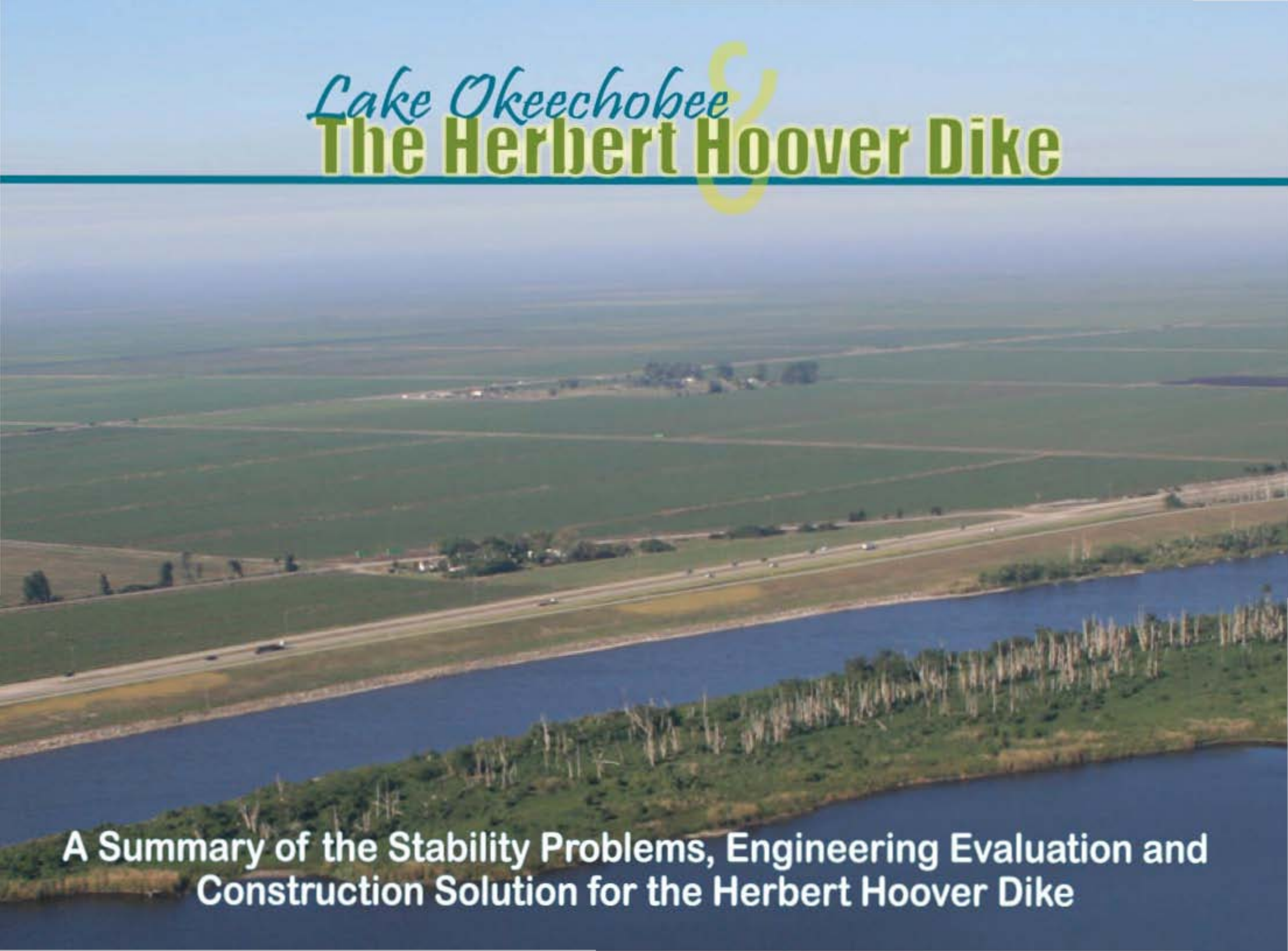
Lake Okeechobee & The Herbert Hoover Dike



A Summary of the Stability Problems, Engineering Evaluation and Construction Solution for the Herbert Hoover Dike

The People. The Land. The Water.

Lake Okeechobee and the Herbert Hoover Dike Are Important to South Florida

Lake Okeechobee is the second largest freshwater lake that lies entirely within the United States.

Tourists from around the world sightsee, fish for bass and camp. Scores of bird watchers seek a peek at the rare Everglades Kite. To the north, cowboys on horseback raise cattle. Deer, turkey and wild boar are at home here. Sixteen threatened or endangered species are found near the lake.

Miles and miles of citrus groves play neighbor to a sugarcane industry that generates thousands of jobs and more than $1.5 billion annually for the economy of the region.

Seminoles named it "Big Water." And tens of thousands of men, women and children living in communities like Lakeport, Moore Haven, Okeechobee, Clewiston, Lake Harbor, South Bay, Belle Glade, Pahokee, Canal Point, Port Mayaca and Indiantown call Lake Okeechobee home.

The Herbert Hoover Dike

The 143-mile earthen dike system that encircles Lake Okeechobee has numerous water control structures that provide flood damage reduction, navigation, recreation and fresh water for the communities of south Florida, water for agriculture, prevention of saltwater intrusion to coastal estuaries and enhancement of environmental resources.

In short — *the people, the land and the water all depend on each other.*

Lake Okeechobee, the "Heart of the Everglades," is used to store water from a 4,000-square-mile basin north of the lake. Historically, there were many more natural water storage areas in central and south Florida. Now, most of these wetlands and uplands have been developed and water is stored in Lake Okeechobee, with the help of the dike. However, this additional water is harmful to the lake's ecology and is dangerous, considering the dike's current condition.

Since 1984, the U.S. Army Corps of Engineers, Jacksonville District, has completed several engineering reports documenting areas of the dike that are prone to water seepage and piping (internal erosion), causing stability concerns. To understand the stability problems of the Herbert Hoover Dike, you must first understand how water flows into Lake Okeechobee and how it is held there by the dike.

Water flows into Lake Okeechobee from a vast watershed that includes the Kissimmee River. During the rainy season and as a result of tropical storms or hurricanes, heavy rains cause water levels to rise quickly because it can enter the lake six times faster than it can be released. During periods of high lake levels, rapid releases to lower the lake are not possible because the outlet canals are so small. Thus, it is important that the dike be capable of withstanding elevated lake levels for extended periods of time, during which gradual reduction of the lake can be accomplished. However, in its present state, the dike does not possess that capability.

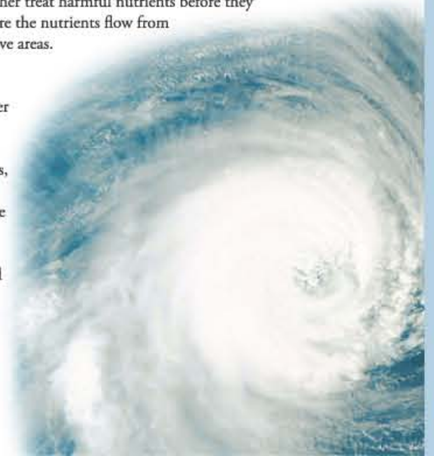
Water levels in the lake are managed according to a regulation schedule developed through the cooperative efforts of federal, state and local interests. Typically, the lake's water level is lowered prior to the hurricane season in preparation for receiving additional rain and basin inflow.

In 2004, during an unusually active hurricane season, lake water levels rose to over 18 feet — a very high elevation — after four hurricanes passed over south Florida in rapid succession. Water levels were lowered via the only available outlets, the St. Lucie Canal and the Caloosahatchee River to coastal estuaries. Unfortunately, these discharges were very damaging to the estuaries.

Modifying the regulation schedule to maintain lower water levels on the lake year-round is an immediate step aimed at reducing the level of Lake Okeechobee and reducing the likelihood for harmful discharges to the estuaries. However, the only way to permanently reduce the lake's water level is to store water elsewhere.

The Comprehensive Everglades Restoration Plan (CERP) includes water storage reservoirs and wells for water that would normally flow into or out of the lake. Collectively, these water storage areas in the lake's basin could reduce its level by as much as one foot. Additionally, they will either treat harmful nutrients before they flow into the lake or before the nutrients flow from the lake into other sensitive areas.

The state of Florida has important programs under way, as well, to benefit the lake's water quality. Improved use of fertilizers, water treatment projects, and identification of more places to store water north of the lake (in addition to those planned under CERP) are among them. Until there is additional storage and the dike is strengthened, communities may be at risk.



The Problem

The Aging Herbert Hoover Dike

Here's what we have found

Seepage led to piping, the creation of an open path through the dike.

Simply stated, the problem is that when water levels in Lake Okeechobee get too high, water seeps through the dike from lakeside to landside – sometimes eroding from inside or under the dike. The movement of soil or erosion is known as piping. Piping creates a continuous, open path through which water moves even more soil and could form large cavities in the dike. When water from the lake runs through these cavities, it weakens the dike, creating the potential for a breach. A breach would result in large releases of water from Lake Okeechobee, flooding surrounding land.

How Piping Occurs

Building the Dike

In the 1930s, the dike was designed, built and maintained within the accepted standards existing at the time. The dike was originally constructed using hydraulic dredge and dragline techniques that concentrated deposits of pervious shell, rock and gravel within the dike. The hydraulic dredging methods used to construct the first levees were state-of-the-art and fully acceptable in the 1930s; however, due to an improved understanding of material properties and seepage mechanisms, those same methods would not be acceptable today.

Dragline - early dike construction.

In addition, the foundation beneath the dike has pervious layers of limestone, sand, gravel and shell. As a result of the pervious zones, some areas of the dike are prone to excessive seepage.

What is a Dike Failure?

When we say 'dike failure', we mean a breach or open gap in the dike, caused by internal erosion, that allows water from Lake Okeechobee to flood adjacent land. We do not mean 'over-topping' of the dike – where waters would rise 35 feet or higher to flow over the top of the dike.

Some dike problems may be harmless – such as the formation of springs and wet areas along the landside toe of the dike. These conditions are undesirable but do not pose immediate safety hazards. We have found, during recent high water events, that numerous areas of the dike have seepage and piping problems when the lake elevation reaches 18 feet.

The Danger: At a lake elevation of 18 feet or higher, flooding would be severe and warning time would be limited. With tens of thousands of people living in the communities protected by the Herbert Hoover Dike, the potential for human suffering and loss of life is significant.

It's a risk we can't afford to take.

How Serious is It?

There is limited potential for dike failure with lake elevations as low as 17 feet. But as the lake level rises, so does the risk of dike failure. Our analytical studies show a dike failure would be likely at one or more locations if the water elevation in Lake Okeechobee reached elevation 21 feet, such as would happen during a 100-year flood event.

Statistically, a 100-year flood event would be expected to happen on average once every 100 years. But in reality, it can happen during any given year. In fact, Lake Okeechobee reached an elevation of 18.6 and 18.5 feet — both 30-year events — in 1995 and 1998. Following four hurricanes in 2004, the lake level rose to 18.02 (another 30-year event), and following Dennis, Emily, Katrina, Rita and Wilma in 2005, the lake rose to 17.12 feet.

"Seepage and piping failures may occur without warning. They may result, in part, from accumulated damage from previous high water events and/or high water duration, in addition to differential head."
— Excerpt from Expert Review Panel Report of Findings and Recommendations, 1998

While people in the post-Katrina era may be more aware of flood dangers than before, that awareness may overlook an important fact: Flood risks are not confined to coastal regions or areas dependent on levees for flood protection. Everyone lives in a flood zone, but most people aren't aware of that. Since May 2006, flood disasters have been declared in Arizona, Massachusetts, New Mexico, New York, Pennsylvania, Texas and Virginia.

The Precedence

Disaster Led to the Building of the Dike

Violent Storms and Lost Lives

The ravages of nature struck Lake Okeechobee in September of 1926. Herbert Hoover Dike did not exist – there was only a small muck dike that had been made to keep the lake from drowning crops. Hurricane winds thrashed the town of Moore Haven with a wall of water that killed nearly 400 people. Engineers, lawyers and politicians looked for a solution to make sure such a tragedy never happened again. In the meantime, though, another hurricane struck in September 1928. Nearly 2,000 people were killed as hurricane winds pushed water out of the lake and flooded the young communities of Pahokee, Belle Glade, South Bay, Indiantown and Lake Harbor.

Typical during hurricane season, storm winds and surge assault a south Florida community.

This illustration indicates the areas of damage from the hurricanes of 1926 and 1928.

1932

Construction Begins

These tragedies prompted Florida to request federal assistance to provide flood damage reduction for lakeside communities. As a result, the Corps of Engineers began construction of the Herbert Hoover Dike in 1932. The 68-mile south shore was completed in 1936, and an additional 16-mile north shore was completed in 1938. Subsequent construction has increased the dike so it completely surrounds the lake and extends over 140 miles.

The Corps has maintained a diligent schedule of maintenance and repair ever since. Even so, time has taken its toll.

May 1974

North Shore Dike Breach

In 1974, a portion of the north shore dike at the intersection of a drainage canal breached due to piping. Fortunately, due to low lake levels at the time, the breach resulted in a flood release from the canal that flowed into Lake Okeechobee rather than out of the lake. As a result, the only damage that occurred was to the dike and a water control structure.

1979

Florida Power & Light Dike Failure

The nearby Florida Power and Light Cooling Reservoir Dike failed in 1979, causing considerable flooding damages. It failed as a result of piping through its foundation. Similar foundation conditions and piping potential would exist for the portions of Herbert Hoover Dike north of Port Mayaca.

Home demolished during the 1928 Hurricane near Chancy Bay in Okeechobee County, Florida

Hurricane flood damage at the Belle Glade Experiment Station.

What the World Experts Say:

The National Oceanic and Atmospheric Administration weather experts say we're in the midst of a cycle of hurricanes. This era has been unfolding in the Atlantic since 1995, and is expected to continue for the next several decades or perhaps longer.

The U.S. Army Corps of Engineers, Jacksonville District and expert panels of the world's foremost authorities in geotechnical engineering say that, in its present condition, the dike poses a threat. Recently, an expert panel applied lessons learned from Hurricane Katrina's impact on the New Orleans hurricane protection levees in 2005. The panel recommended lifting all design constraints on the Herbert Hoover Dike major rehabilitation project, and building resiliency and redundancy into the design.

The Threat

High Lake Levels Create an Unacceptable Risk

Year-round residents in Okeechobee and other communities rely on the Herbert Hoover Dike to keep them safe.

Weather Extremes

The subtropical climate of the Lake Okeechobee area produces steamy summers and dry winters.

And it rains a lot – between 55 and 60 inches every year. Any excessive rainfall would result in higher lake levels, if it falls directly on the lake or within its drainage basin. There is no reason to be afraid of a spring shower. But if it rains . . . and rains . . . and keeps raining — like it often does in South Florida — stress is placed on the dike as the rain causes lake levels to rise. And then there's hurricane season. It happens — without fail — every year.

From June 1 to November 30, hurricane season, the people who live in the communities around Lake Okeechobee are prepared. They watch closely as a storm approaches. And if they do not evacuate, it may be because they have confidence that the dike will protect them.

The effects of a hurricane — with its strong winds, heavy rains, and storm surges on the lake — could weaken the dike and contribute to loss of life and property. But the dike has been stressed during recent high water events – even without a hurricane.

1995

High Water Event

In the late summer and early fall of 1995, the lake rose to elevation 18.6 feet. The dike showed substantial distress, but it did not breach. However, several significant problem areas were identified. Inspection teams discovered excessive seepage, piping and sinkhole formation on the dike crest. Cloudy water exiting the landside toe of the dike and the accumulation of fine sands indicated internal erosion of the dike. Emergency repairs in the form of seepage berms were completed in time for the 1996 hurricane season, but these repairs were not intended or designed to be a permanent solution to the seepage and stability problems.

Emergency repairs are made by Corps teams, but these are not permanent fixes.

1998

High Water Event

In March of 1998 the lake rose to elevation 18.5 feet. Again, the Herbert Hoover Dike stood fast. But overall conditions continued to worsen. Additional boil formation and seepage appeared – presumably cumulative damage resulting from each successive high water event.

During recent demucking operations, Corps crews found signs of potential piping in the toe ditch on the landward side of the dike.

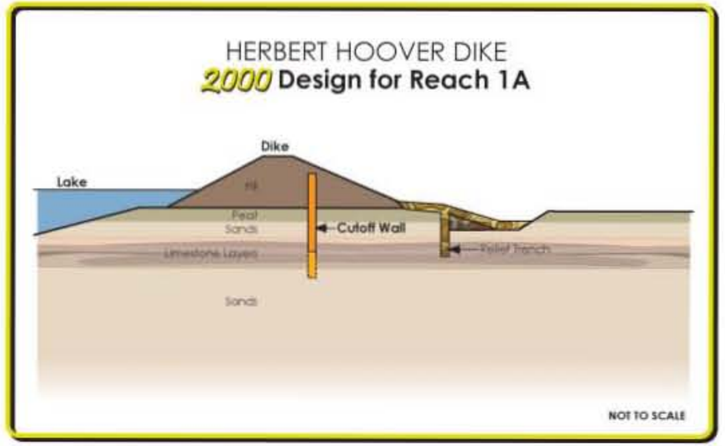
The Risk is Unacceptable

It could be a hurricane, a tropical storm or just lots of heavy rain. The risk increases significantly anytime the lake reaches an elevation above 18 feet.

Major Rehabilitation of the Dike

Original Design Plan

In the late 1990s, the Jacksonville District published reports based on extensive studies that indicated areas of vulnerability in the Herbert Hoover Dike. In 2000, we received congressional approval to design a project to rehabilitate, or reinforce, the dike. This project, as originally designed, met the objectives identified in our earlier studies. Construction began in December 2005.



Until Hurricane Katrina in 2005, concern about dike failure was relatively low. What happened in New Orleans changed public perception nationally and around the world, and raised the level of awareness and concern. The Corps' national evaluation of levees took on more urgency, and we decided to reevaluate the project design originally approved in 2000.

After receiving input from a variety of expert sources and in light of lessons learned following Hurricane Katrina, we convened an Independent Technical Review (ITR) panel to further evaluate the design. The panel included Corps experts from across the nation and representatives of the South Florida Water Management District (SFWMD). Several panel members had also served on the Interagency Performance Evaluation Task Force developing an evaluation report of the New Orleans and Southeast Louisiana Hurricane Protection System.

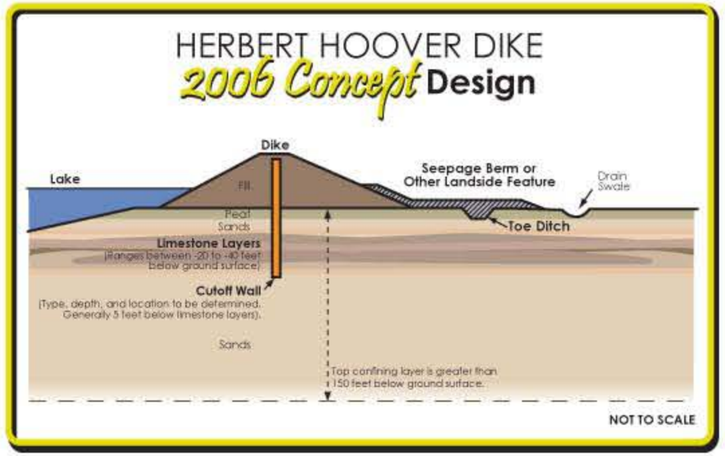
After the panel review, we conducted a second level of evaluation to review the ITR findings and to discuss future actions for strengthening the dike. Participants included the ITR panel and additional scientists and engineers from the SFWMD, URS (a global engineering design firm) and BCI (authors of the state-sponsored engineering report on the HHD, released in May 2006).

Katrina's impact on New Orleans' levees spear-headed a movement that allows the Corps to overcome significant constraints.

Major Rehabilitation of the Dike

The New Rehabilitation Design

The new design concept includes a seepage berm or other landside feature for decreasing piping and a cutoff wall for sealing pre-existing piping pathways and added resilience. The design approach will also incorporate additional protection features where needed. It is important that this design allows for upgrading if and when we determine that to be necessary.



This design approach closely mirrors an alternative that we developed in 2000, but was not chosen by the state and federal partners at that time because it required additional and costly acquisition of real estate and may have impacted regional groundwater. That decision was based on the team's knowledge and best professional judgment at that time. The post-Katrina environment empowered us to overcome significant constraints and focus solely on public safety and risk reduction goals.

Our solution involves filling in the toe ditch at the landside of the dike, constructing a seepage berm or landside feature, and constructing a cutoff wall inside the dike foundation. In other words, we are building redundancy and resiliency into the dike.

In January 2007, we began toe ditch work within the Corps right of way.

The seepage berm appears to be the best long-term solution to address piping, or internal erosion. The actual size of the berm may vary around the dike, depending on need and available space. Our goal is to avoid impacting homes and private structures to the maximum extent possible. Our first priority, however, is the health and safety of the public. During their analysis, the design team will address the best design and cost-effectiveness to provide slope stability and reduce piping.

The seepage berm serves two functions: to strengthen the dike by providing additional mass to resist the water pressure from the lake and to serve as a filter that prevents piping of material from the landside of the dike. Depending on geology, some areas may not require a robust berm, and in some areas there may not be enough room to construct the seepage berm. In those areas, different solutions may be necessary. Other landside features considered are construction of pressure relief wells and replacement of the peat layer will filer materials. Design plans will be based on specific geology and will take into consideration structures, properties and topography. We have to strike a realistic balance, but our goal is to avoid negative impacts to the maximum extent possible.

We will ensure that cutoff walls are installed to the depth that will provide the greatest project success. This is dependent on the local geologic conditions. For the intended purpose, the cutoff wall only needs to be deep enough to intercept all potential internal erosion pathways in the dike's foundation. The height of the cutoff wall will be enough to provide protection to a lake elevation of 26 feet.

In 2007, Corps contractors began installing a partially penetrating cutoff wall in the dike. The cutoff wall serves as a barrier to water pathways, which can lead to internal erosion. This cutoff wall reaches from the top of the dike through the limestone bedrock, about 60 feet below ground surface.

The Threat Reduced

Interim Risk Reduction Measures

Katrina changed everything, not only in New Orleans, but around the world. It forced everyone to be aware of the risks involved in living near water, and to prepare for the possible eventuality of a flood. Following Katrina, we took immediate measures to lower the risk of a dike breach and to assist emergency officials in developing their emergency plans.

We lowered Lake Okeechobee water elevation to below average ground level prior to the 2006 hurricane season. Our goal is to enter future hurricane seasons with the lake at a lower water elevation than in the past, maintaining the lake between 12.5 and 15.5 throughout the year. With our federal, state and local partners, we also developed an interim lake regulation schedule to reduce lake levels. Even with this plan, however, extreme rainfall events in the Kissimmee Basin can cause the lake to fill six times faster than waters can be released.

On a calm day at Lake Okeechobee, visitors can almost believe the lake goes on forever as it extends for miles in every direction.

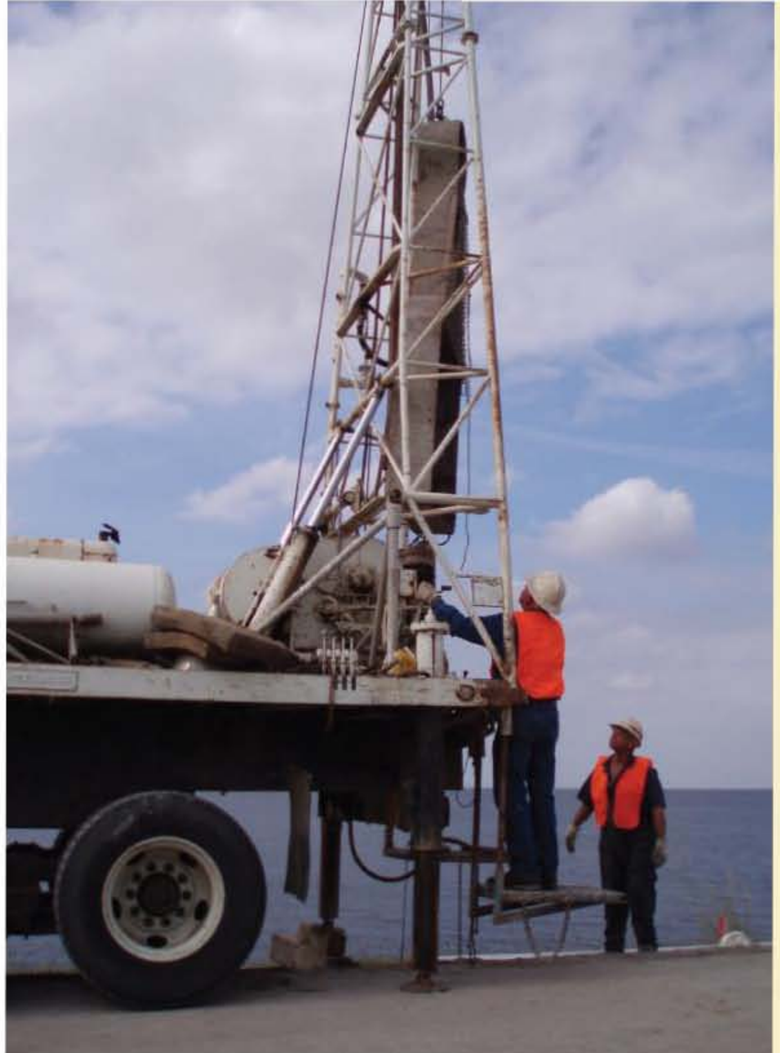
The Corps stockpiled materials around the lake that will help crews immediately address the effects of piping.

We developed a new Emergency Action Plan for the Herbert Hoover Dike and Lake Okeechobee structures, and we're coordinating the plan with each county's emergency management office. As part of the plan, we'll begin daily inspections once the lake reaches elevation 16.5 feet. If we observe a weakened condition, we'll initiate a formal notification process that proceeds rapidly from the federal government, to state and county emergency operations centers. The counties surrounding the lake will notify residents of any actions, such as evacuations, that should occur.

We have stockpiled and pre-positioned equipment and materials at 20 locations around the dike to allow quick and ready access for emergency repairs. Along with first responder personnel from our Clewiston Operations Office, the plan also calls for mobilizing personnel as needed from the Jacksonville District and contractors to augment the team in making emergency repairs or closing a possible breach.

We have also assisted lakeside counties in preparing their emergency evacuation plans in the event of a breach. We developed and provided updated inundation maps for all the counties in mid-2007. Inundation maps and associated information allow emergency planners to prioritize their efforts and develop detailed plans to ensure that precious time and resources are leveraged. The modeling includes various simulated breaches and various water elevations – 15.5, 18 (30-year), 21 (100-year), and 26 feet (Standard Project Flood – 935 years). Ultimately, the dike rehabilitation will be built to withstand a 26-foot water elevation; that is, it will afford protection for an event that occurs once in a 935-year period.

While all risk cannot be eliminated totally, knowing the condition of the dike and the risk associated with living or working near Lake Okeechobee is a critical factor in managing flood risk. When local decision makers and the public better understand risk, they are better equipped to make informed decisions about protecting lives and property.



Geology exploration and the data it provides are key to defining design dimensions for specific areas throughout the dike.

The Plan in Action

With Speed, Efficiency and Diligence

The Plan Applied

We have identified reaches 1, 2, 3 and 7 as the highest priorities. Within these reaches, we have further identified sub-reaches and areas that are in most need of repair.

The first phase of construction is Reach 1, which extends 22 miles along the southeast shore of the lake from Belle Glade to Port Mayaca. The second phase includes reaches 2 and 3, followed closely by Reach 7. We will address each of the reaches of the dike in engineering reports.

The 2007 estimated cost of the dike rehabilitation is $856 million, nearly three times the estimated cost of the 2000 design. Though much of this figure takes into account the rising costs of construction and materials, which are in high demand nationwide, the heftier increase is due to the cost of the redundant features (cutoff wall and seepage berm or other landside alternative), which provide additional defense against piping and improve overall dike reliability. As each feature is completed, it will provide a higher level of protection to lakeside residents.

It Will Take Time

The Corps is 100 percent responsible for the dike maintenance and rehabilitation, while the South Florida Water Management District is responsible for the real estate acquisition needed for the rehabilitation.

The current funding schedule allows the team to complete the first phase, which includes the three highest-risk reaches, by 2020. The estimated completion date for the entire rehabilitation project is 2030. If federal funding is provided at capability level, the rehabilitation schedule could be accelerated.

The Herbert Hoover Dike was built to protect the people who live around Lake Okeechobee. The dike has provided significant benefits to the people and economy of South Florida for more than 70 years.

Our engineering studies and recent high water events have demonstrated that the dike does not provide the required level of flood protection when lake levels exceed 18 feet.

But it can. We have the solution. We can protect the good life – for the people who live here . . . work here . . . play here.

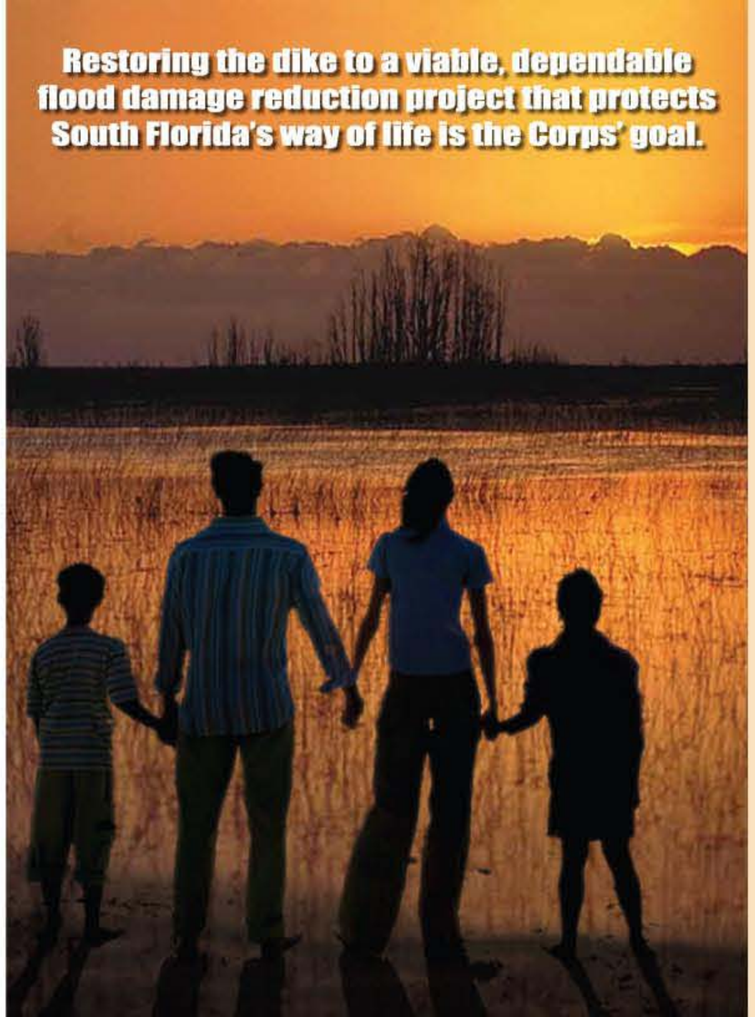
For their children & for future generations

Those are the challenges we face. We hope you'll support this very important project. If you would like to receive periodic updates on our dike rehabilitation progress, please send your name and address to:

U. S. Army Corps of Engineers
Jacksonville District
Attention: Corporate Communication Office
P.O. Box 4970
Jacksonville, Florida 32232-0019

Or email:
PublicMail.CESAJ-CC@saj.usace.army.mil

If your neighborhood or organization would like a presentation on the Herbert Hoover Dike project, please contact us at the above address.



The Team

Relevant, Ready, Responsive, Reliable

Jacksonville District...Setting the Pace

The U.S. Army Corps of Engineers was born on the battlefield of the American Revolution at Bunker Hill, and our Civilians and Soldiers have been among the first to respond ever since. As a branch of the U.S. Army, the Corps of Engineers plays a vital role by providing engineering, construction and environmental management services for the nation.

Jacksonville District, established in 1884, is the second largest civil works district in the nation, with an area of responsibility that encompasses the state of Florida and the Caribbean. We are one of 41 Corps districts in the United States, Europe and Asia, and one of five within the South Atlantic Division.

We provide quality planning, engineering, construction and operations products and services to meet the needs of the Armed Forces and the nation.

Home of the Jacksonville District, located on the Southbanks of downtown Jacksonville.

Our missions include five broad areas:

- Water resources
- Environment
- Infrastructure
- Homeland security
- Warfighting

The Jacksonville District team contributes to all of these mission areas through a wide variety of programs and projects to:

- Provide navigable harbors and channels
- Ensure flood and storm damage reduction
- Deliver force protection, safe facilities and base camps
- Restore ecosystems
- Protect wetlands
- Stabilize shorelines
- Respond in emergency situations
- Provide recreational opportunities
- Provide technical services to other local, state, federal and international agencies on a reimbursable basis

Jacksonville District's multidisciplinary team of almost 1,000 civilian employees is a diverse pool of talent, expertise and knowledge, led by a military district commander and deputy district commander. Our highly qualified and talented work force includes engineers, biologists, geologists, archeologists, attorneys, real estate, economists, contracting, accounting, security and communication professionals, and more. This unique team works together with one common goal – to serve the Armed Forces and the nation in peace and war.

Our team is further supported by a network of over 34,000 civilian and 650 military professionals in 41 districts and eight regional headquarters, as well as eight research and development laboratories and seven specialized engineering, design and support centers. Our one door to the Corps approach means that our customers benefit from access to this vast expertise.

As an Army values-based organization, our team demonstrates loyalty, duty, respect, selfless service, honor, integrity and personal courage on a daily basis.

U.S. Army Corps of Engineers
Jacksonville District
701 San Marco Boulevard
Jacksonville, FL 32207-0019
Phone: 904-232-2568

Gulf Coast Area Office
6320 S. Dale Mabry
Tampa, FL 33611
Phone: 813-831-4894

North Florida Area Office
4070 Boulevard Center Drive, Suite 201
Jacksonville, FL 32207-2823
Phone: 904-232-2086

North Florida Area Office, Melbourne
1515 Elizabeth Street, Suite A
Melbourne, FL 32901
Phone: 321-984-7097

Sebring Project Office
6406 US Highway 27S
Sebring, FL 33876-5711
Phone: 863-471-1741

South Florida Area Office
4400 PGA Boulevard, Suite 203
Palm Beach Gardens, FL 33410-6555
Phone: 561-472-3500

South Florida Operations Office
525 Ridgelawn Road
Clewiston, FL 33440-5399
Phone: 863-983-8101

St. Lucie Visitor Center
2170 SW Canal Street
Stuart, FL 34997-7002
Phone: 772-219-4575

Regulatory Field Offices
Cocoa: 321-504-3771
Fort Myers: 239-334-1975
Gainesville: 352-331-0732
Jacksonville: 904-232-1681
Miami: 305-526-7181
Palatka: 904-264-1273
Palm Beach Gardens: 561-472-3504
Panama City: 850-763-0717
Pensacola: 850-433-8732
Tampa: 813-769-7073

US Army Corps of Engineers®
Jacksonville District
701 San Marco Blvd.
Jacksonville, FL 32207
904.232.2234 • 800.291.9405
http://www.saj.usace.army.mil

2009