Appendix A. Dam Safety Action Decision Summary (DSADS)

Herbert Hoover Dike
Dam Safety Modification Study

1. Dam Safety Action Decision Summary (DSADS)

1.1 Introduction

Herbert Hoover Dike (HHD) is the primary infrastructure containing the waters of Lake Okeechobee, and requires urgent repairs to minimize risks to public safety and provide an increased level of economic, social and environmental security in the region. Remediation of the dike will significantly reduce the risk of economic damages to the south Florida agricultural industry and catastrophic impacts to the Everglades.

Concerns regarding the dam's ability to perform satisfactorily for lake levels above elevation 15.5-ft NGVD (14.2-ft NAVD) has resulted in its identification as a high-risk project. Therefore, in 2006 HHD was assigned a Dam Safety Action Classification rating of 1. Without intervention, progression toward probable failure was confirmed to be taking place at several locations on the south and southeast sides of the embankment under elevated reservoir loading. Emergency repairs were completed at the locations where failure modes were observed to be progressing. Depending on the potential location of a breach, the life loss, economic, and adverse environmental consequences of a breach are considered very high. In recognition of the repairs needed at HHD, over $870 million has been invested in projects designed to reduce the risk of catastrophic failure of the aging structure. Actions taken include constructing an approximate 22-mile long cutoff wall along the southeastern shore of Lake Okeechobee adjacent to the cities of Pahokee and Belle Glade, removing and replacing water control structures/culverts, and conducting a dam safety modification study (DSMS) to help ensure the safety of south Florida residents. Removal and replacement of the 32 Federal culverts is scheduled for completion in 2022, and construction of an additional 6.8-mile cutoff wall is slated to begin in 2017 and be completed by 2020, as described in the 2015 Supplement to the Reach 1 Major Rehabilitation Report (MRR).

1.2 Justification for a Dam Safety Modification Study

The purpose of this report is to identify and recommend solutions to reduce the remaining risk of dike failure and life loss, and the associated inundation related economic, environmental and social damages to the communities surrounding Lake Okeechobee. This document describes the results of the DSMS and presents the recommended future actions needed to further reduce the risk at HHD.

HHD was assigned a Dam Safety Action Classification (DSAC) rating of 1 in 2006 due to the urgency of repairs needed and the high consequences of a potential dam failure. Repairs to 22 miles of HHD were initiated as a results of the DSAC 1 rating and completed in 2012; however, the risk for the remaining 128 miles of embankments remained uncertain. The existing condition risk assessment completed for HHD in 2014 identifies significant potential failure modes (PFM) that were determined to be intolerable for large portions of the dam. The DSMS is required to address these failure modes and identify and recommend the mitigation needed to reduce the probability of catastrophic failure of the dam (dike).

The primary dam safety risk drivers are internal erosion and overtopping of the embankment. Justification for federal action is largely based upon the probability and consequences of a dike failure for both current and

projected future conditions. HHD and Lake Okeechobee provide nationally significant benefits for flood risk management, navigation, recreation, water supply and ecosystem restoration.

1.3 Project Description

HHD almost encircles the 730 square miles of Lake Okeechobee, except for one uncontrolled opening at Fisheating Creek. Regional topography around the lake varies in elevation, but is relatively flat adjacent to the lake. In the event of a dam breach, inundation of the lake's surrounding areas would spread over a wide area instead of following a narrow downstream path. In addition, prolonged releases via controlled structures could cause local flooding in low lying areas near HHD and along connected canals. The embankment geometry existing today generally consists of 1V:6H slopes on the lake side, 1V:3H to 4H on the land side, and an approximate 10 to 15 foot wide crest ranging in elevation from 30 to 45 feet.

In addition to direct rainfall contributions to Lake Okeechobee levels, inflow to the lake occurs from Fisheating Creek, Harney Pond Canal, Indian Prairie Canal, the Kissimmee River, Nubbin Slough and Taylor Creek. In total about 5,600 square miles of surrounding land contributes inflow into the lake, primarily from the north and west. Water can also be directed into the lake from nine pump stations located throughout the system. HHD does not have a conventional spillway, and as a result, the outflow capability is significantly lower than inflow capacities. Outflow is limited to the St. Lucie Canal, the Caloosahatchee River, and four canals leading south to water conservation areas. There are also numerous culverts located throughout HHD, which discharge into landside canals and downstream toe swales / ditches. Outflow capacity constraints result in a maximum discharge capacity of approximately 19,000-cfs, (excluding evapotranspiration) or approximately 0.1 feet of drawdown per day. This outflow corresponds to roughly a sixth of the inflow potential. As a result, HHD needs the capacity to withstand large hydraulic loads for extended periods after significant inflows, while the lake level is gradually lowered.

1.4 Delineation of HHD

Herbert Hoover Dike has been sub-divided into distinct geographic areas to facilitate the description of planning conditions, the evaluation of risk, and the determination of consequences in the aftermath of a dam failure due to the extensive length of the dike system and variability of conditions existing along its length. Evaluation of sub-divided segments will prevent overrepresentation of life loss consequences, increase risk estimates accuracy across geologic and geometric changes, and reduce overall uncertainty inherent in evaluating markedly longer reaches.

The risk assessment divided HHD into thirty-two (32) segments based on significant changes in geologic conditions, embankment geometry, tail water conditions, and downstream consequences (Figure 1-1).

Common economic, social and environmental impacts can occur due to overlapping inundation patterns occurring from a breach anywhere within a specified common inundation zone (CIZ). The highly compartmentalized nature of the landscape surrounding Lake Okeechobee dictated by major canal and levee systems yields seven different inundation zones in which the post breach inundation will largely be contained. These seven CIZs (A-G) were identified with post-breach hydrologic modeling results based on inundation patterns following a breach up to reservoir elevation 26.3-ft NGVD (25.0-ft NAVD) (Figure 1-1). Since each CIZ would experience similar inundation patterns, breach-related social, economic and environmental damages for a given CIZ are not fully reduced unless all of the segments in that CIZ are remediated.

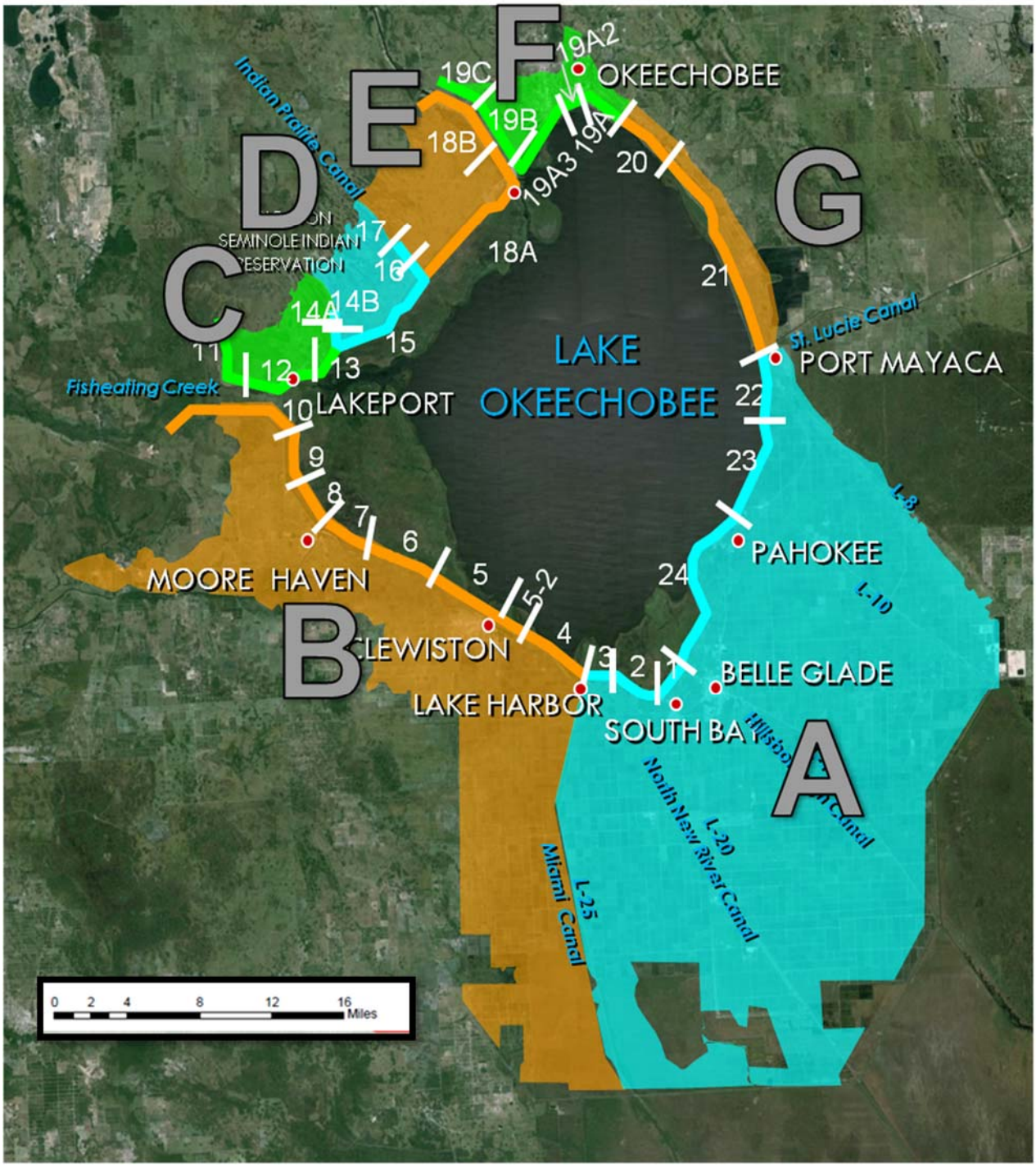


Figure 1-1 Seven Common Inundation Zones and 32 Herbert Hoover Dike Segments

1.5 Project History

Construction of HHD occurred in two major phases. Sixteen miles of levee on the north shore of Lake Okeechobee and sixty-eight miles of levee on the south shore of Lake Okeechobee were constructed using both dragline and hydraulic fill placement methods in the early 1930s. In the 1960s, the previously constructed levees were raised and widened and an additional 59 miles of levee were constructed around the remaining perimeter using dragline excavation and placement methods. No systematic compaction efforts are evident from the construction

photographs in either era of construction. HHD currently consists of approximately 150 miles of interconnected levees completely encircling the lake, with the exception of a small area on the west around Fisheating Creek where the embankment ties back into higher ground surface elevations.

1.5.1 Completed Risk Reduction Measures

Over the past several years, several risk reduction measures have been implemented to reduce the current operating risk. Including installation of a partially penetrating (hanging) seepage cutoff wall for the entire length of Reach 1 (~22 miles in length), with the exception of offsets (gaps) at existing structures and the Tory Island access bridge; completed in 2012. The following culverts are also being replaced in-kind: Culverts 1, 1A, 2, 3, 4A, 5, 5A, 6, 8, 10, 10A, 11, 12, 12A, 13 and 16. Culverts 7, 9, 14 and Taylor Creek Culverts operational functions were discontinued in prior years by abandonment and burial and have been or will be removed or remediated by other measures.

Additionally the following risk reduction measures have been implemented and/or evaluated to date:

- Tree removal
- Filling of toe ditches where excessive seepage has been observed and filling the existing rock quarry
- Installation of temporary drainage features
- Interior slope armoring of “hot spots”
- Perform emergency response exercise with cooperator (SFWMD) in a table top sessions to include breach scenario and a hurricane impact
- Interim surveillance plan which calls for increased inspections when the lake levels are low.
- Update the emergency management plan to include an associated breach repair plan and actions required under a Category 5 hurricane hit on the lake

1.6 Timeline of historical Events

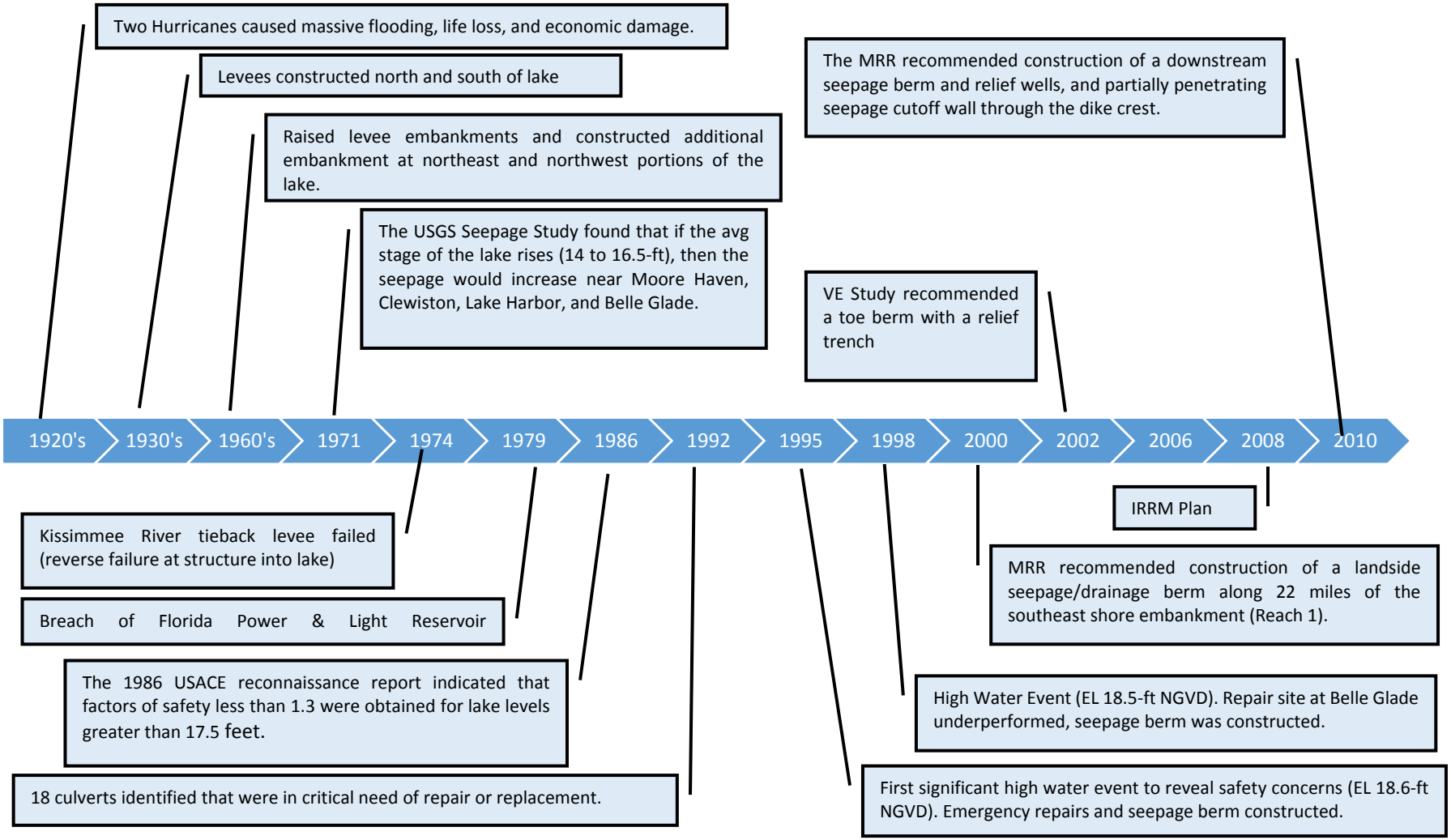


Figure 1-2: Timeline of Historical Events

1.7 Purposes Warrant Continued Federal Investment

Lake Okeechobee and HHD are a significant component of central and south Florida's water management system. HHD's authorized project purposes provide: flood protection and municipal and agricultural water supply to hundreds of thousands of people; commercial navigation; and a source of valuable recreation opportunities for tens of thousands of people. Additionally, HHD and Lake Okeechobee are critical for the continuation of ecosystem restoration in the Everglades. The most recent comprehensive study of flood protection is the HHD evaluation report (November 2000) and estimated the annual expected flood damages would be over $225 million (2012 price levels) if HHD ceased to function.

Lake Okeechobee is also an important source of agricultural and municipal and industrial (M&I) water supply in south Florida. According to the most recent available data (SFWMD 2005), Belle Glade, Pahokee, and South Bay still make some surface water withdrawals from Lake Okeechobee. Lake Okeechobee is a supplementary source of water for agricultural users and other municipal users, including Sarasota and Palm Beach County. Finally, the Lake provides inflow capacity for the Stormwater Treatment Areas (STAs) and Water Conservation Areas (WCAs).

The Lake Okeechobee Waterway is the only commercial waterway in Florida that connects the Gulf of Mexico to the Atlantic Ocean. Maintained by the USACE, the waterway includes 154 miles of navigable channels from Ft. Myers to Stuart. Two commercial channels traverse Lake Okeechobee, both of which connect the Port Mayaca lock to the Moore Haven lock. Annual benefits of the waterway is calculated as the difference between the costs of sending a commercial vessel through the waterway versus the cost of sending it around the southern tip of Florida. If the waterway were no longer functional, the loss of annual navigation benefits would be approximately $850,000.

Recreation resources for the project amount to 5,616,000 visits per year and the annual recreation benefits for Lake Okeechobee is greater than $8 million.

Lake Okeechobee is a crucial element of future plans for providing environmental flows to the Everglades and other natural areas in south Florida. While the dollar value of ecosystem services provided by HHD is difficult to quantify, Everglades National Park's designation as a World Heritage Site, a Biosphere Reserve, a Wetland of International Significance, and an Outstanding Florida Water demonstrates its ecological significance.

1.8 Significant Failure Modes

The failure modes described in the following sections are considered credible and significant based on the risk assessment of HHD; however, not all failure modes are significant in all 32 Segments. The significant failure modes described below were identified by the risk assessment (see Risk Assessment Technical Summary Part 2 Dated November 2015) as high-risk contributors to the project and should be mitigated in segments where these risks are considered intolerable.

1.8.1 Internal Erosion through the Embankment and Foundation

Internal erosion through the embankment and/or foundation is the main driver of HHD performance issues for many of the segments surrounding HHD. Internal erosion can be described as the movement of the soil within HHD caused by water seeping through the embankment and foundation from Lake Okeechobee. This internal erosion through the embankment or foundation is heavily influenced by the geologic conditions, embankment geometry and previous construction methodology (Figure 1-3).

Typically internal erosion failure progression depends upon a number of factors:

1. *Hydraulic Loading* – pool rises to a certain elevation
2. *Erosion Initiates* – seepage forces are sufficiently high to erode soil type present in the embankment or foundation
3. *Continuation* – there is sufficient energy from the lake to continue erosion back through the embankment or foundation and there are not filtering layers of impervious zones in the embankment to prevent continuation of erosion.
4. *Intervention Unsuccessful* – all attempts made to stop the erosion are unsuccessful.
5. *Breach* – pipe enlarges sufficiently to allow collapse of the embankment and the ensuing breach enlarges until the reservoir is emptied

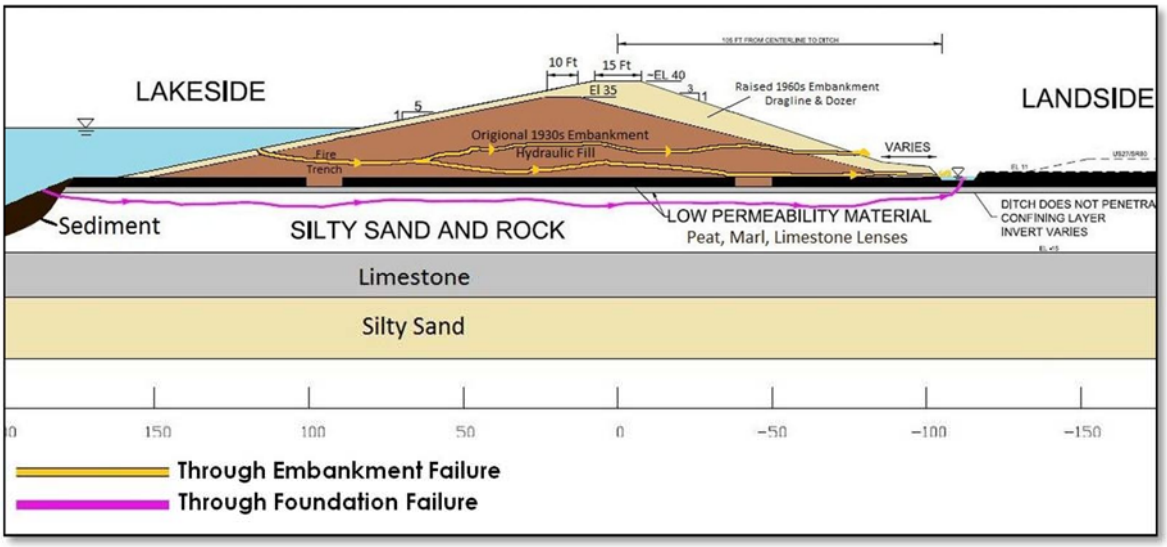


Figure 1-3: Typical failure mode paths for internal erosion through embankment and through foundation. This figure also shows typical geology around the southern half of the dam as well as the cross section of the 2 construction eras (i.e. 1930s regional construction and the 1960s raising and widening of the embankment).

1.8.2 Internal Erosion at Structures

There are 69 structure penetrations through the 150-mile long embankment. These include water control structures consisting of culverts, spillways, locks, and pump stations. Thirty-two federal culverts are currently being replaced, removed or abandoned. Many of these structures are under construction and all 32 are assumed to be remediated for the purposes of this DSMR. These structures are being designed to current industry standards and upon completion of their remediation will pose low risk. The remaining 37 structures were included in the risk assessment. Failure modes identified at the structure include internal erosion along the side of the structure, internal erosion through the foundation under the structures and internal erosion into the structure through a defect. Structures with actionable failure modes reside within segments which are actionable and will be remediated along with the segment.

1.8.3 Overtopping of the Embankment

The crest of HHD is high enough in most areas to prevent overtopping of all credible static pool levels. HHD is also subject to temporary higher water levels caused by wind induced storm surge and waves since the lake has a very

large surface area and is subject to tropical cyclone wind events. Overtopping has been identified as a credible failure mode for HHD, but overwash leading to dam failure has not been identified as an actionable failure mode. HHD failure due to overtopping requires the combination of two loading events to occur for the failure mode to initiate. The lake level must rise followed by a wind event that results in storm surge and waves. If the combined elevated lake levels and wind driven surge cause the water surface to exceed the crest elevation, the embankment can overtop for the duration of the wind event. The higher the reservoir elevation at the time of the storm event, the lower the wind velocity needed to result in overtopping. Overwash occurs when the waves break on the interior of the dam and run up the slope and over the crest of the embankment, but is not considered a credible threat to HHD.

The sequence of logical events necessary for the PFMs to begin, continue, and ultimately cause dam failure were identified.

1) *Hydraulic loading* – pool rises to a certain elevation

2) *Wind* – wind event creates setup and wave action

3) *Overwash* - waves run up and over the crest of the dam and/or water flows over the crest causing erosion on the landside face or toe. Overwash continues for sufficient duration and overwash volume to lose freeboard and results in breach.

4) *Overtopping* - wind setup continues resulting in a reservoir elevation that exceeds the dam crest elevation resulting in overtopping. Erosion leads breach.

Several locations on the tieback segments are excessively low, such that overtopping risk from reservoir/wind loading events was above tolerable levels. All areas of HHD could overtop or overwash under extreme hurricane loading if impact were to occur on an already excessively high reservoir level. The probability of these events occurring is low and the coincident probability of these events occurring at the same time is even lower; therefore, the elevation of most areas of HHD are considered adequately designed.

1.9 Risk Assessment and Consequences

Risk for HHD considers the probability that the dam could fail on any given year, the potential of life loss resulting from a failure, the economic and social impacts to the communities around HHD and the environmental impacts from breach floodwaters. The framework for decision-making focuses on the most serious risks in a consistent manner across the USACE portfolio of dams. Tolerable Risk Guidelines (TRGs) have been adopted by the USACE to categorize the nature of risks and facilitate identifying where action to reduce risk may be needed. The concept of tolerable risk is used to highlight that risk can be so low the minute probability of occurrence or limited consequences should be tolerated, since unconditional safety or guarantee a breach will not occur is not practicable. While TRGs do not provide a definitive answer to making investment decisions, they help identify what level of risk is tolerable or intolerable. It should be noted that risk simply exceeding tolerable risk guidelines does not mandate action, as in certain situations where the annual probability of failure slightly exceeds guidelines and the consequences of failure are low the risk may be tolerable. Based on the extent that risks exceed TRGs, the justification and urgency to take action increases, likewise as the degree of risk falls below TRGs, the justification to take action diminishes.

Numerical standards have been established to reflect tolerable risk levels for life loss and the annual probability that a breach could occur. For HHD to be considered tolerable there should be an expectation of less than 0.001 lives lost on an average annual basis. Additionally, the Annual Probability of Failure (APF) should be less than a 1 in 10,000 chance of occurring when economic, social or environmental consequences of a breach are significant.

Figure 1-4 identifies the results of the assessment of the probability of dam failure. The green to red shading represents the relative probability of failure for HHD. There are no areas around the lake for which there are no

risks (green shading) since there remains a remote possibility of extreme rainfall events and storm conditions which could lead to dam failure. The area of the existing cutoff wall is still identified as one of the areas of highest relative risk for HHD. There are still several non-remediated sections of the dike adjacent to structures in the area where the cutoff wall has been constructed that are slated to be complete in the next several years. Additionally, the 6.8 miles of cutoff wall approved for the area between the Miami and North New River Canals is expected to be complete by 2020.

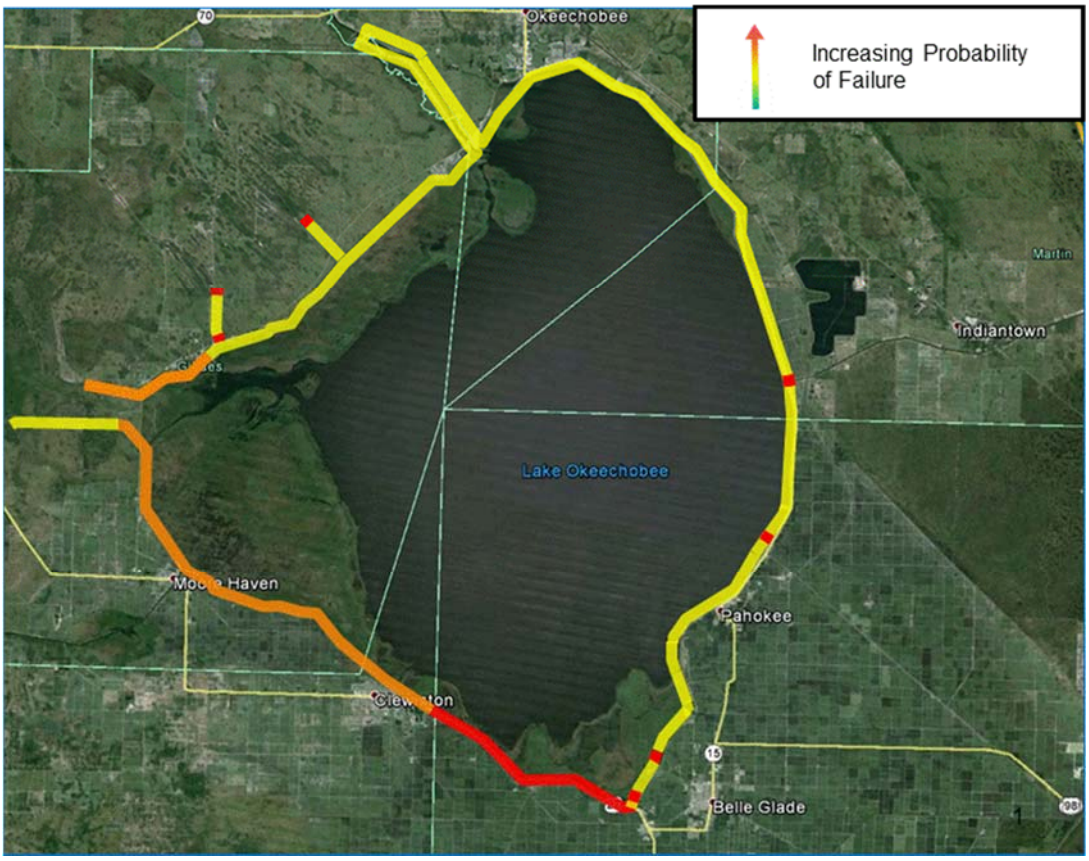


Figure 1-4: This figure portrays the relative probability of failure for HHD. The red shading is the highest concern of internal erosion or overtopping failure modes. The areas shaded in yellow are considered the lowest concern. No areas around HHD are shaded green in acknowledgement that even the previously rehabilitated conditions do not meet all USACE and Industry Essential Guidelines, and continued monitoring and inspections are needed to manage residual risk.

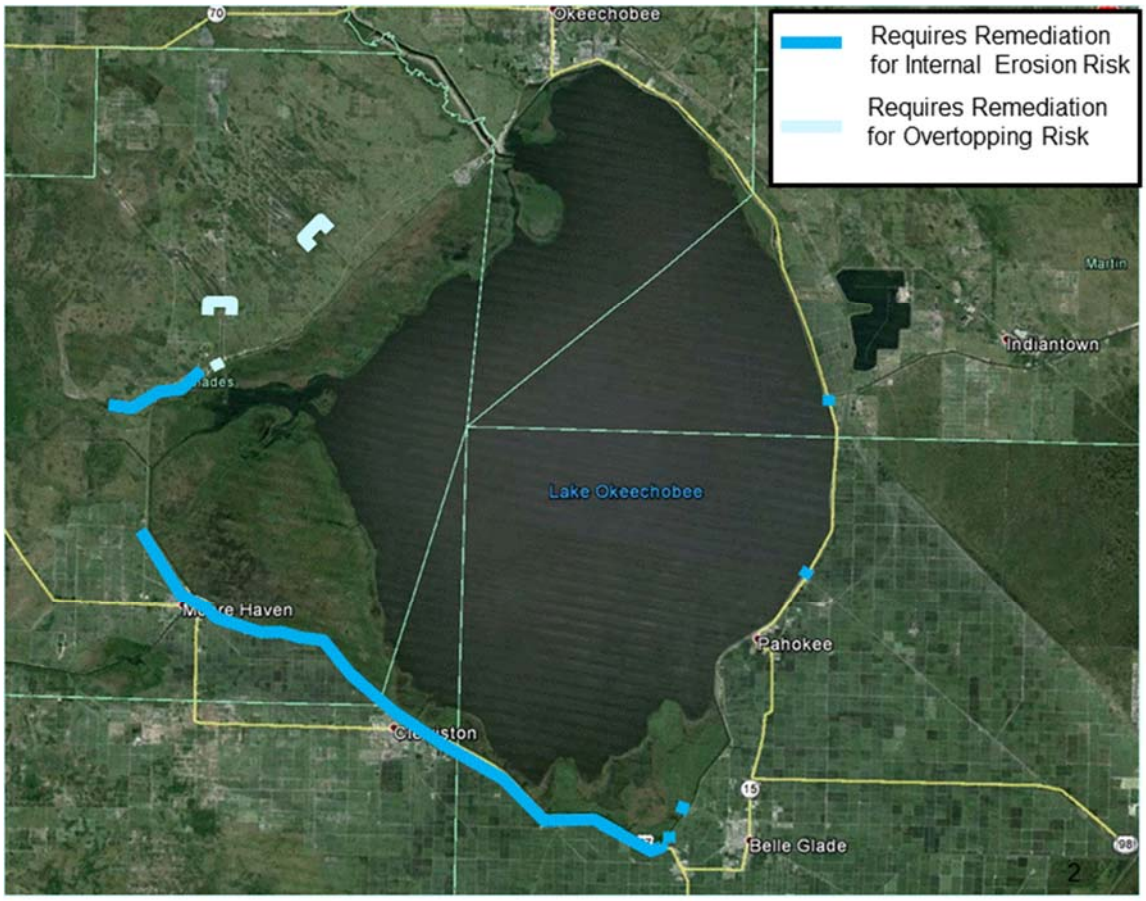


Figure 1-5: This figure portrays the locations where risks have been identified as intolerable due to combination of high probability of failure and the consequences of a failure.

A summary of the consequences of a breach are included in Table 1. Common Inundation Zone A is not listed in this table since the in-progress construction efforts are considered sufficient to reduce the risk to tolerable levels. No further action is anticipated in this area.

Table 1 Summary of Economic, Social and Environmental Consequences of a Breach

		Common Inundation Zone B	Common Inundation Zone C	Common Inundation Zone D	Common Inundation Zone E	Common Inundation Zone F	Common Inundation Zone G
Segments exceeding Tolerable Risk Guidelines		4,5,5-2,6,7,8,9	12, partial 13 Structure 71	Harney Pond Bridge Structures 71 and 72	Structure 72	None	None
Economic Impacts of a Breach							
Direct Economic Impacts	31ft	**$2,415,764,000**	**$204,653,000**	**$203,533,000**	**$272,223,000**	**$1,681,796,000**	**$411,556,000**
	25ft	**$1,453,393,000**	**$176,166,000**	**$120,643,000**	**$226,460,000**	**$1,005,327,000**	**$169,713,000**
	20ft	**$711,407,000**	**$142,629,000**	**$96,939,000**	**$184,695,000**	**$440,931,000**	**$97,799,000**
Number of Residents Relocated	25ft	13,231	1,045	709	1,692	13,027	717
	20ft	4,836	900	253	1653	8,423	519
Social Impacts of a Breach							
Schools		10 Schools; total enrollment: 4,321	No reported schools	No reported schools	No reported schools	5 schools, total enrollment around 3,000	No reported schools
Medical Facilities		Hendry County Medical Facility - 25 bed	No major medical facilities	No major medical facilities	No major medical facilities	100 beds hospital and medical offices	No major medical facilities
Government		1000 Inmate Prison; 1 fire department; 2 police stations; and Glades County government buildings	No police, fire or governmental services in inundation zone	No police, fire or governmental services in inundation zone	No police, fire or governmental services in inundation zone	2 Fire stations, 2 police stations, and several municipal and county government buildings	No police, fire or governmental services in inundation zone
Cultural Impacts		6 historic structures in Clewiston, 2 in Moore Haven	Potential flooding of tribal lands from a breach at SPF or greater lake stages	Potential flooding of tribal lands from a breach at SPF or greater lake stages			
Social Impact Summary		Breach at high lake stage could permanently disrupt viability of Clewiston and Moore Haven				Breach at high lake stage could permanently disrupt the city of Okeechobee	

	Common Inundation Zone B	Common Inundation Zone C	Common Inundation Zone D	Common Inundation Zone E	Common Inundation Zone F	Common Inundation Zone G
Environmental Impacts of a Breach						
Overall Ecology	Flooding throughout the WCAs and Everglades National Park, leading to destruction of tree islands and upland refugia. Substantial freshwater loading of the Caloosahatchee and St Lucie Estuaries leading to flora and fauna impact.	Substantial freshwater loading of the Caloosahatchee Estuary leading to flora and fauna impacts	Substantial freshwater loading of the Caloosahatchee Estuary leading to flora and fauna impacts	Substantial freshwater loading of the Caloosahatchee Estuary leading to flora and fauna impacts	Inundation of Eagle Bay	Substantial freshwater loading of the St Lucie Estuary leading to flora and fauna impacts
Threatened and Endangered Species	Snail kite critical habitat could be negatively impacted due to lower lake levels. Multiple state and federally protected species within south Florida would be negatively impacted due to a loss of habitat.	Snail kite critical habitat could be negatively impacted due to lower lake levels.	Snail kite critical habitat could be negatively impacted due to lower lake levels.	Snail kite critical habitat could be negatively impacted due to lower lake levels.	Snail kite critical habitat could be negatively impacted due to lower lake levels.	Snail kite critical habitat could be negatively impacted due to lower lake levels.

1.10 Risk Management Plan Formulation

Risk Management Plan (RMP) alternatives were formulated to meet the objectives of the HHD DSMS, minimize impacts to identified concerns and arrive at an efficient solution for failure modes posing intolerable risks to the public.

The formulation, evaluation, and comparison of alternative RMPs progressed from conceptual measures to a detailed final array of alternatives. As formulation progressed, the evaluation criteria increased in complexity and transitioned from qualitative analyses to quantitative analysis. A general overview of this formulation concept is described below.

Management Measure Screening: Multiple risk management measures (measures) were considered and screened to identify a subset of efficient and effective measures that serve as the building block of alternatives. These measures were identified as a means to reduce risk by either:

- reducing the loading on the dam
- reducing the likelihood the dam would fail
- reducing the consequences if a breach occurs

Initial Array of Alternatives Screening: The initial suite of alternatives for HHD is composed of combinations of retained structural and/or non-structural measures that address each significant failure mode. Structural measures are considered solutions that address the structural stability of the dike itself, while non-structural measures include measures intended to reduce risk by either reducing the loading of the lake or reducing the consequences if the dike were to fail. RMPs are broadly categorized into three different concepts that adopt retained measures to form an initial array of Alternative RMPs providing holistic risk solutions.

Formulation of alternatives follows these three concepts as described in the following section:

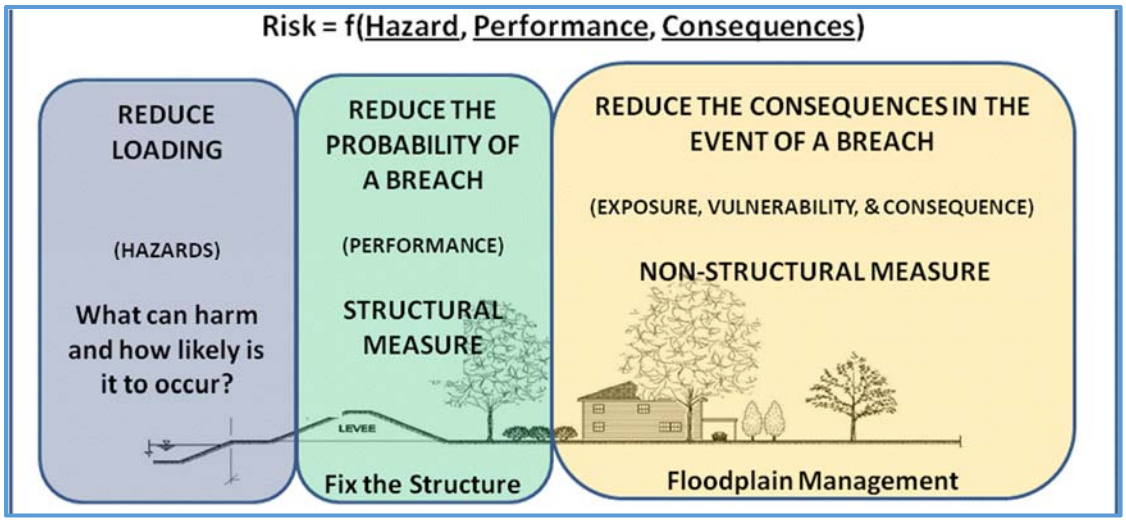
- System-wide structural remediation
- System-wide non-structural solutions
- Segmental structural and non-structural solutions

The initial array of Alternatives RMPs was evaluated using both qualitative and quantitative screening criteria, and alternatives were eliminated from further consideration based on their ability to meet tolerable risk guideline thresholds, construction related risk, cost effectiveness, economic and environmental impacts, and excessive implementation time. The result of this screening is the final array of alternatives.

Final Array of Alternatives Evaluation and Comparison: The final array of Alternative RMPs was then evaluated and compared based on cost, cost-effectiveness in achieving risk reduction, contribution to the USACE four Principles and Guidelines accounts, meeting DSAC V objectives (realizing tolerable residual risk and meeting essential USACE and industry engineering guidelines) to identify a recommended plan.

1.10.1 Risk reduction measures

Three organizational concepts were applied to the development and screening of management measures. These concepts include minimizing the likelihood of a failure by reducing the hydrologic and hydraulic loading on the dike, reducing the probability of failure via remediation of the dike, and reducing the consequences in the event of a dike failure. Each of these concepts has unique solutions.



A common set of qualitative evaluation criteria using a hierarchical approach was established to determine whether a measure would be evaluated in detail. The criteria are as follows:

Primary Criteria

- Effectiveness of risk reduction
- Construction cost efficiency

Secondary Criteria

- Constructability
- Robustness
- Proven Acceptance
- Environmental & Offsite Impacts
- Compatibility between measures was considered. A measure implemented at a structure must be compatible with a measure implemented at the embankment; as such, each embankment measure considered had a companion structure measure.

1.10.1.1 Reduce Loading on the Dam

The following measures were proposed to reduce loading on the dam:

Structural Measures

- Remove a section(s) of the dike so HHD no longer permanently impounds water
- Construct a new service spillway
- Create a controlled breach in selected location in order to avoid an uncontrolled breach at an unpredictable location

Non-Structural Measures

- Revise the Lake Okeechobee regulation schedule to reduce high water conditions

All identified structural management measures that reduce loading on the dike were retained for further evaluation as they were determined to be relatively similar in cost and effectiveness at reducing risk. In addition to the structural measures, the non-structural measure of changing the Lake Okeechobee Regulation Schedule (LORS) was retained as a low cost option requiring further analysis of effectiveness.

1.10.1.2 Reduce Probability of Failure

Given the expected hydrologic loading on HHD, measures were developed to reduce the probability of failure of the dam for each of the failure modes described in the Risk Assessment. All measures addressing the physical integrity of the dike (or the dike fragility) are formulated to improve the system response in the face of certain loading conditions and as such are structural in nature.

1.10.1.3 Internal Erosion through Embankment or Foundation Screening

Management measures for internal erosion through the embankment or foundation were screened using the common management measures screening criteria. The criteria and corresponding ranking was relative to each measure considered. The full suite of management measures were ranked relative to the other measures. The top measures were further refined to meet site-specific conditions evident in the different segments.

Carried Forward:

Although numerous variations of measures to protect against internal erosion failure modes were evaluated during the risk reduction process, retained structural measures can be generalized into two categories; cutoff walls and internal drainage systems. The depth of cutoff wall varied around the dam due to changes in geology and changes in downstream canal features that parallel the dam. Different variations of cutoff wall depths and internal drainage systems designed specific to the segment geometry were analyzed for effectiveness at risk reduction.

Table 2-1: Management measures retained for internal erosion through the embankment or foundation

Partially Penetrating Cutoff Wall	Internal Filters and Drains
Locations: Crest & Lakeside	Chimney drain extending to EL 17.0 to 25 ft in the embankment
Types: Cement bentonite, or soil cement bentonite slurry walls	Variations: Trench drain in the foundation with continuous discharge to ditch; trapezoidal collection & trench drain with pumped discharge locations; filter lining in ditch

Not Carried Forward:

- **Upstream barriers** are less effective at reducing hydraulic gradients through the foundation, and are subject to wave attack or erosion, and would have high environmental impacts.

- **Landside berms** are not as cost effective as the other measures being evaluated. The landside berm requires real estate (land) outside the federal right of way. The cost for the additional lands made this measure substantially more costly than other measures evaluated. The landside berms would also not be as effective at suppressing the internal erosion through embankment and foundation failure modes as other measures evaluated.

- **Relief wells** are not considered to be an effective solutions for treating the failure modes identified at HHD.

1.10.1.4 Measures - Internal Erosion along Existing Structures

Management measures were formulated to address internal erosion along structures when either the stand-alone structure was considered to have an intolerable level of risk, or it was necessary to tie into the structure sidewalls when risk reduction measures required for the embankment and foundation are adjacent to the structures.

Only one structure was estimated to be intolerable as a stand-alone failure mode, the US Sugar Raw Water Intake located in Segment 5-2. Although all other structures were estimated to pose be tolerable risk, it is still necessary to tie into the structure sidewalls when adjacent risk reduction measures are required for the embankment and foundation. This will prevent end around flow from concentrating at structures that penetrate the cutoff wall alignment and will prevent internal drains from stopping at an arbitrary point outside of a structure.

The management measures addressing internal erosion at structures carried forward or not carried forward for development of conceptual plans and detailed cost estimates are identified in the list below:

A. Concrete structures penetrating the embankment and adjacent embankment measure is a partially penetrating seepage cutoff wall

Carried Forward:

- Jet grout constructed secant columns to connect embankment cutoff wall to structure.
- Secant sand filters constructed from cased drill holes and parallel jet grout cutoff wall to connect embankment cutoff wall to structure.
- Braced open excavation and construction of zoned backfill to connect cutoff wall to structure.

Not Carried Forward:

- Secant concrete piles with jet grout closure at structure sidewall; this measure is a subtle variation of the jet grout cutoff wall above. This measure requires two specialty techniques and is therefore less cost effective than jet grout columns alone over a short distance.
- Slurry cutoff wall with jet grout closure at structure sidewall; this alternative was a subtle variation of jet grout columns above; as it was considered to only describe how a slurry wall through the main embankment would be connected to a structure side wall.
- Specialty techniques such as Trench cutting Re-mixing Deep wall (TRD), Cutter Soil Mix (CSM), Hydromill, or slurry supported trench with long reach backhoe were eliminated from consideration since the cutoff wall cannot be constructed to be in direct contact with the various structure sidewall geometries.
- Open excavation with a low permeable backfill core. Open excavation is not constructible given the limited space around the structure, the required slopes for a stable open excavation, and the inability to guarantee control of the reservoir at levels throughout construction.
- Braced open excavation and backfill with cementitious flowable backfill was considered to be a similar but less effective measure as compared to the braced open excavation and zoned backfill.. Flowable fill was considered less effective, considering tension cracks could develop due to hydration shrinkage of the cement component of the backfill.
- Sheet pile cutoff wall adjacent to structure with a jet grout closure between sheet piles and the structure wall; this alternative was a subtle variation of jet grout columns above; as it was considered to only describe how a sheet pile wall through the main embankment would be connected to a structure side wall.

B. Concrete structures penetrating the embankment and adjacent embankment measure is an internal drainage system

Carried Forward:

- Secant columns of filter soil constructed from cased drill holes that connects the drain to structure.
- Secant columns of filter soil and parallel jet grout cutoff wall that connects the embankment drain to structure

- Braced open excavation and construction of a zoned embankment that connects a downstream filter to the adjacent embankment drain.

Not Carried Forward:

- Open excavation and construction of a zoned embankment is not constructible given the required slopes for a stable excavation and the inability to guarantee control of the reservoir levels throughout construction.

C. <u>Pipes penetrating through the embankment and adjacent embankment structural measure is a partially penetrating seepage cutoff wall</u>

Carried Forward:

- Jet grout columns between and around conduits that connects the adjacent embankment cutoff wall across the pipe penetration.
- Open excavation to remove a section of pipe, install cutoff wall, reconnect pipes in concrete encasement, and reconstruct embankment with low permeability backfill that connects the adjacent embankment cutoff wall across the pipe penetration.
- Open excavation to remove a section of pipe, install cutoff wall, backfill with low permeability backfill, and reconstruct pipes through higher elevation in the embankment

D. <u>Pipes penetrating through the embankment and adjacent embankment structure measure is an internal drainage system</u>

Carried Forward:

- Open excavation on downstream side of embankment, install trench drain to intercept foundation seepage, and backfill around pipes with filter soil on downstream third of the pipe alignments.

1.10.1.5 Wind Driven Wave Overtopping of Embankment and Where Roadways Cross the Embankment

Risk reduction measures to address potential failure modes for overtopping at SR 78 roadway crossing of the Harney Pond embankment were developed. At this location, the embankment crest dips to meet the roadway profile crest elevation. The measures were screened using the same three screening criteria as internal erosion failure modes: effectiveness in reducing risk, cost/cost effectiveness, and environmental and off-site impacts. The measures carried forward and not carried forward for development of conceptual plans and detailed cost estimates are identified in the list below:

Carried Forward:

- Armoring the crest and downstream embankment to prevent erosion of the embankment during a limited duration overtopping or overwash event.
- Raising the embankment by floodwall
- Harden embankment around bridges/roadways so temporary overtopping does not result in breach of the embankment. Recommend to the Florida Department of Transportation (FDOT) the bridges be constructed to higher elevations when they are replaced (either from completion of service life or due to roadway widening).

Not Carried Forward:

- Construct floodwall across spillways or bridges. It is not possible to construct floodwall across these structures without eliminating their intended function.
- Raising the embankment with fill (landside or lakeside) was eliminated since an earthen embankment raising is not a cost-effective measure due to lack of a borrow source at HHD and the need to mitigate for environmental impacts on the interior littoral shelf or acquire real-estate on the downstream toe. Additionally,

areas of high risk for this failure mode are adjacent to structures; therefore, raising the embankment would also require reconstruction of the structure to higher elevations.

- Riprap on the lakeside slope cost was excessive compared to the other alternatives considered.
- Hard armor landside slope with concrete, asphalt, or soil cement are considered less effective variations of Articulated Concrete Block Mattress (ACBM).
- Place flexible/permeable soft armor on the landside slope such as a geocell, or turf reinforcement mat or geotextile are considered ineffective at reducing risk associated with overwash and overtopping failure mode.
- Replacing and raising the bridge and approach ramps is not as cost effective as armoring the slopes.
- Raising the bridge and the roadway approaches was considered to be as costly as replacing the bridge.
- Reconstructing the embankment around the bridge is not as cost effective as armoring the slopes.
- Constructing floodgates at the bridge crossings is not cost effective in comparison to armoring the slopes and would also result in temporary closure of the emergency evacuation route.
- Constructing floodwalls around the bridge does not address overtopping at the roadway.
- Constructing hurricane gates is not cost effective as armoring the slopes.

1.10.2 Non Structural Measures to Reduce the Probability of Failure

Several non-structural risk reduction measures to detecting initiation of a failure mode and allowing early intervention were formulated, but none was carried forward.

Not Carried Forward:

- Installing a fiber optic seepage monitoring system on the HHD landside embankment to detect initiation of a failure mode to allow rapid intervention was considered ineffective in significantly reducing probability of failure, as this measure would only detect seepage and not initiation or progression of a failure mode.
- Unmanned thermal surveillance aerial vehicles (drones) do not detect seepage below surface water (water absorbs the thermal signal) and would not be able to distinguish between seepage and initiation for above surface water seepage.

1.10.3 Reduce Consequences if a Breach in the Dam Occurs

Risk reduction measures to reduce life loss and economic, environmental and social impacts if a breach in the dam were to occur were examined; however, no viable measures were carried forward. The measures identified in the list below are the responsibility of the State and local governments.

Not Carried Forward:

- Alleviate compartmental flooding which results in localized deeper inundation by providing flow paths (providing box culverts underneath roads/levees, construct bridges, lower roadway/levees) for more efficient flow downstream. This measure was eliminated due to high cost and significant off-site impacts.
- Construct a flood protection levee around population centers. In many instances, the cost of constructing flood protection levees was the same as remediating the dike when taking into account access, internal drainage issues, and physical characteristics of the levees required.
- Elevating structures (flood-proofing) by raising them off their foundation to prevent inundation. This was determined to be impractical when considering the constructability and viability of elevating the existing housing stock. The number of houses requiring raising also made for an unacceptably long implementation time.
- Property acquisition and relocation of residents in areas where life safety concerns exist. Real estate acquisitions would cost many times more than a structural fix and require a significant amount of time to acquire the property.

- Property acquisition of impacted properties in areas experiencing intolerable economic or social impacts.

The cost of acquiring Clewiston, Moore Haven and flowage easements through agricultural lands would be many times greater than the cost of structural fixes.

Responsibility of the State/Local Interests - Not considered for Federal action

- Provide reverse 911 service to all adjacent population centers and areas around HHD
- Install warning sirens around HHD and in adjacent population centers
- Provide/improve upon emergency broadcasts (radio/TV/internet)
- Increase public education for risk (installation of poles with flood stages on them, meetings to show inundation areas, informing public of risk residing downstream of a dam)
- Improve transportation systems (traffic and evacuation management, providing emergency busing)

1.11 Risk Management Plans

Figure 1-6 displays the initial suite of alternatives considered for remediating HHD. The alternatives shaded in green represent the five plans required to be examined in a USACE dam safety study and the alternatives shaded in white were additional alternatives identified.

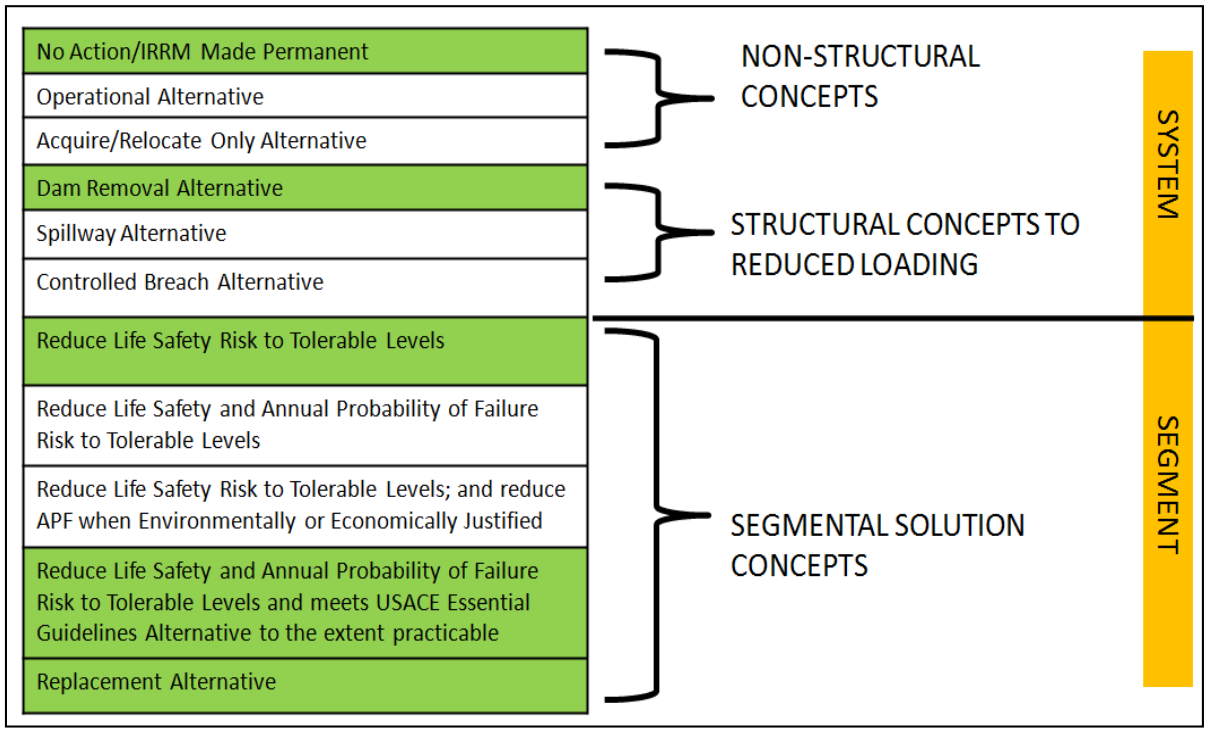


Figure 1-6: Overview of Initial Array of Alternatives

1.11.1 Screening of System Non Structural Risk Management Plans

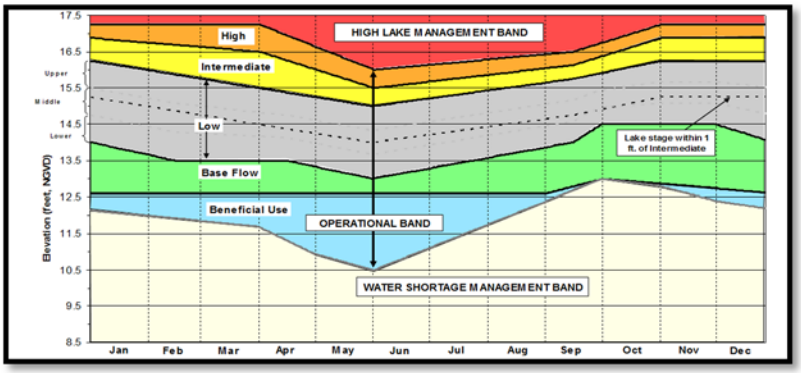
1.11.1.1 No Action/IRRM Made Permanent

The No Action Alternative is defined as not taking Federal action to improve the existing system. This alternative assumes the lake is operated according to the current interim regulation schedule (Lake Okeechobee Regulation Schedule, LORS 2008). The schedule is intended to contain the lake stage within a band that best satisfies the Central and Southern Florida Project flood damage reduction, water supply, navigation, and environmental

objectives, while reducing the likelihood of a lake stage that could cause dam failure. The baseline risk assessment demonstrated, even with the loading restrictions imposed by the current regulation schedule, the existing risk is still well above tolerable risk guidelines in many areas. This plan offers no opportunity to restore authorized project benefits or reduce risk to tolerable levels. The No Action alternative is retained for further analysis in this DSMR and used as a baseline of comparison among the other alternatives.

1.11.1.2 New Lake Okeechobee Regulation Schedule

Several Lake Okeechobee regulation schedules were considered to determine if a change in the lake regulation schedule could significantly reduce the loading on the dam, and therefore the necessary rehabilitation.



As part of the HHD Major Rehabilitation Report 2000, a stage-frequency analysis was conducted demonstrating, even with an initial lake stage of 10.4-ft NGVD (9.1-ft NAVD), the Standard Project Flood (SPF) event results in a peak lake stage of 25.0-ft NGVD (23.7-ft NAVD). This situation is caused by a large volume of water flowing into the lake during a standard project flood (SPF) event combined with a limited lake discharge capacity. Therefore, implementing a modified operational schedule would not significantly reduce lake stages during large storm events, and this alternative was screened from further consideration in this DSMR.

1.11.1.3 Relocate Population at Risk

In order to reduce the life loss, economic damages and social impacts to the communities surrounding Lake Okeechobee, acquisition and relocation of all private lands would be required. The relocation of the entire structure inventory and prevention of future development in the area of inundation from a potential breach at a probable maximum lake stage is estimated to cost approximately $18.4 billion. This cost is considered prohibitive.

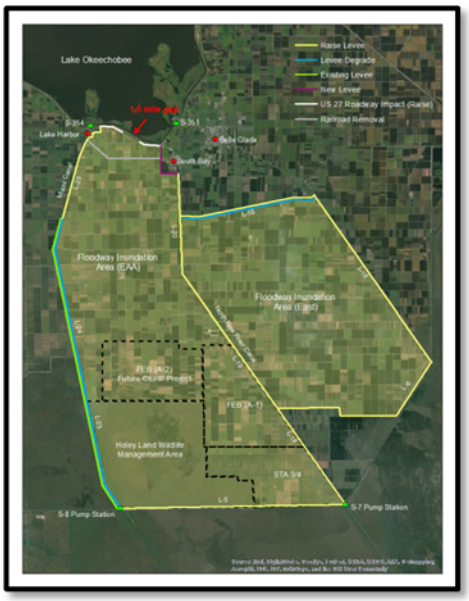
However, this alternative was further refined to focus only on relocating the population in three areas the estimated average annual life loss is considered intolerable. The intolerable average annual life loss at the Raw Water Intake in Segment 5-2, in Segment 8 and in Segments 12/13 all coincide with high population centers and a high probability of failure. The cost to relocate the population in these areas would be far greater than the least costly structural solution as it is difficult to pinpoint exactly which structure may see fatalities requiring the acquisition of large areas of homes within a high-risk zone. Acquiring and relocating just residents with intolerable risk of life loss would also leave the remainder of communities susceptible to property damage.

1.11.2 Screening of System-Wide Structural Risk Management Plans

1.11.2.1 Dam Removal

The intent of this alternative is to remove some portion(s) of the dike, or water control structures, so the dike no longer retains a permanently impounded pool. Because the dike and its associated water control structures are integral components of the Central and Southern Florida (C&SF) Project, this plan would require de-authorization of major portions of the C&SF Project.

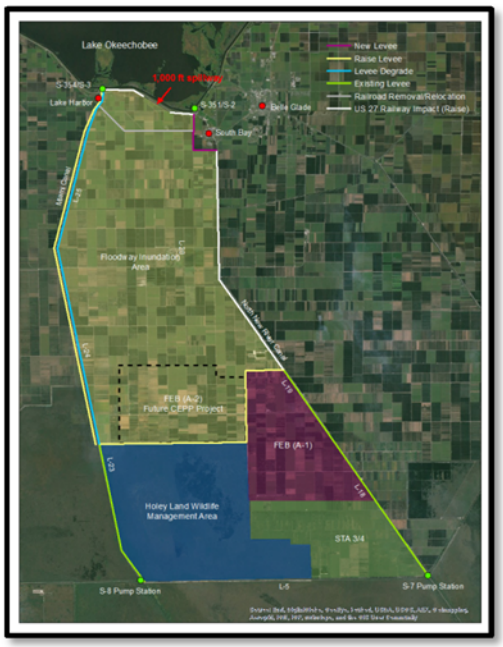
Based on analysis performed to route the SPF storm event, the dam removal alternative includes the degradation of a 1.0 mile portion of the dam in Segment 2 to a crest elevation of 10.3-ft NGVD (9.5-ft NAVD). Lake stages were limited to 16.8-ft NGVD (15.5-ft NAVD) based on an assessment of risk associated with lake stages. The resulting peak lake stage during the SPF event was 13.6-ft NGVD (12.3-ft NAVD), which fell within the maximum stage requirement. The downstream area required to: 1) sufficiently capture discharges to meet the maximum lake stage, and 2) meet the desired downstream pool depth (depth of 6ft or less to allow emergent vegetation to dampen wind effects) resulted in use of lands between the North New River Canal and Miami Canal, as well as land east of the North New River Canal. Levee modifications to the multiple canals are included. Additionally, the alternative includes reconstruction of a portion of US Hwy 27 including a bridge; relocation of a railroad; demolition of an industrial complex; and remediation of soil contaminated with agriculture industry chemicals will be required. The estimated real estate cost alone would be $1.6 to $1.9 billion. Construction costs would be additional. The Dam Removal Alternative is not carried forward because of the high cost, time to implement, and the significant adverse impacts to the benefits provided by Lake Okeechobee and the entire C&SF Project.



1.11.2.2 Gated Spillway

The gated spillway would be constructed using a multi-bay bottom-hinge (crest elevation 14.0 ft with gate closed (in "up" position) and 10.5 ft with gate open (in "down" position)) and an 89,000 acre downstream water retention area. The downstream retention area is required to retain the discharges and prevent the potentially detrimental water quality from reaching the Everglades. The Lake Okeechobee pool stage requirement is the same for the spillway option as described in the Dam Removal. Such a pool restriction is expected to reduce risk to within the tolerable risk guidelines, while preserving C&SF water supply and navigation benefits, and having only minimal adverse effects on the existing lake ecology. This plan would require reauthorization of major portions of the C&SF Project. The spillway configuration reduced the peak stage to 17.2-ft NGVD (15.9-ft NAVD) during an SPF event and would sufficiently reduce risk at the facility.

The retention area would be formed by levee modifications adjacent to the Miami Canal, the North New River Canal, and Holey Land, and new levee construction near the town of South Bay, and partial levee degrading along the Miami Canal north of Holey Land. This plan also includes reconstruction of a portion of US Hwy 27, including a new 1,000 ft bridge to allow water through the roadway corridor; relocation of a railroad that traverses the retention area; demolition of an existing industrial complex; and remediation of soil contaminated with agriculture industry chemicals. This plan is intended to preserve the function of the State's existing Stormwater Treatment Area 3/4 and future A-1 Flow Equalization Basin, although the infrastructure modifications required doing so have not been investigated. The estimated real estate cost would be approximately $1.6 to $1.9 billion not including construction.



The gated spillway alternative is not pursued further in this DSMS because of the high cost and time to implement.

1.11.2.3 Controlled Breach and Retention Area

This plan includes deliberately breaching the dam at a predetermined location to result in no/low potential for life loss and prevent a breach in a location that would result in a much higher expected life loss. This plan differs from the Dam Removal Alternative since this plan is based on a scenario in which an internal erosion failure has progressed, intervention has failed, and a breach will occur within 24 to 36 hours absent a rapid drop in lake stage. Within a short notice period (2-3 hours), local law enforcement should clear the population at risk from the predetermined impacted/inundation area and re-route all traffic accordingly. The proposed controlled breach location is the same as the new service spillway, to take advantage of a low-lying downstream agricultural area to serve as a breach flood getaway and temporary retention area, assuming required flowage easements are secured. The breach width necessary to lower the reservoir within 24 hours is estimated to be 3.75 miles.

Although this plan offers an opportunity to reduce risks, it does not reduce risk associated with a wind-driven wave overwash failure and, despite the efforts of local law enforcement; transient populations will likely remain in the inundation area. Additionally, the effectiveness of this plan is questionable and relies on the failure mode to be discovered in advance with sufficient notice to complete the above listed activities prior to breach.

Downstream property damages would likely include damages to US Hwy 27 (emergency and interior hurricane evacuation route for south Florida region), a railroad, an existing industrial complex, and others. In addition to infrastructure damage, indirect damages include economics of the region with loss of crops and flooded quarries for an extended period of time (e.g. months to years), as well as catastrophic environmental damages to a sensitive and unique ecosystem undergoing billions of dollars in Federal and state capital investments. Potentially, flood damages may occur elsewhere within the C&SF system as the main floodwater storage components of the system (Lake, Water Conservation Areas, future reservoirs) would be strained with dewatering of the flooded EAA area for up to a year (e.g. lack of pumped water storage, excess seepage from the conservation areas over long duration, canal storage, etc.).

Based on a screening level evaluation, this plan was eliminated from further consideration.

1.11.2.4 Dam Replacement

This plan includes replacing the existing dam with a new dam, built in increments, along the same alignment. Existing embankment material would be reused to the extent practical. This plan would require reauthorization of major portions of the C&SF Project. Dam replacement may require multiple decades to complete, with an estimated construction cost of $15 billion.

The Dam Replacement Alternative is not pursued further in this DSMR because of the high cost and time to implement.

1.12 Initial Array of Risk Management Plans – Screening Summary

There were 11 distinct alternatives evaluated in the initial array. These alternatives were evaluated on their effectiveness at meeting project objectives, specifically the ability to reduce risk to tolerable levels, cost and cost effectiveness, constructability, and length of time to implement. The four alternatives identified by combining discrete solutions at the segment and consequence zone level were retained as viable alternative that provide actionable solutions to be further evaluated in the final array. The remaining 7 alternatives were eliminated from further consideration and the rational for elimination is included in the following table:

Table 2-3: Screening of Initial Array of Risk Management Plans

Alternative	Effectiveness	Efficiency	Constructability	Implementation Time
Non-Structural System Alternatives				
Operational Alternative	Not effective at reducing risk			
Real Estate Acquisition and Relocation	Does not reduce risk to environmental resources	Excessive Cost Requires acquisition of thousands of properties		Substantial property acquisition and authority
System-Wide Remediation Alternatives				
Dam Removal	Substantial economic and environmental impacts			Requires de-authorization of C&SF
Spillway		Excessive Cost	Substantial flood barrier construction	Substantial land acquisition
Controlled Breach	Substantial economic damages	Excessive Cost		Substantial land acquisition
Dam Replacement		Excessive Cost		

1.13 Final Array of Alternatives

1.13.1 Internal Erosion Failure Modes

Four alternatives that increase the structural integrity of HHD (Alternatives 1-4) and reduce the risk of internal erosion failure modes were evaluated and compared to identify the efficient alternatives meeting the objectives of the DSMS. Taking no further federal action is not recommended since there remains an intolerable level of risk to the communities around HHD. Alternatives also include measures to reduce the risk of overwash at three low spots around the dam, which is described following the alternative descriptions below.

1.13.2 Segmental Risk Management Plan Formulation

While system-wide solutions are geared towards universally remediating the failure modes in the dike, segmental solutions are based on the understanding that different failure modes exist in discrete areas of the dike and as such, different solutions may be more appropriate for one area than another. As previously described, the dike was divided into thirty-two segments for which performance of adjacent lengths are considered statistically independent. Alternative plans were formulated and evaluated for each segment based on their measured success at meeting the Federal objective of identifying a risk management plan supporting the expeditious and cost effective reduction of risk within the overall USACE portfolio of dams and satisfying or partially satisfying specific study objectives of:

1. Reduce societal life safety risks to tolerable levels for the entire system with efficient and technically acceptable solution
2. Reduce societal and individual life safety risks and the probability of failure to tolerable levels for the entire dam (holistic solutions) with efficient and technically acceptable solutions
3. Comply with essential USACE guidelines with cost effective solutions to the extent practicable

Formulation of alternatives by segments followed a series of steps to identify solutions satisfying tolerable risk guidelines.

Step 1: The risk assessment of each segment for both existing and future without federal action conditions (FWAC) was examined to identify where formulation of risk reduction measures is needed.

The first criterion in identifying minimally acceptable alternatives pertains to remediating areas of the dike where the risks of public safety and loss of life is intolerable. Since societal life loss is paramount to the Dam Safety program, a conservative approach was taken to account for uncertainty and formulate any segment without considering the potential for intervention. At a minimum, all alternatives in the final array must reduce risks to greater than an order of magnitude below societal life safety TRGs.

Life safety risks in Segments 5-2, 8, and 12 were determined to be intolerable.

The second criterion examined the probability of a dike breach occurring in any given Segment on an annual basis. Contrary to the formulation of segments for societal life loss and public safety, an alternate approach was taken when formulating solutions based on the annual probability of a dike failure and consideration for intervention was included.

Segments 4 through 9, and 12 are all considered to have an annual probability of failure that causes concern and are included in the formulation of alternatives.

Structures S-71, S-72 and the Harney Pond Canal Bridge crossing also cause concern for an overtopping driven dike failure due to low dike elevations at these points. The remediation of these structures (ACBM or floodwall) is included in all of the alternatives as the cost of remediation is low when compared to the economic, social and environmental damages that would occur from a breach at these locations.

Step 2: Alternative formulation then focused on identifying combinations of segmental measures within CIZs in order to reduce the probability of a breach, and the resulting economic, social and environmental risks to tolerable levels for the entire zone. Common economic, social and environmental impacts will occur due to overlapping inundation patterns occurring from a breach in any segment within a CIZ. The annual probability of a breach and the economic and environmental risks for a given zone are not tolerable unless each segment in the zone is tolerable. Leaving a "weak link" or intolerable segment in any of the zones would render the entire zone intolerable.

Step 3: After solutions were formulated per segment, they were categorized into alternative concepts. The resulting measures identified at the segment were simply combined to form four alternatives at the CIZ. Respective alternatives per CIZ were then combined to provide four complete alternatives based on segmental solutions.

The four alternatives are as follows:

Alternative 1: Alternative 1 reduces societal life safety risk to tolerable levels for every segment using the most cost-effective approach. As societal life safety is of paramount concern to the nation, the segments included in this minimal alternative are also included in Alternatives 2-4.

Alternative 2: Alternative 2 includes the risk management plans identified in Alternative 1 to reduce societal life safety risk and includes segments where the risk to individuals and the probability of a dike breach are intolerable. Additionally, for segments that life safety risk is tolerable, this alternative includes remediation of segments or CIZs having an intolerable probability of failure, regardless of the economic, environmental or social consequences.

Alternative 3: Alternative 3 reduces risks for all segments in which either societal or individual life safety risks were determined to be intolerable. Additionally, for segments that life safety risk is tolerable but the annual

probability of failure is intolerable, this alternative includes risk reduction if there are significant economic, social or environmental risks as can be noted in CIZ A-F.

Alternative 4: Alternative 4, similar to Alternative 2, also reduces individual and societal risk for every segment, and brings the probability of failure to tolerable levels for every segment regardless of the economic, environmental or social consequences. However, this alternative is formulated to achieve a complete remediation of the individual failure modes being addressed to support the ultimate goal of having an adequately safe dam that meets essential USACE guidelines and the total residual risk for the dam is considered tolerable (DSAC V).

1.13.2.1 Segmental Risk Management Measures Considered

Structural risk reduction measures for internal erosion can be generalized into two categories; cutoff walls and internal drainage systems. Three general variations of cutoff wall and three general variations of internal drainage systems were evaluated. For cutoff walls, these variations include different depth governing criteria based on the location specific geology and the cross sectional details of the embankment in each segment. Two different alignments of the cutoff wall were also considered (i.e. in the lakeside face of embankment or along the centerline). Variations in the internal drainage system included depth or presence of a foundation trench to intercept through foundation seepage, presence of a chimney drain in the embankment to intercept through embankment seepage, and the materials and layers within the blanket drain.

Segmental structural designs do not completely rehabilitate the dam for all conceivable reservoir elevations, but measures were modified as necessary to provide adequate risk reduction as estimated by the risk reduction team.

1.13.2.1.1 Cutoff Walls

Cutoff wall depth varied by segment based on local geologic conditions (permeability of the strata penetrated by the wall, erodability of the foundation strata, reduction in estimated seepage forces, etc.). The proposed wall depths were also influenced by the cross sectional characteristics of the embankment influencing the depth of an internal erosion failure path; such as ground surface elevations at the toe and ditch or canal invert elevations. Cutoff walls are proposed to be located in the center of the crest and constructed of a soil-cement-bentonite (SCB) mixture, constructed by mixing cement bentonite clay slurry with existing HHD soils. This will result in a low permeability barrier with strength characteristics similar to weak concrete. An alternative alignment considered along the upstream face of the embankment was screened out since this location provided no additional risk reduction and required fill for the temporary construction platform to be placed over the existing riprap and in some locations into the littoral zone of the lake. This upstream location would also increase construction related risk to the dam during construction as significant excavation would be required into the embankment.

Generally, the proposed cutoff walls can be separated into three categories:

1) **Traditional cutoff walls** tie into a confining layer and cut off most seepage, reduce downstream pressure and seepage forces, cut off horizontal failure paths and force a failure path to advance through less erodible soils or limestone. This solution is applicable where geologic layers exist to tie into (Portions of Segments 12/13, Segments 5, and 6).

2) **Partly penetrating cutoff walls** achieve risk reduction by increasing the seepage path length, interrupting the horizontal failure path through the embankment and shallow foundation, add a vertical component to the failure mode progression and force a failure path to advance through less erodible soils, and significantly increase the reservoir levels that could initiate and progress an internal erosion failure mode to failure. This cutoff wall is proposed for a few isolated areas in the south of HHD.

3) **Partly penetrating cutoff walls that penetrate limestone** are similar to that discussed above but with the additional benefit of forcing seepage flows and the failure path through non-erodible limestone or through a more tortuous path that must progress through defects in the limestone. This type of cutoff wall is applicable to most

of the southern segments of HHD. The magnitude of risk reduction is significantly different for the various wall types and therefore the depth requirements of the wall are variable around the dam.

1.13.2.1.2 Internal Drainage Systems

Three general configurations of internal drainage systems were evaluated. The design and effectiveness of an internal drainage system varied around the dam considering local geologic conditions, actionable failure modes, and adjacent features such as ground surface elevations and ditch or canal invert elevations. The proposed internal drainage systems are composed of different variations of chimney, blanket and trench drains. The functionality of the various drainage systems is the same; however, some have trenches to intercept through foundation seepage while other variations simply line the seepage exit point with filter materials. All of the drains are passive systems with the exception of the trapezoidal drain containing a sump and pump and is not reliant on the upstream to downstream gradient.

All of these drains consist of variations of the three basic designs presented below. The internal drainage systems generally utilize an ASTM – C33 fine aggregate (concrete sand) as the filter component; this material will allow passage of seepage water while retaining (filtering) the existing embankment and foundation soils.

(1) **Chimney, blanket and trench drains** systems include a chimney to intercept through embankment seepage, a trench to intercept and drain through foundation seepage, and a continuous blanket that discharges to a downstream ditch or canal.

(2) **Trapezoidal Drains** are similar to that described above, except seepage is collected into a trapezoidal drain with imbedded perforated pipe. Seepage is collected in sumps and point discharged by pumping to downstream ditch or canal.

(3) **Chimney, blanket and ditch lining systems** also include a chimney and blanket with continuous discharge through a blanket drain into the downstream toe ditch; however, this measure eliminates the trench feature in the foundation and utilized an inverted filter in the ditch. This measure is only applicable at location where the downstream side of the dam is paralleled by shallow toe ditch (rather than deep canal)

1.13.2.2 Wind Driven Wave Overwash and Overtopping

The areas identified for remediation are the embankment adjacent to S-71 on the Harney Pond Canal, the State Road 78 Bridge crossing over the Harney Pond Canal, and the embankment adjacent to S-72 on the Indian Prairie Canal. Risk reduction adjacent to Structure S-71 and S-72 includes localized floodwalls ranging in height from 1 to 7 feet above existing crest elevations. These floodwalls would be located from the structure a few hundred feet in each direction until the floodwalls match typical crest elevations of the tieback levees.

Raising the embankment elevation at the SR-78 Bridge would require replacement of the bridge; therefore, is is recommend the State of Florida Department of Transportation (FDOT) reconstruct the bridge to match HHD design grades at the end of the bridge's service life. In the interim, the low area surrounding the bridge would be armored with ACBM (or a combination of armoring with a few hundred feet of flood wall) such that the embankment would not fail under short duration, shallow depth overtopping as could occur under certain elevated lake levels in combination with tropical cyclone impact to the lake.

1.13.3 Description of Segmental Alternatives

Table2-3 presents the results for all four of the segmental alternatives arranged by common environmental and economic zone. Each of these alternatives were determined to be cost effective solutions providing at a minimum life safety, and to varying degrees reduce risks in order to lower the likelihood of expected annual economic and environmental damages. **Table 2-4** presents the results of the overtopping alternatives arranged by common environmental and economic zone.

Table2-3. Segmental Alternatives Description for Internal Erosion Failure Modes

Segment	Intolerable Probability of a Breach (Yes/No?)	Intolerable Societal Life Loss (Yes/No?)	Alternative 1 (Meets Life Safety TRG's)	Alternative 2 (Meets all Life Safety and APF)	Alternative 3 (Meets life safety and APF guidelines when economically, environmentally and/or socially justified)	Alternative 4 (Meets all Life safety and APF guidelines using USACE Essentials guidelines /extent practicable)
ZONE A						
22, 23, 24	NO	NO	No action included in the DSMR: Cutoff-wall constructed as part of the 2000 MRR			
1	YES	YES	No action included in the DSMR: To be completed as part of the 2015 MRR Supplement			
2 and 3	YES	NO				
ZONE B						
4, 5, 6 and 7	YES	NO	No Action Recommended	Cutoff Wall	Cutoff Wall	Internal Drainage System
5-2 and 8	YES	YES	Filter at the Raw Water Intake	Cutoff Wall and Filter at Raw Water Intake	Cutoff Wall and Filter at Raw Water Intake	Internal Drainage System and Filter at Raw Water Intake
8	YES	YES	Cutoff Wall	Cutoff Wall	Cutoff Wall	Internal Drainage System
9	YES	NO	No Action Recommended	Cutoff Wall (Full Segment)	Cutoff Wall to C-5A	Internal Drainage System (Complete Segment)
Segment 10: No action is recommended. Risk is considerable tolerable.						
ZONE C						
Segments 11 and 14A: No action is recommended. Risk is considered tolerable.						
12	YES	YES	Cutoff wall from the interceptor levee east to segment end	Cutoff wall (Full Segment)	Cutoff wall from the interceptor levee east to segment end	Internal Drainage System (Complete Segment)
13	NO	YES (Adjacent to Segment 12)	Cutoff Wall- segment start to Sta. 4665	Cutoff Wall- segment start to Sta. 4665	Cutoff Wall - segment start to Sta. 4665	Internal Drainage System - segment start to Sta. 4665
Zone E						
Segments 17, 18A, 18A-2 and 18B: No action is recommended. Risk is considered tolerable.						
Zone F						
Segments 19A, 19A-2, 19A-3, 19B and 19C: No action is recommended. Risk is considered tolerable.						
Zone G						
Segments 20 and 21: No action is recommended. Risk is considered tolerable.						

Table 2-4. Overwash and Overtopping Alternatives Organized by Segment.

Segment	Intolerable Probability of a	Intolerable Societal Life	Alternative 1 (Meets Life Safety TRG's)	Alternative 2 (Meets all Life Safety and APF)	Alternative 3 (Meets life safety and APF guidelines when economically,	Alternative 4 (Meets all Life safety and APF guidelines using USACE Essentials guidelines /extent practicable)

	Breach (Yes/No?)	Loss (Yes/No?)			environmentally and/or socially justified)	
ZONE A, B, F and G– No Overwash and Overtopping Failure Modes						
ZONE C						
13	YES	NO	No Action Recommended	Armoring West Harney Pond Bridge – Have State Raises Bridge	Armoring West Harney Pond Bridge – Have State Raises Bridge	Armoring West Harney Pond Bridge – Have State Raises Bridge
14A	YES	NO	No Action Recommended	Floodwall at S-71 (West)	Floodwall at S-71 (West)	Floodwall at S-71 (West)
ZONE D						
14B	YES	NO	No Action Recommended	Floodwall at S-71 (East)	Floodwall at S-71 (East)	Floodwall at S-71 (East)
15	YES	NO	No Action Recommended	Armoring at East side of Harney Pond Bridge – Have State Raises Bridge	Armoring at East side of Harney Pond Bridge – Have State Raises Bridge	Armoring at East side of Harney Pond Bridge – Have State Raises Bridge
16	YES	NO	No Action Recommended	Floodwall at S-72 (East)	Floodwall at S-72 (East)	Floodwall at S-72 (East)
ZONE E						
17	YES	NO	No Action Recommended	Floodwall at S-72 (West)	Floodwall at S-72 (West)	Floodwall at S-72 (West)

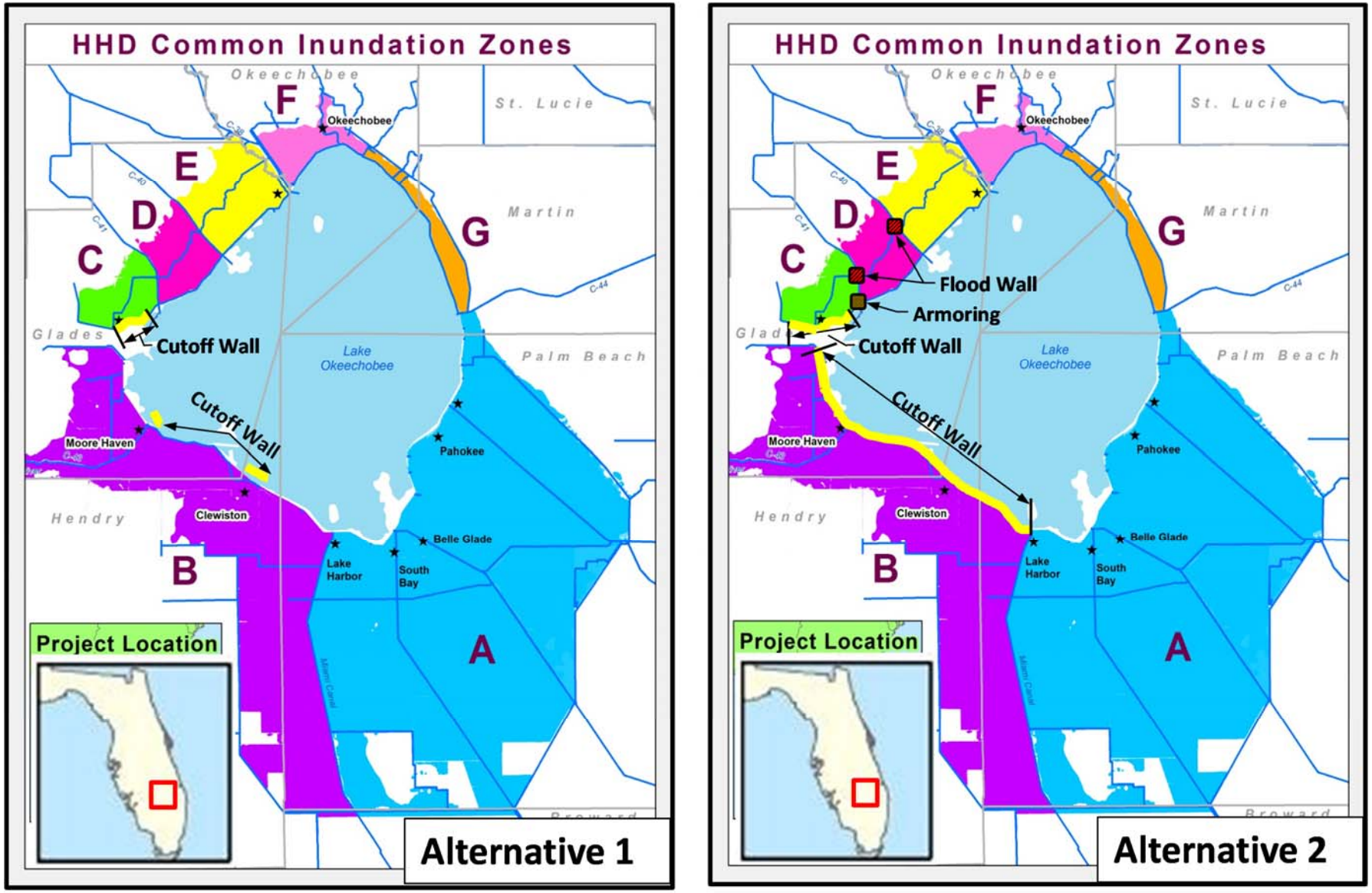


Figure 1-7 Map showing feature and location of the Final Array of Alternatives

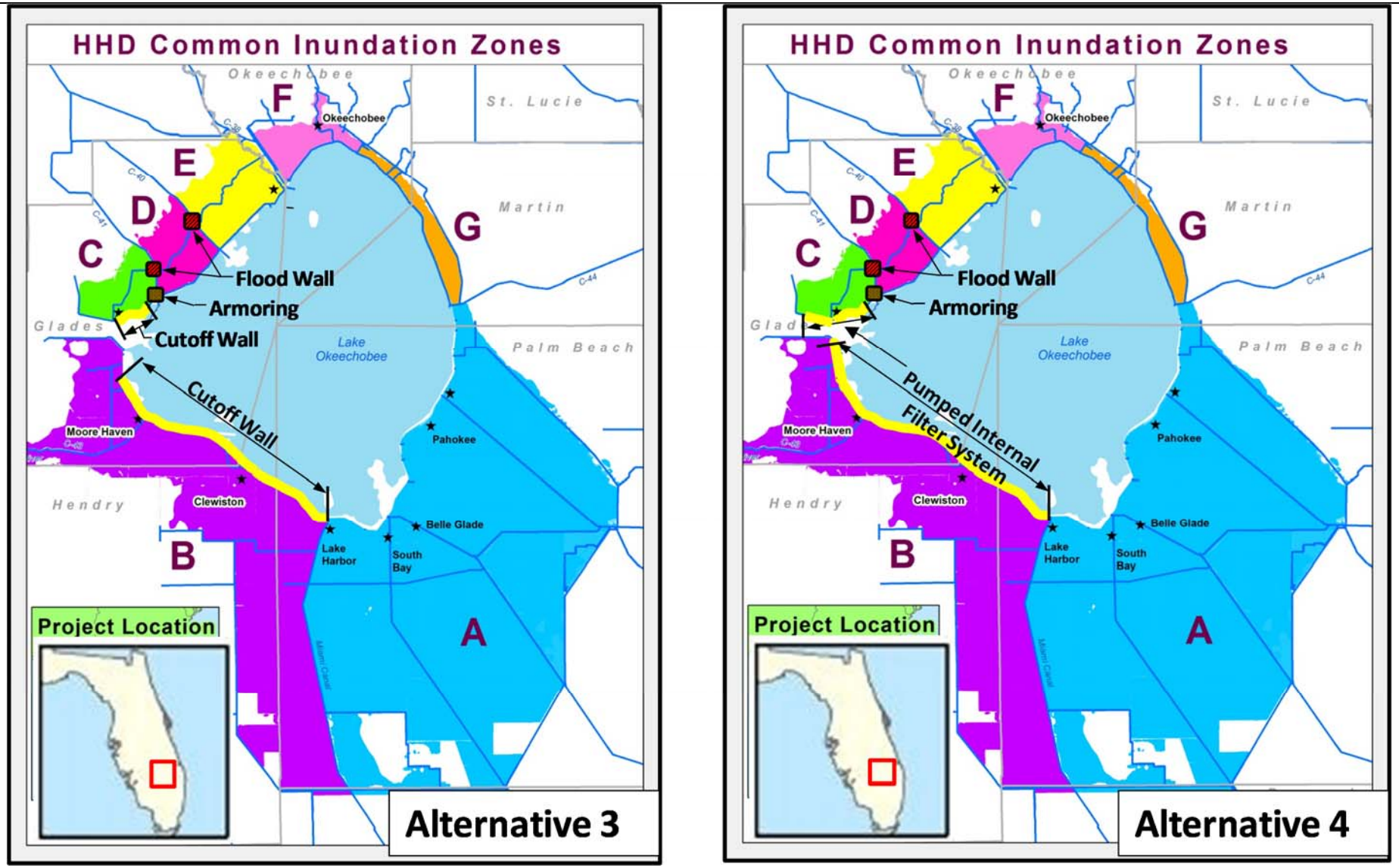


Figure 1-8 Map showing features and location of the Final Array of Alternatives

1.13.4 Alternative 1

Alternative 1 contains the minimal solutions to ensure any segment presenting intolerable societal life loss is remediated. This alternative applies where significant populations of people live downstream of HHD. This includes the areas of HHD protecting the cities of Clewiston (Segments 5-2), Moore Haven (Segment 8) and Lake Port (Segment 12 from the interceptor levee to the end of the segment and the eastern half of Segment 13).

Risk reduction proposed for Segment 5-2 under this alternative includes construction of a filter and drainage blanket around the downstream end of the US Sugar Raw Water Intake pipes. These pipes penetrate the HHD Embankment and were constructed with no seepage protection as would be required by modern design standards. The proposed risk reduction for these pipes requires they be retrofitted with a drain at the downstream toe of HHD. The drainage system would wrap around the pipes and intercept seepage (lake water seepage could be concentrating and flowing around the exterior of these pipes) through the embankment and collect, filter and discharge the seepage through designed sand and gravel filter.

Risk reduction proposed for Segment 8 and 12/13 under this alternative includes construction of a 24 inch wide, Soil Cement Bentonite (SCB) cutoff wall that would extend through the embankment from a minimum top elevation of 25-ft NAVD (likely constructed to within a foot or two of the crest) and into the foundation to a bottom elevation between approximately -10-ft to -30-ft NAVD. The proposed cutoff wall location would be along the approximate centerline of the embankment, with construction platforms needed to temporarily widen the crest for the duration of construction.

1.13.5 Alternative 2

Alternative 2 is tailored to reduce societal risk for life safety concerns, similar to Alternative 1, but also includes measures to reduce risk in all segments determined to pose intolerable annual probability of failure. This alternative would reduce the annual probability of failure for the entire southern perimeter of the embankment, from just west of Lake Harbor (areas east of Lake Harbor already approved for remediation) to Fisheating Creek (north of Moore Haven); Segments 4 through 9, and all of Segment 12.

In addition to the cutoff walls proposed for reducing the annual probability of failure, cutoff wall would also be proposed to provide societal life safety risk reduction in Lakeport (eastern half of Segment 13). Risk reduction proposed for these areas includes construction of a SCB cutoff wall that would extend through the embankment and into the foundation. The cutoff wall would have a minimum top elevation of 25-ft NAVD (but will likely be constructed to within a foot or two of the crest) with varying bottom elevations throughout the segment based on variations in local geologic and topographic characteristics of the Segment. Proposed range of possible termination depths for the cutoff wall is -10-ft to -30-ft NAVD.

The cutoff walls described above would be connected to the side of the concrete structures that penetrate HHD throughout these segments. Additionally, the drain around the lakeside of the US Sugar Raw Water Intake in Segment 5-2 is also included in Alternative 2.

1.13.6 Alternative 3

Alternative 3 is tailored to reduce societal risk for life safety concerns, similar to Alternative 1, but also includes measures to reduce risk in segments determined to pose intolerable annual probability of failure (APF) where economically, environmentally, and or socially justified. This alternative evaluates risk reduction for all areas that exceed risk guidelines for annual probability of failure; however, only recommends risk reduction for those areas where the benefits can justify the monetary investment to construct the risk reduction measures. This alternative would reduce the probability of dam failure for the entire southern perimeter of the embankment, from just west of Lake Harbor (areas east of Lake Harbor already approved for remediation) to just east of Moore Haven; Segments 4 through a portion of Segment 9. A cutoff wall through a portion of Segments 12/13 would also be proposed under this alternative to reduce the probability of life loss in Lakeport. Unlike Alternative 2, no

remediation is recommended in the section of Segment 12 east of the interceptor levee and in Segment 9 north of the vicinity of the L-41 canal/Culvert 5A due to the low environmental and economic consequences realized from a breach in this area.

Risk reduction proposed for these areas also includes construction of a SCB cutoff wall that would extend through the embankment and into the foundation. The cutoff wall would have a minimum top elevation of 25-ft NAVD with varying bottom elevations (based on local geologic and topographic characteristics of the Segment). The range of depths proposed for the cutoff wall is -10-ft to -30-ft NAVD.

The cutoff walls described above would be connected to the side of the concrete structures that penetrate HHD throughout these segments. Additionally, the drain around the lakeside portion of the US Sugar Raw Water Intake in Segment 5-2 is included in Alternative 3.

1.13.7 Alternative 4

Alternative 4 is tailored to reduce societal risk for life safety concerns and includes measures to reduce risk in all segments determined to pose intolerable annual probability of failure (APF) (similar to Alternative 2) and also meets USACE essential guidelines to the extent practical. This alternative would reduce APF for the entire southern perimeter of the embankment, from just west of Lake Harbor (areas east of Lake Harbor already approved for remediation) to Fisheating Creek (north of Moore Haven); Segments 4 through 9. The areas of embankment protecting Lakeport (Segment 12 and a portion of 13) would also be included to reduce the risk of life loss. Risk reduction proposed under this alternative includes an internal drainage system constructed within the embankment and foundation.

This alternative consists of an internal drainage system to intercept and filter seepage in lieu of a cutoff wall. The internal drainage system would intercept seepage waters (water that historically seeps uncontrolled into the downstream ditches and canals) and collect, filter, and discharge this seepage through a designed sand and gravel filter. This alternative includes a chimney drain in the embankment that extends to a top elevation of 17 ft. The chimney connects to a drainage blanket and foundation trench drain at the toe of the embankment. The foundation trench drain extends vertically into the foundation to the tip elevations noted below. Seepage collected in this system is piped to sumps located on approximate 1,000 foot spacing along the toe. Electric pumps then pump the collected seepage from the sump to the adjacent canal or ditch. The trench feature would extend to elevations ranging from -7-ft to -20-ft NAVD.

The drain described above would be connected to the side of the concrete structures that penetrate HHD throughout these segments. The drain around the lakeside portion of the US Sugar Raw Water Intake in Segment 5-2 is also included in Alternative 4.

1.13.8 Overtopping Measures Included in Alternatives 2, 3 and 4

Alternatives 2, 3 and 4 also include remediation of several low spots in the crest of HHD that exceed APF guidelines. It is predicted that these locations could overtop from hurricane storm surge under the right wind and reservoir elevation combinations. These low crest elevations occur on both sides of S-71 and S-72 at the terminus of the Harney Pond and Indian Prairie tie back embankments, respectively (Segments 14A, 14B, 16 and 17). Remediation in these areas will include construction of several hundred feet of floodwall (raising elevations to match adjacent embankment crest elevations – an approximate 7 ft maximum wall height) adjacent to Structures S-71 and S-72. The embankment crest is also low where State Road 78 Bridge crosses the Harney Pond Canal embankments (Segments 13 and 15). At these locations, the embankment crest is lower to allow vehicle access to the structures or to match abutment grades of the bridge. Remediation here includes placement of Articulated Concrete Block and riprap armoring to protect the embankment from failure during a temporary overtopping event at the SR-78 Crossing of Harney Pond Canal. The armoring will cover the crest and landsides of the embankment in these areas.

Additionally, a recommendation will be provided to FDOT to raise the abutments of the bridge when it reaches the end of its service life and requires replacement.

1.14 Identifying Alternative 3 as the Recommended Plan

The principal goal of the USACE Dam Safety Program is to reduce the risk to human safety from a federally operated and maintained dam, but there is also federal interest in reducing risk if there is an intolerable annual probability of failure or significant economic, environmental or social impacts that would occur from a breach. The recomended plan was identified by evaluating and comparing alternatives on the efficiency and effectiveness of reducing risk below tolerable risk guidelines. Additional consideration was given to the robustness, resiliency and redundancy of the alternatives. Detailed drawings, designs and planning level cost estimates were generated for both the seepage cutoff wall and the internal drain system and the seepage cutoff wall resulted in the most cost effective means to reduce risk. Construction of a cutoff wall at the locations described in Alternative 3; designed to increase resiliency and robustness while decreasing risk uncertainty, meets the primary objective of reducing risk to life safety below tolerable risk guidelines in a cost effective and economically efficient manner. This alternative will also reduce the intolerable risk of catastrophic economic and social impacts and impacts on essential infrastructure for every major population center surrounding the dike, including Clewiston, Moore Haven and Lake Port and has been identified as the recommended plan.

Alternative 1 is effective in reducing the risk of life loss for HHD but was eliminated as a stand-alone solution due to the unmitigated areas or “weak links” that would remain in the southern portion of HHD. These weak links leave intolerable economic and social risk to residents in Clewiston and Moore Haven. Damages to government services including police, health services, fire and emergency, utilities, transportation, education, and other services could last from months to years depending on the lake stage at time of breach. The environmental consequences to the Everglades and water conservation areas would also be catastrophic and could severely impair the Comprehensive Everglades Restoration Plan efforts. There could also be a multiple year impact to 25% of the nation’s sugar supply due to lost production in the EAA from a breach in CIZ B.

CIZ B, on the southwest corner of Lake Okeechobee, poses the highest residual risk remaining for Herbert Hoover Dike pending completion of the CIZ A cutoff-wall. This CIZ has two areas that have intolerable risk of life loss (the U.S. Sugar raw water intake and Segment 8) and the entire CIZ B has an intolerable annual probability of failure. Alternative 3 includes a cutoff-wall constructed in Segments 4-8, and the southern half of Segment 9, thereby reducing the risk to life safety and the annual probability of failure in CIZ B below tolerable risk guidelines. Alternative 3 effectively reduces the risk to both the nationally significant agricultural production in the EAA and the nationally significant ecosystem of the Everglades.

Unlike Alternative 3, Alternative 2 reduces both APF and Average Annualized Life Loss (AALL) below TRGs for the entire HHD regardless of economic, environmental and life safety consequences. For example, the economic and environmental consequences in CIZ G and north of the interceptor levee in CIZ B are relatively low when compared to remediation costs and there is virtually no expected annual life loss. Due to lack of economic, environmental or life safety justification, no action is being recommended for these areas (consistent with Alternative 3) and therefore Alternative 2 was eliminated from further consideration.

Alternative 4, the internal drain system, is considered the plan that most fully meets USACE guidelines and provides the greatest risk reduction. However, cutoff walls are 2-6 times less costly than the pumped internal drainage system included in Alternative 4. Internal drainage systems are not a practicable means of remediating the dike and Alternative 4 was eliminated from further consideration.

Table 2-5 Summary Comparison of the Final Array

	Alternative Features	Cost[1]	Effectiveness	Efficiency	Completeness	Acceptability
Alternative 1 (Life Safety Plan)	Cutoff Wall in Segments 8, 12/13 Filter around U.S Sugar Raw Water Intake in Segment 5-2	$65M	Effective at meeting the AALL objective, but in CIZ B, C, and G leaves "weak links" that could cause significant economic and environmental impacts in Clewiston and Moore Haven	Least cost and most efficient alternative to achieve life safety TRGs.	All alternatives rely on continuing Federal O&M investments and updated inspection plans to increase the success of intervention. Additionally, completion of non-Federal responsibilities including warning systems and increased mobilization is required.	All alternatives comply with statutory requirements and are policy compliant.
Alternative 2 (Life Safety and Annual Probability of Failure Alternative)	Cutoff Wall in Segments 4-9, 12, and a portion of 13 Filter around U.S Sugar Raw Water Intake in Segment 5-2	$435M	Effective at reducing the risk of life loss and the annual probability of failure to tolerable levels for the entire dike	Not economically efficient due to inclusion of remediation measures in northern half of Segment 9 and in Segment 12 west of the interceptor levee where economic and environmental consequences are low		
Alternative 3 (Life Safety and Annual Probability of Failure when Economically, Environmentally and Social Efficient Justified Alternative)	Cutoff Wall in Segments 4-8, Southern Half of 9, Segment 12 east of the interceptor levee and a portion of 13 Filter around U.S Sugar Raw Water Intake in Segment 5-2	$345M	Effective at reducing the risk of life loss, leaves the northern half of segment 9 and Segment 12 west of the interceptor levee slightly above tolerable guidelines	Most efficient alternative to achieve life safety and environmental and economic risk reduction		
Alternative 4 (Life Safety and Annual Probability of Failure that meets essential USACE guidelines)	Pumped Internal Drainage Filter System in Segments 4-9, 12 and a portion of 13 Filter around U.S Sugar Raw Water Intake in Segment 5-2	$792M	Effective at reducing the risk of life loss and the annual probability of failure to tolerable levels for the entire dike. Provides the greatest risk reduction	Not economically efficient due to inclusion of remediation measures in northern half of Segment 9 and in Segment 12 west of the interceptor levee where consequences are minimal		

1 Costs included in this table are FY 15 planning level costs. The cost for the recommended plan has been updated based on refined design details and price level updates.

1.15 Recommended Plan Description

A cutoff wall was determined to be the most efficient and technically acceptable risk reduction solution to remediate areas of HHD that were identified as having intolerable internal erosion risk. The proposed cutoff wall location would be 2 ft. wide Soil Cement Bentonite along the approximate centerline of the embankment, with temporary construction platforms needed to widen the crest for the duration of construction. A total of 27.3 miles of cutoff wall would be constructed at project first cost of approximately $495 million (FY16 price levels, includes $22.5M in sunk costs). The fully funded cost estimate is approximately $548 million.

The construction would span from just west of Lake Harbor (areas east of Lake Harbor already approved for remediation) to just east of Moore Haven; Segments 4 through a portion of Segment 9. A cutoff wall through a portion of Segments 12/13 would also be proposed under this alternative to reduce the probability of life loss in Lakeport and Okeechobee. No remediation is recommended in the section of Segment 12 east of the interceptor levee and in Segment 9 north of the vicinity of the L-41 canal/Culvert 5A due to the low environmental and economic consequences realized from a breach in these area. Risk reduction proposed for these areas also includes construction of a SCB cutoff wall that would extend through the embankment and into the foundation. The cutoff wall would have a minimum top elevation of 25-ft NAVD (but will likely be constructed to within a foot or two of the crest) with varying bottom elevations (based on local geologic and topographic characteristics of the Segment). The range of depths proposed for the cutoff wall are -10-ft to -35-ft NAVD (Table 2-6).

Table 2-6 Recommended Plan Cutoff Wall Termination Elevations.

Segment	Proposed Cutoff Wall Termination Elevation (ft. NAVD 88)[(1)]
Segment 4	-10 to -30
Segment 5-2	-25
Segment 5	-25
Segment 6	-20 to -25
Segment 7	-20 to -25
Segment 8	-12 to -25
Segment 9	-10 to -12
Segment 12/13	-10

(1) Cutoff wall depths are approximate. Additional subsurface investigation will be completed to support final design of the walls. Minor adjustments to the cutoff wall termination depths may be required to correct for variations in geology (minor variations would include adjustments of the cutoff wall depths by several feet to adjust for elevation variations of the subsurface unit being targeted by the design).

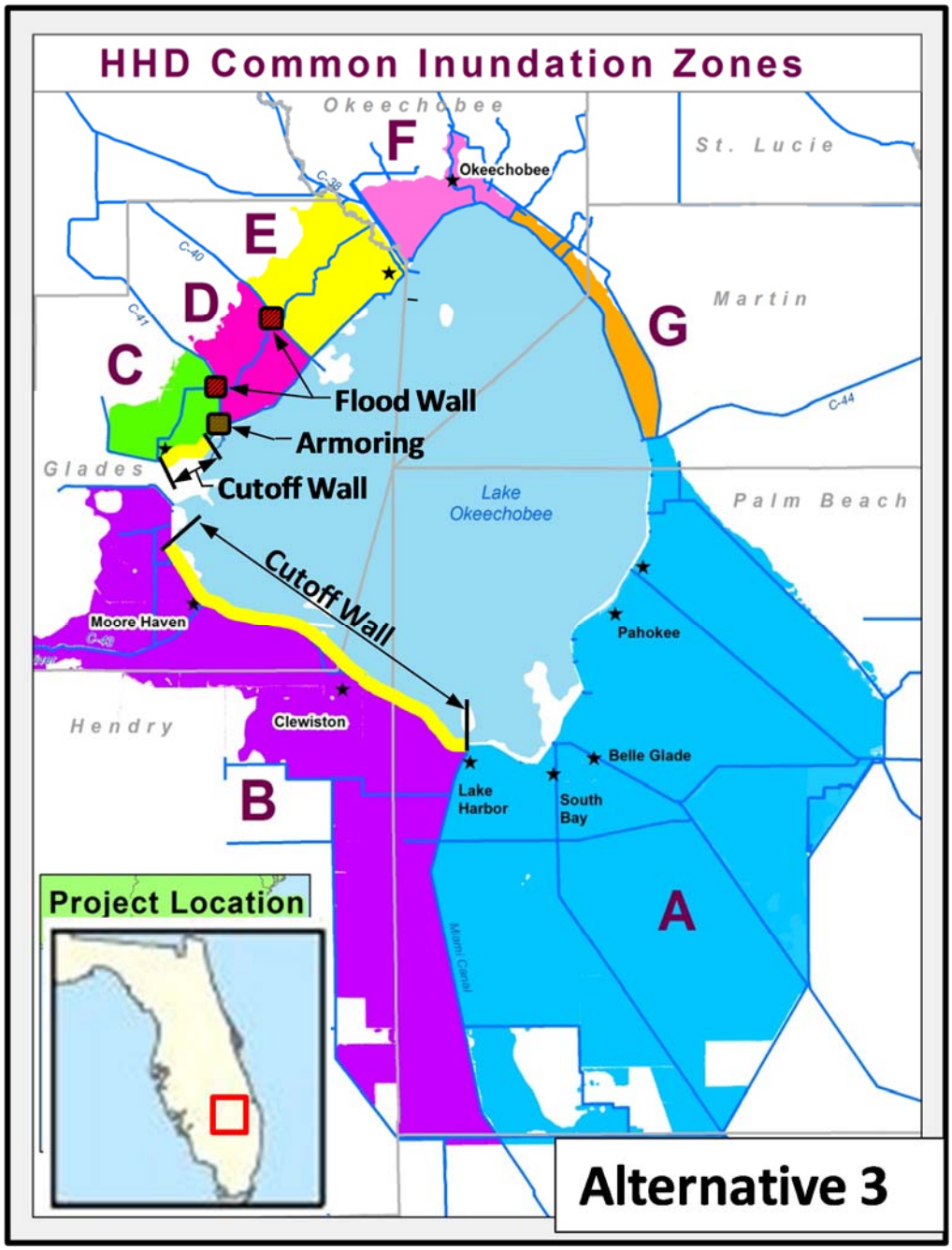


Figure 1-9 Location and Components of the Tentatively Selected Plan

In addition to the cutoff wall, Alternative 3 includes three locations where the embankment is low and intolerably susceptible to overwash or overtopping. These locations include the embankment adjacent to S-71 (Segments 14A & 14B) located on the Harney Pond Canal, the embankment adjacent to S-72 (Segments 16 & 17) located on Indian Prairie, and the embankment at the intersection of SR-78 bridge and Harney Pond Canal (Segments 13 and 15).

Armoring the embankment at the intersection of the bridge at the SR-78 and Harney Pond Canal with ACBM is proposed (a few hundred of floodwall may also be included in the design for this area). While this configuration would not provide a greater level of service for flood protection, armoring would greatly

reduce risks of breach during a short duration overtopping event from storm surge. Additional coordination is needed with the non-Federal sponsor identifying the need to raise the bridges (Harney Pond Canal and Indian Prairie Canal) in the future. The Non-Federal sponsor through coordination with the State of Florida's Department of Transportation should ensure that bridges, bridge abutments, and corresponding road be raised as part of the State's regularly schedule bridge replacement.

S-71 and S-72 are structures located on the Harney Pond Canal and Indian Prairie Canal. They are nearly identical in design and construction and are the terminus of HHD to the north. At these locations, the HHD earthen embankment drops down in elevation to meet the service platform of each structure. A similar situation occurs at the intersection of SR-78 Bridge and Harney Pond canal. The embankment drops down in elevation to meet the bridge abutment. A floodwall ranging in height from 1 to 7 feet or embankment armoring would be constructed adjacent to these structures.

1.15.1 Implementation of the Recommended Plan

Upon approval, the recommended plan will be implemented as quickly as funding and legal constraints allow. The order of work will be prioritized based on the highest life safety segments, and will be influenced by site constraints (access points, staging areas, etc.) and other factors (relocation of existing utilities, modifications to boat ramps and campgrounds, etc.). Segments with lower life safety risk will not be rehabilitated prior to higher risk segments simply due to administrative or contractual convenience. Implementation of the recommended plan is expected to begin in Fiscal Year 2019. After implementation of the recommended plan, the dike's Dam Safety Action Classification will be revisited.

This DSMR and corresponding EIS utilized the current Lake Okeechobee Regulation Schedule (LORS), and assume that in the absence of Federal risk reduction measures being implemented the current regulation schedule will continue into the future. Any proposed revisions to the current LORS will require an updated risk evaluation and be part of a future and independent lake regulation study for informed decision making. A study for a new regulation schedule could be undertaken concurrently while risk reduction features identified in the DSMR are constructed. Implementation of any new regulation schedule will depend on the magnitude and associated effects resulting from a change to the current LORS revised regulation schedule and is not expected before 2020.

1.15.2 DSADS Security Guidance

For security reasons, numerical risk results, aggregate lists of dams with the assigned DSAC, detailed description of dam deficiencies, and portfolio ranking should not be released to the public. Such information may be provided on a regional and project specific basis to Federal agencies, adjacent and potentially impacted dam and levee owners and sponsors, and state and local authorities who provide emergency management services. Information should only be provided on a need to know basis, when it assists those entities in protecting health, safety and welfare. This will limit the extent the information could be used to threaten the project's security while advancing Federal Governmental interests. Sharing of inundation maps and associated data must be in accordance with current USACE policy.