responsible for implementing the SUXOS's responsibilities outlined in Paragraph 3.2.

3.4 UXO SAFETY OFFICER

The UXO Safety Officer (UXOSO) will be responsible for ensuring that the safety and health hazards and control techniques associated with this SOP are discussed during the initial site hazard training and the daily tailgate safety briefings. The UXOSO will also be responsible for daily inspection of site operations and conditions to ensure their initial and continued compliance with this SOP and other regulatory guidelines.

4.0 PROCEDURE

All personnel, including contractor and subcontractor personnel, involved in heavy equipment operations will be familiar with the potential safety and health hazards associated with the conduct of this operation, and with the work practices and control techniques to be used to reduce or eliminate these hazards. In the event that ordnance and explosives are present at the work site, the procedures for anomaly avoidance and soil excavation will be presented in the Work Plan and Site Safety and Health Plan (SSHP).

4.1 SAFETY HAZARDS AND OPERATIONAL CONTROL TECHNIQUES

The operational control techniques to be used during conduct of heavy equipment operations are discussed below:

- The operation of heavy equipment will be limited to authorized personnel specifically trained in its operation.
- A competent person will visually inspect heavy equipment daily prior to operation, and report any abnormalities/deficiencies to the UXOSO.
- The operator will use the safety devices provided with the equipment, including seat belts and backup warning indicators, and horns will be operable at all times.
- While in operation, all personnel not directly required in the area will keep a safe distance from the equipment.
- The operator's cab will be kept free of all non-essential items, and all loose items will be secured.
- Personnel will avoid moving into the path of operating equipment, and areas blinded from the operator's vision will be avoided.
- Heavy equipment requiring an operator will not be permitted to run unattended.
- Except for equipment designed to be serviced while in operation, all equipment will be shut down and positive means taken to prevent its operation while repair or servicing is being conducted.
- All equipment will be secured at the end of the day, or when not in operation, with the blades/buckets of earth-moving equipment placed on the ground.
- Equipment operated on the highway will be equipped with turn signals visible from the front and rear.
- Stationary machinery and equipment will be placed on a firm foundation and secured before being operated.
- All points requiring lubrication during operation will have fittings so located or guarded as to be accessible without hazardous exposure.
- Mobile-type equipment operating within an off-highway job site not open to public traffic will have a service brake system and a parking brake system capable of stopping and holding the equipment fully loaded on the grade of operation.
- Heavy equipment will be shut down prior to and during fueling operations.
- All equipment with windshields will be equipped with powered wipers and equipment that operates under conditions that cause fogging or frosting of windshields will be equipped with operable defogging or defrosting devices.
- Whenever the equipment is parked, the parking brake will be set, and equipment parked on inclines will have the wheels chocked or track mechanism blocked and the parking brake set.
- Personnel will not work or pass under the buckets or booms of loaders in operation.
- Each bulldozer, scraper, drag-line, crane, motor grader, front-end loader, mechanical shovel, backhoe, dump truck, and other similar equipment will be equipped with at least one dry chemical fire extinguisher having a minimum Underwriters Laboratories (UL) rating of 5-B:C.
- When heavy equipment must negotiate in tight quarters, or if operators of earth-moving equipment cannot see the bucket, a secondary person will be stationed to guide the operator.
- Additional riders will not be allowed on equipment, unless it is specifically designed for that purpose (i.e., there is an additional seat with a seat belt).

4.2 SAFETY AND PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS

The following safety measures and personal protective equipment (PPE) will be used in preventing or reducing exposures associated with heavy equipment operations. These requirements will be implemented, unless superseded by site-specific requirements stated in the SSHP.

- Heavy equipment operators will have received training which addresses the safe operation of the equipment to be used.
- Heavy equipment operators will wear the level of PPE as specified in the SSHP.

5.0 REFERENCES

The following Occupational Safety and Health Administration (OSHA) standards and U.S. Army Corps of Engineers (USACE) requirements directly apply to the conduct of operations associated with the SOP. In the event that other hazards are associated with the conduct of this SOP, consultation of other SOPs and regulatory references may be needed:

- OSHA Construction Industry Standard 29 CFR, Part 1926, Subpart O (applicable parts)
- OSHA General Industry Standard 29 CFR, Part 191, Subpart N (applicable parts)
- USACE Engineer Manual 385-1-1, Section 16.

OPS 13- MPPEH MANAGEMENT

1. PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide procedures that ensure that interior and exterior of all recovered MPPEH is inspected to determine what explosive hazard, if any exist, requiring further treatment before shipping off site for final treatment. These procedures are general in nature and may be refined with the concurrence of the Senior UXO Supervisor (SUXOS) to adapt to specific site conditions and circumstances.

2. SCOPE

These procedures will be conducted in accordance with the Work Plan, the Site Health and Safety Plan (SHSP) and the Explosives Safety Submission (ESS). This SOP provides the MPPEH management process that describes the inspection, storage, certification/verification procedures, and the chain of custody requirements for materials documented as safe (MDAS) slated for shipment to an authorized recycler. Specific requirements for personnel, training, equipment/material, surface search, and documentation are found in the Work Plan (WP).

3. INSPECTION PROCESS

All recovered MPPEH items will undergo a 100% inspection and an independent 100% re-inspection to determine and document whether it is safe (MDAS) or whether it is known to have or is suspected of having an explosive hazard [material documented as an explosive hazard (MDEH)]. The sequence of events in the inspection process is summarized in Figure 1. A Material Inspection and Release Form (Attachment 2) will be completed to document the two 100% inspections performed on all recovered materials.

A UXOTII (a UXOTI can tentatively identify items, however, a UXOTII or UXOTIII must confirm the identification) will perform a 100% inspection of each item as it is recovered and determine:

- If the item is MDAS, requiring no additional treatment prior to containerizing for off-site shipment
- If the item is MDEH that requires additional treatment (demilitarization, i.e. detonation or venting to expose a dangerous filler)
- If item is range related debris that may require draining fluids or removal of visible liquid hazardous, toxic or radiological waste (HTRW) materials.

A UXOTIII will:

- Conduct a 100% re-inspection of all recovered items to determine the proper classification as MDAS, MDEH or an item containing other dangerous fillers or HTRW constituents.
- Supervise the segregation of items by category to ensure no co-mingling of MDAS and MDEH or HTRW items.

The UXOQCS will:

- Conduct daily audits of UXO Teams performing the MPPEH inspection process and will conduct and document random sampling of all processed MDAS, MDEH and HTRW items to ensure no co-mingling occurs.

The UXOSO will:

- Ensure specific procedures and responsibilities for processing MPPEH for certification as MDAS MDEH or range-related debris outlined in the WP and this SOP are being followed
- Ensure all procedures for processing are being performed safely and consistent with applicable regulations.

The SUXOS will:

- Perform random checks to determine that the munitions debris and range-related debris are free from explosive hazards necessary to complete the appropriate Requisition and Turn-in Document, DD Form 1348-1A (see Attachment 1)
- Ensure that a DD Form 1348-1A is completed for all MDAS and range-related debris to be transferred for final disposition
- Ensure the WP, QC Plan and this SOP outline the procedures and responsibilities for processing MPPEH for final disposition as MDAS or range-related debris
- Certify all MDAS and range-related debris with one of the following statements as applicable –

  "This certifies that the material listed has been 100 percent properly inspected and, to the best of our knowledge and belief, are free of explosive hazards, engine fluid, illuminating dials and other visible liquid HTRW materials."[1]

  "This certifies and verifies that the material listed has been 100 percent inspected and to the best of our knowledge and belief, are inert and/or free of explosives or related materials."[2]

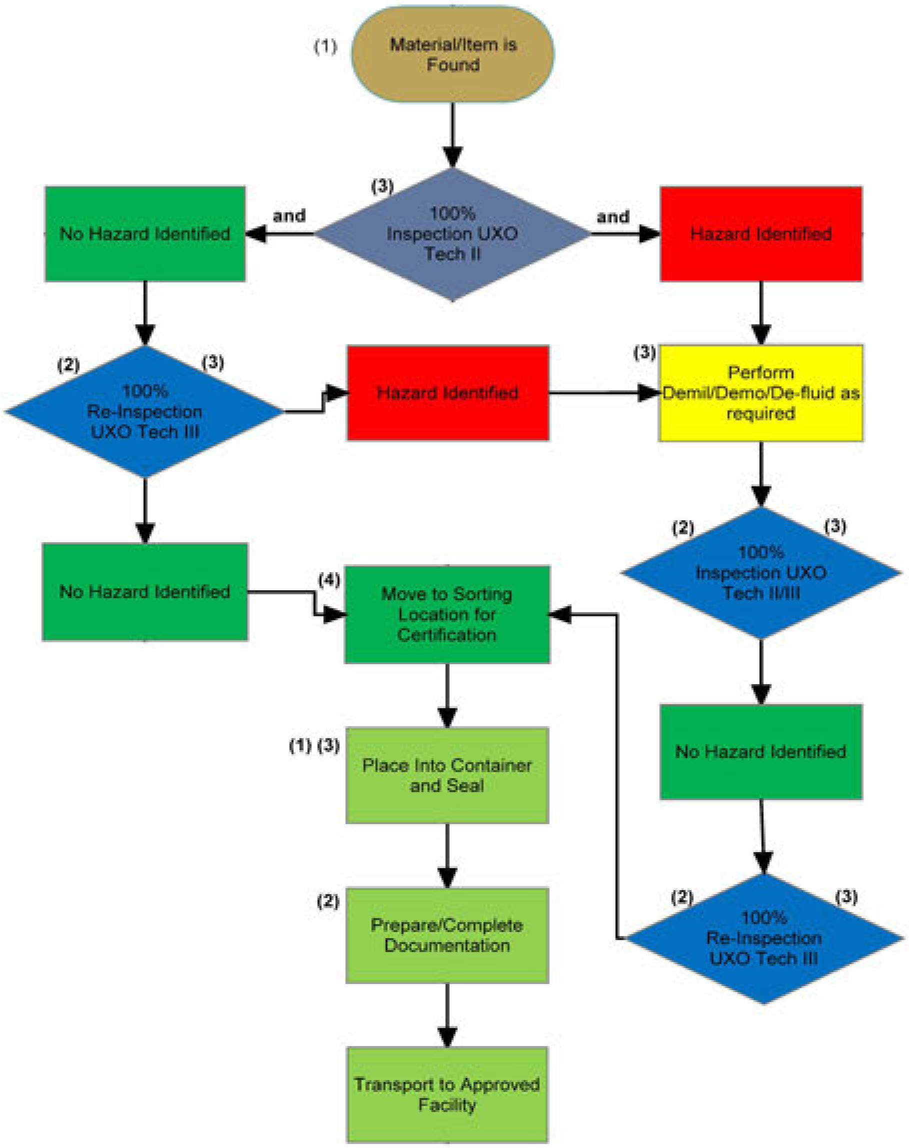
- Ensure that inspected debris is secured in sealed and labeled containers.

This space is intentionally left blank.

[1] This statement will be used on any ranges where range-related debris is being processed along with munitions debris

[2] This statement will be used for properties where only munitions debris is being processed

Figure 1: MPPEH INSPECTION PROCESS



Notes:

During performance of the steps within the MPPEH Inspection Process, Notes 1 - 4 below are utilized to ensure supervision and compliance requirements are met.

(1) The UXOQCS will conduct daily audits of procedures used by UXO teams for MPPEH processing

(2) The UXOQCS will perform random sampling of recovered material/items and documents for accuracy/completeness

(3) The UXOSO will observe procedures to ensure compliance with the approved plans and safety measures

(4) The SUXOS will perform random checks to satisfy that the munitions debris and range-related debris is free from explosive hazards necessary to complete DD Form 1348-1A

4. MDAS CONTAINERIZATION

MDAS is placed in closed containers that will be sequentially number and:

- Closed in such a manner that the applied seal will be broken if the container is opened
- Clearly labeled with USA Environmental, Inc., the installation/project name, the sequence number (e.g. 0001), and the container's unique seal identification, see Attachment 3 for detailed requirements for completing the label

5. MDAS CERTIFICATION AND VERIFICATION

The SUXOS will certify the MDAS by preparing and signing the DD Form 1348-1A for all shipments of recovered materials as discussed in Section 3 above. The designated government representative will verify the shipments if available, otherwise the shipment verification is delegated to the UXOQCS.

The 1348-1A will contain the appropriate statement as mentioned in Section 3 and prepared to provide the required information as shown in Attachment 1.

6. MAINTAINING THE CHAIN OF CUSTODY

The chain of custody must remain intact until the MDAS is released from DOD control that is received and signed for by the qualified receiver to further manage and process the material in accordance with DOD Instruction 4140.62. The qualified receiver will:

- Receive the unopened labeled containers
- Review and concur with the supporting documents
- Sign the 1348-1A and provide on company letterhead stating the contents of the sealed containers will not be sold, traded or otherwise given to another party prior to smelting and are only identifiable by their basic contents
- Send the supporting documentation and notification to USA that the MDAS in the sealed containers has been smelted and is only identifiable by its basic content.

If the chain of custody is broken at any time during shipment, the contents of the affected container will revert to MPPEH and will require a second 100% inspection and a 100% re-inspection, be documented as certified and verified as MDAS by qualified USA personnel.

ATTACHMENT 1.
DD FORM 1348-1A EXAMPLES

DD FORM 1348-1A, JUL 91 (EG) ISSUE RELEASE/RECEIPT DOCUMENT

PREVIOUS EDITION MAY BE USED

1. TOTAL PRICE	UNIT PRICE: DOLLARS / CTS; TOTAL PRICE: DOLLARS / CTS
2. SHIP FROM	3. SHIP TO
4. MARK FOR	
5. DOC DATE	6. NMFC
7. FRT RATE	8. TYPE CARGO
9. PS	10. QTY. REC'D
11. UP	12. UNIT WEIGHT
13. UNIT CUBE	14. UFC
15. SL	16. FREIGHT CLASSIFICATION NOMENCLATURE
17. ITEM NOMENCLATURE	
18. TY CONT	19. NO CONT
20. TOTAL WEIGHT	21. TOTAL CUBE
22. RECEIVED BY	23. DATE RECEIVED

DOC IDENT; RI FROM; M&S; UNIT ISS; QUANTITY; SERV; SUPPLEMENTARY ADDRESS; SIG; FUND; DISTRIBUTION; PROJECT; PRI; REQD DATE; ADV; RI; O/P; COND; MGT

24. DOCUMENT NUMBER & SUFFIX (30-44)

25. NATIONAL STOCK NO. & ADD (8-22)

26. RIC (4-6) UI (23-24) QTY (25-29) CON CODE (71) DIST (55-56) UP (74-80)

27. ADDITIONAL DATA

Basic Material Content: ____________________

Estimate Weight (lbs): ____________

Container ID No.: __________________ Seal ID No.: __________________

Site Address: ____________________

____

Site Telephone No.: ____________________

This certifies and verifies that the material listed has been100 percent inspected and to the best of our knowledge and belief, are inert and/or free of explosives or related materials.

Certify By: Verify By:

______________________ Date:____________ ______________________ Date: ____________

Senior UXO Supervisor / Team Leader USACE OE Safety Specialist

USA Environmental, Inc., 720 Brooker Creek Boulevard, Suite 204, Oldsmar, Florida 34677, Telephone: 813.343.6336, Fax: 813.343.637

PerFORM (DLA)

Reset

DD Form 1348-1A: FOR USE FOR PROPERTIES WHERE ONLY MUNITIONS DEBRIS IS BEING PROCESSED

DD FORM 1348-1A, JUL 91 (EG) ISSUE RELEASE/RECEIPT DOCUMENT

1. TOTAL PRICE (DOLLARS / CTS)	2. SHIP FROM	3. SHIP TO
UNIT PRICE (DOLLARS / CTS)	4. MARK FOR	

DOC IDENT | RI FROM | M&S | UNIT ISS | QUANTITY | SER | SUPPLEMENTARY ADDRESS | SIG | FUND | DISTRIBUTION | PROJECT | PRI | REQD DEL DATE | ADV | RI | O/P | COND | MGT

24. DOCUMENT NUMBER & SUFFIX (30-44)

25. NATIONAL STOCK NO. & ADD (8-22)

26. RIC (4-6) UI (23-24) QTY (25-29) CON CODE (71) DIST (55-56) UP (74-80)

27. ADDITIONAL DATA

Basic Material Content: ____________________

Estimate Weight (lbs): ____________

Container ID No.: ______________ Seal ID No.: ______________

Site Address: ____________________

____

Site Telephone No.: ____________________

5. DOC DATE	6. NMFC	7. FRT RATE	8. TYPE CARGO	9. PS	
10. QTY. REC'D	11. UP	12. UNIT WEIGHT	13. UNIT CUBE	14. UFC	15. SL
16. FREIGHT CLASSIFICATION NOMENCLATURE					
17. ITEM NOMENCLATURE					
18. TY CONT	19. NO CONT	20. TOTAL WEIGHT	21. TOTAL CUBE		
22. RECEIVED BY			23. DATE RECEIVED		

This certifies that the material listed has been 100 percent properly inspected and, to the best of our knowledge and belief, are free of explosive hazards, engine fluids, illuminating dials and other visible liquid HTWR materials.

Certify By: Verify By:

______________________ Date: __________ ______________________ Date: __________

Senior UXO Supervisor / Team Leader USACE OE Safety Specialist

USA Environmental, Inc., 720 Brooker Creek Boulevard, Suite 204, Oldsmar, Florida 34677, Telephone: 813.343.6336, Fax: 813.343.637

PREVIOUS EDITION MAY BE USED

PerFORM (DLA)

Reset

DD Form 1348-1A: FOR USE WHERE RANGE-RELATED DEBRIS IS PROCESSED WITH MUNITIONS DEBRIS

ATTACHMENT 2.
MATERIAL INSPECTION AND RELEASE FORM

USA 100% MATERIAL INSPECTION AND RELEASE FORM

Project:		Document Date:
Location:		Document Number:

Container Number:	Seal #:	Initials 1st:	Initials 2nd:	Reseal #:	Initials 1st:	Initials 2nd:	Comments:

The above listed containers have received two separate 100% inspections to ensure proper classification of material.
A copy of this form is to accompany the listed containers to final disposition and be retained for a period of 3 years.
This form is used to document the inspections performed by two UXO qualified personnel, one of whom must be a Technician III or higher.
This form is not to be used in place of other required documents for the transportation and/or accountibilty of material.

Name of First 100% Inspector:	Title:	Date:
Name of Second 100% Re-Inspector:	Title:	Date:

ATTACHMENT 3.
NON-HAZARDOUS WASTE (CONTAINER LABEL)

NON-HAZARDOUS WASTE

Solid Waste Excluded From Regulation Under 40 CFR 261.4 (b)

SHIPPER: USA Environmental, Inc.

PROJECT ADDRESS / LOCATION:

CITY, STATE, ZIP:

PROJECT CONTACT AND TELEPHONE NUMBER:

USACE IDENTIFIER / INSTALLATION NAME OR CONTRACT #:

UNIQUE CONTAINER # (i.e., 0001 of 0001): of

UNIQUE SEAL IDENTIFICATION #:

Date:	Seal Number:	1st Initials:	2nd Initials:	Comments:

☐ **DD Form 1348-1A** ☐ **100% Material Inspection and Release Form**

**NOTE: See DD Form 1348-1A For Additional Information.
Check box(s) if DD Form 1348-1A and/or the 100% Inspection Form will accompany this shipment.**

CONTACT INFORMATION: **USA Environmental, Inc.
720 Brooker Creek Blvd., Suite 204
Oldsmar, FL. 34677
(813) 343-6336**

CONTAINER LABEL

STANDARD OPERATING PROCEDURE – OPS-14
MEC ANALOG DETECTION AND REMOVAL ACTIONS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide all USA Environmental, Inc. (USAE) employees and subcontractors with the minimum procedures and safety and health requirements applicable to the conduct of analog detection and removal actions (mag and dig) at sites potentially containing unexploded ordnance (UXO) and/or munitions and explosives of concern (MEC).

2.0 SCOPE

This SOP applies to all USAE site personnel, including contractor and subcontractor personnel, involved in the conduct of analog detection and removal actions (mag and dig) on a UXO/MEC contaminated site. The following USAE policies and procedures are not all inclusive nor are they applicable in all situations. This SOP is not a stand-alone document and is to be used together with Work Plans, other USAE SOPs, the USAE Site Safety and Health Plan (SSHP), applicable Federal, State, and local regulations, and contract restrictions and guidance. Consult the documents listed in Section 7.0 of this SOP for additional compliance issues.

3.0 RESPONSIBILITIES

3.1 PROJECT MANAGER

The Project Manager is responsible for ensuring availability of resources to safely and effectively implement this SOP.

3.2 SITE MANAGER

The Site Manager is responsible for incorporating this SOP in plans, procedures, and training. In addition, he is responsible for oversight and supervision of field personnel, and ensuring compliance with this SOP.

3.3 UXO SAFETY OFFICER

The UXO Safety Officer (UXOSO) ensures that all mag and dig activities are conducted in a safe manner, in accordance with the approved Work Plan, the SSHP, this SOP, and all applicable regulatory guidance. The UXOSO's duties shall include, but are not limited to: analyzing UXO explosives operational risk, hazards, and safety requirements; establishing and ensuring compliance with all site-specific safety requirements for UXO and explosives operations; enforcing personnel limits and safety exclusion zones (EZ) for UXO clearance operations; and all activities associated with UXO and explosives transportation, storage, and destruction.

3.4 UXO QUALITY CONTROL SPECIALIST

The UXO Quality Control Specialist (UXOQCS) ensures compliance with the project Quality Control (QC) Plan and performs analog QC checks of completed grids in accordance with the Work Plan.

4.0 OPERATIONS

4.1 ANALOG DETECTION AND REMOVAL ACTIONS

All analog detection and removal (mag and dig) activities at MEC sites will be under the supervision of UXO qualified personnel. Non-UXO qualified personnel will not be allowed in the EZ during intrusive operations. If access is required by non-UXO qualified personnel, all work will stop while they are in the EZ. During operations, USAE personnel will strictly adhere to the SSHP and the following general safety practices:

- Operations will be conducted during daylight hours only.
- Access to operating areas will be limited to only those personnel necessary to accomplish the specific operation.
- UXO will only be handled by qualified UXO Technicians.
- During UXO operations the minimum separation distance (MSD) between UXO and non-UXO operations is fragmentation distance of the munition with the greatest fragmentation distance (MGFD), as stated in the Work Plan.
- MEC Teams will adhere to the team separation distance as established in the WP.
- During demolition operations personnel remaining on site will be limited to those personnel needed to safely and efficiently prepare the item/s for destruction.).
- All personnel will attend the daily safety briefing (tailgate safety briefing) prior to entering the operating area.
- Anyone can stop operations for an unsafe act or situation.
- Safety violations and/or unsafe acts will be immediately reported to the UXOSO.
- Failure to comply with safety rules/procedures may result in termination of employment.

4.2 GRID LAYOUT

A registered land surveyor will survey each of the clearance areas, accompanied by a UXO escort. Surveying activities will consist of locating clearance area boundaries, establishing permanent survey monuments, and establishing grids for geophysical investigation activities within the clearance areas.

Depending on the method selected and approved by the customer, the site layout and search grids will be established using a Global Positioning System (GPS), licensed surveyor, or compass and measuring tape. Survey crews will be escorted in the field by a UXO Technician II or above who will provide UXO avoidance including checking the intended survey stake locations with a magnetometer prior to driving stakes into the ground. This will prevent driving stakes into buried MEC.

4.3 ANALOG SWEEP PROCEDURES

Intrusive investigation team(s) will consist of a Team Leader (UXO Technician III) and UXO Technicians II/I. During intrusive operations UXO Technicians I will operate under the supervision of UXO Technicians II or III. UXO operations will only be performed by qualified UXO Technicians, which are defined as:

- MEC identification
- Access procedures such as excavation, either by hand or using heavy equipment
- Handling of MEC/UXO, explosives, or explosive items
- Disposal, including movement, transportation, and final disposal of MEC

Analog detector sweeps (i.e., mag and dig) are particularly effective in areas where vegetation and terrain limit the use of larger digital systems. Also, mag and dig approaches should be used when there is insufficient difference between UXO at the site and other metallic fragments and debris, such that digital discrimination is ineffective or cost prohibitive.

Initially, individual search lanes will be established approximately 5 feet (ft) wide. Each lane will be surveyed using a Schonstedt GA-52CX and/or White's XLT magnetometer. The operation will begin at one end of each lane and move in a forward direction toward the opposing baseline. During the forward movement the technician moves the magnetometer back and forth from one side of the lane to the other. Both forward movement and the swing of the magnetometer are performed at a pace that ensures the entire lane is searched and that the instrument is able to appropriately respond to subsurface anomalies. When a subsurface anomaly or metallic surface object is encountered, the UXO Technician halts and investigates the anomaly at that time. Throughout this operation the team leader closely monitors the team's individual performance to ensure these procedures are being performed correctly.

4.4 SURFACE UXO

Upon encountering a surface MEC it will be identified by two UXO Technicians and marked in accordance with the approved Work Plan for future disposition. If detonation cannot be arranged the same day as the MEC is identified, a guard will be posted during the non-working hours to ensure the item is not disturbed.

4.5 SUBSURFACE ANOMALIES

4.5.1 MANUAL EXCAVATIONS

Subsurface anomalies will be investigated by UXO-qualified personnel as they are identified during the sweep. All identified anomalies within the grid will be intrusively investigated. Excavations for individual anomalies will be conducted using the Schonstedt GA-52CX and/or White's XLT magnetometers to assist the team in determining the location and orientation of the target item. The UXO Technicians excavating anomalies shall initially remove no more than a 6-inch layer of soil along side the location of the anomaly, being careful not to impact the anomalous feature. The UXO Technician will conduct a visual and electronic search of the excavation to further pin point the anomaly source as needed. This process shall be repeated until the audible signal from the magnetometer indicates the object is close to the surface. Once this determination has been made, soil will be removed by hand until the source of the anomaly is located. Once an anomaly is removed, the UXO Technician will check to ensure that no additional sources of the audible remain. Excavations on individual anomalies greater than 4 ft below the ground surface (bgs) will not be made without prior approval of the U.S. Army Corps of Engineers (USACE) OE Safety Specialist.

4.5.2 MECHANICAL HANDLING EQUIPMENT

Mechanical Handling Equipment (MHE) may be used to excavate large anomalies (e.g., pits) or those deeper than 4 ft bgs if required (e.g., to confirm the anomaly is not a MEC). Any decision to use MHE to excavate these anomalies will be made by the SUXOS and the USACE OE Safety Specialist (see SOP OPS-06, Excavation and Trenching for detailed MHE procedures). The excavation will proceed slowly to ensure the item is not broached by the MHE. If the excavated material is considered to be a MEC, it shall be uncovered sufficiently by hand to obtain a positive identification of the item. If the item is identified as UXO/MEC, a determination will subsequently be made as to whether it is fuzed or not.

While excavating with MHE, a UXO Technician will be stationed in a position that is out of the reach of the excavation equipment but affords a view of the excavation site. This observer will ensure that the next lift is visually free of UXO. The excavated material will be placed onto the ground within a screening area that has been surface swept and the boundaries recorded. The soil spoils will be spread across the screening area using the excavator bucket. The excavated material will be screened for range related debris, munitions debris, and UXO/MEC items. UXO technicians will recover all pieces of munitions debris or range related debris and any ordnance items. After screening, the soil spoils will be stockpiled to the side of the screening area.

5.0 RECORD KEEPING

The team leader will maintain a field logbook, which at a minimum will contain a record of the following:

- Weather
- Instrument details and serial number
- Team Personnel
- Grids worked
- Start and stop times
- MEC/UXO items encountered

The data to be recorded for each item discovered during anomaly excavation will include the following (as applicable):

- Type (e.g., MD, MPPEH, UXO, and non-MEC Scrap)
- Description (e.g., "projo, 20-mm, practice, MK105" and "base, coupling, firing device")
- Initial Condition (e.g., expended, inert, live, and to be determined [TBD])
- Approximate length
- Approximate width
- Depth
- Approximate weight
- Found in a pit?
- Piece of frag?
- Initial disposition (e.g., left in place and removed to scrap pile)
- Requires demolition?

All data will be turned into the Site Geophysicist at the end of the day.

6.0 DISPOSAL OPERATIONS

Fuzed UXO/MEC items will be blown in place (BIP), and un-fuzed UXO/MEC items will be consolidated whenever possible in accordance with USACE Engineer Pamphlet 1110-1-17, Establishing a Temporary Open Burn and Open Detonation Site for Conventional Ordnance and Explosives Projects, dated 16 July 1999, Appendix D. In no case shall the SUXOS authorize or undertake destruction of UXO/MEC when there is sufficient reason to believe that the disposal action will result in personnel casualties or property damage. The USACE OE Safety Specialist will be consulted for guidance in the event that there is sufficient reason to believe that the disposal action will result in personnel casualties or property damage.

7.0 REFERENCES

- USACE Safety Considerations for UXO
- USAE Corporate Safety and Health Program (CSHP)
- OSHA, 29 CFR 1910, Occupational Safety and Health Standards
- OSHA, 29 CFR 1926, Construction Standards
- Applicable sections of EPA, 40 CFR Parts 260 to 299, Protection of Environment
- Applicable sections of DOT, 49 CFR Parts 100 to 199, Transportation
- USACE EM 385-1-1, Safety and Health Requirements Manual
- USACE ER 385-1-92, Safety and Occupational Health Document Requirements for Hazardous Waste Remedial Actions
- DOD 4145.26-M, Contractors' Safety Manual for Ammunition and Explosives
- DOD 6055.9-STD, DOD Ammunition and Explosives Safety Standards
- DOD 4160.21-M, Defense Reutilization and Marketing Manual
- DA PAM 385-64, Ammunition and Explosives Safety Standards
- AR 385-64, Ammunition and Explosives Safety Standards
- AR 200-1, Environmental Protection and Enhancement
- AR 385-10, The Army Safety Program
- AR 385-16, System Safety Engineering and Management
- AR 385-40 w/USACE supplement, Accident Reporting and Records
- TM 9-1300-200, Ammunition General
- TM 9-1300-214, Military Explosives
- TM 60 Series Publications

STANDARD OPERATING PROCEDURE – OPS-15
UXO/MEC AVOIDANCE

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide all USA Environmental, Inc. (USAE) employees and subcontractors with the minimum procedures and safety and health requirements applicable to perform avoidance operations at sites potentially containing unexploded ordnance (UXO) and/or munitions and explosives of concern (MEC).

2.0 SCOPE

This SOP applies to all USAE site personnel, including contractor and subcontractor personnel, involved in the conduct avoidance operations on a UXO/MEC contaminated site. The following USAE policies and procedures are not all inclusive nor are they applicable in all situations. This SOP is not a stand-alone document and is to be used together with Work Plans, other USAE SOPs, the USAE Site Safety and Health Plan (SSHP), applicable Federal, State, and local regulations, and contract restrictions and guidance. Consult the documents listed in Section 8.0 of this SOP for additional compliance issues.

3.0 MEC/UXO BASIC AND GENERAL SAFETY PRECAUTIONS

These basic safety precautions are the minimum MEC safety requirements required of all personnel on site. Other precautions and requirements are in other applicable MEC manuals.

3.1 BASIC CONSIDERATIONS

The following should be taken into consideration when planning or conducting MEC avoidance support operations:

- SAFETY IS PARAMOUNT
- Do not move or disturb unidentified items
- Do not collect souvenirs
- Do not smoke except in designated areas
- Do not carry fire or spark producing devices into the site
- All MEC operations will use the "Buddy" system
- Prohibit non-essential personnel from visiting the site

3.2 BASIC SAFETY PRECAUTIONS

The following safety precautions are applicable to all MEC:

- Suspend all operations immediately upon approach of an electrical storm.
- Observe the hazards of electromagnetic radiation (EMR) precautions and grounding procedures when working with, or on, electrically initiated or susceptible MEC.
- Do not unnecessarily dismantle, strip, or handle any MEC.
- Avoid inhalation and skin contact with smoke, fumes, dust, and vapors of detonations and MEC

residue.

- Do not attempt to extinguish burning explosives or any fire that might involve explosive materials.
- Do not manipulate external features of ordnance items.
- Incorporate appropriate property and personnel protective measures for shock and fragmentation when conducting MEC operations.
- Do not subject MEC to rough handling or transportation. Sand bag, chock, and block appropriately.
- Hand carry no more than two items (one in each hand) at a time and then only as required by the operation being performed.
- Do not transport damaged white phosphorous munitions unless fully submerged in water.
- Avoid unnecessary movement of armed or damaged UXOs.
- Avoid the forward portions of munitions employing proximity fuzing.
- Assume unknown fuzes contain cocked strikers or anti-disturbance features.

3.3 GENERAL SAFETY PRECAUTIONS

The following sub-paragraphs describe safety precautions for various types of munitions/disposal operations:

3.3.1 BOMBS

- Ensure fuze wells do not contain fuze components.

3.3.2 CLUSTERS, DISPENSERS, LAUNCHERS

- Approach and work from the sides of a dispenser.
- Consider an intact dispenser as fully or partially loaded.
- Consider any payloads outside the container or dislodged inside as armed.
- Take precautions for the most hazardous payloads until positively identified.

3.3.3 PROJECTILES

- Determine if the projectile has been fired and if so consider it armed.
- Check for the presence of unburned tracers.
- Avoid the rear and front of rocket assisted projectiles,
- Handle projectile components such as powder increments, cartridges, and primers with caution.
- Seal the open ends of projectiles or sheared projectile components with tape or other suitable

material before transporting.

3.3.4 GRENADES

- Do not attempt to re-install safety pins on a dud-fired grenade.
- Do not attempt to withdraw impinged firing pins from the fuze of a dud-fired grenade.
- Do not dispose of grenades by functioning them as designed.

3.3.5 ROCKETS

- Approach and work on rockets from the side.
- Do not dismantle or strip dud fired rockets or rocket motors.
- Do not expose electrically fired munitions to radio transmissions within 25 feet.
- Do not transport an unfired rocket motor until having shielded the motor igniter from EMR.

3.3.6 GUIDED MISSILES

- When found, restrict vehicular movement in the area of a guided missile.
- Avoid entanglement with guidance wires of wire guided missiles.
- Restrict radio communications in the vicinity of a dud-fired missile.
- Approach and work on missiles from the side and rear quarter.
- Do not dismantle or strip dud-fired missiles or missile motors.
- Do not transport an unfired missile motor until having shielded the motor igniter from EMR.

4.0 MEC AVOIDANCE FOR SAMPLING AND DRILLING OPERATIONS

MEC avoidance operations may be required in support of soil sampling operations and the drilling of monitoring wells on some contracts. Avoidance operations will consist of a team composed of two UXO qualified personnel. The team will consist of a UXO Technician III and a UXO Technician II or UXO Technician I. The team will not destroy any MEC encountered. All MEC contacts and suspected MEC anomalies will be reported to the Site Manager who will in turn notify the On-site Safety Representative or local Explosive Ordnance Disposal (EOD) unit.

4.1 ACCESS ROUTES TO SAMPLING LOCATIONS

Prior to sampling or well drilling crews going on site, the MEC team will conduct a reconnaissance of the sampling area. The reconnaissance will include locating the designated sampling or drilling location and insuring that it is free of anomalies. If anomalies are detected the point will be relocated as directed in the Work Plan. Once the designated point has been cleared, an access route for the sampling crews, vehicles and equipment will be cleared. The access route, at a minimum, will be twice the width of the widest vehicle and the boundaries will be clearly marked to prevent personnel from straying into un-cleared areas. If surface MEC is encountered, the MEC team will mark and report the item, and divert the approach path around the MEC. A magnetometer will be used to ensure there are no subsurface MEC within the approach path. If a subsurface magnetic anomaly is encountered, it will be assumed to be a possible MEC and the path diverted to avoid it.

4.2 SOIL SAMPLING AND WELL DRILLING SITES

The MEC team will clear a work site for soil samples and well drilling and clearly mark the boundaries. The area will be large enough to accommodate the drilling equipment and provide a work area for the crews. As a minimum, the cleared area will be a square, with a side dimension equal to twice the length of the largest vehicle or piece of equipment for use on site. If a pre-selected area indicates magnetic anomalies, a new sampling/drilling site will be chosen.

4.3 AVOIDANCE PROCEDURES FOR BOREHOLE SAMPLING

If surface samples are required they will be obtained prior to the start of boring. The borehole procedures will be completed using a hand auger, powered auger, or Direct Push Technology (DPT) equipment. The MEC Team will check the borehole with a down-hole magnetometer, a minimum of every 2 feet, to the deepest sampling depth, or a minimum of 6 feet, to ensure that smaller items of MEC, undetectable from the surface, will be detected.

- **Hand Auger Procedures:** The hand auger will be advanced to the first sampling depth and the auger will be withdrawn. A clean auger bucket will be attached to the handle, returned to the borehole and a sample will be collected. At this point the MEC Team will check the borehole with a magnetometer and if no magnetic anomalies are found, the procedure repeated to obtain the required samples.

- **Power Auger Procedures:** The power auger will be advanced to the first sampling depth and the auger will be withdrawn. A clean hand auger will then be used to collect the sample. The MEC Team will check the borehole with a magnetometer and if no magnetic anomalies are found, the procedure will be repeated to collect the required samples.

- **DPT Procedures:** The DPT rig will be positioned over the sampling point and the rod will be advanced to a maximum depth of 2 feet. The DPT rig will then move a minimum of 20 feet away from the sampling point to prevent the rig from influencing the magnetometer. The MEC Team will then check the borehole with a magnetometer and if no magnetic anomalies are found, the procedure will be repeated to collect the required samples.

4.4 AVOIDANCE PROCEDURES FOR MONITORING WELL INSTALLATION

Prior to drilling equipment being moved to the proposed site, the MEC Team will have checked the designated site, using a magnetometer; to assure that the well location is anomaly free to a depth of 2 feet. If surface samples are required they will be collected prior to the start of drilling. To complete the subsurface magnetometer checks, one of two methods may be used:

- Monitoring, at 2-foot increments, during the actual well drilling operation. This will require the withdrawal of the drill rod or augers from the well and moving the drill rig a minimum of 20 feet away from the well location to prevent the rig from influencing the magnetometer, or

- Installing an offset monitoring hole within 2 feet of the well location. This monitoring hole can be installed by the MEC Team, with a hand or power auger, and monitored at 2-foot increments to the desired well depth or a minimum of 6 feet. This will then allow uninterrupted well installation and/or sampling to continue.

5.0 MEC AVOIDANCE AND CONSTRUCTION SUPPORT

MEC avoidance support is normally comprised of a two-man team consisting of a UXO Technician III (Team Leader) and a UXO Technician II. At sites where the expectation of encountering MEC is low, the

MEC support may only consist of the UXO Technician III as MEC safety escort. The intent of MEC avoidance is to detect and avoid MEC and UXO. The following paragraphs outline minimum procedures for the designated operations.

5.1 LOCATION SURVEYS AND GEOPHYSICAL ESCORT

MEC escort for survey and geophysical operations consists of a visual surface search for MEC. Any UXO or MEC encountered will be marked, avoided, and reported to the appropriate authorities. Prior to driving stakes for grid corners or installing monuments, the UXO Technician will search the location with a magnetometer. Any subsurface anomaly will be assumed to be MEC and an alternate anomaly-free location will be chosen.

5.2 TRENCHING AND PIT EXCAVATIONS

Prior to trenching or excavation crews going on site, the MEC Team will conduct a reconnaissance of the approach route to the site. The reconnaissance will include locating a clear path for the crews, vehicles, and equipment. The approach path, at a minimum, will be twice the width of the widest vehicle. The boundaries of the approach path will be clearly marked to prevent personnel from straying into un-cleared areas. If MEC is encountered, the MEC team will mark and report the item, and divert the approach path around the MEC. Personnel will be instructed to remain within the marked boundary limits. A magnetometer will be used to search for near surface anomalies within the approach path. If a magnetic anomaly is encountered, it will be assumed to be a possible MEC, it will be marked, the approach path diverted, and reported.

5.2.1 EXCAVATION

During excavation operations the UXO Technician(s) will position themselves near (outside the reach of the swing) the earth moving machinery (EMM) (backhoe) where they can observe the excavation. If UXO or MEC is spotted the UXO Technician will signal the EMM operator to stop digging, move the bucket and place it on the ground outside the trench, and remove his hands from the controls. The UXO Technician will then investigate the MEC, which will be handled in accordance with Section 6.0. If MEC that cannot be moved is encountered the excavation operations will be either relocated to another area of operations or suspended until the item is disposed of or rendered safe to move.

5.2.2 HEAVY EQUIPMENT OPERATION

Heavy equipment safety will be in accordance with the SSHP.

5.2.3 EXCAVATION SAFETY

Excavation safety will be in accordance with the SSHP.

5.2.4 EQUIPMENT

The minimum equipment requirements for this activity include:

- Level D PPE
- EMM, (trenching & excavation)
- Schonstedt GA-52CX Magnetometer
- Marking material listed in Table 1
- Miscellaneous common hand tools (e.g. hammer, shovel, etc.)

Table 1: Color Codes – MEC Avoidance

Color	Description
Red Pin Flag/Caution Tape	Danger, identified suspect MEC/UXO, special precaution required
White Pin Flag	Boundary or temporary marker
Green Paint	Marking MEC-related scrap

6.0 LIVE AND SUSPECT MEC

UXO or MEC items encountered a will be inspected by the UXO Technician(s). Items that are safe to move may be relocated to a bermed or sandbagged area a safe distance from ongoing operations. No items will be moved unless positively identified and determined safe to move. The item(s) will be marked and reported to the Site Manager. MEC encountered that is ***NOT*** safe to move will be marked in place and operations will be moved to another location. MEC will be marked by installing four wooden stakes and encircling the stakes with flagging tape (see Table 1). Prior to installing stakes the location will be checked with a magnetometer to avoid driving the stake into a subsurface anomaly. All live and suspect live items will be inspected and identified by UXO Technicians. If the item cannot be positively identified and determined to be inert and safe to move, it will be marked and reported.

Note: If during identification of UXO or MEC it becomes necessary to move or handle the item, non-UXO qualified personnel will withdraw to a safe distance.

6.1 MEC RELATED MATERIAL

Adjacent to each operating area, the UXO Technicians will establish a MEC-related scrap (munitions debris) collection point. During operations items that are free of explosive contamination (i.e., fragments, parachutes, etc.) will be placed into these collection points and marked (see Table 1). Upon completion of operations the materials in these temporary collection points will be transferred to a central collection point for disposal. As the material is being loaded, the UXO Technician(s) will perform a second inspection of the material to ensure it is free of explosives and other hazardous materials.

7.0 DISPOSAL OPERATIONS

All MEC and Material Potentially Presenting and Explosive Hazard (MPPEH) will be disposed of in accordance with the project scope or the Work Plan. All hazardous material encountered will be reported to the Site Manager for disposition.

8.0 SUMMARY

USAE uses proven procedures and methods to provide MEC Support Services. Only qualified UXO personnel will perform tasks associated with MEC location, identification, and item condition determination. The procedures outlined in this SOP are based on industry standards and ensure that operations are safely and efficiently performed.

9.0 REFERENCES

- EP 385-1-95a, Basic Safety Concepts and Considerations for Ordnance and Explosives Operations
- EP 75-1-2, UXO Support during HTRW and Construction Activities
- USAE Corporate Safety and Health Program (CSHP)

- OSHA, 29 CFR 1910, Occupational Safety and Health Standards
- OSHA, 29 CFR 1926, Construction Standards
- Applicable sections of EPA, 40 CFR Parts 260 to 299, Protection of Environment
- Applicable sections of DOT, 49 CFR Parts 100 to 199, Transportation
- USACE EM 385-1-1, Safety and Health Requirements Manual
- USACE ER 385-1-92, Safety and Occupational Health Document Requirements for Hazardous Waste Remedial Actions
- DOD 4145.26-M, Contractors' Safety Manual for Ammunition and Explosives
- DOD 6055.9-STD, DoD Ammunition and Explosives Safety Standards
- DOD 4160.21-M, Defense Reutilization and Marketing Manual
- DA PAM 385-64, Ammunition and Explosives Safety Standards
- AR 385-64, Ammunition and Explosives Safety Standards
- AR 200-1, Environmental Protection and Enhancement
- AR 385-10, The Army Safety Program
- AR 385-16, System Safety Engineering and Management
- AR 385-40 w/USACE supplement, Accident Reporting and Records
- TM 9-1300-200, Ammunition General
- TM 9-1300-214, Military Explosives
- TM 60 Series Publications

STANDARD OPERATING PROCEDURE – OPS-19
SITE RULES AND PROHIBITED PRACTICES

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide the minimum safety and health requirements, procedures, and site standing orders applicable to the conduct of operations on site. These standing orders outline the rules, which will be strictly enforced during all on-site activities.

2.0 SCOPE

This SOP applies to all site personnel, to include contractor and subcontractor personnel, who are involved in operations in the exclusion, contamination reduction, and support zones (EZ, CRZ, and SZ, respectively). The rules and prohibited practices outlined here are required to help ensure the safety and health of all site personnel, the environment, and the general public. This SOP is not intended to contain all requirements needed to ensure regulatory compliance. Consult the documents listed in Section 3.0 of this SOP for additional compliance issues.

3.0 REGULATORY REFERENCES

The following Occupational Safety and Health Administration (OSHA) standards and U.S. Army Corps of Engineers (USACE) requirements directly apply to the conduct of operations associated with this SOP. In the event that other hazards are associated with the conduct of this SOP, consultation of other SOPs and regulatory references may be needed:

- OSHA Construction Industry Standard 29 CFR, Part 1926.65
- OSHA General Industry Standard 29 CFR, Part 1910.120
- USACE Engineer Manual 385-1-1, Section 28

4.0 RESPONSIBILITIES
4.1 OCCUPATIONAL SAFETY MANAGER

The Occupational Safety Manager (OSM) shall be responsible for ensuring the availability of the resources needed to implement this SOP, and shall also ensure that this SOP is incorporated into plans, procedures, and training for sites where this SOP is to be implemented.

4.2 SENIOR UXO SUPERVISOR

The Senior UXO Supervisor (SUXOS) will ensure that this SOP is implemented in all operations. The SUXOS will also ensure that relevant sections of this SOP are discussed in the tailgate safety briefings, and that information related to its daily implementation is documented in the Site Operational Log.

4.3 UXO TECHNICIAN III

The UXO Technician III (UXOTIII) shall be responsible for the field implementation of this SOP and for implementing the safety and health requirements outlined in Section 5.0 of this SOP. In the absence of a SUXOS, the UXOTIII shall be responsible for implementing the SUXOS's responsibilities outlined in Paragraph 4.2.

4.4 UXO SAFETY OFFICER/SITE SAFETY AND HEALTH OFFICER

The UXO Safety Officer (UXOSO)/Site Safety and Health Officer (SSHO) will be responsible for ensuring that the safety and health hazards and control techniques associated with this SOP are discussed during the initial site hazard training and the daily tailgate safety briefings. The UXOSO/SSHO will also be responsible for daily inspection of site operations and conditions to ensure their initial and continued compliance with this SOP and other regulatory guidelines.

5.0 PROCEDURE

All site personnel, including contractor and subcontractor personnel, involved in any site operation shall be familiar with the rules and prohibited practices listed in this SOP. The items outlined in the standing orders listed below are considered to be the minimum rules and prohibited practices which will be enforced onsite. This list may be expanded by the UXOSO/SSHO, based upon site conditions and characteristics. Since the safety and health of all site personnel, the environment, and the general population is of paramount importance, all personnel will be expected to follow the standing orders at all times. Violation of these standing orders, or those imposed by the UXOSO/SSHO, may lead to personal injury or property damage, and may be grounds for positive disciplinary action.

5.1 SITE STANDING ORDERS

5.1.1 GENERAL STANDING ORDERS FOR THE SITE

The standing orders listed below shall be followed at all times by on-site personnel conducting operations in any location of the site:

- The Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP), Corporate Safety and Health Program, and all other required safety and health guidelines will be met at all times.
- All necessary, and feasible, precautions will be taken to prevent injury to personnel.
- Potentially harmful situations will be immediately reported to the UXOSO/SSHO.
- Spillage and splashing of hazardous materials will be prevented to the extent possible, and spills of hazardous materials will be reported to the UXOSO/SSHO.
- Good housekeeping shall be practiced by keeping the work area neat, clean, and orderly.
- All personal injuries, no matter how minor, will be reported to the UXOSO/SSHO.
- Site equipment shall be maintained in good working order, and defective equipment shall be reported to the UXOSO/SSHO.
- Personnel shall properly inspect, use, and maintain personal protective equipment (PPE) as required by the SHSP and applicable SOPs.
- Running and horseplay are prohibited in all areas of the site, at all times.
- Tobacco product use, eating, and drinking will be allowed only in designated areas while personnel are performing operations within a work zone. The designated break area will, in most cases, be determined by the UXOTIII. Personnel will conduct personal hygiene (i.e., cleaning of hands and face) prior to taking a break in the designated area.
- If site hazards include the potential for airborne or physical contact with chemical contaminants, personnel will refrain from eating, drinking, using tobacco, applying cosmetics, or any other hand-to-face activity while they are in the area of chemical contamination. This requirement will hold true at all times unless procedures are specified in the SSHP which allow for the taking of breaks in the work zone or for using back-mounted hydration packs.
- Ignition of flammable materials in any work zone is prohibited, unless directed otherwise by the UXOSO/SSHO.
- Buddy system procedures shall be enforced during all site operations.
- The number of personnel in the SZ, CRZ, or EZ shall be the minimum number necessary to perform work tasks in a safe and efficient manner.

- Site personnel shall check in with the UXOSO/SSHO prior to leaving the site, and again upon returning to the site.
- Site personnel will report to the UXOSO/SSHO any medical conditions or medications which could affect their ability to perform operations safely.
- Site visitors are to be escorted by UXO-qualified personnel at all times, and site operations will cease if non-UXO-qualified personnel enter an area where UXO operations are being conducted.
- Site personnel shall perform only those tasks that they are trained and qualified to perform.
- Site personnel shall remain aware of site conditions at all times and shall alert the UXOSO/SSHO to any changes which could pose additional hazards.

5.1.2 STANDING ORDERS FOR THE CRZ

The standing orders listed below shall be followed at all times by on-site personnel conducting operations in the CRZ:

- No tobacco product use, eating, drinking, application of cosmetics, or other hand-to-face activities are allowed in this area, unless specifically provided for in the SHSP.
- No matches or lighters in this zone.
- Personnel will check in and out at the access control point upon entrance to or exit from this zone.
- Personnel handling potentially contaminated items shall wear appropriate PPE.
- Entry and exit from this zone will be through designated corridors only.
- Only "Buddies" will enter/exit through this zone, no one passes through this zone alone, unless directed by the UXOSO/SSHO, and then only when line of sight can be maintained.
- Hands and face shall be thoroughly washed upon leaving this zone.
- **Remember**: "The Contamination Stops Here". Do your best to keep it that way.

5.1.3 STANDING ORDERS FOR THE EZ

The standing orders listed below shall be followed at all times by on-site personnel conducting operations in the EZ:

- No tobacco product use, eating, drinking, application of cosmetics, or other hand-to-face activities are allowed in this area unless otherwise directed by the UXOSO/SSHO. The exception to this rule may be the use of hydration backpacks.
- No matches or lighters in this zone, unless otherwise directed by the UXOSO/SSHO.
- Personnel will check in/out at the access control point upon entrance to or exit from this zone.
- Personnel will always have their buddy with them in this zone, and follow the buddy system procedures.
- No personnel are allowed in this area without appropriate PPE, as specified by the SHSP.
- Personnel will remain alert to site conditions, and report any changes or unusual occurrences to the UXOSO/SSHO.
- Personnel will avoid contact with contaminated or potentially contaminated surfaces.
- Whenever possible, personnel will not walk through puddles, mud, or any discolored ground surface.
- Personnel will not kneel on the ground or lean, sit, or place equipment on drums, containers, potentially contaminated vehicles, or the ground, unless the potentially contaminated surface has been covered with plastic.
- Visual or verbal contact shall be maintained between the site personnel and the Command Post at all times.
- **Remember**: Site Safety and Health is Everyone's Responsibility. Do your part.

5.2 USE OF MODIFIED WORK SCHEDULES TO CONTROL EXPOSURES

Except as outlined in the Heat and Cold Stress SOPs, modification of work schedules is not considered an acceptable method to control personnel exposure to chemical or physical hazards. Any and all other feasible and effective means of controlling the degree and level of exposure, to include the use of personal protective equipment, will be developed and used prior to using modified work schedules as a means of control. Only in extreme cases where no other feasible, effective control method is available will work schedules be modified to reduce exposures. In the event that modified work schedules must be used, the procedures for monitoring the respective hazard and modifying personnel work schedules will be clearly outlined in the monitoring section of the SHSP.

5.3 SAFETY AND PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS

Site personnel will at all times comply with safety precautions, safe work practices, and PPE requirements detailed in the SSHP for each task. Deviation from assigned safety precautions, practices, and PPE will be allowed only after approval by the UXOSO/SSHO and the CSHM or Occupational Safety Manager.

STANDARD OPERATING PROCEDURE – OPS-21
VEGETATION REMOVAL OPERATIONS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide USA Environmental, Inc. (USAE) employees and subcontractors with the minimum procedures and safety and health requirements applicable to perform vegetation removal operations on sites contaminated with unexploded ordnance (UXO) or munitions and explosives of concern (MEC).

2.0 SCOPE

This SOP applies to all USAE site personnel, including contractor and subcontractor personnel, involved in the conduct of vegetation removal operations on a site potentially contaminated with UXO/MEC. This SOP is not a stand-alone document and should be used together with Work Plans, other USAE SOPs, the Site Safety and Health Plan (SSHP), applicable Federal, State, local regulations, and contract restrictions and guidance. Consult the documents listed in Section 10.0 of this SOP for additional compliance issues.

3.0 SELECTION

Only those personnel that meet the requirements set forth by the Client and USAE will be utilized at the project site to facilitate safe and efficient vegetation removal operations.

4.0 TRAINING

All training on equipment will be either formal or on-the-job (OJT) training. This training will be documented by site personnel and subject to review for accuracy and completeness.

5.0 PERSONNEL PROTECTIVE EQUIPMENT

Level D personal protective equipment (PPE) is required for all personnel engaged in vegetation removal operations. Clothing includes, but is not limited to:

- Coveralls or work clothing as prescribed
- Work gloves, leather or canvas as appropriate
- Safety Glasses
- Hard Hats
- Hearing protection, noise attenuators or ear plugs
- Dust mask, as required by wind conditions and/or the presence of airborne particulate matter
- Other PPE as needed. (e.g., face shield, chainsaw chaps, etc.)

6.0 TEAM COMPOSITION

The Vegetation Removal Team will consist of three qualified personnel, as a minimum. These personnel may include any or all of the following:

- UXO Technician III
- UXO Technician II or I

- Laborers

6.1 UXO TECHNICIAN III

The UXO Technician III is UXO qualified and directs the operation and other team personnel within the context of removal requirements. In addition, the UXO Technician III must be familiar with the equipment being utilized.

6.2 OPERATOR

The operator(s) will be qualified and trained on the equipment being utilized (e.g., chainsaw, weed eater, etc.) and operate the equipment in a safe and efficient manner. The operator performs daily inspections and maintenance functions as recommended in the operator's manual. The operator will perform other duties as needed or directed.

7.0 SAFETY

Safety is paramount and all personnel will observe those safety precautions/warnings that apply or may apply to vegetation removal operations. The precautions listed below are general in nature and personnel will need to review applicable publications for more specific safety precautions/warnings. Distances listed are the minimum required.

- Maintain a 200 feet minimum distance from other teams.
- Maintain safe separation distance from UXO personnel engaged in intrusive work.
- Distances may be increased by the U.S. Army Corps of Engineers (USACE) OE Safety Specialist as determined by site history, UXO items encountered, terrain features, and other factors that may apply.
- Use equipment safety features.
- Safety precautions/warnings found in the operator's manual/manufacture's publications will be observed.
- Maintain 6 inches of ground clearance during removal operations.
- Communications will be maintained between the Team Leader and Operator(s) at all times.
- Maintain site control.
- Observe UXO safety precautions for items encountered or suspected.
- Ensure PPE is appropriate, serviceable, and worn/used in a proper manner.

8.0 OPERATIONAL PROCEDURES

Personnel will not enter within 10 feet of an operating piece of equipment. If at any time personnel enter closer than 10 feet, the Operator will immediately stop, return the engine to idle speed, and cease operations. Prior to operations commencing, a communications check with all team personnel will be conducted. Hand signals will be devised and used as a means of communication. All team personnel must know these hand signals prior to operations commencing. The hand signals will be documented on the tailgate safety-briefing sheet each morning of operations and at each change of team personnel.

The UXO Technician III will be responsible for the direction and manner in which the vegetation is to be removed. Prior to removal operations commencing, a visual search/survey is conducted to determine the hazards that may be encountered, which may include UXO, terrain slope, vegetation, wildlife, environmental concerns, and PPE requirements. The UXO Technician III will perform a visual search for UXO, ordnance scrap, surface debris, and any other obstruction/object that may pose a hazard to team personnel. Hazardous items, impassable terrain, or vegetation that may affect operations will be marked and team personnel notified.

Team personnel are to ensure that a 6-inch ground clearance is maintained during removal operations. Those areas marked as hazards are to be avoided. The manner in which operations are accomplished will follow safe work practices and procedures. Areas of concern will be addressed to the Senior UXO Supervisor (SUXOS) and/or UXO Safety Officer (UXOSO) as needed. All MEC/UXO items encountered are marked and avoided. Notification of these items will be made to the appropriate personnel.

9.0 SUMMARY

USAE personnel will conduct vegetation removal operations in a safe, efficient, and productive manner and will use this SOP and references, which include changes and revisions.

10.0 REFERENCES

- USAE Corporate Safety and Health Program (CSHP)
- Site-Specific Safety and Health Plan (SSHP)
- Occupational Safety and Health Administration (OSHA) Regulations
- USACE, Engineer Manual 385-1-1
- Operator’s Manual(s) and Manufacture’s Publications

STANDARD OPERATING PROCEDURE
OPS-23 – LEASED AND RENTAL VEHICLES

1.0 GENERAL

The following USA policies and/or procedures will be used by personnel utilizing leased or rental vehicles for project purposes in accordance with USA's Drug Free Work Place Policy. Personnel are reminded to obey and observe all applicable Federal, state, and local traffic laws, regulations, or guidance, as well as contractual restrictions and requirements imposed by the leasing or rental company.

Rental vehicles are to be used for the purpose of transporting project personnel and equipment to and from work locations and other authorized locations or facilities. The use of rental vehicles during non-working hours for personal use is a privilege, not a right, which may be withdrawn by the project contracting authority or USA management. Assigned vehicle operators (see attached form) will follow the requirements of this SOP on Leased and Rental Vehicles.

The driver of any rental vehicle may be liable for damages in the event that vehicle damage is incurred during working or non-working hours and it is determined that the driver has not complied with this SOP.

All vehicles will have a copy of this SOP, Vehicle Inspection Forms, Accident/Incident Report forms, a list of project contact phone numbers, and a disposable camera as well as all safety-related equipment (fire extinguisher, first aid kit, etc.).

1.1 REFERENCES

Information contained in this document was obtained from the below-listed references:

- USA Safety and Health Program (SHP)
- Applicable sections of DOT, 49 CFR Parts 100 to 199, Transportation
- Vehicle owners manual
- Leasing/Rental agreement
- Administrative SOP
- USA Drug Free Workplace Policy.

1.2 REQUIREMENTS

Personnel assigned project vehicles must be listed on the Authorized Drivers List and be legally permitted to operate the assigned vehicle. Personnel assigned project vehicles are responsible for maintaining positive control of keys. Personnel not assigned project vehicles may not use a vehicle unless specifically authorized by the Project Manager (and then only for the authorized personal related activities as described in Section 2.1). The Project Manager may delegate this authority to the Site Manager/SUXOS under special circumstances.

Personnel utilizing leased or rental vehicles will comply with the following:

- Only properly licensed personnel will operate vehicles.
- Operators will obey and observe all applicable traffic laws.
- Operators will be familiar with the vehicle in use.
- Operators will observe the cautions and warnings located in the owner's manual.
- Operators will be familiar with accident reporting procedures.

- Operators will perform daily inspections of vehicles.
- Operators will report all unsafe or defective conditions found.
- Unsafe conditions will be corrected prior to vehicle use.
- Vehicles will be maintained in a clean and serviceable condition.
- Rental/lease contractual requirements will be followed.

2.0 PROCEDURES

The procedures below are to be followed by personnel receiving, using, and returning leased or rental vehicles.

- Receiving – Personnel responsible for receiving leased or rental vehicles are to ensure that:
  - Vehicle documentation is accurate and complete, with proper signatures.
  - Contract documents accurately reflect mileage, fuel level, and overall vehicle condition, including any exterior or interior damage.
  - Operators are properly licensed.
  - Vehicle is clean and in a serviceable condition.
  - Vehicle has all required safety/spare equipment.
  - Owner's/operator's manual is on hand.
  - Copy of lease or rental contract is in vehicle.
  - An inspection of the vehicle is performed prior to acceptance. All damage is noted on the rental contract inspection sheet and a copy of it is obtained. When renting work vehicles, photos are taken of all damage present on the vehicle upon delivery.
  - The "Lower Option" vehicle is used, if available (e.g., vinyl instead of cloth or leather interior).
- Use – Personnel responsible for the use of leased or rental vehicles are to ensure that they:
  - Are properly licensed.
  - Obey and observe all applicable traffic laws.
  - Always use seatbelts.
  - Observe safe operating procedures.
  - Do not allow unauthorized use of the vehicle.
  - Maintain the vehicle in a clean and serviceable condition.
  - Report all unsafe or defective conditions.
  - Do not operate an unsafe vehicle.
  - Report all accidents immediately.
  - Follow all rental/lease contractual requirements.
  - Perform daily/weekly inspections and document these inspections on the Weekly Vehicle Inspection Sheet.
  - Maintain added safety equipment (i.e., fire extinguishers and first aid kits).
  - Purchase (at company expense) materials to assist in keeping the vehicle clean.

- Purchase (at company expense) inexpensive floor mats and/or seat covers, if necessary.
- Utilize "Wash Racks" (at company expense) if high pressure washing is necessary.
- Wipe down and sweep out the interior of the vehicle, as needed.
- Do not use vehicle off road, unless necessary, and then only during working hours.
- Do not overload the vehicle.
- Use/maintain the vehicle in a manner that reflects favorably upon the personnel, the project, and USA.
- Prohibit the use of tobacco products in project vehicles by all occupants at all times.
- Do not use cell phones while operating project vehicles.
- Decrease speed when adverse weather conditions are present.
- Obey Stop, Yield, Parking, and other traffic regulating signage.
- <u>Drinking alcohol and driving leased or rental vehicles is strictly prohibited</u>. Personnel taking "over the counter" medications or prescription medications are prohibited from operating project vehicles until the effects of the medication(s) are known not to inhibit the individual's driving abilities.

• Turn-In – Personnel responsible for the turn-in of leased or rental vehicles are to ensure that:
  - The vehicle is **cleaned**, inside and out, prior to turn-in (should be in "as good or better than when received" condition).
  - The vehicle is inspected and results are recorded. Take photographs of all damage to the vehicle.
  - All documentation is accurate and complete, with proper signatures.
  - Any discrepancies are corrected or reported prior to departure.
  - All rental/lease contractual requirements have been met.
  - Copies of all documentation are received.
  - Copies of all documentation are forwarded to USA's corporate office.
  - Damage requiring claims forms have been initiated and USA's corporate office has been notified.
  - Points of contact for all parties involved in a claim are listed.

2.1 AFTER HOURS FOR PERSONAL USE OF VEHICLES

The use of project vehicles after normal working hours will be limited to the following:

- Travel to and from food stores
- Travel to and from laundry facilities
- Travel to and from restaurants
- Travel to and from medical facilities
- Other locations as authorized by the Project Manager

The off-duty use of project leased vehicles will be authorized under the following conditions:

- Off-duty use must be authorized by the Project Manager on an individual basis utilizing the enclosed Vehicle Liability Form, and a copy of this form must be in the vehicle. The Project Manager may delegate this authority to the Site Manager/SUXOS under special circumstances. After-hours use of project vehicles will be restricted to use by personnel traveling by commercial transportation to the project site.
- Project personnel will receive this SOP upon arrival at the job site. Those who wish to utilize project vehicles for personal use after normal working hours must fully complete and sign the enclosed Vehicle Liability Form; those not wishing to use the vehicle for personal use must indicate this on the form and sign and date it. All forms are to be returned to Human Resources.
- Failure to provide the completed and signed Vehicle Liability Form will be cause for denying the employee use of project vehicles.
- Vehicle used during the week will be parked for the evening at the employee’s quarters not later than 1900 hours local time, and is not to be driven again until regular work time the following morning. (Note: On sites with extended work hours and/or remote locations, the 1900 hours restriction may be extended with the approval of the Project Manager.)
- Car pooling for trips to the store, dinner, etc. is encouraged.
- For weekend usage, operators will complete a vehicle inspection form, record the mileage when receiving the vehicle, and return it on Monday with a full tank of fuel and cleaned inside and out. Weekend use will be limited to 50 miles, and the vehicle must be parked for the evening at the employee’s quarters no later than 1900 hours local time on Friday, Saturday and Sunday. The employee may resume driving the vehicle at 0700 hours on Saturday and Sunday and regular work time on Monday morning. Any exceptions to this rule must have prior approval of the Project Manager. Under no circumstances will vehicles be used for “sightseeing” or travel to other metropolitan areas.
- Project vehicles will not be used to transport non-project personnel.
- Off-duty vehicle users will comply with the guidance elsewhere in this SOP.

2.2 DAMAGE/ACCIDENT REPORTING

Should an employee become involved in an accident while operating a project vehicle or should the vehicle sustain damage while in the possession of the employee, the operator will:

- Immediately notify his/her Team Leader, the UXOSO, SUXOS, or Site Manager of any accident involving another vehicle or personnel injuries.
- Complete an Accident/Near Miss Report Form.
- Further document the accident by photographing the accident scene and damage incurred to the vehicle(s).
- Submit to a blood alcohol content (BAC) test within 2 to 4 hours after the accident. The driver will be driven to the test site by the Team Leader, UXOSO, SUXOS or Site Manager if impairment is suspected.

Site management personnel will report all accidents and incidents in accordance with the procedures outlined in the project Accident Prevention Plan (APP). The Project Manager is to be immediately notified of any accident involving serious injury to the driver or other parties.

2.3 SUMMARY

The procedures contained within this SOP are not all inclusive. Personnel are reminded to comply with the referenced material. To eliminate, reduce, and mitigate the risks to the vehicle operator, vehicle passengers and the surrounding populace, good, safe driving skills and habits are essential to an accident-free project.

AUTHORIZED DRIVERS LIST
USA ENVIRONMENTAL, INC

Project Site/Location:

Date Vehicle Assigned:	Name of Person Vehicle Assigned To:	Drivers License State, Number and Expiration Date:	Type Vehicle Assigned and Identifying Number: (i.e. license plate number)	Signature of Assigned USA Employee:	Signature of Senior USA Employee Assigning Vehicle:

USA Environmental, Inc.
Vehicle Liability Form

USA Environmental, Inc., requires you to complete this form if you are flying to the job site and wish to drive a company-leased vehicle after work hours for personal use. USA Environmental, Inc., will acquire a Motor Vehicle Report (MVR) from the state where your license is issued and may revoke driving privileges based on report results.

If you do not intend to drive a company-leased vehicle after work hours for personal use, please print your name, check the box below and sign and date the form.

Employees will be given a copy of, and are expected to adhere to, the company's Standard Operating Procedures (SOP) for Leased Vehicles. Employees who damage a vehicle while in non-compliance of the SOP may be liable for all damages incurred. USA Environmental, Inc., reserves the right to deduct these costs from your pay, as permitted by applicable state law.

Negligent use of company-leased vehicles may also result in disciplinary action, up to and including termination.

☐ I **do** intend to drive a company-leased vehicle for personal use. The following is my personal information:

Employee Name: ____

Address: ____

City/State/Zip ____

Job Site: ____

Driver's License State: ____

Driver's License Number: ____

Expiration Date: ____

☐ I do **not** intend to drive a company-leased vehicle for personal use.

My signature below verifies that I have received a copy of the SOP for Leased Vehicles.

______________________________ ______________

Signature Date

OPS-25 STANDARD OPERATING PROCEDURE
FIELD PROCEDURE DOCUMENT CHANGE PROTOCOL

1.0 PURPOSE

The purpose of this SOP is to ensure that all changes to field procedures are properly vetted by the proper personnel at USA Environmental, Inc. (USA) and approved by the Contracting Officer prior to implementation. These procedures will ensure proper scoping, safety, and procedural integrity in the field environment. Changes to regulations, references, directives, policies, or contracts may require a change to or revision of the previously issued document. All documents will be reviewed by authorized appropriate personnel for review and approval prior to change and implementation.

2.0 SCOPE

This Field Procedure Document Change Protocol Standard Operating Procedure (SOP) applies to all site personnel, to include contractor and subcontractor personnel, and all operations involved on each individual project site.

3.0 RESPONSIBILITIES

3.1 FIELD PERSONNEL

Field personnel (to include site supervisors) are responsible for forwarding any request for change/revision to an existing document using the procedures outlined within this SOP. Under no circumstance (with the sole exception of immediate safety concerns) should a change/revision be incorporated until it has been reviewed and approved by authorized USA personnel and the appropriate Contracting Officer or his/her representative as needed.

3.2 PROJECT QUALITY MANAGER

The Project Quality Manager (PQCM) is responsible for determining the validity of the change/revision recommendation and, if deemed valid, forwarding the recommendation expeditiously within the USA organizational chain to those personnel responsible for review and approvals.

3.3 PROJECT MANAGER

The Project Manager (PM) is responsible for the overall project management of all operations at USA project sites that the PM manages. The PM sets the tone for procedural integrity at each site. As such, the PM is responsible for ensuring that procedures specified by the Statement of Work (SOW), Work Plan (WP), and accepted SOPs and supporting documents are strictly adhered to throughout the project. However, projects are always dynamic processes and thus changes and/or revisions can and will be identified throughout its duration. It is the responsibility of the PM to ensure that any change/revision to an already agreed upon procedure is processed and authorized prior to implementation.

3.4 PROGRAM QUALITY MANAGER

The Program Quality Control Manager (PQCM) is responsible for the continuous improvement of all processes within his/her program to include the management of specific projects. To accomplish this, the PQCM will be responsible for the following:

- Becoming thoroughly familiar with the procedures of all projects under his/her cognizance.

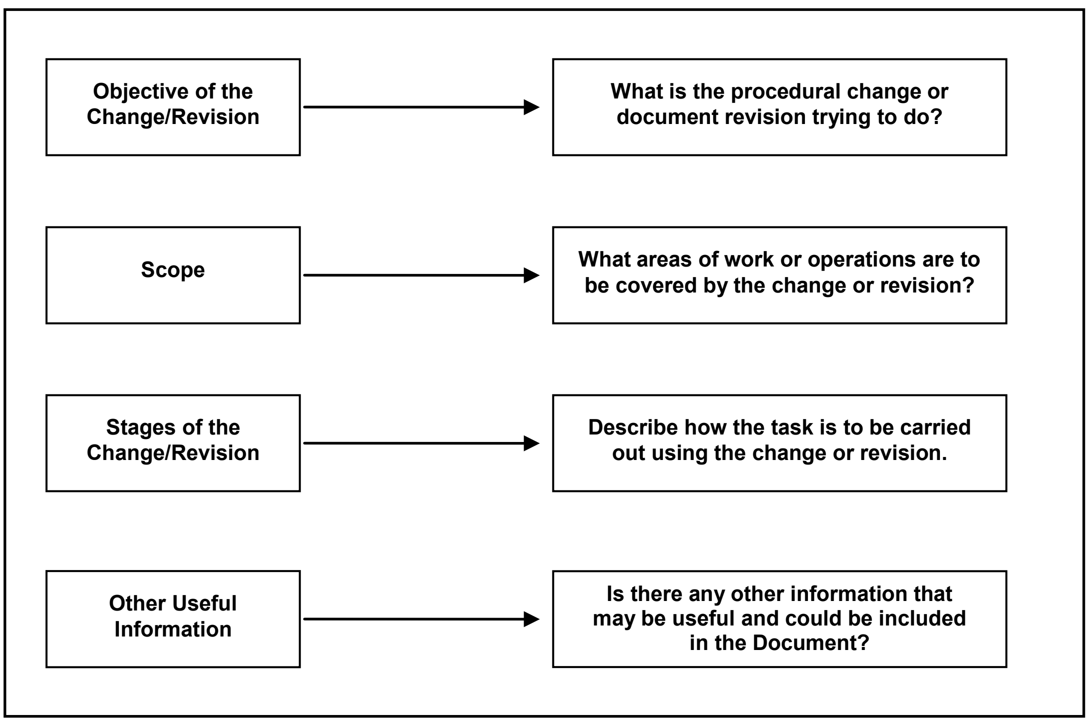
- Observing periodically project management on-site.
- Reviewing procedural change recommendations from field crews and/or project managers.
- Recommending authorization for specific changes/improvements to field operations to the Program Manager.

3.5 PROGRAM MANAGER

The Program Manager will be the final arbiter of the validity for the recommendation within the USA organizational chain. If deemed valid, the PM will contact the Contracting Officer or his/her representative and request that the change be incorporated into field procedures. Documents generated by USA will be drafted, reviewed, finalized, and approved for use by the appropriate sections to include Safety, QC, and Operations.

4.0 SUBMITTAL OF CHANGES OR REVISIONS

Personnel identifying a need for change or revision to an existing document will complete a Change/Revision Request Form and submit it to the management chain for processing. The following guidance is designed to assist in properly addressing the change/revision being sought.



Request for a change or revision to an existing document must be accompanied by a draft of the change or revision being sought. This draft must include the original text, the proposed text, references for the proposed change or revision (i.e., regulatory update, contract change, variation of equipment) to include page, paragraph, bullet, drawing, figure, section, or subsection of the reference material.

5.0 REVIEW AND APPROVAL PROCESS

Request for changes or revisions to an existing document will follow a review and approval process that incorporates the various sections or departments as needed to determine the validity of the request and ensure that authorized, appropriate personnel have agreed to and signed the approval form for a change or revision to be completed. Personnel assigned to review the request will determine the following:

- Has the request been submitted for an existing document;
- Does the request document the change or revision needed;
- Has a draft, with reference material, been submitted;
- Have the various sections or departments affected by the request been notified.

Once the request has been entered into the review and approval process personnel assigned to the request will determine the following:

- Is the change or revision required by a regulatory or contractual document;
- Is the change or revision necessary due to variations in equipment, training, or personnel;
- Will the change or revision affect other document(s) and have they been identified;
- Will the change or revision impact safety, quality, or production in a positive or negative manner and
- Does the proposed change or revision meet the needs of the requirement?

Once a change or revision has been accepted and implemented, outdated or obsolete documents will be removed from use and the change or revision disseminated and briefed to affected personnel, sections or departments. Those changes or revisions that affect other documents will be briefed as well to ensure continuity between the various documents.

Training required by a change or revision will be addressed by site management and have the necessary training scheduled as appropriate.

6.0 SUMMARY

This SOP is designed to assist those personnel requesting a change or revision to an existing document. This document is not to be considered all inclusive and is to be used in conjunction with existing policies, directives, regulations, and guidance. Personnel requesting, reviewing, approving, and implementing documents have an obligation to ensure that subject material, references, interpretations, or other input is accurate and its inclusion suited to the request for change or revision.

USA
FIELD CHANGE/REVISION REQUEST FORM

Date:	**Department:**	**Name:**
Change or Revision:	**Plan/Procedure/SOP Name or #:**	
Site Location:		

Preliminary Information

Current Document	**Check All That Apply**	**Supporting Documentation (List document, page, para., etc.)**	**Submitted By (Initials)**	**Reviewed By (Initials)**
Change or Revision Due To:				
1. Regulatory Update				
2. Contract Requirement				
3. Equipment Change				
4. Newly Identified				
a) Safety Hazard				
b) QC Measure				
c) Operational Issue				
5. Other:				

Summary of Change or Revision: (Identify procedural, contractual, equipment, or operator and how this affects the current SOP)**:**

Change or Revision Requested: (Identify page, para, figure, table, etc. that is changed or revised)

Requestors Signature:	
Change or Revision: Accepted Rejected Reason for Rejection -	**Reviewers Signature:** **Safety/QC Signature:**
Corporate: Concurrence Non-Concurrence	**Corporate Approval Signature:**

STANDARD OPERATING PROCEDURE
OPS-29 -- EXPLOSIVES TRANSPORTATION VIA OPEN WATER VESSELS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide the minimum procedures and safety and health requirements applicable to the transportation, loading, storage, and unloading of explosives (demolition material) by open water vessels.

2.0 SCOPE

This SOP applies to all project personnel, including contractor and subcontractor personnel, involved in the conduct of operations pertaining to the transportation of explosives by open water vessel. This SOP is not intended to contain all of the requirements needed to ensure compliance. Consult the documents listed in Section 3.0 of this SOP for additional compliance issues.

3.0 REFERENCES

Procedures and information contained in this document were obtained from the references below:

- USA Corporate Safety and Health Program (CSHP)
- 29 CFR 1910, Industry Standards
- 33 CFR, Navigation and Navigable Waterways
- 46 CFR, Shipping
- 49 CFR, Department of Transportation, Subtitle B, Subchapter C
- ATF P 5400.7, ATF-Explosives Law and Regulations
- USACE EM 385-1-1, Safety and Health Requirements Manual
- DoD 6055.9-STD, DoD Ammunition and Explosives Safety Standards
- DA PAM 385-64, Ammunition and Explosives Safety Standards
- AR 385-64, Ammunition and Explosives Safety Standards
- AR 190-11, Physical Security
- AR 385-40 w/USACE Supplement, Accident Reporting and Records
- AR 385-10, The Army Safety Program
- TM 9-1300-214, Military Explosives

4.0 RESPONSIBILITIES

4.1 PROJECT MANAGER (PM)

The Project Manager (PM) is responsible for the purchase, delivery, and transportation of explosives ordered through the use of designated or contracted personnel. Personnel will be qualified for the task delegated to them and verification of credentials/qualifications will be documented by the PM.

4.2 SENIOR UXO SUPERVISOR (SUXOS)

The SUXOS will be responsible for the physical movement of explosives for his/her project site. He/she will oversee the loading, storage/stowage, transportation, and unloading of the explosives. The SUXOS will act as the responsible person for all 1.1 – 1.4 explosives and ensure the vessel has a designated competent person prior to open water movement.

4.3 UNEXPLOSIVE ORDNANCE QUALITY CONTROL SPECIALIST (UXOQCS)

The UXOQCS will be responsible for performing inventories and inspections of explosives with the SUXOS. He/she will accomplish this by reviewing the accountability documentation, and inventories of explosives being transported. Inspection including physical security (locks), placarding, containers, firefighting equipment, and emergency response capabilities will be reviewed prior to movement.

5.0 REQUISITION PROCEDURES

The requisition of explosives will be in accordance with (IAW) USA Environmental, Inc.'s (USA's) policy, which requires that three quotes be obtained (when possible) to ensure the best possible price for the task. Of paramount importance in this process is the determination of the location of the supplier(s). Generally, response time to requisitions is better by those suppliers closest to the site. Delivery of the explosives to the vessel is conducted by the vendor. Upon delivery by the vendor, authorized USA personnel will then inventory and sign for the explosives. See the SOP for Requisition of Explosives for details.

6.0 LICENSES/PERMITS

USA will ensure that proper licenses or permits as required are in place for the following:

- Requisition of explosives (Federal and state requirements).
- Use of explosives (State, Local blasters license).
- Transportation of explosives (Federal, state, and local vessel and vehicle requirements).
- Storage of explosives Federal, state, and local requirements).

6.1 FEDERAL LICENSE

In order to requisition explosives, USA will have a valid Bureau of Alcohol, Tobacco, Firearms and Explosives (BATFE) license/permit on hand, to include an Explosives Purchase/Receipt Authorization List for the receipt of explosives. These two documents must be on file at the USA Corporate office and at the project site; additionally, each explosives supplier must have a copy of the documents on file in order to sell explosives to USA.

6.2 STATE BLASTER'S LICENSE/PERMIT

When required by the state in which a project is being conducted, USA personnel will obtain a state blaster's license/permit. This will usually be accomplished by contacting the appropriate state office (e.g., State Fire Marshall, Safety Office, Insurance Office, Law Enforcement, or Licensing Division) to determine the requirements. The PM and SUXOS will be responsible for identifying the need to obtain a blaster's license/permit for a given project and for scheduling personnel, through Human Resources, needed to obtain the requisite license/permit. In some circumstances, permitting may also be required for the use, transportation and storage of explosives. Should this be the case, additional requirements will need to be identified and action taken by the PM and SUXOS. These actions may include securing storage permits and obtaining CDLs, and HAZMAT endorsements.

6.3 STATE/LOCAL PERMITS

In some instances, it is necessary to obtain a state or local permit to conduct operations. This may be accomplished by contacting the appropriate agency for requirements and instructions.

7.0 EXPLOSIVES RECEIPT

Only those individuals named on the authorization list may sign for explosives from the vendor/shipper. In order to ensure that the quantity shipped is the same as the quantity ordered and listed on the shipping documents, two USA personnel will inventory the shipment prior to signing for it.

7.1 SHIPPING DOCUMENTS

Explosive shipments generally are accompanied by the explosive supplier's Bill of Lading (B/L) and the shipping company's shipping document. The initial inventory will include reconciling the two documents with the actual shipment and creating an on-site record that includes these documents and the inventory records. Regardless of the outcome of the initial inventory, one copy of the B/L and the shipping company's shipping document will be attached to a copy of the Purchase Order (PO) request and the PO. One copy of each of these documents will be kept on file at the project site, and one complete set will be forwarded to the corporate office.

7.2 RECEIPT DISCREPANCIES

In the event that there is a discrepancy between the amount shipped and the amount received, the SUXOS will immediately contact the explosives supplier and inform the supplier of the discrepancy. It is then the responsibility of the supplier and shipper to rectify the situation and inform USA of the results. The supplier and/or shipper must then correct their documents and forward the corrected documents to the site. In all cases, only the amount actually received will be entered on the Explosives Accountability Record/Magazine Data Card.

8.0 EXPLOSIVES STORAGE ON BOARD THE VESSEL

Explosives being prepared for movement by open water vessels require the availability and use of approved storage/shipping containers. USA will comply with regulatory storage/stowage procedures.

8.1 EXPLOSIVES CONTAINERS

For transport of explosives aboard an open water vessel, USA will ensure that IME-22 containers are utilized for the storage during movement. These containers are constructed IAW the requirements contained in IME Publication No. 22 and meeting the requirements of applicable sections of 49 CFR Subtitle B, Chapter 1, Subchapter C, Parts 171, 173, 176, 177, and 178.

IME-22 containers will be inspected at least every 24 hours while on board and after heavy seas. This inspection is not an inventory of explosives but is to determine whether an unauthorized entry, attempted entry or damage to the container, locks, or securing means has occurred.

8.1.1 Locks

Each lid/door will be equipped with a padlock fastened in welded hasps and staples meeting the requirements of ATF Publication 5400.7. Padlocks must have at least five tumblers or five blades and a casehardened shackle of at least 3/8 inch in diameter. ***Locks will not be like or master keyed.***

8.1.2 Signage/Placarding

The BATFE and the Department of Defense (DoD) require that all explosive containers be appropriately posted to indicate the hazard class of the contents, the fire fighting hazards, and the emergency notification list. Placarding of explosive containers will be IAW applicable sections of DoD 6055.9-STD and 49 CFR Subtitle B, Chapter 1, Subchapter C, Part 172. This will require that the container be posted for the most hazardous items stored in the container. In the event that there are two fire division or hazard class items in the same container, use the higher hazard division/class placard (lower number).

8.1.3 Emergency Notification List

An emergency notification list containing the names, telephone numbers, and addresses of the individuals or agencies to be notified in the event of an emergency will be kept on the vessel and inside of the container door. This list will include company, client, Federal, state, and local points of contact and notification as required.

8.1.4 Compatibility

Explosive compatibility will be maintained. Table 1 lists the various storage compatibility groups and Table 2 is the compatibility chart. Compatibility will be adhered to and any exceptions will be referenced and documented.

8.1.5 Key Control

Containers will remain locked during transport. The lock(s) on the containers will require two different keys to unlock. ***Locks will not be like or master keyed***. One key will be kept by the SUXOS and the second key by the UXOQCS. This procedure ensures that access to the containers cannot be gained without obtaining the two keys and no one individual can gain access to both containers. Keys may also be kept in two separate locked security boxes, provided no one individual has access to both boxes. Keys must be signed for by the responsible individuals.

Table 1: Category of Material (Hazard Class or Division Number)

Category of Material (Hazard class or division number and additional description, as appropriate)	Placard Name	Placard Design Section Ref.(')
1.1	Explosives 1.1	172.522
1.2	Explosives 1.2	172.522
1.3	Explosives 1.3	172.522
1.4	Explosives 1.4	172.523
1.5	Explosives 1.5	172.524
1.6	Explosives 1.6	172.525

Table 2: Storage Compatibility Chart

Groups	A	B	C	D	E	F	G	H	J	K	L	S
A	X	Z										Z
B	Z	X										X
C			X	Z	Z		Z					X
D			Z	X	X							X
E			Z	X	X							X
F						X						X
G			Z				X					X
H								X				X
J									X			X
K										X	U	
L										U		
S	Z	X	X	X	X	X	X	X	X			X

Notes:
1. The marking of an **X** at an intersection of the above chart indicates that these groups may be combined in storage. Otherwise, mixing is either prohibited or restricted per Note 2 below.
2. The marking of a **Z** at an intersection of the above chart indicates that, when warranted by operational considerations or magazine non-availability, and when safety is not sacrificed, these groups may be combined in storage.
3. Equal numbers of separately packaged components of complete rounds of any single type of ammunition may be stored together. When so stored, compatibility is that of the assembled rounds; e.g., WP Filler in Group H, HE Filler in Groups D, E, or F, as appropriate.
4. Group K requires not only separate storage from other groups, but also requires that munitions having different toxic chemical agent fillers be stored separately from each other.
5. The marking of a **U** on above chart indicates that leaking toxic chemical munitions of one agent type, e.g., GB, with or without explosive components, may be stored together in one magazine specifically designated for storage of leakers of that agent type.
6. Ammunition designated as **PRACTICE** by NSN and nomenclature may be stored with the fully loaded ammunition it simulates.

9.0 TRANSPORTATION BY VESSEL

Transportation of explosives by open water vessel will be accomplished in the following manner.

9.1 VESSEL REQUIREMENTS

The vessel used for the transportation of explosives must meet the minimum requirements for operating as prescribed by DOT (49 CFR) and U.S. Coast Guard standards (33 and 46 CFR). The vessel must be manned by competent personnel and be properly licensed, registered, and insured for the operations being conducted. During movement of explosives the vessel is deemed to be in a non-passenger mode of operation. All personnel on-board will be required to have a personal flotation device.

Vessel size is of paramount importance to allow for proper placement and security of the explosives container. No other cargo will be transported while the explosives container is on board and has explosive material stored inside.

9.2 STOWAGE OF EXPLOSIVES CONTAINER(S)

Explosives containers will be placed for stowage in approved locations (by vessel design) only. Containers will be placed so no other stowage is placed on top of or in front of container doors/lids. Containers will be secured in a manner that precludes movement during transportation. The following will also be accomplished prior to vessel movement.

- Containers will be placarded IAW applicable sections of DoD 6055.9-STD and 49 CFR Subtitle B, Chapter 1, Subchapter C, Part 172.
- Loading and unloading of explosives into the container will be accomplished by two qualified UXO Technicians.
- Inner packaging of explosives will be properly labeled/placarded.
- Dry chemical or foam filled fire extinguishers (two each 20B:C) will be identified and located in near proximity to the container for emergency use.
- Emergency response plans and notifications will be briefed to all on-board personnel to include assigned duties.
- Locks will be placed and secured on the containers. Keys will be maintained IAW Section 8.1.5 of this SOP.

9.3 VESSEL MOVEMENT

Vessel movement will be accomplished only by authorized vessel crew members. The vessel Captain is responsible for all actions taken with regards to operations occurring on-board the vessel. The Captain will ensure that movement is conducted IAW DOT (49 CFR), U.S. Coast Guard (33 and 46 CFR), State, and local requirements.

10.0 EXPLOSIVES ACCOUNTABILITY

Upon receipt of explosives and prior to movement by vessel, the magazine data card (see Figure 1 in the Attachment) is filled in and kept in the container on top of the listed item. A duplicate copy is maintained by either the SUXOS or UXOQCS. All entries will be verified by two individuals. Following movement, the explosives containers are removed from the vessel and surface transportation, storage, use, and inventories are conducted IAW those SOPs.

10.1.1 Issue of Explosives from Vessel

In the event the vessel is used to move explosives from one location to another for use (i.e., demolition operations on another island not accessible by truck from the Explosive Storage Location) and not for transfer to another storage location then the following will be accomplished:

- Applicable sections above will be adhered to at all times during loading, stowage, and movement.

Upon arrival at the destination only those explosives needed for demolition operations will be issued. Procedures for issuing explosives are found in the Explosive Receipt, Storage, and Issue SOP. In addition, the following will be accomplished:

- Issued explosives will be placed in “day boxes” for movement to the demolition site by a minimum of two UXO qualified personnel (one of whom must be a Technician III or higher).
- Day boxes will be properly placarded.

- Explosives remaining aboard the vessel will be observed and secured by a UXO Technician II or above, without access to IME-22 container keys.
- Loading and unloading from the vessel to boat to beach or dock will be under the supervision of a competent vessel crew member and responsible UXO Technician.
- Communications between the demolition operations personnel and the vessel UXO Technician will be in place prior to explosives leaving the vessel.
- Day boxes will be placed in the bottom of the transport boat or other acceptable location away from fuel, motor(s), and boat electrical equipment. The day boxes will be accompanied from the vessel to the beach or dock by qualified UXO technicians.
- The boat will be manned and operated by authorized crew member(s) from the main vessel. USA personnel will not operate the boat.
- All movement will be IAW the minimum requirements for boating operations as prescribed by U.S. Coast Guard standards. These include the use of personal flotation devices, fire extinguishers, and communication equipment.

10.2 INVENTORY DISCREPANCIES

In the event that there is a discrepancy during any inventory after movement by vessel, the item will be recounted a minimum of two additional times utilizing an additional individual if available. If a discrepancy still exists, the PM and the Corporate QC Manager will be notified. Required notifications of law enforcement will be made IAW the Emergency Notifications List. All actions from this point will be dictated by law enforcement or Corporate Management.

11.0 ATTACHMENTS

Figure 1- Magazine Data Card

Magazine Data Card

Nomenclature:

Lot Number: Unit Of Issue:

Date	Name	Received	Issued	Balance	Checkers Initials

Figure 1: Magazine Data Card

STANDARD OPERATING PROCEDURE
DSOP-08: UNDERWATER REMOTELY OPERATED VEHICLE OPERATIONS

1.0 PURPOSE

This Standard Operating Procedure (SOP) will be used to provide the minimum procedures and safety and health requirements applicable to the conduct of underwater Remotely Operated Vehicle (ROV) operations on sites contaminated with unexploded ordnance (UXO) or munitions and explosives of concern (MEC). This specific SOP will highlight procedures and requirements applicable to most underwater MEC operations where utilization of an ROV is planned.

2.0 SCOPE

This SOP applies to all USA Environmental, Inc. (USA) site personnel, including contractor and subcontractor personnel, involved in the conduct of underwater ROV operations on a UXO/MEC contaminated site. This SOP is not intended to contain all of the requirements needed to ensure complete compliance, and should be used in conjunction with approved project plans and applicable referenced regulations.

3.0 EQUIPMENT DESCRIPTION

The ROV unit identified for USA underwater operations is the VideoRay PRO 3 XE GTO. This standard ROV unit contains a multiple thrust propulsion system, high-intensity halogen lights, and high-resolution forward/rear cameras

The following additional components can also be utilized with the system:

- Smart Tether navigation and positioning system
- Detachable 900-kHz multibeam sonar.

Maneuvering the ROV is accomplished through use of a control console situated with the operator. The console also contains a display screen for viewing real time video images of the underwater environment. The console allows activation of a series of options, including depth control functions, magnetic heading and depth display, and video recording. The recorded video can be viewed following completion of underwater operations, and still images can be captured and inserted into associated reports and documents.

Optional sonar images can also be displayed on the console screen, and can be viewed concurrently with video images.

The operational depth range for the VideoRay System extends from 1 to 400 feet (ft), depending on the tether type and length. The system can be deployed while operating from a small boat or land based location, and is powered from a standard 110-volt receptacle, a small gasoline generator, or a 12-Volt vehicle/marine battery with 12VDC to 110VAC power inverter.

4.0 GENERAL OPERATIONAL AND SAFETY PROCEDURE

All personnel, including contractor and subcontractor personnel, involved in ROV operations on UXO/MEC-contaminated sites will be familiar with the potential safety and health hazards associated with the conduct of underwater ROV operations, and with the work practices and control techniques used to reduce or eliminate these hazards.

The VideoRay ROV User Manual and Operations Checklist accompanying this SOP will be utilized for safe and operate the ROV, and the following general procedures are provided to ensure the safe and effective completion of underwater ROV operations:

- Unless otherwise planned and authorized, no physical contact with UXO/MEC will be made during ROV operations
- As required, utilize chase boats, marker buoys, U.S. Coast Guard assets, and local law enforcement agencies to establish and maintain water surface and underwater exclusion areas while conducting ROV operations
- Ensure that electrical safety procedures are closely followed given the power source utilized. These procedures include properly grounded generators, cover/shielding of battery terminals, and protecting electrical outlets from water intrusion. Electrical cords associated with the system should be suspended above the floor/boat deck in order to avoid contact with standing water.
- Generators will only be operated in well ventilated spaces. Spill containment procedures will be followed when refueling generators.

More specific operating and safety procedures will be dependant on the operating location and requirements.

5.0 SPECIAL REQUIREMENTS FOR UNDERWATER ROV OPERATIONS

The presence of sensitive marine habitats or protected marine species may exist in the area where ROV operations are intended. It is imperative to be aware of applicable regulations regarding sensitive marine habits, and comply with all guidelines. Refer to specific, site related information outlined in the associated work plans or provided by other guidance documents.

6.0 REFERENCES

Applicable sections and paragraphs in the documents listed below will be used as references for the conduct of ROV Operations:

- USA Corporate Safety and Health Program
- Basic Safety Concepts and Considerations for Ordnance and Explosives Operations, EP 385-1-95a
- USACE EM 385-1-1, Safety and Health Requirements Manual
- VideoRay PRO 3 XE GTO User's Manual and Operations Checklist

VideoRay

Operating Checklists

Make sure the power switch is set to "Off" before plugging in or unplugging any connections!

Make sure all connections are securely fastened to avoid loss of control or loss of your VideoRay!

Pre-Dive Checklist

- ❑ Visually inspect the vehicle, especially the thruster shaft seals for signs of leaking, low oil or contamination, and the desiccant pack in the rear of the main housing for signs of moisture.
- ❑ Visually inspect the tether for nicks or other signs of damage.
- ❑ Connect all cables and <u>ensure that the tether connectors are screwed together to avoid separation and loss of the VideoRay</u>.
- ❑ Power up the VideoRay by engaging the main **Power** switch to ***On***.

  CAUTION *Do not operate the thrusters for more than 20 seconds when the VideoRay is out of the water. Prolonged operation in a dry environment will result in damage to motor shaft seals.*
- ❑ Ensure that the propellers are free of tangles and check the propeller guards for damage and / or misalignment. Displace the joystick in all directions to test the port and starboard thrusters.
- ❑ Using the **Depth Control** knob, rotate it to test the vertical thruster. Return the knob to the neutral (centered) position.

  CAUTION *Do not operate the lights for more than 60 seconds when the VideoRay is out of the water. Doing so may cause overheating and damage the unit.*
- ❑ Verify that the lights are working by turning the **Lights** knob toward ***Bright***, and then returning the knob to the ***Dim*** position.
- ❑ Check the camera **Tilt** and **Focus** functions and video display operation. If you are using a recording device, check that it is operational. If equipped, check the rear facing camera and lights.
- ❑ Check any other additional accessories according to the specific procedures for each accessory.
- ❑ Ballast the vehicle according to the conditions and make sure the ballast is secure.
- ❑ Check the dive area for potential hazards prior to launching the VideoRay and alert others in the area when you are ready to launch.

Post-Dive Checklist

- ❑ Power down the system by engaging the main **Power** switch to ***Off***.
- ❑ Make sure the VideoRay is securely on-board, unplugging any connections.
- ❑ Visually inspect the VideoRay to ensure that no damage has occurred.
- ❑ Visually check through the ports to ensure that no water has entered the pressure housings.
- ❑ Check that the propeller shafts have not been fouled with material such as fishing line, string, seaweed, or other debris.
- ❑ Thoroughly rinse the vehicle with fresh water prior to being stored away. Be sure to rinse and drain the pressure sensor cavity under the float block (if equipped).
- ❑ Inspect the tether for cuts, nicks and / or kinks in the outer shell. Store the tether properly for the next use.
- ❑ Store all components securely.

For convenience and operational efficiency, use a wipe off marker to complete each checklist.

VideoRay

PRO 3 XE GTO

REMOTELY OPERATED PROFESSIONAL SUBMERSIBLE

580 Wall Street
Phoenixville, PA 19460
USA
http://www.videoray.com

TABLE OF CONTENTS

1 INTRODUCTION

1.1 ABOUT THIS MANUAL

The purpose of this manual is to provide information only. It is subject to change without notice and does not represent a commitment on the part of VideoRay, or its agents.

1.2 ABOUT YOUR VIDEORAY

Prior to shipment, your VideoRay Submersible was tested and found to comply with factory standards.

The serial number of the VideoRay is labeled on the hull under the float block, and inside the hull (visible through the rear dome). The serial number of the controller is engraved on a plate that is attached to the front of the Controller case. Please provide your system serial number(s) whenever corresponding with us.

1.3 FRIENDLY ADVICE

"Flying" the VideoRay can be somewhat addictive. If you are operating VideoRay and have an important appointment later in the day, we strongly recommend you set an alarm clock or arrange to have a friend remind you at the appointed time!

2 GENERAL INFORMATION

2.1 DESCRIPTION

VideoRay is a submersible, Remotely Operated Vehicle (ROV) designed to take advantage of its portability and size. Set up and vehicle control are simple and intuitive, enabling VideoRay to be easily carried, deployed, and operated by one person. VideoRay can go anywhere, powered by conventional AC, or a battery pack and inverter. Operation of the VideoRay is quickly mastered after only a few practice “flights.” Connection to a video monitor provides the operator with a view of everything the VideoRay sees.

VideoRay carries no batteries; it is completely powered and controlled from the surface through a small diameter tether.

For operational safety, the joystick control, vehicle and tether carry a maximum voltage of 48 Volts DC.

2.2 OPERATING ENVIRONMENT

VideoRay ROV

Medium:	Fresh or Salt Water
Operating Temperature:	32-122º F (0-50ºC)

VideoRay Integrated Control Box (ICB)

Caution: While the VideoRay ROV is designed to be operated in water, the Integrated Control Box is splash-resistant and should not be subject to excessive water spray or rain when opened. The Integrated Control Box case is watertight only when closed.

VideoRay is equipped with a universal power supply. The input voltage range is 100-240Volts AC, 50-60 Hz. A standard computer power cable is used, and in general, the controller may use any standard AC electrical source in Europe or North America. An optional adapter may be required for use in some countries.

VideoRay can be powered from a battery using an AC inverter. VideoRay recommends at least a 600 Watt inverter. Sometimes the quality of the inverter can affect the operation of VideoRay. Some inexpensive inverters do not produce a true sine wave AC output. Instead they produce a ‘chopped’ or ‘simulated’ sine wave that can produce a lot of electrical noise. A poor quality inverter may produce enough noise to interfere with operation and/or video quality of VideoRay.

2.3 SPECIFICATIONS

VideoRay is equipped with a forward facing color camera, two lights, two horizontal thrusters and one vertical thruster. A rear black and white camera and rear lights are also included in the Pro III.

Options for the VideoRay Pro III include a manipulator, sonar system positioning system, radiation sensor and more. (See Section 10 on Accessories for more information). Additional options are being added on a regular basis, please check http://www.videoray.com or your VideoRay dealer for the latest information.

Depth Rating	152 m (500 feet)
Depth Gauge	Selectable meters or feet
	Resolution = 0.1 units (meters or feet)
Dimensions	35.5 cm (14 inches) long
	22.5 cm (8-7/8 inches) wide
	22.9 cm (9 inches) high
Weight	3.6 kg (8 lb)
Operating Voltage	100-240 Volts AC controller supply voltage
Internal Voltage	48 Volts DC maximum
Lights	2 - 20 Watts (1 port, 1 starboard)
Front Camera Viewing Angle	+/- 90º
Front Camera Tilt Angle	+/- 75º Pitch (vertical rotation)
Front Camera Focus	From the face of the housing dome to infinity
Rear Camera Tilt / Focus	Fixed
Video Display Monitor	127mm (5 inch) LCD
Tether	76 m (250 feet) Neutrally Buoyant is standard
	Custom length, neutral or negative buoyancy is available
	Minimum bend diameter = approximately 8 cm (3 inches)
Speed	0 – 4 knots

3 SAFETY FIRST!

The following safety tips may prevent injury to you as the operator and those around you, or damage to the VideoRay submersible.

3.1 USE COMMON SENSE

1) Read the safety and operating instructions before operating the VideoRay.
2) Heed all warnings printed on the system components and in the manual.
3) Retain this manual and other safety and operating instructions for future reference.
4) Be aware of and alert to potential hazards in and around water, including weather conditions, and follow standard water safety practices.

3.2 ELECTRICAL AND VIDEORAY SAFETY

1) Electricity and Water don't mix! Use caution with all power supply cables and do not handle them while you are in contact with water or allow them to come into contact with water. The VideoRay submersible, the tether and approved accessories are the only items that can be safely placed in water.
2) Do not use any system that contains broken or ruptured insulation, frayed wires or loose connections. Repair such conditions before resuming operations.
3) Protect the Integrated Control Box from splashes and immersion in water when open. The controller is sealed when closed, and splash resistant when open.
4) Always plug the system into a grounded receptacle.
5) There are no user serviceable parts inside the Integrated Control Box. Only qualified technicians or VideoRay personnel should perform electrical servicing.
6) Do not subject the VideoRay to impact.
7) Never operate the lights for more than 60 seconds out of water. Never operate the thrusters for more than 20 seconds out of water. Your VideoRay is designed for submerged operation and requires water to cool the lights and thrusters.
8) Do not stress or kink the tether or bend it tighter than the minimum bend diameter, which is about 3 inches. Do not allow the tether to be deployed over sharp edges or rough surfaces.

3.3 PERSONAL SAFETY

Be aware of the safety of those around you!

1) Beware of swimmers or boaters. The VideoRay and tether can pose a hazard to swimmers, divers, and small craft, as well as persons in and around the operating area. Obtain the acknowledgment of those around you prior to launch. Make sure everyone within VideoRay's range of operation is aware the vehicle is being deployed.
2) Keep your operating area neat and free of accident causing clutter.
3) Keep fingers and objects clear of the thruster propellers.

4 GETTING FAMILIAR WITH YOUR VIDEORAY

4.1 UNPACKING YOUR VIDEORAY

Your VideoRay Remotely Operated Video Inspection Submersible is packaged and shipped in two rugged Pelican Diver Cases. These cases have O-rings and are sealed against water when closed. The smaller case integrates the power supply, controller, and optional screen and or recording device. The larger wheeled case contains the VideoRay ROV, tether and if purchased, the optional Tether Deployment system.

Upon receiving your VideoRay, check the containers and contents for any damage that may have occurred during transport.

4.2 INSPECTING YOUR VIDEORAY

In the shipping crates you should find these components:

1) Fully assembled VideoRay ROV with tether
2) Integrated Power Supply / Controller
3) Maintenance Tools and Spare Parts Kit
4) Video Monitor (mounted in Controller case cover)
5) This Owner's Manual and related reference cards
6) Any optional accessories you purchased

Should any of these components be missing or damaged, please notify the selling agency.

4.3 PREPARING TO OPERATE YOUR VIDEORAY

Operating your VideoRay controller is like being in the driver's seat of your car. The joystick and switches are used to control your VideoRay ROV, similar to the way you use the steering wheel, pedals and dashboard knobs to control your car's operation. The controller's LCD display provides feedback like your dashboard gauges do, and the Video monitor displays what you might see through the "windshield." Additionally, a video overlay allows some settings to be superimposed over the video image to allow heads-up control and navigation.

Before setting up and operating your VideoRay, we recommend that you read all safety precautions in Section 3. The fundamentals of operation can be found in Section 5. Detailed descriptions of all of the features and functions can be found in Section 6. Section 7 provides advanced handling instructions and tips. Sections 8 and 9 cover maintenance and troubleshooting, and Section 10 describes optional accessories.

Take a moment now to familiarize yourself with the VideoRay ROV, the controller's layout and the feel of the controls. Proper operation, maintenance and safe handling of your VideoRay will provide you with successful dive operations and extended serviceability.

5 YOUR FIRST DIVE

Your VideoRay ROV has been designed with ease of use in mind. This section covers only the most basic aspects of operating your VideoRay. It will walk you through the steps required to make your first dive. Section 6 contains a complete reference to all of the features and functions of your VideoRay.

Note: If the Safety Instructions in Section 3 have not been read, it is recommended you do so before operating your VideoRay.

5.1 DIVE CONDITIONS

Your first dive should be made in conditions that are suitable for learning. The following conditions are optimal:

- Good weather and low wind speed
- Clear water
- Slow water current
- No obstructions above or below the surface

While VideoRay can be used in less than optimal conditions, including some rather extreme conditions, it is best to gain some experience before attempting such challenges. If the conditions are too adverse, it may be wise to postpone your dive or find a more suitable dive location.

Until you feel comfortable operating your VideoRay, you should try to operate it within a close range.

5.2 SETTING UP YOUR VIDEORAY

The following procedures outline the steps required to prepare the VideoRay for operation.

1) Open the Power Supply / Controller box and make sure the Main Power switch is set to the "Off" position.
2) Unpack the VideoRay and tether from the second container. Be careful not to kink the tether. See Section 7.2 for proper tether handling techniques and cautions. A Tether Deployment System (TDS) is an available option that greatly simplifies tether management and reduces the possibility of tether damage from mishandling.
3) Connect the surface end of the tether directly to the controller. Connect the VideoRay ROV end of the tether to the VideoRay ROV. The connectors are different and cannot be accidentally reversed.
4) Using the supplied video cable, connect a video monitor to the Video Out connector. A monitor with a ground prong on its power cord is recommended. (The Integrated Control Box allows an optional color video display to be installed in the cover.)
5) Plug the power cord into an appropriate Alternating Current (AC) power source.
6) You may need to adjust the ballast depending upon dive conditions and the activities you intend to perform. See Section 7.5 for more information on adjusting the ballast.

Once the system is connected together, a Pre-Dive Inspection should be made.

5.3 PRE-DIVE INSPECTION

A Pre-dive check should to be carried out prior to every dive.

1) Visually inspect the vehicle to ensure that the propellers are free of tangles and that the vehicle is in operational condition. Check the propeller guards for damage and / or misalignment.
2) Check the tether for scrapes, nicks or other visible damage.
3) Ensure that all fasteners and the ballast are in place and secure.
4) Ensure that all cables are properly connected and the tether connectors are screwed together tightly to avoid separation and loss of the VideoRay ROV.
5) Power up the system by engaging the Main Power switch to the "On" position.
6) Move the joystick in all directions to test the port and starboard thrusters.

   CAUTION! Do not operate the thrusters for more that 20 seconds when the VideoRay ROV is out of the water. Prolonged operation in a dry environment will result in damage to motor shaft seals.
7) Using the Depth Control knob, rotate it to test the vertical thruster. Return the knob to the neutral position.
8) Verify that both lights are working by turning the light knob toward "Bright", and then returning the knob to the "Dim" position.

   CAUTION! Do not operate the lights for more than 60 seconds when the VideoRay ROV is out of the water. Doing so may cause overheating and damage the unit.
9) Test the camera tilt and focus functions. The Tilt and Focus switches are spring-loaded momentary contact type switches and will return to the neutral position when pressure is released. All switches, except the Main Power switch, work this way.
10) Check the camera and monitor operation. If you are using a VCR, check that the recording and playback functions are operational. Check the rear facing camera operation and rear lights.
11) Check any other additional accessories according to the specific procedures for each accessory.
12) If you are not ready to launch the VideoRay, power down the system until launch time.

5.4 LAUNCHING THE VIDEORAY

CAUTION! Be certain that the tether connectors are securely connected and tightly screwed together to avoid separation and loss of the VideoRay ROV.

1) Power up the VideoRay.
2) The tether should be neatly coiled and made ready to deploy. It must be free of tangles, knots, and other obstructions.
3) Inform swimmers, divers, boaters and others in the area that you are about to deploy the VideoRay and that a tether that will be in the water as well.
4) Avoid dropping or throwing the VideoRay into the water. Rather, use the tether to lower the VideoRay to the water surface. This method will prevent potential of impact of the VideoRay against the pier or vessel from which you are launching.

5.5 MANEUVERING THE VIDEORAY

VideoRay is relatively easy to fly... and fun! Initially, a new operator should spend a few minutes controlling the VideoRay within sight near the surface in order to become familiar with VideoRay's reaction to its controls.

Flying the VideoRay in open water is not difficult and is quickly mastered. Operating the VideoRay in and around obstacles such as boats, pilings, and anchor lines will require a little more practice. In these conditions, it is advisable to go slow and consider the possible effects of any maneuvers.

Basic VideoRay operating instructions:

1) The operation of VideoRay is intuitive and simple. The joystick controls variable speed forward and reverse thrust. Push the joystick forward to move VideoRay forward. Pull the joystick back to back up.

2) Steering VideoRay is accomplished by moving the joystick left or right. Additionally, the joystick rotates (third axis control) to enhance control capabilities, but it is not necessary to use these capabilities on your first dive. See Section 6.2.3 for more details about the third axis control.

3) The Depth Control knob on the left-hand side of the controller controls the vertical thruster. Rotating the knob from the center detent position controls the rate of dive or ascent. Rotating the knob toward “Down” increases the depth. Rotating the knob toward “Up” causes the VideoRay to move toward the surface. VideoRay should be ballasted to always float upwards slowly, so continuous downward thrust is necessary to dive or to maintain a constant depth. When using Automatic Depth Control, the default mode, the controller will maintain a constant depth for you. See Section 6.2.2 for more information about using Auto Depth Control and manual depth control.

   Note: Inadequate ballast will cause VideoRay to float high in the water. When this happens the vertical thruster may not be sufficiently submerged to provide adequate downward thrust, and a rather impressive "water fountain" effect will result. Add more weight to the ballast if this is a problem. See Section 7.5 for tips on proper adjusting the ballast.

4) The front camera may be tilted up or down by engaging the Tilt “Up” / “Down” switch in the desired direction. Releasing the switch causes the camera to hold its orientation.

5) To focus the front camera, engage the Focus ‘In’ / ‘Out’ switch in the desired direction until the optimal focus is achieved. Releasing the switch causes the camera to hold its focus.

6) The intensity of the lights may be adjusted by turning the Lights knob.

Relax and enjoy your dive. Whatever you do, DON'T PANIC.... In the event of a problem, or if the tether appears to have become snagged on an obstacle, the best course of action is to stop and calmly assess the situation. A way out may present itself. Should you experience any problems, see Sections 7 and 9 for tips and troubleshooting.

5.6 RETRIEVING THE VIDEORAY

1) Ensure the tether is free from obstacles on which it may become caught or entangled in the water.

2) Navigate the VideoRay to a retrieval area where the water surface is clear of obstacles.

3) Power down the VideoRay by switching off the main power supply.

4) Retrieve the VideoRay by pulling it out of the water by its tether. Care should be taken to coil the tether properly (see Section 7.2) and avoid collisions between VideoRay and the pier or boat hull.

5) Once the VideoRay is retrieved, perform a Post-Dive Inspection as described below.

5.7 POST-DIVE INSPECTION

A Post-Dive inspection should be carried out after every dive.

1) Make sure the VideoRay is securely on-board.
2) Power Down the system.
3) Unplug the connections.
4) The vehicle should be visually inspected following each dive to ensure that no mechanical damage has occurred.
5) Visually check through the ports to ensure that no water has entered the pressure housings.
6) Check that the propeller shafts have not been fouled with material such as fishing line, string, seaweed, or other debris.
7) **If VideoRay has been used in salt water, thoroughly rinse the vehicle with fresh water prior to being stored away. Turn the vehicle upside down while rinsing to let water drain from the pressure sensor cavity under the float block.**
8) Inspect the tether for cuts, nicks and / or kinks in the outer shell. Store the tether properly for the next use.
9) Store all components securely.

6 VIDEORAY CONTROLLER FEATURES AND FUNCTIONS

6.1 CONNECTORS

6.1.1 TETHER CONNECTION

This connector is used to couple the Controller to the VideoRay ROV using the supplied tether.

6.1.2 VIDEO OUT

This composite video out connector is connected to the integrated video display monitor. Alternatively, it can be connected to a user supplied video monitor or VCR for displaying and/or recording images captured by the VideoRay ROV onboard camera. The signal format complies with either NTSC or PAL as specified when your system was ordered.

6.1.3 100 - 240 VAC 50-60 Hz

This is the power source feed for the Controller's power. For maximum portability, the VideoRay can be run from several common power sources. The AC power cord plugs into any standard outlet supplying 100 through 240 Volts AC. An external battery using an inverter may also be used to power the VideoRay.

6.1.4 RS-232 AUX

This DB-9 style connector provides an RS-232 interface as well as other auxiliary connections for accessories.

6.2 CONTROLS

6.2.1 MAIN POWER (On | Off)

This switch activates the controller. It should remain in the "Off" position when not using your VideoRay or when the system is unattended.

6.2.2 AUXILIARY (On | Off)

This switch is used to change between various Controller modes.

- Momentarily engaging it to "On" cycles Joystick Third Axis Control functions (Section 6.2.3).
- Momentarily engaging it to "Off" toggles Automatic Depth Control on and off (Section 6.2.5).

6.2.3 JOYSTICK (Forward | Left | Right | Reverse)

The joystick controls variable speed forward and reverse thrust. Push the joystick forward to move VideoRay forward. Pull the joystick back to back up. Steering VideoRay is accomplished by moving the joystick left or right. Additionally, the joystick rotates (third axis control) to enhance control capabilities.

Joystick Third Axis Control
The VideoRay joystick incorporates an additional operating technique that greatly increases the user's ability to control the VideoRay. The joystick has a "Third Axis" of operation. In addition to moving both forward and back (first axis) and side to side (second axis,) the knob will rotate either clockwise or counterclockwise (third axis).

A unique and extremely valuable characteristic of the VideoRay is the "user selectable" mode of the third axis control. The third axis mode can be set for any one of the following functions:

1) No Function – In this mode, the third axis does not perform any function. This is the default mode when the VideoRay is powered on.
2) Depth Control Mode - rotating the joystick clockwise causes the VideoRay to dive, rotating counterclockwise causes it to rise. The rate of depth change is proportional to the amount the knob is rotated. In this mode, the joystick knob takes the place of the Depth Control knob, although the Depth Control knob does not return to center with a spring the way the joystick does.
3) Camera Tilt Mode - rotating the knob counterclockwise tilts the camera up, clockwise tilts it down. This takes the place of the Tilt switch, and is therefore not proportional. In other words, rotating the joystick more will not cause the camera to tilt faster.
4) Lights Mode - rotating the knob counterclockwise decreases the brightness of the lights, rotating it clockwise increases the brightness. The amount the knob is rotated determines the rate of change - when centered the brightness level is held constant.
5) Manipulator Mode - rotating the knob counterclockwise opens the manipulator, rotating it clockwise closes the manipulator.

Momentarily engage the Auxiliary switch to "On" to change the mode of the third axis. The mode cycles from "No Function" through the four additional functions in the order they are listed above. The newly selected third axis mode is briefly superimposed on the video display after switching functions.

Note: When the third axis mode is active, the corresponding control switch or knob for that function is disabled.

6.2.4 DEPTH CONTROL (Up | Hold | Down)

A Depth Control knob on the left-hand side of the controller controls the vertical thruster. Rotating the knob from the center detent position controls the rate of dive or ascent. Rotating the knob toward "Down" increases the depth. Rotating the knob toward "Up" causes the VideoRay to move toward the surface. VideoRay should be ballasted to always float upwards, so continuous downward thrust is necessary to dive or to maintain a constant depth. When using Automatic Depth Control, the controller will maintain a constant depth for you. Auto Depth Control is by default set to "Off" when the VideoRay Pro III is powered up.

Automatic Depth Control (Auto-Depth)
When Auto-Depth is on and the Depth Control knob is centered on "Hold," the vertical thruster will attempt to maintain a constant depth. Rotating the Depth Control knob away from the center position will cause the VideoRay to rise or dive. Centering the knob again will then maintain the new depth. There may be some "bounce" or overshoot after adjusting the depth when Auto-Depth is activated. Usually, waiting a few seconds is all that is needed for the new depth to stabilize.

To activate or disable the Auto-Depth function, momentarily engage the Auxiliary switch to the "Off" position. The newly selected on or off state of the Auto-Depth will be briefly superimposed on the video display after toggling the Auxiliary switch. With Auto-Depth off, the Depth Control knob directly and proportionally controls the amount of vertical thruster "up" or "down" power. When the knob is centered, there will be no thrust and the VideoRay will rise or sink depending up on the ballast setting and the presence of any vertical water currents.

6.2.5 CAMERA (Front | Rear)

This switch selects between the front and rear camera. Only one camera may be monitored at any time. When selecting the camera, light control will automatically switch between the forward and rear lights as appropriate. When the rear camera is selected, the VideoRay horizontal thruster control circuit is reversed allowing the VideoRay to be driven backward "normally." This helps to make navigation more intuitive when monitoring the rear camera.

6.2.6 TILT (Down | Up)

The front camera may be tilted up and down by engaging the Tilt "Up" / "Down" switch in the desired direction. Releasing the switch causes the camera to hold its orientation. The rear camera is fixed and cannot be tilted.

6.2.7 FOCUS (Out | In)

To focus the front camera, engage the Focus 'In' / 'Out' switch in the desired direction until the optimal focus is achieved. Releasing the switch causes the camera to hold its focus. The rear camera uses a fixed focus lens that cannot be changed.

6.2.8 LIGHTS (Dim | Bright)

The Lights knob controls the brightness of VideoRay's on-board lights. When rotated to the "Dim" position, the lights may not go out, but glow slightly. Do not set the lights to "Bright" for more than 20 seconds when the VideoRay is out of the water.

6.2.9 MODE (Calibrate | Set)

This switch is used for several purposes. First, it cycles through the Video Overlay modes. The Video Overlay superimposes information over the video image from the camera. Any attached video recording device also records the Video Overlay. Each time the Mode switch is momentarily engaged to "Set," the overlay mode cycles to the next Video Overlay display. The sequence is as follows:

1) No Overlay
2) Date and Time
3) Depth and Compass Heading
4) Date and Time and Depth and Heading

The Mode switch is also used to select the Depth Display Units (Section 6.3.3). The units can be displayed in either feet of meters. By engaging the switch to "Set" while powering up the system, the units displayed will toggle between feet and meters. VideoRay will "remember" the last units used and continue to power up in that mode until changed by the operator.

Finally, the Mode switch is used to calibrate the Compass and Depth Gauge (Section 8.7).

6.2.10 DISPLAY CONTRAST (- | +)

This knob controls the LCD Display contrast. The LCD Display is discussed in the next section.

6.2.11 GRIPPER (Close |Open)

This switch closes or opens the optional gripper.

6.3 LCD DISPLAY

The LCD Display is used to provide feedback to the operator. Display information includes depth, units of depth, heading, a 24 hour clock and run-time clock. The LCD also provides messages for configuration and calibration operations. The LCD display contrast is adjustable for easy viewing under varying light conditions.

6.3.1 CLOCK

VideoRay is equipped with a 24 hour real time clock. The date and time can be set using the steps provided in Section 8.7.

6.3.2 RUN-TIME HOUR METER

The VideoRay controller keeps track of the total number of hours the VideoRay has been powered up. Whenever the VideoRay is powered up, the meter continues from the reading when it was last turned off. The Run-Time meter cannot be reset.

6.3.3 DEPTH GAUGE

Depth is displayed in feet or meters by the digital readout on the LCD display. To toggle the display units, engage the Mode switch to "Set" while powering up the system (See Section 6.2.9). Depth calibration of the pressure sensor is set at the factory for fresh water. See Section 8.7 for instructions on calibrating the Pressure Sensor.

6.3.4 COMPASS

VideoRay is equipped with an internal compass to aid in navigation. The compass rose is presented on the LCD display and is marked with North, South, East, and West directions. The compass is calibrated at the factory, but can be re-calibrated as needed. See Section 8.7 for instructions on calibrating the Compass.

6.4 MONITOR CONTROL

6.4.1 POWER

The monitor powers up automatically when the controller is turned on. The monitor Power button can be used to turn off the video display while the controller is on. Pressing the Power button again will turn the monitor on.

6.4.2 SYSTEM

The System button on the monitor is used to determine the video format (NTSC or PAL). Normally, the format will be set at the factory and should not need to be changed. If the monitor is not displaying the video image properly, this button might have been accidentally bumped. In this case, you can restore the correct display format by pressing the System button.

6.4.3 Additional non-labeled buttons on the display monitor

The four additional buttons on the monitor that are not labeled have no function and may be ignored.

7 "BEST" PRACTICES AND DIVING TIPS

7.1 NAVIGATION

Navigation of a submersible is very different from navigation on land. The largest difference is that VideoRay operates in three dimensions, rather than the familiar two. Below are some tips for navigating with VideoRay in its native environment.

1) The submerged operation and navigation of VideoRay is accomplished by what is commonly referred to as "dead reckoning". This involves the observation and subsequent recognition of landmarks as viewed on your Video Monitor. The compass rose will help you keep track of direction.
2) When operating in areas containing obstructions or obstacles that could snag or foul the tether, the operator should endeavor to remember the route taken to get to any one position. Not only will this information be helpful on the return trip, it will be extremely valuable in the event the tether does become snagged or fouled!
3) In the event obstructions are encountered, or you become lost or disoriented with respect to VideoRay's position, always remember that the safest way back is to follow the tether. VideoRay Pro III includes as an option a Positioning System that can be used to continuously monitor the position of the VideoRay.

7.2 HANDLING THE TETHER

The tether should be considered the most important part of the VideoRay system. It feeds power and control signals to the vehicle and returns data from the sensors. If the tether becomes damaged from improper use, poor handling or an accident, the vehicle may become crippled or inoperable. For maximum tether life and reliability, VideoRay Pro III includes the Tether Deployment System (TDS). When used properly, the TDS can eliminate many of the complications of tether management. The following tether handling tips are provided:

1) Never step on the tether. Trampling the tether underfoot may crush conductors and coax cables, leading to premature failure. Trampling is also abrasive to the tether jacket. Remember, this is a multi-conductor tether, not at electrical extension cord.
2) Never allow a truck, passenger vehicle, or boat to drive over the tether. This will do more concentrated and immediate damage than trampling.
3) Do not allow the tether to be deployed over a sharp edge. This could cause a kink, cut or excessive wear.
4) Do not bend the tether beyond its minimum bend diameter. Most tethers have a minimum bend diameter of three to four inches. If the tether is bent beyond this diameter on pulleys or around corners, wire fatigue will be accelerated. For a general rule of thumb, do not bend the tether any tighter than what would fit around a typical soda pop can.
5) Never kink the tether. A fully bent back kink causes local but permanent deformation in the tether. This can be serious because accelerated wire fatigue is subsequently concentrated at the kink location. Such a kink may also be severe enough to instantly break any coax cables in the tether.
6) Avoid snap loading the tether. This situation may easily occur when a slack tether is reeled onto a motorized spool. Loads may peak at a very high value when the tether snaps taunt. Another dangerous situation for snap loading is a tethered submersible vehicle operated from a pitching ship.

When not using the Tether Deployment System, there are a few proper and many improper ways to wind and unwind a tether. If improper tether handling techniques are used the tether may become tangled, which ultimately leads to kinking, trampling underfoot, and other tether damage. Following are some suggestions for keeping the tether tidy and ready for deployment at any time.

1) The preferred tether storage and deployment method is to use the optional Tether Deployment System.
2) When deploying the tether, a person should be available to tend the unwinding coils to prevent kinks.

7.3 AVOIDING TANGLES

As mentioned above, it is always a good idea to consider where the tether lies as VideoRay moves through the water or along the bottom. The following tips may assist in dealing with and / or avoiding tether problems:

1) Don't feed out unnecessary tether. When flying VideoRay back along its tether, haul in the slack line to avoid leaving a loop behind the vehicle.
2) Avoid weaving in and around fixed objects like pilings, rocks, and anchors. When operating in possibly fouled areas, it is advisable to remain on the surface until VideoRay is approximately above your intended dive objective.

7.4 FREEING A SNAGGED TETHER

1) Do not try to rip a snagged tether free! In the event VideoRay's tether becomes snagged, treat the situation as a challenge rather than a disaster. Fly the VideoRay along the tether to determine the location of the snag. If the problem area can be located visually using the vehicle, appropriate corrective action can be taken.
2) If the problem area cannot be located using VideoRay's camera, try pulling gently on the tether. Turn the vehicle power off and pull from different angles and directions if possible.
3) In the event the tether cannot be otherwise freed, it may be necessary to have a diver retrieve it manually. In that event, turn off the system power and unplug it from its power source.

7.5 BALLAST SETUP

Depending upon the water conditions, the VideoRay ballast must be adjusted for proper operation. The following instructions are provided to properly set up the ballast. The ballast should be adjusted so the VideoRay ROV has slight positive buoyancy. Should the VideoRay rise rapidly, or the vertical thruster create a fountain spray of water when near the surface, more ballast must be added. Should the VideoRay sink, some ballast must be removed. Salt water density is greater than that of fresh water. Additional ballast must be added to the VideoRay ROV when using it in salt water.

7.6 INCREASING THRUSTER POWER

In some situations it may be advantageous to have more thruster power available, particularly when working in currents. There are several steps that can be performed to increase thruster power.

1) To gain more thrust, first remove the grills from the rear of the thruster guards.
2) Second, to gain even additional thrust, remove the thruster guards themselves.

Note: Removing the thruster guards may increase chances of fouling the propellers and should not be attempted in conditions of heavy debris or seaweed.

Additional thruster power can be achieved by minimizing the power consumption of the lights. To maximize the power available to the thrusters, operate the lights at the lowest possible setting that still allows adequate visibility.

7.7 LOSS OF THRUSTER POWER

1) Should VideoRay suddenly become unresponsive in a particular direction, it is possible that one of the thrusters may have lost power. The most common cause of thruster power loss is a fouled propeller. This often is the result of organic or synthetic material becoming tangled in a propeller and subsequently wrapped tightly around the propeller shaft.
2) VideoRay's thrusters are designed to operate at their rated speed for extended periods of time. However, should a propeller become jammed, the motor may burn out if power is continually applied. Power should be turned off, and the vehicle retrieved and inspected. Remove any debris and test the thruster for proper operation. Note that the guards on the VideoRay are specifically designed for rapid and easy removal.

3) If VideoRay's thrusters are not fouled and still do not run, try resetting the VideoRay computer by switching the power supply off, waiting ten seconds, and switching it back on again.

4) Servicing may be necessary if the propeller and shaft are clear and rotate freely, yet the thruster does not respond to its controls.

7.8 FOGGED VIEW PORT AND/ OR LIGHT LENSES

Atmospheric conditions may result in some humidity being present inside VideoRay's pressure housings. This may cause condensation to form on the camera view port and/or light lenses. VideoRay includes a silica gel desiccant package with color-coding. Normally blue, when the stripe on the package is pink, it should be replaced. When performing any maintenance that requires the housing to be open, it should be done in the driest atmospheric conditions possible.

8 VIDEORAY MAINTENANCE

8.1 CLEANING VIDEORAY

1) Always unplug the system from the power source before cleaning.
2) Do not use liquid or aerosol cleaners on the system control box and power supply. Use a damp cloth for cleaning.
3) Disconnect the power before attempting to clear fouled propellers.
4) After use in salt water or chemical solutions, thoroughly rinse VideoRay with fresh water before storing.
5) For general cleaning of VideoRay, use a mild detergent.

8.2 MECHANICAL SERVICING

8.2.1 PRECAUTIONS

DISCONNECT THE SYSTEM POWER AND VEHICLE TETHER BEFORE COMMENCING ANY MAINTENANCE AND/OR REPAIRS!

1) If you are unfamiliar with O-Ring seals, read Section 8.3 "Caring For O-Rings" before attempting to open any sealed compartment or replace any O-Rings.
2) Sealed components are designed to be tight fitting. Be gentle when opening them. Forcing a component open or closed may damage it permanently. Do not use metal tools to pry open sealed parts!
3) Many VideoRay components are anodized aluminum and will be damaged by contact with steel. If components do not come apart with bare hands or "soft" tools, check to ensure that all fasteners have been removed.

8.2.2 REQUIRED TOOLS

The tool kit provided with VideoRay includes all tools necessary for VideoRay maintenance. A list of tools and spare parts is found in Section 12.

8.3 CARING FOR SEALS AND O-RINGS

VideoRay recommends the use of Dow Corning #4 Silicon Grease, as a lubricant for O-rings used as seals. Other lubricants can lead to deterioration and failure of the O-rings and components. DO NOT USE OTHER LUBRICANTS.

8.3.1 INSPECTION

O-rings wear out over time. Inspect all O-rings whenever a sealed assembly is apart. "Healthy" O-rings are soft, flexible and have not been pinched or nicked. Should an O-ring appear brittle, or have apparent cracks, nicks, or evidence of being pinched or permanently compressed, it will require replacement. Sealing surfaces should also be inspected while an assembly is apart. The surfaces should be examined to determine that they are free of dirt, nicks, scratches, or damage, which may result in seal failure once reassembled.

8.3.2 RULE OF THUMB

WHEN IN DOUBT, THROW IT OUT! Generally, when compared to the equipment they are protecting, O-rings are very inexpensive. Should an incorrectly sized or damaged O-ring be installed, the result can be very bad. If there is any doubt as to the suitability or condition of an O-ring it should be replaced.

8.3.3 CARE AND STORAGE

O-rings should be stored in clean plastic bags to protect them from dust when not in use. Avoid prolonged storage in direct sunlight as this may result in deterioration of the O-ring material. Stored O-rings should be sorted with regard to type and size with that information noted on the storage bag. Use of an incorrect O-ring can result in an ineffective seal.

8.3.4 HANDLING SEALED COMPONENTS

O-rings and other components with sealing surfaces should never be handled with dirty or gritty hands. A small amount of dirt trapped next to an O-ring will cause leakage, which could result in serious damage to the equipment the O-rings are intended to protect. The most common situation is a single strand of hair or lint, so care should be taken to ensure a clean work area. Should an O-ring or sealing surface become dirty, wash it with mild soap and water, and then rinse it with clean water. Avoid scratching the surfaces of O-rings and the components that contact them. Do not use sharp objects such as a knife or screwdriver to pry apart sealed assemblies or remove O-rings. Serious damage to the O-ring or the seat may result. When components require storage with the sealing surfaces exposed, they should be stored in a clean, dry location for protection.

8.4 SERVICING THE LIGHTS

8.4.1 REPLACING A LIGHT BULB

CAUTION! The Light Bulb may be very hot.

1) New bulbs should not be handled with bare fingers. Oils and acids from hands and fingers can affect the bulb and result in shortened operating life. Protect the bulb with paper towel or a clean cloth during handling.
2) Open the light housing by carefully unscrewing the light dome. Using a clean rag, grasp the light bulb and pull it from its socket.
3) Insert the replacement bulb and reassemble the light dome, making sure all O-rings are properly installed and seated.

8.5 PROPELLER REMOVAL AND REPLACEMENT

8.5.1 HORIZONTAL PROPELLER

Note: The horizontal thrusters are counter rotating and if the propellers are removed, they must be reinstalled on the proper shaft. When installed properly, the top blade of the propeller will curve toward the hull when viewed from the rear. The easiest way to ensure that the propellers are installed correctly is to remove and replace only one at a time.

1) The horizontal propellers are held in place on smooth shafts using a collet similar to a drill bit. To remove a propeller, loosen the 7/16 inch propeller locking nut. You do not need to remove the nut completely. The propeller should slide freely off of the shaft. If the propeller does not slide off, tap the nut with a wrench or similar tool while pulling the propeller to the rear.

2) To replace the propeller, first ensure the correct one is being installed, and slide the propeller onto the shaft. Then tighten the locking nut.

8.5.2 VERTICAL PROPELLER REMOVAL

1) Remove the flotation block by unscrewing the retaining bolt.
2) The propeller can be removed by first loosening the propeller locking nut (use 7mm wrench), and then unscrewing the propeller from the propeller shaft.
3) Propeller replacement is accomplished by reversing this process. Care must be taken to maintain a 1/32" to 3/64" clearance between the propeller locking nut and the seal spacer to prevent jamming.

Note: Use a piece of rubber (kitchen jar lid opener works great) or rag to help remove a stuck nozzle or propeller

8.6 CARTRIDGE SEAL INSPECTION AND REPLACEMENT

Your VideoRay has been equipped with our new, patent-pending cartridge design. This means that the seals that prevent water from entering the submersible through the motor shafts can be replaced rapidly and without tools. It also means that you can visually check for impending seal failure easily.

There are two "Bal Seals" on the shaft of each of the three thrusters on a VideoRay. Between these two seals is a oil chamber. The cartridge is constructed of machined acrylic and brass, and contains the two seals and the oil.

To change the cartridges:

1) Remove the propeller using the instructions in the previous section.
2) For the vertical thruster only, remove nut and the single nylon washer.
3) Grasp the cartridge seal and gently pull it out twisting it if necessary. There is a nylon washer recessed in the outer side of the seal. Be careful not to lose this washer and replace it when installing a new cartridge.
4) Make sure the cartridge seal cavity and O-ring are clean before installing a new cartridge.
5) Install a new cartridge, and make sure the inner nylon washer is installed and for the vertical motor, the second nylon washer.

Note: If the end seal pops out during install, carefully replace it with the spring facing out.

We recommend that you check for the presence of water in the oil bath every 10-20 hours of usage. This interval should be on the shorter end if you use your VideoRay in deeper water – in excess of 60 feet or 20 meters – for extended periods. If there is water in the oil, the cartridge should be replaced within the next 10-20 hours.

8.6.1 OPENING VIDEORAY'S MAIN HOUSING

Note: To perform this operation, it is necessary to remove the Skid System first by un-screwing the 4 retaining screws.

1) Prior to and that a clean, dry work area is available.
2) Remove opening the main housing, it is important to ensure that VideoRay is clean and dry, the flotation block by removing the screw.
3) Remove the main housing tie-rods by first loosening, then removing the tie-rod acorn nuts and regular nuts at the rear that serve as jam nuts. The acorn nuts at the front are permanently Loctited on and can be used to rotate the rod with a socket driver. Next, pull the tie-rods from their guide holes in the front and rear main port retainers. Remove the main port retaining rings.
4) Both the front and rear main port domes are sealed with O-rings and, while some resistance may be encountered due to a slight internal vacuum, they can be removed by carefully pulling them out of the main housing. The domes have tabs on them to facilitate dome removal. You can use the tool kit nut driver or other blunt tool to apply pressure on these tabs to remove the domes. Do not pry the domes off with a screwdriver as this can damage the domes and the seal surface.
5) A hair dryer may be used to aid in removal of the domes by warming the VideoRay housing and creating a positive interior pressure.

8.6.2 REASSEMBLY OF MAIN HOUSING

1) Once the internal components have been properly re-installed in the main housing, the main ports can be replaced. Care should be taken to ensure the ports are clean and dry and that the O-rings have been cleaned and lubricated prior to installation. Refer to Section 8.3, Caring for Seals and O-Rings.

2) The tie-rods do not provide a means of sealing the main ports to the main housing. The O-ring seals on the main ports that, in normal operation, are held in place by external pressure ensure the watertight integrity of the main housing. The tie-rods are provided as a security measure, to prevent the main ports from "popping out" in the event of a sudden over pressure inside the housing.

3) Re-assembly is accomplished by carefully fitting the main ports into the main housing and re-installing the port retaining rings tie-rods, retaining nuts and washers.

Important: Avoid damage to the acrylic main ports. Do not over-tighten the tie-rod nuts.

8.7 CALIBRATION

Ensure that the Joystick and Depth Control knob are both in the neutral position before powering up the VideoRay. This is critical, because their "zero" positions are calibrated when power is applied.

The additional VideoRay features that can set or calibrated include the date and time, the compass, and the pressure sensor (which is used for determining depth). These features were calibrated at the factory and should not require resetting. However, if maintenance work or electronics replacement should necessitate recalibration, set your unit into calibration mode by turning it on while engaging the Mode switch to the "Calibrate" position.

8.7.1 SETTING the DATE and TIME

Set the date and time by entering the calibration mode.

1) Turn the VideoRay off.

2) Turn the Video Ray on while engaging the Mode switch to "Calibrate."

3) Release the Mode switch.

4) The date and time are now shown on the display. Use the Auxiliary switch to adjust the values ("On" to increase, "Off" to decrease), and engage the Mode switch to "Set" to store the new value and move on to the next item.

5) To exit calibration mode, simply turn off the VideoRay. The new settings will be saved. Wait at least 5 seconds before turning the VideoRay back on. Or, to continue on to calibrate the pressure sensor and/or compass, momentarily engage the Mode switch to "Calibrate," and follow the steps below.

8.7.2 CALIBRATING the PRESSURE SENSOR

This calibration is necessary when the pressure sensor is changed, or when a new control box is mated to a submersible. This task requires an air pressure of 50 PSI (Pounds per Square Inch) be applied to the pressure sensor. The easiest way to accomplish this is to use a calibrated air source and a rubber-tipped air gun. If you are setting the date and time or are calibrating the compass and do not need to reset the pressure sensor, <u>BE CERTAIN TO SKIP THIS PROCEDURE,</u> so as not to disable the pressure sensor. Skip the pressure sensor calibration by either turning the VideoRay off, or momentarily engaging the Mode switch to "Calibrate" two times after setting the date and time.

1) Turn the VideoRay off.

2) Turn the VideoRay on while engaging the Mode switch to "Calibrate."

3) Release the Mode switch.

4) To enter the pressure sensor calibration mode, you must complete the steps to set the date and time. You do not need to change the date and time, but must scroll through the date and time settings (with or without changing them) in order to reach the pressure sensor calibration mode.

5) Once you have set the date and time and have entered the pressure sensor calibration mode, you have two choices. You can either calibrate the pressure sensor, or you can bypass this procedure. You might want to bypass this procedure if all you need to do is set the date and time or calibrate the compass. To bypass this procedure, momentarily engage the Mode switch to "Calibrate," which will activate the compass calibration mode, or, turn the system off to bypass this mode and the compass calibration mode.
6) To calibrate the pressure sensor, follow the on-screen instructions and apply the first pressure to the pressure sensor. This pressure may vary between units depending on options.
7) Momentarily engage the Auxiliary switch to "Off."
8) Apply the second pressure to the pressure sensor.
9) Momentarily engage the Auxiliary switch to "On."
10) To exit the calibration mode, simply turn the VideoRay off. Wait at least 5 seconds before turning the VideoRay back on. Or, to continue on to calibrate the compass, momentarily engage the Mode switch to "Calibrate," and follow the steps below.

8.7.3 CALIBRATING the COMPASS

Large metal objects such as steel buildings and ship's hulls, or other magnetic sources such as electric motors can all affect the reading of a magnetic compass. This calibration is designed to account for external effects on the inboard compass and should be done in an environment that best approximates the conditions in which the VideoRay will be used. To calibrate the compass:

1) Determine NORTH, and lay out lines for North, West, South, and East on a flat surface. It is important that VideoRay be level in order to obtain an accurate calibration.
2) Turn the VideoRay off.
3) Turn the VideoRay on while engaging the Mode switch to "Calibrate."
4) Release the Mode switch.
5) To enter the compass calibration mode, you must complete the steps to set the date and time and either calibrate the pressure sensor or bypass the pressure sensor calibration.
6) Once you have set the date and time and have calibrated the pressure sensor (or bypassed the pressure sensor calibration), you are ready to calibrate the compass.
7) To calibrate the compass, follow the on-screen instructions and aim the front of the VideoRay NORTH. Momentarily engage the Auxiliary switch to "Of" to set this direction.
8) Continue the procedure by aiming the front of the VideoRay EAST and momentarily engaging the Auxiliary switch to "On."
9) Aim SOUTH, and momentarily engage the Auxiliary switch to "Off,"
10) Finally, aim WEST and momentarily engage the Auxiliary switch to "On."
11) To exit calibration mode, momentarily engage the Mode switch to "Calibrate," or turn the VideoRay off. Turning off the VideoRay may be done at any time during calibration without loss. Any settings entered during calibration will be retained. Wait at least 5 seconds before turning the VideoRay back on.
12) Rotate the vehicle to test the compass calibration.

9 FIELD SERVICING

9.1 TROUBLE SHOOTING

The following is a brief diagnostic aid intended to assist the user in determining the nature of problems encountered during the operation of VideoRay.

1) Check to see that the electrical outlet is live.
2) Ensure all power switches are turned on.
3) Check all the cables for proper connection.
4) Check the main fuse in the power supply. (Disconnect power before checking)
5) Check the tether and connectors for damage.

9.1.1 LIGHTS DO NOT WORK

1) Check for power to the vehicle.
2) Check to see if the bulbs have burned out.

9.1.2 LOSS OF THRUST OR MANEUVERABILITY

1) Ensure the propellers and shafts are clear of debris.
2) Ensure the propellers are securely installed.
3) Check to see if the tether is snagged.
4) Check the thrusters to ensure they function properly with VideoRay out of the water.

9.1.3 VIDEO MONITOR DOES NOT SHOW PICTURE

1) Ensure the Video Monitor is plugged into a live electrical outlet.
2) Check all the video connections.
3) Check to see the VideoRay is turned on.
4) Try a different monitor.

9.1.4 POOR PICTURE QUALITY

1) Check for proper cable connections.
2) Check the condition of the connectors. In our experience, poor video cables and video connectors cause many video failures.
3) Check for tether damage.
4) Ensure that the view port on VideoRay is clean and free of condensation.
5) Try a different monitor.

9.2 ORDERING PARTS

Spare and / or replacement parts are available for your VideoRay Submersible. They can be ordered directly from the VideoRay web site:

http://www.videoray.com

If you do not have Internet access, the following contact information may be used.

VideoRay LLC
580 Wall Street
Phoenixville, PA 19460
Telephone (610) 458-3000
Facsimile (610) 458-3010

For Customer Service by Internet, E-mail: support@videoray.com

When ordering parts, please include the serial number of your VideoRay Submersible; the part description and identification number; and the quantity required.

Some sub-assemblies of the VideoRay Submersible are not field-serviceable and will need to be returned to the factory if they malfunction. All returned items must be sent prepaid to VideoRay at the above address.

9.3 WARRANTY REPAIRS

The warranty conditions are specified in Appendix A. In the event any conditions of the manufacturer's warranty have been breached, the warranty may be considered void.

10 ACCESSORIES

10.1 GENERAL INFORMATION ABOUT ACCESSORIES

VideoRay is the delivery platform for a variety of instrumentation. Whether it is a Dissolved Oxygen meter for the aquaculture industry, a Conductivity Potential gauge for the marine construction industry, sonar system, positioning system or other mission-specific instruments, VideoRay effectively transports and operates the instrument at the underwater job site. Please contact VideoRay (http://videoray.com) or your local VideoRay dealer or for assistance in equipping your system to meet your needs. Some of the common accessories are listed below.

10.2 INTEGRATED CONTROL BOX (ICB) with 15-inch monitor

Useful for all in one control, video, and viewing, this crisp, unique 15-inch monitor is built into the Integrated Control Box. With a bigger viewing area than the previous screen, the images from the VideoRay camera eye are larger than life and give you more confidence as you navigate. The monitor works in three different modes. You choose the mode that works best for your project requirements.

Full Screen Video shows images from the VideoRay's front or rear camera eye. At 15-inches, the monitor is easy on the eyes and provides significantly more viewing area to see underwater surroundings.

Full Screen Computer Display shows computer data from accessories, such as sonar, magnetometer, or other gathering devices. Switch between Full Screen Video and Full Screen Computer Display to keep tabs on video and accessory readings.

Full Screen Computer Display with Inset Video (Picture in Picture.) displays readings from a sonar or positioning system on the full screen along with video from the VideoRay camera eye in the smaller inset window. This is invaluable feature for search and recovery operations.

Specifications

PANEL
Type a-si TFT /TN Size 15" Pixel Pitch (mm) 0.297 Brightness (cd/m2)
200 Contrast Ratio 300:1 Viewing Angle 120/110 degrees Computer Interface

FREQUENCY
Horizontal Rate (Analog) 30-70 Vertical Rate 56-85 Bandwidth 100

RESOLUTION
Maximum (Analog) 1024x768 Native 1024x768

COLOR
Maximum 16.2M

SIGNAL INPUT
Input Video Signal Analog RGB
Video Level: Analog
Analog:0.7VP-P Input Connectors 15pin D-sub, RCA connector

PLUG & PLAY DDC
DDC 1/2B

POWER CONSUMPTION
On/Working 52 Watts (Max)

10.3 TETHER DEPLOYMENT SYSTEM (TDS) (Included with the Pro III)

Designed for rapid delivery and fast recoil, the Tether Deployment System simplifies tether management and reduces the chances for damaging the tether. The hand-powered reel inside the Pelican 1620 case easily pays out and takes up the tether, keeping your work area neat and safe. Use the TDS to save time and effort and lower the incidence of tether damage. Just reel in the tether, snap the case shut, and you're ready to move.

10.4 IMAGING SCANNING SONAR SYSTEM

For low-visibility environments and precision searches, imaging sonar is essential for identifying and navigating inspection locations. Whether on a search and rescue mission or scoping out wreck locations, scanning sonar is invaluable. The VideoRay sub is guided by sonar to targets until it is close enough to visually identify them, making search and recovery possible in turbid waters. The sonar features a very small transducer to image targets from the viewpoint of VideoRay and captures data digitally on a laptop computer for easy playback. The sonar fits atop the VideoRay Pro III submersible's float block for unobstructed viewing of the area. The sonar system is neutrally buoyant and streamlined for a minimal effect on the hydrodynamics of the submersible. The sonar data feeds directly through the tether to the surface unit. A separate laptop running Windows 95/98/Me/NT/2000/XP Operating System is required for gathering data. For specifications, see www.videoray.com.

10.5 SHORT BASELINE ACOUSTIC NAVIGATION SYSTEM

Underwater work demands reliable positioning. While GPS navigation has been adapted as a standard throughout the marine industry, GPS signals only penetrate a few millimeters below the surface. To truly know your position, the Star Short baseline (SBL) positioning system acoustic navigation can be used. You'll be a more adventurous and confident ROV pilot because the SBL shows the location of the submersible in relation to acoustic transducers, using the acoustical transponder and depth gauge mounted aboard the submersible. The location of the VideoRay is identified through simple time/distance/triangulation. The system can be integrated with GPS for absolute positioning. Use in combination with the sonar to know where the ROV is, where it is going, and where to swim to targets of interest. The system requires a laptop running Windows 95/98/Me/NT/2000/XP Operating System. For specifications, see www.videoray.com.

10.6 EXTENSION TETHERS

No mission is impossible when you mix and match lengths and types of the VideoRay's tether to reach an underwater destination. VideoRay Pro III systems come standard with 76 m (250 feet) of neutrally buoyant tether, and now you can choose from several combinations of neutrally buoyant or negatively buoyant tether lengths to suit the job at hand. The detachable tethers encourage easier transport and handling as they accommodate specific depths. Modular lengths of neutrally- and positively- buoyant tether can be mixed and matched by simply locking in new sections. Snap on the short tether for a potable water tank inspection. Then switch in seconds to the extended tether for a deepwater application. Use the negatively buoyant tether to reach operational depths, and switch to the neutrally buoyant tether for more maneuvering.

10.7 MANIPULATOR

Find and retrieve items with a manipulator that handily attaches to the VideoRay submersible. From the control box, open and close the jaws to a two-inch distance to retrieve items in confined or hazardous locations. The VideoRay's camera eye focuses in on the manipulator to provide a close view of the operation. The mechanics of the manipulator also provide a platform for several other attachments.

Specifications

10 in./25 cm length

1 in./2.5 cm width

2 in./5 cm Max Jaw Opening

Weight in air: 9 oz./250 g

Closing Force: 5 lb.

Travel time: 8 seconds

11 VIDEORAY TOOLS & SPARE PARTS KIT

QTY	TOOLS / SPARES
1	Tool Box
1	10 in 1 Screw/Socket Driver
1	Open-end 7mm & 8mm Wrench
1	3/16" Hex Wrench
1	3/32" Hex Wrench
1	Silicone Grease Packet
2	12V/20W Halogen Bulbs
1 each	Thruster Propellers (100mm) L & R
1	Thruster Propeller (vertical)
1	Spare Cartridge Seal
O-RING PACKAGE	
3	#011 (Tilt Drive)
3	#014 (Seal Cartridge)
1	#020 (Vertical Thruster Cone)
1	#022 (Focus Pulley)
2	#031 (Horizontal Thruster Cone)
5	#112 (Thruster Tube Spacer, Depth Sensor)
3	#114 (Termination Block, Depth Sensor)
1	#118 (Vertical Thruster Spacer)
4	#122 (Horizontal Thruster Spacer)
2	#133 (Thruster Motor Bracket)
4	#135 (Light Mount, Thruster Cones)
2	#152 (Main Port)
2	#154 (Main PortRing)
2	#224 (Light Port, Light Mount)
STAINLESS STEEL HARDWARE	
1	#¼-20 x 5/8" Socket Cap Screw
1	#¼ x 5/8" Flat Washer
2	#M4 Hex Nut
10	#6 Flat Washer
4	# 8-32 x 1/2" Pan Head Phillips Screw
2	# 4-40 x 1/2" Pan Head Phillips Screw
4	#4-40 x 3/8" Pan Head Phillips Screw
3	#6 Lock Washer
2	#8-32 Nut
2	#8 Lock Washer
4	#8 Flat Washer
2	#6-32 Acorn Nut
3	#6-32 Nyloc Nut
2	#6-32 x 1/2" Phillips Screw

12 APPENDIX A – LIMITED WARRANTY

LIMITED WARRANTY POLICY

VideoRay will repair or replace, at its expense and at its option, any system or component, subject to the limitations and / or exclusions specified herein, which in normal use has proven to be defective in workmanship or material provided that, within one (1) year of the purchase date, the original purchaser returns the product prepaid, accompanied by proof of purchase, from a sales agent authorized by VideoRay, and provides VideoRay with reasonable opportunity to verify the alleged defect by inspection.

Warranty Limitations And/Or Exclusions:

1. This warranty does not apply to light bulbs.
2. Any separate product purchased from, but not manufactured by, VideoRay is sold with only such warranties as are made by the manufacturer therein. VideoRay only warrants that it has title thereto, free of all liens or encumbrances.
3. This warranty does not apply to units that are damaged by connection to improperly wired AC receptacles.
4. Tethers, view ports and other components subject to wear through abrasion are warranted to be free from defects in material and workmanship for a period of ninety (90) days from the date of shipment to the original purchaser.
5. Any damage caused by failure to observe proper packing or to observe instructions for operation and maintenance as contained in the Instruction Manual furnished with the equipment, by accident in transit or elsewhere, will not be covered by the warranty.
6. Repairs are warranted for 90 days.

VideoRay may require that certain components may be returned, prepaid, to an authorized repair station for inspection and repair or replacement.

VideoRay will not be responsible for any asserted defect which has resulted from Acts of God, normal wear, misuse, abuse, improper configuration, repair, or alteration made, or specifically authorized by, anyone other than a representative of VideoRay authorized to do so. The giving of, or failure to give, any advice or recommendation by VideoRay shall not constitute any warranty by, or impose any liability on VideoRay.

The foregoing constitutes the sole and exclusive remedy of the purchaser and the exclusive liability of VideoRay and is in lieu of any and all other warranties, express, implied or statutory as to merchantability, fitness for purpose sold, description, quality productiveness, or any other matter. Under no circumstances shall VideoRay be liable for special, incidental or consequential damages, or for delay in performance of this warranty.

APPENDIX L. LICENSES AND PERMITS

Estado Libre Asociado de Puerto Rico
POLICIA DE PUERTO RICO

SAIC-AH-OESP-DESP-1-101
11 de mayo de 2009

James Keesee
P.O.Box 959
Vieques, P.R. 00765

Estimado señor (a) Keesee

En atención a su solicitud relacionada con las disposiciones de Ley 134 del 28 de junio de 1969, conocida como "Ley de Explosivos", le incluyo Certificado de Cumplimiento, este debe ser renovado treinta días (30) antes de su vencimiento.

Favor de firmar este documento y devolverlo a nuestra oficina a la mayor brevedad posible.

1. James Keesee		001-0041-0000
2. Alan T. Turpin		001-0041-0002
3. James A. Paksi		001-0041-0003
~~4. Phillip C. Fitzwater~~		001-0041-0004
5. Gypsy I. Cordova García	TECH I	001-0041-0005
6. José M. Gómez Morales	TECH II	001-0041-0006

Sgt. Victor M. Torres Medina 8-23758

Sgto. Víctor M. Torres Medina 8-23758
Director, Auxiliar
División Explosivos y Seguridad Pública
Regiones Humacao y Fajardo

James Keesee

Firma del Receptor

15 May 2009

Fecha

Estado Libre Asociado de Puerto Rico
POLICIA DE PUERTO RICO

SAOE-RH-OESP-DESP-1-121

8 de junio de 2009

COPY

JAMES KEESEE
P.O.Box 959
Vieques, P.R. 00765

Estimado señor (a) Keesee

En atención a su solicitud relacionada con las disposiciones de Ley 134 del 28 de junio de 1969, conocida como "Ley de Explosivos", le incluyo Certificado de Cumplimiento, este debe ser renovado treinta días (30) antes de su vencimiento.

Favor de firmar este documento y devolverlo a nuestra oficina a la mayor brevedad posible.

PAUL SCHMIDT		001-0041-0007
EDGAR COLON COLON	TECH I	001-0041-0008
JOHN AGOSTO MALDONADO	TECH I	001-0041-0009

7-0255

Tnte. Amado I. Rivera Montañez 7-0255
Director
División Explosivos y Seguridad Pública
Reginies Humacao y Fajardo

Firma del Receptor

29 JUL 09
Fecha

DEPARTMENT OF THE TREASURY - BUREAU OF ALCOHOL, TOBACCO AND FIREARMS

LICENSE/PERMIT (18 U.S.C. CHAPTER 40, EXPLOSIVES)

In accordance with the provisions of Title XI, Organized Crime Control Act of 1970, and the regulations issued thereunder (27 CFR Part 555)you may engage in the activity specified in this license/permit within the limitations of Chapter 40, Title 18, United States Code and the regulations issued thereunder, until the expiration date shown. See "WARNING" and "NOTICES" on back.

DIRECT ATF CORRESPONDENCE TO

Christopher R. Reeves
Chief, Federal Explosives Licensing Center (FELC)
Bureau of Alcohol, Tobacco, Firearms and Explosives
244 Needy Road
Martinsburg, West Virginia 25405
Telephone: 1-877-283-3352 Fax: 1-304-616-4401

LICENSE/ PERMIT NUMBER: **1-FL-103-20-1J-00784**

EXPIRATION DATE: **September 1, 2011**

NAME

USA ENVIROMENTAL INC

Premises Address CHANGES? You must notify the FELC at least 10 days before the move

720 BROOKER CREEEK BOULEVARD SUITE 204
OLDSMAR, FL 34677-

TYPE OF LICENSE OR PERMIT

20-MANUFACTURER OF HIGH EXPLOSIVES

CHIEF, FEDERAL EXPLOSIVES LICENSING CENTER (FELC)

Christopher R. Reeves

Christopher R. Reeves

PURCHASING CERTIFICATION

I certify that this is a true copy of a license/permit issued to me to engage in the activity specified.

(SIGNATURE OF LICENSEE/PERMITTEE)

The licensee/permittee named herein shall use a reproduction of this license/permit to assist a transferor of explosives to verify the identity and status of the licensee/permittee as provided in 27 CFR Part 555. The signature on each reproduction must be an ORIGINAL signature.

Mailing Address CHANGES? You must notify the FELC at least 10 days before the change

USA ENVIROMENTAL INC
720 BROOKER CREEEK BOULEVARD SUITE 204
OLDSMAR, FL 34677-

ATF F 5400.14/5400.15, Part 1 (8/89)

APPENDIX M. CULEBRA SOPS FOR ENDANGERED SPECIES CONSERVATION

Standard Operating Procedures For Endangered Species Conservation And their Habitat on DERP-FUDS Project No. I02PR006802. Culebra, Puerto Rico

US Army Corps of Engineers
Jacksonville District

Standard Operating Procedures
For Endangered Species Conservation and their Habitat on DERP-FUDS Project No. I02PR006802. Culebra, Puerto Rico

PURPOSE

The intent of this document is to develop a series of standard operating procedures (SOPs) to avoid or minimize impacts to threatened and endangered species listed pursuant to the Endangered Species Act (ESA) during the DERP-FUDS work at locations designated for cleanup on Culebra and adjacent cays and in surrounding waters that serve as habitat for these species. Species include the endangered hawksbill (*Eretmochelys imbricata*) and leatherback (*Dermochelys coriacea*) sea turtles, the threatened green sea turtle (*Chelonia mydas*) and its designated critical habitat 3 nautical miles around Culebra and its surrounding islands and cays, the threatened elkhorn (*Acropora palmata*) and staghorn corals (*Acropora cervicornis*), the West Indian manatee (*Trichechus manatus*), and avian species. These SOPs are in accordance with on-going communication with staff from the U.S. Fish and Wildlife Service (FWS), the National Marine Fisheries Service (NMFS) and the Puerto Rico Department of Natural and Environmental Resources (DNER), as well as pursuant to the Interim Guidelines provided by FWS to work on lands of Culebra National Wildlife Refuge, with the U.S. Army Corps of Engineers (USACE) Regulations and Environmental Operating Principles. These SOPs were prepared to supplement existing and future USACE contracts for work on Culebra and surrounding islands and cays under the DERP/FUDS Program and to satisfy the substantive requirements of Section 7 of the Endangered Species Act. These SOPs do not address requirements related to access approvals from FWS on lands that are within the Culebra National Wildlife Refuge.

SEA TURTLES

Culebra has some of the most important sea turtle nesting beaches in the US Caribbean. Three species of sea turtles utilize these beaches throughout the year. The endangered leatherback and hawksbill sea turtles are the most common nesters, and the threatened green sea turtle also nests on beaches in the project area. The beaches on Culebrita, Cayo Norte, and Playa Larga, Brava and Resaca on Culebra were designated as critical habitat under the Endangered Species Act by FWS in recognition of their vital importance to the future of these species (50 CFR 17.95). Similarly, waters surrounding the island of Culebra (50 CFR 226.208) from the mean high water line seaward to 3 nautical miles (5.6 km) are designated as critical habitat for the green sea turtle. These waters include Culebra’s outlying Keys including Cayo Norte, Cayo Ballena, Cayos Geniquí, Isla

Culebrita, Arrecife Culebrita, Cayo de Luis Peña, Las Hermanas, El Mono, Cayo Lobo, Cayo Lobito, Cayo Botijuela, Alcarraza, Los Gemelos, and Piedra Steven where cleanup efforts are anticipated. Sea grass beds within these waters are foraging habitat for the species. In addition, the benthic habitat, including seagrass beds, coral reefs, and colonized hardbottom, around Culebra and its surrounding islands and cays provides foraging and refuge habitat for sea turtles.

Nesting Seasons

The following nesting season information was obtained from the USFWS sea turtle fact sheets and local agencies.

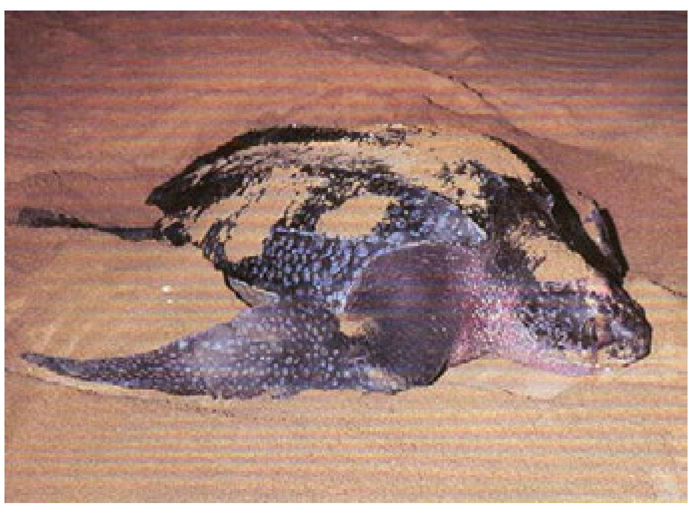
Green Sea Turtle: The nesting season varies with the locality. In Puerto Rico, it is roughly June through October. Nesting occurs nocturnally at 2, 3, or 4-year intervals. Only occasionally do females produce clutches in successive years. A female may lay as a many as nine clutches within a nesting season (overall average is about 3.3 nests per season) at about 13-day intervals. Clutch size varies from 75 to 200 eggs, with an average clutch size of 136 eggs reported for Florida. Incubation ranges from about 45 to 75 days, depending on incubation temperatures. Hatchlings generally emerge at night. Age at sexual maturity is believed to be 20 to 50 years. Nesting data for Puerto Rico, specifically for Culebra beaches shall be obtained from the FWS. However, the DNER indicated that nesting of green turtles in Culebra beaches is infrequent and not as common as the other species.

Green Sea Turtle

Hawksbill Turtle: The nesting season varies with locality, in Culebra, as per DNER, nesting occurs all year long with the peak between August to November. Hawksbills nest at night and, on average, about 4.5 times per season at intervals of approximately 14 days. In Florida and the U.S. Caribbean, clutch size is approximately 140 eggs, although several records exist of over 200 eggs per nest. They nest under the vegetation on the high beach and nests have been observed having the last eggs of the clutch as close as 3 inches from the sand's surface. Remigration intervals of 2 to 3 years predominate. The incubation period averages 60 days. Hawksbills recruit into the reef environment at about 35 cm in length and are believed to begin breeding about 30 years later. However, the time required to reach 35 cm in length is unknown and growth rates vary geographically. As a result, actual age at sexual maturity is not known.

Hawksbill Sea Turtle

Leatherback Turtle: On Culebra nesting occurs from about February to August with the peak occurring around April to May. Female leatherbacks nest an average of 5 to 7 times within a nesting season, with an observed maximum of 11 nests. The average internesting interval is about 9 to 10 days. The nests are constructed at night in clutches of about 70 to 80 yolked eggs. The white spherical eggs are approximately 2 inches in diameter. Typically incubation takes from 55 to 75 days, and emergence of the hatchlings occurs at night. Most leatherbacks return to their nesting beaches at 2 to 3-year intervals. Leatherbacks are believed to reach sexual maturity in 6 to 10 years. Culebra beaches most used by the species are Flamenco, Brava and Resaca.



Leatherback Sea Turtle

Acroporid Corals

Since the preparation of some of the Culebra Project work plans, two coral species have been listed as threatened by the National Marine Fisheries Service effective May 8, 2006. Elkhorn coral (*Acropora palmata*) and staghorn coral (*Acropora cervicornis*) belong to the most abundant group of corals in the world and once represented the most dominant reef building species throughout Florida and the Caribbean. Elkhorn corals are found in shallow reefs, typically in water depths from 0-35 feet, as these corals prefer areas where wave action causes constant water movement. Staghorn corals are found in water depths ranging from 1-160 feet, although they are most common in depths from 10-60 feet. In addition to growing on reefs, staghorn corals often form colonies on bare sand. Acroporid corals have relatively high growth rates (5-6 inches per year) for corals and exhibit branching morphologies that provide important habitat for other reef organisms. The abundance of these corals has been declining for several decades due in part to hurricane damage and disease.

Acropora cervicornis

Acropora palmata

<u>Measures to Avoid or Minimize Possible Impacts Resulting from Munitions Clearance and Detonation Activities</u>

Vegetation Removal:

A standard 70 meter setback (from mean high water) is usually designated to avoid impacts to hawksbill sea turtle nesting habitat during nesting season. Based on the characteristics of the nesting habitat in Culebra and the surrounding cays, an appropriate setback will have to be established for beaches that are part of the cleanup project. For instance, hawksbill sea turtle nesting habitat might be designated from the line of woody vegetation instead of from the high water line. Measuring and flagging the setback on project beaches might be easier if measured landward from the edge of the existing woody vegetation since the high water line may change daily.

Beach Monitoring

To the maximum extent practicable detonation activities shall be realized when it is not sea turtle nesting season and when hatchlings are not present on beaches. To the maximum extent practicable, ground intrusive activities, including detonation, will not occur during the peak nesting seasons from March to November.

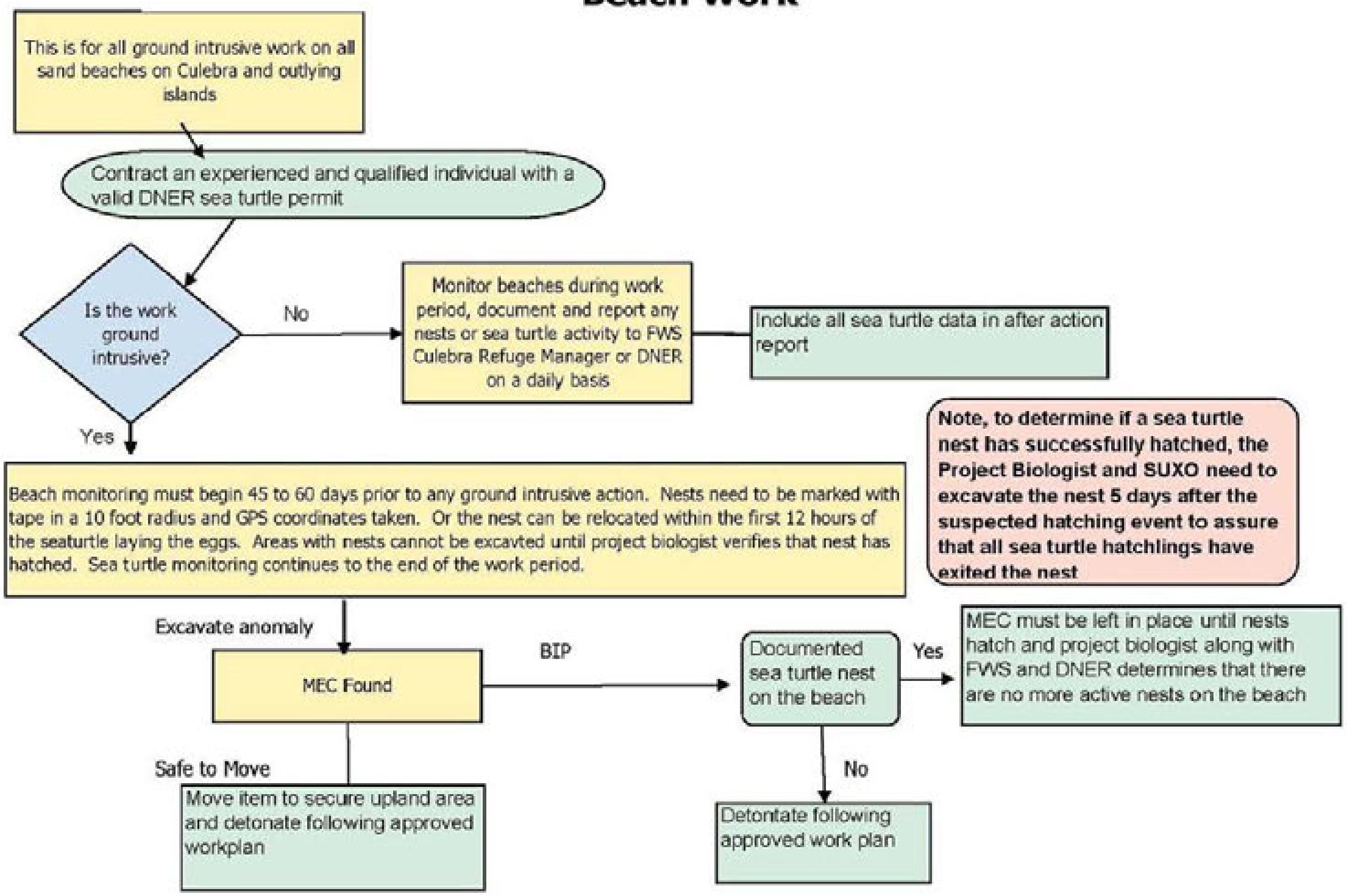
Prior to commencement of clearance activities, including vegetation removal and removal of unexploded ordnance, on Culebra, Culebrita, Cayo Norte and Cayo Luis Peña the contractor shall appoint a Project Biologist whose qualifications shall be submitted for the approval of the contracting officer and the FWS. All beach clearance activities, including vegetation removal and removal of unexploded ordnance, will be closely coordinated with FWS. In lieu of an independent Project Biologist, a USACE biologist could assist the contractor in this effort provided the USACE biologist has the appropriate training for conducting beach surveys. The Project Biologist shall perform morning beach patrols to identify the potential presence of new nests prior to and during the nesting season. When it is not nesting season, the Project Biologist or appropriately trained personnel shall conduct morning beach surveys prior to crews commencing daily activities to determine whether sea turtle nesting has occurred and to ensure that activities may be accommodated in a window of time when no nests are present.

If sea turtle nests are found on beaches being cleared of unexploded ordnance, the Project Biologist, the UXO supervisor, and/or monitoring personnel will communicate daily with the FWS Boqueron Endangered Species Specialist and the Culebra Islands NWR Refuge Manager as to whether new nests have been located, and their locations within the work area. If agreed upon by FWS, nest locations will be clearly marked to ensure clearance personnel avoid nests and no clearance activities will take place in the area until the hatchlings emerge and vacate the nest. Otherwise, nests will be relocated to a safe beach within 6-12 hours following nesting. The relocation program will be carried out by the Project Biologist and experienced personnel with the required DNER endangered species permits. This approach has been utilized by DNER personnel on Vieques from 1990-2000 to protect sea turtle nests from military operations with a hatching success of relocated nests of over 80%.

The Project Biologist shall also be responsible for training beach clearance crews prior to the initiation of clearance activities regarding the importance of endangered species, in particular the status of sea turtles at this location; the potential penalties associated with violations of the ESA; measures for crawl and nest identification; and sea turtle biology.

As an additional tool for sea turtle conservation, the following decision tree was prepared by the FWS to provide guidance on the sequence of events during ground-intrusive beach work. Project biologist shall work closely with UXO personnel to ensure these steps are followed.

Sea Turtle Conservation Measures for Ground Intrusive Beach Work



Designation of Beach Zones for Vegetation Removal and Munitions Detonation:

The information contained in this section was provided by the USFWS based on zones established during clearing activities for a Navy-led project in Vieques. The designation of zones based on number of nests, restrictions within the zones, etc. must be developed in coordination with the FWS to be specific to Culebra. The Corps shall require UXO contractors through the Project Biologist, to establish three work zones, based on sea turtle nesting data, and site inspections to ensure sea turtle nest protection during vegetation removal and munitions detonation activities. It shall be the Project Biologists responsibility to obtain specific nesting data for the beach area where the contractors will be working. This data can be obtained from the FWS Ecological Services Office in Cabo Rojo or the DNER office on Culebra or Fajardo.

The work zones proposed are:

<u>Zone 1</u>. No restrictions because sea turtle nesting is not expected within the area (rocky shore, no sand, etc).

<u>Zone 2</u>. Minor restrictions because of low historical sea turtle nesting events (fewer that 4 nests per year have occurred within the zone). Zone 2, beaches will be surveyed twice a week, 75 days prior to the activity by experienced and qualified personnel. Surveys should cover both the open sand and the area below the vegetation. No driving on the beach will occur. If no nests are found, cutting of trees smaller than 3 inches in diameter may occur. Manual cutting using machetes is the preferred alternative to allow for re-growth. If power tools such as chain saws are required, the FWS recommended pruning low branches instead of removing the trees (except for mesquite trees). Both techniques would allow for re-growth of suitable habitat. Mechanized removal of vegetation using mowers of vehicles should not be used near beach areas. When nests are found, a protection or exclusion zone of 8m should be designated around the nest and marked with flagging tape. Vegetation removal outside of the exclusion zone may occur if conducted manually. Vegetation removal within the nest area should be postponed until 5 days after hatching is documented, unless UXO is found in the vicinity of the nest.

Vegetation removal within the hawksbill sea turtle nesting habitat should not occur from June to mid December (peak of the nesting season). Hawksbill sea turtle nesting habitat varies from 10 m to 25m from the edge of the woody vegetation.

<u>Zone 3</u>. Major restrictions because 4 or more historical sea turtle nesting events have occurred within the zone. Zone 3, beaches will be surveyed every morning by a qualified biologist utilizing pedestrian surveys beginning 75 days prior to the scheduled start date of the project and until ordnance or vegetation removal actions are completed. Minimizing the amount of woody vegetation such as sea grape cleared would help minimize impacts to nesting hawksbill sea turtles. The rest of the conditions are the same as Zone 2.

When no nests are found on Zone 3 beaches, vegetation cutting may be conducted outside of the peak nesting season of the hawksbill sea turtle. A protection zone of 10 meters (measured landward from the edge of the woody vegetation) should be established to protect leatherback and green sea turtle nesting habitat. If leatherback and/or green sea turtle nests are left in situ (in place), vegetation removal activities should not occur within 10 meters of the landward edge of the nest track. The preferred alternative for cutting the vegetation, if nests are in situ, is hand cutting using machetes or power tools.

Vehicular Traffic

It should be noted that driving on sand beaches as a means of site access should be regarded as a measure of last resort after all other site access options have been explored. A designated entrance and an exit at the beach area, and monitoring of nesting events by qualified and experienced personnel is needed for vehicular beach access. If vehicular access is needed, we recommend the vehicular access be limited to the intertidal zone (below mean high water). Driving above the intertidal zone should not be allowed. All known nests should be marked by stake and survey tape or string in an area at least 20 feet (6 meters) in any direction from the center of the nest. No activities should enter in this area. Other alternative routes should be explored to avoid driving on sea turtle nesting beaches.

Vessel Traffic

For beach access from the ocean, should landing a vessel on the beach be necessary, the landing site shall be coordinated with the FWS Culebra National Wildlife Refuge personnel and the DNER. The route of the vessel shall be coordinated with NMFS to ensure that impacts to designated critical habitat and listed coral species are avoided. However, landing vessels on beaches should be regarded as a measure of last resort.

Beach activities on Culebrita, need to be coordinated with NMFS and FWS, the following vessel access SOPs will be implemented to minimize impacts to sea turtle refuge and foraging habitat, designated critical habitat, and listed coral species:

1. Culebrita will be accessed by entering Bahia Tortuga, the bay north of Beach E (as identified in the Engineering Evaluation/Cost Analysis for the cleanup of beaches on Culebrita and Flamenco Beach on Culebra). Contractors will tie boats to existing mooring buoys or, if the draft of vessels is shallow, anchor in the unvegetated, sandy zone between the seagrass beds and the beach.

2. No additional access points to beaches A, B, C, or D will be established as the contractor will bring all equipment and supplies to Beach E for offloading and transport overland or will offload personnel and equipment from an unanchored vessel into a inflatable craft that will then transit to access point previously established in coordination with NMFS and FWS. These access points do not currently exist and would have to be agreed upon.

In meetings with USACE, FWS, DNER, EQB and NMFS, it was agreed that the following cays will not be part of the cleanup project as they are inaccessible. The cays are:

1. Cayo Tiburón
2. Whale Rock
3. El Mono
4. Cayo Mono
5. Alcarazza/Fungi Bowl
6. The Washer

It was further agreed that access to the some of the cays that will be part of the cleanup project will be as follows:

1. Cayo Botella – contractors will use the Culebrita Island access in the bay northwest of the largest beach (Beach E) or anchor boats in the sandy bottom area south of the cay and use a inflatable craft, kayak, or swim to access the cay from the southeast where there is a small sand channel between areas of coral reefs.

2. Cayo Norte – boats will anchor in sand bottom in the small bay off the beach on the southeast of the island.

3. Pajarito Cay – from anchorage or mooring in Culebrita or Cayo Norte, access will be by inflatable craft entering the south side of the cay.

4. Cross Cay/Cayo Lobo – boats can anchor in unvegetated sandy bottom in the bay on the southeast side of the cay and anchors will not be dropped in areas containing coral colonies or seagrass beds.

The Corps, in coordination with the FWS, NMFS and DNER personnel have agreed that, in order to avoid impacts to listed coral species and designated critical habitat, the installation of mooring buoys to access Palada Cay/Cayo Geniqui, Cayo de Agua, Cayo Yerba and Cayo Ratón (also called Los Gemelos/Twin Rocks) will be completed if the clean-up activities will take place on these cays for more than two weeks. Prior to installation of mooring buoys at any given location in Culebra waters, the proposed locations shall be assessed for presence/absence of unexploded ordnance and to select final locations in unvegetated, sandy bottom. If the mooring buoys are not installed, the contractor will use a transit vessel to transport personnel to a site near each cay. The transit vessel will not weigh anchor and personnel will access the cays via an inflatable craft.

The following areas were identified using aerial photography, nautical charts and area maps and are proposed for installation of mooring buoys:

1. Cayo Geniquí/Palada Cay: Mooring buoy in 20-30 feet of water in the hardbottom area south of the cay to moor the transport boat. Access to the cay will be via inflatable craft.

2. Cayo del Agua: Mooring buoy in 20-30 feet of water on the south side of the cay to moor the transport boat. Access to the cay will be via inflatable craft.

3. Los Gemelos/Twin Rocks (Cayos Ratón and Yerba): Transit vessel will moor to the buoy serving Cayo del Agua and a inflatable craft will be used to access the cays.

These mooring buoy locations shall be coordinated with the United States Coast Guard.

In addition to establishment of access points, the following protocols shall be followed to minimize impacts to sea turtle refuge and foraging habitat, designated critical habitat, and listed coral species:

1. Access to the cays that have not been determined to be inaccessible and therefore form part of cleanup efforts will be dependent on wind, wave, and current conditions. During periods of rough seas, cays will not be accessed in order to minimize the potential for accidental groundings.

2. The transport boat utilized to provide access to the smaller cays will remain offshore and will not weigh anchor

   Clearance crews and equipment will be ferried to the cays with an inflatable-type craft and the landing point for this craft will be determined in coordination with NMFS and FWS.

NMFS Protected Species Vessel Strike Avoidance Measures and Reporting

Background
The National Marine Fisheries Service (NMFS) has determined that collisions with vessels can injure or kill protected species (e.g., endangered and threatened species, and marine mammals). The following standard measures should be implemented to reduce the risk associated with vessel strikes or disturbance of these protected species to discountable levels. NMFS should be contacted to identify any additional conservation and recovery issues of concern, and to assist in the development of measures that may be necessary.

Protected Species Identification Training
Vessel crews should use an Atlantic and Gulf of Mexico reference guide that helps identify protected species that might be encountered in U.S. waters of the Atlantic Ocean, including the Caribbean Sea, and Gulf of Mexico. Additional training should be provided regarding information and resources available regarding federal laws and regulations for protected

species, ship strike information, critical habitat, migratory routes and seasonal abundance, and recent sightings of protected species.

Vessel Strike Avoidance

In order to avoid causing injury or death to marine mammals and sea turtles the following measures should be taken when consistent with safe navigation:

1. Vessel operators and crews should maintain a vigilant watch for marine mammals and sea turtles to avoid striking sighted protected species.

2. When whales are sighted, maintain a distance of 100 yards or greater between the whale and the vessel.

3. When sea turtles or small cetaceans are sighted, attempt to maintain a distance of 50 yards or greater between the animal and the vessel whenever possible.

4. When small cetaceans are sighted while a vessel is underway (e.g., bow-riding), attempt to remain parallel to the animal's course. Avoid excessive speed or abrupt changes in direction until the cetacean has left the area.

5. Reduce vessel speed to 10 knots or less when mother/calf pairs, groups, or large assemblages of cetaceans are observed near an underway vessel, when safety permits. A single cetacean at the surface may indicate the presence of submerged animals in the vicinity; therefore, prudent precautionary measures should always be exercised. The vessel should attempt to route around the animals, maintaining a minimum distance of 100 yards whenever possible.

6. Whales may surface in unpredictable locations or approach slowly moving vessels. When an animal is sighted in the vessel's path or in close proximity to a moving vessel and when safety permits, reduce speed and shift the engine to neutral. Do not engage the engines until the animals are clear of the area.

Additional Requirements for the North Atlantic Right Whale

The NMFS guidance includes additional requirements for the North Atlantic right whale, but these do not apply for the Culebra activities.

Injured or Dead Protected Species Reporting

Vessel crews should report sightings of any injured or dead protected species immediately, regardless of whether the injury or death is caused by your vessel.
Report marine mammals to the Southeast U.S. Stranding Hotline: 877-433-8299
Report sea turtles to the NMFS Southeast Regional Office: 727-824-5312
If the injury or death of a marine mammal was caused by a collision with your vessel, responsible parties should remain available to assist the respective salvage and stranding network as needed. NMFS' Southeast Regional Office should be immediately notified of the strike by email (takereport.nmfsser@noaa.gov) using the attached vessel strike reporting form.

For additional information, please contact the Protected Resources Division at:
NOAA Fisheries Service
Southeast Regional Office
263 13th Avenue South
St. Petersburg, FL 33701
Tel: (727) 824-5312
Or visit their website at: http://sero.nmfs.noaa.gov

Considerations for Other Species

The Corps and its contractors shall avoid contact with any bird or reptile found injured or otherwise in the way of the cleanup activities, until adequate coordination is done with the resource agencies. Detonation of UXO on cays should be conducted outside of the seabird nesting season. Some seabirds nest year round, in the event an item needs to be detonated near nests, the birds should be captured and held prior to the blow in place. This should be coordinated with the Project Biologist, FWS and DNER. In the event of manatee sighting in the vicinity of a work area, the work will stop until the animal(s) are at a safe distance.

Point of Contact for SOP Coordination

José Méndez, Project Manager
Jose.Mendez2@usace.army.mil
787-729-6893

Iván Acosta, Environmental Engineer
Ivan.Acosta@usace.army.mil
904-232-1693

Nelson Colón, Biologist
Nelson.R.Colon@usace.army.mil
904-232-2442

APPENDIX O. GEOPHYSICAL DATA QUALITY OBJECTIVES

APPENDIX O

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O.0 GEOPHYSICAL DATA QUALITY OBJECTIVES

O.1 DQO FOR GEOPHYSICAL EQUIPMENT PERFORMANCE

A. State the Problem

1. Identify performance criteria for geophysical equipment which will result in data of sufficient quality to support remedial investigation/feasibility study (RI/FS).
2. Identify methodologies with which to measure geophysical equipment (analog and digital) performance. Transect data sufficient to cover each MRS in accordance with the PWS and approved work plan. Anomalies identified along transects, as well as any/all historic or observed surface MEC are used to generate anomaly density maps for each MRS. 100% coverage grids (50' x 50' or equivalent rectangular area) are used to establish the nature and extent of anomalies (potential MEC) in each high density area (anomaly density > 5 to 6 times the background density). Certain physical constraints, such as slopes greater than 30 degrees, vegetation removal constraints, such as endangered species and critical habitat, as well as rights of entry (ROE), will limit data collection.

B. Identify the Decision

1. Determine appropriate performance criteria for the geophysical equipment and operator to be used in the RI/FS field work.
2. Determine appropriate methods for measurement of equipment performance.
3. Determine if selected equipment and operator meet the performance standard.

C. Identify Inputs to the Decision

1. Data requirements for the RI/FS.
2. Contractual Requirements.
3. Environmental factors influencing equipment operation, including vegetation.
4. Characteristic MEC present or suspected of being present at Culebra MRSs.

D. Define the Study Boundaries

1. MEC of interest.
2. Sampling density for the EM61-MK2 EM data.
3. Soil/geology.
4. Site environmental factors.
5. Vegetation removal to permit acceptable DGM operations (surface vegetation cut to a height of no more than 12 inches, tree limbs removed to a height of 6 ft (1.83 m) above ground level, and 3 ft (0.91 m) of additional devegetation outside grids to allow for turns and overlap). Transects in MRS 13 (Luis Pena) need to be a minimum of 2.5-ft wide. Transects on all other MRSs need to be a minimum of 4-ft wide.

E. Develop a Decision Rule

1. Primary Target Acquisition Equipment

   This equipment must be man portable in rolling and vegetated terrain and must remain operational in inclement weather, including periods of rainfall and winds. Other factors that may be evaluated in the performance of equipment include the relative influence of magnetic geological features on the equipment performance and ease of operation.

This equipment must achieve a probability of detection (Pd) of 100% as determined in accordance with the approved test strip for this project.

Area coverage by Geophysics is 100% of planned survey area. Area not so covered will be explained and justified.

2. Target Reacquisition Equipment

   This equipment must achieve a Pd of 100% with a confidence of 95% as determined in accordance with the approved test strip for this project. Reacquisition must be repeatable within 2m, or as finalized in the initial test strip report.

   This equipment must be man portable in rolling and vegetated terrain and must remain operational in inclement weather, including periods of rainfall and winds.

F. Specify Limits to Decision Errors – Equipment found to be functioning improperly or outside of the stated performance criteria will not be utilized until it has been reset, re-calibrated, repaired, or otherwise modified to correct noted inconsistencies in performance or operation.

   a. Static Repeatability: Response (mean static spike minus mean static background) +-10% of original value on all channels

   b. Along Line Measurement Spacing: 98% <=25cm along line

   c. Speed: 95% within max project design speed of <= 3.4mph

   d. Grid Coverage: >90% coverage at project design line spacing (2.5 feet).

   e. Dynamic Detection Repeatability – Grids: Test item anomaly characteristics (peak response and size) repeatable with allowable variation +/-25%.

   f. Dynamic Detection Repeatability – Transects: Test item (in test strip or on transect) anomaly characteristics (peak response and size) repeatable with allowable variation +/-25%. Or Fit coefficient over test strip is acceptable.

   g. Static Positioning Accuracy: The coordinates being obtained from the positioning system are at a sufficient accuracy to allow for appropriate relocation of MEC for intrusive investigation. Measurement performance criteria: The error from a known location does not exceed +/- 2m from a known location from the reoccupation test.

   h. Dynamic Positioning Repeatability, Grids: Position offset of Test item target <=35cm + 1/2 line spacing[11] (<=50cm + 1/2 line spacing for fiducially positioned data).

   i. Dynamic Positioning Repeatability, Transects with reacquisition/digging: Test item anomaly characteristics (peak response and size) repeatable with allowable variation +/-25% and position offset <=2m.

   j. Target Selection: The systems reliably detect the required MEC, as specified in the PWS, or to their typical maximum detection depth (11 times diameter rule of thumb). The daily test strip will document actual detection capabilities of ISO object responses fall within published response curves. In MRSs with grid surveys, additional test strip data is acquired to simulate grid surveys. Additional anomaly classification analysis will be performed. Geosoft's Signal to Noise Ratio (SNR) utility will be used to help classify anomalies as MEC like or not MEC like. All selected anomalies will be screened for proper time gate decay.

G. Optimize the Design for Obtaining Data – Design elements of this process will be evaluated on a continuing basis with field data for review, analysis, design improvement, acceptance, and implementation. All initial DGM metrics will be documented, including:

   - Dynamic background noise levels for each time gate.

- DGM sample density.
  - Along track sample density (sample rate and survey speed)
  - Across track sample density (line spacing) for grids
- Anomaly selection methodology.
  - MEC like
  - Not MEC like
- Anomaly location accuracy.

O.2 DQO FOR SURVEY/LOCATION EQUIPMENT PERFORMANCE

A. State the Problem –

1. Identify performance criteria for location equipment that will result in data of sufficient quality to support the RI/FS.
2. Identify methodologies with which to measure performance of location equipment.

B. Identify the Decision –

1. Determine appropriate performance criteria for the location equipment to be used in the RI/FS field work.
2. Determine appropriate methods for measurement of equipment performance.

C. Identify Inputs to the Decision –

1. Contractual requirements.
2. Data requirements for the RI/FS.
3. Environmental factors influencing equipment operation.

D. Define the Study Boundaries – All MEC survey and intrusive investigations within range, area, or grid locations.

E. Develop a Decision Rule –

1. The instrumentation used for location data acquisition shall be a differential global positioning system (DGPS) submeter accurate and shall have the capability to export location data points at a frequency of at least 1 per second.
2. The equipment must be man-portable in rolling and vegetated terrain and must remain operational in inclement weather, including periods of rainfall and winds.
3. A less accurate GPS will be used for general navigation about the project site, as well as recording location data during reconnaissance activities. The unit may be used to record the location of surface MEC sited. This unit will be accurate to within 4.57m and collect location data points at a frequency of 1 per second.

F. Specify Limits to Decision Errors – Equipment found to be functioning improperly or outside of the stated performance criteria will not be utilized for data collection until it has been reset, re-calibrated, repaired, or otherwise modified to correct noted inconsistencies in performance or operation.

Transect and grid boundaries will not vary beyond: 4.57m; verified by GIS integration.

G. Optimize the Design for Obtaining Data – Design elements of this process will be evaluated on a continuing basis with field data for review, analysis, design improvement, acceptance, and implementation.

O.3 DQO FOR DATA COLLECTION

A. State the Problem – Collect a sufficient quantity of data of acceptable quality to support the RI/FS.

B. Identify the Decision –

1. Determine what type of data to collect
2. Determine how much data to collect
3. Determine the quality parameters for data.

C. Identify Inputs to the Decision – Data requirements for the RI/FS IAW the PWS.

D. Define the Study Boundaries – Munitions Response Sites (MRSs) identified by the PWS.

E. Develop a Decision Rule –

1. Geophysical

   During the search mode of operation, the following data items/samples will be recorded/obtained:

   - Equipment verification data (daily, prior to field activities).
   - Known anomalies [examples are daily test strip seed items and grid dynamic repeat response seed items (ISOs) to within 2m)].
   - Geophysical track data (continually during search mode operations. Data frequency in accordance with DQO for DGPS performance). Geophysical coverage is compared to the approved RI design to document actual coverage achieved.
   - Positional location data [for the geophysical track and any surface MEC discovered during the search mode (collect at all times while geophysical equipment is in use; frequency of data points in accordance with equipment performance specifications)]
   - Erosion feature data (As needed to document relevant field conditions. Record general location and description, and obtain photograph or video footage.)
   - Data processing and analysis [performed uniformly and selected anomaly locations are of sufficient accuracy for effective reacquisition and investigation (e.g., within 2 m)].
   - Processing [all processing performed to produce final datasets, will be evaluated on an individual basis to confirm routines do not significantly alter original measured peak responses (above background) over anomalies. Final datasets processing routines will not alter the peak response of anomalies by more than 5% or 5 mV, whichever is less. This DQO does not apply to advanced data processing that may be performed as part of anomaly selection processes)].
   - Data management [provides accurate tracking, archiving, and delivery of all data (raw sensor and positioning, processed sensor and positioning, and analysis results)].
   - Video/digital photographic data (sufficient quantities to adequately document site conditions and activities).

2. Intrusive Investigation

   During intrusive investigation, the following data items will be recorded/obtained:

   - Reacquire location, anomaly peak response, offset, and direction data.

- Depth to anomalies [measured to the nearest 0.25 ft (0.08 m) using a graduated tape measure or ruler]
- Anomaly characteristics (For MEC see DQO for MEC Identification).
- Video/digital photographic data (All MEC will be photographed and sufficient quantities of photographic/video data will be collected to adequately document site conditions and activities).

F. Specify Limits to Decision Errors – No quantified tolerable limits apply to this process. The QC protocol will be applied to evaluate whether data collected is consistent with the DQO. Deficiencies identified will be corrected using the procedures outlined in the QC Plan.

G. Optimize the Design for Obtaining Data – Design elements of this process will be evaluated on a continuing basis with field data for review, analysis, design improvement, acceptance, and implementation.

O.4 DQO FOR MEC IDENTIFICATION

A. State the Problem –

1. Identify MEC found during the investigation with sufficient accuracy to support the RI/FS and safe procedures/disposal.
2. Secondarily, identify Materials Potentially Presenting an Explosive Hazard (MPPEH), Munitions Debris (MD), and range-related debris (RRD) (if practicably possible) with sufficient accuracy to support the RI/FS.

B. Identify the Decision –

1. Determine in the field the type, size, state (fired, unfired, fuzed, fuzed), fuzing (point detonating, timed, etc.), and general filler type for MEC found.
2. Determine during data processing the filler type, net explosive weight, and nomenclature for MEC found.
3. Determine the same information for MPPEH, MD, or RRD where practical.

C. Identify Inputs to the Decision –

1. Field observations, photos, and measurements.
2. Knowledge of MEC materials and military operations.
3. Characteristic MEC present or suspected of being present at Culebra MRSs.
4. Appropriate references for determination of filler type, probable net weight explosive and nomenclature.

D. Define the Study Boundaries –

1. MEC discovered in RI/FS MRS areas.
2. Ability/potential to identify items despite physical deterioration, physical damage or other factors that may impede the identification process.

E. Develop a Decision Rule –

1. Efforts will be made to identify all MEC in the field using visual indicators and knowledge/training. Identification will be performed by two fully qualified UXO personnel, one of whom must be a UXOTIII.
2. If items cannot be identified in the field, photos will be taken. The length and width of these items will be recorded to the nearest 0.125 inch (0.32 cm) using a tape measure or ruler and efforts will be made to identify the items using reference materials (e.g. OP 1664, TM 43 Series Publications, DoD or Ord Data II (NAVEOD technical database) or Ord Data Online.

F. Specify Limits to Decision Errors – No quantified tolerable limits apply to this process. The Senior UXO Supervisor will supervise the performance of MEC identification in order to provide the largest base of experience and knowledge to this process.

G. Optimize the Design for Obtaining Data – Design elements of this process will be evaluated on a continuing basis with field data for review, analysis, design improvement, acceptance, and implementation.

O.5 DQO FOR DATA MANAGEMENT

A. State the Problem

1. Manage project data with sufficient accuracy to ensure defensible documentation of RI data.

B. Identify the Decision

1. Criteria agreed upon by the stakeholders and regulatory agencies as meeting a decision standard of being complete, current, and correct. Developed during the TPP.
2. All field data is digitally archived on-site and on project ftp site
3. All GIS data is stored in the project Geodatabase

C. Inputs to the decision

1. Data types, processed from:
    - Form
    - Spreadsheet
    - Tabulated
    - Metadata
2. Data criteria and quantities:
    - Meeting the requirements of the PWS
    - Meeting the requirements of the TPP
    - Meeting the requirements of the DID
3. Contractual requirements
4. Post processing requirements including:
    - Raw data
    - Advanced processed data
    - Final data
5. End use of data (mapping requirements):
    - Transect maps
    - Transect target map (Luis Pena)
    - Anomaly density maps by MRS
    - Grid target maps
6. Data provided by:
    - Anomaly track log
    - Anomaly table
    - Target selection
    - Reacquisition table
    - Intrusive results table

D. Define the Study Boundaries

All field data collected during field operations of a GIS, DGM, Analog, or other data collection methods.

E. Develop a Decision Rule

Daily operations Search /Position Data will be collected and stored in the collection equipment data logger and downloaded to the Project PC daily, or in the case of remote operations, within three days of collection. All geophysical search data collected, in conjunction with position data will be backed up daily and stored in an appropriate container on site and a copy transferred to the project FTP site for distribution and storage. MEC/UXO identification data and intrusive investigation data will be collected backed up, transferred and stored in the same manner.

F. Specify Limits to Decision Errors

N/A for this task. Data will be managed IAW this DQO and the corresponding SOP.

G. Optimize the Design for Obtaining Data

Design elements of this process will be evaluated on a continuing basis with field data for review, analysis, design improvement, acceptance, and implementation.

O.6 DQO FOR OPERATIONAL VERIFICATION OF SURVEY/INVESTIGATION EQUIPMENT

A. State the Problem – Identify methodologies with which to verify that data collection equipment is operational.

B. Identify the Decision – Determine appropriate testing to verify that data collection equipment is functioning properly prior to daily deployment.

C. Identify Inputs to the Decision – Operational parameters for instrumentation.

D. Define the Study Boundaries – Data collection instrumentation including the EM61-Mk2 all-metals detector, White DFX300 all metals locator, DGPS.

E. Develop a Decision Rule –

1. Primary Target Acquisition Equipment

This equipment will be walked over the Instrument Verification Strip (daily test strip), seeded with small and medium ISOs, two consecutive times at the beginning and end of each data collection session. The data from this activity will be evaluated during data processing to verify that the equipment was functioning properly (e.g. seed item responses are within ranges established at the project start). In addition, field staff will check available readouts to verify that the equipment is physically functioning. If the response values fall outside of the established range, a root cause analysis will be performed with a corrective action recommendation. If the recommendation includes equipment repair/replacement, the test strip test will be redone and affected data recollected.

2. Target Reacquisition Equipment

This equipment (DGPS and EM61-MK2) will be walked over a stationary metallic target to ensure that an audible/detection signal is produced.

3. Location Acquisition Equipment

The positioning equipment shall be tested weekly to verify that that it is operating properly. Testing shall consist of placing the positioning equipment directly on the survey monument and comparing the location reading obtained to the known coordinates for that monument. This equipment must reacquire the position of the known monument within 2 m. In addition, field staff will check available readouts daily prior to equipment deployment to verify that the equipment is physically functioning. The GPS equipment shall be tested weekly in the same manner as the DGPS; however, the reacquisition range for the GPS is within 4.57 m.

4. Analog Equipment

The analog instrument will be walked over a test strip, seeded with small and medium ISOs to ensure that an audible/detection signal is produced.

5. Radio Equipment

VHF radios and walk abouts will be tested prior to leaving the field office, after arriving at the work site, and every hour during field work by contacting the base station in the field office to ensure that radios are transmitting and reception is acceptable.

F. Specify Limits to Decision Errors – Equipment found to be functioning improperly or outside of the stated performance criteria will not be utilized for data collection until it has been reset, re-calibrated, repaired, or otherwise modified to correct noted inconsistencies in performance or operation.

G. Optimize the Design for Obtaining Data – Design elements of this process will be evaluated on a continuing basis with field data for review, analysis, design improvement, acceptance, and implementation.

O.7 DQO FOR DETECTOR TEAM PERFORMANCE EVALUATION

A. State the Problem –

1. Determine that detector teams, their equipment, data processing processes, and target selection processes meet the requirements for probability detection (Pd) at confidence levels (CLs) for all types of targets anticipated. Equipment must achieve a probability of detection (Pd) of 100% as determined in accordance with the approved Test Strip report for this project.
2. Determine the team's execution of Operational Control, area coverage, and detection/location equipment operation.

B. Identify the Decision – To verify performance of the following:

1. Have the detector teams been qualified to an existing system for validation of detection?
2. Are the operational detector teams certified?
3. Are there procedures in place to meet detection, location, and safety requirements?
4. Are acceptable operational and post data processing processes in place?
5. Is the target selection process adequate?

C. Identify Inputs to the Decision – Factors considered include:

1. Training – Determine operator qualification requirements. Team personnel selected on basis of formal training, education, or on-the-job training (OJT) (reviewed by the Senior Geophysicist).
2. Test facility – Satisfactory completion of the test strip and selection results.
3. Target - Classification estimation capability of MEC like or not MEC like.
4. Safety - Electromagnetic Radiation (EMR), portability through rolling and vegetated terrain.
5. Probability of Detection.
6. Team capability of reproducibility of detection results.
7. Response to ISO seed items fall within published response curves.
8. Established DGM metrics are met or exceeded.

D. Define the Study Boundaries – The performance evaluation process will be determined by the MEC of interest at the depths defined by the PWS and the contract. The project requirement for Probability of Detection (100%) and Confidence Level (95%) per team with assigned equipment.

E. Develop a Decision Rule – Proper evaluation of detector teams is mandated through the use of an approved GPO and test facility. Teams are qualified based on the outcome of the GPO test and ability to follow operational procedures on DGM setup and mapping, reacquisition of test targets, determining errors, and applying corrective action.

F. Specify Limits to Decision Errors – The minimum requirements for team performance evaluation criteria are inflexible.

G. Optimize the Design for Obtaining Data – Design elements of this process will be evaluated on a continuing basis with field data for review, analysis, design improvement, acceptance, and implementation.

O.8 DQO FOR ANALOG INSTRUMENT SYSTEM PERFORMANCE

A. State the Problem – Evaluate analog instrument system's (sensor and operator) performance and identify maximum detection capability.

B. Identify the Decision – To find analog instrument system detection performance that will:

   1. Detect the MEC of interest.
   2. Detect the MEC to the desired depth. Each operator/analog sensor demonstrates positive detection on a daily basis of the smallest and largest expected MEC (e.g. small and large ISOs in test strip) of interest when it is placed at both its best and worst orientations and buried between 95% and 100% of their respective maximum consistent detection depth.
   3. Operate adequately in the existing environmental conditions.
   4. Best productivity/cost ratio.

C. Identify Inputs to the Decision – Factors considered include:

   1. Environmental – geology, topography, humidity, soil conditions (moisture, magnetic properties, etc.), vegetation, weather.
   2. Target – size/class, materials (ferrous and non-ferrous).
   3. Safety – man-portability through rolling and vegetated terrain.
   4. Human – compatible ergonomics, compatible with the environment, and ease of use.
   5. Ability to detect all seed items.
   6. Ability to reduce background detects.
   7. Target classification and depth estimation capability.
   8. Site specific depth matrix (based on the PWS – MEC found and corresponding depths).
   9. Operator qualification requirements.

D. Define the Study Boundaries – The performance process will be limited by the MEC of interest at the depths defined by the PWS, contract, land end use, minimum MEC detection requirements from U.S. Army Corps of Engineers (Corps) DID MR-005-05, site environmental factors, and cost per unit productivity and time per unit productivity.

E. Develop a Decision Rule – The analog instrument selected will meet the minimum requirements for detection of the selected items at appropriate depths.

F. Specify Limits to Decision Errors – The minimum requirements are inflexible.

G. Optimize the Design for Obtaining Data – Design elements of this process will be evaluated on a continuing basis with field data for review, analysis, design improvement, acceptance, and implementation.

APPENDIX P. EXPLOSIVES SITE PLAN

Explosives Site Plan

PROJECT NUMBER I02PRA00068

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

MRS 06 Artillery Firing Area
MRS 08 Cayo Norte Impact Area
MRS 09 Soldado Point Mortar and Bombing Area
MRS 10 Defensive Firing Area No. 1
MRS 11 Defensive Firing Area No. 2
MRS 13 Cayo Luis Pena Impact Areas

ISLA CULEBRA
CULEBRA ISLAND, PUERTO RICO

4 February, 2011

Prepared by

USA ENVIRONMENTAL, INC.
720 Brooker Creek Boulevard, Suite 204, Oldsmar, Florida 34677

CONTRACT W912DY-04-D-0006 TASK ORDER NO. 0022

for

U.S. ARMY CORPS OF ENGINEERS
Engineering and Support Center, Huntsville

U.S. ARMY CORPS OF ENGINEERS
Jacksonville District

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1.0 SITE

a. Name: Culebra Island

b. State: Commonwealth of Puerto Rico
(See Appendix A, Figure 1)

c. This remedial investigation (RI) is being performed under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and is part of the overall Remedial Action Process. Subsequent removal responses may be dictated in the future during the remainder of the remedial response process, as determined by action memoranda or other decision documents. Based on the results of this characterization and subsequent decision document, an Explosives Safety Submission (ESS) will be submitted in accordance with DoD 6055.09-M.

2.0 ANTICIPATED START DATE

February 2011

3.0 PURPOSE

Work performed under this plan is limited to the execution of those tasks required to perform both Analog and Digital Geophysical Mapping (DGM) to conduct a Remedial Investigation/Feasibility Study (RI/FS) to characterize the nature and extent of explosive hazards within the selected Munition Response Sites (MRS) of Culebra Island, Puerto Rico response site. (See Appendix A, Figure 2.)

All activities involving work in areas potentially containing Munitions and Explosives of Concern (MEC) will be conducted in full compliance with U.S. Army Engineering and Support Center, Huntsville (USAESCH), U.S. Army Corps of Engineers (USACE), Department of the Army (DA), and Department of Defense (DoD) requirements regarding personnel, equipment, and procedures, and with Occupational Safety and Health Administration (OSHA) Standard 29 Code of Federal Regulation (CFR) Part 1910. All UXO personnel are qualified under DDESB TP-18, Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel.

4.0 SITE BACKGROUND AND CURRENT CONDITIONS

4.1 SITE HISTORY

Culebra came under Navy control in 1901; the Navy built a small base that same year and an airfield about 20 years later. The Culebra Island Archipelago was used for training purposes by the U.S. Navy and U.S. Marines, and was later used by the North Atlantic Treaty Organization (NATO). The U.S. Marines used portions of Culebra Island as a training facility from 1902 through 1941. Culebra Island was used as a bombing and gunnery range from 1935 through 1975. To support the increased training needs during Viet Nam operations, the Navy acquired additional training areas on cays east and west of Culebra Island for use as air-to-ground ranges. Live ordnance operations reached their peak in 1969 as the fleet was training pilots for Viet Nam. Aircraft bombing and strafing of the Flamenco Peninsula ended around 1970, while the use of live rounds for naval gunfire support training ended in 1971. Subsequent naval support training was conducted using quieter puff rounds until ordnance use was terminated on September 30, 1975. Between 1975 and 1982, the facilities were turned over to the General Services Administration (GSA).

4.2 REASON FOR MEC

The historical records indicate a wide difference in documenting the MEC within the MRS. Archives on the various MRSs fail to delineate the exact amounts of ordnance fired, but the reports listed Naval ship gunfire, Marine landings, firing of infantry weapons and artillery, and aerial bombing and strafing (see Appendix A, Figure 2.). The figure shows the location of the six MRS under Task Order 0022.

a. MRS 06 Artillery Firing Area

- Located on the eastern end of the island of Culebra. The site consists of some 826 acres. The Marine Corps established artillery firing points in this vicinity for the various training exercises from 1922 through the late 1940s. Some small arms training may have also taken place is this area. This area is immediately to the east of the Mortar and Combat Range Area. There is a slight potential for MPPEH contamination. (INPR Revised July 2005)
- 1914 3-inch Battery; Fleet Landing Exercise (FLEX) #2 1936, 37mm gun position, Mosquito Bay shoreline; FLEX #5 1939, Artillery Firing near Mosquito Bay toward Culebrita, Whale Rock, Cayo Botella, Cayo Tiburon and Cayos Geniqui. Fire was not directed at NE Cay; Beach Defensive Area #1 and #2 and AA Range into water near Area 06; FLEX #5 1939, 37mm rounds fired from beach at Mosquito Bay to moving target in water between Point Vaca and Snapper Shoals and shrapnel rounds fired at a floating target at Yellow Shoals (Site Investigation Final Report, Sep 2007, Appendix J Conceptual Site Model)
- The 81mm mortar was chosen as the Munition with the Greatest Fragmentation Distance (MGFD) for the southern portion of the MRS due to the known Beach Defensive Areas identified on the southern side of the MRS. (Archives Search Report, Plate 2, December 2004) The 37mm MK II projectile, MK II was selected as the munition with the greatest fragmentation distance for the land impact area located in the northern portion of the MRS based on known discoveries of these items in the vicinity. Other identified guns were eliminated because they were firing at targets outside the MRS, i.e., the island of Culebrita MRS 7.

b. MRS 08 Cayo Norte Impact Area

- Located on Cayo Norte immediately off the northern coast of Culebra. The site consisting of some 306 acres is identified as Area 08 on Plates No. 1 and No. 2. This area was established in the earliest Marine Corps training exercises as an impact area for operational artillery firing. Cayo Norte is also immediately adjacent to other cayos that were used for Navy aerial ordnance training. There is potential for MPPEH contamination remaining at this site.
- Historical documents identified that Cayo Norte had been leased by the Marine Corps during their training exercises for use as an artillery impact area. Unexploded ordnance items have not been reported on the cayo. (INPR Revised July 2005)
- FLEX #2 1936, Artillery Impact Area # 2. (Site Investigation Final Report, Sep 2007, Appendix J Conceptual Site Model)
- The 75mm projectile, MK1 HE was selected as the MGFD due to the identified *"1924 Artillery Targets" on the north side* of the cayo. (Archives Search Report, Plate 2, December 2004)

c. MRS 09 Soldado Point Mortar and Bombing Area

- Located on southeast tip of the Southeast Peninsula on the island of Culebra. The site consisting of some 328 acres is identified as **Area 09** on Plates No. 1 and No. 2. The site was utilized by the Marine Corps for boat-to-shore mortar firing and aerial bombing and strafing during the various training exercises from the mid-1930s through the late 1940s. There is a potential of MPPEH contamination remaining at this site. (INPR Revised July 2005)
- Historical documents identified the site as having been used by the Marine Corps for aerial bombardment and mortars fired from boats during their various training exercises on Culebra. Unexploded ordnance items have not been reported in the area. Historical documentation

indicates that this site is immediately adjacent to a heavily used Navy gunnery and bombardment area that was used mainly from 1934 to 1975. (INPR Revised July 2005)

- 1914 5-inch battery; FLEX #1 1935, .30 cal, .45 cal and .50 cal, 37mm, 75mm and 155mm, 3-inch; FLEX #2 1936, 30-lb frag, 100-lb HE bombs; Possible 1924 Anti-Aircraft Fire on hill 200; FLEX #5 1939 Marine Defensive Area #1 and Aircraft Bombing and Machine Gun Range; 1938 Mortar Firing from Boats to Shore. (Site Investigation Final Report, Sep 2007, Appendix J Conceptual Site Model)
- The 100lb bomb, AN-M30A1 was chosen as the MGFD for the *aircraft bombing target,* located on the south side of the MRS, based on the reports of FLEX #1 in 1934 and FLEX #5 in 1938. The 3" Common projectile, MK3 Mod 7 was chosen as the MGFD for the *direct fire range* on the north side of the MRS.

d. MRS 10 Defensive Firing Area No. 1

- Located southeast of the town of Dewey on the island of Culebra. The site consisting of some 547 acres is identified as **Area 10** on Plates No. 1 and No. 2. This tract was one of the areas that the Marine Corps used during the various training exercises from the 1920s through the late 1940s for practicing defensive firing. Marine units stationed on the high ridge would practice firing mortars onto the southern shore area. It also contains one of the original Navy gun mount sites. There is potential for MPPEH contamination remaining at this site. (INPR Revised July 2005)
- Historical documents identified the site as having been used by the Marine Corps for firing mortars from the higher ground onto the beach area during their various training exercises on Culebra. Unexploded ordnance items have not been reported in the area. This tract also includes the site of one of the former Navy gun mounts. Possible 1924 Anti-Aircraft Fire on hill 325; FLEX #5 1939 Marine Defensive Area #1 and may have dropped mortars on beach from high ground (Site Investigation Final Report, Sep 2007, Appendix J Conceptual Site Model)
- The 81mm mortar was selected as the MGFD for the known *Beach Defensive Area #1* identified on the south side of the MRS and the 3" Common projectile, MK3 Mod 7 was chosen for the MGFD for the *direct fire range* on the north and eastern sides of the MRS. (Archives Search Report, Plate 2, December 2004)

e. MRS 11 Defensive Firing Area No. 2

- The **Defensive Firing Area #2** is located northwest of the town of Dewey on the island of Culebra. The site consisting of some 719 acres is identified as **Area 11** on Plates No. 1 and No. 2. This tract was one of the areas that the Marine Corps used during the various training exercises from the 1920s through the late 1940s for practicing defensive firing. Marine units stationed on the high ridge would practice firing mortars onto the southern shore area. They also fired artillery from this area onto Cayo Luis Pena and the cayos west of Culebra. This area also served as the backdrop for beach mortar barrage firing from offshore boats. It also contains one of the original Navy gun mount sites. Additionally, it is located immediately adjacent to the former Northwest Peninsula gunnery and bombardment area. There is potential for MPPEH contamination remaining at this site. (INPR Revised July 2005)
- Historical documents identified the site as having been used by the Marine Corps for firing mortars from the higher ground onto the beach area during their various training exercises on Culebra. Portions of the site were also used as an impact area for barrage mortar firing from boats. Additionally, the site is located immediately adjacent to the former Northwest Peninsula bombardment area. Unexploded ordnance items have been reported in the area. This tract also includes the site of one the former Navy gun mounts. 1922 155mm gun firing point for fire toward Mono Cay; Possible 1924 Anti-Aircraft Fire on hill 310; FLEX #4 Target at Firewood Bay beach barrage firing; FLEX #5 1939 Marine Defensive Area #2; FLEX #7 1941 Training with 5-inch anti-aircraft projectiles and 6-inch flat nose projectiles at beach targets in Seine Bay and Firewood Bay. (Site Investigation Final Report, Sep 2007, Appendix J Conceptual Site Model)

- The 4.2” mortar, M3A1 was selected as the MGFD based on the Marine Corps history of developing the use of the mortar in amphibious operations and the identified *“mortar boat firing area*” off the northwestern side of MRS 11. The 81mm mortar was chosen as the MGFD for the known *beach defensive fire* on to the beaches south of the mortar boat firing areas identified on the western side of the MRS. The 3” Common projectile, MK3 Mod 7 as chosen as the MGFD for the *direct fire range* on the southern portion of the of the MRS. (Archives Search Report, Plate 2, December 2004)

f. MRS 13 Cayo Luis Pena Impact Areas

- Located on the Cayo Luis Pena, which is situated west of the main island of Culebra. The site consists of some 864 acres. This acreage includes both the island and the surrounding waters that could have been affected by the military operations. Cayo Luis Pena was one of the areas that the Marine Corps used during the various training exercises from the 1920s through the late 1940s for munitions firing. Marine units stationed on Culebra fired artillery onto the northern areas. They also used the entire area for aerial bombing and gunnery practice. One historical document indicated that the Marines had also dropped napalm onto Cayo Luis Pena. Additionally, it is located in the vicinity of the former Northwest Peninsula gunnery and bombardment area. MPPEH items have been reported in the waters around the cayo. (INPR Revised July 2005)
- Historical documentation and maps indicate this area was used the Marine Corps as an artillery impact area and later as an observation point for adjacent bombing and gunnery ranges on the Cayos to the northwest. Additionally, it is located in the immediate vicinity of the Northwest Peninsula that was the main bombardment and impact area during the Navy and Marine training exercises. MPPEH items have been reported in the waters around the cayo. (Historical Activities Report Part of the Supplemental Archives Search Report for Culebra PR September 2005)
- 1924 Impact Area 155mm Grande Puissance Filloux (GPF) and 75mm AA, machine gun tanks, 37mm, 8-inch and 6-inch naval guns, seaplanes; FLEX #5 1939 Aircraft Bombing and Machine Gun Range; Helicopter Pad. (Site Investigation Final Report, Sep 2007, Appendix J Conceptual Site Model)
- The 75mm, MK1 HE was selected as the MGFD for the *northern peninsula* based on the historical usage by the Marines of the 75mm gun as a direct fire in this portion of the MRS. The 5” projectile, MK41 was selected as the MGFD for the remaining portion of the MRS based on the time frame it may have been used as an *impact area*. (Archives Search Report, Plate 2, December 2004)

4.3 LAND USE

Table 4-1 describes the current site conditions of the MRS and site dynamics relating to future land use.

Table 4-1: Current Land Use (Final ASR 2005)

Site	Current Land Use Conditions
MRS 06	This tract contains several residential areas. The site conditions are subject to change in the future, but are believed to be stable at the present. Examples would be excessive soil erosion on beaches or streams, and increasing land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. **Site Dynamics:** Portions of this tract are currently being developed, with others listed for sale for potential development.
MRS 08	This is a privately owned island; however, there are no barriers. The site conditions are subject to change in the future, but are believed to be stable at the present. Examples would be excessive soil erosion on beaches or streams, and increasing land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. **Site Dynamics:** Reportedly, the island is for sale; however, any change in future use is not known.
MRS 09	There are no restrictions for using the beach areas or entering the surrounding waters for recreational activities. The site conditions are subject to change in the future, but are believed to be stable at the present. Examples would be excessive soil erosion on beaches or streams, and increasing land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. **Site Dynamics:** Seasonal surf action could cause changes in the bottoms of the surrounding waters. The site is controlled by the Puerto Rico Department of Natural Resources and residential development is not supposed to be allowed on the site. Public area structures could be developed at some point in the future.
MRS 10	Residential areas have been developed on the hills overlooking the mortar impact areas. The site conditions are subject to change in the future, but are believed to be stable at the present. Examples would be excessive soil erosion on beaches or streams, and increasing land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. **Site Dynamics:** Seasonal surf action could cause changes in the bottoms of the surrounding waters. The water area adjacent to this shore is generally not used for recreational activities. Additional homes could be developed in the area of the firing points, but development is not expected in the impact zone.
MRS 11	Residential areas have been developed on the hills overlooking the mortar impact areas. The site conditions are subject to change in the future, but are believed to be stable at the present. Examples would be excessive soil erosion on beaches or streams, and increasing land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. **Site Dynamics:** Portions of this tract are currently offered for sale. Development could occur throughout the site. The immediate offshore waters that are part of the Luis Pena Water Refuge are covered under a separate project.
MRS 13	Residential areas have been developed immediately across the channel from this cayo. The site, which is under the control of the US Fish and Wildlife agency and is part of the Culebra National Refuge, does not have barriers for access. Examples would be excessive soil erosion on beaches or streams, and increasing land development that could reduce distances from the site to inhabited areas or otherwise increase accessibility. **Site Dynamics:** This area deals with site conditions that are subject to change in the future, but are believed to be stable at the present.

5.0 EXECUTING AGENCIES

a. U.S. Army Engineering and Support Center, Huntsville

b. U.S. Army Corps of Engineers, Jacksonville District

a. USA Environmental, Inc., Oldsmar, Florida

6.0 SCOPE OF INVESTIGATIVE/CHARACTERIZATION ACTION

6.1 OBJECTIVE

Conduct a Remedial Investigation (RI), Feasibility Study (FS) and all necessary activities required to accomplish this objective. Obtain acceptance of a Decision Document meeting the requirements of ER 200-3-1 and CX Interim Guidance 06-04 EP 1110-1-18, Munitions Response Process.

Figure 6-1: RI/FS Munitions Response Sites (MRS)

Site	Type of Investigation	Total Acreage	Investigation Acreage
MRS 06 Defensive Firing Area No. 1	Manual intrusive investigation	826	8
MRS 08 Cayo Luis Pena Impact Areas	Manual intrusive investigation	306	4
MRS 09 Defensive Firing Area No. 2	Manual intrusive investigation	328	3
MRS 10 Cayo Norte Impact Area	Manual intrusive investigation	547	6
MRS 11 Soldado Point Mortar and Bombing Area	Manual intrusive investigation	719	7
MRS 13 Artillery Firing Area	Manual intrusive investigation	864	6
	Totals	3,590	34

6.2 WORK TO BE ACCOMPLISHED

The following are specific tasks to be performed under the PWS: The work includes 26 acres of DGM transects and 8 acres of grids. USA will investigate 2,000 anomalies and perform 18 demolition shots.

Land Investigation: All anomalies identified for sampling will be intrusively investigated manually, unless removal of surface metallic debris can be verified as accounting for the mapped geophysical anomaly. Anomalies within 3 ft of the surface will be excavated using hand tools.

Detection:

Land: On upland locations, the digital sensor will be an EM61-MK2 or EM61-MK2A in either the standard wheel mode or the stretched mode. Along upland transects, the EM61-MK2 will be deployed with the narrow (0.5-m) edge forward and positioned with a Trimble GeoXH, or equivalent, with an external antenna.

Beaches: On the accessible beaches, USA will use an analog sensor (e.g., White's Surf PI Dual Field Metal Detector in the traditional analog and flag mode) marking each anomaly with a large metal washer tagged with surveyor tape.

7.0 SAFETY CRITERIA

7.1 MINIMUM SEPARATION DISTANCE (MSD)

The Minimum Separation Distance (MSD) at the site is identified in Table 7-2. During the course of this RI/FS if MEC with a greater fragmentation distance is encountered, the minimum separation distance (MSD) will be adjusted in accordance with DDESB Technical Paper 16, operations will continue, and an amendment to this ESP submitted expeditiously for approval. The quantity-distance (Q-D) arcs will be adjusted accordingly.

The MGFD for each MRS is shown in Table 7-2. Items with smaller fragmentation distances may be found. Demolition of these items may be done using the item specific minimum separation distances and engineering controls in accordance with DDESB TP 16 Fragmentation Database. For items not in the DDESB TP 16 Fragmentation Database, the maximum fragment distance may be calculated IAW the generic equations in DDESB TP 16. (Note: the Generic Equation Calculator (GEQ) is available on the DDESB's secure website at http://www.ddesb.pentagon.mil/.)

See Appendix A for Maps of the individual MRS and MSD.

See Appendix B for Fragmentation Data Sheets. Table 7-1 lists the data sheets included in Appendix B.

Table 7-1: DDESB Calculation Sheets for MEC

Type of MEC Expected
75mm projectile, MKI
4.2" M3A1
100lb bomb, AN-M30A1
37mm projectile, MK II
81mm mortar, M43
3" Common projectile, MK 3 Mod 7
5" projectile MK 41

USA will notify the following agencies at least 36 hours in advance of performing any demolition operations. These agencies will also be used to assist in securing the area, as appropriate, where the item presenting an explosive hazard is located until demolition operations have occurred

- US Coast Guard, Mr. John Reyes, Marine Information Specialist (787) 729-5381), Sector San Juan AtoN & WWM Officer, 787-289-2086, fax 729-2377. This is for a Broadcast to Mariners of the scheduled demolition shot. Alison.M.Schmidt@uscg.mil
- FAA Coordination Facility for a Notice to Airmen on flight restriction above the demolition area. (787) 253-8664 Mr. Gilberto Iglesias or Mr. Felipe Fraticelli, www.nes.notams.faa.gov
- Municipal Police (787) 742-0106 for any activity on Flamenco Beach. USA SUXOS or UXOSO will coordinate directly with the police department to overcome any language difficulties on demolition operations.
- Puerto Rican State Police (787) 742-3501, for any activities on Culebra. USA SUXOS or UXOSO will coordinate directly with the police department to overcome any language difficulties on demolition operations.

MRS 08 Cayo Norte and MRS 13 island of Luis Pena precludes the stationing of a security guard overnight due to the lack of reliable communications and the ability to evacuate personnel off the cayo at night.

When an MEC item is located the item will be marked using wooden stakes and flagging ribbon. During working hours UXO personnel will maintain a secure perimeter and after hours local law enforcement will be utilized to provide a secure perimeter until the item is disposed of by detonation.

USA will request assistance from the local authorities on Culebra to notify residents at least 36 hours prior to performing intrusive operations on an MRS. Areas within exclusion zones will require evacuations during intrusive investigations and demolition operations due to the proximity of residences. If for any reason the resident(s) refuse or do not evacuate, USA will notify the USACE Project Manager for resolution. USA will coordinate with USACE for notification of the local population and appropriate regulatory agencies before a demolition event.

USA will coordinate with USACE to evacuate the public during the demolition of a UXO item if all other engineering controls are not adequate. See Section 8.1 for a detailed description of the type of engineering controls proposed for use during the field effort. USA will conduct demolition operations only after all personnel protective measures have been completed and reported to the SUXOS.

Table 7-2: Minimum Separation Distance (MSD)

Area [2]	MEC [3]	MSD (ft)[1]			
		For Unintentional Detonations		For Intentional Detonations	
		Team Separation Distance (K40)	Hazardous Fragment Distance (HFD)	Without Engineering Controls	Using Sandbag Mitigation
MRS 06					
Land Impact Area	37mm MK II	15	90	982	200
Beach Defensive Area #1 & #2	81mm Mortar	66 [4]	247 [5]	1,579 [6]	200
MRS 08					
Land	75mm MKI HE	47	239	1,873	200
MRS 09					
Aircraft Bombing Target	100lb AN-M30A1 HE	162	413	1,833	N/A [7]
Direct Fire Area	3” Common MK 3 Mod 7	26	126	1,700	200
MRS 10					
Beach Defensive Area	81mm Mortar	66 [4]	247 [5]	1,579 [6]	200
Direct Fire Area	3” Common MK 3 Mod 7	26	126	1,700	200
MRS 11					
Mortar Boat Firing Area	4.2” M3A1 HE	81	316	1,670	200
Beach Defensive Area	81mm Mortar	66 [4]	247 [5]	1,579 [6]	200
Direct Fire Area	3” Common MK 3 Mod 7	26	126	1,700	200

Area [2]	MEC [3]	MSD (ft)[1]			
		For Unintentional Detonations		For Intentional Detonations	
		Team Separation Distance (K40)	Hazardou s Fragment Distance (HFD)	Without Engineering Controls	Using Sandbag Mitigation
MRS 13					
Northern Impact Area	75mm MKI HE	47	239	1,873	200
Land	5" MK 41	74	359	2,377	220

Notes:

1. See Appendix B for calculation sheets with documentation of MSD.

2. See Appendix A for Maps of the MSD for each MRS.

3. Historical records and reports provided by the USACE provide the information for the MEC items located in each MRS and the Area within each MRS that specific MEC items are expected to be located.

4. The K40 for the 81mm mortar is based on the M45 version.

5. The HFD for the 81mm mortar is based on the M362A1 version.

6. The MFD-H for the 81mm mortar is based on the M43 version.

7. Mitigation used for the 100lb AN-M30A1 HE bomb will be Buried Explosion Module; to be calculated when item is found.

Personnel will be permitted to re-enter the area only after the demolition point has been inspected and the “all clear" has been given by the SUXOS.

The residential development in MRS 10 and 11, along with the City of Dewey, requires the use of engineering controls during the performance of the RI/FS and coordination of local officials to characterize the areas to the north and south of the city. (See Appendix A, Figures 15 through 22.)

Until Rights of Entry (ROE) are obtained, it is unknown how close buildings/residents will be located to possible transect or grid locations.

Figure 7-1: Site of Type II Magazine

7.2 STORAGE MAGAZINE FOR DEMOLITION EXPLOSIVES

- Explosives will be stored in an ATF Type II magazine with an attached cap magazine. The magazine location is shown on the map in Figure 28, located in Appendix A. (18 degrees 20"04.56"N; 65 degrees 19"26.79"W)
- The magazine location chosen for this effort is located at the end of a desolate dirt road (See Figure 3-1). It has controlled access. There are dual gates, one at the entrance to the magazine location, and one at the magazine location. All gates are to be locked at all times when not under supervision. There is a fence that restricts access to the entire Northwest Peninsula, and the magazine is located within the restricted area. The magazine will be placed on the ground and grounding/lightning protection and a fence will be provided in accordance with EM 1110-1-4009, NFPA 780.
- Commercial explosives being stored will have assigned DOD hazard division/storage compatibility groups (HD/SCG) and will be stored in accordance with DOD 6055.09-M, DA Pam 385-64 and any local regulations.
- The magazine will be positioned in accordance with EP 1110-1-18 and Section 55.206 of ATFP 5400.7, Alcohol, Tobacco, and Firearms (ATF) Explosives Law and Regulations. The magazine complies with Commonwealth of Puerto Rico laws for 10-ft fence and a 24/7 security guard will be in place while explosives are stored. Warning signs will be posted in accordance with local rules and regulations.
- Table 7-3 lists typical donor explosives and quantities required for this type of project. The total net explosive weight (NEW) stored in the magazine will not exceed the approved amount of 31 lb.
- Commercial explosives will have assigned DoD hazard division/storage compatibility groups (HD/SCG) and will be stored in accordance with DoD 6055.09-M and DA Pam 385-64.
- DoD 6055.09-M, Table V3.E2.T2 lists the inhabited building distance (IBD) for a NEW of 31 pounds as 200 ft for magazines that are not earth-covered. The traffic in the area is less than 400 car/rail passengers per day, and less than 80 ship passengers per day. Therefore, no Minimum Fragment Distance (MFD) is required for public traffic route (PTR) distance (DA PAM 385-64 Section 5-5, and DoD 6055.09-M Section V3.E3.1.2.1.1.5.3).
- The magazine is owned by USA Environmental, Inc., and will be rented to Explosive Ordnance Technologies, Inc. (EOTI) for their use. This magazine has been approved/sited by DDESB on 10/15/10 IAW DDESB. A Standard Operating Procedure is in place for accountability and security issues between the two contractors.

Table 7-3: Typical Explosives and Quantities for RI/FS

Type of Explosive	Descriptions	Quantity
Electric Caps	Rock Start Detonators	100 ea
Detonating Cord	80 Grain	1 roll
Perforators	19.5 gram Shaped Charges	50 ea

8.0 METHODS OF DISPOSAL

All explosive operations will follow the procedures outlined in TM 60A-1-1-31 and EM 385-1-97, Explosives Safety and Health Requirements Manual. All personnel involved in disposal of MEC meet the requirements set forth in DDESB Technical Paper (TP) 18; Dive Team personnel will consist of qualified UXO Technicians III and II who are also qualified as US Navy Divers.

8.1 LAND DISPOSAL

In-Place Destruction. USA will destroy in place all MEC that is identified determined **unacceptable** to move by both the SUXOS and USOSO combined; this method is commonly known as blow in place (BIP). The USA SUXOS and UXOSO will follow the procedures in the WP and this ESP for Evacuation and Site Control; Fragmentation Distance; Blow-in-Place Procedures; and Operations in Populated/Sensitive Areas when destroying MEC in place. When this technique is employed, engineering controls may be used to minimize the blast and fragmentation effects.

On-Site Destruction. USA will use the on-site destruction method to move MEC items that are identified acceptable to move by the SUXOS and USOSO combined, to a central location for destruction within the same MRS or beach. Procedures in the WP and this ESP for Evacuation and Site Control, Fragmentation Distances, and Operations in Populated/Sensitive Areas will be followed. When this technique is employed, engineering controls may be used to minimize the blast effects.

Any occupied buildings or public roadways/waterways in the MSD areas during MEC operations will be evacuated and/or roadways/waterways blocked to prevent non-essential personnel from entering during the conduct of MEC operations.

Sandbags (HNC-ED-CS-S-98-7, HNC Safety Advisory dated 12 July 2010, and the DDESB Memorandum "Clarifications Regarding Use of Sandbags for Mitigation of Fragmentation and Blast Effects due to Intentional Detonation of Munitions", Nov. 29 2010) may be used to reduce the intentional detonation MSD as shown in Table 7-1. Tamping (single or multiple items) may be used in accordance with DDESB Technical Paper 16 and the Buried Explosion Module (BEM). If a MEC item is found that is not in the Fragmentation Database, Sandbag Mitigation will not be used without a munition-specific calculation. These reports and advisories will be available on site for all mitigation methods used.

MPPEH. All Material Potentially Presenting an Explosive Hazard (MPPEH) and MD will be inspected, certified, verified and disposed of in accordance with DOD Instruction 4140.62, *Management and Disposition of MPPEH* and EM 1110-1-4009, *Military Munitions Response Actions* and Errata Sheet No. 2. This inspection will be certified and verified on DD Form 1348-1 as follows:

"All Material Potentially Presenting an Explosive Hazard (MPPEH) will be assessed and its explosives safety status determined and documented prior to transfer within the DoD or release from DoD control. Prior to release to the public, MPPEH will be documented by authorized and technically qualified personnel as Material Documented as Safe (MDAS) after a 100% inspection and an independent 100% re-inspection to determine that it is safe from an explosives safety perspective.."

Collection Points: Collection points are those areas used to temporarily accumulate MEC pending destruction at the end of the day using consolidated shots. MEC items at collection points must be laid out as shown in "Procedures for Demolition of Multiple Rounds (Consolidated Shots) on Ordnance and Explosives (OE) Sites". The maximum net explosive weight (NEW) at a collection point will be limited such that the K40 overpressure distance for the total NEW does not exceed the HFD for the area. Consolidating multiple MEC is not anticipated for this project.

Consolidating Multiple MEC: Consolidating multiple MEC is anticipated for this project. The USAESCH publication, "Procedures for Demolition of Multiple Rounds (Consolidated Shots) on Ordnance and Explosive (OE) Sites." dated March 2000, will be used and a copy of this report will be available on site. The maximum NEW for a consolidated shot will be limited such that the K328 overpressure distance for the total NEW (including donor charges) does not exceed the MSD for the intentional detonation.

9.0 MAPS

See Appendix A for maps:

Location Map	Figure 1	
RI/FS MRS Locations	Figure 2	
MRS 06 Site Map	Figure 3	
Beach Defensive Area 1 & 2	Figure 4	Q-D Arcs
Artillery Firing Area Land Impact Area	Figure 5	Q-D Arcs
MRS 08 Site Map	Figure 6	
Land Impact Area	Figure 7	Q-D Arcs
MRS 09 Site Map	Figure 8	
Soladado Point Direct Fire Area	Figure 9	Q-D Arcs
Aircraft Bombing Target	Figure 10	Q-D Arcs
MRS 10 Site Map	Figure 11	
Beach Defensive Area	Figure 12	Q-D Arcs
Direct Fire Area	Figure 13	Q-D Arcs
MRS 11 Site Map	Figure 14	
Mortar Boat Firing Area	Figure 15	Q-D Arcs
Beach Defensive Area	Figure 16	Q-D Arcs
Direct Fire Area	Figure 17	Q-D Arcs
MRS 13 Site Map	Figure 18	
Northern Impact Area	Figure 19	Q-D Arcs
Land Areas (Impact)	Figure 20	Q-D Arcs
Magazine	Figure 21	Q-D Arcs

See Appendix B for Fragmentation Calculation Sheets

APPENDIX A. MAPS

This appendix contains the following maps:

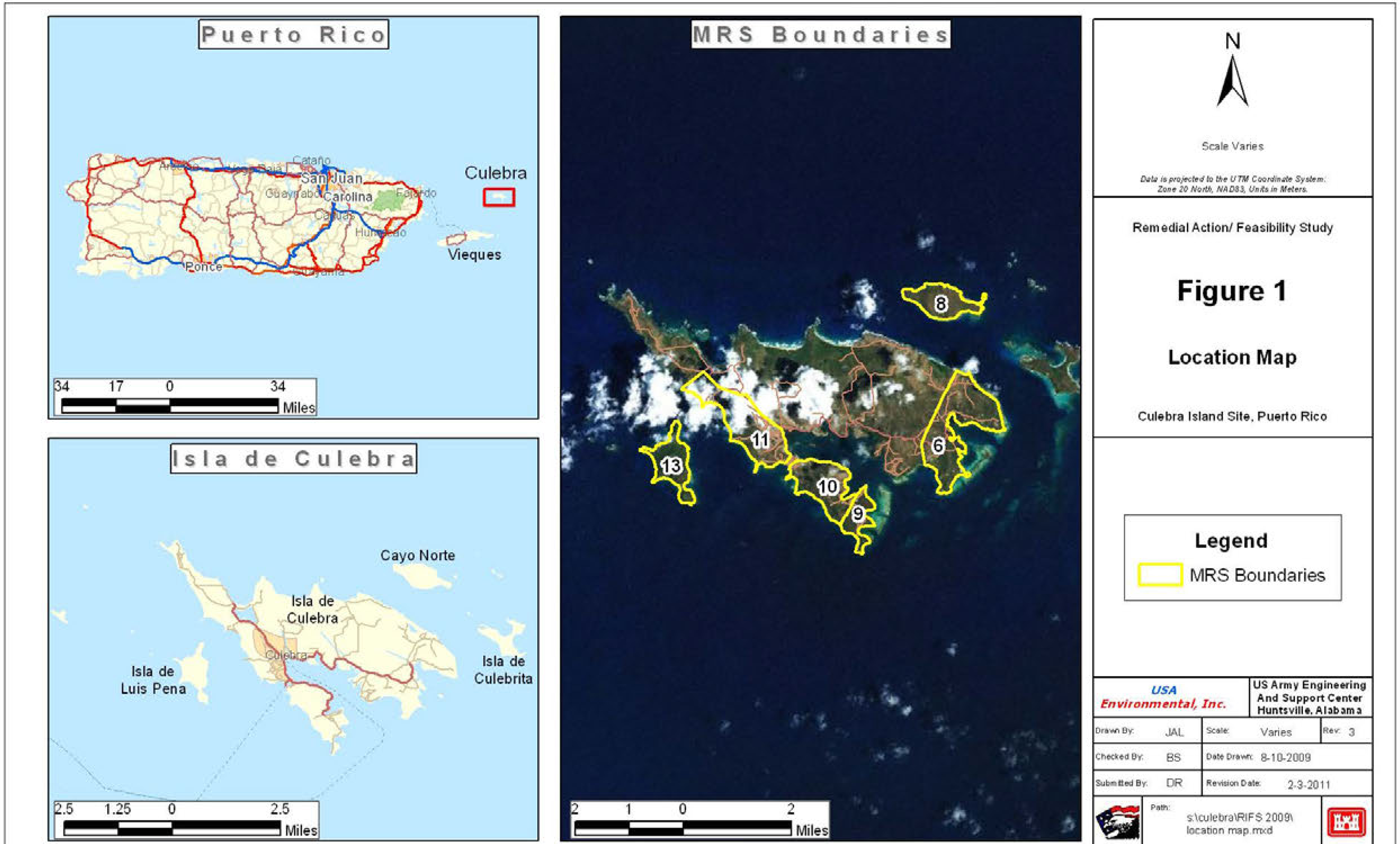

Figure 1: Location Map

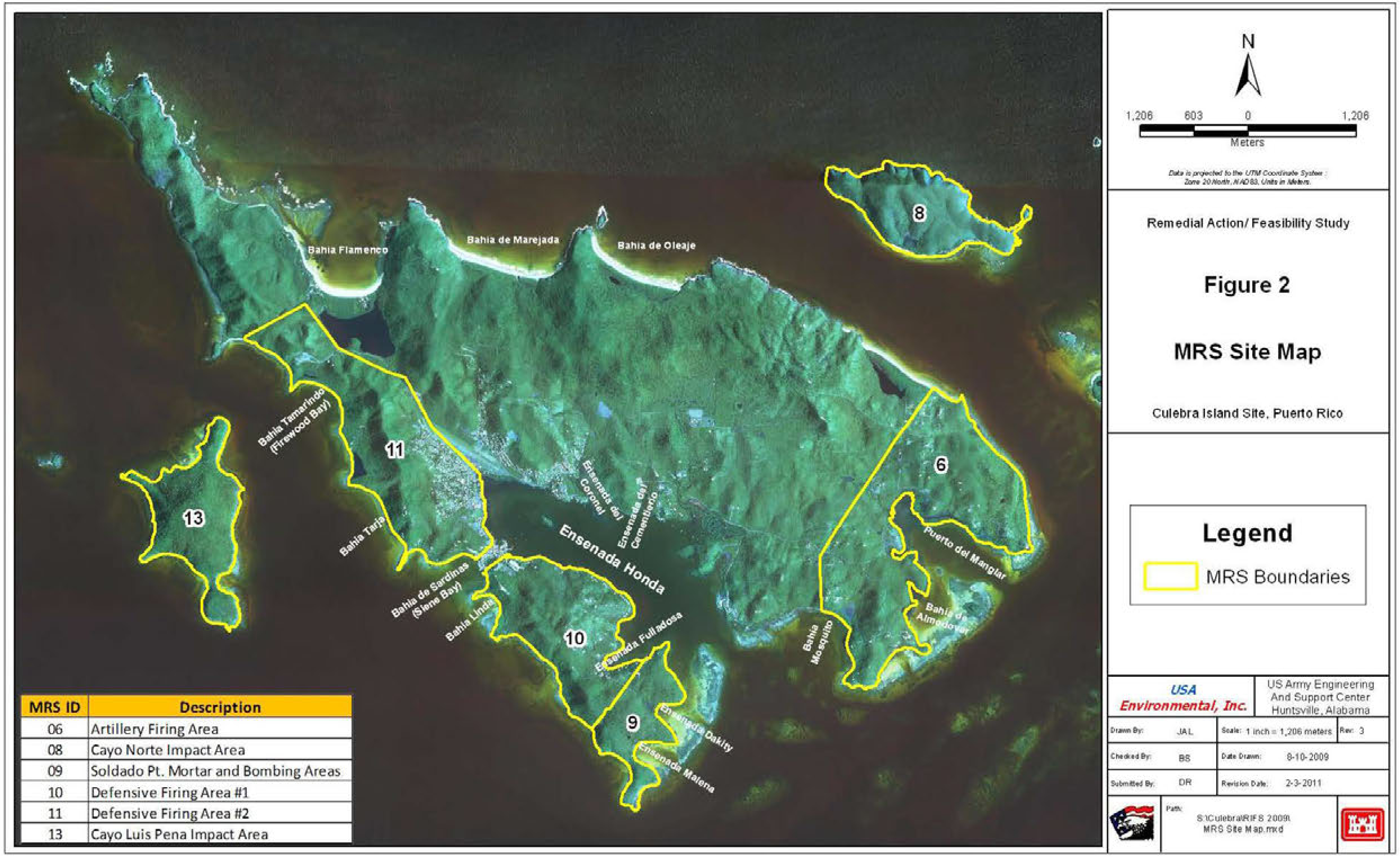

Figure 2: MRS Site Map

Figure 3: MRS 6 – Artillery Firing Area Site Map

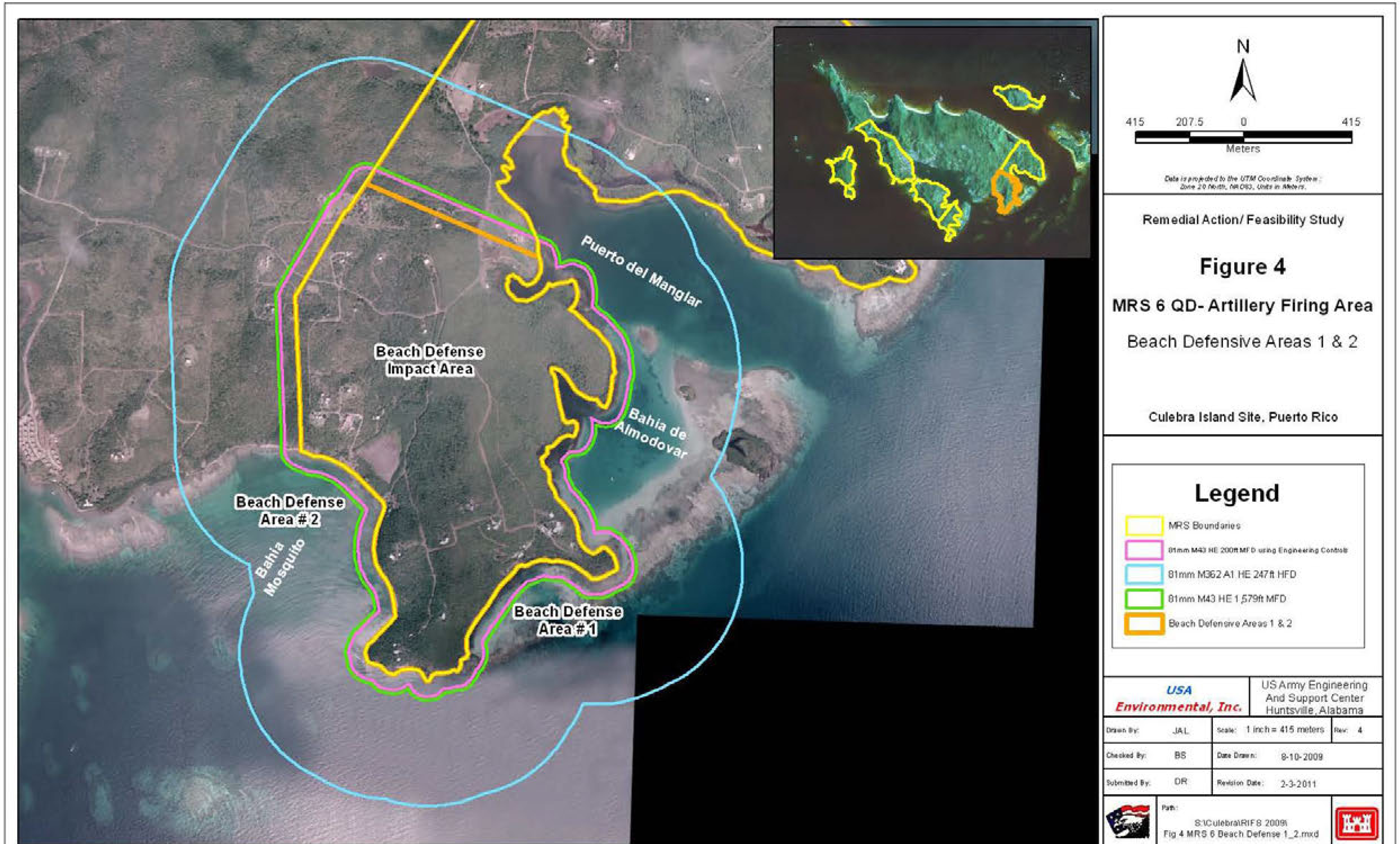

Figure 4: MRS 6 QD -- Artillery Firing Area Beach Defensive Areas 1 & 2

Figure 5: MRS 6 QD – Artillery Firing Area Land Impact Area

Figure 6: MRS 8 – Cayo Norte Impact Area Site Map

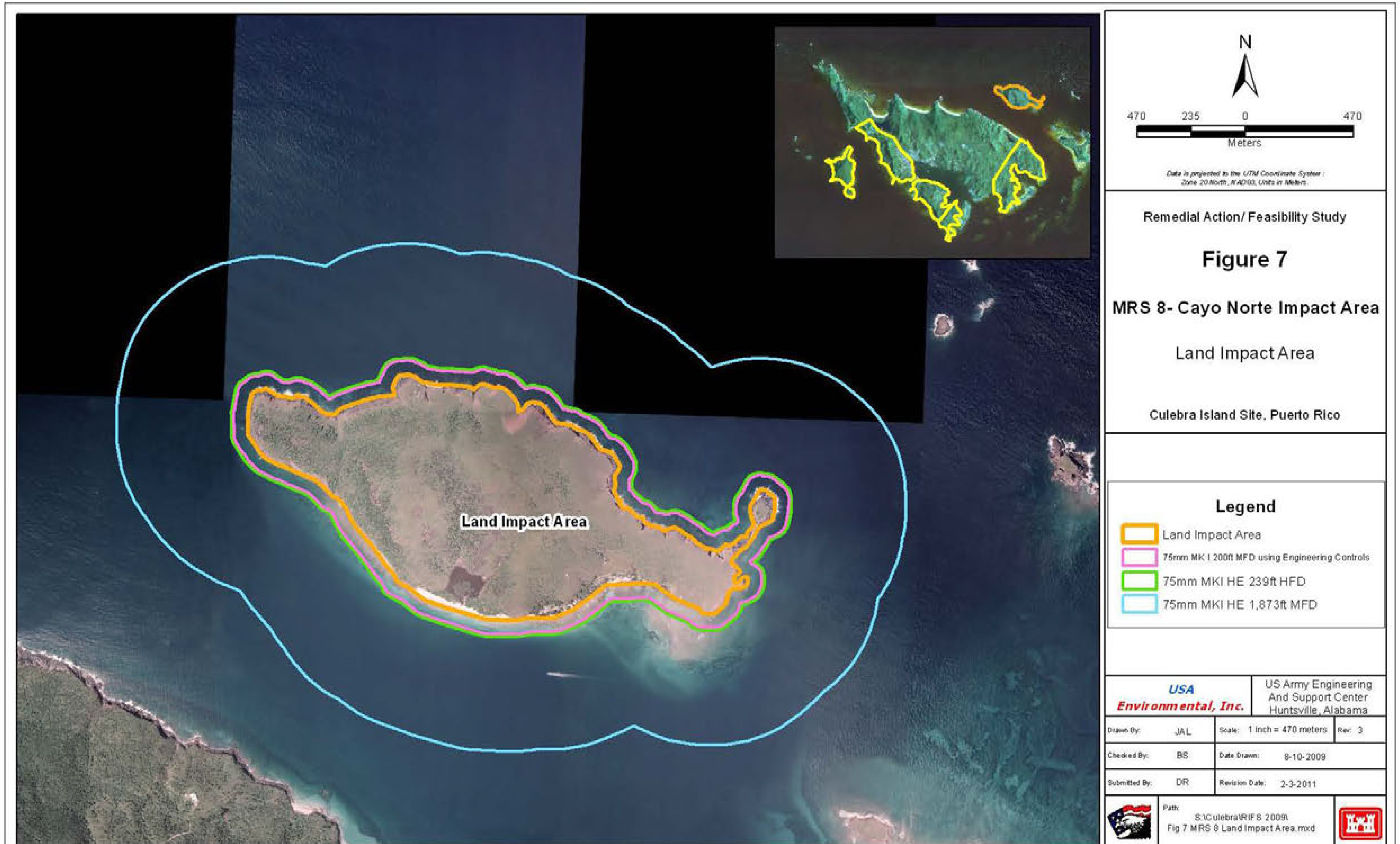

Figure 7: MRS 8 – Cayo Norte Impact Area Land Impact Area

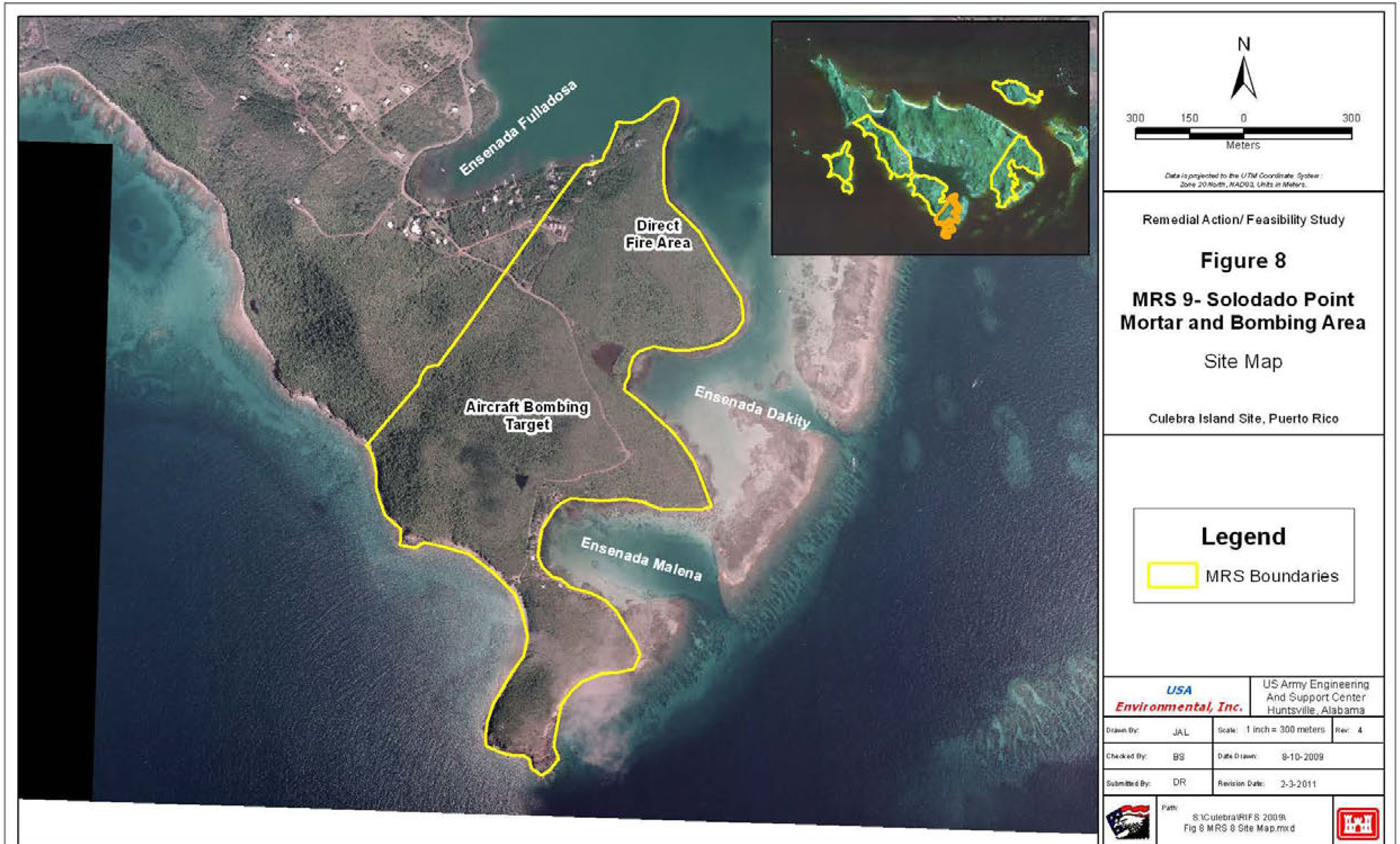

Figure 8: MRS 9 – Solodado Point Mortar and Bombing Area Site Map

Figure 9: MRS 9 – Solodado Point Mortar and Bombing Area Direct Fire Area

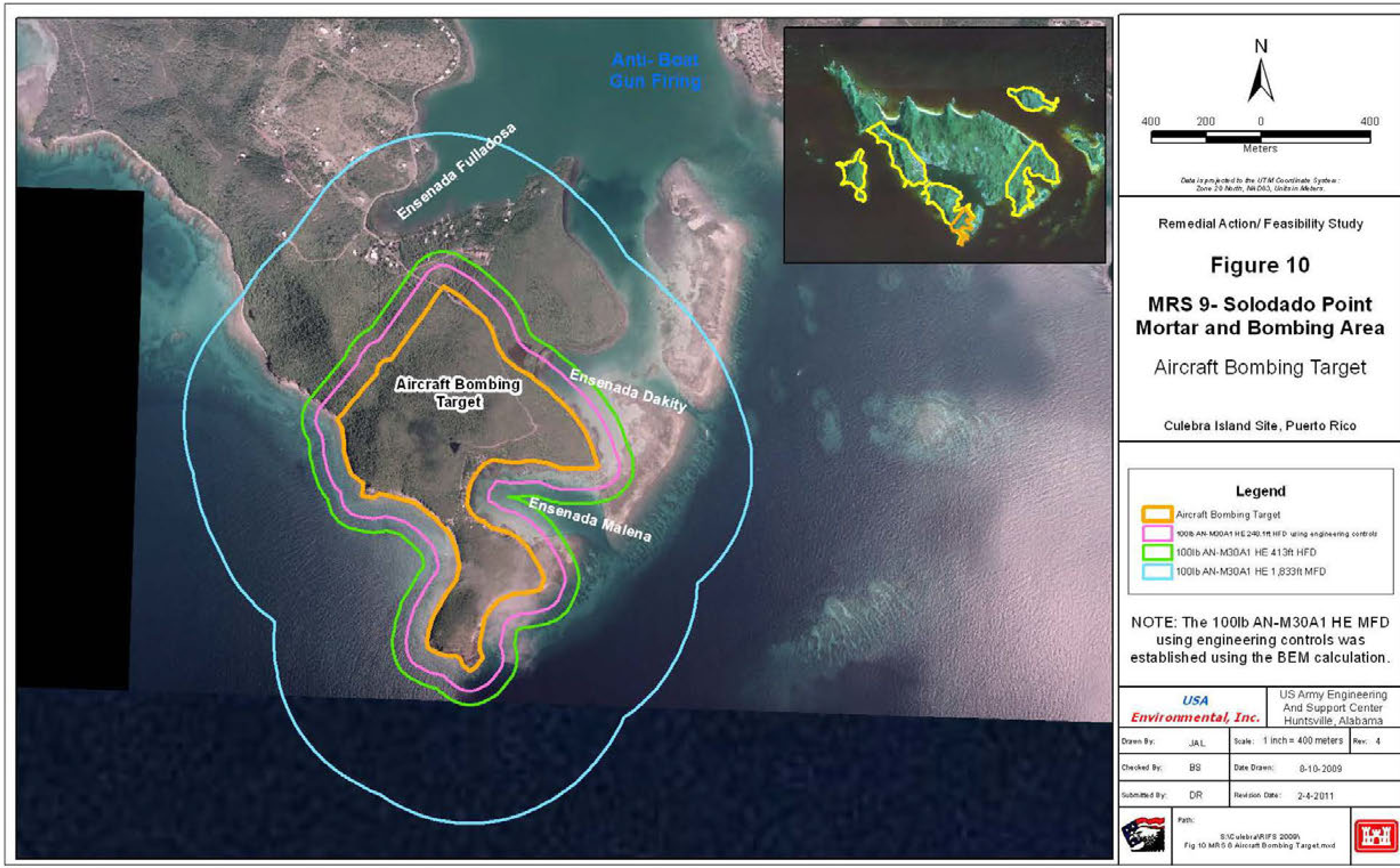

Figure 10: MRS 9 – Solodado Point Mortar and Bombing Area Aircraft Bombing Target

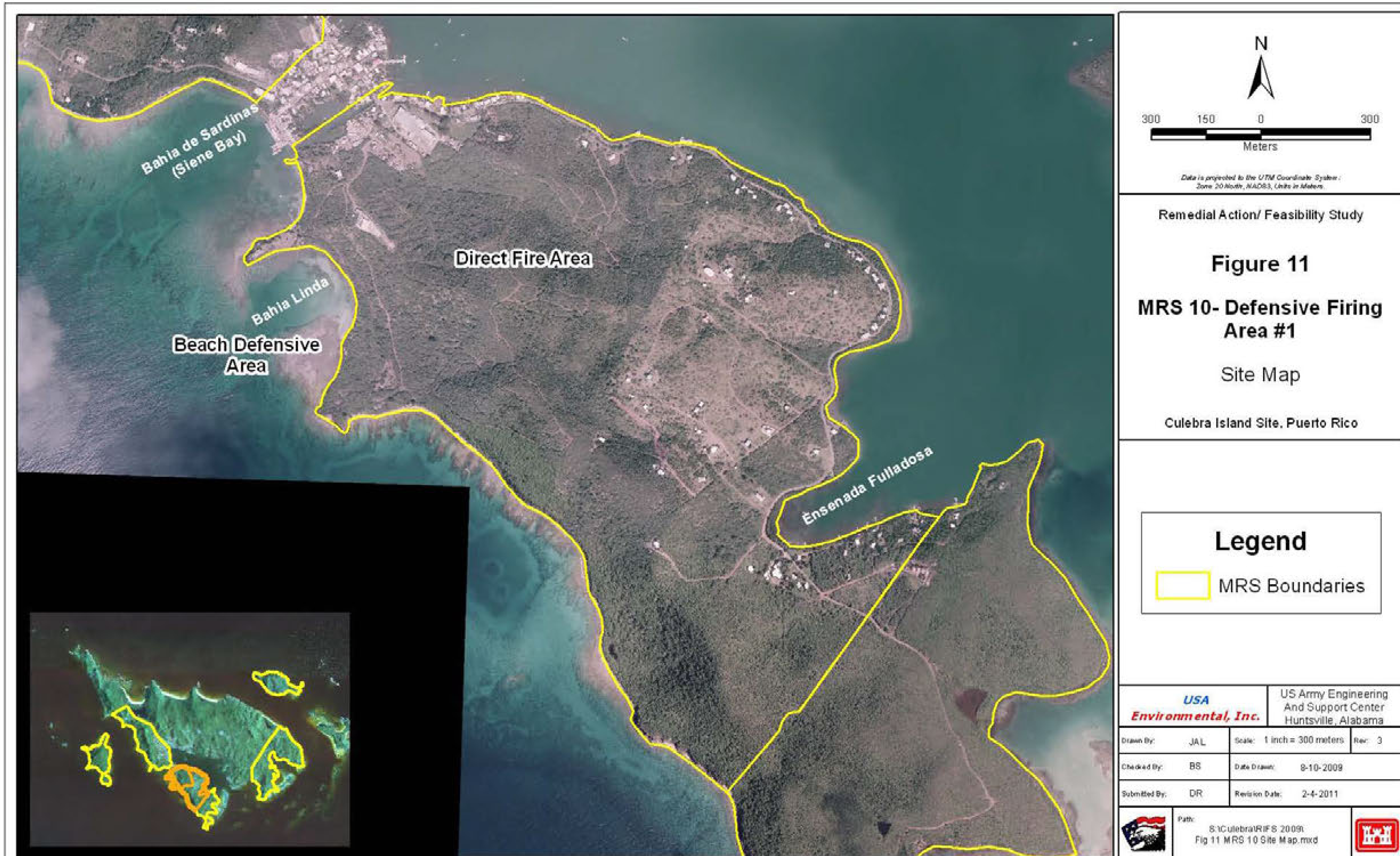

Figure 11: MRS 10 – Defensive Firing Area #1 Site Map

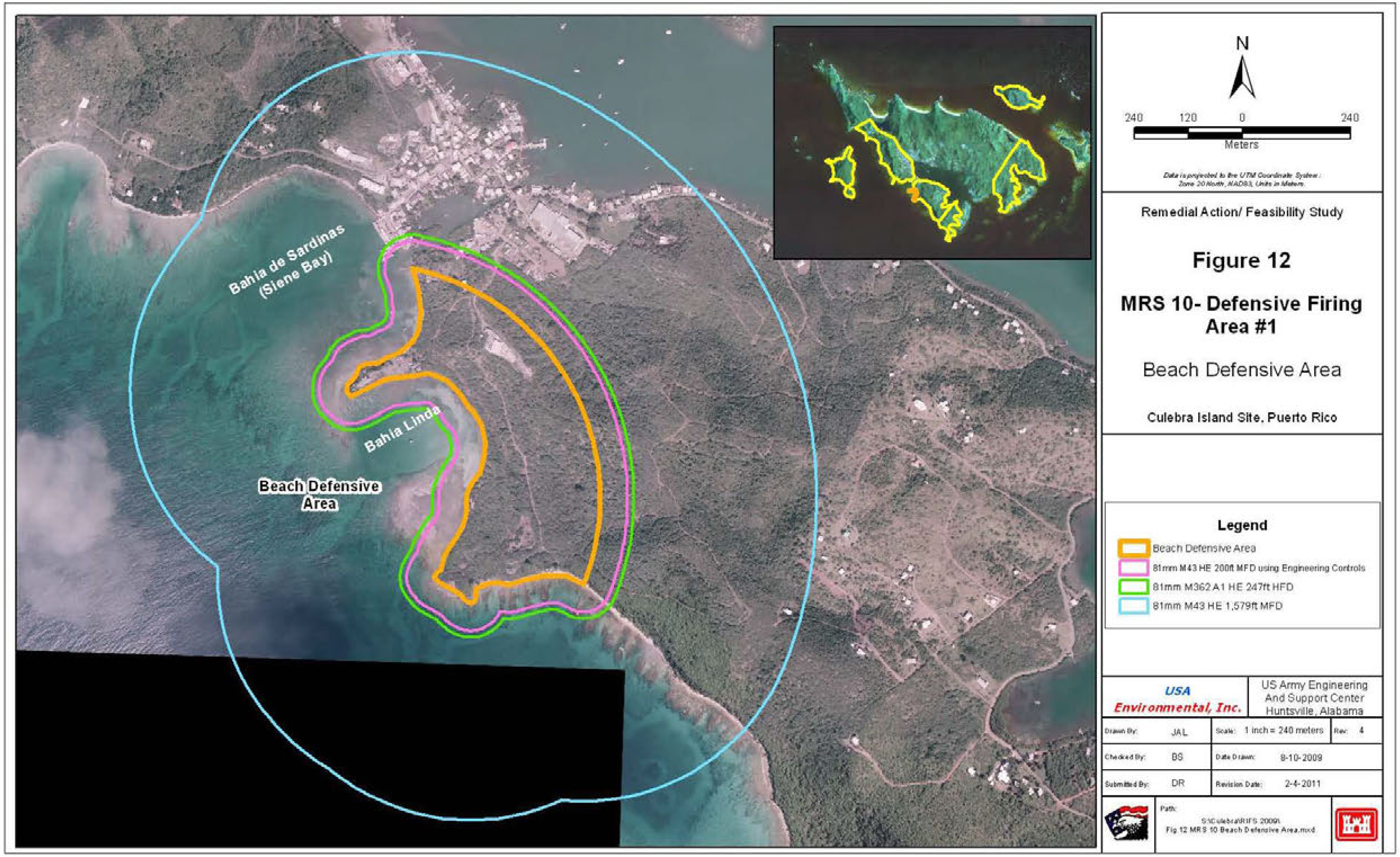

Figure 12: MRS 10 – Defensive Firing Area #1 Beach Defensive Area

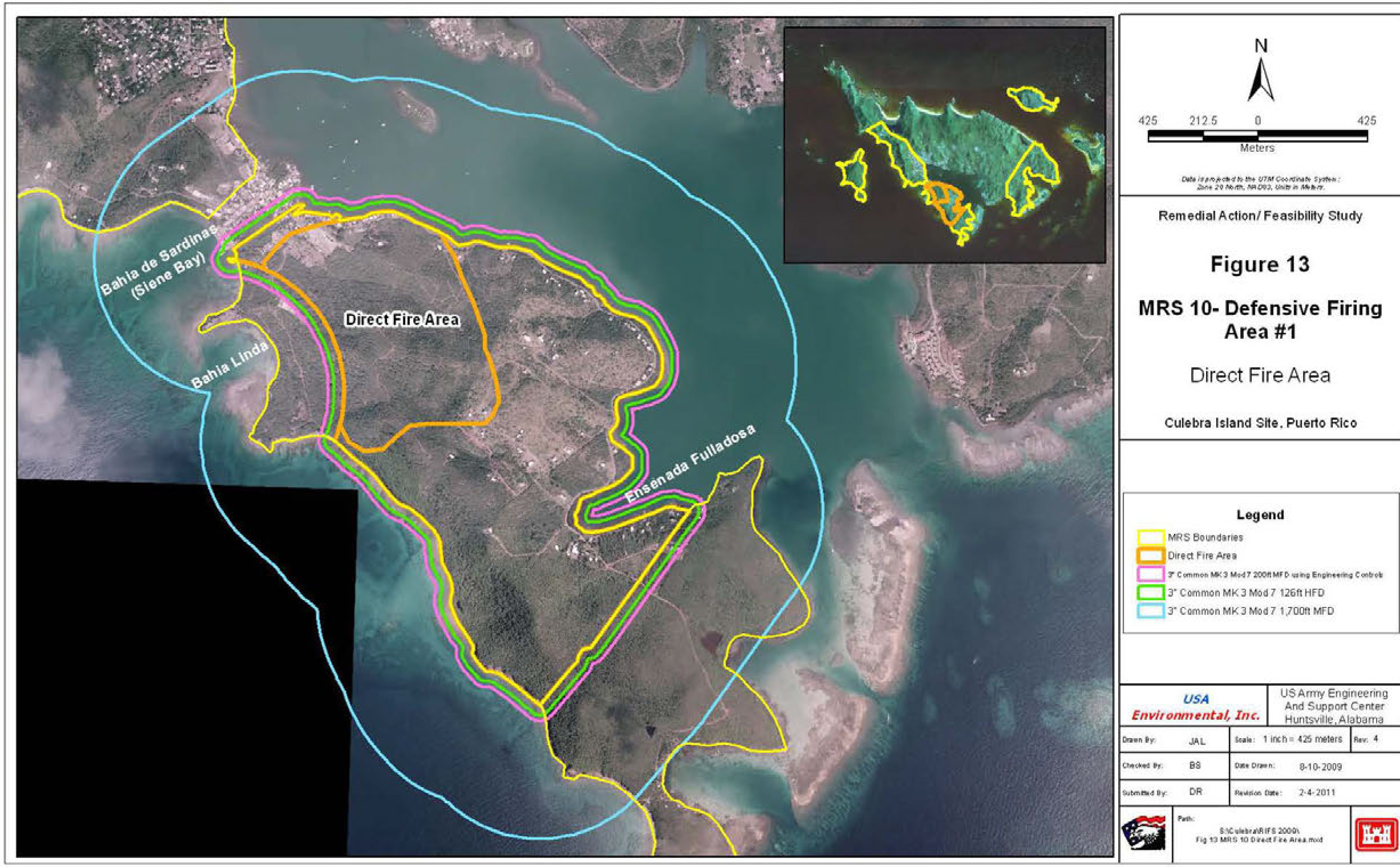

Figure 13: MRS 10 – Defensive Firing Area #1 Direct Fire Area

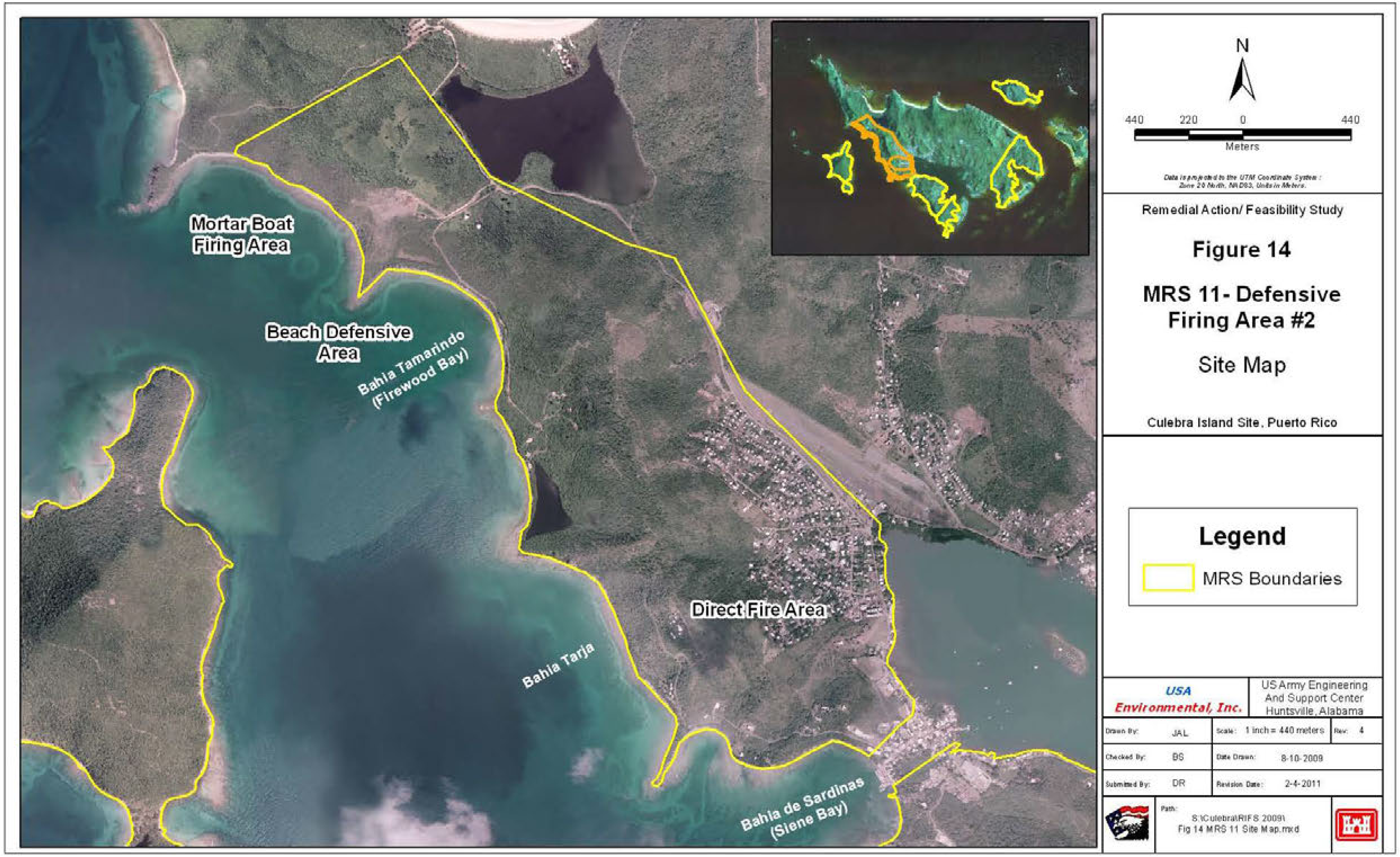

Figure 14: MRS 11 – Defensive Firing Area #2 Site Map

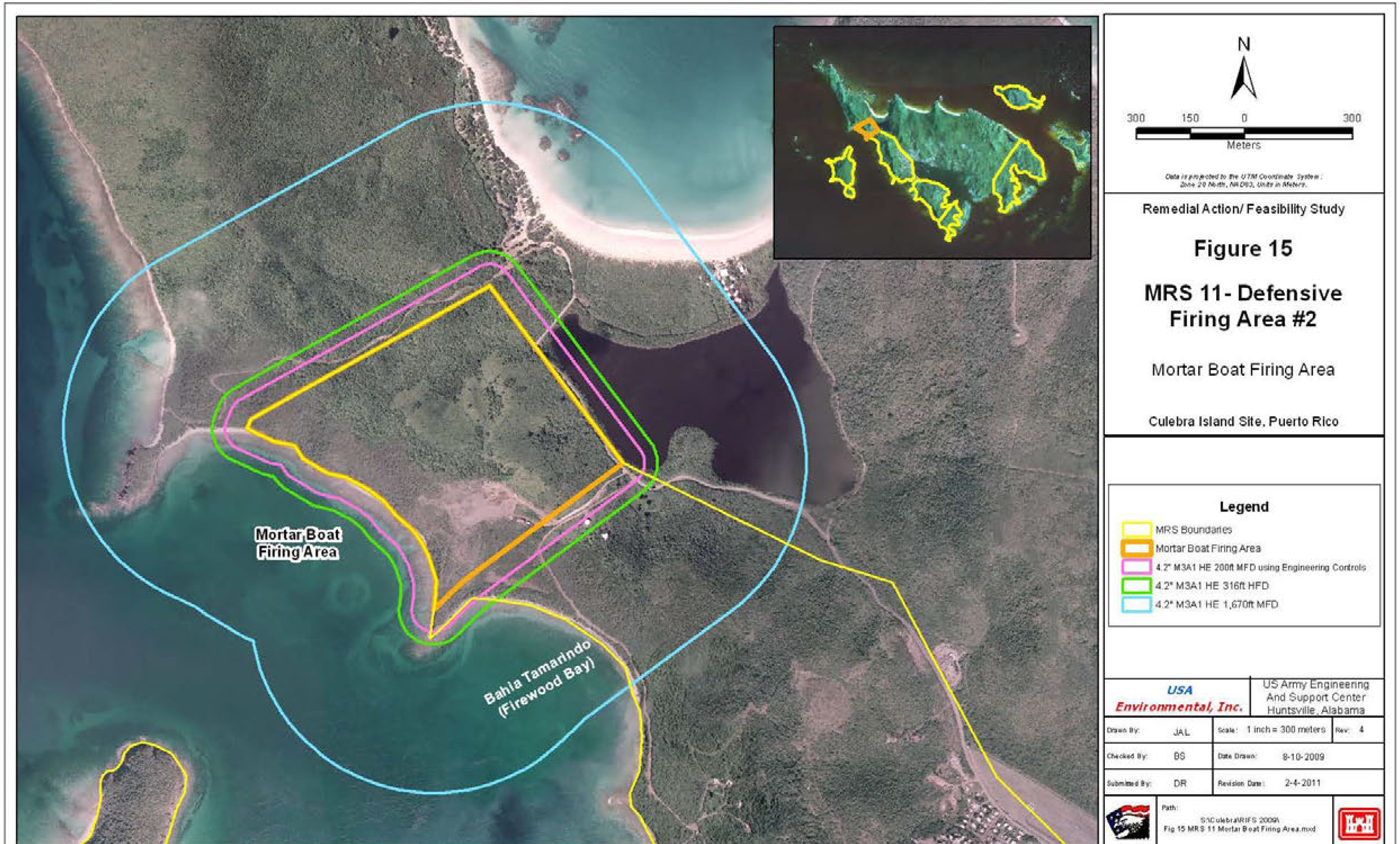

Figure 15: MRS 11 – Defensive Firing Area #2 Mortar Boat Firing Area

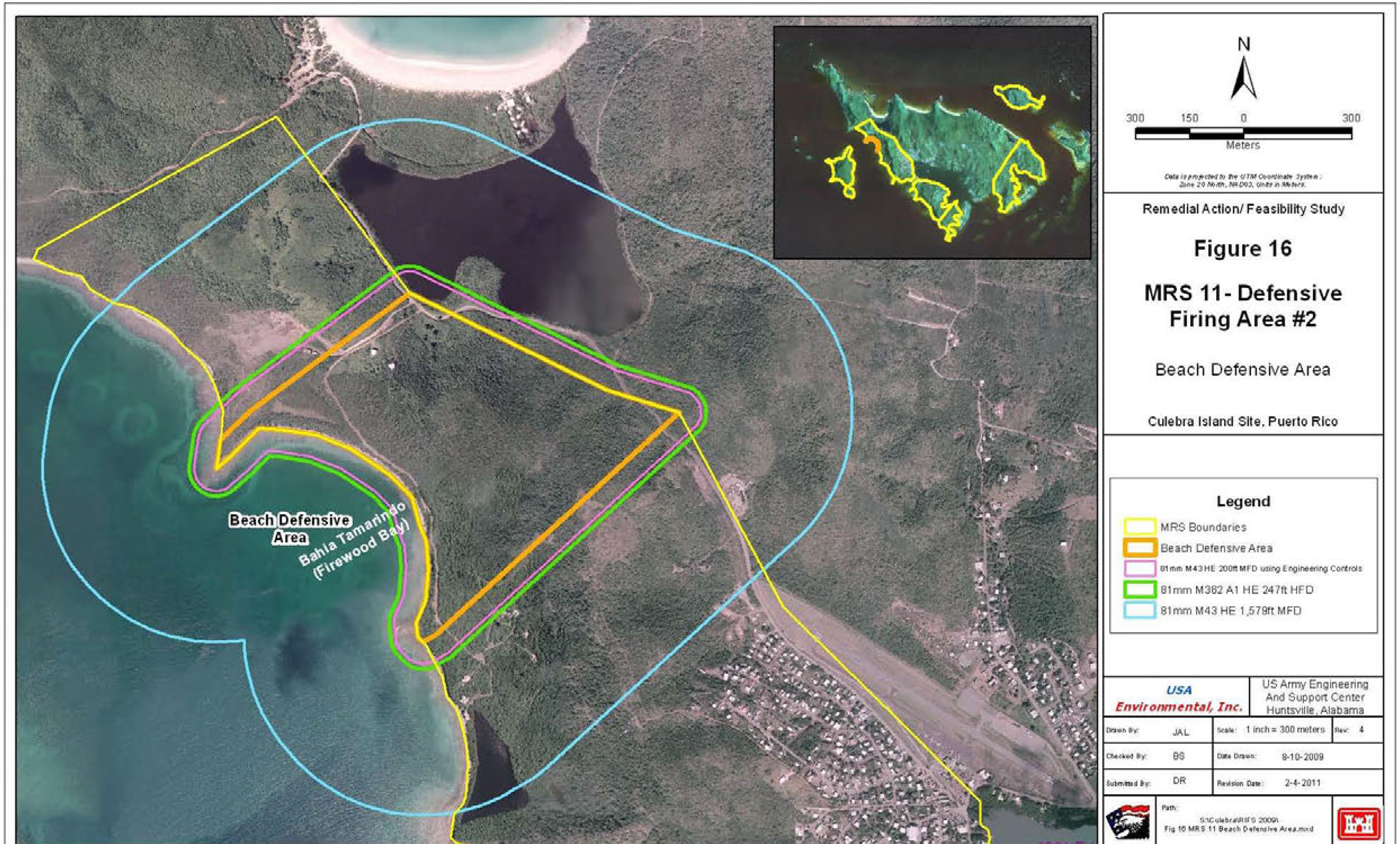

Figure 16: MRS 11 – Defensive Firing Area #2 Beach Defensive Area

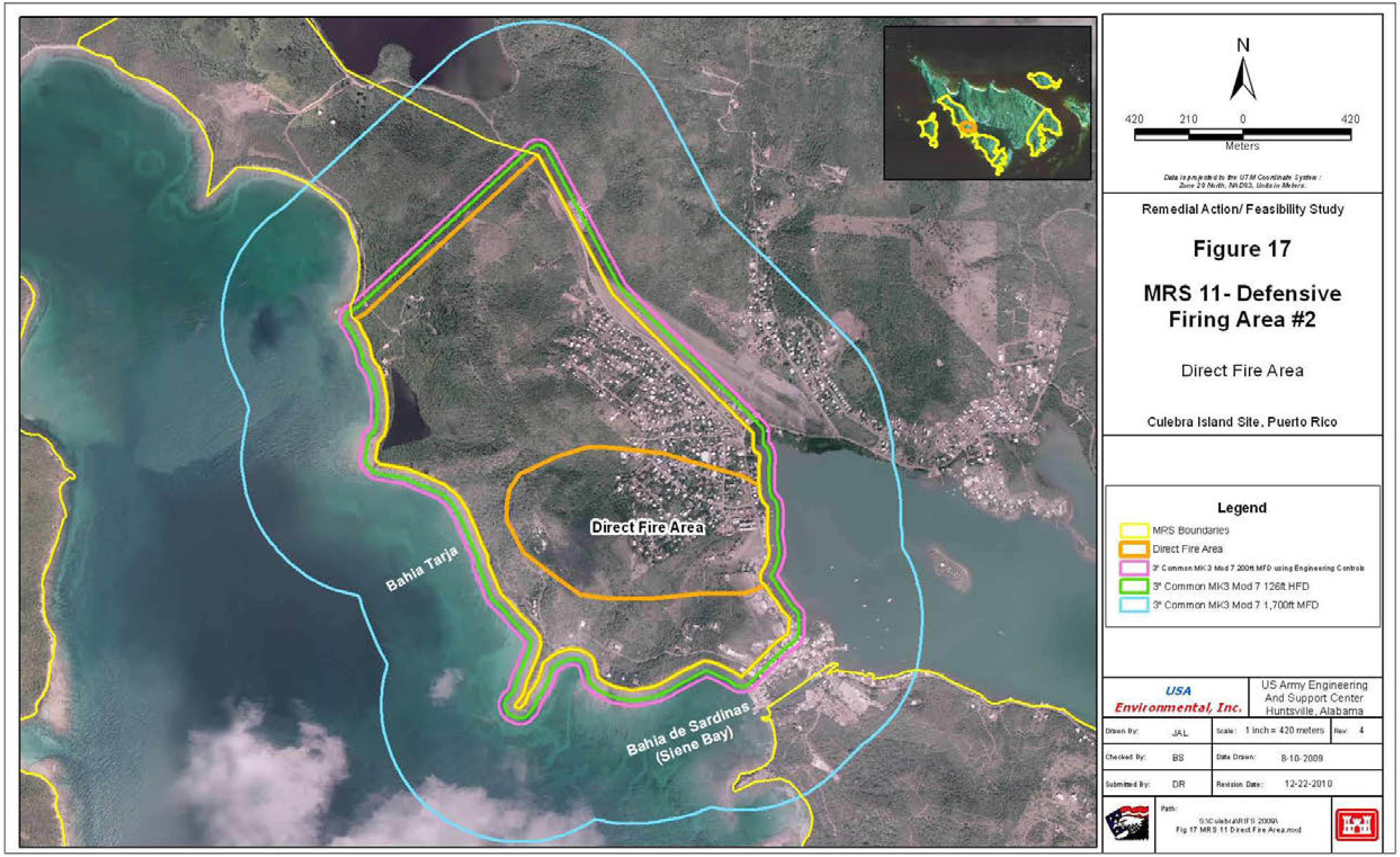

Figure 17: MRS 11 – Defensive Firing Area #2 Direct Fire Area

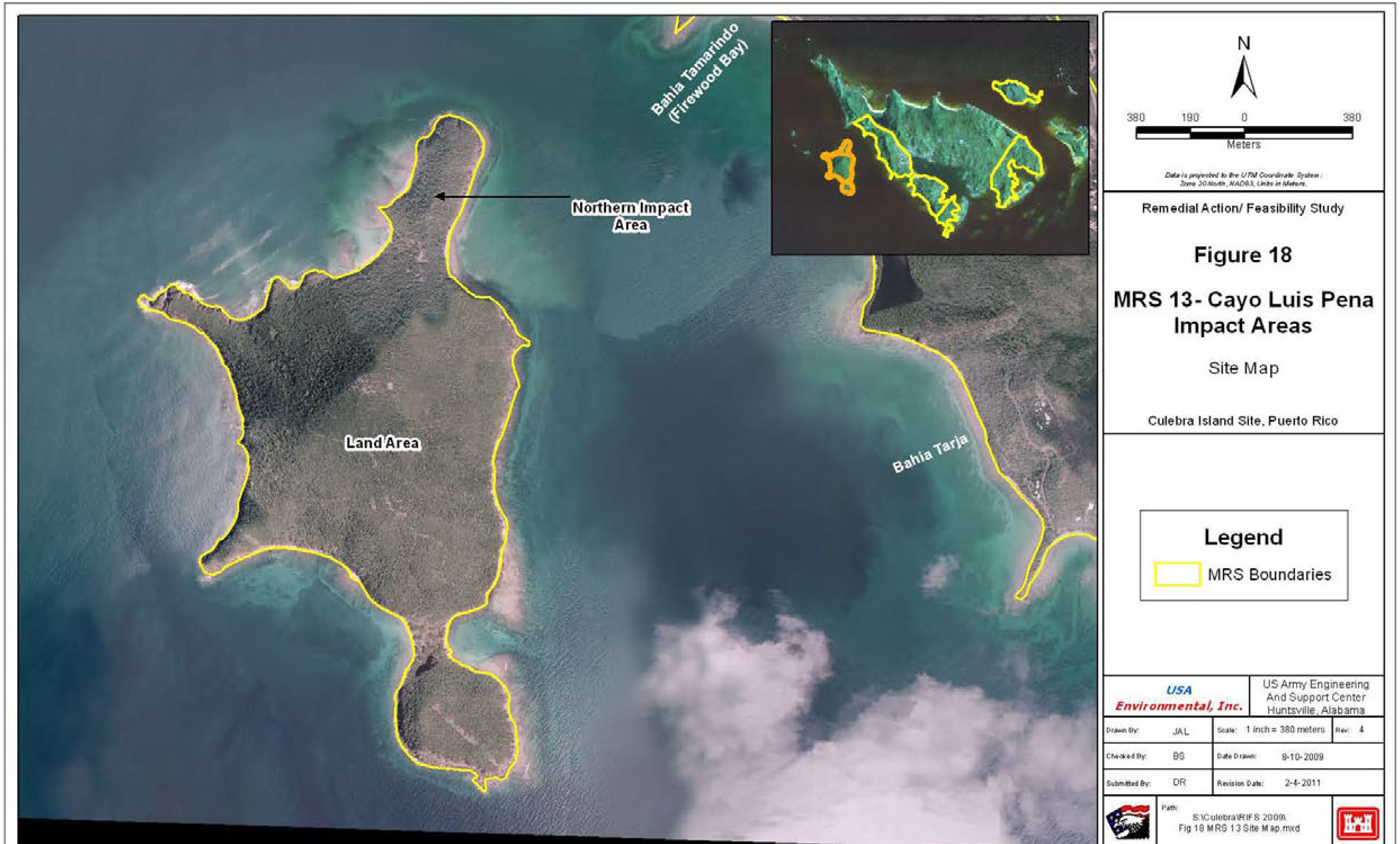

Figure 18: MRS 13 – Cayo Luis Pena Impact Areas Site Map

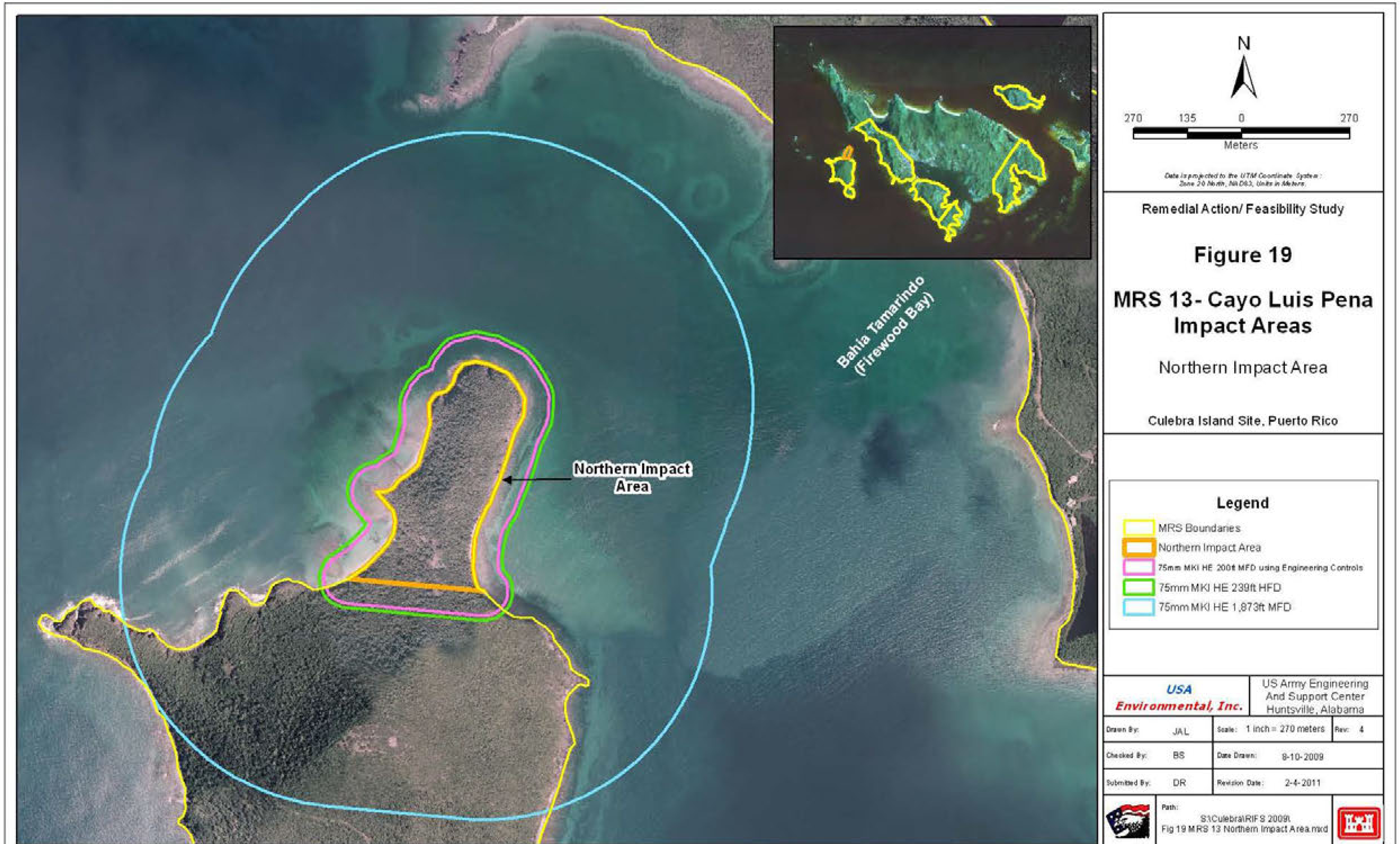

Figure 19: MRS 13 – Cayo Luis Pena Impact Areas

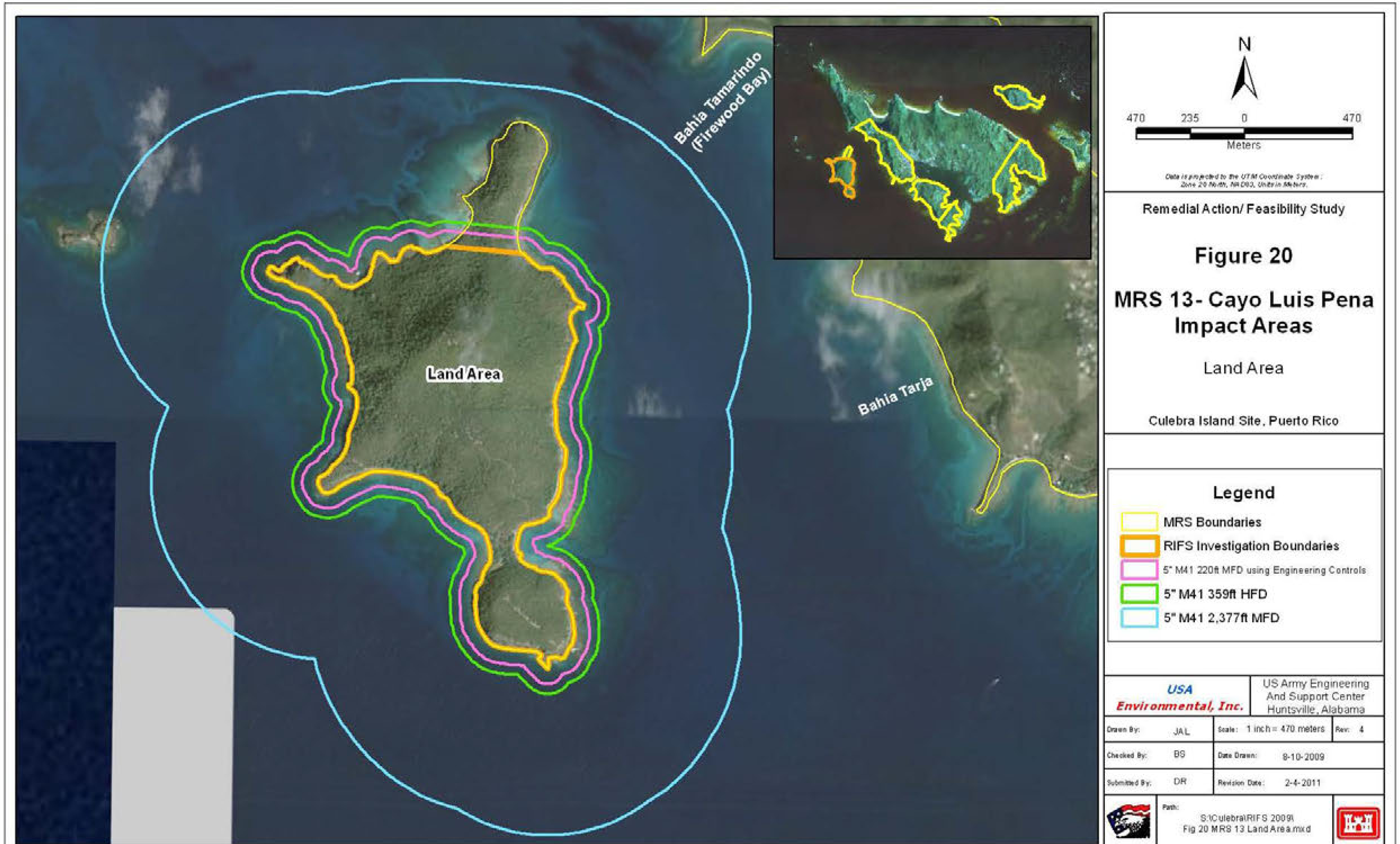

Figure 20: MRS 13 – Cayo Luis Pena Impact Areas Land Area

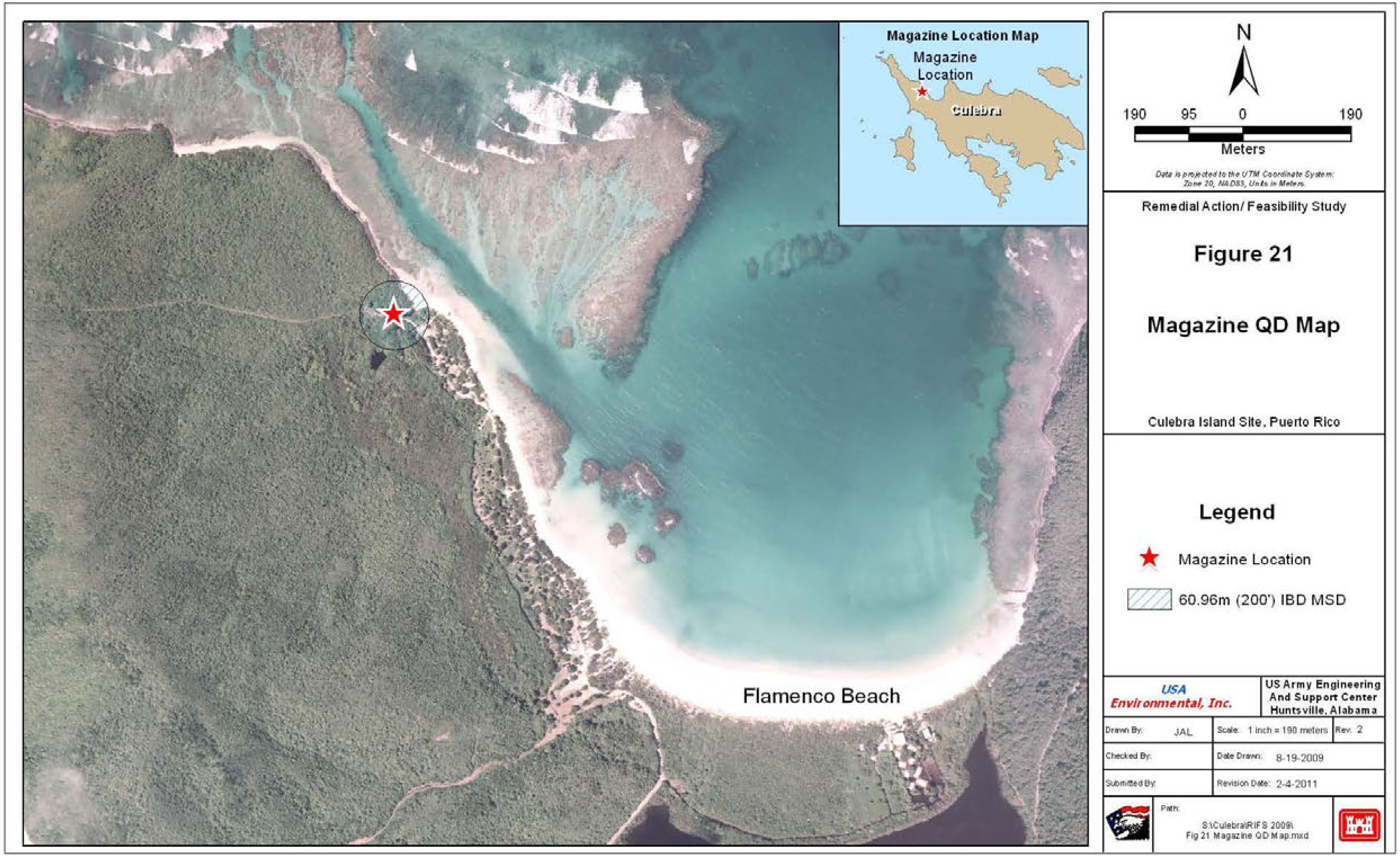

Figure 21: Magazine QD Map

APPENDIX B. FRAGMENTATION CALCULATION SHEETS

This appendix contains the following Fragmentation Calculation Sheets:

- 75mm projectile, MKI
- 4.2" M3A1
- 100lb bomb, AN-M30A1
- 37mm projectile, MK II
- 81mm mortar, M45
- 81mm mortar, M362A1
- 81mm mortar, M43
- 3" Common projectile, MK 3 Mod 7
- 5" projectile MK 41

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Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds	DODIC:	
Munition:	75 mm HE Mk I	Date Record Created:	9/21/2004
Case Material:	Steel, Mild	Record Created By:	MC
Fragmentation Method:	Naturally Fragmenting	Last Date Record Updated:	3/8/2010
Secondary Database Category:	Projectile	Individual Last Updated Record:	SDH
Munition Case Classification:	Robust	Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	1.64
Diameter (in):	2.9528
Maximum Fragment Weight (Intentional) (lb):	0.2135
Design Fragment Weight (95%) (Unintentional) (lb):	0.0392
Critical Fragment Velocity (fps):	3468

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	1.640
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	21
Public Traffic Route Distance (2.3 psi); K24 Distance:	28
Inhabited Building Distance (1.2 psi), K40 Distance:	47
Intentional MSD (0.0655 psi), K328 Distance:	387

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	1.640
Kinetic Energy 10^6 (lb-ft²/s²):	1.2839
Required Wall & Roof Sandbag Thickness (in)	24
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	239
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1873
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1425

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	7.22	3.71
Mild Steel:	1.40	0.72
Hard Steel:	1.15	0.59
Aluminum:	2.77	1.47
LEXAN:	7.36	4.86
Plexi-glass:	5.75	3.32
Bullet Resist Glass:	5.02	2.73

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	1.640
Kinetic Energy 106 (lb-ft²/s²):	1.2839
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
DODIC:	
Munition:	4.2 in M3A1
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Robust
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	2/16/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	8.17
Diameter (in):	4.2000
Maximum Fragment Weight (Intentional) (lb):	0.0864
Design Fragment Weight (95%) (Unintentional) (lb):	0.0119
Critical Fragment Velocity (fps):	6538

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	8.170
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	36
Public Traffic Route Distance (2.3 psi); K24 Distance:	48
Inhabited Building Distance (1.2 psi), K40 Distance:	81
Intentional MSD (0.0655 psi), K328 Distance:	661

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	8.170
Kinetic Energy 10^6 (lb-ft²/s²):	1.8466
Required Wall & Roof Sandbag Thickness (in)	24
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	316
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1670
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1326

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	11.03	4.85
Mild Steel:	1.97	0.90
Hard Steel:	1.62	0.74
Aluminum:	3.98	1.90
LEXAN:	8.37	5.15
Plexi-glass:	6.80	3.57
Bullet Resist Glass:	5.87	2.87

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	8.170
Kinetic Energy 106 (lb-ft²/s²):	1.8466
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	275

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Air-Launched HE Rounds
Munition:	100 lb AN-M30A1
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Bomb
Munition Case Classification:	Non-Robust

DODIC:	
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	12/23/2009
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	Tritonal (TNT/Al=80/20)
Explosive Weight (lb):	62
Diameter (in):	8.1800
Maximum Fragment Weight (Intentional) (lb):	0.1001
Design Fragment Weight (95%) (Unintentional) (lb):	0.0106
Critical Fragment Velocity (fps):	8410

Overpressure Distances

TNT Equivalent (Pressure):	1.07
TNT Equivalent Weight - Pressure (lbs):	66.340
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	73
Public Traffic Route Distance (2.3 psi); K24 Distance:	97
Inhabited Building Distance (1.2 psi), K40 Distance:	162
Intentional MSD (0.0655 psi), K328 Distance:	1328

Required Sandbag Thickness

TNT Equivalent (Impulse):	0.9600
TNT Equivalent Weight - Impulse (lbs):	59.520
Kinetic Energy 10^6 (lb-ft²/s²):	3.5399
Required Wall & Roof Sandbag Thickness (in)	N/A
Expected Maximum Sandbag Throw Distance (ft):	N/A
Minimum Separation Distance (ft):	N/A

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	413
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1833
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1469

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	17.09	6.66
Mild Steel:	2.76	1.13
Hard Steel:	2.26	0.93
Aluminum:	5.55	2.41
LEXAN:	9.97	5.76
Plexi-glass:	8.56	4.13
Bullet Resist Glass:	7.50	3.34

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	0.9600
TNT Equivalent Weight - Impulse (lbs):	59.520
Kinetic Energy 106 (lb-ft²/s²):	3.5399
Water Containment System:	N/A
Minimum Separation Distance (ft):	N/A

Item Notes

An example calculation for engineering controls using BEM is shown on the following page. Calculation may change based on conditions.

BURIED EXPLOSION MODULE

(Version 6.2)

Based on DDESB Technical Paper 16 Revision 3, EARTHEX software, and NSWCDD/TR-92/196

(ENGLISH UNITS)

SELECT BURIAL MEDIUM Soil

SELECT SOIL TYPE Dry Sand

(See TP 16, Revision 3 for soil details)

SELECT ITEM DESCRIPTION 100 lb AN-M30A1

ENTER TOTAL NUMBER OF ITEMS	1
ENTER TOTAL WEIGHT OF ALL DONOR CHARGES (lbs)	1.00
SINGLE ITEM NEW (lbs)	62.00
SINGLE ITEM MAXIMUM FRAGMENT WEIGHT (lbs)	0.0997
FRAGMENT WEIGHT USED IN CALCULATIONS (lbs)	0.0997
SINGLE ITEM MAXIMUM FRAGMENT VELOCITY (ft/s)	8,414
FRAGMENT VELOCITY USED IN CALCULATIONS (ft/s)	8,414
TOTAL TNT WEIGHT USED (lbs)	67.34
ENTER DEPTH OF BURIAL (ft)	4.00
ENTER HORIZONTAL RANGE (for pressure calculation) (ft)	600

CRATER OR CAMOUFLET?

CRATER

TRUE CRATER RADIUS (ft)	9.22
MAXIMUM SOIL EJECTA DISTANCE (ft)	472

FRAGMENT EXIT VELOCITY (ft/s)	105.6	FRAGMENT LAUNCH ANGLE (°)	23.5

MAXIMUM FRAGMENT DISTANCE (ft) 248.1

*Distance at which pressure is 0.066 psi=

Open Air Withdrawal Distance, K328 (ft): 1,334.4

Blast Withdrawal Distance (buried/undex) (ft)*		351.5
Fragment Hazard Distance (ft)		471.9
Pressure at Fragment Hazard Distance	(psi)	0.0469
	(dB)	144.2
Pressure at Range Entered	(psi)	0.0357
	(dB)	141.8

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
DODIC:	
Munition:	37 mm Mk II
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Projectile
Munition Case Classification:	Extremely Heavy Case
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	1/11/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	0.053
Diameter (in):	1.4567
Maximum Fragment Weight (Intentional) (lb):	0.0305
Design Fragment Weight (95%) (Unintentional) (lb):	0.0213
Critical Fragment Velocity (fps):	3307

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	0.053
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	7
Public Traffic Route Distance (2.3 psi); K24 Distance:	9
Inhabited Building Distance (1.2 psi), K40 Distance:	15
Intentional MSD (0.0655 psi), K328 Distance:	123

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	0.053
Kinetic Energy 10^6 (lb-ft²/s²):	0.1668
Required Wall & Roof Sandbag Thickness (in)	12
Expected Maximum Sandbag Throw Distance (ft):	25
Minimum Separation Distance (ft):	200

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	90
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	982
MFD-V [Maximum Fragment Distance, Vertical] (ft):	756

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	2.96	1.95
Mild Steel:	0.57	0.37
Hard Steel:	0.46	0.30
Aluminum:	1.18	0.79
LEXAN:	4.23	3.25
Plexi-glass:	2.76	1.94
Bullet Resist Glass:	2.23	1.51

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	0.053
Kinetic Energy 106 (lb-ft²/s²):	0.1668
Water Containment System:	5 gal carboys/ inflatable pool
Minimum Separation Distance (ft):	200/200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
DODIC:	
Munition:	81 mm M45
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Non-Robust
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	3/2/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	4.48
Diameter (in):	3.1890
Maximum Fragment Weight (Intentional) (lb):	0.0265
Design Fragment Weight (95%) (Unintentional) (lb):	0.0034
Critical Fragment Velocity (fps):	7384

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	4.480
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	30
Public Traffic Route Distance (2.3 psi); K24 Distance:	40
Inhabited Building Distance (1.2 psi), K40 Distance:	66
Intentional MSD (0.0655 psi), K328 Distance:	541

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	4.480
Kinetic Energy 10^6 (lb-ft²/s²):	0.7224
Required Wall & Roof Sandbag Thickness (in)	24
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	242
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1199
MFD-V [Maximum Fragment Distance, Vertical] (ft):	963

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	8.05	3.43
Mild Steel:	1.41	0.63
Hard Steel:	1.16	0.51
Aluminum:	2.93	1.37
LEXAN:	6.71	4.06
Plexi-glass:	5.06	2.60
Bullet Resist Glass:	4.21	2.01

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	4.480
Kinetic Energy 106 (lb-ft²/s²):	0.7224
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
DODIC:	C222
Munition:	81 mm M362A1
Case Material:	Iron, Pure
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Robust
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	2/18/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	Composition B
Explosive Weight (lb):	2.1
Diameter (in):	3.1890
Maximum Fragment Weight (Intentional) (lb):	0.0441
Design Fragment Weight (95%) (Unintentional) (lb):	0.0071
Critical Fragment Velocity (fps):	5990

Overpressure Distances

TNT Equivalent (Pressure):	1.16
TNT Equivalent Weight - Pressure (lbs):	2.436
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	24
Public Traffic Route Distance (2.3 psi); K24 Distance:	32
Inhabited Building Distance (1.2 psi), K40 Distance:	54
Intentional MSD (0.0655 psi), K328 Distance:	441

Required Sandbag Thickness

TNT Equivalent (Impulse):	1.16
TNT Equivalent Weight - Impulse (lbs):	2.436
Kinetic Energy 10^6 (lb-ft²/s²):	0.7912
Required Wall & Roof Sandbag Thickness (in)	24
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	247
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1342
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1066

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	7.51	3.55
Mild Steel:	1.40	0.68
Hard Steel:	1.15	0.56
Aluminum:	2.87	1.45
LEXAN:	6.91	4.42
Plexi-glass:	5.23	2.89
Bullet Resist Glass:	4.40	2.28

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1.16
TNT Equivalent Weight - Impulse (lbs):	2.436
Kinetic Energy 106 (lb-ft²/s²):	0.7912
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
DODIC:	C225
Munition:	81 mm M43
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Robust
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	3/10/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	1.23
Diameter (in):	3.1890
Maximum Fragment Weight (Intentional) (lb):	0.1096
Design Fragment Weight (95%) (Unintentional) (lb):	0.0377
Critical Fragment Velocity (fps):	3776

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	1.230
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	19
Public Traffic Route Distance (2.3 psi); K24 Distance:	26
Inhabited Building Distance (1.2 psi), K40 Distance:	43
Intentional MSD (0.0655 psi), K328 Distance:	351

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	1.230
Kinetic Energy 10^6 (lb-ft²/s²):	0.7813
Required Wall & Roof Sandbag Thickness (in)	24
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

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Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	209
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1579
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1215

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	6.61	3.98
Mild Steel:	1.27	0.77
Hard Steel:	1.04	0.63
Aluminum:	2.59	1.60
LEXAN:	6.62	5.05
Plexi-glass:	4.99	3.49
Bullet Resist Glass:	4.22	2.87

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	1.230
Kinetic Energy 106 (lb-ft²/s²):	0.7813
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
Munition:	3 in Common Mk 3 Mod 7
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Projectile
Munition Case Classification:	Extremely Heavy Case

DODIC:	
Date Record Created:	6/2/2008
Record Created By:	MC
Last Date Record Updated:	3/25/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT & Black Powder
Explosive Weight (lb):	0.28
Diameter (in):	3.0000
Maximum Fragment Weight (Intentional) (lb):	0.1949
Design Fragment Weight (95%) (Unintentional) (lb):	0.0628
Critical Fragment Velocity (fps):	2720

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	0.280
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	12
Public Traffic Route Distance (2.3 psi); K24 Distance:	16
Inhabited Building Distance (1.2 psi), K40 Distance:	26
Intentional MSD (0.0655 psi), K328 Distance:	215

Required Sandbag Thickness

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	0.280
Kinetic Energy 10^6 (lb-ft²/s²):	0.7208
Required Wall & Roof Sandbag Thickness (in)	20
Expected Maximum Sandbag Throw Distance (ft):	125
Minimum Separation Distance (ft):	200

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Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	126
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1700
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1271

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	5.55	3.60
Mild Steel:	1.03	0.66
Hard Steel:	0.85	0.54
Aluminum:	2.05	1.34
LEXAN:	6.29	4.77
Plexi-glass:	4.68	3.24
Bullet Resist Glass:	4.04	2.69

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	0.280
Kinetic Energy 106 (lb-ft²/s²):	0.7208
Water Containment System:	5 gal carboys/ inflatable pool
Minimum Separation Distance (ft):	264/200

Item Notes

Fragmentation Data Review Form

Database Revision Date 9/30/10

Category:	Surface-Launched HE Rounds
Munition:	5 in Mk 41
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Projectile
Munition Case Classification:	Robust

DODIC:	D320
Date Record Created:	9/21/2004
Record Created By:	MC
Last Date Record Updated:	2/17/2010
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	Explosive D
Explosive Weight (lb):	7.38
Diameter (in):	5.0000
Maximum Fragment Weight (Intentional) (lb):	0.6726
Design Fragment Weight (95%) (Unintentional) (lb):	0.1367
Critical Fragment Velocity (fps):	2538

Overpressure Distances

TNT Equivalent (Pressure):	0.85
TNT Equivalent Weight - Pressure (lbs):	6.273
Unbarricaded Intraline Distance (3.5 psi), K18 Distance:	33
Public Traffic Route Distance (2.3 psi); K24 Distance:	44
Inhabited Building Distance (1.2 psi), K40 Distance:	74
Intentional MSD (0.0655 psi), K328 Distance:	605

Required Sandbag Thickness

TNT Equivalent (Impulse):	0.85
TNT Equivalent Weight - Impulse (lbs):	6.273
Kinetic Energy 10^6 (lb-ft²/s²):	2.1663
Required Wall & Roof Sandbag Thickness (in)	36
Expected Maximum Sandbag Throw Distance (ft):	220
Minimum Separation Distance (ft):	220

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Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	359
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	2377
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1748

Minimum Thickness to Prevent Perforation

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	9.17	4.80
Mild Steel:	1.77	0.92
Hard Steel:	1.45	0.75
Aluminum:	3.43	1.86
LEXAN:	8.58	5.73
Plexi-glass:	7.05	4.13
Bullet Resist Glass:	6.32	3.49

Water Containment System and Minimum Separation Distance:

TNT Equivalent (Impulse):	0.85
TNT Equivalent Weight - Impulse (lbs):	6.273
Kinetic Energy 106 (lb-ft²/s²):	2.1663
Water Containment System:	1100 gal tank
Minimum Separation Distance (ft):	275

Item Notes

APPENDIX Q. CONCEPTUAL SITE MODELS

This appendix contains the following figures:

- Figure Q-1: MRS 13 – Wire-frame Conceptual Site Model
- Figure Q-2: MRS 10 – Wire-frame Conceptual Site Model
- Figure Q-3: MRS-11 – Wire-frame Conceptual Site Model
- Figure Q-4: MRS 06 – Wire-frame Conceptual Site Model
- Figure Q-5: MRS 09 – Wire-frame Conceptual Site Model
- Figure Q-6: MRS 08 – Wire-frame Conceptual Site Model
- Figure Q-7: MRS 13 – 3D Graphical Conceptual Site Model
- Figure Q-8: MRS 10 – 3D Graphical Conceptual Site Model
- Figure Q-9: MRS-11 – 3D Graphical Conceptual Site Model
- Figure Q-10: MRS 06 – 3D Graphical Conceptual Site Model
- Figure Q-11: MRS 09 – 3D Graphical Conceptual Site Model
- Figure Q-12: MRS 08 – 3D Graphical Conceptual Site Model

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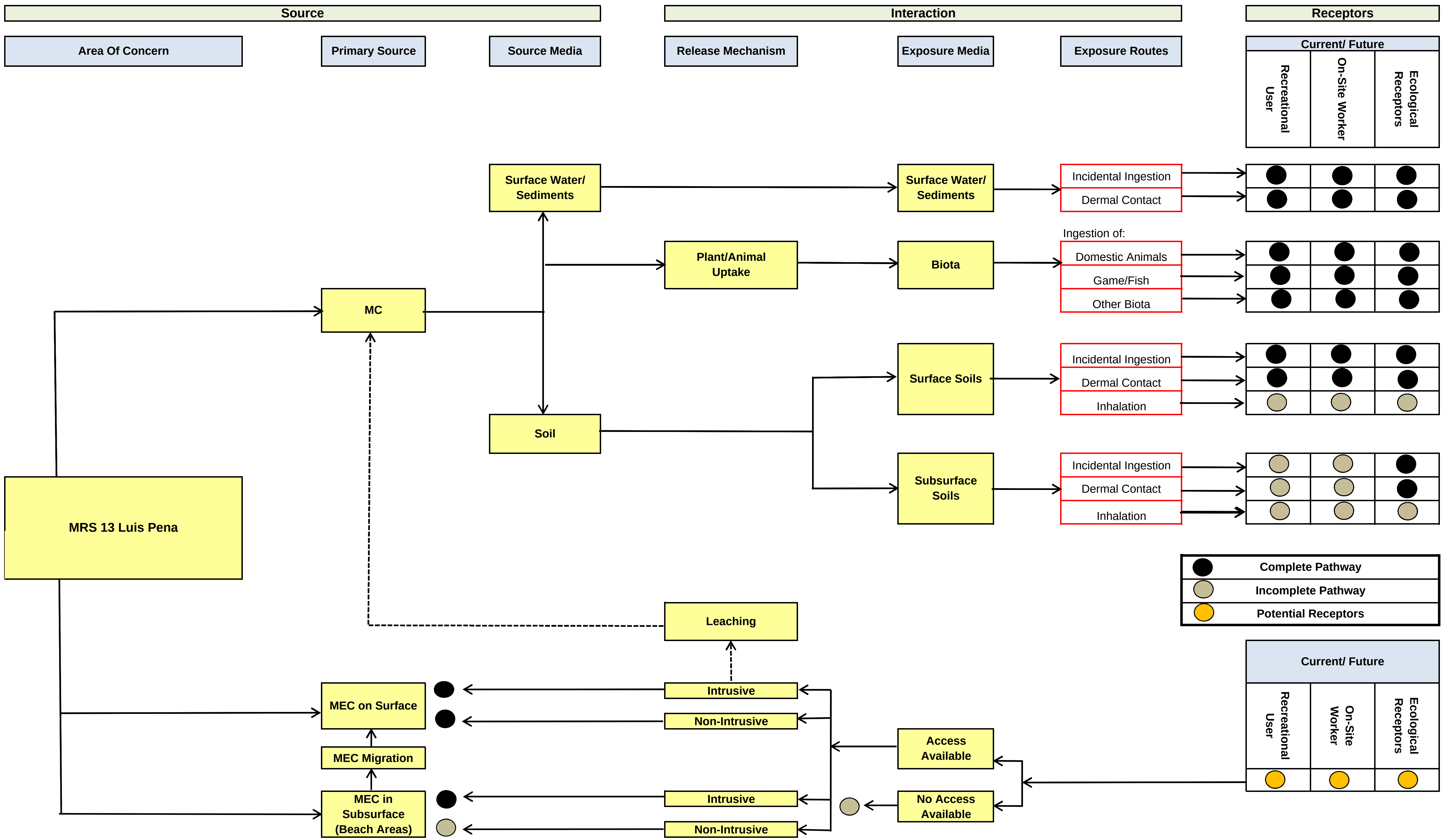
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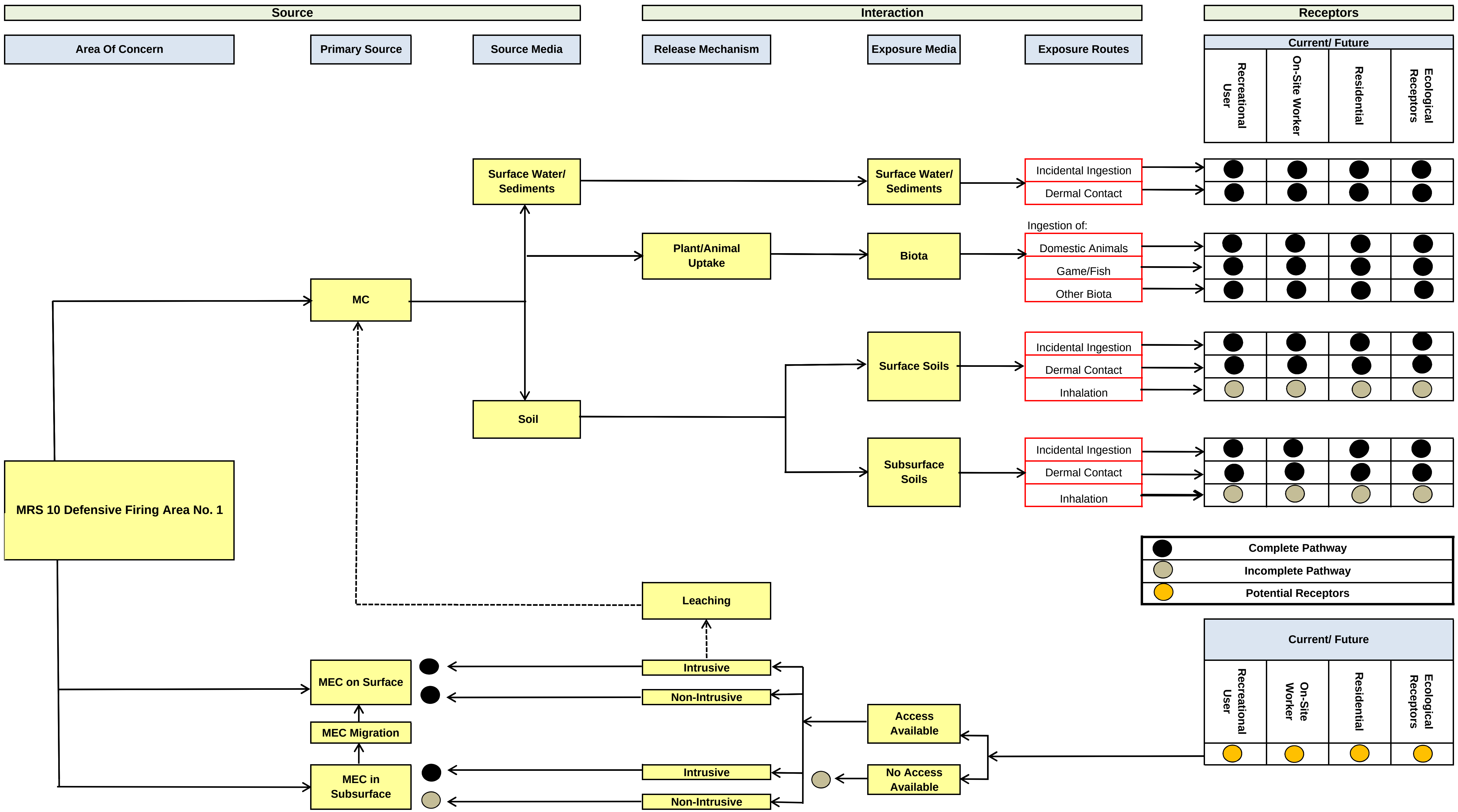
Receptors
Area Of Concern
Primary Source
Source Media
Release Mechanism
Exposure Media
Exposure Routes
Current/ Future
Recreational User
On-Site Worker
Ecological Receptors
Surface Water/ Sediments
Surface Water/ Sediments
Incidental Ingestion
Dermal Contact
Ingestion of:
Plant/Animal Uptake
Biota
Domestic Animals
Game/Fish
Other Biota
MC
Surface Soils
Incidental Ingestion
Dermal Contact
Inhalation
Soil
Subsurface Soils
Incidental Ingestion
Dermal Contact
Inhalation
MRS 13 Luis Pena
Complete Pathway
Incomplete Pathway
Potential Receptors
Leaching
Current/ Future
Recreational User
On-Site Worker
Ecological Receptors
MEC on Surface
Intrusive
Non-Intrusive
Access Available
MEC Migration
MEC in Subsurface (Beach Areas)
Intrusive
Non-Intrusive
No Access Available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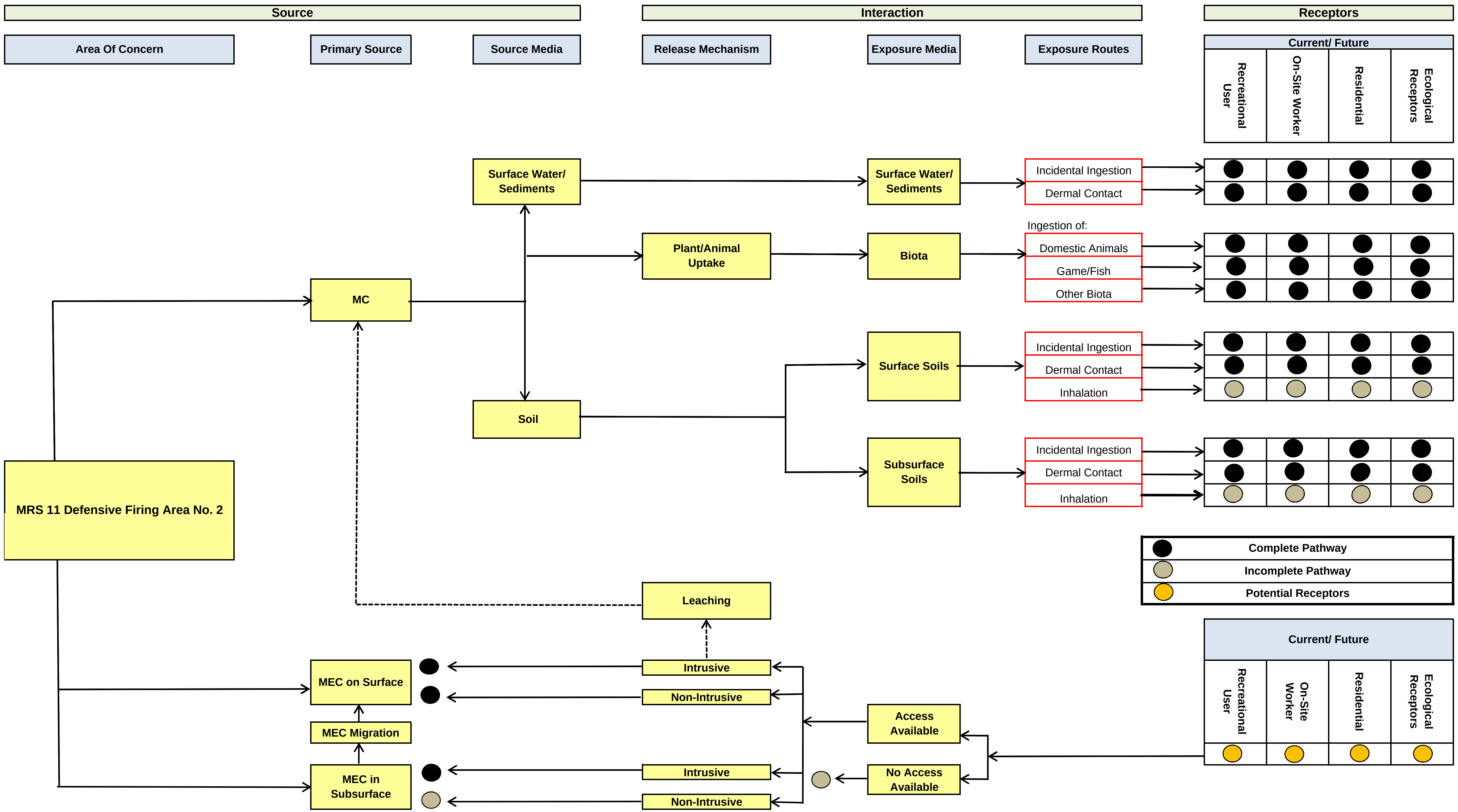
Area Of Concern
Primary Source
Source Media
Release Mechanism
Exposure Media
Exposure Routes
Current/ Future
Recreational User
On-Site Worker
Residential
Ecological Receptors
Surface Water/ Sediments
Surface Water/ Sediments
Incidental Ingestion
Dermal Contact
Ingestion of:
Plant/Animal Uptake
Biota
Domestic Animals
Game/Fish
Other Biota
MC
Surface Soils
Incidental Ingestion
Dermal Contact
Inhalation
Soil
Subsurface Soils
Incidental Ingestion
Dermal Contact
Inhalation
MRS 10 Defensive Firing Area No. 1
Complete Pathway
Incomplete Pathway
Potential Receptors
Leaching
Current/ Future
Recreational User
On-Site Worker
Residential
Ecological Receptors
MEC on Surface
Intrusive
Non-Intrusive
Access Available
MEC Migration
MEC in Subsurface
Intrusive
Non-Intrusive
No Access Available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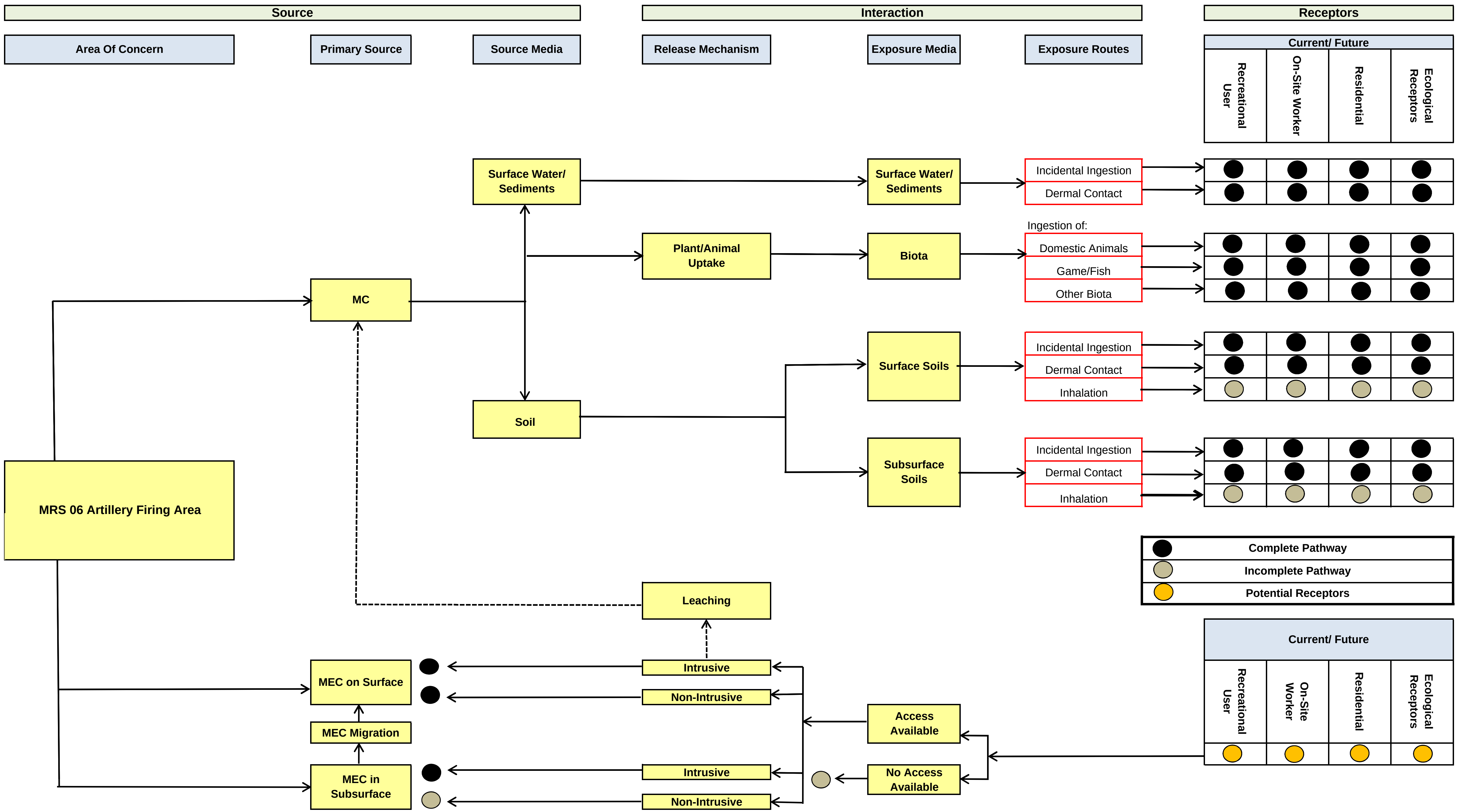
Receptors
Area Of Concern
Primary Source
Source Media
Release Mechanism
Exposure Media
Exposure Routes
Current/ Future
Recreational User
On-Site Worker
Residential
Ecological Receptors
Surface Water/ Sediments
Surface Water/ Sediments
Incidental Ingestion
Dermal Contact
Ingestion of:
Plant/Animal Uptake
Biota
Domestic Animals
Game/Fish
Other Biota
MC
Surface Soils
Incidental Ingestion
Dermal Contact
Inhalation
Soil
Subsurface Soils
Incidental Ingestion
Dermal Contact
Inhalation
MRS 11 Defensive Firing Area No. 2
Complete Pathway
Incomplete Pathway
Potential Receptors
Leaching
Current/ Future
Recreational User
On-Site Worker
Residential
Ecological Receptors
MEC on Surface
Intrusive
Non-Intrusive
MEC Migration
Access Available
MEC in Subsurface
Intrusive
Non-Intrusive
No Access Available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Receptors
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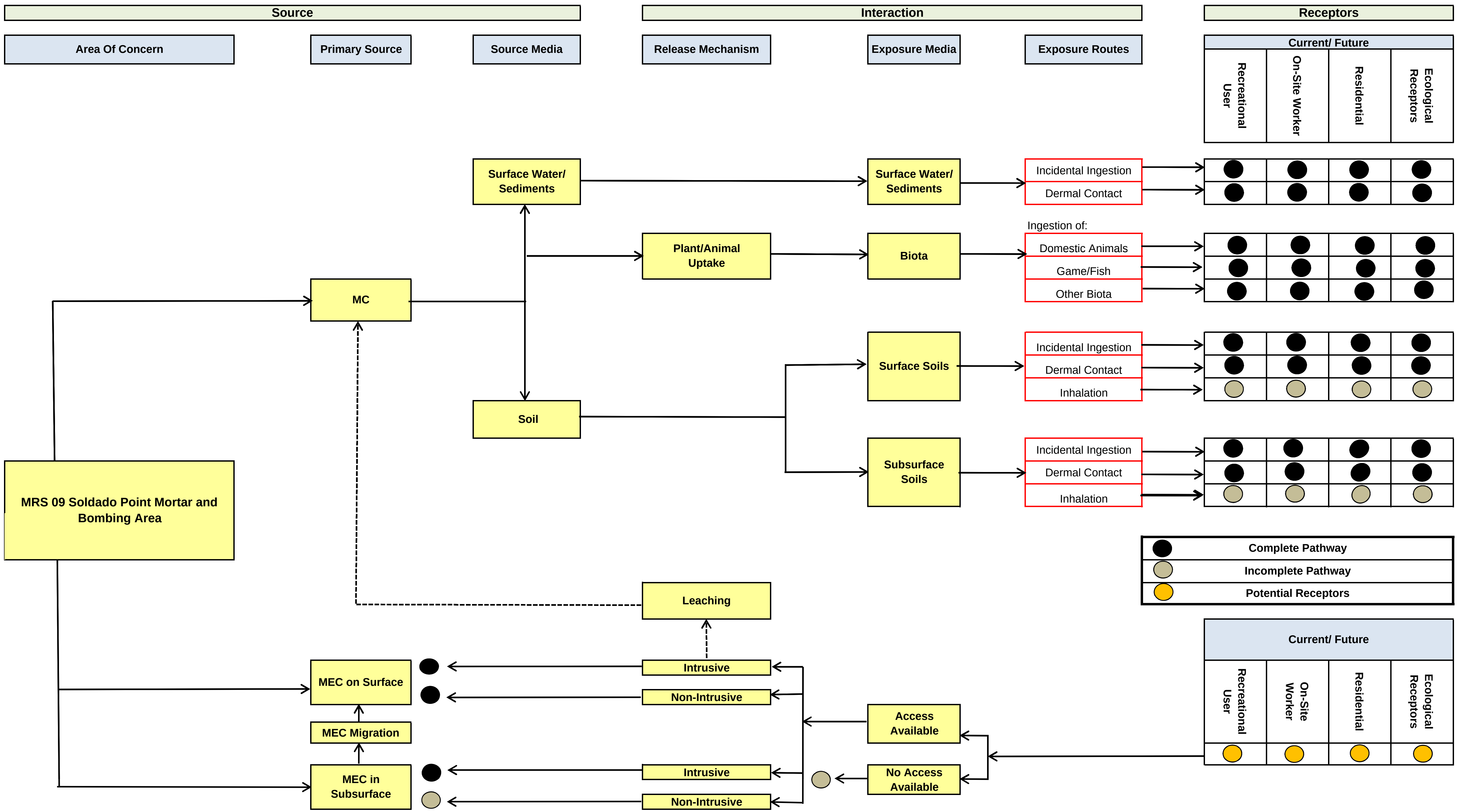
Primary Source
Source Media
Release Mechanism
Exposure Media
Exposure Routes
Current/ Future
Recreational User
On-Site Worker
Residential
Ecological Receptors
Surface Water/ Sediments
Surface Water/ Sediments
Incidental Ingestion
Dermal Contact
Ingestion of:
Plant/Animal Uptake
Biota
Domestic Animals
Game/Fish
Other Biota
MC
Surface Soils
Incidental Ingestion
Dermal Contact
Inhalation
Soil
Subsurface Soils
Incidental Ingestion
Dermal Contact
Inhalation
MRS 06 Artillery Firing Area
Complete Pathway
Incomplete Pathway
Potential Receptors
Leaching
Current/ Future
Recreational User
On-Site Worker
Residential
Ecological Receptors
MEC on Surface
Intrusive
Non-Intrusive
Access Available
MEC Migration
MEC in Subsurface
Intrusive
Non-Intrusive
No Access Available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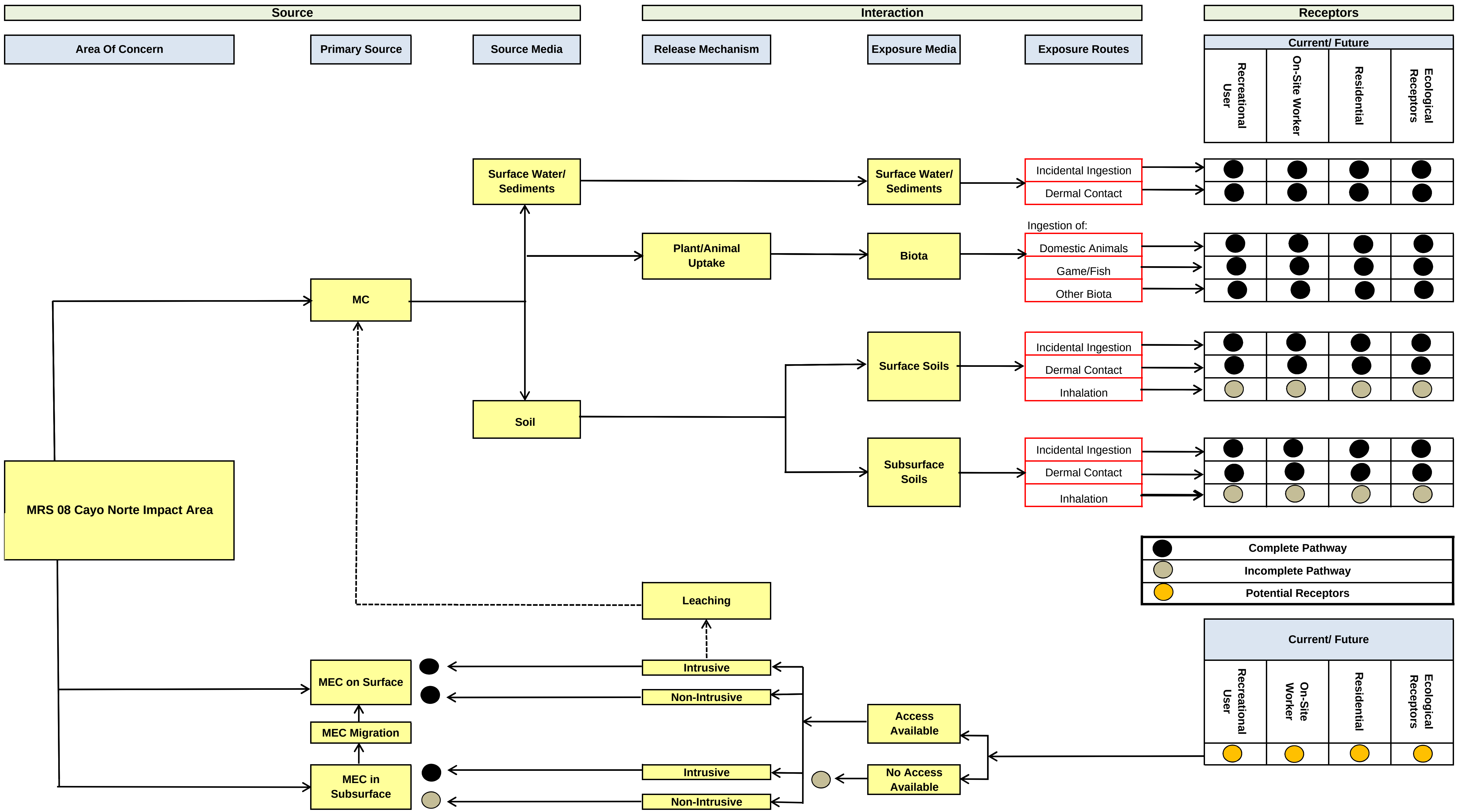
Interaction
Receptors
Area Of Concern
Primary Source
Source Media
Release Mechanism
Exposure Media
Exposure Routes
Current/ Future
Recreational User
On-Site Worker
Residential
Ecological Receptors
Surface Water/ Sediments
Surface Water/ Sediments
Incidental Ingestion
Dermal Contact
Plant/Animal Uptake
Biota
Ingestion of:
Domestic Animals
Game/Fish
Other Biota
MC
Surface Soils
Incidental Ingestion
Dermal Contact
Inhalation
Soil
Subsurface Soils
Incidental Ingestion
Dermal Contact
Inhalation
MRS 09 Soldado Point Mortar and Bombing Area
Complete Pathway
Incomplete Pathway
Potential Receptors
Leaching
Current/ Future
MEC on Surface
Intrusive
Non-Intrusive
Recreational User
On-Site Worker
Residential
Ecological Receptors
MEC Migration
Access Available
MEC in Subsurface
Intrusive
Non-Intrusive
No Access Available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Interaction
Receptors
Area Of Concern
Primary Source
Source Media
Release Mechanism
Exposure Media
Exposure Routes
Current/ Future
Recreational User
On-Site Worker
Residential
Ecological Receptors
Surface Water/ Sediments
Surface Water/ Sediments
Incidental Ingestion
Dermal Contact
Ingestion of:
Plant/Animal Uptake
Biota
Domestic Animals
Game/Fish
Other Biota
MC
Surface Soils
Incidental Ingestion
Dermal Contact
Inhalation
Soil
Subsurface Soils
Incidental Ingestion
Dermal Contact
Inhalation
MRS 08 Cayo Norte Impact Area
Complete Pathway
Incomplete Pathway
Potential Receptors
Leaching
Current/ Future
Recreational User
On-Site Worker
Residential
Ecological Receptors
MEC on Surface
Intrusive
Non-Intrusive
Access Available
MEC Migration
MEC in Subsurface
Intrusive
Non-Intrusive
No Access Available

Kayakers, Hikers, and Beachcombers:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Incidental contact with MEC.

Bombs and Projectiles (Source of Contamination)

Surface Runoff / Erosion

Aquatic Organisms:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Bioaccumulation through food web.

On-site Workers:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Incidental contact with MEC.

Not To Scale

Remedial Action/ Feasibility Study

Figure Q-7

MRS 13 - Cayo Luis Pena Impact Areas

3D Graphical Conceptual Site Model

Culebra Island Site, Puerto Rico

Legend

- Ephemeral Streams
- Depositional Areas

USA Environmental, Inc.

US Army Engineering And Support Center Huntsville, Alabama

Drawn By:	JAL	Scale:	Not To Scale	Rev:	
Checked By:	MT	Date Drawn:	9-15-2010		
Submitted By:	DR	Revision Date:			

Path: S:\Culebra\RIFS 2009\Work Plan B-12 MRS 9 Transect Map.mxd

On-site Workers, Hikers, and Beachcombers:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Incidental contact with MEC.

Bombs and Projectiles (Source of Contamination)

Residents:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Incidental contact with MEC.

Surface Runoff / Erosion

Aquatic Organisms:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Bioaccumulation through food web.

N

Not To Scale

Remedial Action/ Feasibility Study

Figure Q-8

MRS 10- Defensive Firing Area #1

3D Graphical Conceptual Site Model

Culebra Island Site, Puerto Rico

Legend

- Ephemeral Streams
- Investigation Sub-areas
- MRS Boundary
- Depositional Areas

USA Environmental, Inc.

US Army Engineering And Support Center Huntsville, Alabama

Drawn By:	JAL	Scale:	Not To Scale	Rev:	1
Checked By:	MT	Date Drawn:	9-15-2010		
Submitted By:	DR	Revision Date:	1-6-2011		

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On-site Workers, Hikers, and Beachcombers:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Incidental contact with MEC.

Bombs and Projectiles (Source of Contamination)

Residents:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Incidental contact with MEC.

Aquatic Organisms:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Bioaccumulation through food web.

Surface Runoff / Erosion

N

Not To Scale

Remedial Action/ Feasibility Study

Figure Q-9

MRS 11- Defensive Firing Area #2

3D Graphical Conceptual Site Model

Culebra Island Site, Puerto Rico

Legend

- Ephemeral Streams
- Investigation Sub-areas
- MRS Boundary
- Depositional Areas

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Drawn By: JAL	Scale: Not To Scale		Rev: 1
Checked By: MT	Date Drawn: 9-15-2010		
Submitted By: DR	Revision Date: 1-6-2011		

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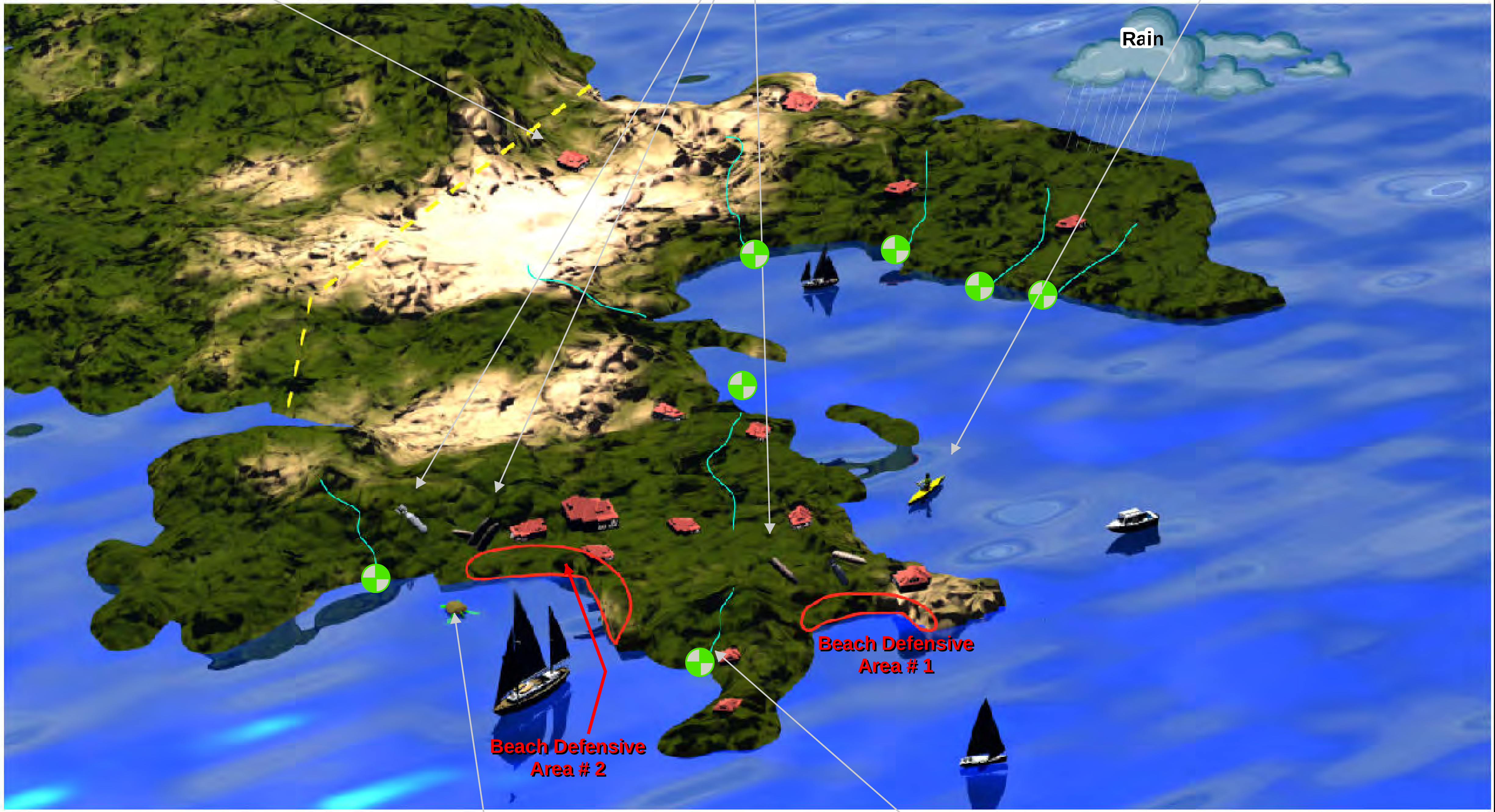
Residents:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Incidental contact with MEC.

Bombs and Projectiles (Source of Contamination)

On-site Workers, Hikers, and Beachcombers:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Incidental contact with MEC.



Aquatic Organisms:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Bioaccumulation through food web.

Surface Runoff / Erosion

N

Not To Scale

Remedial Action/ Feasibility Study

Figure Q-10

MRS 6- Artillery Firing Area

3D Graphical Conceptual Site Model

Culebra Island Site, Puerto Rico

Legend

- Ephemeral Streams
- Investigation Sub-areas
- MRS Boundary
- Depositional Area

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Checked By: MT	Date Drawn: 9-15-2010		
Submitted By: DR	Revision Date: 1-6-2011		
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On-site Workers, Hikers, and Beachcombers:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Incidental contact with MEC.

Bombs and Projectiles (Source of Contamination)

Residents:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Incidental contact with MEC.

Surface Runoff / Erosion

Aquatic Organisms:

-Incidental ingestion of, and dermal contact with surface soil, surface water and sediment.
-Bioaccumulation through food web.

N

Not To Scale

Remedial Action/ Feasibility Study

Figure Q-11

MRS 9 - Solodado Point Mortar and Bombing Area

3D Graphical Conceptual Site Model

Culebra Island Site, Puerto Rico

Legend

- Ephemeral Streams
- Investigation Sub-areas
- Depositional Areas

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Checked By:	MT	Date Drawn:	9-15-2010		
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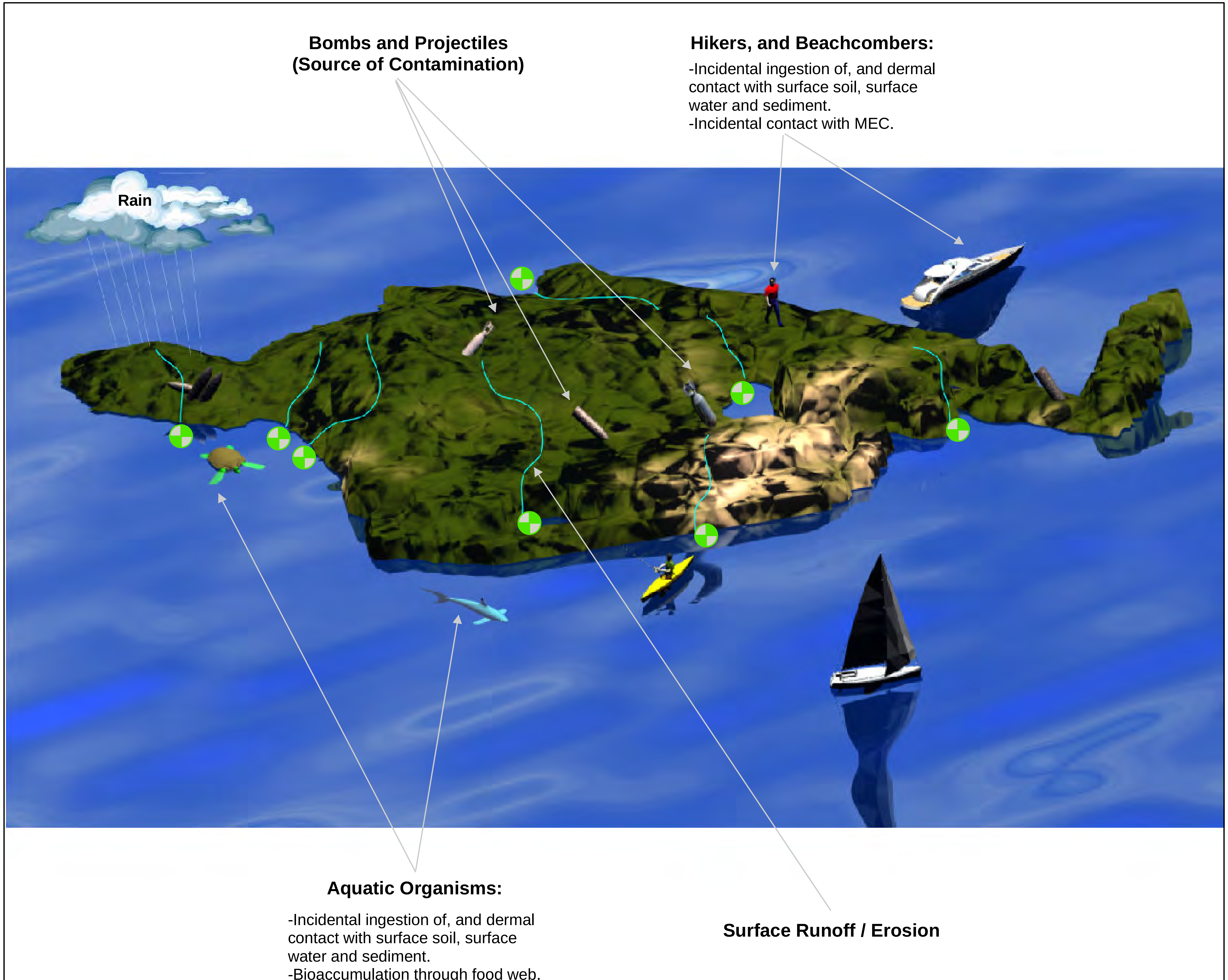

Remedial Action/ Feasibility Study

Figure Q-12

MRS 8- Cayo Norte Impact Area

3D Graphical Conceptual Site Model

Culebra Island Site, Puerto Rico

Legend

- Ephemeral Streams
- Depositional Area

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Checked By:	MT	Date Drawn:	9-15-2010		
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