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## 6.0 Geophysical Investigation Plan

### 6.1 Unexploded Ordnance Safety

6.1.01 Geophysical investigation teams will maintain at least a 200-foot separation distance from any other teams for safety while performing their tasks. This avoidance effort will be facilitated by use of electromagnetic detectors to detect surface anomalies in their paths. MEC items that are located on the surface during the geophysical investigation will be reported to the site manager and the SUXOS immediately. The grid coordinates will be recorded for all discovered MEC and other surface features such as craters, bunkers, and military equipment that will assist in demarcating target areas. These data will be incorporated into the project MEC database as surface finds.

6.1.02 The safety of all persons on the project site will be paramount during field operations. A safety and work assignment briefing will be conducted prior to the beginning of each day's field activities. A tailgate safety briefing will address any known hazards of concern for the particular area(s) to be investigated.

### 6.2 Personnel Responsibilities and Qualifications

6.2.01 During initial field work and surface clearance activities, an individual meeting the UXO Technician II qualifications will accompany the surveyor during the grid layout operations. The UXO Technician II shall conduct visual surveys for surface ordnance and an electromagnetic survey of each specific intrusive activity (e.g., driving stakes) to ensure that the site is anomaly-free. The UXO Technician II will not be required to perform MEC avoidance activities on a full-time basis.

6.2.02 At minimum, personnel using the geophysical field equipment will have completed the OSHA training course for hazardous waste operations and/or the 8-hour refresher. All training will be in accordance with 29 CFR 1910.120, EM 385-1-1 (CEHNC Safety and Health Requirements Manual), and ER 385-1-92 (Safety and Occupational Health Requirements for HTRW and OE Activities). Additionally, the medical surveillance program will be in effect, with personnel (generally UXO Technician I personnel) having received their latest examination within the last 12 months.

## 6.3 Geophysical Investigation Plan Outline

### 6.3.1 Site Description

A comprehensive description of the site is included in Chapter 1 of this Work Plan.

#### 6.3.1.1 Geophysical Data Quality Objectives

The geophysical data quality objectives are presented in the following table.

Table 6-1. Geophysical Data Quality Objectives

Step	Description	Application to Remedial Investigation
1	State the problem	Members of the decision team: EEG, CEHNC, CESAJ, Puerto Rico DNER, FWS, Puerto Rico EQB, Municipality of Culebra, EPA, NMFS  The goal is to remove surface MEC and MC from 30 acres on the western flank of Cerro Balcon, 82 acres of the northwest end of Isla Culebra, and up to 39.5 acres of additional cays including Cayo Botella, Cayo Tiburon, Los Gemelos, Cayo del Agua, Cayos Genequi, Cayo Lobo, and Cayo Alcarraza. The Conceptual Site Model is included as Appendix I.
2	Identify the decision	Decision Statement: Complete the removal of surface MEC in accordance with the EE/CA Action Memorandum based on present land use.
3	Identify inputs to the decision	Inputs to the decision criteria will be provided through: <ul style="list-style-type: none"> <li>• Initial review of existing data <ul style="list-style-type: none"> <li>—Review of EE/CA Action Memorandum</li> <li>—Assessment of quantity and types of items to be found</li> <li>—Review of ASRs</li> <li>—Review of area geologic and geographic characteristics</li> </ul> </li> <li>• Meetings <ul style="list-style-type: none"> <li>—Input from stakeholders, residents, and property owners</li> </ul> </li> <li>• Site visit <ul style="list-style-type: none"> <li>—Determine site boundaries for removal action</li> </ul> </li> </ul>
4	Define study boundaries	The boundaries of the removal action sites are presented in the maps provided in Appendix B.
5	Develop decision rules	Initial action levels include: <ul style="list-style-type: none"> <li>• Determining applicability of instrumentation to the site-specific conditions</li> <li>• Determining the proper geophysical equipment that will detect the size of MEC expected at the surface</li> <li>• Expanding the boundary of the removal action if MEC is found to exceed the site boundary</li> <li>• Checking the geophysical sensors daily to ensure that they are able to perform per specifications</li> <li>• Removing all surface MEC and performing QA/QC checks before acceptance of a grid</li> </ul>

Step	Description	Application to Remedial Investigation
6	Specify limits on decision errors	<p>The precision and accuracy for all positioning data will not exceed <math>\pm 1</math> foot. Performance metrics for the removal action include:</p> <ul style="list-style-type: none"> <li>• OOU-3, Cerro Balcon: No explosive hazards or MEC objects with a width (diameter) or thickness inclusive of MK 23 and larger</li> <li>• OOU-4, Isla Culebrita: No explosive hazards or MEC objects with a width (diameter) or thickness of 20 mm and larger</li> <li>• OOU-5, Adjacent Cays: No explosive hazards or MEC objects with a width (diameter) or thickness of a 3-inch navy gun fired projectile and larger</li> </ul>
7	Optimize the design for obtaining data	<p>Assessment of existing and site-derived data must be able to show that all MEC and explosives hazards have been removed from the surface of the site. The data quality objectives will be reviewed and continually evaluated during the removal action to ensure that failures are recognized and corrective actions are implemented as soon as possible.</p> <p>EEG will conduct geophysical sweeps using 4-foot or less survey lane spacing to optimize coverage of the survey grid.</p> <p>EEG will perform operation checks of the instrumentation and operators several times a day (at least at the start of work, at lunch, and at least one test in the afternoon) to ensure the instrument is performing within guidelines (able to detect surface items at the height of instrumentation that is being used).</p> <p>We have chosen an initial two foot target height in order to cut less native vegetation. If the equipment can not detect the items at that height, a lesser target height will be used. The instrument must be able to detect all surface items at that height. The design will be optimized based on the tests to allow the greatest instrument height without losing the ability to detect target items identified in Step 6.</p>

### 6.3.1.2 Areas To Be Investigated

MEC will be removed from 30 acres on the western flank of Cerro Balcon, 82 acres of the northwest end of Isla Culebrita, and up to 39.5 acres of additional cays, including Cayo Botella, Cayo Tiburon, Los Gemelos, Cayo del Agua, Cayos Genequi, Cayo Lobo, and Cayo Alcarraza. Maps B-3 through B-8 (Appendix B) present the locations of these sites. A detailed description of the site and environmental protections are provided in the Environmental Protection Plan (Chapter 11).

### 6.3.1.3 Past, Current, and Future Use

6.3.1.3.01 OOU-3 is located in the east-central part of Culebra Island on the western slope of the hill named Cerro Balcon. The OOU encompasses approximately 30 acres and extends from the southern part of the San Isidro region of the island to the northern part of the Fraile region. The entire unit is privately owned and used primarily for grazing. Part of the unit is fenced. Access by the public is restricted by the landowner, poor roads, thick vegetation, and the fencing.

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At the time of the EE/CA Action Memorandum, the future land use was to remain as grazing; however, present plans are for possible residential land development in this area. Houses have begun to be constructed atop the overlooking hills.

6.3.1.3.02 OOU-4 includes an 82-acre portion of the 266-acre Isla Culebrita, located east of Culebra Island. The island is currently administered by FWS. Past use was minor recreation, and current use is recreation, including swimming, boating, and hiking. The island is accessible only by boat. Access to the island will be coordinated with FWS. Approximately 21,000 people visit the island in a typical year. Several tour guides are permitted access to the island. The north bay of Isla Culebrita is a popular area for boaters and beach visitors. The island will remain under the administration of FWS and may be further developed with hiking trails.

6.3.1.3.03 OOU-5 consists of all the small cays that were identified by the ASR as being part of the Culebra Island naval facility, including Cayo Botella, Cayo Alcarraza, Los Gemelos, Cayo Lobo, Cayo del Agua, Cayo Tiburon, and Cayos Geniqui. All of the islands have rugged terrain and limited beach areas. Most of the small cays are accessible only during calm seas and good weather. Access is currently limited to FWS personnel.

#### 6.3.1.4 Anticipated MEC Type, Composition, and Quantity

6.3.1.4.01 The Cerro Balcon area was used as a mortar practice range. Some fragments of inert 81 mm mortars and one 76 mm mortar were discovered during previous sampling. Historical accounts of finding explosive ordnance items exist. Ordnance would most likely be found in the primary target area but could be found anywhere within the range. The contaminated portion of the mortar range at Cerro Balcon is estimated to comprise 30 acres. Some contamination should be expected anywhere within this area.

6.3.1.4.02 Strafing activity on Isla Culebrita was confined to an 82-acre strafing range located on the western end of the island. Sampling of the strafing range recovered only 20 mm projectiles. Many of these projectiles contained high-explosive incendiary fill. All were recovered from a depth of less than 6 inches.

6.3.1.4.03 All of the other adjacent cays were used as target areas for bombing and rocket fire. No data are available to indicate the relative ordnance intensity on each of the cays. Grids sampled during the EE/CA field investigation had MEC densities ranging from 0 (zero) for all four of the Cayo Lobo sites to 373 MEC items per acre on Cayo Botello.

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### 6.3.1.5 Anticipated Depth

The investigation areas will be surfaced-cleared only. No subsurface clearance will be conducted. Intrusive work might be performed only if a discovered item were partially exposed at the surface.

### 6.3.1.6 Digital Topographic Maps

6.3.1.6.01 EEG will use aerial photography collected by others to be used as base maps for this investigation. The preparation of digital topographic maps is not part of this SOW. Further description of the geospatial data to be developed during this project is included in Chapter 7 of this plan.

6.3.1.6.02 EEG will obtain elevation and location data of the grid corners from a Puerto Rico-licensed surveyor. The measured elevation data will be referenced to the North American Vertical Datum of 1988 (NAVD88). This data will be entered into the Surfer version 8 software by Golden Software, Inc. to determine the approximate surface area of each grid only.

### 6.3.1.7 Vegetation

6.3.1.7.01 The vegetation at the Cerro Balcon site is generally thick brush, consisting of mesquite-acacia association and thick, tall grasses. An occasional cactus can be found throughout the area.

6.3.1.7.02 Vegetation on the undeveloped areas of Culebra Island and the larger cays ranges from moderately to extremely dense. These forested areas are thick with undergrowth, including plants with long, sharp thorns (mesquite-acacia). The smaller cays are predominantly rock with sparse or no vegetation other than cactus, thorny brush (mesquite-acacia), and/or tall grasses. The poisonous manzillo tree is present on Flemenco Peninsula and may potentially be found in other areas.

### 6.3.1.8 Geologic Conditions

Culebra Island and the adjacent cays are underlain by both intrusive and extrusive volcanic rock of Upper Cretaceous Age. Andesite lava and andesite tuff are the most dominant volcanic rocks seen on Culebra and the adjacent cays. Toward the north central portion of Culebra, the tuff and lava contain diorite porphyry inclusions. The volcanic rocks exhibit little or no porosity due to

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compaction and filling of the pores with quartz and calcite. The volcanic rocks exhibit strong magnetic properties that can affect magnetometer readings.

#### 6.3.1.9 Soil Conditions

Soil is predominately a saprolite (weathered rock), and on average it extends to a maximum depth of approximately 4 feet. Most soils, except along the slopes, are the result of weathering bedrock. The Desculabrado series is found on slopes of 20 to 40 percent and located over 75 percent of Culebra Island. The soils are well-drained, runoff is rapid, and permeability is moderate. Igneous rock underlies the saprolite.

#### 6.3.1.10 Shallow Groundwater Conditions

Groundwater is rare at the site and generally found either in a joint in the bedrock or at the soil/bedrock interface. Extensive water-bearing units do not exist in the proposed work areas.

#### 6.3.1.11 Geophysical Conditions

The bedrock and soil at the site are derived from rocks and minerals that have high iron content with associated magnetic properties, which may result in false positive anomalies. In general, the topography is relatively gentle in most of the site areas and ranges to extremely high-angle vertical slopes around Cerro Balcon and Cayo Alcarraza. Thick vegetation may exist in the site areas.

#### 6.3.1.12 Site Utilities

No utilities are in and around the site areas due to the shallow depth to bedrock and the remoteness of the site.

#### 6.3.1.13 Manmade Features Potentially Affecting Geophysical Investigations

Manmade features that will affect geophysical investigations are buildings, sidewalks, and fences; aboveground and underground utilities; sewer covers and culverts; roads and curbs; and buried trash, debris, and artifacts. Fences are installed at property lines at Cerro Balcon. No other manmade features are expected to affect the investigation at any of the other sites.

#### 6.3.1.14 Site-Specific Dynamics

No site-specific dynamic events such as tides, unusually strong winds, or other unusual factors affecting site operations will have a detrimental effect on our instrumentation for surface clearance operations.

#### 6.3.1.15 Site Accessibility and Impediments

Trails to the sites on Cerro Balcon already exist; however, they are overgrown with dense vegetation. The cays are accessible by boat. Access to the cays will be difficult during periods of high waves and wind. On the large cays, the dense vegetation will impede movement toward the interior and across most of the cay.

#### 6.3.1.16 Potential Worker Hazards

Physical hazards expected to be encountered in conducting operations are heat stress, flammable materials, lifting, operation of hand and power tools, inclement weather, uneven or unstable surfaces, sharp objects (e.g., nails and broken glass), trips and falls, excessive noise, dense vegetation, biological hazards, heavy equipment, and explosive hazards. These are further described in the Accident Prevention Plan (Appendix D of this Work Plan).

### 6.3.2 Geophysical Investigation

Using techniques demonstrated during previous investigations on Culebra, EEG will conduct a surface removal action using visual and electromagnetic methods to locate items at or near the ground surface.

#### 6.3.2.1 Survey Type

Surface clearance surveys will be conducted within 200-by-200-foot grids (based on map projections) along parallel lanes approximately 5 feet wide.

#### 6.3.2.2 Equipment

6.3.2.2.01 EEG will use White's electromagnetic detectors or a Schonstedt GA-52 CX flux gate magnetometer to supplement visual inspection of the site for MPPEH items. The White's electromagnetic detector is a hand-portable system that includes transmitter and receiver coils. It is meant for a detect-and-flag-type operation and cannot be used for mapping in its present

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configuration. The Schonstedt GA-52 CX is a flux gate magnetometer which is also a hand-portable analog system that also cannot be used for mapping in its present configuration.

6.3.2.2.02 Should problems occur with the White's detector or Schonstedt GA-52 CX flux gate magnetometer, alternative detectors may be used upon acceptance by the contracting officer.

### 6.3.2.3 Procedures

6.3.2.3.01 The site will be gridded into several 200-by-200-foot grids and the corners marked as described in Subchapter 2.9 of this Work Plan. EEG personnel will use the grid system as a starting point for the removal action. Sweep lanes (no wider than 4 feet) will be established in a pattern that will allow UXO personnel optimum sweep rates and coverage. In the event that the vegetation is impenetrable, the procedures described in Subchapter 2.9 will be applied.

6.3.2.3.02 Once an anomaly is located, EEG personnel will visually observe the item to see if it is at the ground surface. If the item is inert, it will be removed from the site. If the item is partly buried (i.e., a portion of the item can be seen from visual inspection of the ground surface), EEG will excavate the item to determine if it is MEC, MC, munitions debris, or other, and to determine the item's condition (i.e., whether it is fused). Inert items will be immediately removed from the site. MEC or MC items will be identified, their condition assessed and documented, and the item disposal method will be determined.

6.3.2.3.03 EEG will use a polyvinyl chloride (PVC) flags with the unique identifier number recorded on it with indelible ink to mark the location of a MEC item. Where the ground is impenetrable by the flag, the ground will be spray-painted with high-visibility paint. The locations will be determined by GPS or in some cases by hand measurement. In areas of high concentrations of MEC defined herein as greater than 25 items in a quarter of the grid or subgrid, the center of the MEC area will be located by GPS, and the number of items found in that area will be identified on the grid map. If the MEC is concentrated in a pile, the pile will be mapped using GPS. This will be necessary primarily at Isla Culebrita, where large quantities of 20 mm rounds are anticipated.

6.3.2.3.04 The location of MEC will be recorded using a Global Positioning System (GPS) and all related information (i.e. depth, size, and condition) will be recorded on a Grid Sweep Log. Small arms (less than 50 caliber), non-hazardous OE scrap, and metallic debris shall be recorded by weight on a per-area basis.

6.3.2.3.05 During the removal action, all MPPEH encountered will be inspected and classified by the Military Munitions Response Program (MMRP), and the data will be formatted and reported in accordance with most recent guidance for SDSFIE. EEG UXO personnel (as discussed in Subchapter 2.18) will measure the weight of scrap collected in each category on a daily basis and place the data on a grid-specific Grid Sweep Log.

6.3.2.3.06 The UXO team leaders will submit all of their completed paperwork to the UXOQCS at the end of each working day. The UXOQCS will review paperwork for completeness and accuracy. After review (and correction, if required), the information on all of the forms will be entered into the site's database.

#### 6.3.2.4 Personnel

All MEC operations will be performed under the direction and supervision of a team leader. During these operations, the UXOQC/SO will closely monitor the operations, strictly enforce safety and adherence to procedures, and ensure that the exclusion area is appropriately evacuated. The team will consist of UXO sweep, UXO Technician I, and UXO Technician II personnel. The SUXOS will periodically work with team personnel. The site manager may also assist getting GPS coordinates of MEC items.

#### 6.3.2.5 Production Rates

Production rates will be affected by vegetation, topography, difficult weather, and access to cays. EEG hopes to average at least 2 acres per day using 2 teams.

#### 6.3.2.6 Data Spatial Density

Not applicable for this type of operation.

#### 6.3.3 Instrument Standardization

Not applicable for this type of operation.

#### 6.3.4 Data Processing, Corrections, and Analysis

Not applicable for this type of operation.

#### 6.3.4.1 Initial Field Processing

Not applicable for this type of operation.

#### 6.3.4.2 Standard Data Analysis

Not applicable for this type of operation.

#### 6.3.4.3 Advanced Data Processing (if applicable)

Not applicable for this type of operation.

#### 6.3.4.4 Anomaly Selection and Decision Criteria

Not applicable for this type of operation.

#### 6.3.5 Dig Sheet Development

Not applicable for this type of operation.

#### 6.3.6 Anomaly Reacquisition

EEG will flag each anomaly or item found. The coordinates will be found either by GPS or by mapping. EEG may measure the distance of the item from two grid corners and place the location on a grid map.

#### 6.3.7 Feedback Process

Not applicable for this type of operation.

#### 6.3.8 Quality Control

6.3.8.01 QC procedures for standard equipment tests and data quality requirements will be performed in accordance with the QC section of this Work Plan (Chapter 10).

6.3.8.02 The electromagnetic detectors will require balancing to remove background effects. Balancing will be conducted in accordance with manufacturer's instructions at the startup of operations each day and prior to conducting equipment operational checks periodically each day to ensure that the balancing does not affect the ability of the instrument to detect a surface item.

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6.3.8.03 The frequency of operational checks will be no less than once at the start, once at the end of the day or the completion of the grid or subgrid. At least one additional check must be performed during one of the breaks during the day and/or when a piece of equipment is suspected of not functioning properly. Both electromagnetic detectors and magnetometers will also undergo a simple “Go”/“No Go” field operational check each day before and after data collection at the frequency stated above. Balancing and selection of sensor mode will be performed at the startup of each electromagnetic device per manufacturer requirements.

6.3.8.04 Additional operational checks of the instrumentation will be performed pursuant to **Table 10-1**.

6.3.8.05 EEG will conduct a test to determine the maximum height at which the instrument can be operated and still reliably detect surface MEC. A blanket affixed with metal items same size or smaller than the target item at the site will be placed with MEC facing down and no evidence of MEC will be seen at the surface. The instrument will be raised off the ground to determine the effective height at which it can reliably and consistently detect each target item. This will become the maximum allowable height for the use of the instrument for that period of operation. The instrument will be operated as close to the surface as possible at all times, not to exceed a height of 2 feet.

6.3.8.06 The results of the operational check, the detection height and the date will be recorded on an Equipment Operational Check Log.

6.3.8.07 Repeatability of response(s) will be checked by performing the check two times per grid or subgrid.

### 6.3.9 Corrective Measures

Instruments that do not meet the accuracy of the standard checks will be tagged as inoperable and will be removed from the site until they can be repaired. Indications of operational deficiencies and corrective measures are addressed in Chapter 10.

### 6.3.10 Records Management

6.3.10.01 The SUXOS will provide the UXOQC/SO a detailed account of all ordnance, ammunition, and explosive items, components, or munitions debris encountered, including quantity, type, depth, condition, and final disposition of all items located in each area. The

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demolition supervisor will maintain an MEC Accountability Log providing the SUXOS with the details required for the official record.

6.3.10.02 The Daily Operations Log will be kept by the SUXOS or the site manager and will be considered the official log. The site manager shall maintain a spreadsheet or database that records MEC positions, number of like MEC items, nomenclature (if possible), sweep dates, QC/QA dates, coordinates, quantities of munitions debris, range residue, and other related scrap, drum inventory, and other pertinent data. The Daily Operations Log will be part of the information and data for the final report.

#### 6.3.11 Interim Reporting

The site manager will provide the project manager with the data from the Daily Operations Log summarizing the daily activities at the site.

#### 6.3.12 Map Format

Coordinates of all MEC located by the geophysical survey will be recorded using a Trimble Pro XSR GPS or other similar type unit. Coordinates will be in the Universal Transverse Mercator (UTM) Zone 19 projection using the North American Datum of 1927 (Puerto Rico). The maps will be provided in ESRI format.

### 6.4 Geophysical Investigation Performance Goals

#### 6.4.1 Detection of MEC or Other Munitions

Performance metrics for the detection of MEC are as follows.

- OOU-3, Cerro Balcon – No explosive hazards or MEC objects with a width (diameter) or thickness inclusive of MK 23 and larger
- OOU-4, Isla Culebrita – No explosive hazards or MEC objects with a width (diameter) or thickness of 20 mm and larger
- OOU-5, Adjacent Cays – No explosive hazards or MEC objects with a width (diameter) or thickness of a 3-inch navy gun fired projectile and larger

#### 6.4.2 Horizontal Accuracy

The precision and accuracy for all positioning data will not exceed  $\pm 1$  foot.

### 6.4.3 False Positives

False positives will not effect a detect-and-flag operation.

## 6.5 Geophysical Mapping Data

### 6.5.1 Monuments of Survey Markers

Monuments and survey markers will not be established during this project. Monuments already exist at Cerro Balcon, Isla Culebrita, Cayo Botella, Cayo Lobo, and Cayo del Agua. Temporary control points will be established at four corners of the investigation area at Cerro Balcon and at accessible points on Isla . The smaller cays will contain only one control point. Each control point will consist of a 3-foot length of number 8 rebar set to ground level.

### 6.5.2 Geophysical Data Analysis, Field Reacquisition, and Reporting

Not applicable for this type of operation.

### 6.5.3 Anomaly Reacquisition and Marking

Not applicable for this type of operation.

### 6.5.4 Anomaly Excavation Reporting

A final report detailing all field activities and including an inventory of all MEC items encountered, their disposition, and their coordinates will be furnished to USACE as required by the SOW. The final report will be provided in accordance with contract requirements.