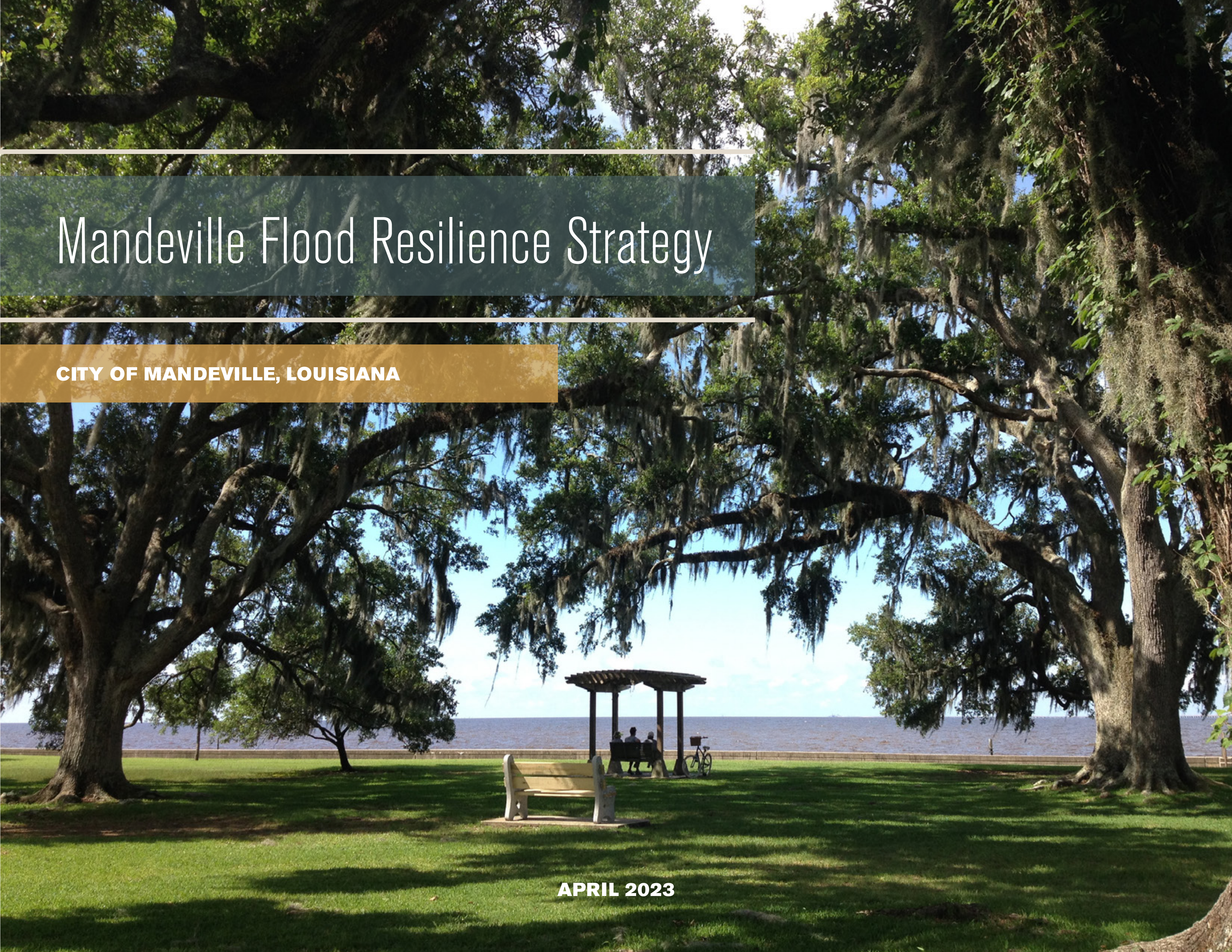


Mandeville Flood Resilience Strategy

CITY OF MANDEVILLE, LOUISIANA

APRIL 2023

Mandeville Flood Resilience Strategy

CITY OF MANDEVILLE, LOUISIANA

APRIL 2023

Produced For

City of Mandeville, Louisiana

MANDEVILLE
A Historic Lakefront Community

Funded By

Coastal Protection and Restoration Agency

COASTAL PROTECTION AND RESTORATION AUTHORITY
CPRA

Prepared By

CSRS, Inc.

CSRS
BUILDING STRONGER,
SMARTER COMMUNITIES
TOGETHER.

With support from Waggonner & Ball Architects & original artwork by Jeff Bell.

COVER PHOTO: iStock

Letter from Mayor

April 20, 2023

Dear Friends,

I am thrilled to introduce the Mandeville Flood Resilience Strategy: a road map for a safe and resilient future for our fine city.

I believe that the strategies identified in this plan will succeed in reducing flood risk for the whole Mandeville community, ensuring that future generations can benefit from and continue to enjoy the economic, social, and natural amenities that our city offers.

This plan is focused on reducing Mandeville's flood risk, while also preserving and enhancing the sense of place and character that makes the city unique. As a steward of Mandeville's economy and environment, I am confident that the innovative strategies recommended in this plan, based on cutting edge scientific analysis and hydraulic modeling, will make Mandeville a leader in coastal risk reduction and an example for communities near and far.

Though living in a coastal, flood-prone geography such as ours involves a level of risk, we can minimize that risk through the smart, cross-cutting interventions recommended in this plan. I thank the Coastal Protection and Restoration Authority for their partnership and support in this endeavor and look forward to expanding our collaboration with state and local government as we move forward to realize this work. I am honored and excited to lead the charge of implementing these strategies, protecting Mandeville's future and enabling our community to continue to grow and thrive for years to come.

Sincerely,

Clay Madden, Mayor

Message from CPRA

April 20, 2023

Dear Friends,

CPRA is excited to have partnered with the City of Mandeville in creating this Flood Resilience Strategy. The nonstructural adaptation strategies described in this document will be transformative for Mandeville's future, and we expect them to be models for other coastal communities facing the challenges of coastal adaptation.

The nuanced analysis of both environmental factors and the built environment that contribute to place-based vulnerability, from hydraulic modeling to demographic analysis, has resulted in a product that is holistic and comprehensive in its scope. This plan represents strategies that are both unique to the challenges faced by the City of Mandeville, and replicable for other coastal communities in Louisiana and beyond.

We are confident that implementation of this plan will be a critical step in the long journey of adaptation across the Louisiana coast.

Sincerely,

Chip Kline,
Coastal Protection and Restoration Agency (CPRA)

IMAGE CREDIT: iStock

Table of Contents

Another Bayou Sunset

Local Baton Rouge artist, oil paint on canvas.

IMAGE CREDIT: Jeff Bell

MANDEVILLE FLOOD RESILIENCE STRATEGY

1. Review of Existing Conditions & Plans

- HISTORICAL DEVELOPMENT ANALYSIS
- REVIEW OF EXISTING PLANS

Historical Development Analysis

MANDEVILLE FLOOD RESILIENCE STRATEGY

HISTORICAL DEVELOPMENT ANALYSIS

Looking Back

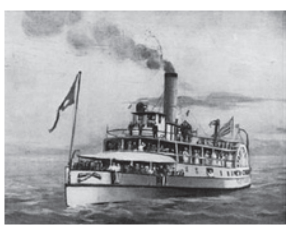
1906 nautical map for Lake Pontchartrain showing earliest street grid in Mandeville

1834

FOUNDED
by Bernard Xavier de Marigny de Mandeville.

mid-19th century

Mandeville became a summer destination for wealthy New Orleanians, and later to middle-class residents with the regular steamboat traffic across Lake Pontchartrain.
SUMMER DESTINATION



"New Camelia" steamboat on Lake Ponchartrain

Section of seawall at Mandeville in the 1930s

1930s

SEAWALL CONSTRUCTION
WPA, the Works Progress Administration, constructed a concrete seawall to help stop beach erosion for a while.

1956

The longest continuous bridge over water in the world, opened in 1956 spanning Lake Pontchartrain connecting New Orleans to Mandeville.
CAUSEWAY BRIDGE

Lake Ponchartrain Causeway under construction in June 1956

1980-90s

FLOODING EVENTS
Causeway bridge spurred the growth of Mandeville as a suburban commuter community for people working in New Orleans.

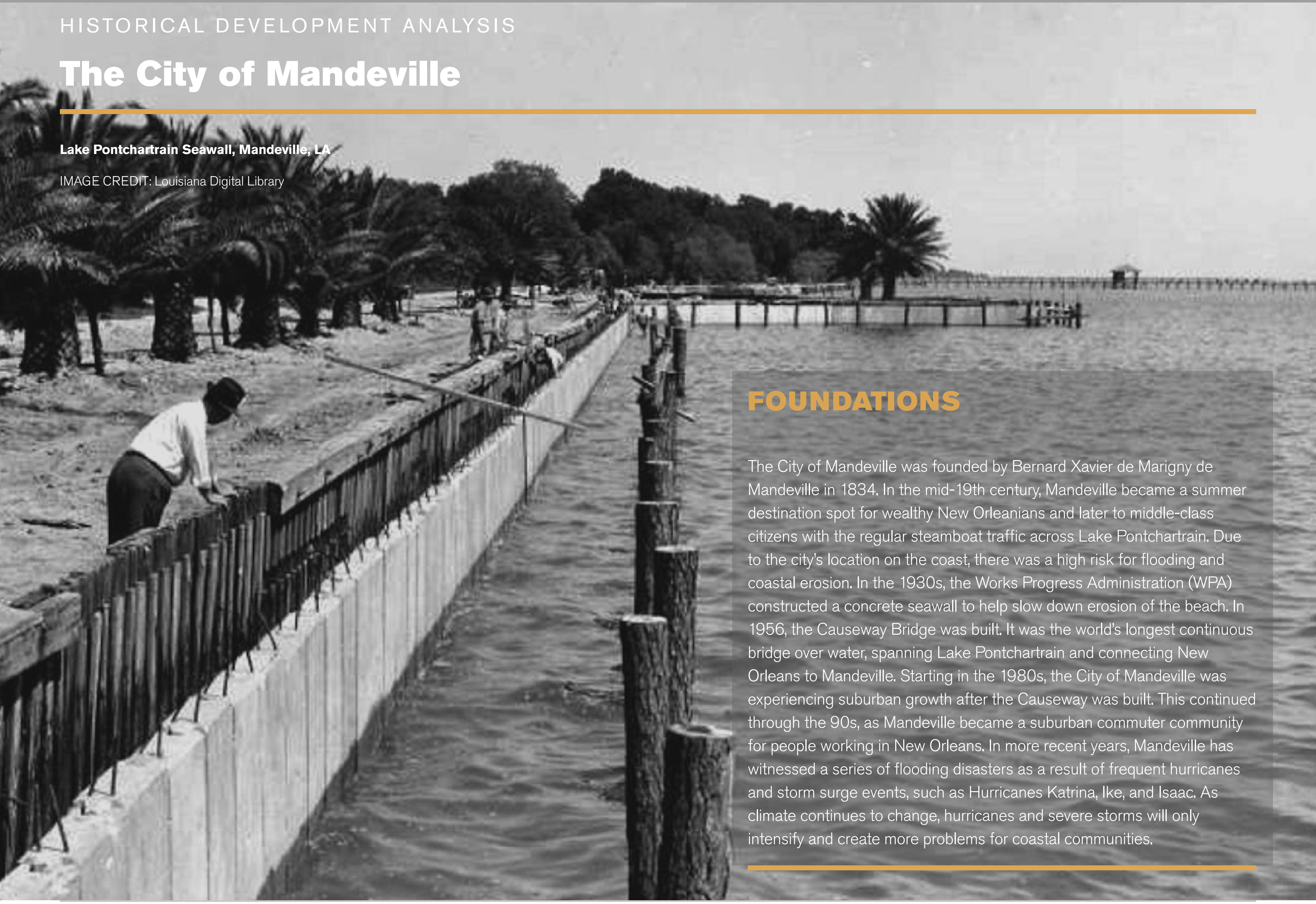
2000s

Mandeville is witnessing a series of flood disasters as a result of frequent hurricanes and storm surge events; such as from hurricane Katrina, Ike, Isaac, etc.
FLOODING EVENTS

Mandeville shoreline flooded during 2017 flooding

HISTORICAL DEVELOPMENT ANALYSIS

The City of Mandeville



Lake Pontchartrain Seawall, Mandeville, LA

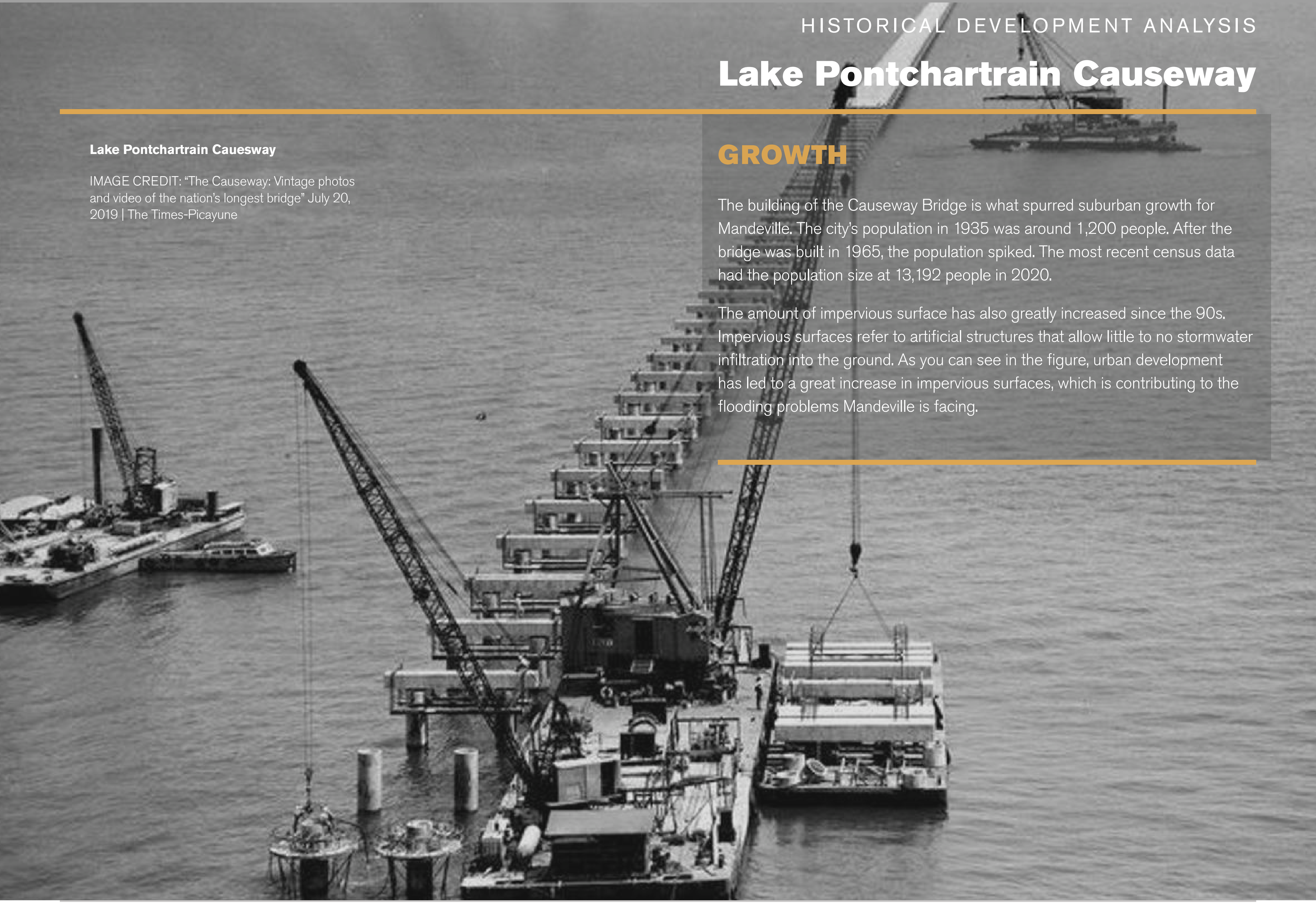
IMAGE CREDIT: Louisiana Digital Library

FOUNDATIONS

The City of Mandeville was founded by Bernard Xavier de Marigny de Mandeville in 1834. In the mid-19th century, Mandeville became a summer destination spot for wealthy New Orleanians and later to middle-class citizens with the regular steamboat traffic across Lake Pontchartrain. Due to the city's location on the coast, there was a high risk for flooding and coastal erosion. In the 1930s, the Works Progress Administration (WPA) constructed a concrete seawall to help slow down erosion of the beach. In 1956, the Causeway Bridge was built. It was the world's longest continuous bridge over water, spanning Lake Pontchartrain and connecting New Orleans to Mandeville. Starting in the 1980s, the City of Mandeville was experiencing suburban growth after the Causeway was built. This continued through the 90s, as Mandeville became a suburban commuter community for people working in New Orleans. In more recent years, Mandeville has witnessed a series of flooding disasters as a result of frequent hurricanes and storm surge events, such as Hurricanes Katrina, Ike, and Isaac. As climate continues to change, hurricanes and severe storms will only intensify and create more problems for coastal communities.

HISTORICAL DEVELOPMENT ANALYSIS

Lake Pontchartrain Causeway



Lake Pontchartrain Cauesway

IMAGE CREDIT: “The Causeway: Vintage photos and video of the nation’s longest bridge” July 20, 2019 | The Times-Picayune

GROWTH

The building of the Causeway Bridge is what spurred suburban growth for Mandeville. The city’s population in 1935 was around 1,200 people. After the bridge was built in 1965, the population spiked. The most recent census data had the population size at 13,192 people in 2020.

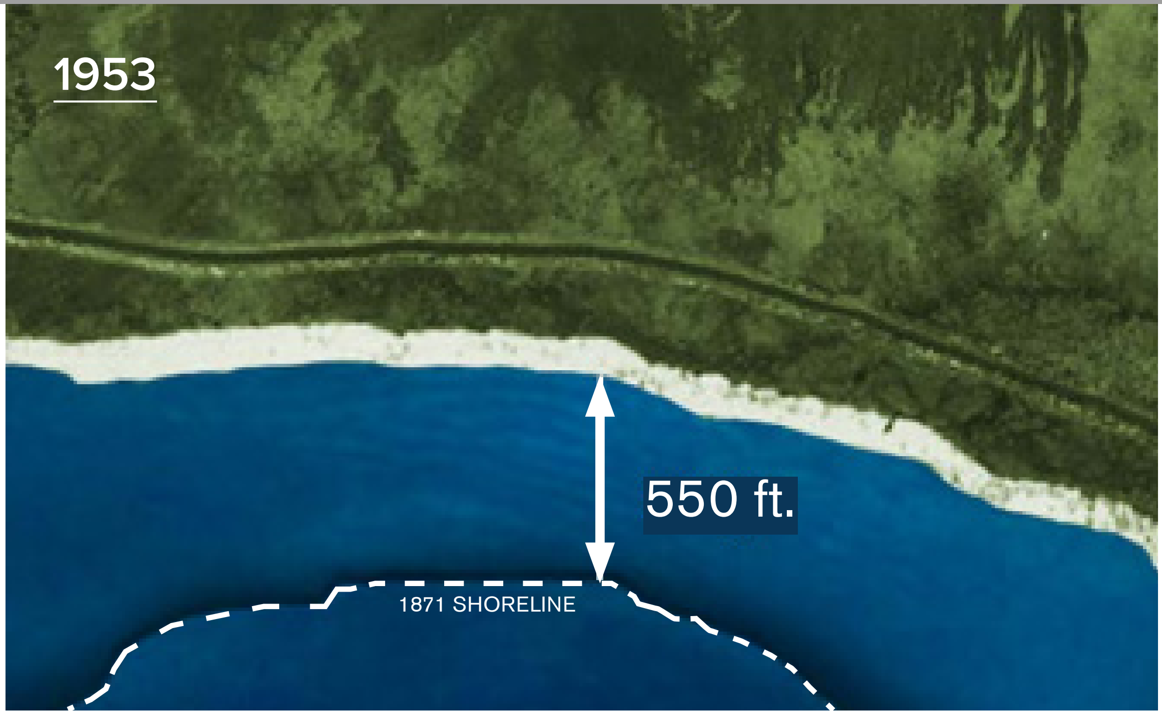
The amount of impervious surface has also greatly increased since the 90s. Impervious surfaces refer to artificial structures that allow little to no stormwater infiltration into the ground. As you can see in the figure, urban development has led to a great increase in impervious surfaces, which is contributing to the flooding problems Mandeville is facing.

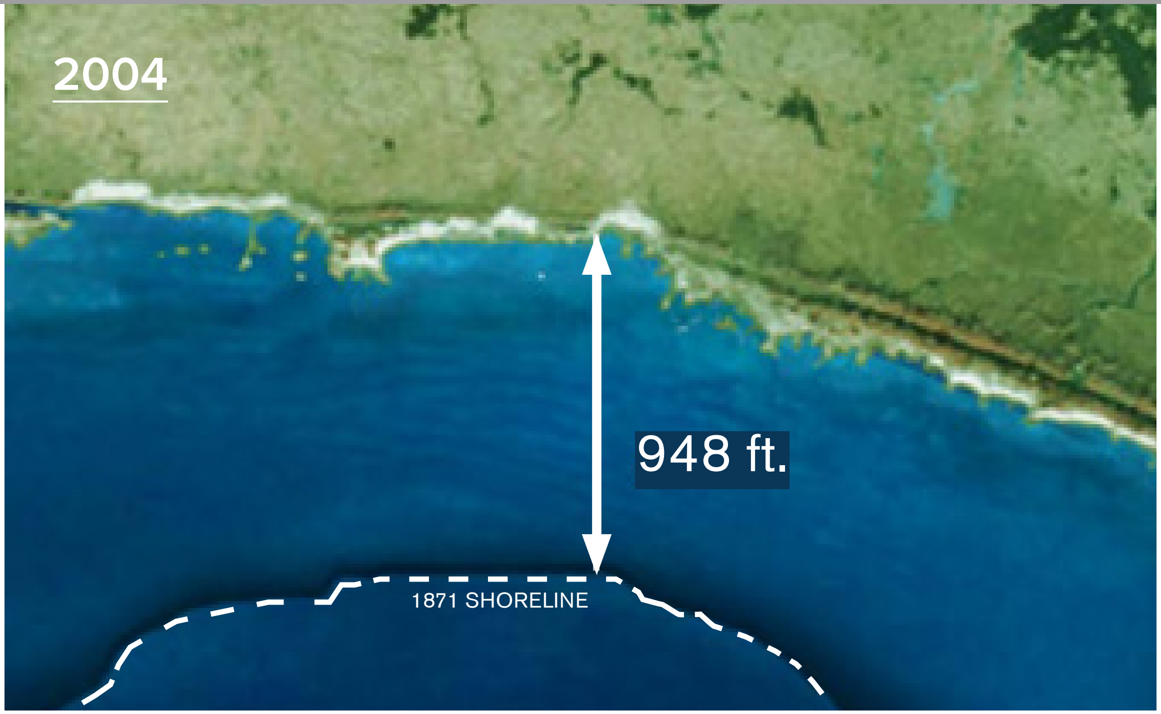
HISTORICAL DEVELOPMENT ANALYSIS

Coastal Erosion

STORM SURGE

From 1871 to 1953, the shoreline eroded inward by 455 ft. As time progressed, the shoreline continued to erode. As of 2004, the shoreline had eroded by 948 ft, resulting in the breaching of both canal banks. The loss of land is evident and will continue to grow every year with the changing climate. Storm surge will continue to have a worsened impact on the City of Mandeville as the coast continues to erode into the lake.





Storm surge is also a significant problem for the city. When Hurricane Katrina hit Mandeville's shoreline in 2005, the storm surge impacted 162 properties in Mandeville. During Hurricane Ike three years later, there were 463 impacted properties. In 2012, Hurricane Isaac hit resulting in 1,110 properties impacted, a significantly higher number than in 2005. The number of impacted properties has increased after every storm, as hurricanes intensify and the coast continues to erode, leaving the city exposed to large waves and flooding.

Continuous wave action from Lake Pontchartrain has caused coastal erosion in Mandeville. Mandeville currently has a seawall, but only part of the city is protected. There is a section of the natural shoreline of Lake Pontchartrain that has not been protected by the seawall. The seawall has prevented loss of shoreline property and minimized flooding caused by storm surge. However, the concrete structure needs ongoing repairs and maintenance. This can be an expensive process and the degradation can have a harmful impact on the surrounding marsh ecosystem.

1953 - 2004 Shoreline Loss

Although the sand bank remains across the breadth of the shoreline erosion has breached the banks of the canal and has caused interior ponding to develop.

IMAGE CREDIT: City of Mandeville

Review of Existing Plans

MANDEVILLE FLOOD RESILIENCE STRATEGY

REVIEW OF EXISTING PLANS

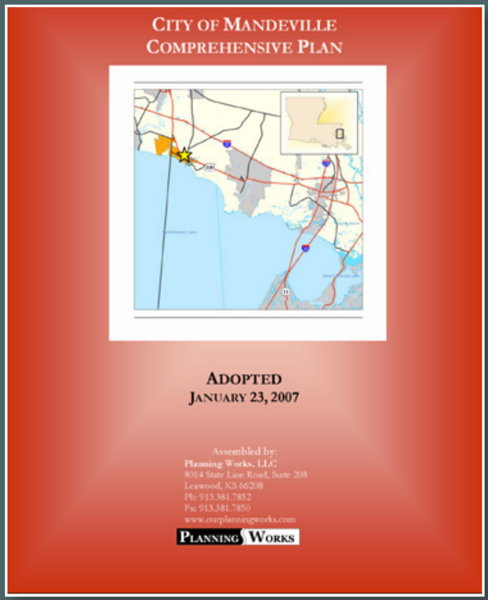
City of Mandeville Comprehensive Plan

DATE: 2007

SCHEDULED UPDATE: 2020 (delayed due to COVID)

NAME OF AGENCY:
Mandeville City Planning Commission

PURPOSE OF PLAN:
Comprehensive Plan to guide City of Mandeville's future goals and policies on land use, growth, housing, economic development, natural resources and public facilities.



PLAN SUMMARY

Plan focuses on key issues as determined through 2-year public consultation: Environmental, Soci-Economic, Public Facilities and Services, Transportation, and Land use and Growth. The Implementation Element is to be reviewed annually and result in Short Term Work Programs to be tied to City's annual budget.

Relevant findings from the Comprehensive Plan include:

- Guides decisions through 2020. Planning area includes areas not in City of Mandeville.
- Growth Management agreement with St Tammany Parish.
- Large percentage of City at low elevations: threat of flooding from Lake Pontchartrain and upstream runoff.
- Nearly all of the City of Mandeville is within the 100 year (class A) floodplain as defined by FEMA (updated maps now classify as AE).
- Many drainage problems originate from development outside City.
- Stormwater runoff from the undeveloped northern portions of the planning area must be conveyed through the City to Lake Pontchartrain.
- Drainage patterns in the Greater Mandeville Area are defined by Bayou Chinchuba and Bayou Castain, which flow into Lake Pontchartrain, and Bayou Tete L'Ours and Pontchitolawa Creek, which are tributaries of the Tchefuncte River.

REVIEW OF EXISTING PLANS

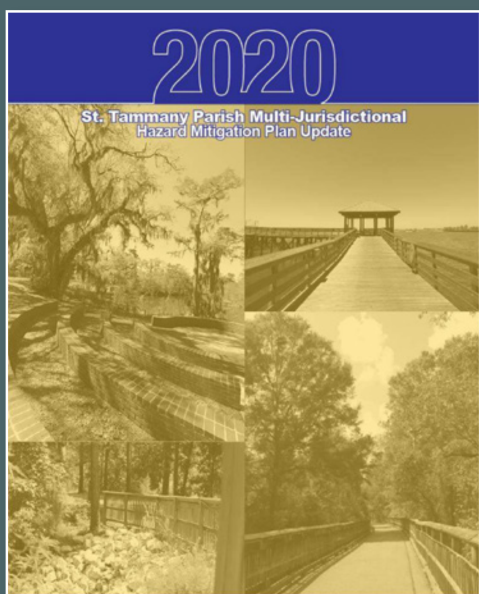
St. Tammany Hazard Mitigation Plan

DATE: 2020

SCHEDULED UPDATE: 2025

NAME OF AGENCY:
St Tammany Parish Government

PURPOSE OF PLAN:
Comprehensive plan for disaster resiliency in St. Tammany Parish.



PLAN SUMMARY

The Hazard Mitigation Plan (HMP) identifies activities that can be undertaken by both the public and the private sectors to reduce safety hazards, health hazards, and property damage caused by natural hazards. The St Tammany HMP covers 8 incorporated communities, including City of Mandeville.

St. Tammany Parish is at high risk of water inundation from various sources, including flooding and tropical cyclone activity. The entire parish is also at high risk of damages from high winds and wind-borne debris caused by various meteorological phenomena. Although many hazards are evaluated in the HMP, hurricanes are the main focus of the plan.

- Mandeville has 100% chance of re-occurrence for the following hazards: coastal hazards, thunderstorm high winds, hailstorms, tropical cyclones, and tornadoes.
- Mandeville has the second highest (40%) chance of re-occurrence for flooding out of the 8 communities in St Tammany Parish.
- Mandeville is experiencing coastal land loss and subsidence rates of approximately 10mm annually.
- The Digital Elevation Model shows that large portions of Mandeville are under 3 feet.
- Worst case storm surge scenarios for Mandeville are flood depths of approximately 18 feet.
- HMP identifies 15 ongoing mitigation projects in Mandeville and 9 new ones. Most ongoing projects focus on flood mitigation and wind retrofits of public facilities.

REVIEW OF EXISTING PLANS

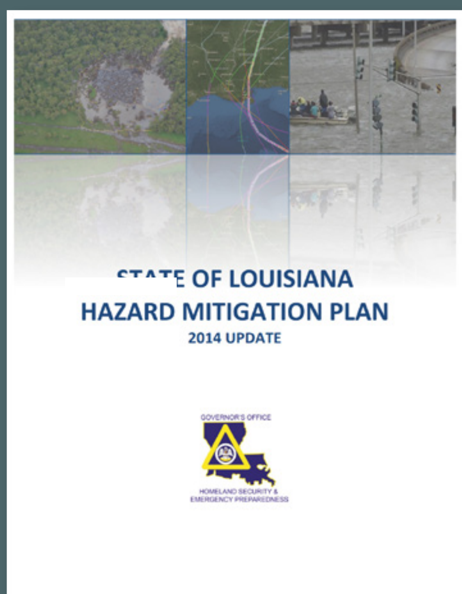
State of Louisiana Hazard Mitigation Plan

DATE: 2019

SCHEDULED UPDATE: 2023

NAME OF AGENCY:
Governor's Office of Homeland Security and Emergency Preparedness

PURPOSE OF PLAN:
Comprehensive plan for disaster resilience for state of LA



PLAN SUMMARY

Statewide HMP incorporates state and local planning goals and provides a vehicle for local and regional cooperation for effective hazard mitigation. The plan groups the hazards facing Louisiana into four categories: temperature hazards, wind hazards, flood hazards (including coastal hazards), and geologic hazards. A planning time horizon of 25 years was selected, projecting the potential impacts of natural hazards in the year 2043.

- St. Tammany Parish was ranked 3rd out of the top 5 jurisdictions most vulnerable to identified hazards in the State.
- Plan emphasizes importance of uniformity amongst jurisdictional HMPs through following FEMA guidelines to guarantee eligibility for Federal mitigation funds.
- Because of broad, state-wide scope, no details specific to Mandeville.

REVIEW OF EXISTING PLANS

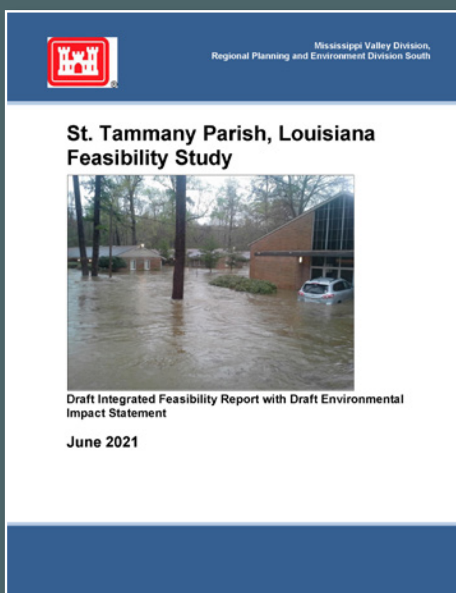
St Tammany Louisiana Feasibility Study

DATE: 2021

SCHEDULED UPDATE: N/A

NAME OF AGENCY:
US Army Corps of Engineers

PURPOSE OF PLAN:
To investigate flood risk management and coastal storm risk management solutions to reduce flood damages caused by rainfall and coastal storm flooding in St. Tammany Parish.



PLAN SUMMARY

This study describes a process of the identification and evaluation of 195 site specific management measures aimed at reducing flood risk in St. Tammany Parish through study of existing plans, stakeholder input, and public recommendations. The evaluation and narrowing process undertaken by the Corps is as follows: Measures, Initial Array, Focused Array, Final Array, and ultimately the Tentatively Selected Plan or action. The action is “the construction (and operation) of a total of approximately 16.3 miles of a hurricane and storm damage risk reduction levee and floodwall from west Slidell to south Slidell, 5 pump stations, 5 floodgates, ramps, channel improvements to Bayou Patassat in Slidell, channel improvements to Mile Branch in Covington, and nonstructural home elevations and floodproofing for eligible structures in the Parish. The proposed action would reduce flood risk to approximately 15,800 structures in the study area”.

- A project for the Mandeville Lakefront was in the Final Array of 9 alternatives and eliminated because of a low Benefit Cost Ratio.
- The Mandeville Lakefront measure was analyzed using 3 variations:

  1. Replacing the existing seawall, with new 7.3 feet seawall and construction of 4 pump stations along the lakefront seawall ($17.2M)
  2. Replacing the existing seawall, with new 7.3 feet seawall, and construction of floodwalls, 2 pump stations, and floodgates. ($18.6M)
  3. New 18 foot Seawall with the construction of 2 pump stations, floodwalls, and floodgates. ($5.19M)

REVIEW OF EXISTING PLANS

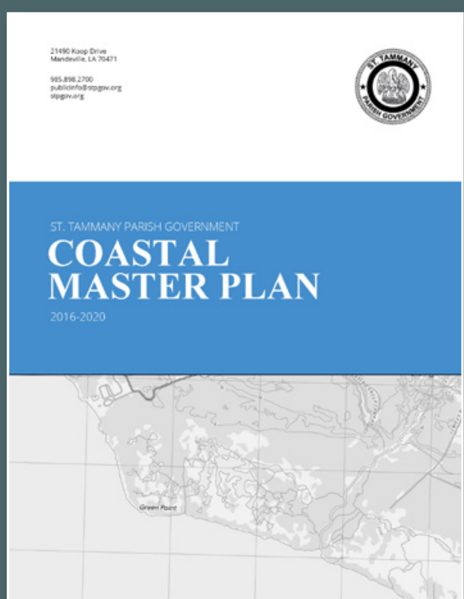
St Tammany Parish Coastal Master Plan

DATE: 2016-2020

SCHEDULED UPDATE: 2024

NAME OF AGENCY:
St Tammany Parish Government

PURPOSE OF PLAN:
The Parish's Coastal Master Plan is the collection of projects that will provide protection for citizens and improvements in the coastal environment.



PLAN SUMMARY

Plan outlines eight nonstructural projects and one structural project, providing project summaries and cost estimates.

- Home Elevation is listed as the first project, with a goal of elevating all structures in St. Tammany parish's surge zone, of which they estimate to be 780, including structures in Mandeville.
- Other nonstructural projects include shoreline protection along Lake Pontchartrain, and marsh restoration, none located in Mandeville.

REVIEW OF EXISTING PLANS

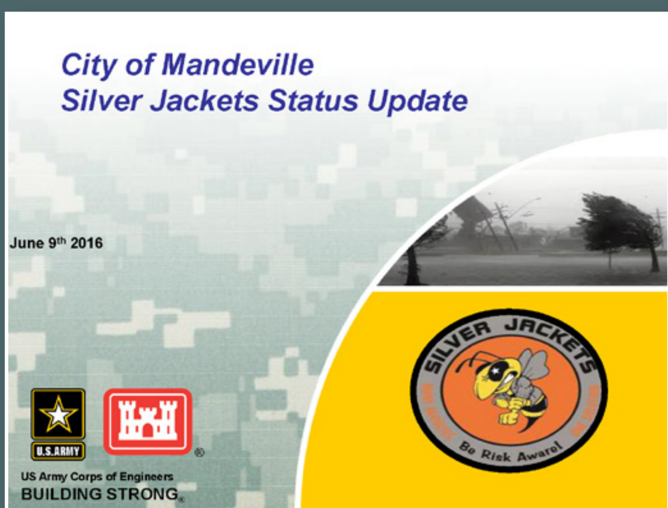
City of Mandeville Silver Jackets Status Update

DATE: 2016

SCHEDULED UPDATE: N/A

NAME OF AGENCY:
US Army Corps of Engineers

PURPOSE OF PLAN:
To investigate flood risk management and coastal storm risk management solutions to reduce flood damages caused by rainfall and coastal storm flooding in St. Tammany Parish.



PLAN SUMMARY

Alternatives evaluated for Lake Stages of 3.0, 4.2, 5.3, 7.3, and 9.5 Feet. A range of structural and nonstructural alternatives considered.

- Structural alternatives were considered for Lake stages of 3.0 (1-year event), 4.2 (2-year event), 5.3 (5-year event), and 7.3 (20-year event) feet.
- Mix of gates on stormwater drainage pipes, berms, temporary barriers, sheet pile walls and a cap on existing seawall.
- Nonstructural alternatives were evaluated for Lake Stages of 7.3 (20-year event) and 9.5 Feet (100 -year event).
- Costs were estimated for 1st floor elevation below 7.3 raised to 12.0 and 1st floor elevation below 9.5 raised to 12.0 for 1,000+ identified properties.
- Recommends moving forward with a 3 phase US Army Corps of Engineers Continuing Authorities Program , Small Flood Control Projects.

REVIEW OF EXISTING PLANS

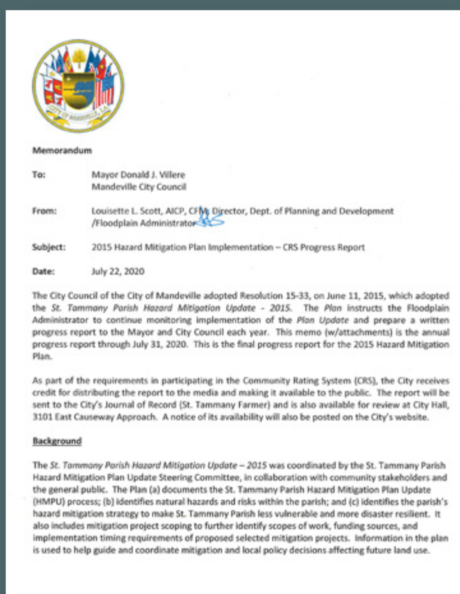
Mandeville Hazard Mitigation 2019 Plan Update

DATE: 2019

SCHEDULED UPDATE: Annually

NAME OF AGENCY:
City of Mandeville

PURPOSE OF PLAN:
Annual update to St. Tammany Parish Hazard Mitigation Plan



Memorandum

To: Mayor Donald J. Villere
Mandeville City Council

From: Louisette L. Scott, AICP, CFM, Director, Dept. of Planning and Development
/Floodplain Administrator

Subject: 2015 Hazard Mitigation Plan Implementation – CRS Progress Report

Date: July 22, 2020

The City Council of the City of Mandeville adopted Resolution 15-33, on June 11, 2015, which adopted the *St. Tammany Parish Hazard Mitigation Update - 2015*. The *Plan* instructs the Floodplain Administrator to continue monitoring implementation of the *Plan Update* and prepare a written progress report to the Mayor and City Council each year. This memo (w/attachments) is the annual progress report through July 31, 2020. This is the final progress report for the 2015 Hazard Mitigation Plan.

As part of the requirements in participating in the Community Rating System (CRS), the City receives credit for distributing the report to the media and making it available to the public. The report will be sent to the City's Journal of Record (St. Tammany Farmer) and is also available for review at City Hall, 3101 East Causeway Approach. A notice of its availability will also be posted on the City's website.

Background

The *St. Tammany Parish Hazard Mitigation Update – 2015* was coordinated by the St. Tammany Parish Hazard Mitigation Plan Update Steering Committee, in collaboration with community stakeholders and the general public. The Plan (a) documents the St. Tammany Parish Hazard Mitigation Plan Update (HMPU) process; (b) identifies natural hazards and risks within the parish; and (c) identifies the parish's hazard mitigation strategy to make St. Tammany Parish less vulnerable and more disaster resilient. It also includes mitigation project scoping to further identify scopes of work, funding sources, and implementation timing requirements of proposed selected mitigation projects. Information in the plan is used to help guide and coordinate mitigation and local policy decisions affecting future land use.

PLAN SUMMARY

Reviews a variety of measures to reduce problems when flooding occurs. These measures include maintenance on drainage systems, upgrading the storm drainage system, maintenance of rights-of-way, floodproofing, elevation of SRL/RL structures, wind retrofit of public buildings, building regulations and public information. The plan update includes 33 action items specific to Mandeville.

- Of the 33 action items, 18 are ongoing, annual, or maintenance activities and 15 have been completed.
- Ongoing action items include: elevation of SRL/RL structures, Sewerage Treatment Plant flood mitigation, wind retrofit of public buildings, cypress swamp coastal restoration and armoring, flow capacity for stormwater, participation in FEMA grant programs, and CRS rating.

PREVIEW OF EXISTING PLANS

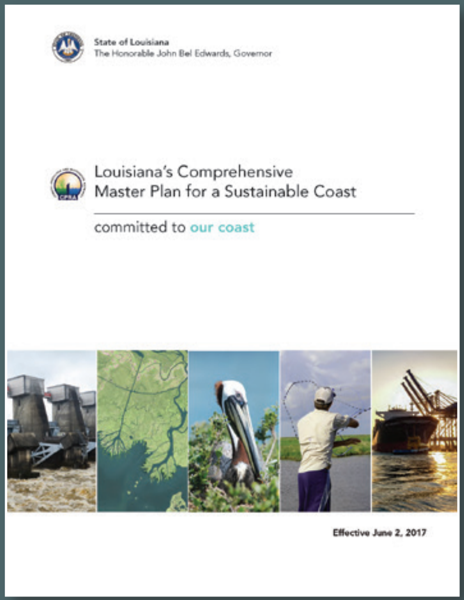
Louisiana Master Plan for a Sustainable Coast

DATE: 2017

SCHEDULED UPDATE: 2023

NAME OF AGENCY:
CPRA – Coastal Protection and Restoration Authority

PURPOSE OF PLAN:
Comprehensive plan for a more sustainable coastal Louisiana landscape.



PLAN SUMMARY

The Master Plan includes protection and restoration goals for reducing coastal flood risk, promoting sustainable ecosystems by providing habitats for a variety of commercial and recreational activities, and support to regional and national business and industry. The 2017 Master Plan recommends a diversity of projects to build land and reduce flood risk to balance short-term needs with long-term goals.

- Louisiana will likely experience a decrease in the number of tropical depressions, tropical storms and Category 1 and 2 hurricanes, but an increase in the frequency of Category 3-5 hurricanes. Frequency estimated to increase by 13% to 83% from 2015-2065.
- Predictions for flood risk for next 50 years using the "high risk" scenario of sea level rise and land loss with "no action" are for 13-15 ft all along the St Tammany coast and 15+ ft in certain areas.
- Coastal St. Tammany Parish (including Mandeville) has been identified as an area for nonstructural risk reduction, identified in the Plan as: floodproofing non-residential structures for 1 to 3 ft flood depths, elevation of residential structures for 3 to 14 ft flood depths, and voluntary acquisition or residential properties for 14+ ft flood depths.

REVIEW OF EXISTING PLANS

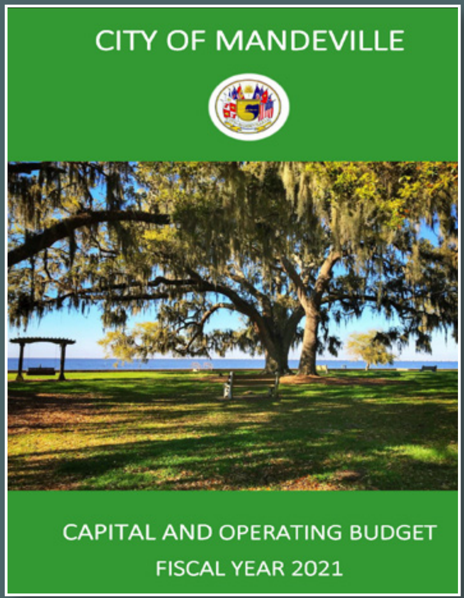
City of Mandeville Capital and Operating Budget

DATE: FY 2021

SCHEDULED UPDATE: N/A

NAME OF AGENCY:
City of Mandeville

PURPOSE OF PLAN:
Budget document that serves as a policy document, as a financial plan, and as an operations guide for the City of Mandeville.



PLAN SUMMARY

The budget document is a framework of how the City will allocate its resources, including departmental operating budgets, a five-year (2021-2025) Capital Improvement Plan, Financial Plan, Vehicle Replacement Plan, and Equipment Replacement Plan. The City's total budget revenue is $29 million, operating expenditures of $22.2 million, with a capital budget of $25.1 million. The statutory debt limit and amount available for general obligation borrowings is approximately $16.9 million. The City currently has no bond issue outstanding.

- Goals section of Budget call for open space plan to protect critical and sensitive land areas to help maintain absorption of rainwater and tree preservation to prevent flooding.
- Capital Improvement projects planned for increase resiliency include:
  - Mandeville Lakefront Wetlands Restoration project providing flood control to the Hermitage Subdivision, rebuilding the wetlands, removing the structures from the V-Zone and lowering flood insurance premiums for all the homes affected. Construction planned for FY21. Estimated construction cost $3M.
  - Eastside and Westside shoreline protection and flood control
  - Repairing sheet pile wall at harbor
- City is actively pursuing all resources available home elevations, contracting with Solutient since 2013, which has identified all SRL properties, and manages all grant funded home elevations.
- As a first step in an Open Space Master Plan, the City worked with The Conservation Fund on an assessment of existing vacant lands within the city limits for suitability as use as open space with multiple benefits such as stormwater management/flood protection and public use.

REVIEW OF EXISTING PLANS

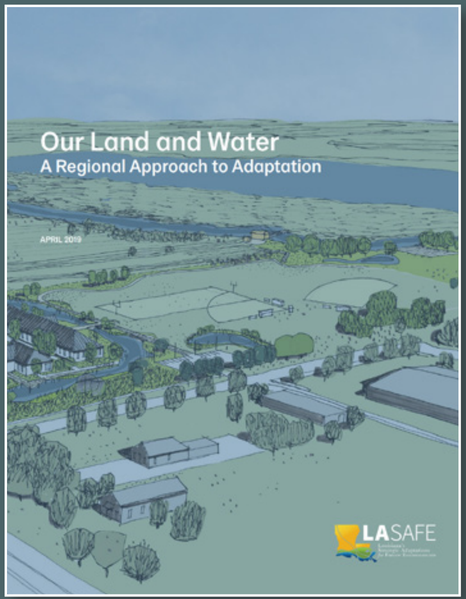
LASAFE: Louisiana's Strategic Adaptations for Future Environments

DATE: 2018-2019

SCHEDULED UPDATE: N/A

NAME OF AGENCY:
Joint venture between the State of Louisiana and the Foundation for Louisiana

PURPOSE OF PLAN:
To generate parish-wide, community-driven adaptation strategies for coastal challenges and environmental changes.



PLAN SUMMARY

LA SAFE is the result of 9-month long engagement and outreach process with over 2,800 residents, parish officials, and other stakeholders across 6 coastal Parishes: Plaquemines, Terrebonne, Lafourche, St. John the Baptist, St. Tammany, and Jefferson Parish. Ultimately one project per parish was selected. In St. Tammany Parish, the project selected is Safe Haven Blue-Green Campus & Trails. In 2019, LASAFE released set of seven climate adaptation strategies created for six coastal parishes.

- The Safe Haven Blue-Green Campus & Trails project is a Community Nonstructural Mitigation/Flood Risk Reduction and Public Services project that will enhance detention capabilities in a critical drainage area adjacent to Cane Bayou, protecting campus facilities and surrounding neighborhood residences. The site is the former Southeast Louisiana Hospital, in Mandeville.
- During the engagement process, residents of Mandeville prioritized projects that increased greenspace and stormwater retention capabilities and improved connectivity in areas of low and moderate risk.
- Key goals in the St. Tammy adaption strategy:
  - Manage Flooding and Subsidence Goal
  - Direct Growth to Low-Risk Areas
  - Improve Mobility Throughout the Parish and Region
  - Strengthen and Diversity Local Economies

Existing Plans Matrix

SOLUTIONS CONSIDERED / PLANS REVIEWED	CITY OF MANDEVILLE COMPREHENSIVE PLAN	ST. TAMMANY HAZARD MITIGATION PLAN	STATE OF LOUISIANA HAZARD MITIGATION PLAN	US ARMY CORPS OF ENGINEERS: ST. TAMMANY FEASIBILITY STUDY	ST. TAMMANY COASTAL MASTER PLAN	MANDEVILLE SILVER JACKET UPDATE	MANDEVILLE FY 21 CAPITAL AND OPERATING BUDGET	LOUISIANA MASTER PLAN FOR A SUSTAINABLE COAST	LASAFE	MANDEVILLE HAZARD MITIGATION 2019 PLAN UPDATE
DRAINAGE / MAINTENANCE							●			●
NONSTRUCTURAL			●		●	●		●	●	
STRUCTURAL				●		●				
LAND USE	●								●	
STORMWATER							●		●	

REVIEW OF EXISTING PLANS

Findings

There are several key opportunity areas to reduce flood risk in Mandeville that were not included in the existing plans. We recommend exploring the following topics further for their inclusion in the flood resilience planning process.

REGIONAL FLOOD RISK ANALYSIS

Much of Mandeville's flood risk is driven by factors outside of its jurisdiction, such as floodwaters from upstream communities. A regional flood risk analysis would show what areas and interventions Mandeville could focus on in partnership with the parish and neighboring communities to reduce its risk.

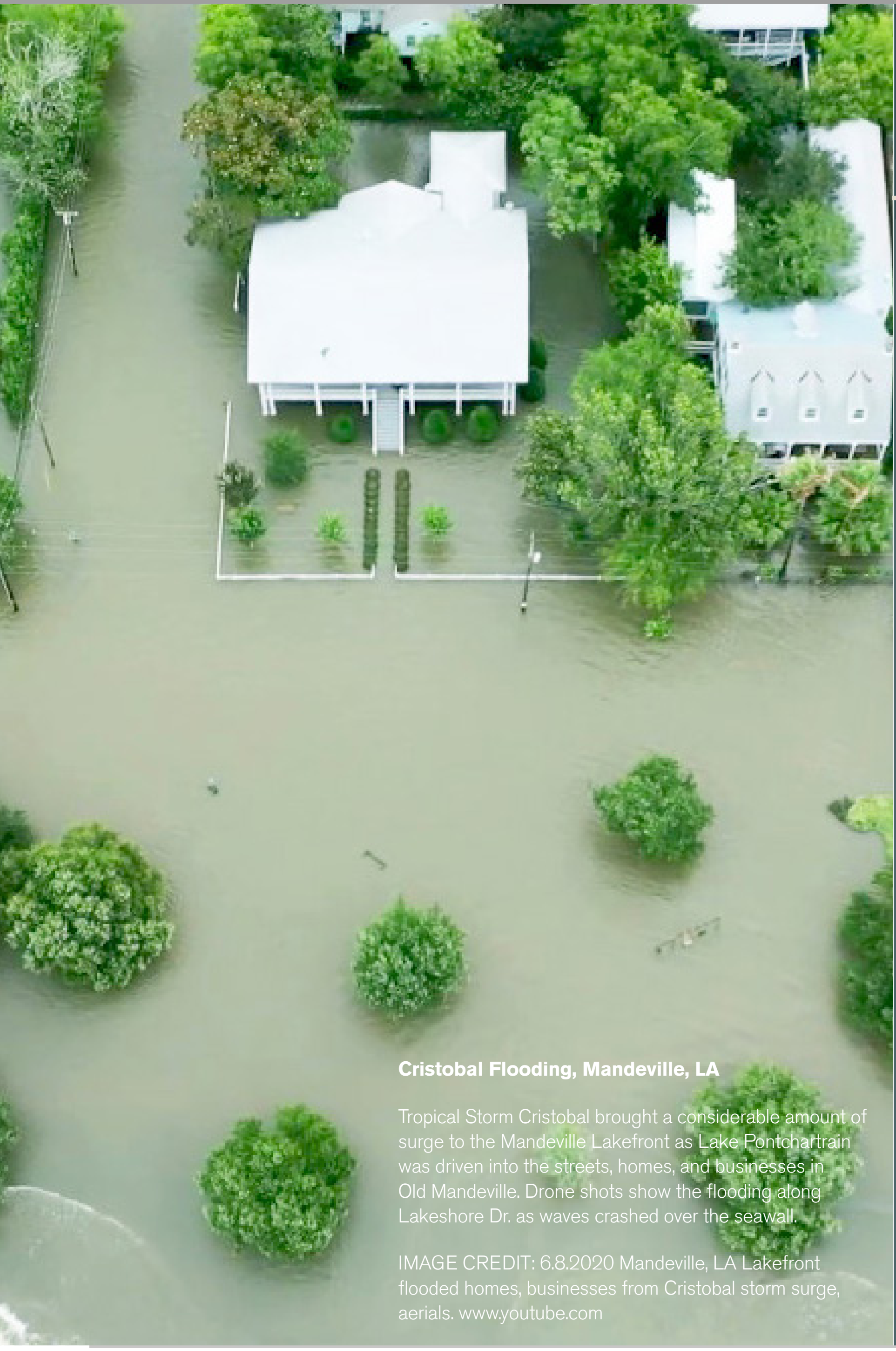
The Louisiana Watershed Initiative provides an opportunity for local governments to collaborate with neighboring jurisdictions on regional strategies to their shared flood risk challenges and will make available regional watershed modeling to assess challenges and development regional-scale solutions.

NON-STRUCTURAL ADAPTATION STRATEGY

In cases where repetitive flooding is anticipated to impact existing structures, and where physical barriers (structural solutions) are either infeasible or undesirable, elevation and voluntary acquisition should be an option that the city facilitates in coordination with local, state, and federal partners to permanently reduce flood risk.

LAND USE REGULATION & INCENTIVES

The future land use and physical footprint of Mandeville may need to adapt over time to reduce the city's flood risk, focusing growth in areas with low flood risk and reducing exposure in high flood risk areas. Land use regulations and incentives could be an important tool for the city to use in spurring this adaptation in partnership with private property owners.



Cristobal Flooding, Mandeville, LA

Tropical Storm Cristobal brought a considerable amount of surge to the Mandeville Lakefront as Lake Pontchartrain was driven into the streets, homes, and businesses in Old Mandeville. Drone shots show the flooding along Lakeshore Dr. as waves crashed over the seawall.

IMAGE CREDIT: 6.8.2020 Mandeville, LA Lakefront flooded homes, businesses from Cristobal storm surge, aerials. www.youtube.com

OPEN SPACE / GREEN SPACE ANALYSIS FOR FLOOD RISK REDUCTION

By establishing or enhancing open spaces, both large and small, that can store and reduce pollutants in stormwater, the city may be able to enhance its natural environment and cultural amenities while also reducing its flood risk.

INTEGRATED INFRASTRUCTURE ANALYSIS

None of the existing plans and studies examined flood risk in context with transportation, utilities, and other infrastructure to determine what coordinated and integrated solutions might come from planning them in an integrated fashion. For instance, how might some roads or bridges be redesigned and rebuilt to reduce flood risk?

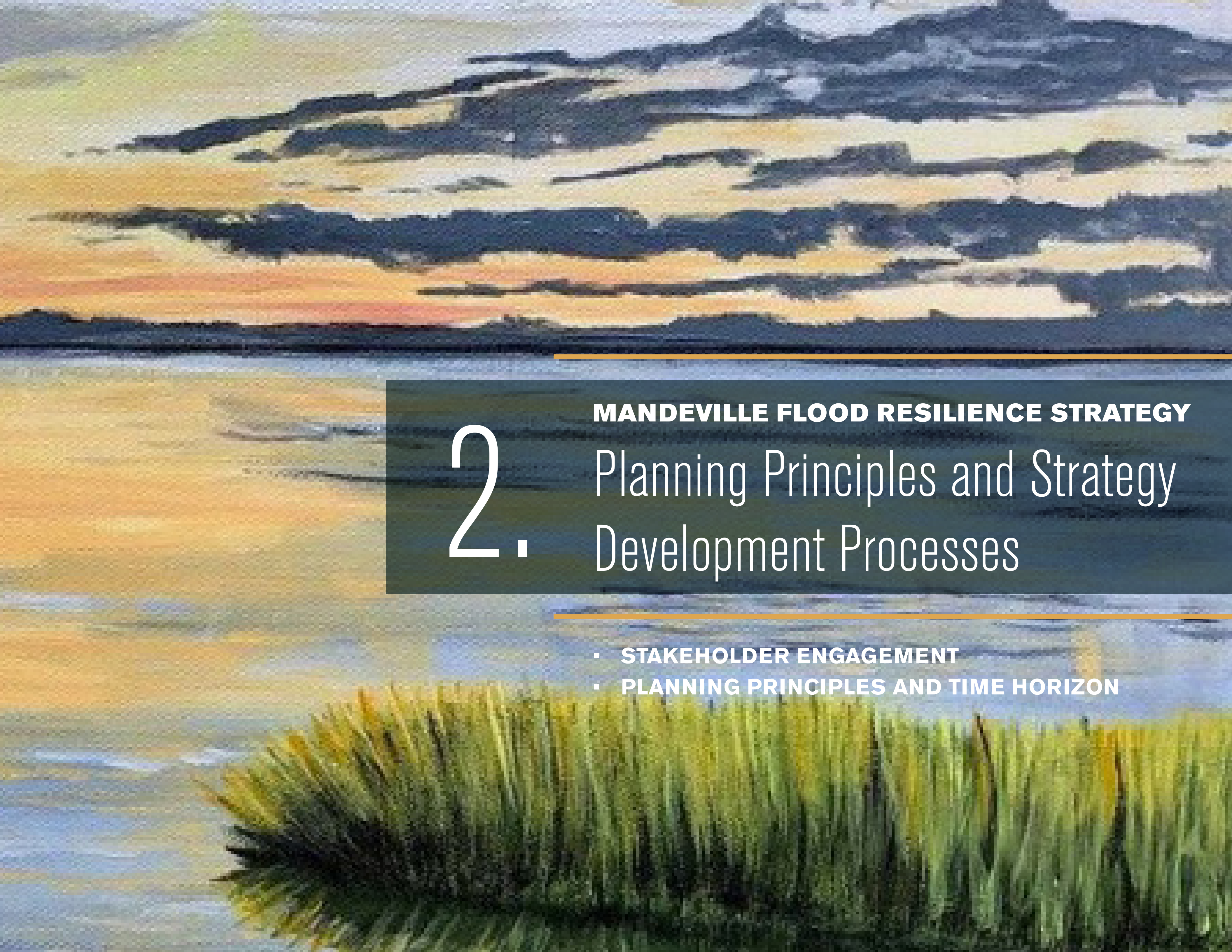
FUNDING SOURCES AND FINANCING MECHANISMS

Critical to implementing these strategies will be a comprehensive approach to funding opportunities and financing mechanisms so the city can leverage its investment and maximize its impact. The city has a critical window of opportunity to take advantage of the massive state and federal investment in infrastructure to enhance its flood resilience.

Good Morning

Jeff Bell, oil paint on canvas.

IMAGE CREDIT: Jeff Bell. https://www.instagram.com/p/CUAfAB6LuVg/



MANDEVILLE FLOOD RESILIENCE STRATEGY

2. Planning Principles and Strategy Development Processes

- STAKEHOLDER ENGAGEMENT
- PLANNING PRINCIPLES AND TIME HORIZON

Stakeholder Engagement

STRATEGY DEVELOPMENT PROCESS

Stakeholder Engagement

COMMITTEE MEETINGS AND PUBLIC WORKSHOPS

CSRS had several meetings with the City of Mandeville to discuss the vision and goals for the recovery plan. On multiple occasions, CSRS met with the Advisory Committee to discuss the values for the plan, analyze recent flooding, and provide an overview for the modeling approach. A public workshop was also held to inform residents on the potential non-structural solutions for Mandeville, such as elevations and stormwater storage. The community was able to interact with the consultant team to identify areas in the city that could use improvement and stormwater management projects. Meetings were also held with key stakeholders to have an in-depth review of the results produced by the CSRS modeling team and take suggestions on focus areas and potential projects to pursue as well

WHAT WE HEARD FROM STAKEHOLDERS

It is important through this process to preserve the character and sense of place that Mandeville exemplifies. What we learned from the various meetings with stakeholders is that protecting the environment is key. There is no desire for a new flood wall in Mandeville, because the structure will continue to erode the coast and cause more flooding for the city. Non-structural solutions are the best option for the continued success and development of Mandeville. This includes the potential to create an early warning system to alert residents about flash flooding events or implementing more dual use projects such as stormwater parks that offer health and stormwater detention benefits.

Planning Principles and Time Horizon

MANDEVILLE FLOOD RESILIENCE STRATEGY

PLANNING PRINCIPLES AND TIME HORIZON

Plan Principles

PLAN PRINCIPLES

- Protect and restore the natural environment and natural functions of the floodplain.
- Preserve the character of Mandeville while enhancing its ability to attract and retain residents and investors.
- Plan and act now so future generations can benefit and continue to enjoy the economic, social, and natural amenities of Mandeville.
- Reduce risk across all factors of flood risk - surge, riverine, and flash floods, and plan for their interactions and interdependencies.

PLANNING PRINCIPLES AND TIME HORIZON

Planning for Coastal Change

PLAN HORIZON 50-100 YEARS

In alignment with the Coastal Master Plan, we acknowledge that the data provided by CPRA shows a very different coastline in the next 50 to 100 years. Increasing sea level poses an urgent threat for coastal communities. Hydraulic modeling can show estimated sea level rise projections to identify potential restoration and risk reduction solutions.

1 FT Inundation Above MHHW

Legend

Sea Level Rise in Low-lying Areas

1 FT - 6 FT - Sea Level Rise Depth

6 FT Inundation Above MHHW

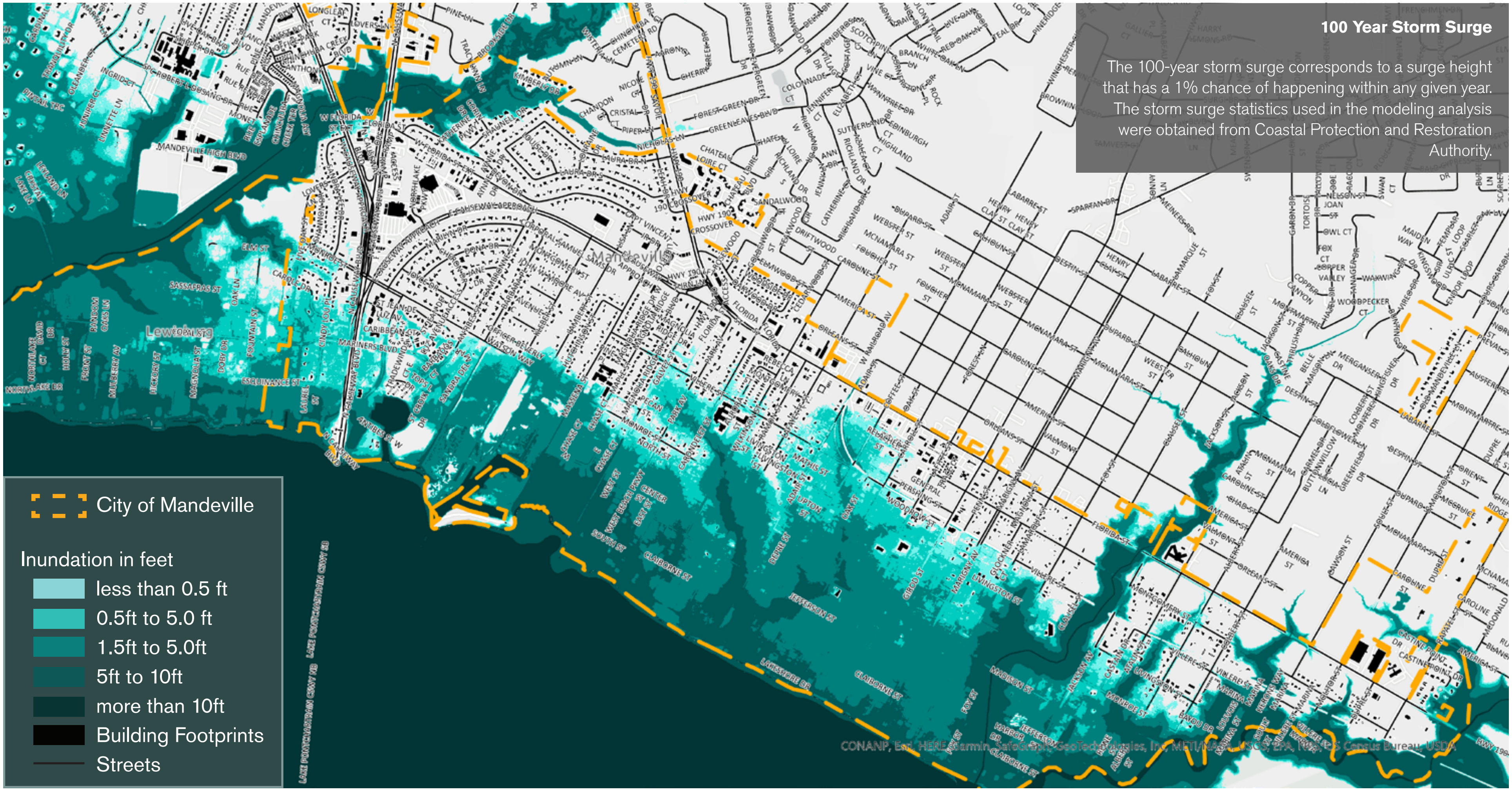
Mean Higher High Water Inundation

Top image shows potential sea level rise inundation of 1ft above current Mean Higher High Water (MHHW) for the area. Bottom image shows potential sea level rise inundation of 6 ft above current Mean Higher High Water for the area.

IMAGE CREDIT: Esri Bar: Zoom in Zoom out Maxar | NOAA Office for Coastal Management (coastal.info@noaa.gov) | CONANP, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, EPA, NPS, US Census Bureau, USDA.

PLANNING PRINCIPLES AND TIME HORIZON

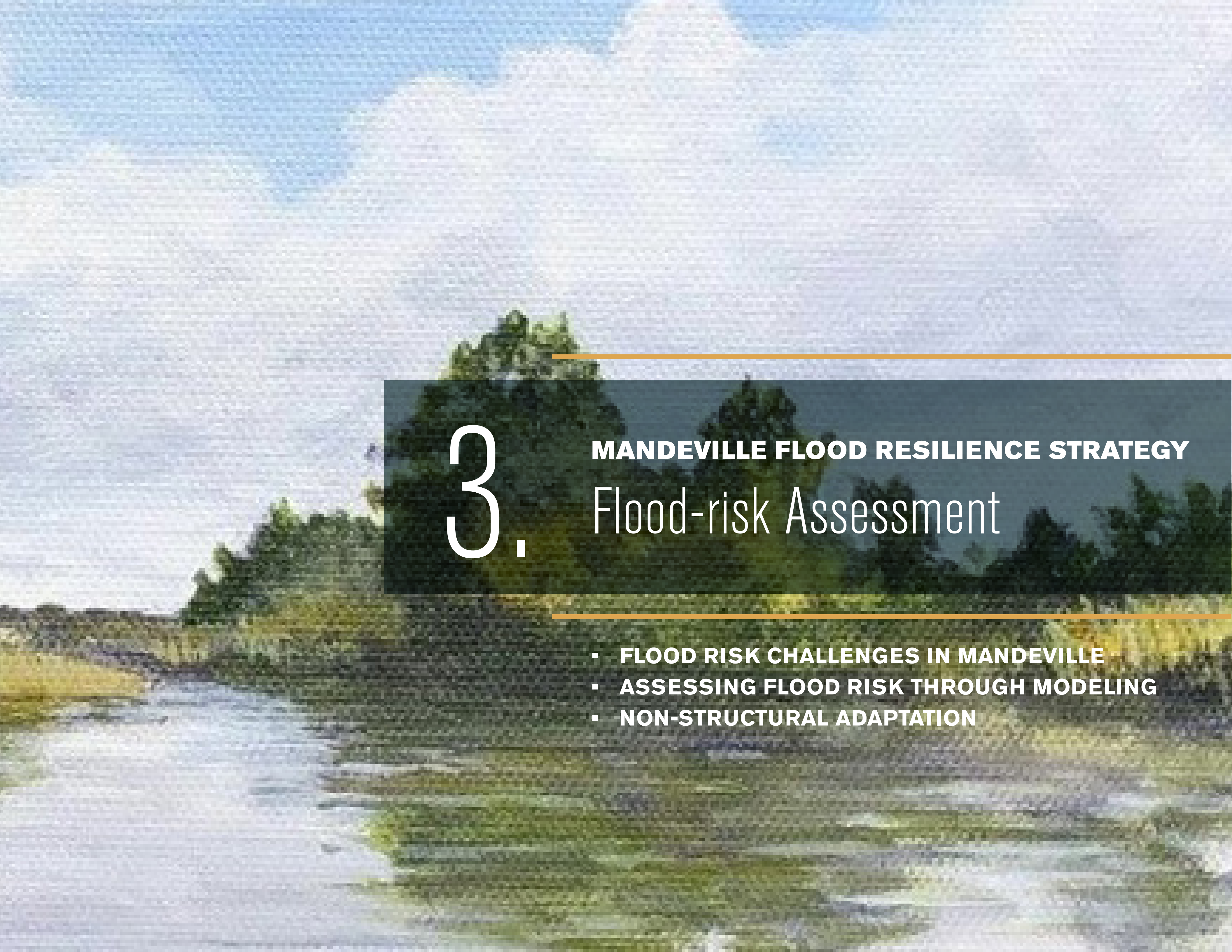
100 Year Storm Surge



Cane Bayou at the Lake

Local Baton Rouge artist, oil paint on canvas.

IMAGE CREDIT: Jeff Bell. https://www.instagram.com/p/CUAfAB6LuVg/



3. MANDEVILLE FLOOD RESILIENCE STRATEGY
Flood-risk Assessment

- FLOOD RISK CHALLENGES IN MANDEVILLE
- ASSESSING FLOOD RISK THROUGH MODELING
- NON-STRUCTURAL ADAPTATION

Flood Risk Challenges in Mandeville

MANDEVILLE FLOOD RESILIENCE STRATEGY

FLOOD RISK CHALLENGES IN MANDEVILLE

Coastal Flooding

Lake Pontchartrain lakefront, Mandeville, LA

As Isaac hammered the North Shore with high winds and high tides young people played in the high surf against the advice of authorities.

IMAGE CREDIT: "Isaac bears down on the Gulf Coast" Aug. 28, 2012. Photo by Ted Jackson | The Times-Picayune. www.timesunion.com

COASTAL FLOOD RISK

A coastal flood can be the result of tidal conditions, wind, or severe weather. Storm surge — produced when high winds from hurricanes and other storms push water onshore — is the leading cause of coastal flooding and can be the greatest threat associated with a tropical storm. In this type of flood, water overwhelms low-lying land and can cause devastating loss of life and property.

FLOOD RISK CHALLENGES IN MANDEVILLE

Riverine Flooding

RIVERINE (FLUVIAL) FLOOD RISK

Fluvial, or riverine flooding, occurs when excessive rainfall over an extended period of time causes a river or waterway to exceed its capacity. It can also be caused by logjams or debris. The damage from a riverine flood can be widespread as the overflow affects smaller rivers downstream, often causing nearby areas to swamp.

St. Tammany Flooding

Aerial photo of Covington, Louisiana and the surrounding area showing the Bogue Falaya River flooding the city March 12, 2016.

IMAGE CREDIT: Photo by G. Andrew Boyd, NOLA.com | The Times-Picayune

North Causeway Approach, Mandeville, LA (outside city limits)

On Tuesday, July 20, 2021 heavy rainfalls totaling up to 8 inches in some areas caused flooding, stranding motorists and damaging businesses and homes.

IMAGE CREDIT: "Photos: Flooding in Mandeville as storms dump 8 inches of rain" July, 20, 2021. Photo by Chris Granger | The Times-Picayune | The New Orleans Advocate.

FLOOD RISK CHALLENGES IN MANDEVILLE

Urban Flash Flooding

FLASH (PLUVIAL) FLOOD RISK

A pluvial, or surface water flood, is caused when heavy rainfall exceeds the capacity of the local drainage system and creates a flood event independent of an overflowing water body. One of the most common misconceptions about flood risk is that one must be located near a body of water to be at risk. Pluvial flooding can happen in any urban area — even higher elevation areas that lie above coastal and river floodplains.

Assessing Flood Risk Through Modeling

MANDEVILLE FLOOD RESILIENCE STRATEGY

Cristobal Flooding, Mandeville, LA

Lakeshore Drive and Nearby streets flooded in Old Mandeville as Tropical Storm Cristobal moved through the region.

IMAGE CREDIT: flprivateadjusters.com

ASSESSING FLOOD RISK THROUGH MODELING

Modeling

HYDROLOGIC AND HYDRAULIC MODELS

In order to develop a nuanced and detailed understanding of flood risk in Mandeville, using the best science available, we developed a planning-level 2-D hydrologic and hydraulic model of existing conditions for Mandeville and its surrounds. The hydrologic and hydraulic model is a planning tool used to develop the proposed actions in this plan and a tool that Mandeville can continue to use to assess future investments and guide further adaptation strategies. The model created for this planning process built upon previous models but designed with more detail to assess flood risk from rainfall events, coastal surge events, and combined events. The modeling showed that rainfall events, even very intense events, do not present nearly as significant a risk as do coastal flood events. Similarly, rainfall events where floodwaters originate outside of Mandeville's boundaries but then flow through the city, present a relatively low risk with a few exceptions where houses are located very close to the waterway. This analysis is critical to understanding what is truly driving flood risk and crucial for developing strategies and projects that will actually reduce this risk. For further details regarding the modeling conducted, refer to the Appendix for an in-depth analysis of the process and results.

ASSESSING FLOOD RISK THROUGH MODELING

Watershed Modeling

SIMULATING STRATEGIES

The hydrologic and hydraulic model not only tells us what areas of the city face which types of flood risk but also allows us to test how much various strategies could reduce this risk. In this planning process, four mitigation concepts were tested: 1) elevating structures, 2) upstream stormwater detention, 3) stormwater parks, and 4) channel capacity improvements. Mitigation concepts were assessed by modifying the existing conditions hydrologic and hydraulic model and comparing simulation results. The modeling analysis projects how much the mitigation concepts reduce flood risk related to both structure and nuisance flooding in Mandeville for present and future conditions. Through the modeling it was determined that while they may be helpful to alleviating nuisance flooding, stormwater detention projects, stormwater parks, and channel capacity improvements did little to reduce significant flood risk. **The primary strategy must focus on non-structural solutions.**

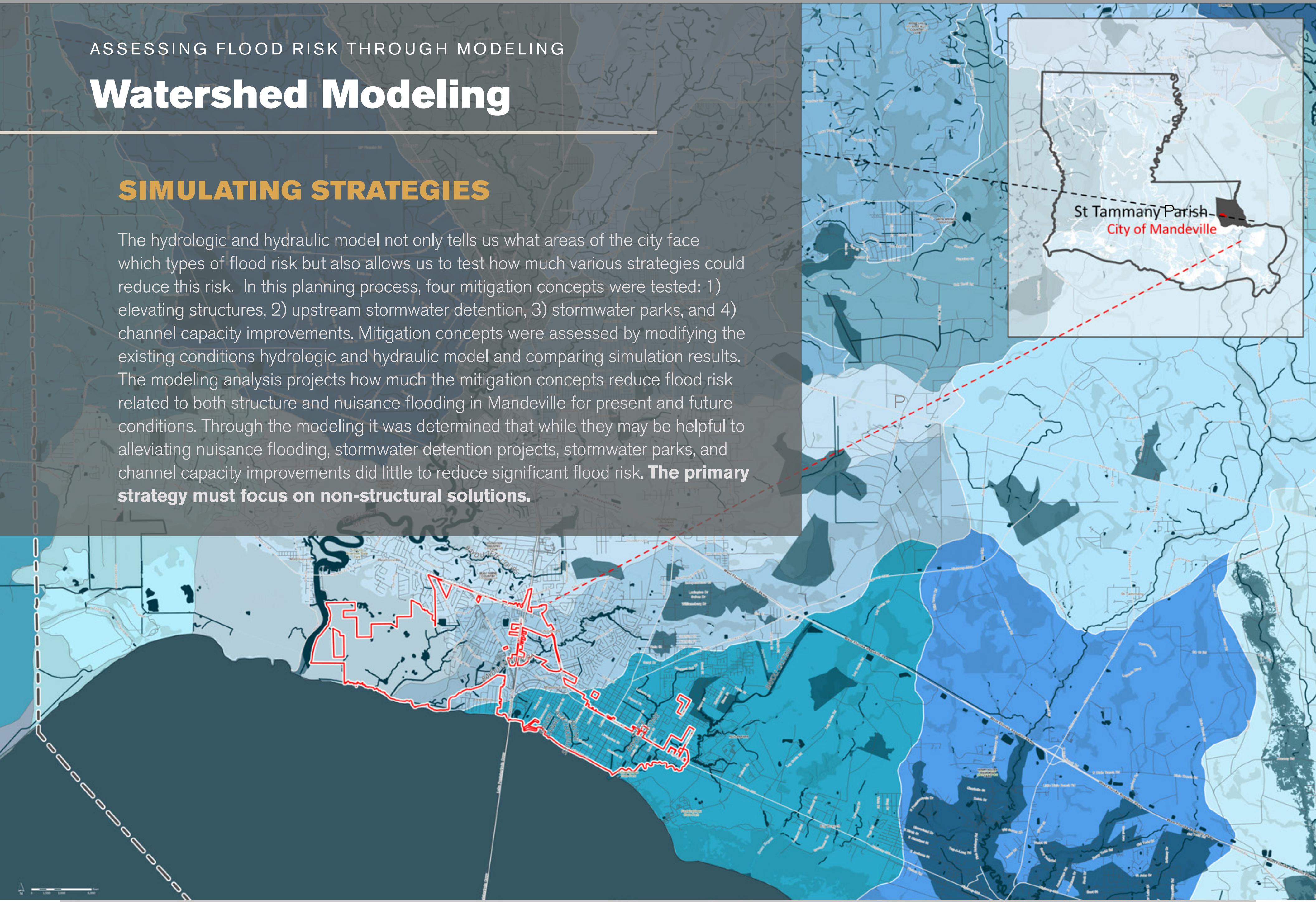


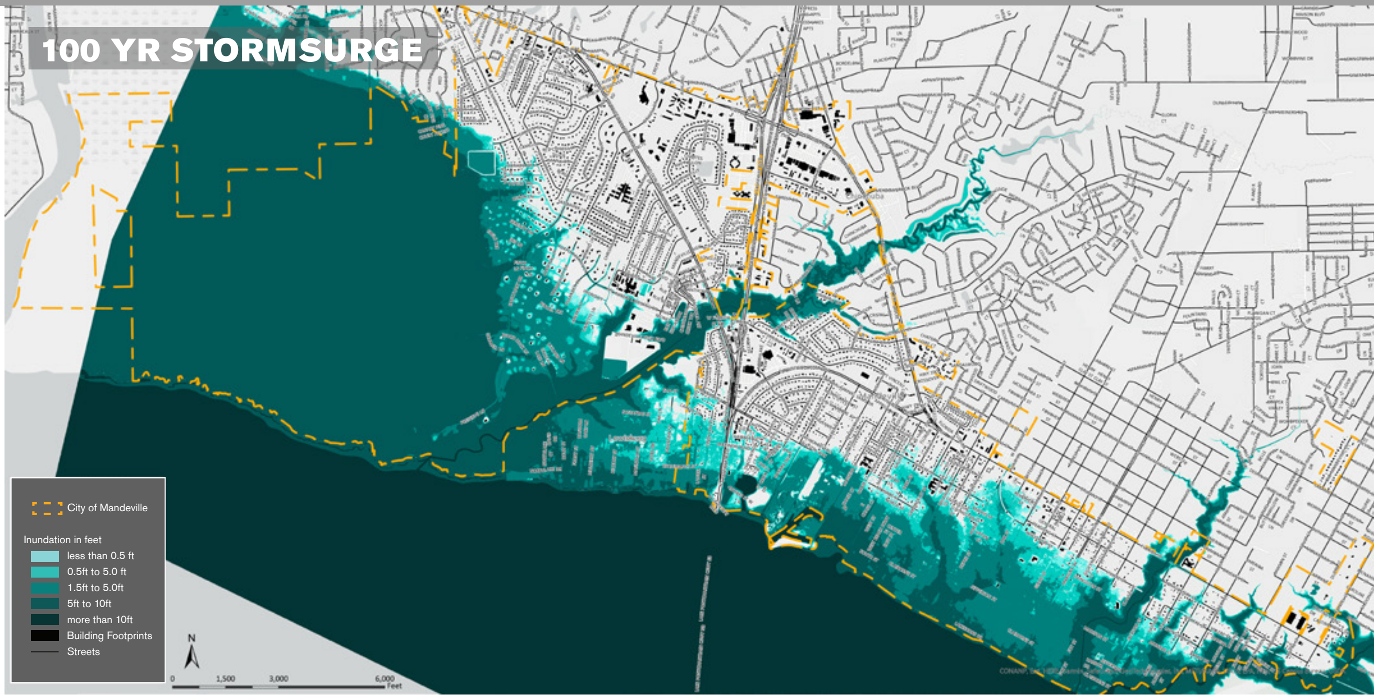

IMAGE CREDIT: iStock

ASSESSING FLOOD RISK THROUGH MODELING

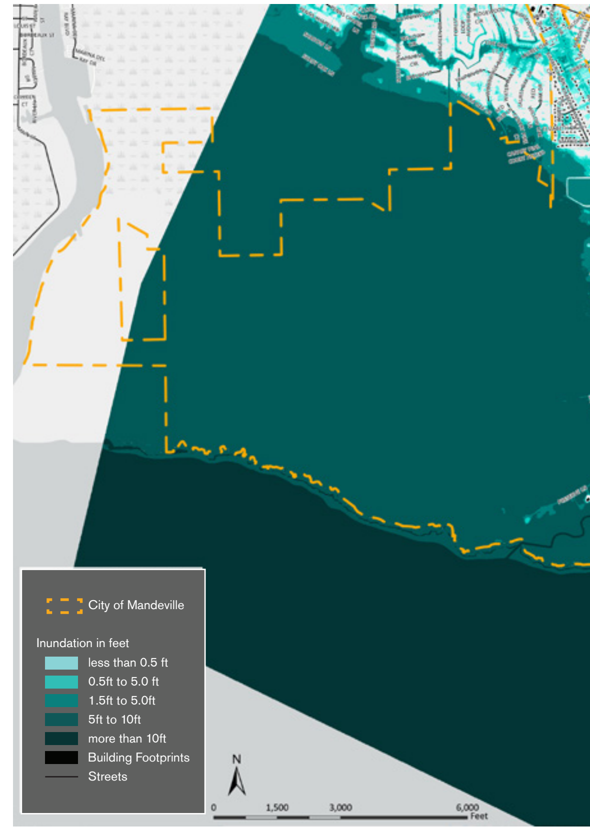
Mitigation Testing

MITIGATING CATASTROPHIC FLOODING

Coastal inundation from storm surge events by far present the greatest risk to Mandeville and the risk is expected to drastically increase over the coming decades with sea level rise. In this flood resilience strategy, we are focusing primarily on reducing flood risk to this long-term, potentially catastrophic risk to preserve Mandeville's economic and cultural viability for the many years to come. In this situation, there are only two options to mitigate this type of flood risk: 1) Raise the lakefront flood defense by constructing a massive levee and install the requisite flood gates and pumps along the outfall waterways, or 2) Elevate and floodproof structures prone to coastal flooding to mitigate their risk. The former has been rejected by both the Mandeville public as it would severely impact the lakefront setting and by the US Army Corps of Engineers since the costs of building and maintaining this system would outweigh its benefits. As a result, the only real avenue Mandeville has to significantly reduce its risk is to elevate and floodproof structures that have not yet been mitigated.

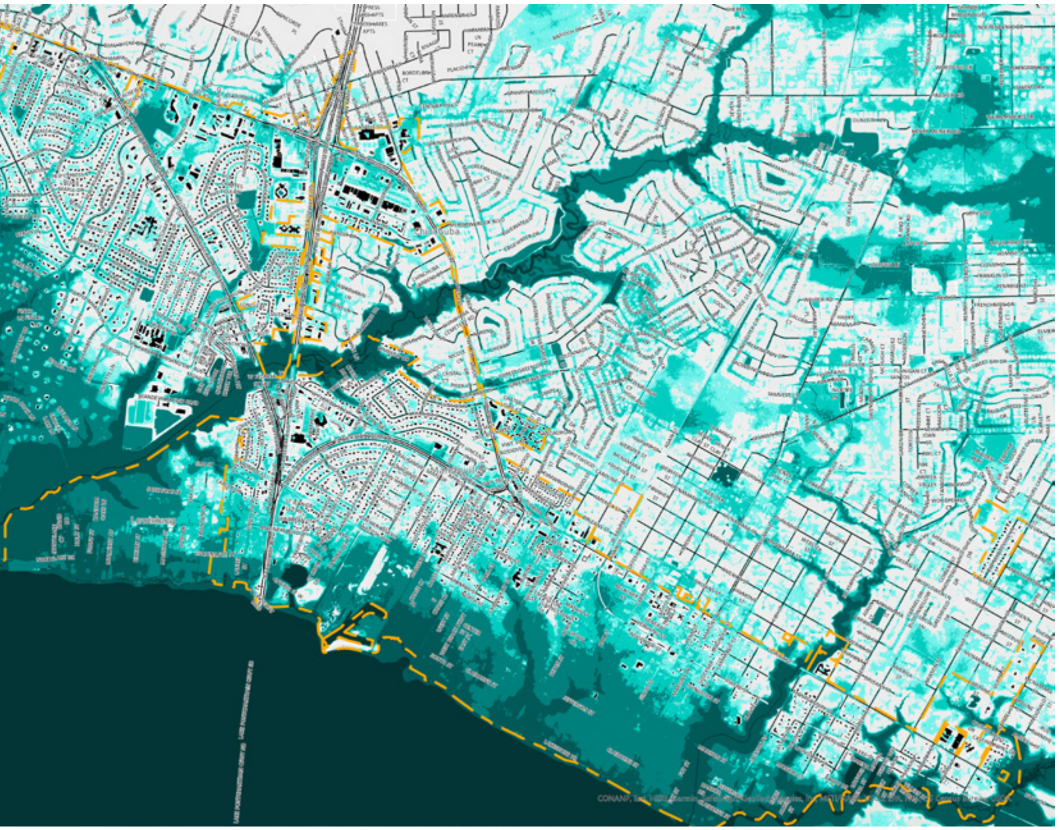

100 YR STORMSURGE
City of Mandeville
Inundation in feet
less than 0.5 ft
0.5ft to 5.0 ft
1.5ft to 5.0ft
5ft to 10ft
more than 10ft
Building Footprints
Streets
N
0
1,500
3,000
6,000
Feet


100 YR RAINFALL
City of Mandeville
Inundation in feet
less than 0.5 ft
0.5ft to 5.0 ft
1.5ft to 5.0ft
5ft to 10ft
more than 10ft
Building Footprints
Streets
N
0
1,500
3,000
6,000
Feet


City of Mandeville
Inundation in feet
less than 0.5 ft
0.5ft to 5.0 ft
1.5ft to 5.0ft
5ft to 10ft
more than 10ft
Building Footprints
Streets
N
0
1,500
3,000
6,000
Feet

Risk Mitigation

MITIGATING NUISANCE FLOODING



More frequent but less damaging coastal flood events which cause the nuisance interruptions of flooded driveways, yards, and streets is of concern but are treated separately in this strategy from the lower-probability and higher-consequence coastal surge events. These nuisance flooding events can be caused by high tides or even strong southerly winds, and by extreme rainfall events. While the flood impacts from these events can be disruptive to daily life, they rarely cause extensive property damage, major economic disruptions, or threats to life and limb.

Although nuisance flood events from coastal inundation could grow more severe with sea level rise, in the near-term they can be mitigated by installing modest flood gates and pumps where outfall channels meet the lakefront. These modifications can be made without raising the lakefront sea wall or significantly altering the landscape by installing them under roadway crossings and pedestrian bridges. Such investments could significantly reduce the extent of nuisance flood events. For nuisance flooding caused by extreme rainfall events, some of the local flood impacts can be mitigated with local stormwater detention facilities like stormwater parks, improvements to the city's drainage system, and conveyance improvements in local channels and bayous. Several of the strategies to address nuisance flooding are addressed in Flood Resilience Strategies and Activities section.

Non-structural Adaptation

MANDEVILLE FLOOD RESILIENCE STRATEGY

Structural vs. Non-Structural Solutions

STRUCTURAL SOLUTIONS

Structural solutions include any physical construction to reduce or avoid possible impacts of flooding or the application of engineering techniques or technology to achieve hazard resistance and resilience.

Structural solutions, though effective in the short-term, require periodic maintenance and costly upgrades, and may fail during more severe disaster events.

STRUCTURAL FLOOD MITIGATION MEASURES

- Floodwalls/Seawalls
- Floodgates
- Levees, Dams
- Drainage Pumps

Some structural solutions such as lakefront levees and pumping stations have been explored in previous studies – see the review of existing plans above – and have been judged too expensive for the benefit they would provide and out of sync with the city's character. The city of Mandeville will not be implementing any structural solutions in this resilience strategy. Instead, this strategy focuses on several non-structural solutions that would be more cost-effective and have better long-term benefits for the city.

LEVEE NEW ORLEANS, LA
IMAGE CREDIT: Mario Tama | Getty Images

FLOOD WALL MOUNT VERNON, WA
IMAGE CREDIT: Elaine Thompson | The Associated Press

NON-STRUCTURAL ADAPTATION

In Search of Non-structural Solutions

NON-STRUCTURAL SOLUTIONS

Non-structural solutions to flood mitigation include reducing damage by moving property to reduce its flood risk or making room for flood waters in our cities. It includes diverting floodwaters into wetlands, floodplains, bioswales, etc., which allows for a controlled release of water outside of residential or metropolitan areas.

Non- structural measures can be sustainable over the longterm, while providing ecological and social benefits.

NON-STRUCTURAL FLOOD MITIGATION MEASURES

- Floodproofing, Elevations, Acquisitions, Relocations
- Living shorelines
- Floodwater Diversion and Storage
- Low Impact Development/Green Infrastructure
- Floodplain and Stream restoration
- Flood Resilience and Emergency Planning, Land Use regulations, Public awareness
- Building Codes/Elevation Standards

ELEVATED HOUSE
IMAGE CREDIT: climatechangenews.com

STORMWATER PARK FARMINGTON, MN, USA
Balmori Associates
IMAGE CREDIT: balmori.com

NON-STRUCTURAL ADAPTATION

Making Room for Water: Elevation

ELEVATION

One of the most common retrofitting methods is elevating a house to a required or desired flood protection elevation. Ideally when a house is properly elevated, the living area will be above all but the most severe floods (such as the 0.2% or 500-year flood).

Several elevation techniques are available. In general, they involve:

- lifting the house and building a new, or extending the existing, foundation below it, or
- leaving the house in place and either building an elevated floor within the house or adding a new upper story.

FLOOD RISKS MITIGATED

- Coastal Flooding
- Riverine Flooding
- Urban/Flash Flooding

CO-BENEFITS

- Added storage, parking, and recreational area
- Lower Flood Insurance Premiums
- Downstream pollutant reduction

IMAGE CREDIT: insurancejournal.com

NON-STRUCTURAL ADAPTATION

Making Room for Water: Buyouts

BUYOUTS

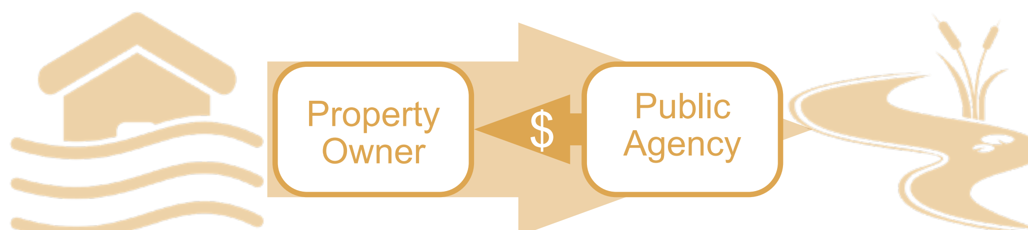
Buyouts are when a private owner voluntarily sells their property due to its flood risk and the structure is permanently removed from the floodplain. Many buyout programs also encourage a “buy-in” component where residents relocate nearby to a lower-risk area.

RELATED FLOOD RISKS

- Coastal Flooding
- Riverine Flooding
- Urban/Flash Flooding

POTENTIAL CO-BENEFITS

- Restoration of Floodplain
- Enhances Communities
- Downstream Pollutant Reduction



Making Room for Water: Floodproofing

WET FLOODPROOFING

Wet floodproofing is any combination of permanent and non-permanent measures that prevent flood damage by allowing floodwater to enter the structure.

RELATED FLOOD RISKS

- Coastal Flooding
- Flash Flooding
- Riverine Flooding
- Urban Flooding

POTENTIAL CO-BENEFITS

- Decreased Hydrostatic Pressure
- Limits Damage
- Protects Utilities

DRY FLOODPROOFING

Dry floodproofing a building involves sealing the portion of the building below the highest expected flood level to make it as watertight and as impermeable to floodwaters as possible. These techniques are especially important for commercial and historic structures which cannot be elevated.

RELATED FLOOD RISKS

- Coastal Flooding
- Riverine Flooding
- Urban Flooding

POTENTIAL CO-BENEFITS

- Down Stream Pollutant Reduction
- Cost Effective
- Temporary Visibility (Removable)

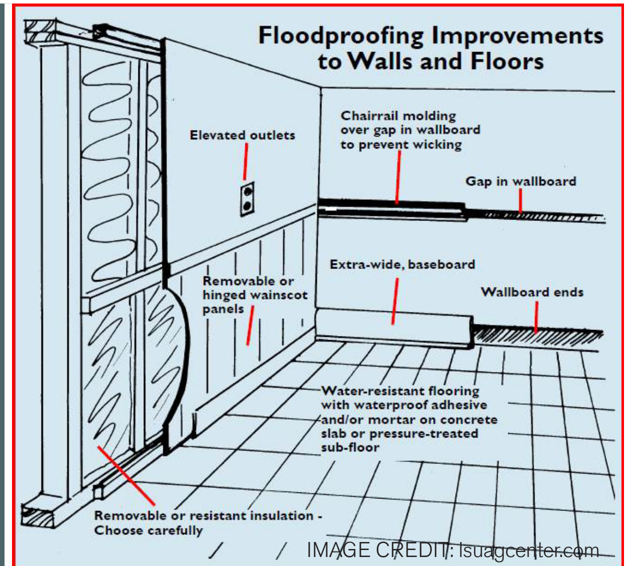


IMAGE CREDIT: lsuagcenter.com

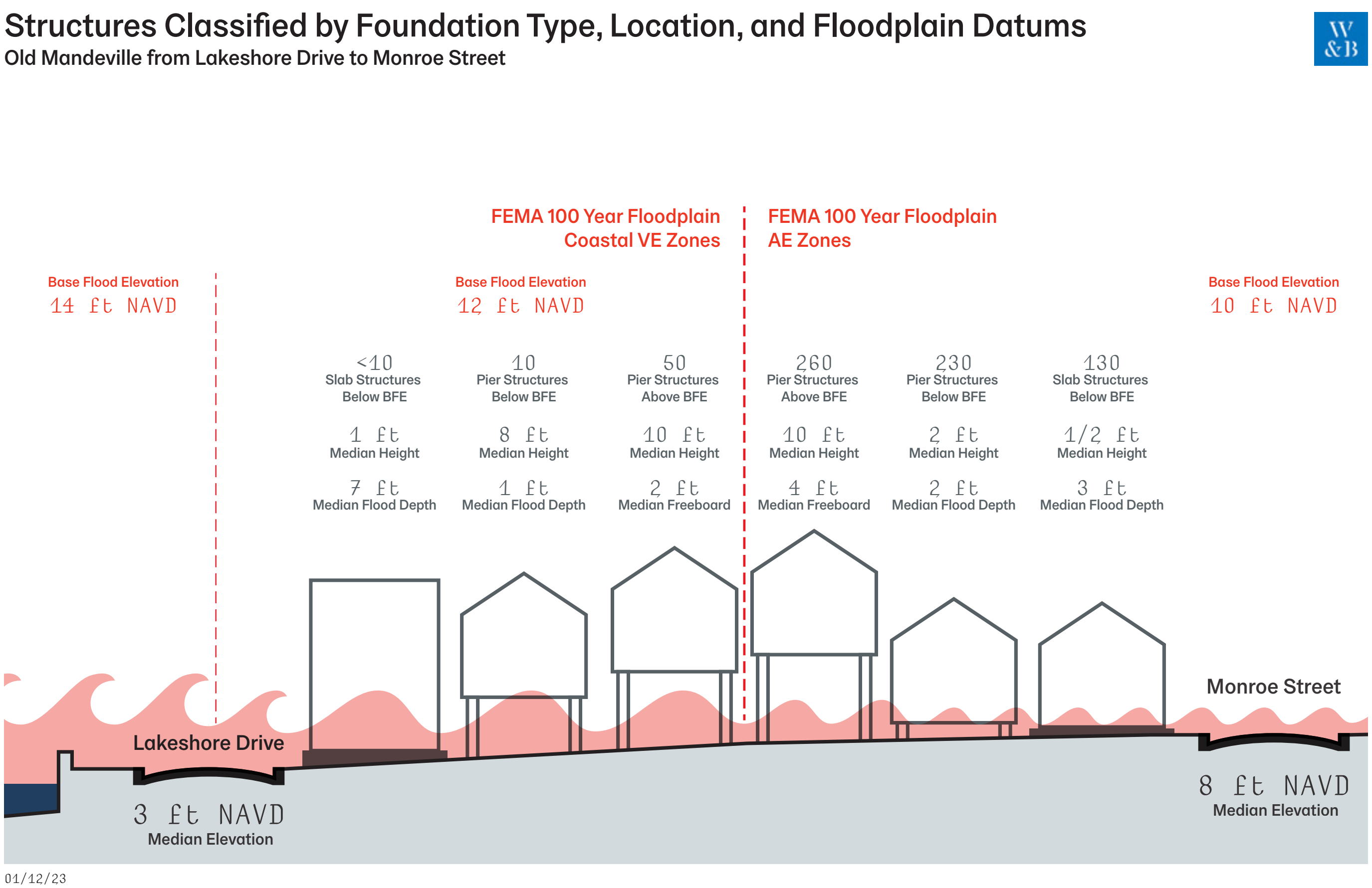

IMAGE CREDIT: psindustries.com

NON-STRUCTURAL ADAPTATION

Section Graphics

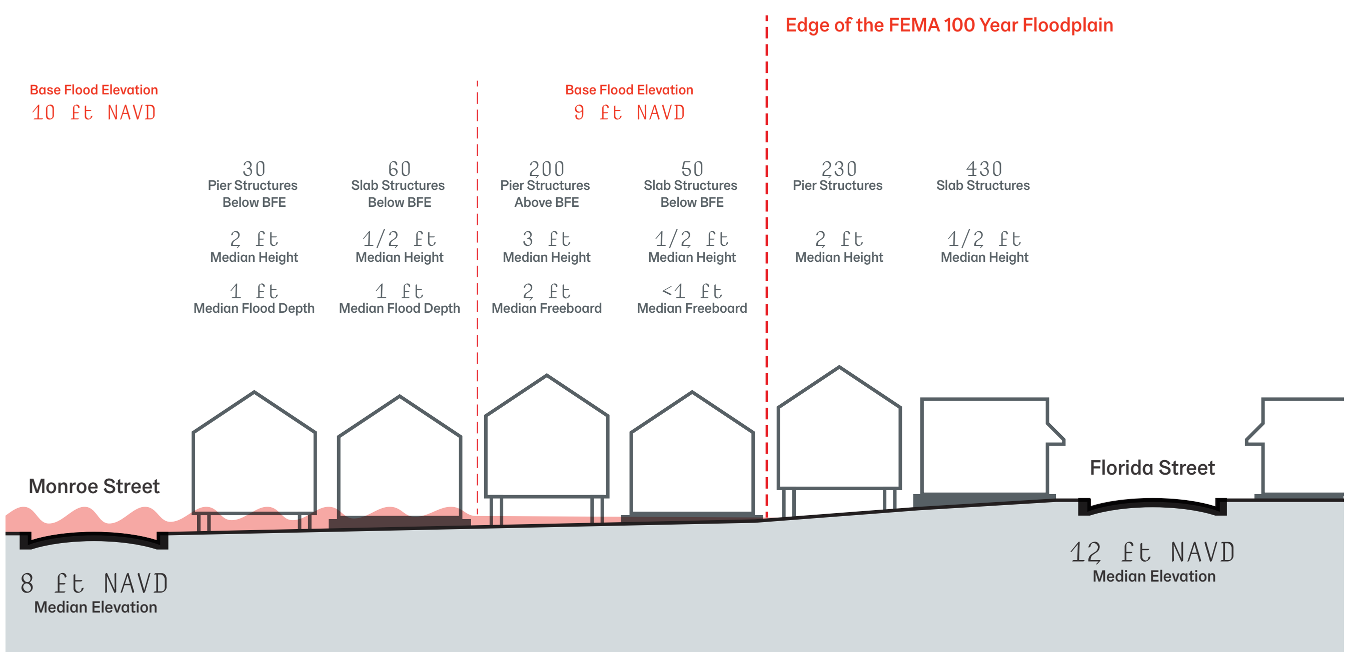
STRUCTURES CLASSIFIED BY FOUNDATION TYPE, LOCATION, AND FLOODPLAIN DATUMS

Starting from Lakeshore Drive, the median elevation is about three feet and a base flood elevation of about 14 ft. Structures that are not elevated closest to the lake front will experience worse effects from flooding than elevated structures. Moving further onshore towards Monroe Street, the elevation rises to about eight feet and the base flood elevation lowers to about ten feet. Buildings in this area are at a lower flood risk and do not need as high a base flood elevation.



Moving further inland towards Florida street, the median elevation reaches approximately twelve feet and is out of range of the FEMA 100 Year Floodplain. Residents in this area have yet lower flood risk, as they are not in range of the BFE. Structures in this area need less elevation, as they are highest above the flood water levels.

Structures Classified by Foundation Type, Location, and Floodplain Datums
Old Mandeville from Monroe Street to Florida St

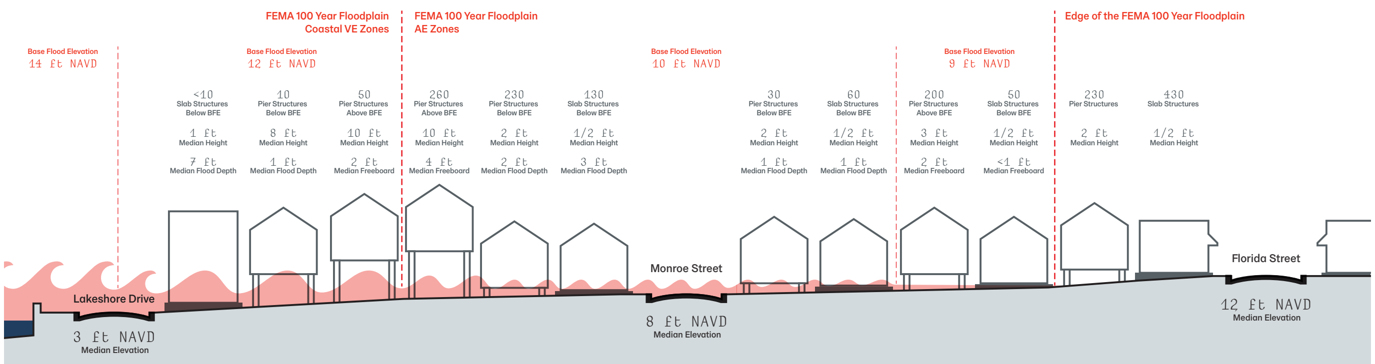


01/12/23

Structures closest to Lake Pontchartrain have the highest flood risk due to the low elevation and high-water levels. Elevated structures will better withstand severe flood events than non-elevated structures, resulting in less damage. Structures closest inland by Florida Street have lower flood risk due to the higher land elevation. The best option for the residents of Mandeville will be to elevate structures or move farther inland, away from the high storm surge produced from severe storms.

Structures Classified by Foundation Type, Location, and Floodplain Datums

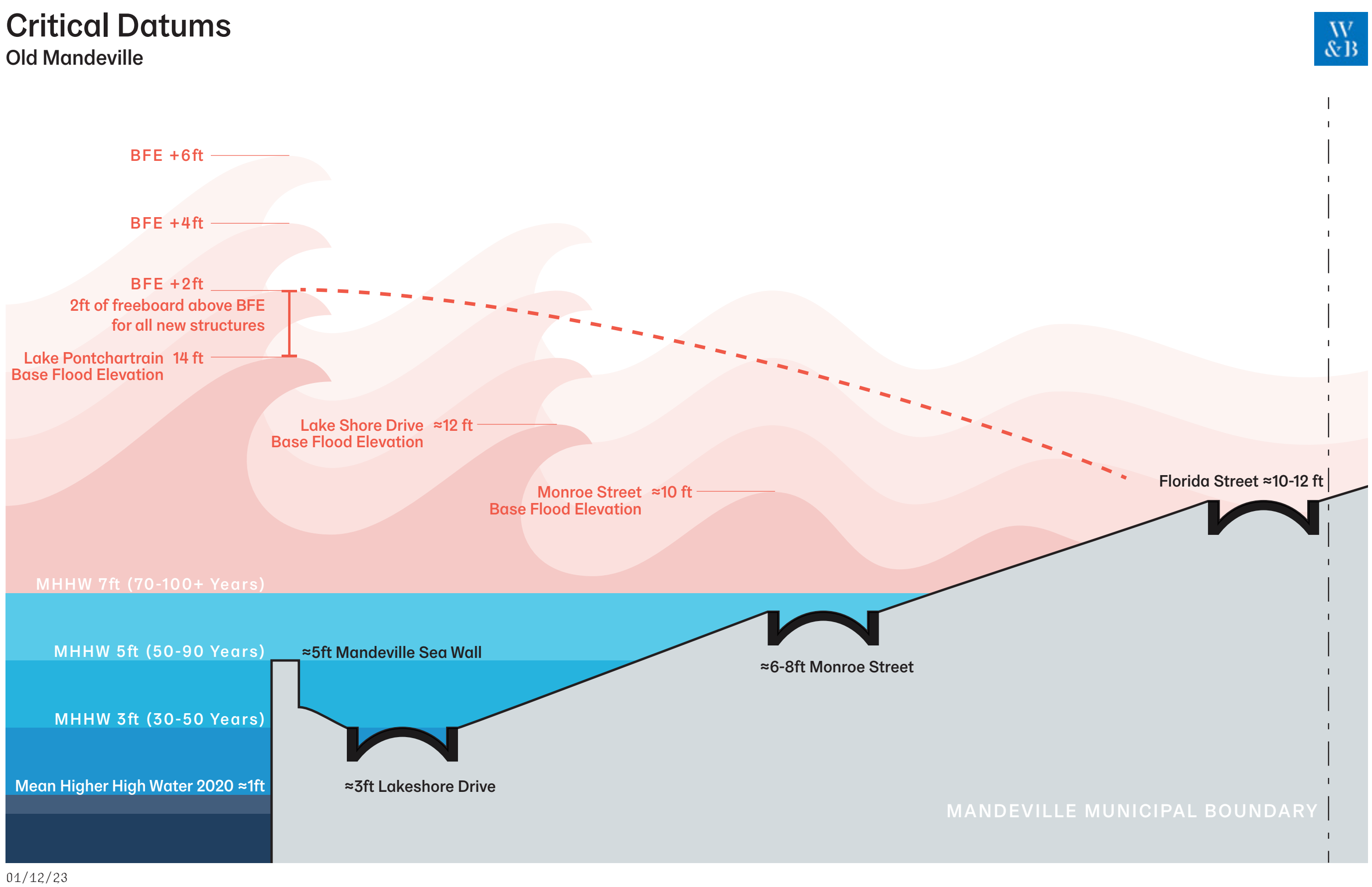
Old Mandeville from Lakeshore Drive to Florida Street



01/12/23

CRITICAL DATUMS

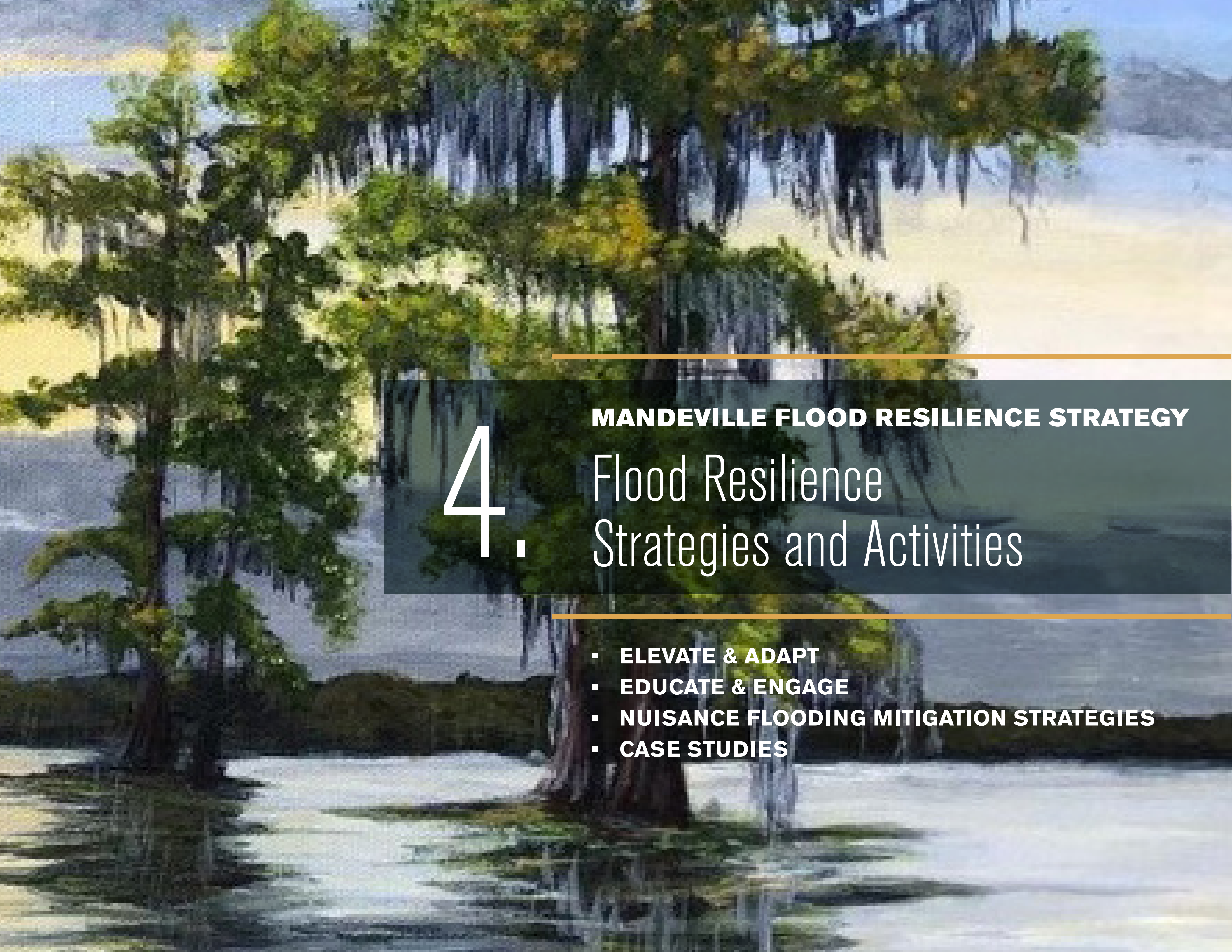
The graphic shows the Mean High Water (MHW) level and the base Flood Elevation (BFE) compared to the land elevations in Old Mandeville. As the water surface elevations rises over the coming decades, the number of homes exposed to severe flood damage will increase as will the intensity of the potential damage. This projection calls for an urgent effort to proactively elevate structure to mitigate the risk the rising water levels.



Lake Martin

Local Baton Rouge artist, oil painting on canvas.

IMAGE CREDIT: Jeff Bell. https://www.instagram.com/p/CiIOWcUOgZJ/



MANDEVILLE FLOOD RESILIENCE STRATEGY

4. Flood Resilience Strategies and Activities

- ELEVATE & ADAPT
- EDUCATE & ENGAGE
- NUISANCE FLOODING MITIGATION STRATEGIES
- CASE STUDIES

Elevate & Adapt

MANDEVILLE FLOOD RESILIENCE STRATEGY

Elevated Home, Mandeville, LA

This Creole cottage built around 1843 has defied floodwaters for over 100 years. Now with rising insurance rates, homes in the flood zone must be elevated.

IMAGE CREDIT: prcno.org

ELEVATE & ADAPT

Solutions

SUMMARY

This element includes on-going programmatic investments the city can pursue to continually reduce flood risk, with a focus on non-structural programs and projects. Nonstructural adaptation to flood risk involves altering the built environment – buildings, roads, and public spaces – to make room for floodwaters or reduce exposure to flooding. While most of our modern approaches to reducing flood risk involve moving water with pumps and pipes or blocking water with levees and floodgates, these structural solutions have their limitations in extreme flood events. Nonstructural adaptation acknowledges that some flooding cannot be avoided and that it is the human-made environment that must change to accommodate nature, and not the other way around. The most common components of nonstructural flood mitigation include acquisition, elevation, and floodproofing. Acquisition involves purchasing properties in higher flood risk areas, removing any existing structures, and allowing the land to serve as floodplain or stormwater storage or conveyance during flood events. Elevation is the lifting of structures above a likely inundation level to avoid serious flood damage. Floodproofing is altering a buildings material and/or construction (such as electrical outlets, HVAC systems, and sealing entryways) to reduce flood damages. These adaptations to the built environment will be critical to Mandeville long-term prospects in the face of increasing flood risk. For more information regarding elevation, see section 5.2 in the Appendix.

ESTABLISH A COMPREHENSIVE NONSTRUCTURAL ADAPTATION PROGRAM

Description: Mandeville has already demonstrated experience and success in elevating homes with federal mitigation grants. However, those programs are limited to eligible properties and constrained by available funds. A comprehensive nonstructural program would broaden the array of funding mechanisms and sources and create an on-going approach to adaptation less subject to funding cycles and more focused on achieving an adaptation standard across the city and property types. This would allow a broader range of property owner and types to participate and would be available on a rolling basis and so would allow owners to participate when they were ready, rather than being beholden only to grant deadlines. The city could conduct a nonstructural adaptation program by partnering with state and federal agencies to access grant funding, by partnering with private lending institutions to establish financing programs, by leading by example in mitigating its own properties and by requiring new construction to be built to North Shore program standards.

Elevated Home, Mandeville, LA

A lakefront house elevated in 2016 to protect against flooding.

IMAGE CREDIT: marketplace.org

Flood Resilience Benefits: Since a major coastal surge event is the greatest flood risk threat to Mandeville, this program could result in the most flood resilience benefits of any of the proposed project and programs in this strategy. While the benefits would accrue one property at a time, it is the collective benefit of a shortened recovery time and reduced economic impacts of rebuilding large areas of the city that would benefit the entire community. As the bar chart below describes, even a relatively minor surge event could cause tens of millions of dollars in damage. With this risk increasing over time due to sea level rise, the city stands to protect vast amounts of value, both private and collective value, by proactively elevating and floodproofing homes and businesses now.

PUBLIC-PRIVATE FINANCING FOR NONSTRUCTURAL ADAPTATION

Description: Mandeville enjoys relatively high and stable property values, however some of this value will be threatened with increasing flood risk. An opportunity to address this by reducing risk through nonstructural adaptations such as elevations and floodproofing is to partner with private lenders that would lend to property owners to invest in the adaptation and thereby protect the value of their homes and properties. The city could enable this loan fund by providing seed capital or a loan-loss reserve fund to reduce the risk to lenders. The city already pursues grant funding from state and federal agencies and should redouble its efforts to identify funds for elevation and floodproofing in partnership with state departments and federal agencies.

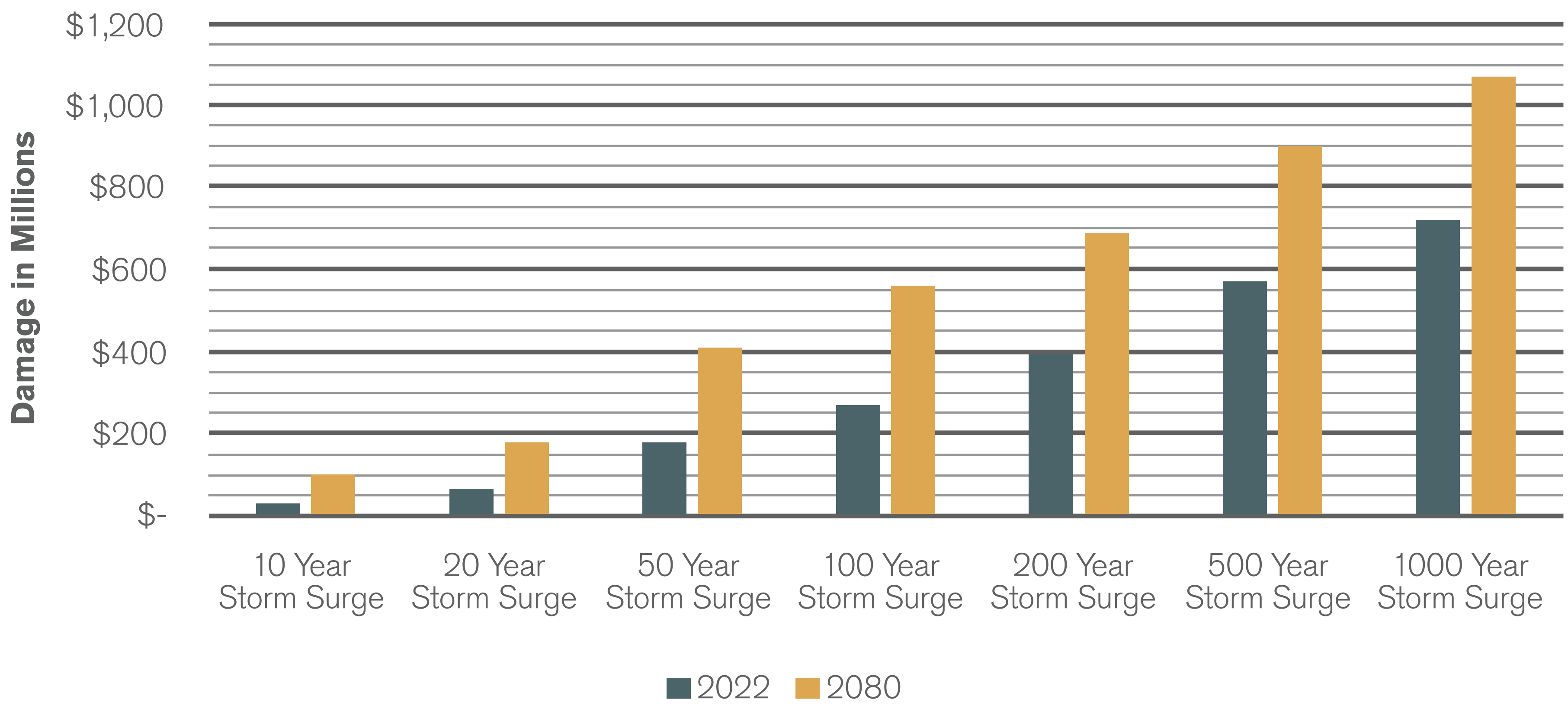
Flood Resilience Benefits: Access to capital for nonstructural adaptation could broaden the eligible properties, property types, and income levels that could participate in an elevation and floodproofing program. This broader access could accelerate nonstructural adaptation in Mandeville and reduce the burden on public funds as the sole source for elevations and floodproofing projects.

The chart on pg. 66 demonstrates the aggregate value of real estate (using 2021 median home values) that would be at risk at increasing risk levels and compounded by sea level rise. Even a 10-year storm surge in 2080 could be capable of causing $100M in property damage due to sea level rise.

IMAGE CREDIT: businessdiary.com

istock: Janis Abolins

IMPACTS OF SEA LEVEL RISE



ADOPT A UNIVERSAL ADAPTATION STANDARD

Description: The increasing flood risk that Mandeville will face over the coming decades requires that the city must continue elevating structures and reducing exposure to flood risk in a proactive manner. However, there is no universal standard to which the city must adapt. While the National Flood Insurance Program creates standards in order to acquire flood insurance, this by no means addresses all property types or adequately factors in increasing risk over time. To protect property values and the city's viability in the latter half of the 21st century, Mandeville could act now by adopting a standard to which all properties and critical infrastructure must adapt through elevation, flood-proofing, or managed retreat. The risk modeling conducted for this strategy could be used to establish a standard that all properties must achieve by a certain time period, such as being elevated or floodproofed to avoid damages from a 500-year return event inundation levels by 2050. This goal could then be implemented through a mixture of public grant funding and private financing (see the elevation financing program, below).

Flood Resilience Benefits: By adopting a universal standard for nonstructural adaptation, the city of Mandeville would become a model for cities around the world. The formal requirement would send a signal to property owners and investors that the city is seeking to ensure its resilience for decades to come. Such a standard could also be applied to jurisdictions across coastal Louisiana.

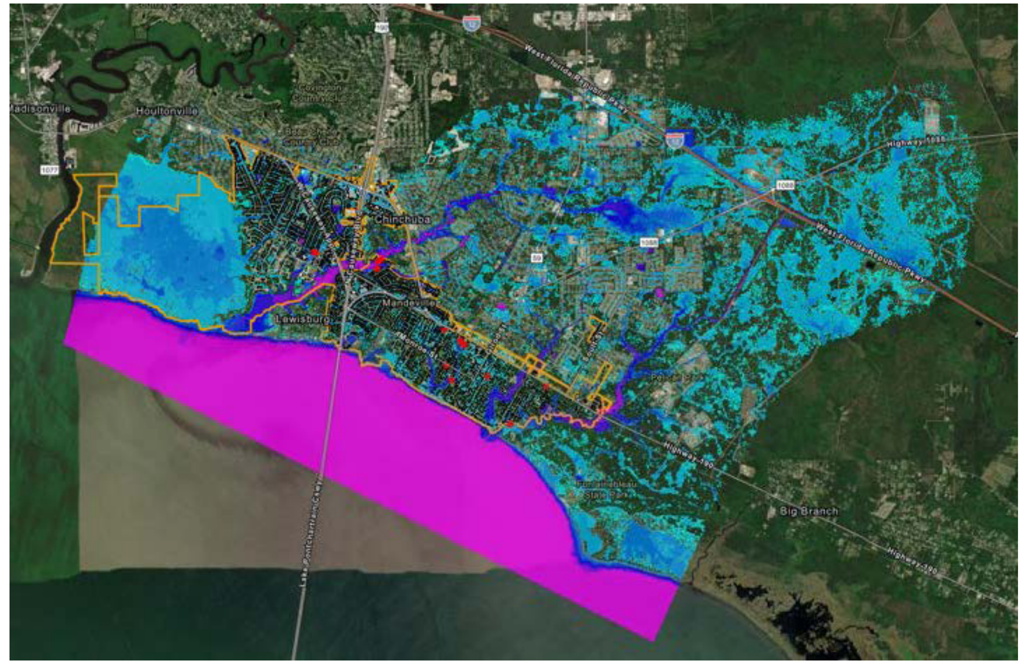


IMAGE CREDIT: NewScientist - U.S. Air Force Master Sgt Mark C Olsen/Alamy

Educate & Engage

MANDEVILLE FLOOD RESILIENCE STRATEGY

Educate & Engage

SUMMARY

This element of the plan focuses on Mandeville residents and the daily business of the City of Mandeville and how integrating education and capacity building on flood risk can help build broader understanding of flood risk and increase community support for adaptation programs and projects.

IMAGE CREDIT: iStock

FLOOD RISK EDUCATION CAMPAIGN

Description: While Mandeville residents have general knowledge of flood risk in their community, a more comprehensive understanding of flood risk and where those risks fall in the landscape can help property owners and residents make important adaptive decisions to reduce their risk. By investing in education materials and resources for the community at-large, the city can reduce its collective risk at relatively low cost. The city will take a comprehensive approach to this education campaign with content and communication methods designed for various audiences. The city will harness the insights of the hydraulic and hydrologic modeling conducted for this flood resilience strategy and citizen scientists active in environmental preservation help make the knowledge gained from this process more widely available, accessible, and understandable.

Flood Resilience Benefits: When homeowners have a better understanding of their flood risk, they can adapt accordingly by taking on mitigating activities such as elevating their structures or air-conditioning units, or other floodproofing measures.

Water rescues at Fontainebleau State Park; 19 people evacuated amid Cristobal flooding

Emergency crews with the Mandeville Fire Dept. and EMS are conducting water rescues from several cabins inside Fontainebleau State Park.

IMAGE CREDIT: www.wafb.com

BUILD CITY CAPACITY TO MANAGE FLOOD RISK

Description: As a small community, the city of Mandeville enjoys a relatively large amount of capacity when it comes to planning for flood risk resilience. This initiative recognizes that this is a continual investment that the city will need to make in order to maintain and enhance the city staff's expertise and capacity to conduct floodplain management activities and programs. This investment includes training employees, adding equipment, maintaining the hydrologic and hydraulic model, and possibly adding positions as needed to manage the implementation of the elements of this plan.

Mandeville can use its newly created watershed model to assess future investments in flood protection and anticipate the potential effects of a coming storm event and create a set of expectations to inform its emergency management and preparedness actions. This can give both government and residents more time to prepare for flooding events. The city can also integrate the early warning system with the public education campaign. Since the city's flood risk will continue to change over time, it will be critical for the city to continually use risk modeling to inform capital projects.

City Council Chamber, Mandeville, LA

IMAGE CREDIT: mandevilledaily.files.wordpress.com

The City of Mandeville plans to expand its system of river, lakefront, and rain gauges to better understand, measure, and predict the impact of weather events on the flood risk conditions throughout the city. The city will add these gauges to the supervisory control and data acquisition (SCADA) system the city uses to manage and monitor systems remotely. Having better real-time and longitudinal data will allow the city to provide notifications for potential flood conditions during, or even in advance of, flooding in specific areas.

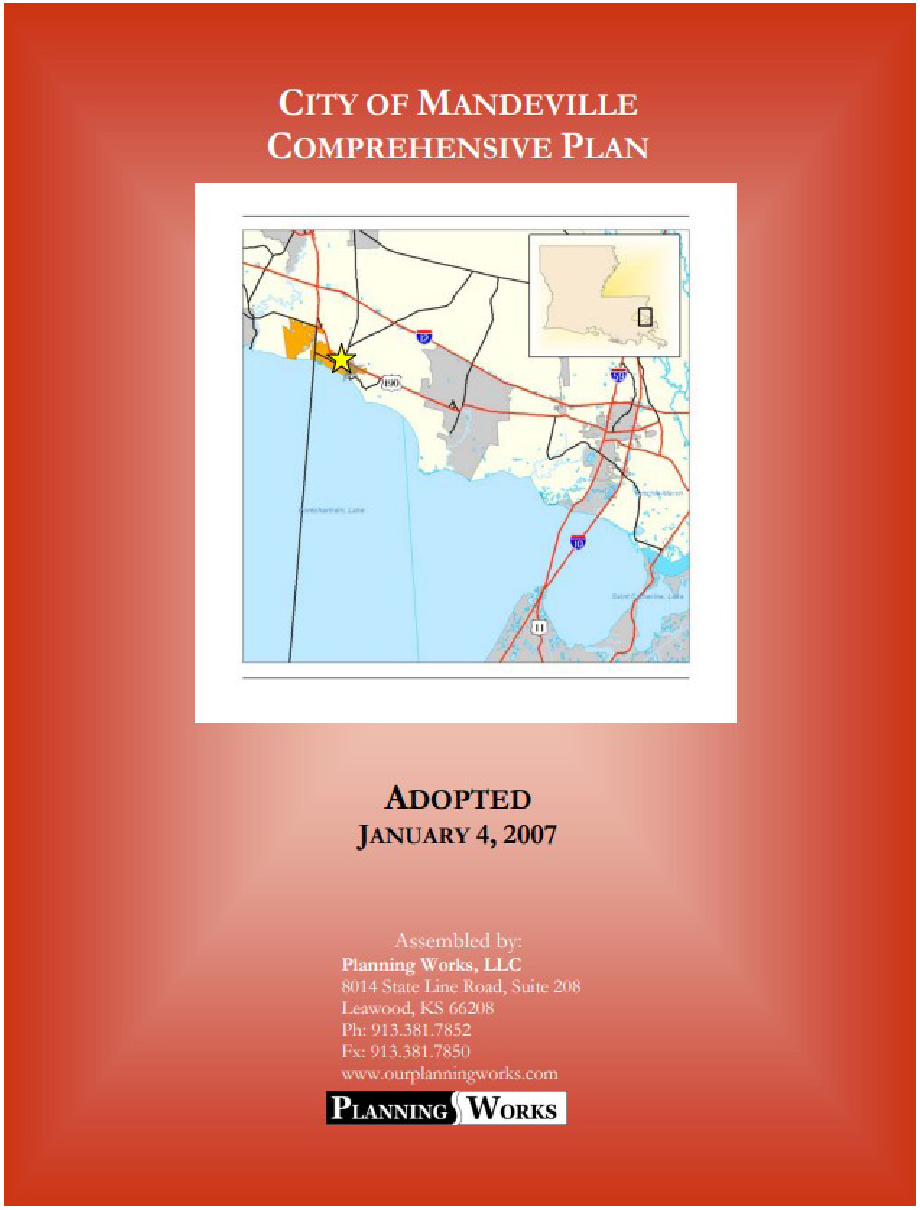
Flood Resilience Benefits: Much of the implementation of this flood resilience strategy will be driven by city staff. By investing in its local capacity and expertise, the city stands to gain additional funding for stormwater management projects, financing mechanisms for non-structural adaptation initiatives, and can stay up on the latest best practices for floodplain management and flood resilience. By having a sense of what areas may be impacted and to what extent by a potential storm, the city and residents can plan accordingly. This could include preemptively closing sections of roadways that could be become dangerous, elevating or securing valuable movable assets or inventory, deploying dry floodproofing systems like floodgates on building openings, and alerting others in how to prepare and potentially reduce damages.

By continuing to update and use a detailed stormwater model to inform policy decisions and infrastructure projects, the city can ensure that public and private investments are not exacerbating any flooding issues and can even design them to reduce flood risk.

INTEGRATE FLOOD RESILIENCE INTO CITY PLANS & ORDINANCES

Description: The City plans to the update to the Comprehensive Plan and associated Comprehensive Land Use Regulations Ordinance which guide development and growth. This update process is the perfect opportunity to integrate the current flood risk analysis into the planning process and adopt land use policies that mitigate this risk. Included in this section are several specific land use tools that should be considered during this process. However, the most comprehensive approach is to update the city's master plan and land use regulation ordinance to address flood risk. This can be done by identifying areas to restrict development where flood risk is higher, identifying areas for growth where flood risk is lower, and identifying projects to connect areas of investment to the surrounding parish.

Updates to the land use regulations could include regulations that require property owners who are building new buildings or substantially renovating existing buildings to manage stormwater on site. This often requires measuring the pre- and post-development runoff and then designing interventions that detain runoff so that no additional runoff is created by the development or even reduce runoff. Other modifications could include incentives for property owners to increase pervious surfaces or use Low Impact Development designs, materials, and construction practices to reduce urban runoff and environmental impacts.


CITY OF MANDEVILLE
COMPREHENSIVE PLAN

ADOPTED
JANUARY 4, 2007

Assembled by:
Planning Works, LLC
8014 State Line Road, Suite 208
Leawood, KS 66208
Ph: 913.381.7852
Fx: 913.381.7850
www.ourplanningworks.com
PLANNING WORKS

Flood Resilience Benefits: Integrating flood risk mitigation into the city's land use policies would not only demonstrate to residents the government's commitment to flood resilience, but it would also initiate a long-term adaptation to limit future exposure to flood risk by limiting development in higher-risk areas and increasing growth in lower risk areas. While individual detentions systems on private property will not reduce citywide flood risk, these interventions can provide solutions for localized flooding. When enough of these installations are implemented in a neighborhood, nuisance flooding of streets and yards from rainfall events can be reduced.

Nuisance Flooding Mitigation Strategies

SUMMARY

While most of Mandeville's flood risk is best mitigated through nonstructural adaptation, there are several potential stormwater management projects that could provide smaller, localized benefits. These include stormwater parks, conveyance improvements along local waterways, and upstream stormwater detention. In this strategy, several specific sites have been evaluated for their potential flood risk mitigation benefits.

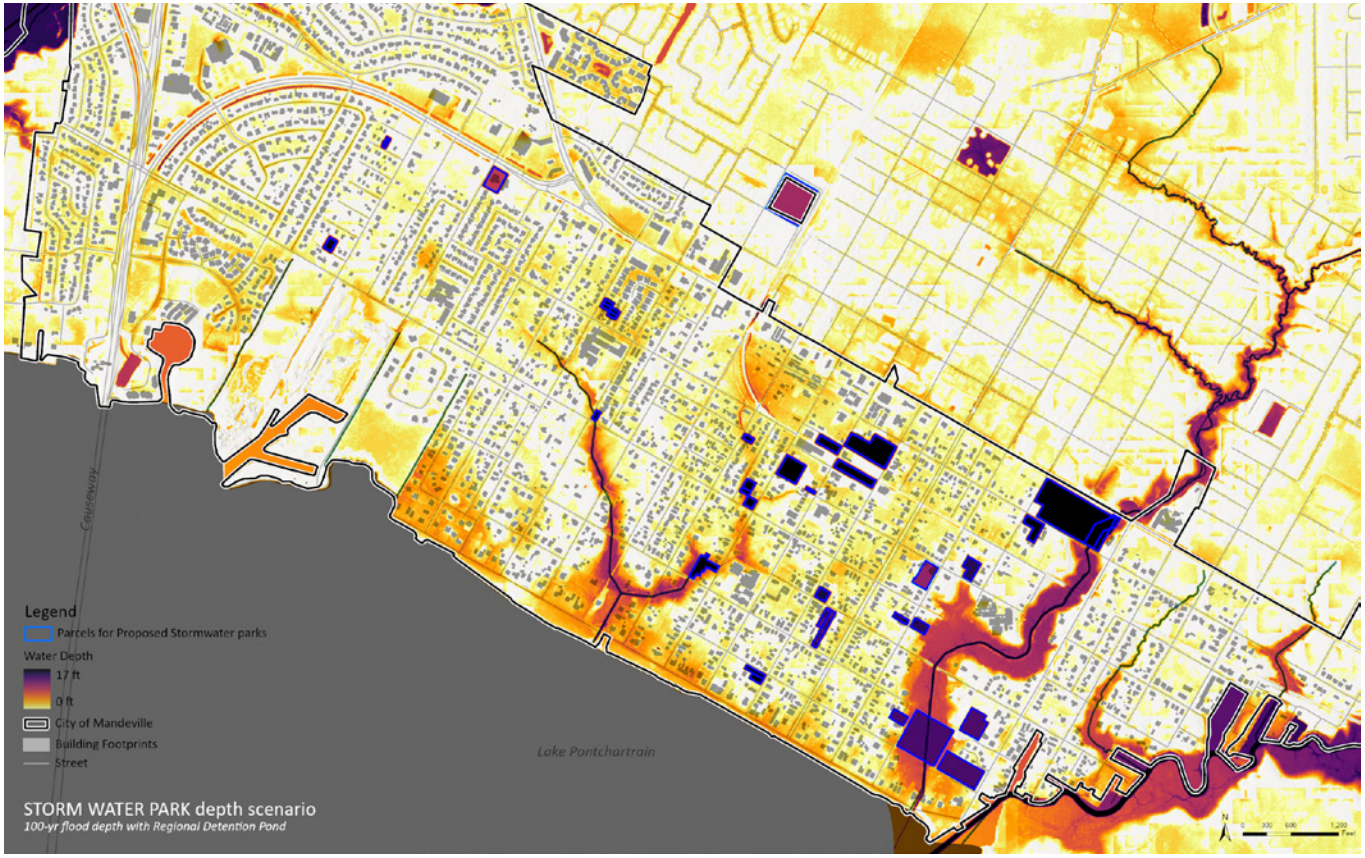
NUISANCE FLOODING MITIGATION STRATEGIES

Localized Strategies

STORMWATER PARKS

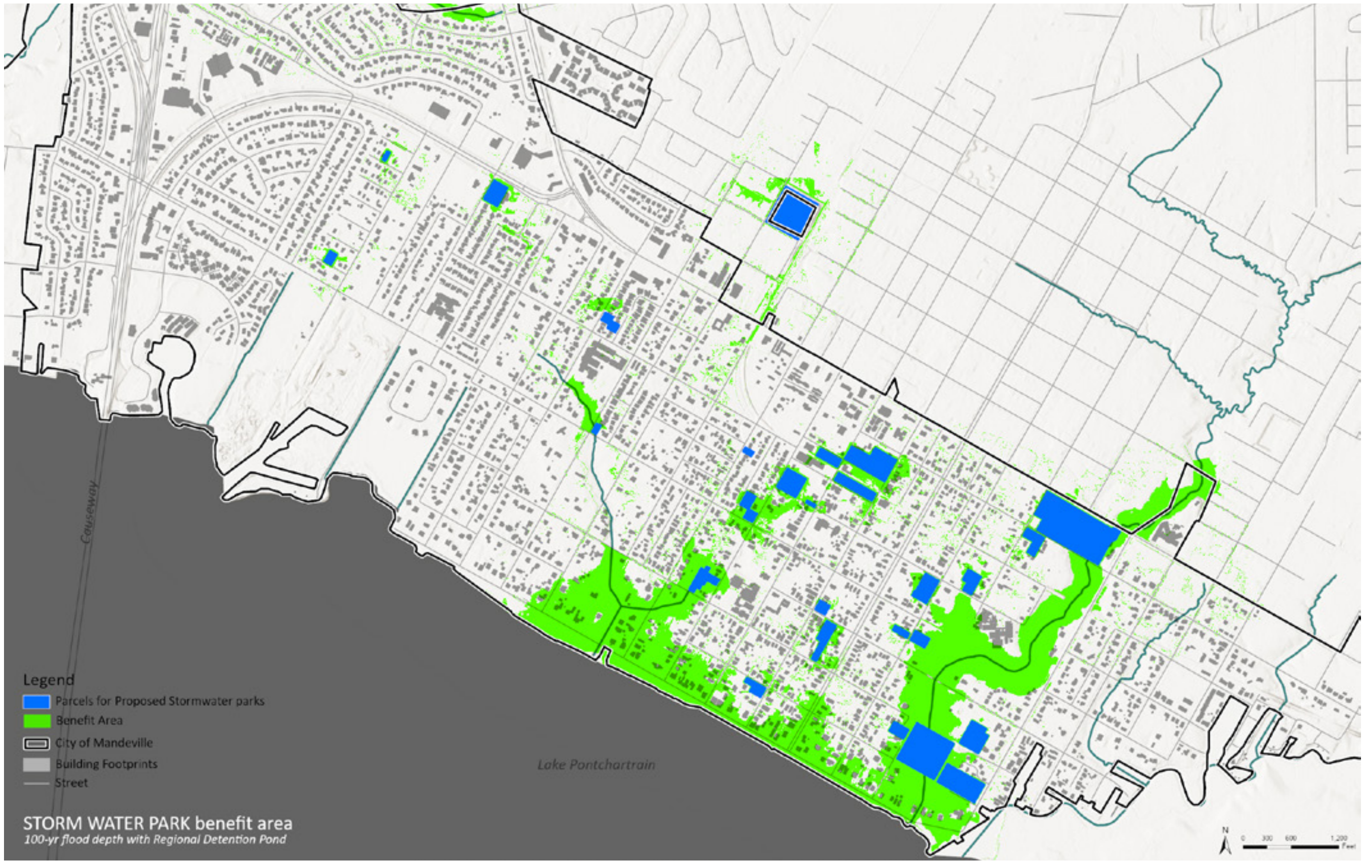
Description: The hydraulic modeling conducted for this strategy helped to identify several city-owned parcels that are currently green or open space that could be transformed into stormwater parks to reduce localized flooding and provide other amenities. Examples of these could include ballpark field retrofits and lagoon systems where stormwater storage at the surface or subsurface delays its entry into the drainage system.

Stormwater Parks - East



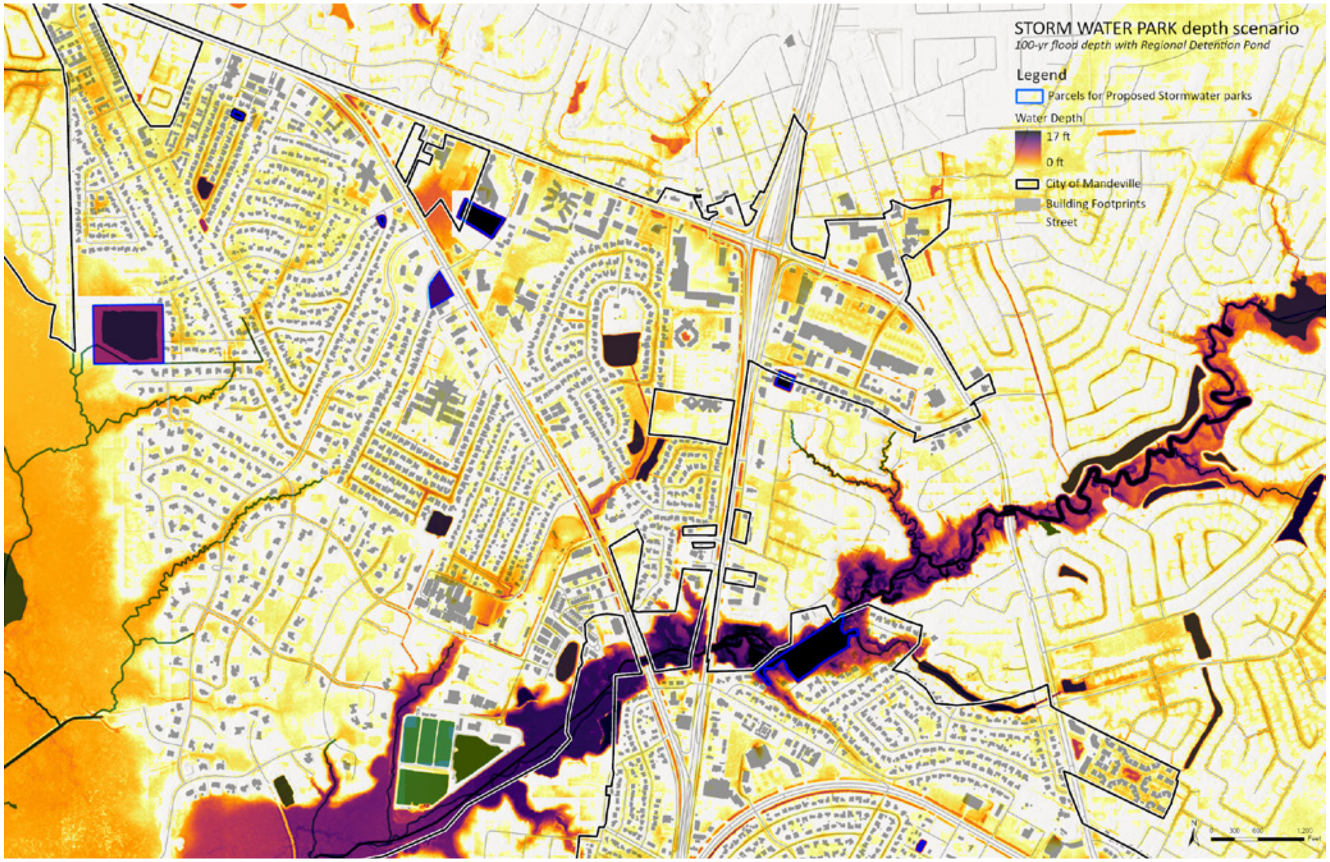
One of the mitigation concepts included implementing stormwater parks throughout Mandeville. Stormwater park locations were selected based on city owned parcels that could be readily adapted, which are identified in the figure on the right. The simulation selected locations that would be able to store the most water, resulting in a decrease in water surface elevation and nuisance flooding in the surrounding area. For further explanation, see sections 5.4 in the Appendix.

Stormwater Parks - East Benefit Area



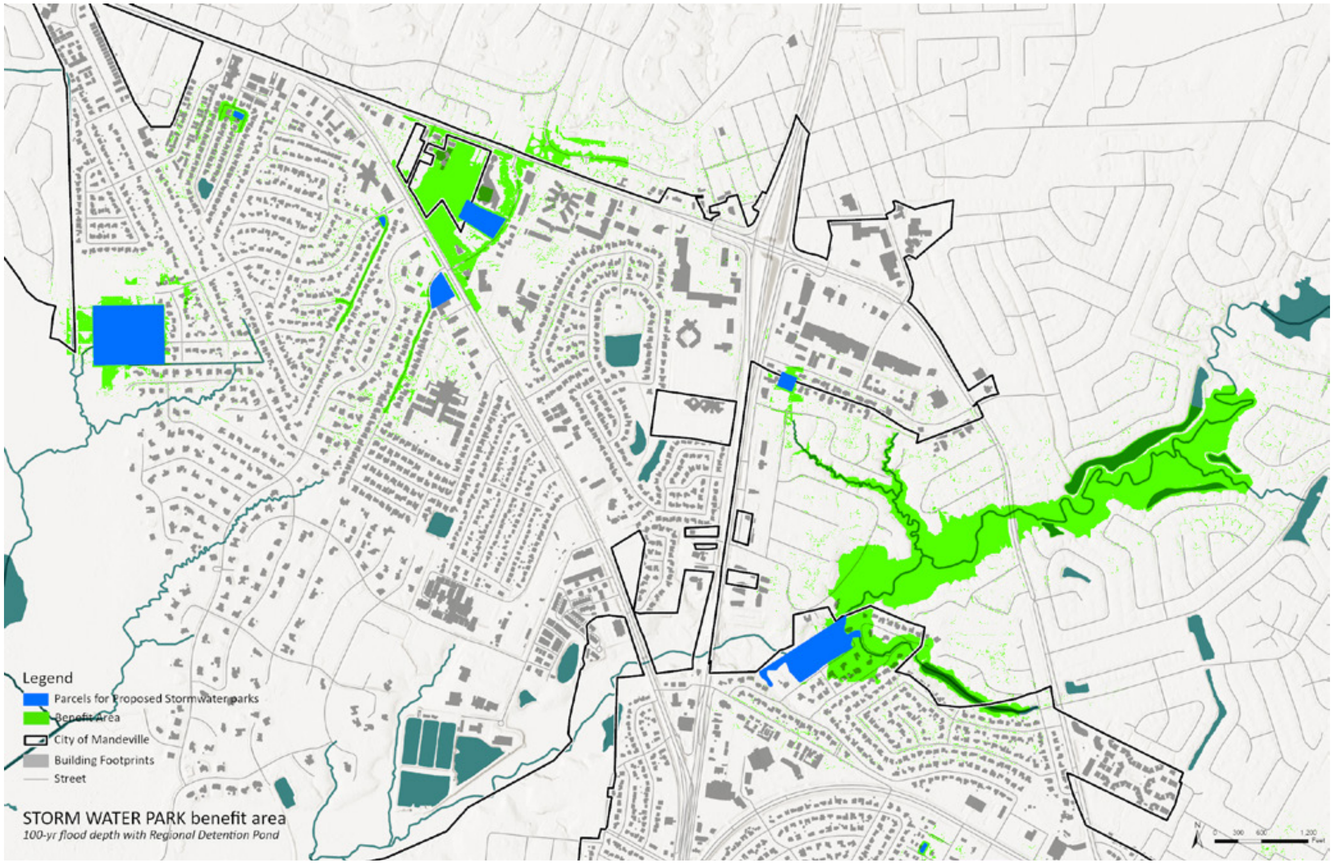
Flood Resilience Benefits: Stormwater parks could reduce localized flooding, primarily nuisance flooding that affects streets and yards, by delaying the rate at which stormwater flows into the drainage system, and if designed to also serve as active or passive parks, could provide additional recreational amenities.

Stormwater Parks - West



One of the mitigation concepts included implementing stormwater parks throughout Mandeville. Stormwater park locations were selected based on city owned parcels that could be readily adapted, which are identified in the figure on the right. The simulation selected locations that would be able to store the most water, resulting in a decrease in water surface elevation and nuisance flooding in the surrounding area. For further explanation, see sections 5.4 in the Appendix.

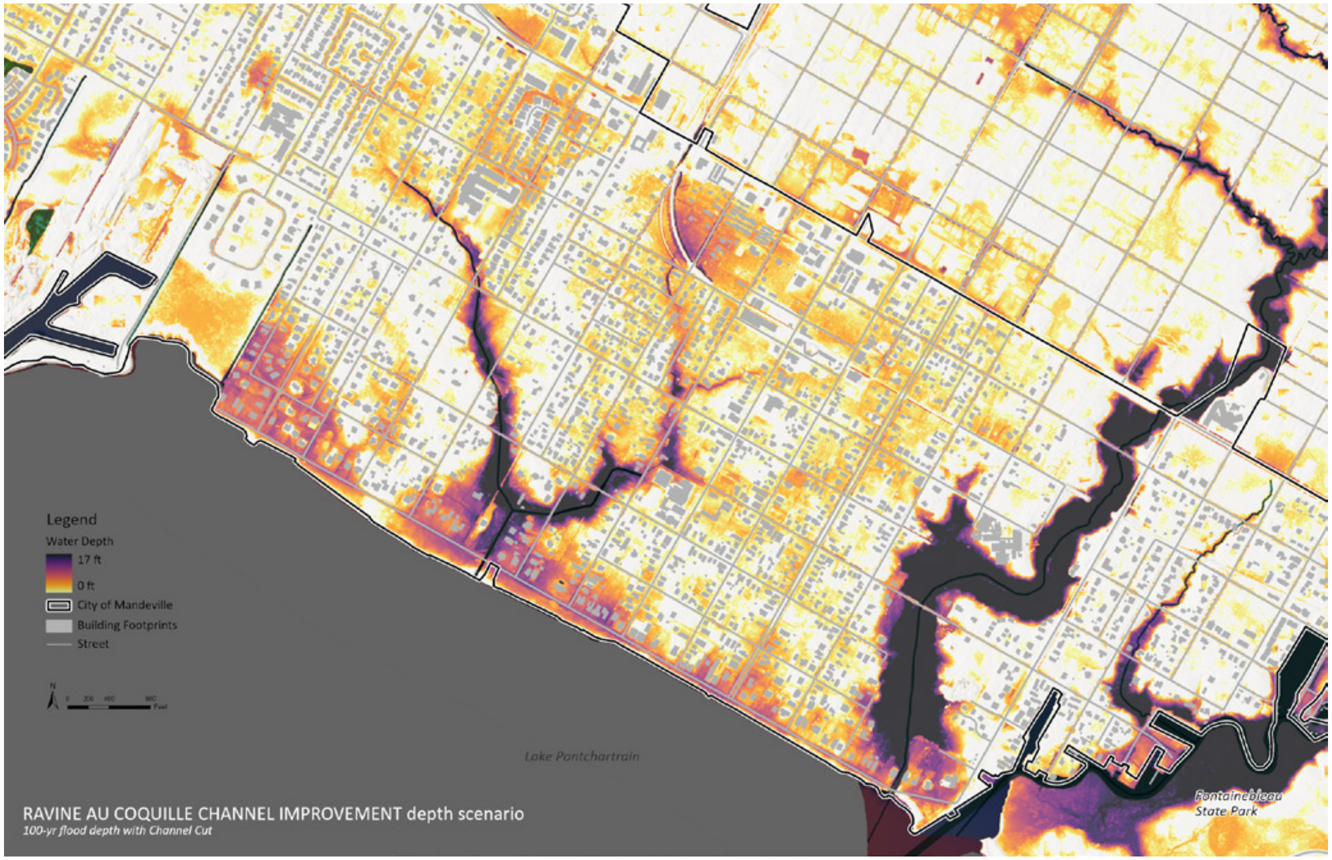
Stormwater Parks - West Benefit Area



CHANNEL CAPACITY AND CONVEYANCE IMPROVEMENTS

Description: Mandeville could gain some local flood resilience benefits by improving the conveyance and capacity of its historic waterways. One example examined in the model was along Ravine Au Coquille's West and East branches as they lead into the outfall at the waterfront. Modeling showed that by increasing the cross-section of the waterway, flood risk benefits would accrue to the properties along Ravine Au Coquille and along the waterfront near the outfall. This modification would also require replacement of the Lakeshore drive bridge with a similar capacity flap gate structure.

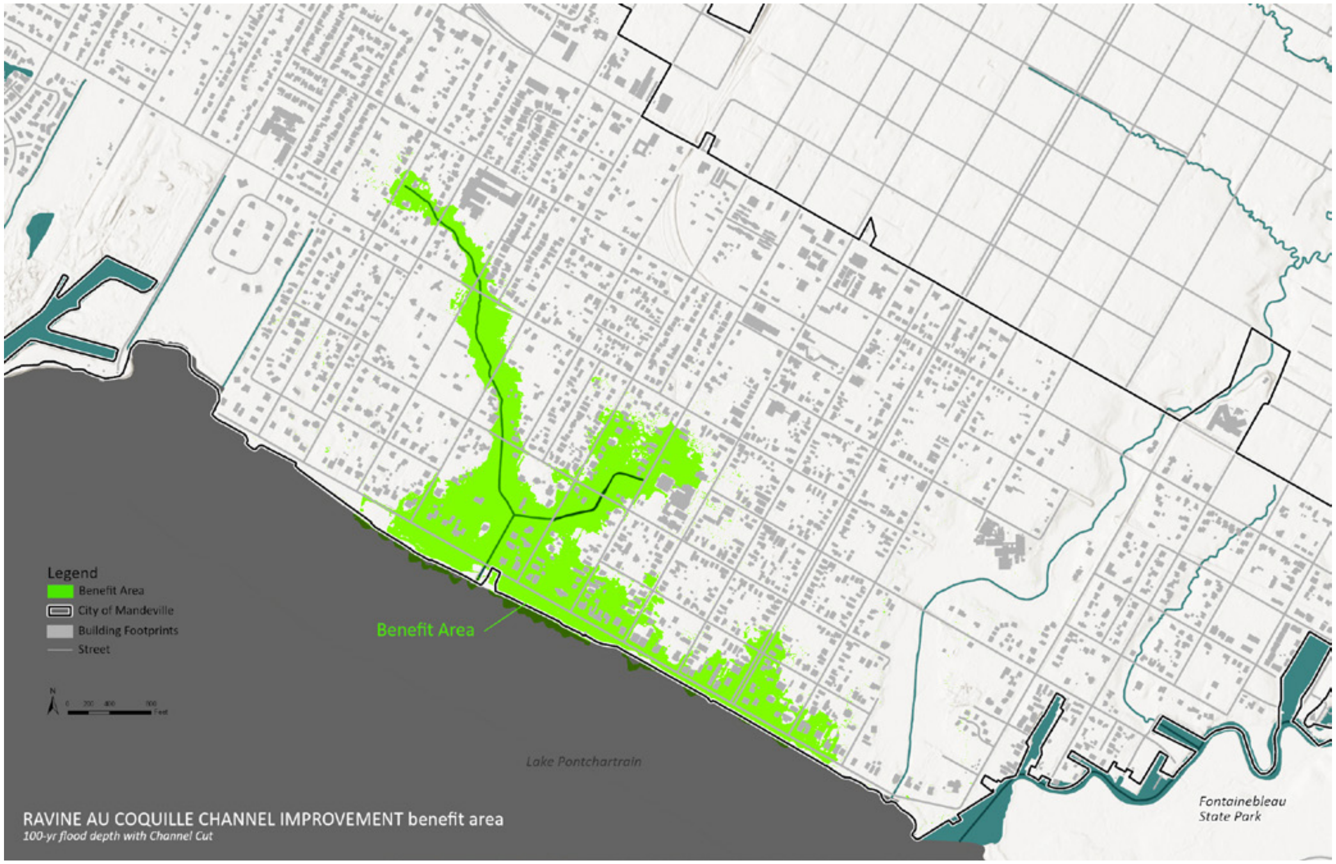
Ravine Au Coquille Capacity Improvements



The modeling also looked at the possibility of widening both branches of Ravine aux Coquille to hold the estimated 25-year flow rate within the banks. A gate structure would also be places at the outfall of the ravine to prevent backflow from Lake Ponchatrain during high-water events. This would increase storage in the channel and better mitigate the immediate impact of high tide and storm surge. For more information, refer to section 5.5 in the Appendix.

Flood Resilience Benefits: These improvements could reduce yard and street flooding in areas which drain to the Ravine. The capacity improvements help to limit the impacts of high tailwater caused by tidal or wind influences on stormwater conveyance. The primary areas that benefit are immediately adjacent to the waterway or along the waterfront where excess stormwater can overwhelm the existing outfall structure.

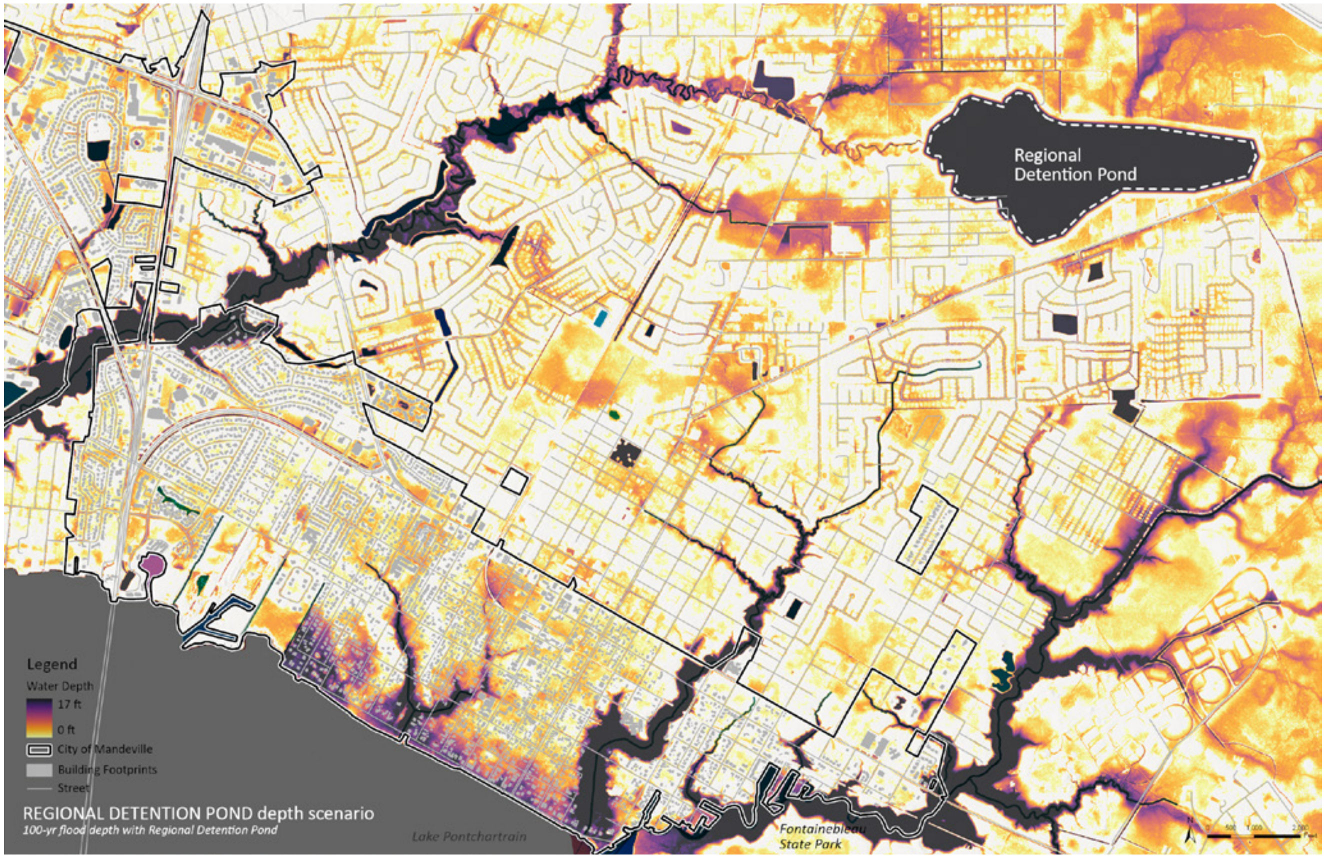
Ravine Au Coquille - Benefit Area



UPSTREAM REGIONAL STORMWATER DETENTION

Description: While only a small component of Mandeville's flood risk originates upstream in waterbodies beyond the city's boundary, there is an opportunity to modestly reduce the city's risk here as well by creating stormwater detention in upstream areas to reduce the amount and rate that stormwater flows into the city. This would need to happen in partnership with St Tammany Parish since this land is outside the city's jurisdiction but could be a cooperative endeavor to limit the impacts of any future development along the I-12 corridor that would potential increase downstream runoff. The model also showed that a regional detention area would lower peak water surface elevation in Bayou Chinchuba, resulting in nuisance flooding in the surrounding area. For more information on the regional detention modeling, see section 5.3 in the Appendix.

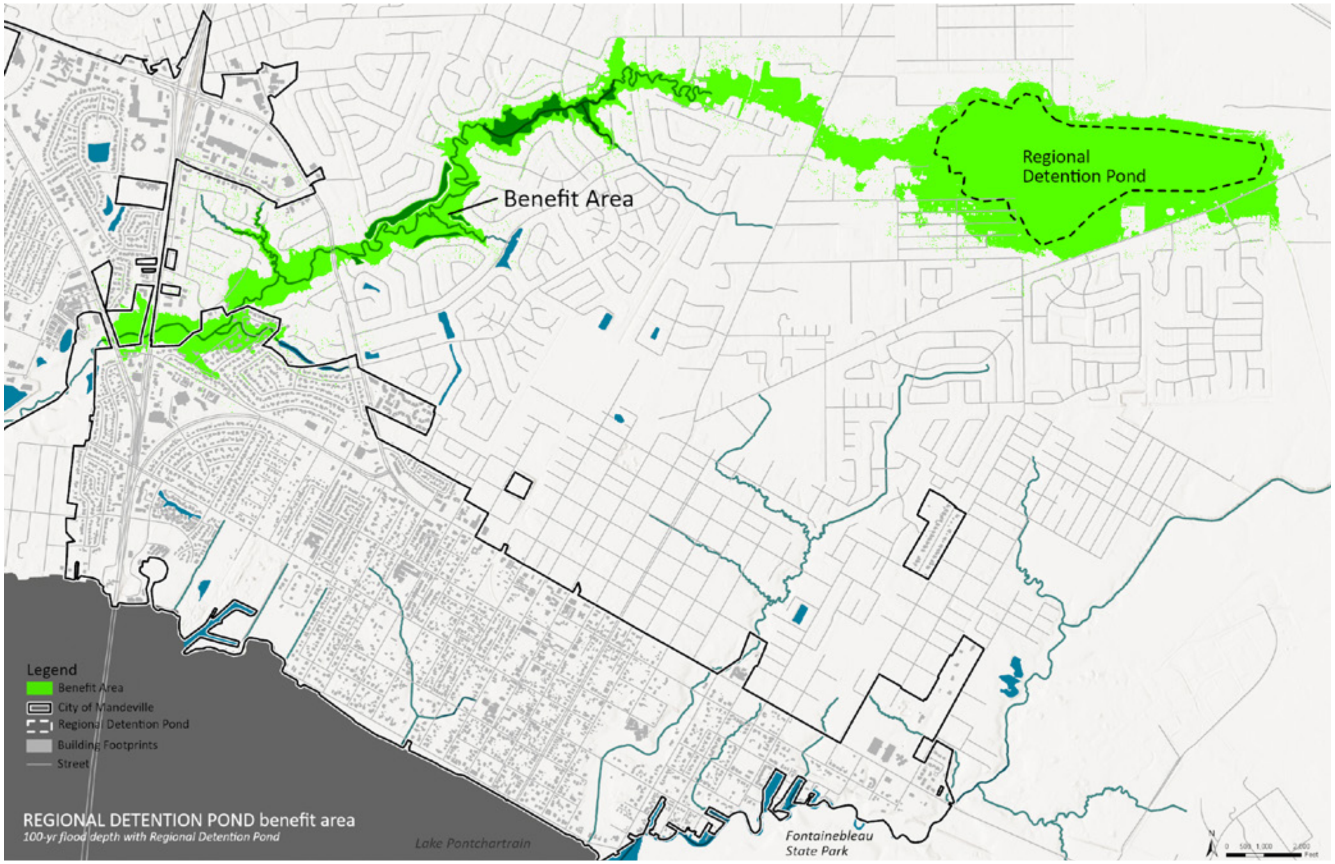
Regional Stormwater Detention



Concern was raised by the city regarding the forested area northeast of Interstate 12. Development in the area could impact the drainage further downstream in the watershed and result in an increase in water surface elevations for the city. The figure shows the model selected for a potential regional detention basin to mitigate nuisance flooding in the area. It was determined that development north of Interstate 12 would have a minimum impact on the increased flood risk due to existing conveyance underneath I-12.

Flood Resilience Benefits: Hydrologic and Hydraulic modeling demonstrated that a 260-acre, 1,840 acre-ft volume (the equivalent of 3,700 olympic size swimming pools) detention pond in the section of Bayou Chinchuba upstream of the city limits would reduce significantly decrease flood risk for structures located near the detention area and would reduce nuisance yard and structure flooding for properties along Bayou Chinchuba.

Regional Stormwater Detention - Benefit



LAKEFRONT FLOODGATES AND LIVING SHORELINE

Description: While the city does not plan to include structural protection from storm surge flooding in the form of a levee or flood wall, Mandeville could reduce the impact of wave action from high wind and surge events by reducing the power of storm surge by constructing a “Living Shoreline” and by installing small floodgates and pumps under existing bridges to reduce coastal inundation. Many coastal communities are exploring the benefits of Living Shorelines – human-made barriers that reduce the strength of surge and tidal flooding that can also provide fish and wildlife habitat. St Tammany Parish is currently considering a sub-surface barrier that would reduce the power of storm surge and provide aquatic habitat while re-purposing construction debris in a sustainable manner.

Flood Resilience Benefits: A Living Shoreline project would reduce wave action from surge and tidal events, benefiting those structures closest to the lakefront.

Living Shorelines

Living shorelines are a suite of shoreline erosion control techniques that combine natural coastal habitats with a natural or engineered means of breaking up a waves energy

IMAGE CREDIT: nrcsolutions.org

Case Studies

MANDEVILLE FLOOD RESILIENCE STRATEGY

CASE STUDY

Norfolk's Vision 2100


IMAGE CREDIT: iStock

NORFOLK'S RESILIENCE STRATEGY & VISION AREAS

As part of its commitment to the 100RC initiative, Norfolk completed a resilience strategy built around three main goals:

- Design the coastal community of the future.
- Create economic opportunity by growing new and existing sectors.
- Advance initiatives to connect communities, deconcentrate poverty, and strengthen neighborhoods.

The focus of Vision 2100 is coastal resilience; however its actions also address economic and social resilience. Norfolk's world is changing and the prospect of sea level rise is a major consideration due to both global water rise and local land subsidence. While it is understood that the relative sea levels along Norfolk's coastline are rising, the rate and extent of these projections remains uncertain.

Norfolk's population is growing and should continue to do so given the national trend of American inner cities gaining population relative to their suburbs. Accommodating the exponential population growth will require additional housing units, which should be constructed in low-risk areas. In addition, Norfolk's present-day infrastructure is aging and the long-term infrastructure investments needs to be well planned for both today and tomorrow.

CASE STUDY

Norfolk's Vision 2100

Vision 2100 divides the City into four vision areas and identifies a set of goals and actions intended to respond to the unique set of circumstances in each. The best way to understand the distinction between each vision area is to compare them by their identified risks and assets along two competing axes. The vertical axis represents the number of key city-wide assets in the present or future, while the horizontal axis represents the risk presented by sea level rise or recurrent flooding.

Red Area - Enhancing Economic Engines
Key economic assets essential to the city's future, many of which cannot be feasibly relocated or recreated. Expand the flood protection system, enhance the transportation network, diversify the housing options available and strengthen economic diversity.

Yellow Area – Adapting to Rising Waters
Established neighborhoods that experience more frequent flooding, sea level rise adaptation in historic neighborhoods, while other development is encouraged to gradually retreat from shorelines via housing buyouts.

Green Area – Designing New Urban Centers
Low risk of flooding and have potential for high density, mixed-use, and walkable neighborhoods, building the infrastructure necessary to support new urban centers.

Purple Area – Establishing the Neighborhoods of the Future
Established neighborhoods at less risk of flooding, maintaining housing affordability, while improving connections between these areas and key economic assets.

Vision 2100 Map
IMAGE CREDIT: City of Norfolk, norfolk.gov

STORMWATER PARKS

Moncus Park - Lafayette, LA

Moncus Park, Lafayette LA

IMAGE CREDIT: moncuspark.org/about/

SITE SUMMARY

Moncus Park is a 100-acre nature-based community park centrally located within the city of Lafayette, Louisiana.

RAIN GARDEN

- Incorporation of native plantings and water retention system
- Manages stormwater in parking lots
- Retains stormwater and slowly drains within 72 hours

WETLAND POND

- Four acres, 9 feet deep
- Built to contain four irrigation pumps
- Filled with diverted neighborhood stormwater
- Source of all irrigation
- Contains submerged islands, 6 inches below the surface to increase water quality

RISKS ADDRESSED

- Flash Flooding
- Urban flooding
- Future plans include tiered temporary detention of diverted stormwater from Coulee Mine which will alleviate riverine flooding due to its outflow into the Vermillion River

STORMWATER PARKS

Gretna's City Hall Plaza - Gretna, LA

SITE SUMMARY

Gretna's "Downtown 2020" was a drainage project constructed to incorporate green infrastructure while showcasing the vibrant and historic charm of downtown Gretna. Located near the Mississippi River Levee System. Gretna has long experienced flooding within its streets, a result of stormwater overwhelming and quickly filling the drainage system.

FEATURES

- Landscaping designed to filter and absorb stormwater
- Buried underneath is a system of containers capable of holding 35 average size swimming pools worth of water
- Once captured, storm water is filtered and slowly released to prevent the cities drainage becoming overwhelmed

RISKS ADDRESSED

- Flash Flooding
- Urban Flooding

CHANNEL CAPACITY AND CONVEYANCE IMPROVEMENTS

Fox Run Floodplain Restoration - Dover Township, PA

Fox Run Floodplain Restoration, Pennsylvania

The Fox Run Floodplain Restoration was a comprehensive floodplain restoration project on two unnamed tributaries to Fox Run in Dover Township, Pennsylvania.

IMAGE CREDIT: www.flywayexcavating.com

SITE SUMMARY

The Fox Run Floodplain Restoration was a comprehensive floodplain restoration project on two unnamed tributaries. The project replaced the function of an existing regional basin located on a dilapidated golf course to accommodate future offsite economic development and create a community park centered around the natural environment.

DESIGN MEDIATIONS

- Relocation of an existing 43,000-cubic-yard fill pile
- Excavation of the 27,000-cubic-yard floodplain
- All fill excavated from the floodplain was used to create an adjacent sloped field area to increase drainage and provide a more level surface for the construction of the park
- Restoration of approximately 3,440 lineal feet of stream channel by removing legacy sediments
- Used natural woody debris as grade control and fish habitat
- Following completion, the project has greatly improved water quality and provided increased stormwater management facilities

RISKS ADDRESSED

- Flash Flooding
- Urban Flooding
- Riverine Flooding

UPSTREAM REGIONAL STORMWATER DETENTION

Bayou Chinchuba Water Quality Pond - Mandeville, LA

SITE SUMMARY

Located within the Mandeville area, north-east of highway 190 is the recently completed Bayou Chinchuba Water Quality Pond. Initially constructed to address decreasing water quality and oxygen levels in Bayou Chinchuba and the previous detention pond within the Oak Island subdivision, this project incorporated numerous components to increase stormwater capacity and mitigate flood risk within communities located downstream.

PROJECT IMPACTS

- Neighborhoods located downstream saw a rapid increase of oxygen levels in Bayou Chinchuba
- Increased storm water drainage capacity for the surrounding watershed
- Long-term benefits include the disintegration of waste products before entering Bayou Chinchuba, resulting in higher oxygenation for native plants and animals
- Partially funded through Federal grants, the project required matching funds of $486,573
- The project included a drainage pipe from Bayou Chinchuba into the pond, construction of a weir connecting the existing pond, new excavation, a wrap-around berm, installation of an aerator within the pond, fencing, and sod/ native vegetation.

St. Tammany Parish Water Quality Protection Area

IMAGE CREDIT: deq.louisiana.gov

RISKS ADDRESSED

- Flash Flooding
- Urban Flooding
- Riverine Flooding
- Water Quality

LAKEFRONT FLOODGATE AND LIVING SHORELINE

Living Shorelines in the Hurricane Sandy Coastal Resilience Program

Living Shoreline Projects of Long Island Sound

IMAGE CREDIT: longislandsoundstudy.net

SITE SUMMARY

An in-depth cost-effectiveness analysis was performed on 11 projects, encompassing 22 project sites, in the Hurricane Sandy Program portfolio to reduce coastal erosion through the creation of living shorelines.

DESIGN MEDIATIONS

- The nearly 53,000 feet of living shorelines helped sustain wildlife habitat and protect the coastlines avoid erosion on up to 440 acres of land
- These projects helped restore approximately 40 acres of marshes, beaches, oyster reefs, and submerged aquatic vegetation
- Living shorelines were typically more cost-effective than stone revetments
- Living shorelines provide more ecological benefits through habitat restoration over other gray systems

RISKS ADDRESSED

- Coastal Erosion
- Habitat Destruction
- Coastal Resilience

Mandeville Flood Resilience Strategy

CITY OF MANDEVILLE, LOUISIANA

MANDEVILLE
A Historic Lakefront Community
cityofmandeville.com

COASTAL PROTECTION AND RESTORATION AUTHORITY
CPRA
coastal.la.gov

CSRS
BUILDING STRONGER, SMARTER COMMUNITIES TOGETHER.
csrsinc.com

Wishing I Was Fishing

Local Baton Rouge artist, oil painting on canvas.

IMAGE CREDIT: Jeff Bell. https://www.instagram.com/p/Cm1z6y0LmgH/

5. MANDEVILLE FLOOD RESILIENCE STRATEGY
Technical Report

MANDEVILLE'S FLOOD RESILIENCE STRATEGY: HYDROLOGIC AND HYDRAULIC ANALYSIS REPORT

CSRS | BUILDING STRONGER, SMARTER COMMUNITIES TOGETHER.

Mandeville's Flood Resilience Strategy: Hydrologic and Hydraulic Analysis Report

SUBMITTED BY:

CSRS LLC
8555 United Plaza Blvd.
Baton Rouge, LA 70809

REVISION HISTORY

Rev. No.	1	2	3	4
Issue Purpose	Final Draft			
Date	1/19/2023			
By	JW			
QC	BMC			
QA	SB			

Contents

1. Introduction

CSRS, LLC (CSRS) was contracted by the Coastal Protection and Restoration Authority (CPRA) to complete a non-structural flood mitigation assessment for the City of Mandeville (Mandeville). Mandeville is located in St. Tammany Parish on the north shore of Lake Ponchatrain. Mandeville is bounded by the Tchefuncte River to the west and Bayou Castine to the east. There are also several large drainage features within Mandeville: from east to west there are Little Bayou Castine, Ravine aux Coquilles, and Bayou Chinchuba. Figure 1-1 shows the extents of Mandeville and the major drainage features.

Mandeville, historically, has seen flooding caused by several sources: short duration, high intensity storms that result in overland flooding, a combination of coastal flooding resulting from storm surge and intense rainfall, and a combination rainfall with the addition of a north wind at hightide. CSRS developed a hydraulic model of Mandeville and its surrounding watersheds to assess the flooding sources mentioned above. This document summarizes the hydraulic analysis completed to evaluate Mandeville and strategies to mitigate future increases in flood risk. The modeling approach was completed using the United States Army Corps of Engineers Hydraulic Engineering Center River Analysis System (HEC-RAS) version 6.2.

Figure 1-1: Project Area and Drainage Channels

2. Data Collection

CSRS conducted an evaluation of existing data to form the basis of the hydrologic and hydraulic analysis. Table 2-1 below lists the sources alphabetically, items obtained from each source, and how the items were incorporated into this analysis.

Table 2-1: Data Collection Summary

Source	Item Received	Use
City of Mandeville GIS Department	City Boundaries, City-owned Properties, Subsurface System Data, Building Footprints, Building First Floor Elevations	For reference, structure flooding estimation, and to develop mitigation concept H&H models
Coastal Protection and Restoration Authority (CPRA)	NGOM2 LiDAR/Bathymetry Raster, Coastal Master Plan Sea-level Rise Projections	H&H model terrain and development of H&H model boundary conditions
Digital Engineering (Mandeville's engineering consultant)	Existing H&H Models, Capital Projects List	For reference only
Federal Emergency Management Agency (FEMA)	Effective Flood Insurance Rate Maps, Effective Flood Insurance Study Report, Models for Effective Flood Insurance Study	As a reference for estimating channel bathymetry and for validation of model results
National Ocean and Atmospheric Administration (NOAA)	Atlas 14 existing return interval-duration-rainfall depths	Development of H&H model boundary conditions
United States Army Corps of Engineers (USACE) New Orleans District	St. Tammany Parish 3x3 Study Regional HEC-RAS Model, Coastal Stage Frequency Data	For reference, development of H&H model boundary conditions, and for assessment of storm surge heights for multiple return intervals
United States Department of Agriculture (USDA)	gSSURGO Soil Type Data	Soils layer for H&H model
United States Geological Survey (USGS)	LA Upper Delta Plain 2017 LiDAR Raster, National Land Cover Dataset	Model terrain and land cover for H&H model

3. Existing Conditions

3.1. Introduction

After the completion of data acquisition, the existing conditions model was established using the United States Army Corps of Engineers River Analysis System, HEC-RAS v.6.2. This system was used to generate a full 2-D unsteady flow hydraulic model of the project area. This included a 2-D computational mesh, geospatial layers, and boundary conditions. The channel cross-sections that were obtained during data acquisition contributed to the channel bathymetry which was inputted using the terrain modification layer in RAS Mapper. Where refined channel data was not available, channel bathymetry was estimated using a 3:1 side slope and a 0.1% channel grade. Multiple iterations of mesh refinement were conducted to ensure accuracy and fix any stability issues. Finally, the existing model was calibrated using a historical event; photographs of flooding from this event were used to estimate highwater marks which were compared to model results.

3.2. Model Geometry

The 2-D computational mesh (Figure 3-1) mentioned above has a base square cell size of 150 by 150 feet. The final mesh has approximately 65,000 cells. The mesh was developed to capture necessary high-ground features and channel features using 90 breaklines with varied resolutions allowing the mesh to adjust its alignment so that cell faces fall atop these critical features.

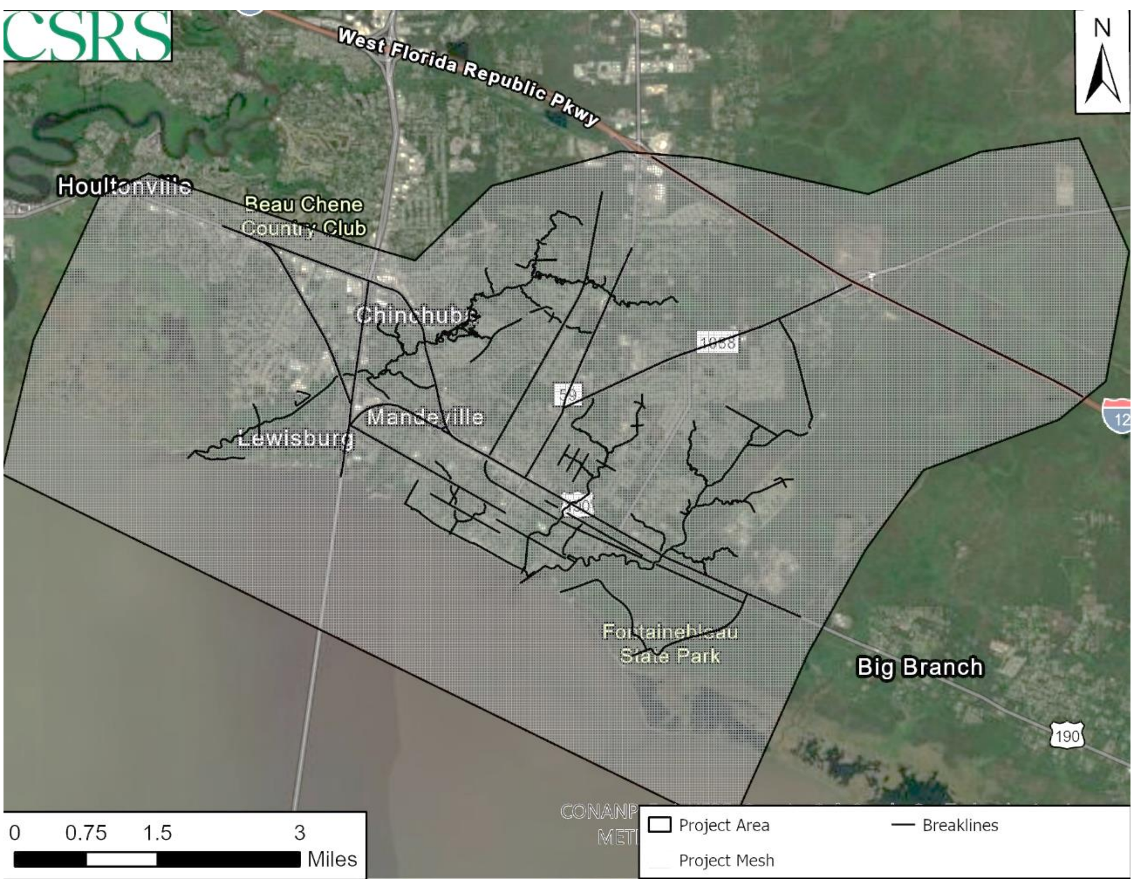


Figure 3-1: 2-D Computational Mesh with Breaklines

3.3. Geospatial Layers

The hydrologic and hydraulic parameters for the geospatial layers were next established in RAS Mapper. The geospatial layers include the terrain, land cover, soils, and infiltration layers.

3.3.1. Topographic Data

The topography used in the HEC-RAS model is based on the Digital Elevation Model (NAVD 88, GEOID 12B) obtained from United States Geological Survey (USGS) during the data collection phase of this project. All available channel cross-section data was used to generate channel bathymetry. The cross-section data was merged with the base DEM using terrain modifications in RAS Mapper to create a final terrain for the model. The terrain modification tool available in RAS Mapper was also used to hydro-enforce locations of hydraulic structures that were not explicitly modeled to maintain hydraulic connectivity. Figure 3-2 shows the terrain used for the existing and the mitigation concept model.

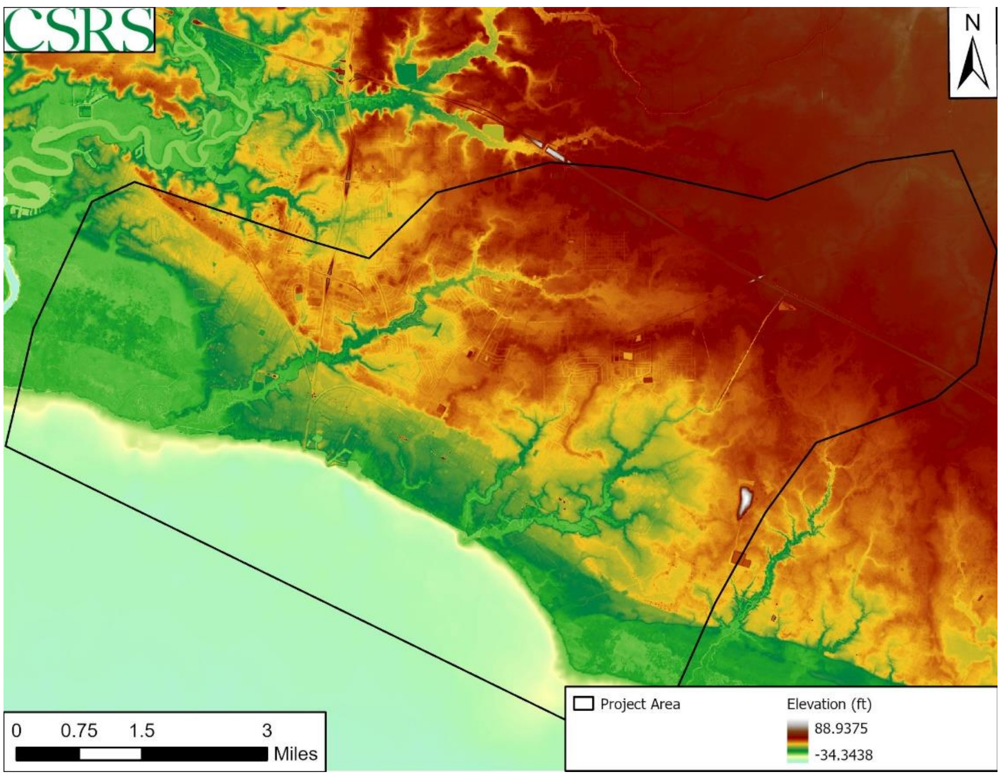


Figure 3-2: Model Terrain

3.3.2. Land Cover and Soils Layers

The land cover layer obtained from the National Land Cover Database's (NLCD) 2019 gridded dataset. The soils layer was created using the gridded Soil Survey Geographic (gSSURGO) 2020 Dataset available through the USDA's website. Figure 3-3 shows the land cover layer and Figure 3-4 shows the soils layer.

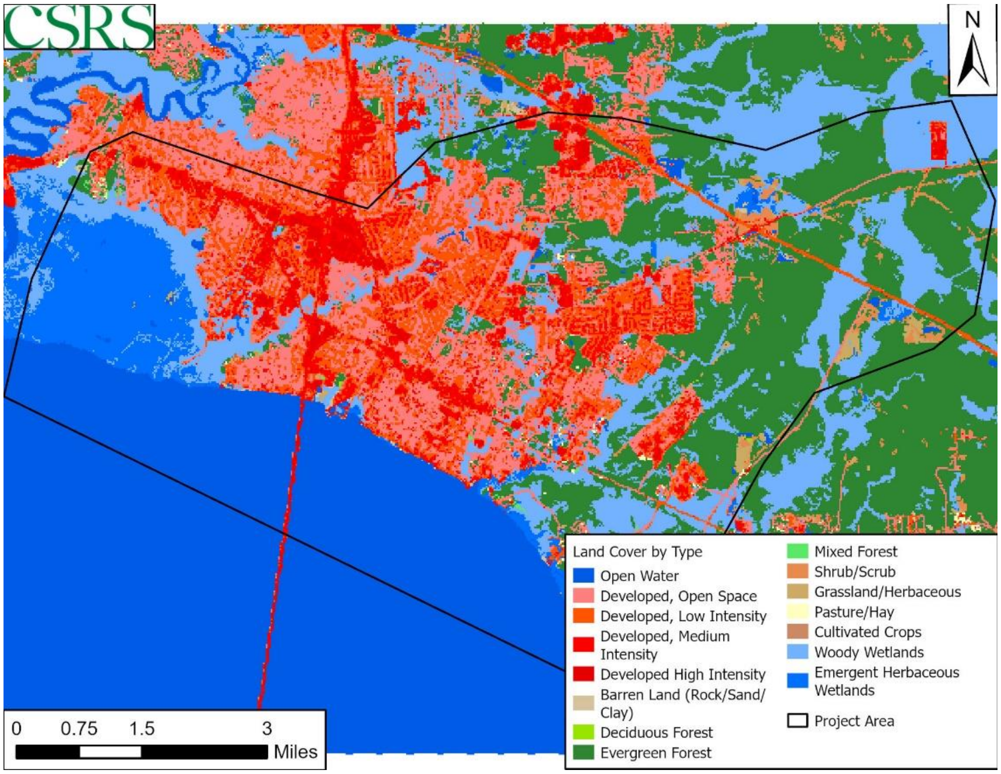


Figure 3-3: Landcover Mapping Layer

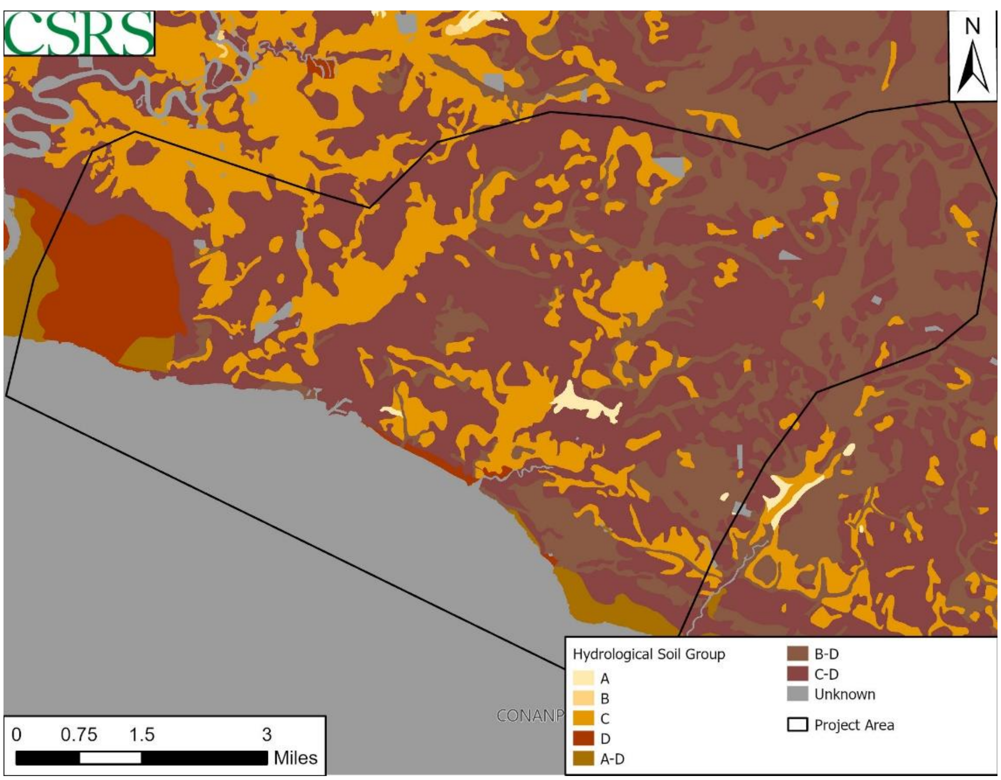


Figure 3-4: Soils Mapping Layer

3.3.3. Infiltration Layer

The infiltration layer was created in RAS Mapper using the SCS Curve Number infiltration method. The soils layer and land cover layer were referenced when creating the infiltration layer. Curve numbers were defined based on HEC-RAS official documentation which is shown in Attachment A. Figure 3-5 shows the infiltration layer.

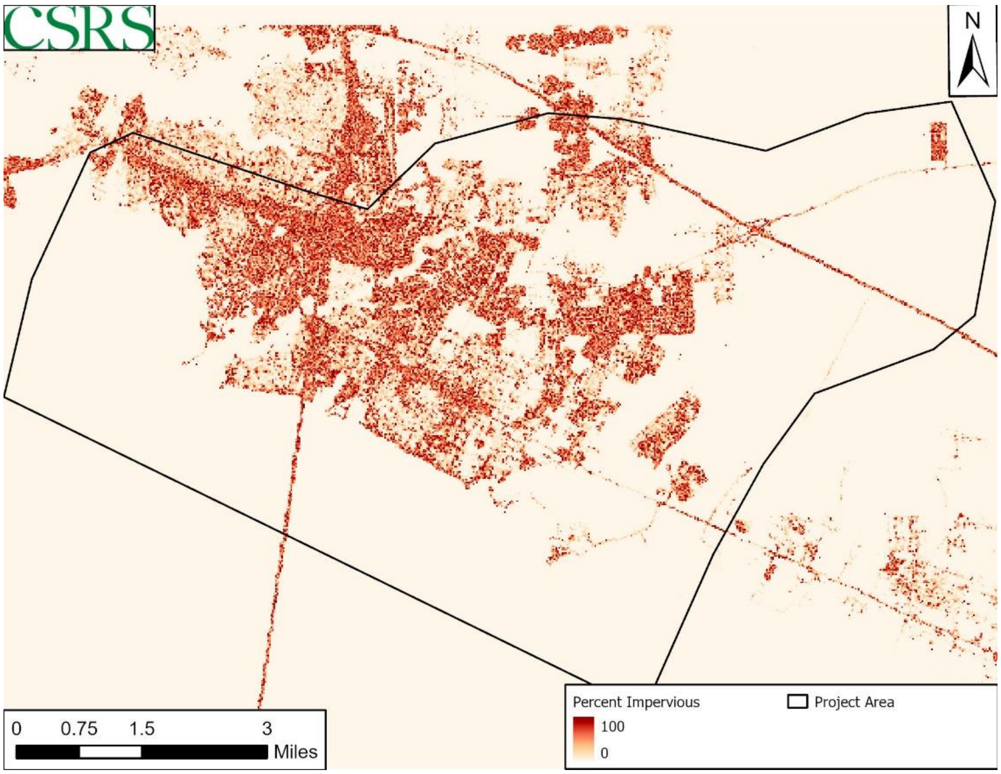


Figure 3-5: Infiltration Mapping

3.3.4. Manning's Roughness Layer

Manning's roughness (n) values were defined for the 2-D flow area with the land cover layer based on the middle range recommended values in the HEC-RAS 2-D User's Manual. This established the base values to be used during calculations. Table 3-1 shows the Manning's n values used.

Table 3-1: Manning's n Values

Code Value	Land Cover Classification (NLCD)	Manning's n-value (roughness coefficient)	
		Overland Areas	Floodplain Areas
11	Open Water	0.056	0.03
21	Developed, Open Space	0.06	0.03
22	Developed, Low Intensity	0.135	0.03
23	Developed, Medium Intensity	0.18	0.06
24	Developed, High Intensity	0.24	0.045
31	Barren Land	0.040	0.038
41	Deciduous Forest	0.225	0.06
42	Evergreen Forest	0.18	0.03
43	Mixed Forest	0.21	0.075
52	Shrub/Scrub	0.173	0.034
71	Grassland/Herbaceous	0.394	0.03
81	Pasture/Hay	0.394	0.09
82	Cultivated Crops	0.39	0.053
90	Woody Wetlands	0.146	0.03
95	Emergent Herbaceous Wetlands	0.101	0.06

3.4. Computation Methods

The HEC-RAS model used the diffusive wave (DW) equation set to perform hydraulic calculations. Both the DW and Full Momentum (FM) equation sets were evaluated to assess the performance and accuracy. It was concluded that using the FM equations is not necessary for Mandeville project area because the DW equations produce comparable results with significantly shorter run times.

3.5. Boundary Conditions

Boundary conditions were used to define the edges of the 2-D mesh. The upper boundary condition was defined using normal depth that was calculated using the average land slope at the edge of the basin. The downstream boundary condition was defined using a stage hydrograph that was changed depending on the return interval of the storm surge. For simulations without a storm surge, the downstream boundary was set at mean high tide for Lake Pontchartrain and did not change throughout the simulations.

Rain-on-Grid precipitation was used to simulate rainfall in the model. The method was defined differently for the simulation events and the historical events. Table 3-1 shows the rainfall depth used for the simulation events. Table 3-1 also shows the peak water elevation for the downstream boundary in Lake Pontchartrain.

Table 3-1: Hydrologic and Hydraulic Input Data

Simulation Description	Rainfall Depth (inches)	Peak Water Elevation of Downstream Boundary (ft NAVD88 G12B)
100-year 6hr, Q1P10	9.67	1.31
10-year 12hr, Q1P10	6.66	1.31
100-Year 12hr, Q1P10	11.1	1.31
5-Year 24hr, Q4P90	6.58	1.31
10-year 24hr, Q4P90	7.84	1.31
25-year 24hr, Q4P90	9.77	1.31
50-year 24hr, Q4P90	11.40	1.31
100-year 24hr, Q4P90	13.20	1.31
200-year 24hr, Q4P90	15.10	1.31
500-year 24hr, Q4P90	17.80	1.31
10-year 24hr, Q4P90 w/ 10-year Storm Surge	7.84	6.26
100-year 24hr, Q4P90 w/ 50-year Storm Surge	11.40	8.46
100-year 24hr, Q4P90 w/ 100-year Storm Surge	13.20	9.4
100-year Storm Surge Only	None	9.4
10-year 24hr, Q4P90 w/ Lower SLR	7.84	2.95
100-year 24hr, Q4P90 w/ Lower SLR	13.20	2.95
10-year 24hr, Q4P90 w/ Higher SLR	7.84	3.84
100-year 24hr, Q4P90 w/ Higher SLR	13.20	3.84

3.6. Calibration

The model was then calibrated to a recent historical event where data was available. The data for the event was obtained from the July 20th, 2022, event, which resulted in 11" of rainfall. The historical event simulation was 28 days long allowing the model area to become inundated during the event and completely drain after the event. Photographs of historic flooding were used to estimate high water elevations. Examples of photographs used to estimate WSE are Figure 3-6 and 3-7. The model results were compared to these elevations.

Figure 3-6: Flooding at Florida Street

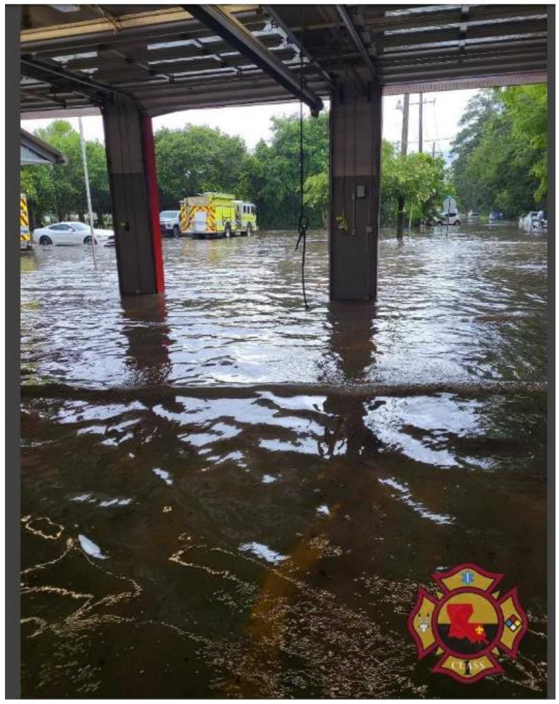


Figure 3-7: Flooding at Girard Street Fire Station

Adjustments were made to the model geometry based on the comparison to maximize model accuracy.

4. Existing Flood Risk Assessment

4.1. Critical Duration Analysis

A critical duration analysis was performed to identify which storm duration produced the greatest flood risk throughout the model. The 6-hour, 12-hour, and 24-hour duration 10-year and 100-year storm events were simulated. Figure 4-1 shows the analysis of the results, which revealed that the 24-hour duration event produced the greatest flood risk and as such, this duration was used for all event simulations.

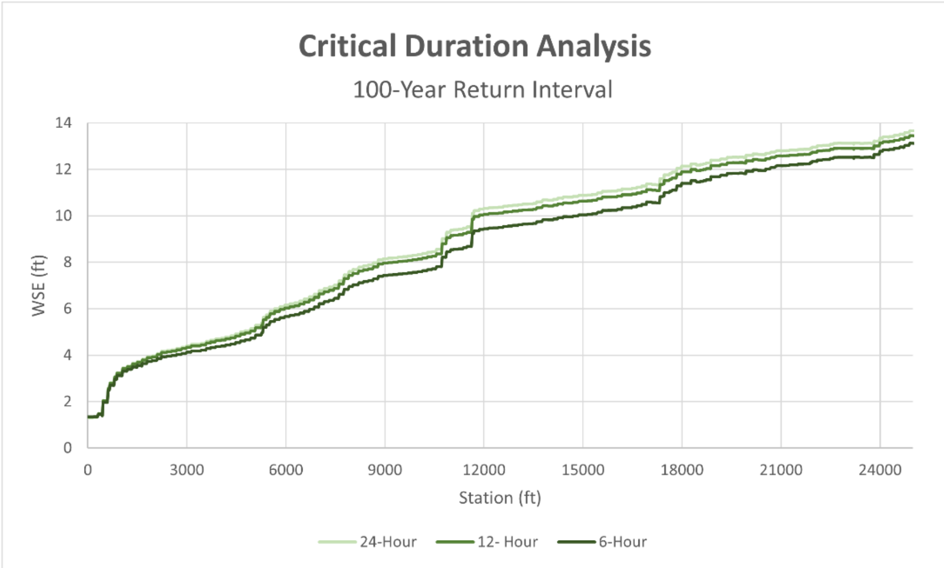


Figure 4-1: Critical Duration Analysis for 100-Year Return Interval

4.2. Storm Surge, Rainfall and Transition Zone

Structures found in transition zones are subject to increased risk due to the combination of storm surge/high-tide and rainfall. The transition zone was analyzed using three iterations of the 100-year storm: the 100-year storm surge only, 100-year rainfall with no storm surge, and the 100-year rainfall with storm surge. Figure 4-2 shows the staining that was used to estimate the transition zones. Figure 4-1, Figure 4-2, and Figure 4-3 show the regions where the peak water surface elevations of the events mentioned above with increased risk of flooding during a combined rainfall and storm surge event.

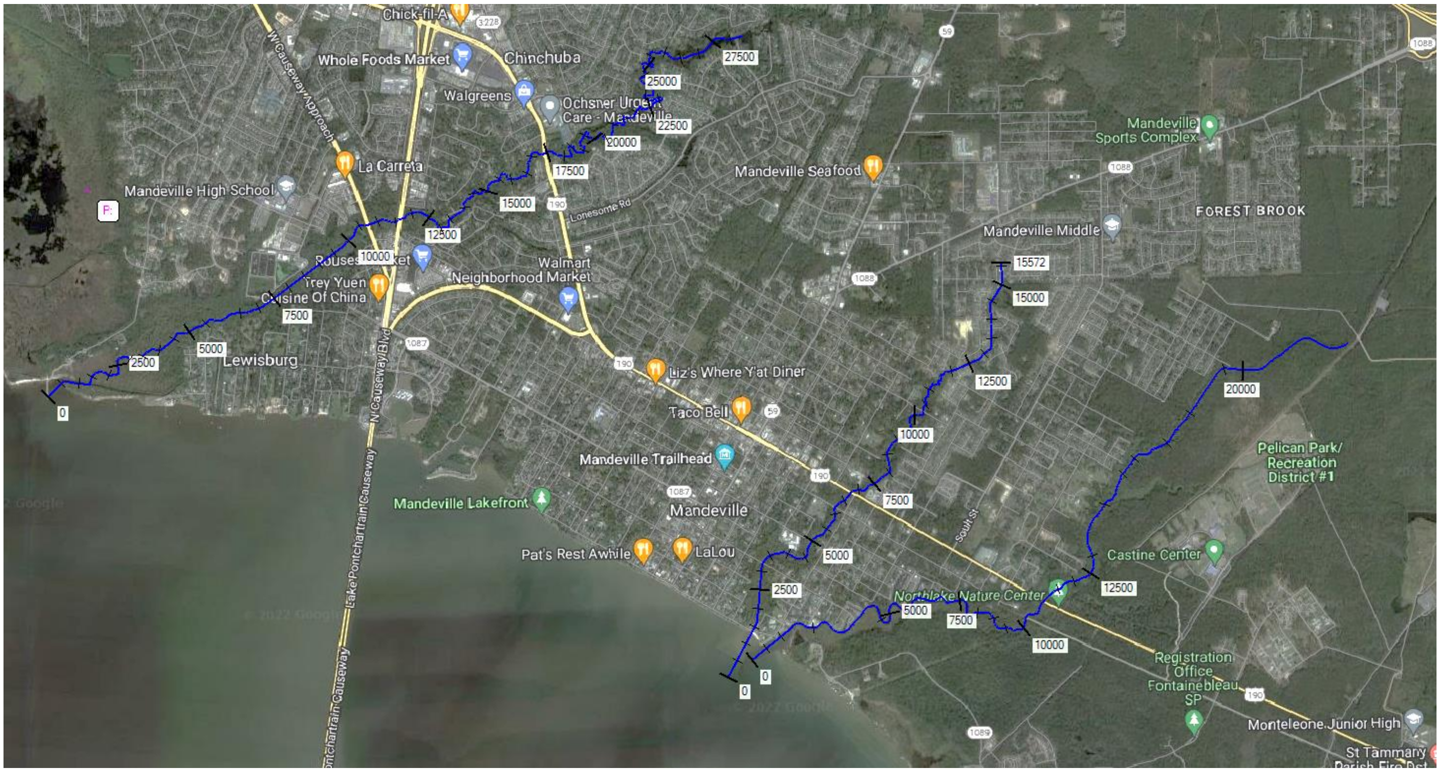


Figure 4-2: River Stationing (ft)

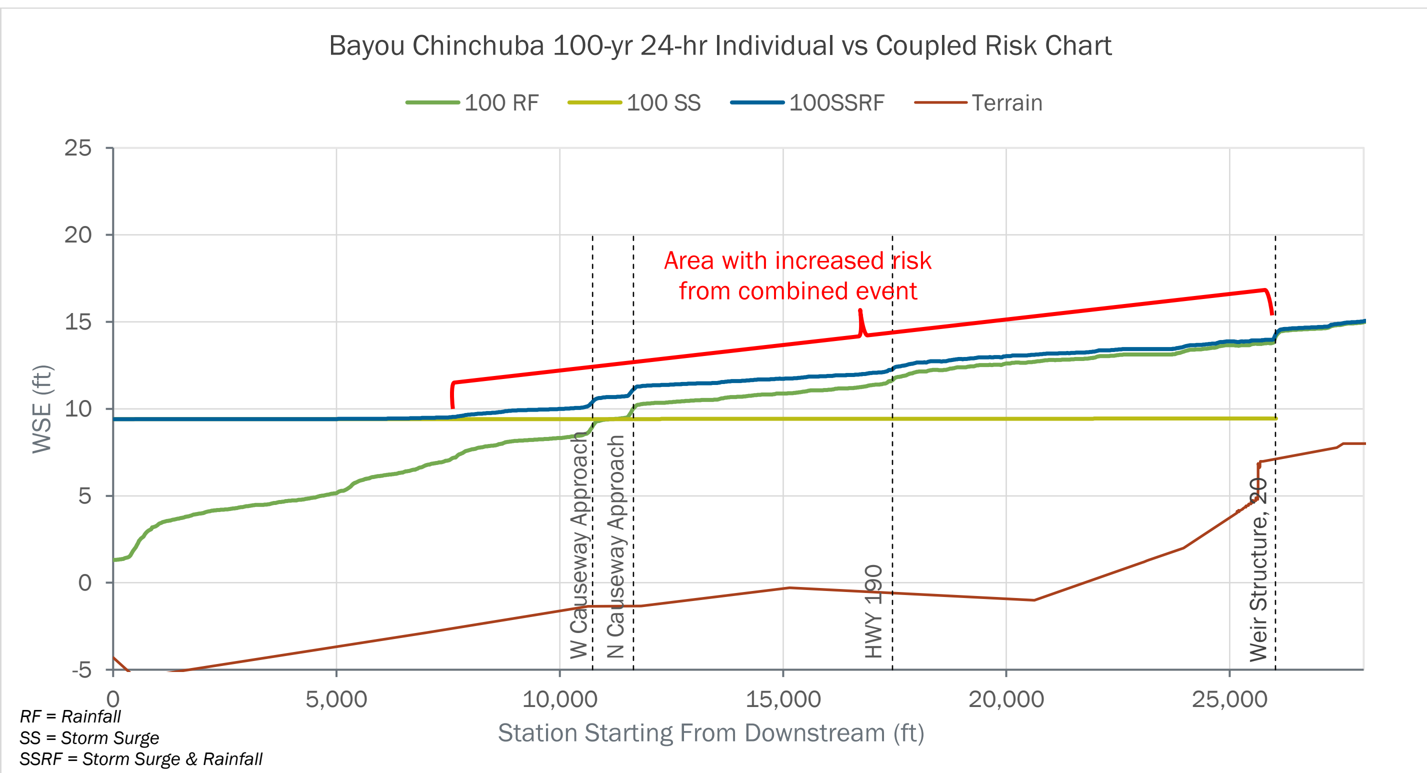


Figure 4-1: Coupled Risk in Bayou Chinchuba

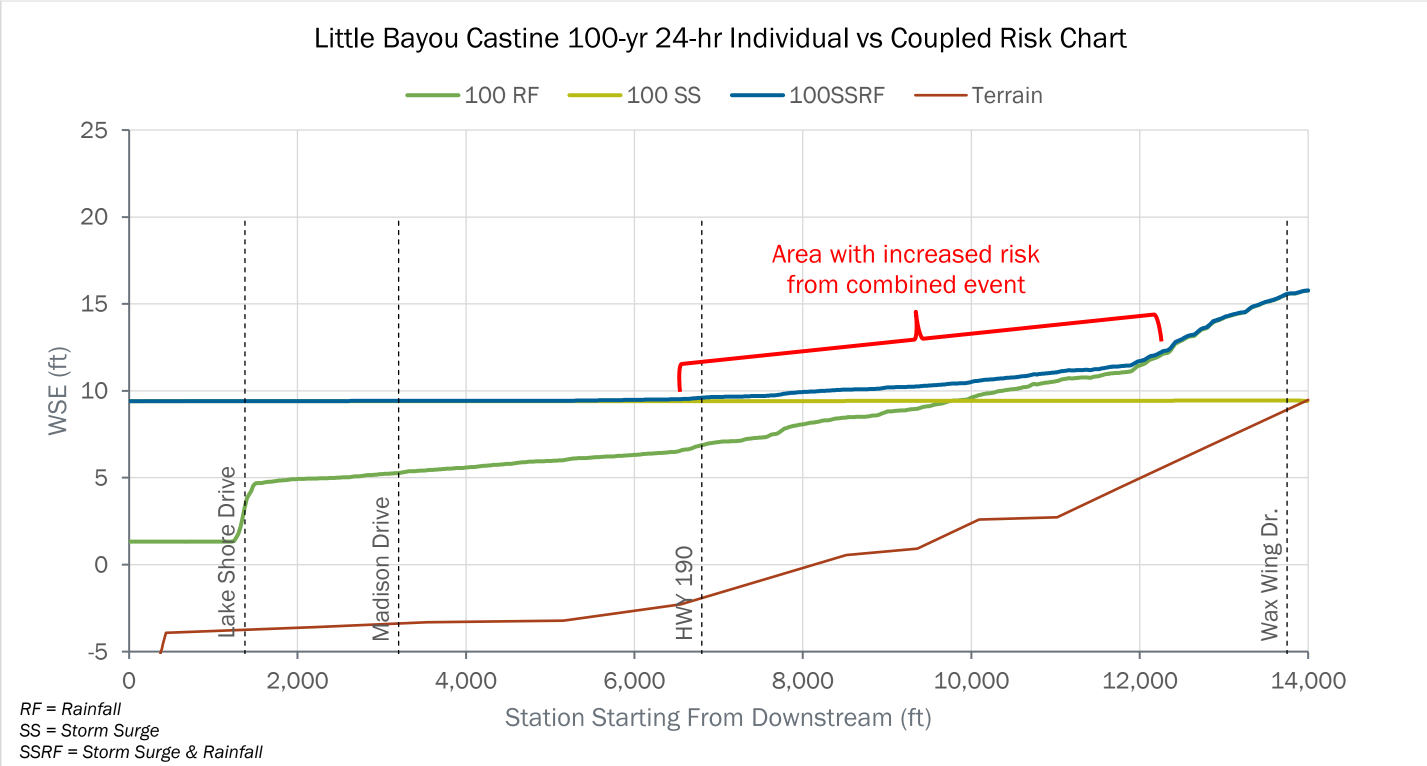


Figure 4-2: Coupled Risk in Little Bayou Castine

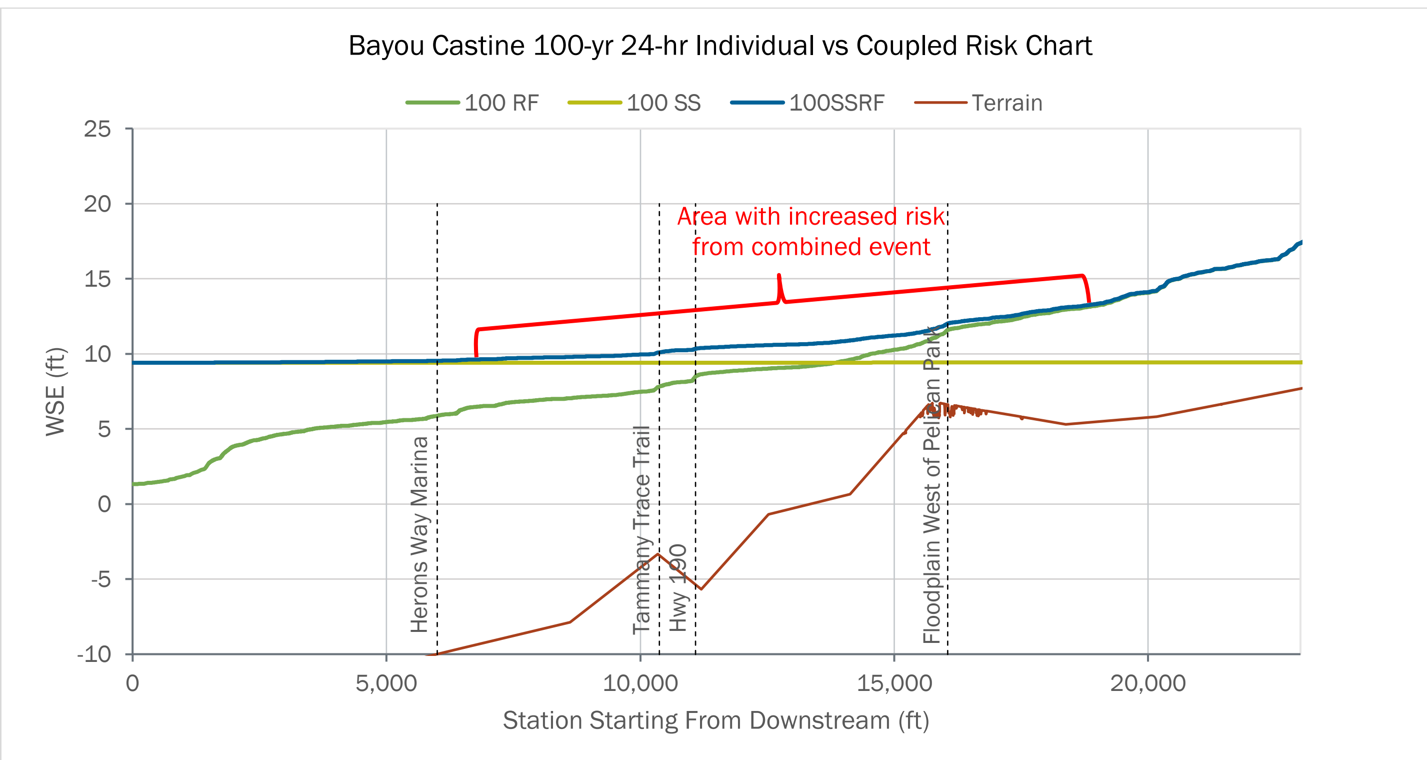


Figure 4-3: Coupled Risk in Bayou Castine

4.3. Varying Peak Rainfall and Storm Surge Analysis

Varying the time to peak rainfall compared to the time to peak storm surge can impact the max water surface elevation (WSE). The maximum WSE was identified by adjusting the rainfall peak times with respect to the peak time of the storm surge for the 100-year 24-hour rainfall and 100-year storm surge simulation. Figure 4-4, Figure 4-5, and Figure 4-6 show the results of hydrographs at three locations to compare the resulting WSE's. The simulations suggest that the highest flood levels occur when the peak rainfall happens approximately two hours after the peak storm surge.

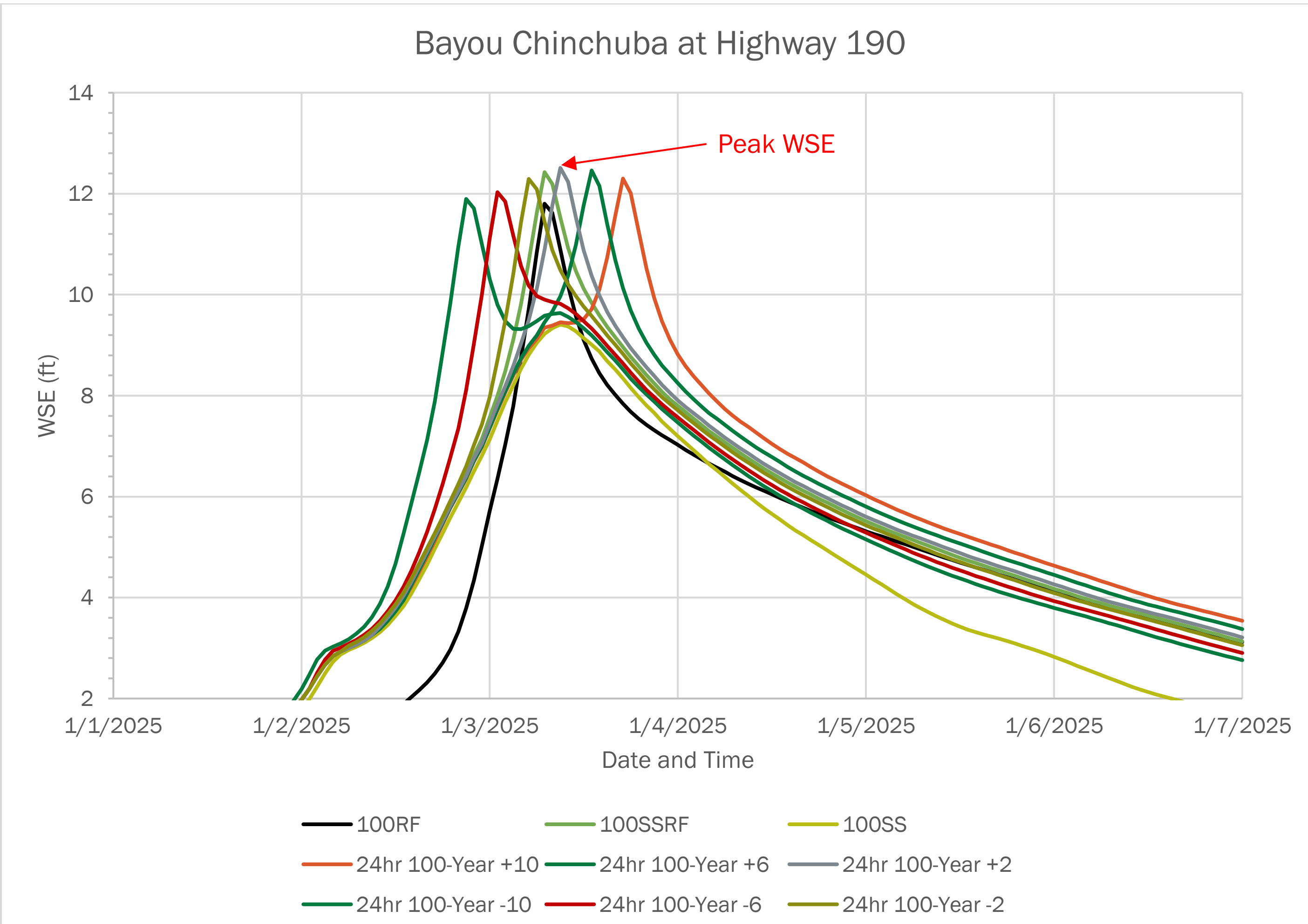


Figure 4-4: Analysis of Peak WSE with varying time of peak Rainfall for Bayou Chinchuba at Highway 190

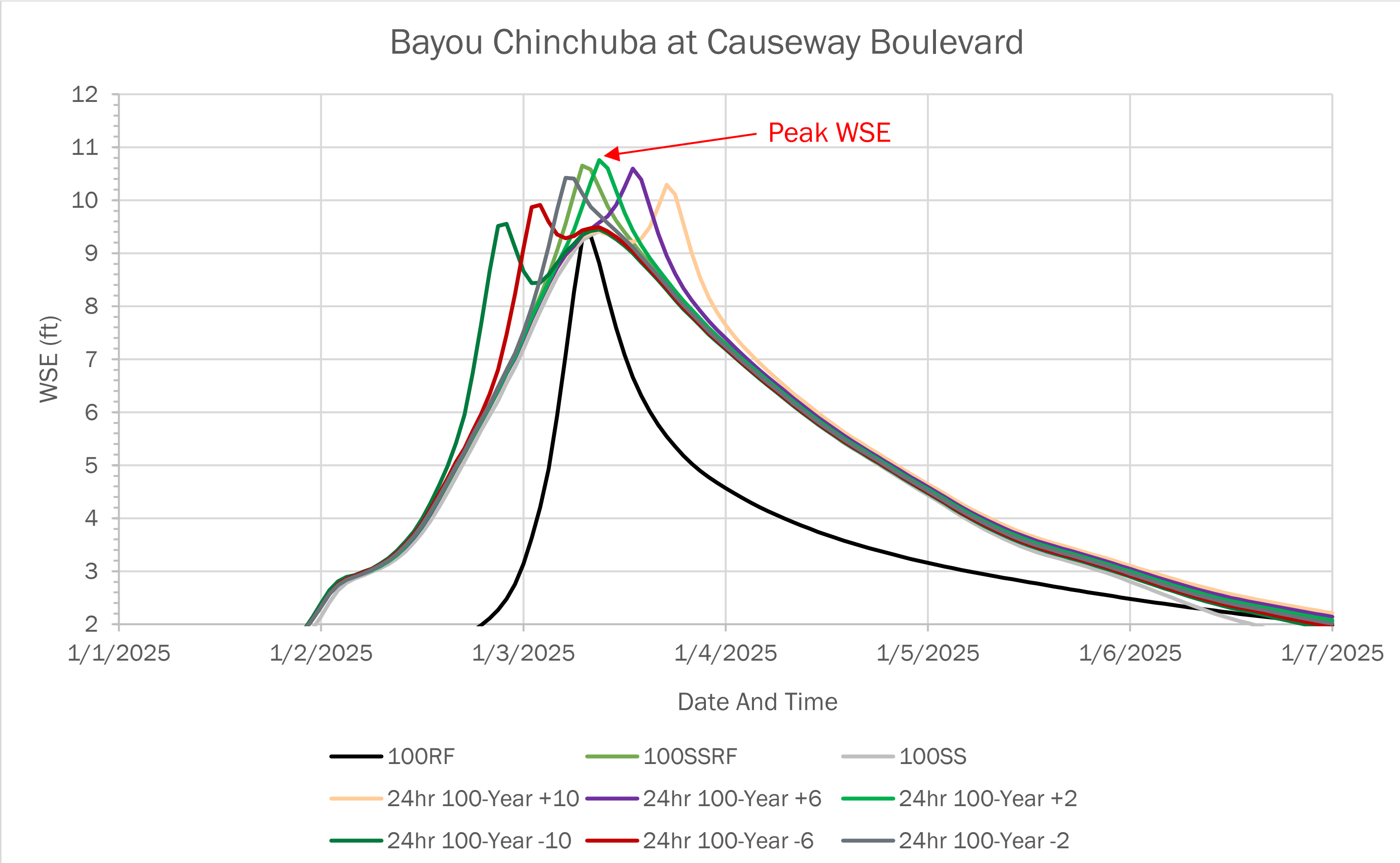


Figure 4-5:Analysis of Peak WSE with varying time of peak Rainfall for Bayou Chinchuba at Causeway Blvd.

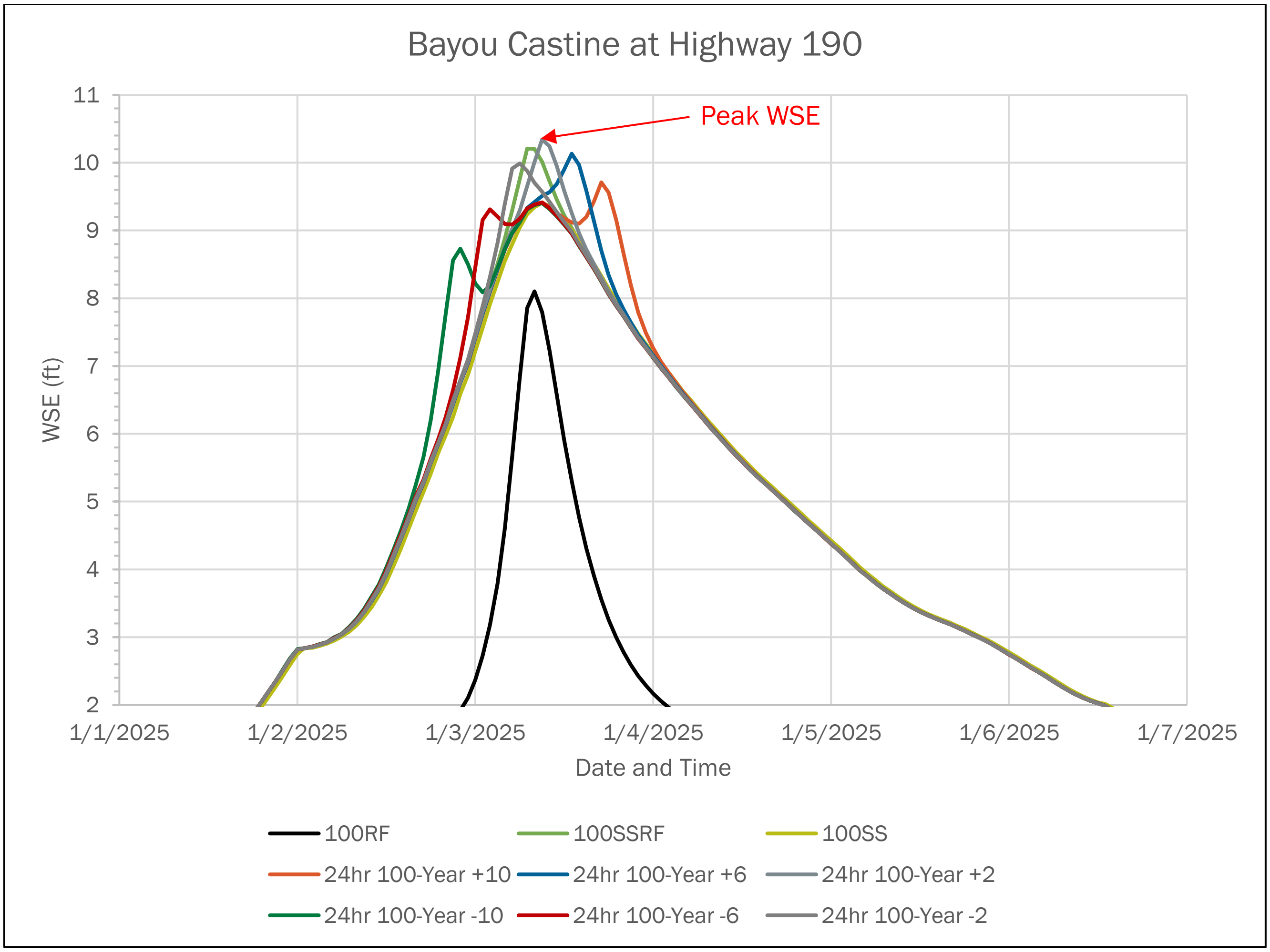


Figure 4-6: Analysis of Peak WSE with varying time of peak Rainfall for Bayou Castine at Highway 190

5. Flood Risk Reduction Concepts

5.1. Introduction

Based on the existing conditions model results and discussions with Mandeville and the planning team for Mandeville's Flood Resilience Strategy, four mitigation concepts were proposed to reduce flood risk in the project area.

1) A non-structural program that attempts to mitigate structures at risk in the city by elevating them
2) A regional detention area that would increase floodplain storage in the northern reaches of Bayou Chinchuba
3) A city-wide green infrastructure plan that would take city owned properties and convert them into stormwater parks or other green infrastructure components to store rainfall runoff
4) A channel improvement effort for Ravine aux Coquilles which would increase capacity of the ravine

Mitigation concepts 2 through 4 are projected to improve surface water conveyance and increase storm water storage in the city resulting in decreased flood risk. Each mitigation concept is explained below in more detail.

5.2. Structure Elevations

Raising the foundation of a structure reduces or eliminates property damage due to high water events. The goal of this mitigation concept analysis was to evaluate the potential flood risk of the structures in Mandeville and establish elevations that structures should be raised above. The criteria used to evaluate the residential structures was the first-floor elevations (FFE) of structures and storm surge elevations. The analysis was performed for the current (2022) and projected (2080) storm surge elevations. Storm surge elevations for 2080 were estimated by adding sea-level rise projections from the Coastal Protection and Restoration Authority's Louisiana Coastal Master Plan to current storm surge elevations for each return interval. The Louisiana Coastal Master Plan provides a lower and higher scenario corresponding to a rise of 1.64 ft (0.5 meters) and 2.53 ft (0.77 meters), respectively, by 2080. The lower scenario was used for this analysis. Figure 5-1 shows a comparison of first-floor elevation to storm surge. Figure 5-2 shows the impact of sea-level rise on the percent of flooded structures.

Table 5-1 shows the number of structures flooded in the project area based on FFE. Using the estimated flooded structures for both 2022 and 2080 a high-level damage assessment was completed to evaluate the monetary impact of each storm surge alternative to the city. Table 5-2 shows the estimated dollar amount of damages.

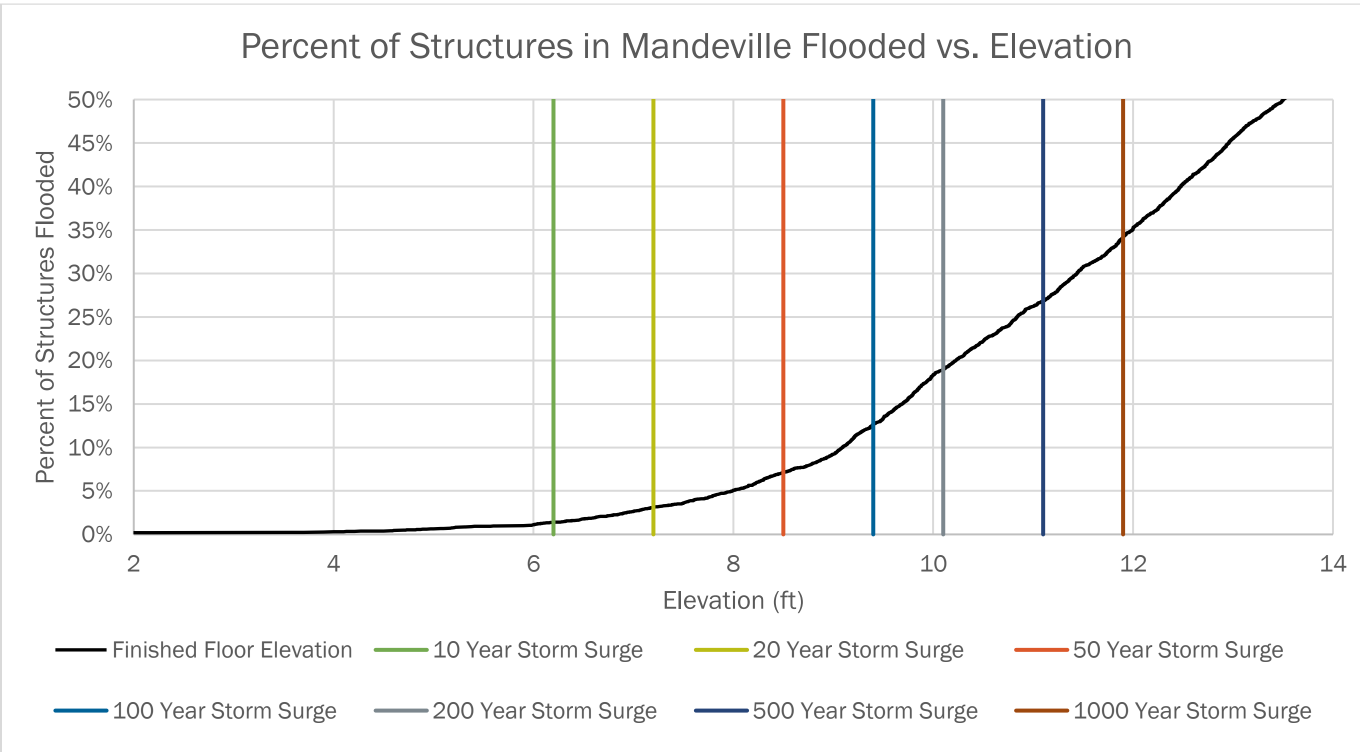


Figure 5-1: Percent of Structures Estimated to Flood for Existing (2022) Storm Surge Return Intervals

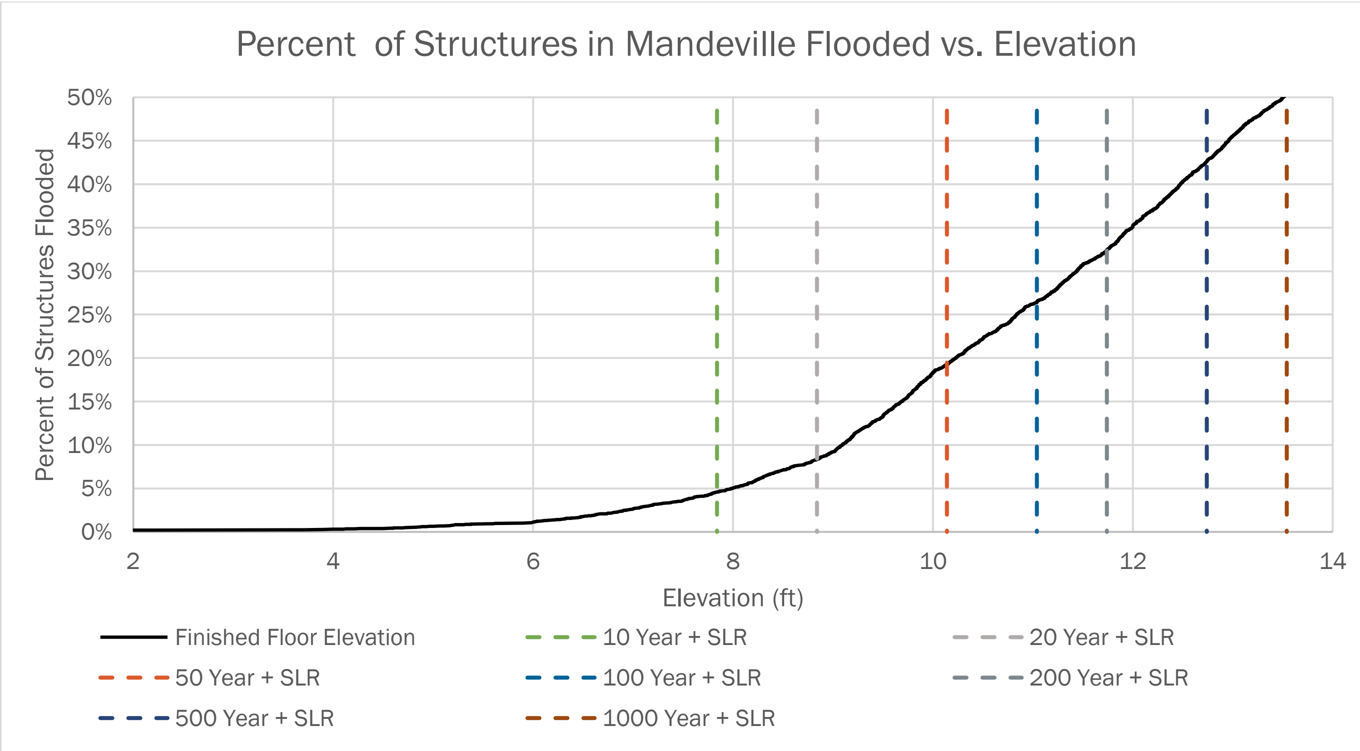


Figure 5-2: Percent of Structures Estimated to Flood for Storm Surge Return Intervals plus 2080 Sea-Level Rise

Table 5-1: Estimated Flooded Structures per Storm Surge Return Interval

Storm Surge Return Period	10-Year	20-Year	50-Year	100-Year	200-Year	500-Year	1000-Year
Estimated Flooded Structures Count 2022	77	173	403	715	1073	1519	1933
Estimated Flooded Structures Count 2080	260	472	1092	1496	1835	2413	2856

Table 5-2: Estimated Damages in Millions

Storm Surge Return Period	10-Year	20-Year	50-Year	100-Year	200-Year	500-Year	1000-Year
Estimated Damages ($Mill) 2022	$30	$70	$150	$270	$400	$570	$730
Estimated Damages ($Mill) 2080	$100	$180	$410	$560	$690	$910	$1,070

5.3. Regional Detention

The second mitigation concept was a regional detention area. Concern was raised by Mandeville that development in the forested area northeast of Interstate 12 (I-12) might have a negative impact on drainage further downstream in the watershed resulting in an increase in water surface elevations for the city. A location south of I-12 was modeled as a regional detention basin to mitigate potential structural and nuisance flooding from the potential development. Figure 5-3 shows the selected location for the regional detention basin and figure 5-4 shows the area that was modeled as residential. The model included terrain edits to simulate the detention basin and curve number value adjustments to simulate increases in impervious areas northeast of I-12. It was concluded that the development north of I-12 would have a minimal impact on the increasing flood risk south of I-12 because of the existing conveyance under I-12. Changes in the 10-, 25-, and 100-Year peak water surface elevations (WSE) between the existing conditions and mitigation concept are shown in Figure 5-4, Figure 5-5, and Figure 5-6, respectively. The simulations identify that a regional detention area would lower peak WSE's in Bayou Chinchuba resulting in a reduction in structure and nuisance flooding in the surrounding area of Bayou Chinchuba.

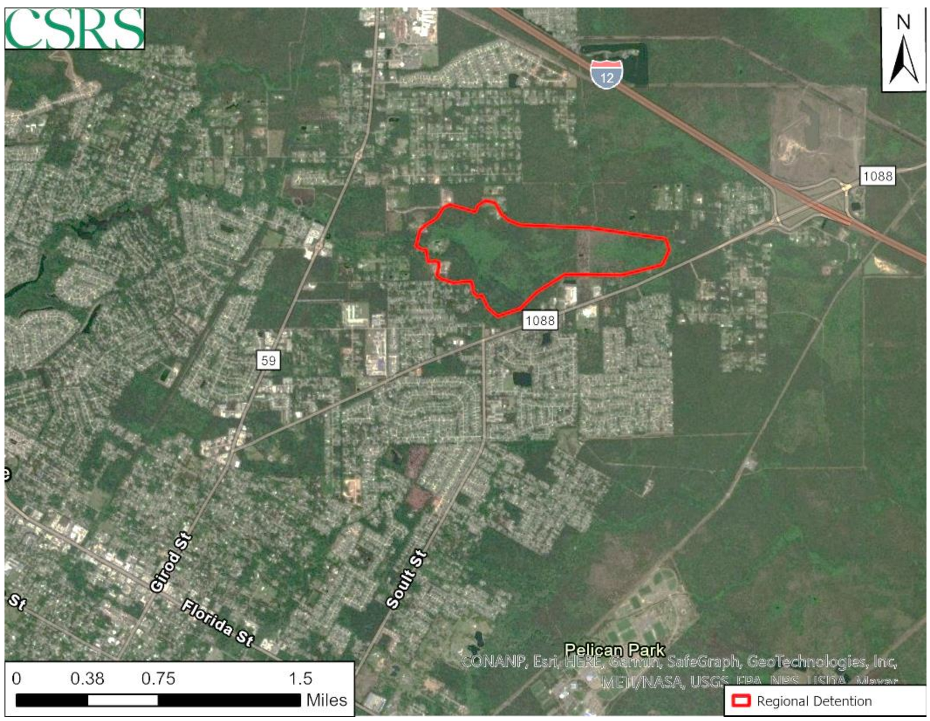


Figure 5-3: Regional Detention Basin Mitigation Concept

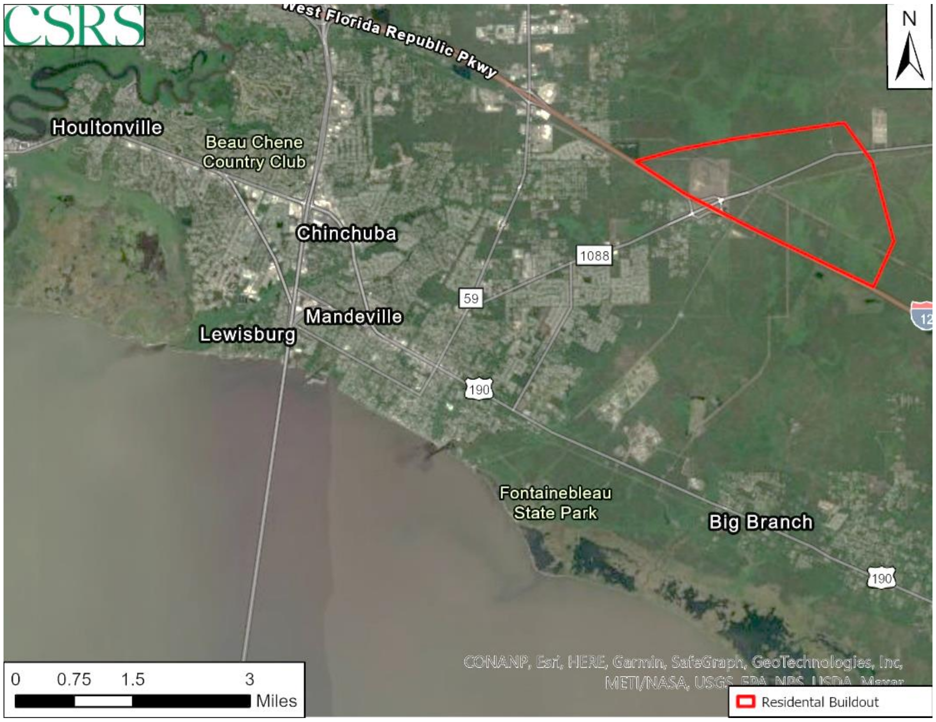


Figure 5-4: Modeled Residential Buildout

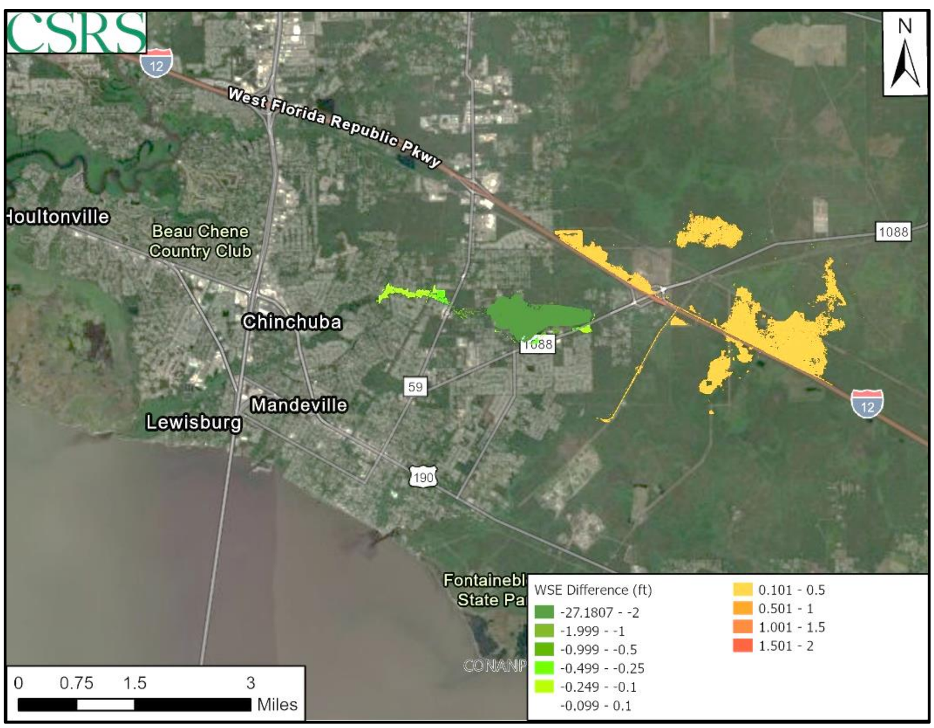


Figure 5-4: 10-Year WSE Difference for Regional Detention Basin Mitigation Concept

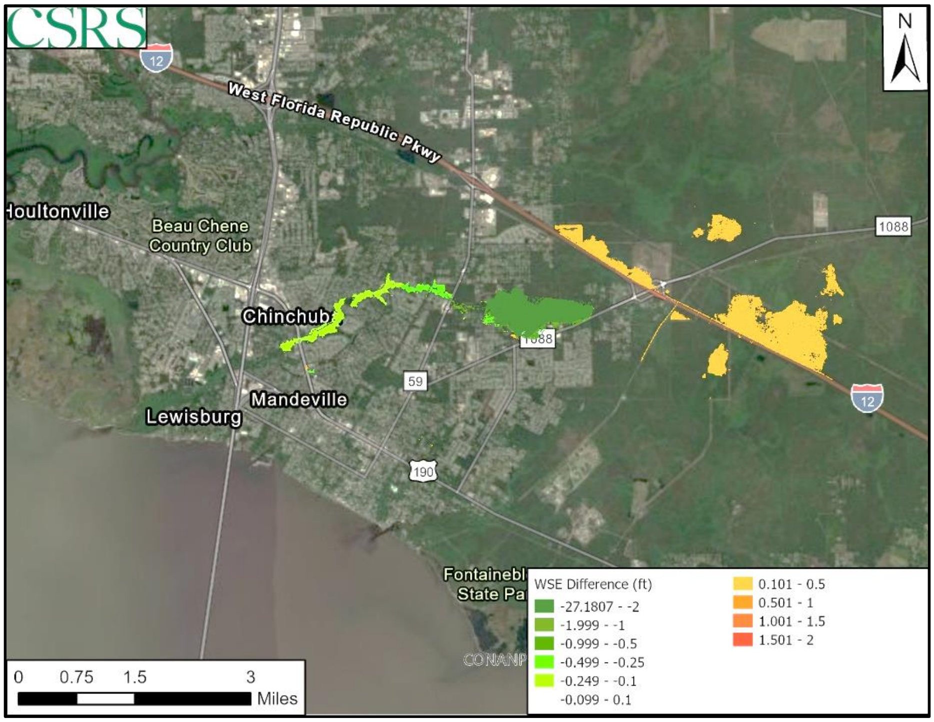


Figure 5-5: 25-Year WSE Difference for Regional Detention Basin Mitigation Concept

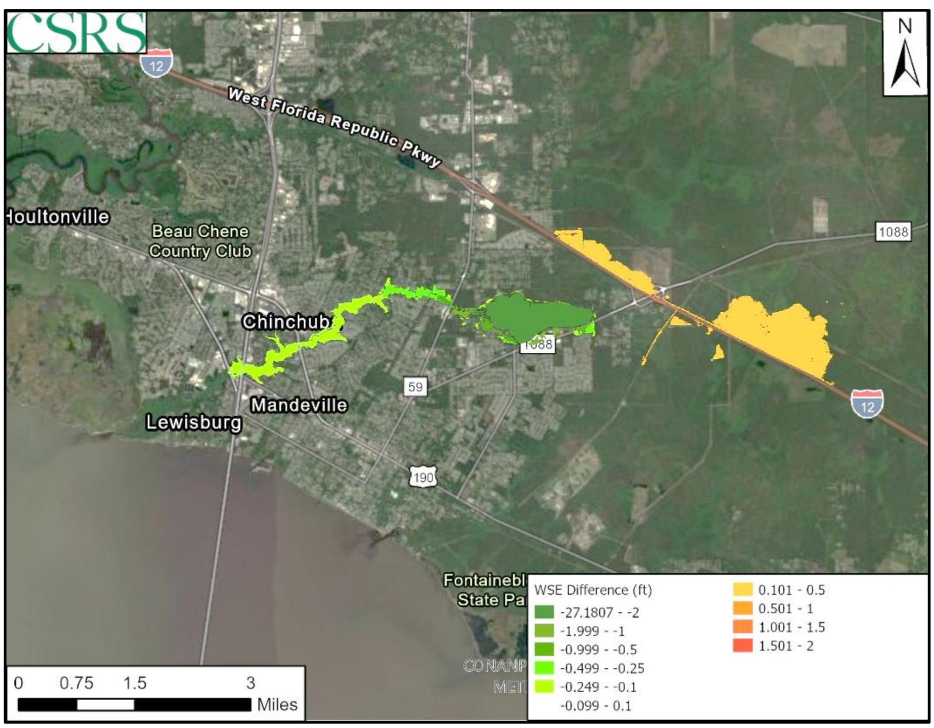


Figure 5-6: 100-Year WSE Difference for Regional Detention Basin Mitigation Concept

5.4. Green Infrastructure Mitigation Concept

The third mitigation concept that was evaluated was the implementation of storm water parks throughout the city. Storm water parks are designed to integrate functional drainage with public use spaces resulting is increased storm water storage. Storm water park locations were selected based on city owned parcels that could be readily adapted. The increase in storage for each area was simulated by lowering the model terrain. Figure 5-7 shows the location of all the areas that were used to be modeled storm water parks. Figure 5-8, Figure 5-9, and Figure 5-10 show the resulting difference in WSE for the 10-, 25- , and 100-year rainfall events, respectively. The simulations identify that effective implementation of storm water parks would increase the amount of storm water storage available in the project area resulting in a decrease in WSE in areas near the storm water parks. The decrease in WSE would result in a decrease in nuisance flooding for Mandeville.

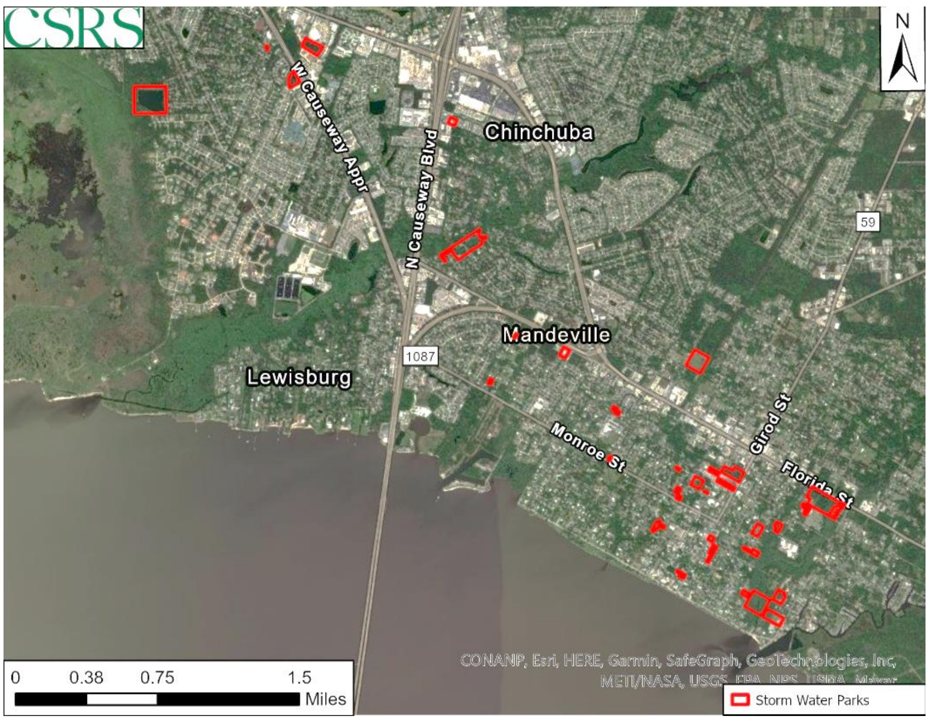


Figure 5-7: Storm Water Park Mitigation Concept Locations

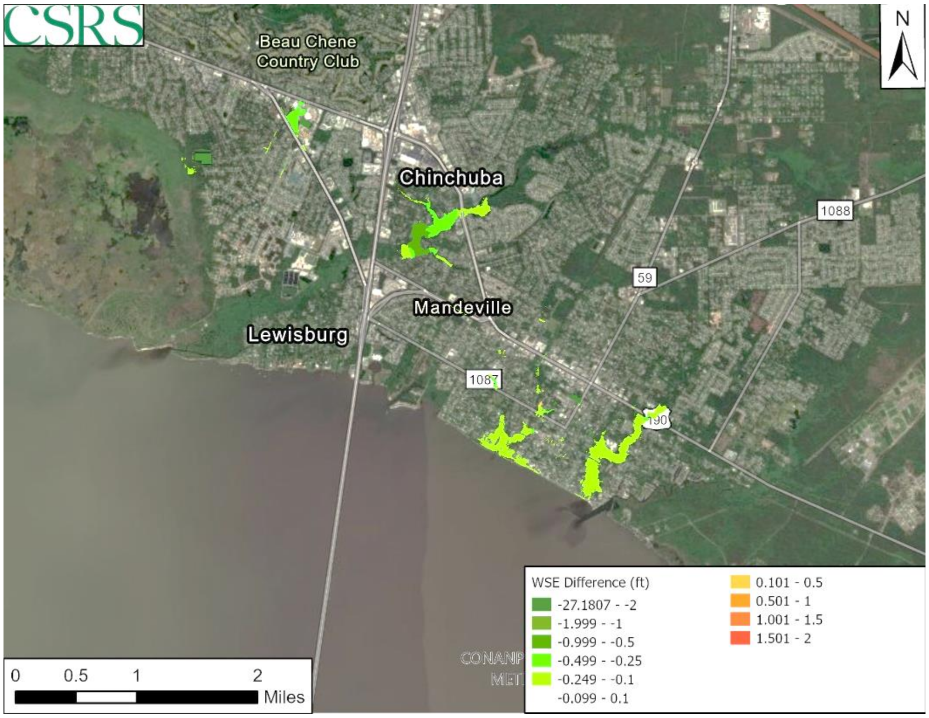


Figure 5-8: 10-Year WSE Difference for Storm Water Park Mitigation Concept

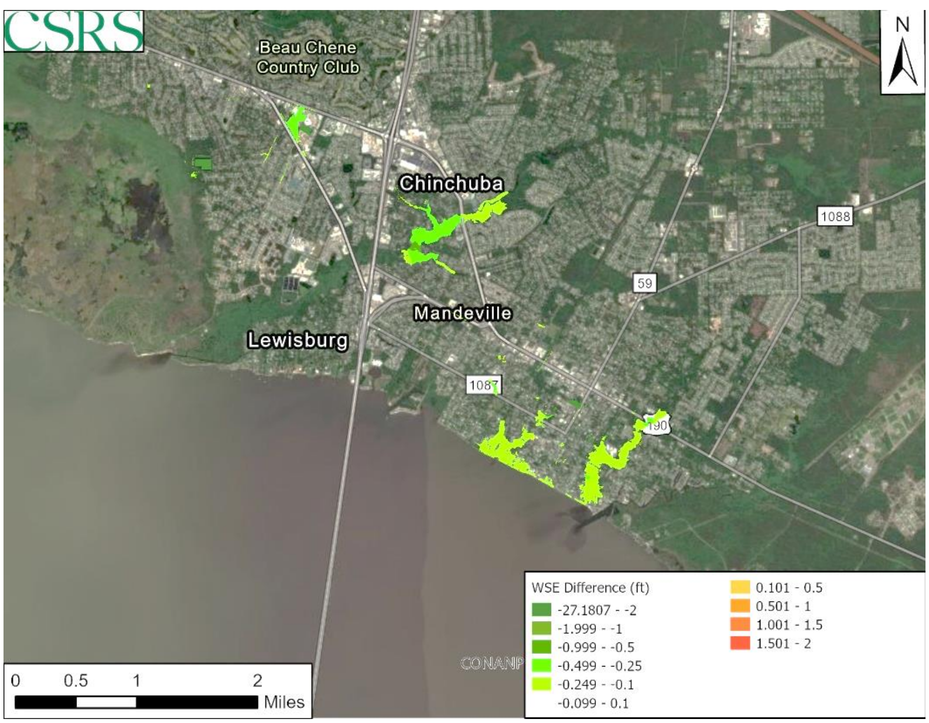


Figure 5-9: 25-Year WSE Difference for Storm Water Park Mitigation Concept

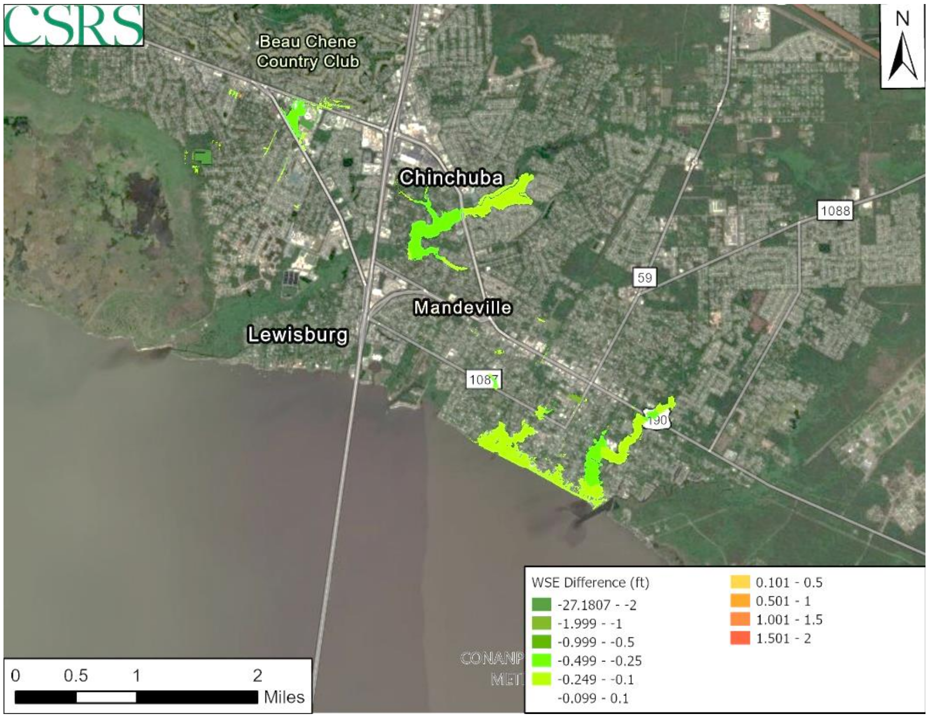


Figure 5-10: 100-Year WSE Difference for Storm Water Park Mitigation Concept

5.5. Ravine aux Coquille Improvements

The final mitigation concept is Ravine aux Coquille Improvements. The project proposes widening both branches of the ravine to hold the estimated 25-year flow rate within the banks and a gate structure at the outfall of the ravine to prevent backflow from Lake Ponchatrain during high-water events. The combination of channel widening, and gate would allow for more storage in the channel during large events and would assist in mitigating the immediate impact of high tide and minor storm surge decreasing the impact of nuisance flooding and low-lying structural flooding in the immediate area. Figure 5-11 shows location of the mitigation concept channel widening concept. The simulations suggest that widening Ravine Au Coquille would lower the peak WSE in and near the channel. Figure 5-12, Figure 5-13, and Figure 5-14 shows the WSE difference for the basin for the 10-, 25-, and 100-year storm.

Figure 5-11: Channel Improvement Mitigation Concept

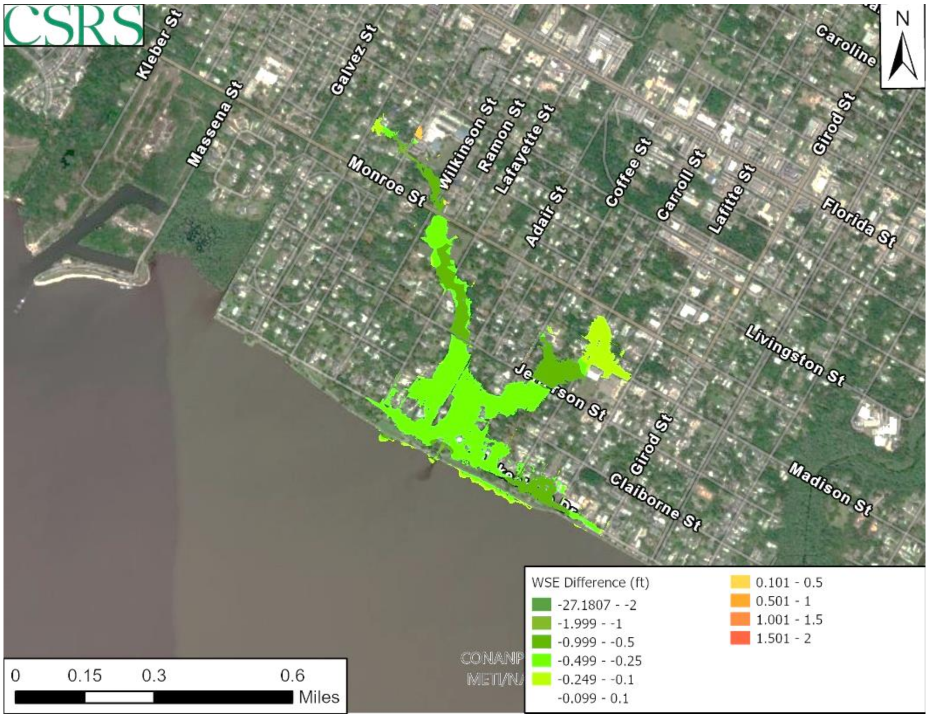


Figure 5-12: 10-Year WSE Difference for Channel Improvement Mitigation Concept

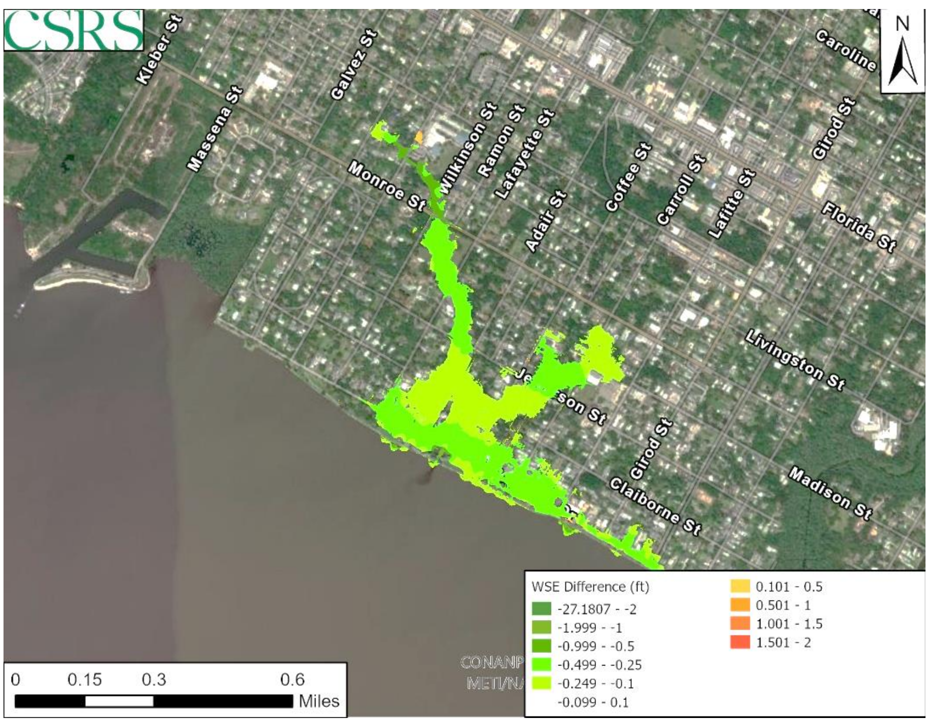


Figure 5-13: 25-Year WSE Difference for Channel Improvement Mitigation Concept

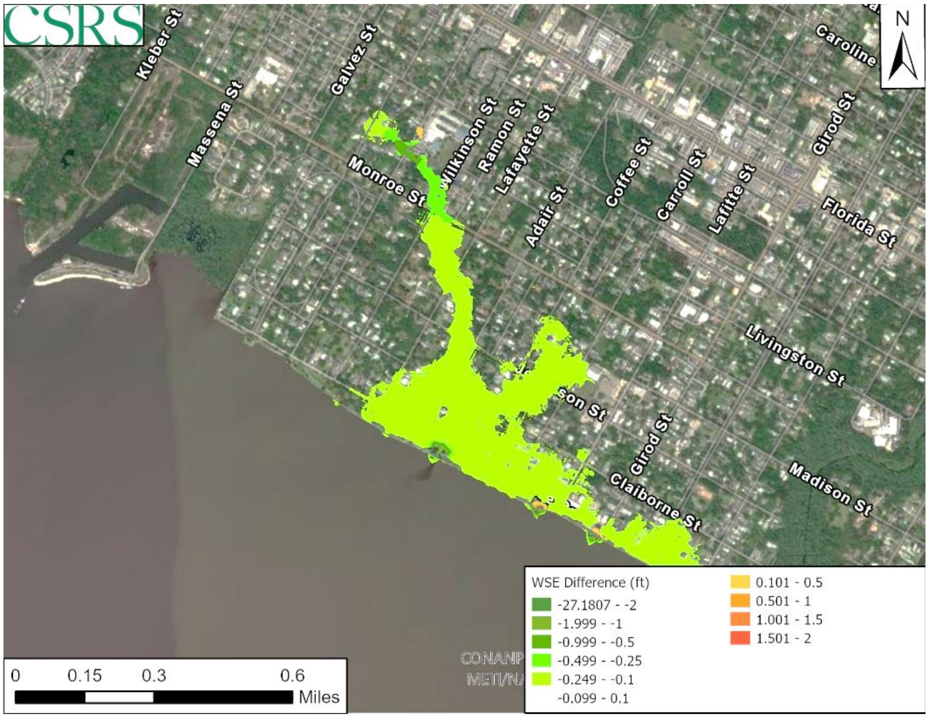


Figure 5-14: 100-Year WSE Difference for Channel Improvement Mitigation Concept

6. Conclusion

This report presents the results of a planning level flood modeling assessment of Mandeville. The purpose of this assessment was to identify mitigation concepts to decrease the impact of flood water during large rainfall and storm surge events. A planning-level HEC-RAS 2-D hydrologic and hydraulic model of existing conditions was developed for Mandeville and area draining through it. The hydrologic and hydraulic model is a planning-level tool Mandeville can utilize to assess drainage patterns in the city and guide further adaptation strategies. Not all drainage structures were simulated for this planning level analysis, therefore, deficiencies may exist within the city drainage system which are not described here. The mitigation concepts included structure elevation, regional detention, stormwater parks/green infrastructure, and improvement of the Ravine aux Coquilles. Mitigation concepts were assessed by modifying the existing conditions model and comparing simulation results. This analysis projects that the mitigation concepts would reduce flood risk in Mandeville for present and future conditions.

Attachment A: Curve Number Table

Land Cover Type and Soil Type	Curve Number
Woody Wetlands: No Data	100
Woody Wetlands: C-D	100
Woody Wetlands: C	100
Woody Wetlands: D	100
Woody Wetlands: (none)	100
Woody Wetlands: B-D	100
Woody Wetlands: B	100
Woody Wetlands: A	100
Woody Wetlands: A-D	100
Evergreen Forest: No Data	80
Evergreen Forest: C-D	77
Evergreen Forest: C	73
Evergreen Forest: D	80
Evergreen Forest: (none)	80
Evergreen Forest: B-D	69
Evergreen Forest: B	58
Evergreen Forest: A	58
Evergreen Forest: A-D	69
Developed, Open Space: No Data	80
Developed, Open Space: C-D	77
Developed, Open Space: C	74
Developed, Open Space: D	80
Developed, Open Space: (none)	80
Developed, Open Space: B-D	71
Developed, Open Space: B	61
Developed, Open Space: A	39
Developed, Open Space: A-D	60
Shrub-Scrub: No Data	77
Shrub-Scrub: C-D	74
Shrub-Scrub: C	70
Shrub-Scrub: D	77
Shrub-Scrub: (none)	77
Shrub-Scrub: B-D	67
Shrub-Scrub: B	56
Shrub-Scrub: A	35
Shrub-Scrub: A-D	56
Emergent Herbaceous Wetlands: No Data	100
Emergent Herbaceous Wetlands: C-D	100

Land Cover Type and Soil Type	Curve Number
Emergent Herbaceous Wetlands: C	100
Emergent Herbaceous Wetlands: D	100
Emergent Herbaceous Wetlands: (none)	100
Emergent Herbaceous Wetlands: B-D	100
Emergent Herbaceous Wetlands: B	100
Emergent Herbaceous Wetlands: A	100
Emergent Herbaceous Wetlands: A-D	100
Grassland-Herbaceous: No Data	93
Grassland-Herbaceous: C-D	87
Grassland-Herbaceous: C	81
Grassland-Herbaceous: D	93
Grassland-Herbaceous: (none)	93
Grassland-Herbaceous: B-D	82
Grassland-Herbaceous: B	71
Grassland-Herbaceous: A	71
Grassland-Herbaceous: A-D	82
Developed, Low Intensity: No Data	80
Developed, Low Intensity: C-D	77
Developed, Low Intensity: C	74
Developed, Low Intensity: D	80
Developed, Low Intensity: (none)	80
Developed, Low Intensity: B-D	71
Developed, Low Intensity: B	61
Developed, Low Intensity: A	39
Developed, Low Intensity: A-D	60
Developed, High Intensity: No Data	80
Developed, High Intensity: C-D	77
Developed, High Intensity: C	74
Developed, High Intensity: D	80
Developed, High Intensity: (none)	80
Developed, High Intensity: B-D	71
Developed, High Intensity: B	61
Developed, High Intensity: A	39
Developed, High Intensity: A-D	60
Developed, Medium Intensity: No Data	80
Developed, Medium Intensity: C-D	77
Developed, Medium Intensity: C	74

Land Cover Type and Soil Type	Curve Number
Developed, Medium Intensity: D	80
Developed, Medium Intensity: (none)	80
Developed, Medium Intensity: B-D	71
Developed, Medium Intensity: B	61
Developed, Medium Intensity: A	39
Developed, Medium Intensity: A-D	60
Deciduous Forest: No Data	63
Deciduous Forest: C-D	60
Deciduous Forest: C	57
Deciduous Forest: D	63
Deciduous Forest: (none)	63
Deciduous Forest: B-D	56
Deciduous Forest: B	48
Deciduous Forest: A	48
Deciduous Forest: A-D	56
Pasture-Hay: No Data	84
Pasture-Hay: C-D	82
Pasture-Hay: C	79
Pasture-Hay: D	84
Pasture-Hay: (none)	84
Pasture-Hay: B-D	77
Pasture-Hay: B	69
Pasture-Hay: A	49
Pasture-Hay: A-D	67
Open Water: No Data	100
Open Water: C-D	100
Open Water: C	100
Open Water: D	100
Open Water: (none)	100
Open Water: B-D	100
Open Water: B	100
Open Water: A	100
Open Water: A-D	100
Cultivated Crops: No Data	89
Cultivated Crops: C-D	87
Cultivated Crops: C	85
Cultivated Crops: D	89
Cultivated Crops: (none)	89
Cultivated Crops: B-D	84

Land Cover Type and Soil Type	Curve Number
Cultivated Crops: B	78
Cultivated Crops: A	67
Cultivated Crops: A-D	78
Barren Land Rock-Sand-Clay: No Data	94
Barren Land Rock-Sand-Clay: C-D	93
Barren Land Rock-Sand-Clay: C	91
Barren Land Rock-Sand-Clay: D	94
Barren Land Rock-Sand-Clay: (none)	94
Barren Land Rock-Sand-Clay: B-D	90
Barren Land Rock-Sand-Clay: B	86
Barren Land Rock-Sand-Clay: A	77
Barren Land Rock-Sand-Clay: A-D	86
Mixed Forest: No Data	79
Mixed Forest: C-D	76
Mixed Forest: C	73
Mixed Forest: D	79
Mixed Forest: (none)	79
Mixed Forest: B-D	70
Mixed Forest: B	60
Mixed Forest: A	36
Mixed Forest: A-D	58