City of Gretna
Stormwater Master Plan

GRETNA, LOUISIANA

DECEMBER 2024

Gretna Stormwater Master Plan

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OVERVIEW

The Gretna Stormwater Master Plan is a comprehensive assessment of flood risk in the City of Gretna, Louisiana.

The assessment combines local knowledge, publicly available data, and state-of-the-art simulation tools to provide a complete picture of flood risk and to demonstrate risk reduction solutions, including projects and programs aligned with federal and state funding opportunities.

PRODUCED FOR

Gretna, Louisiana

City of Gretna
Stormwater Master Plan

PREPARED BY

CSRS, Inc.

CSRS | BUILDING STRONGER, SMARTER COMMUNITIES **TOGETHER.**

Letter from Mayor

December 30, 2024

Dear Residents of Gretna,

Flooding has long been a challenge for our community, threatening homes, businesses, and infrastructure with each passing storm. As we continue to grow and thrive, we must also take bold, strategic steps to ensure that our city remains resilient in the face of increasing flood risks. That is why I am proud to introduce the Gretna Stormwater Master Plan (GSMP)—a forward-thinking, data-driven blueprint for protecting our community from future storm events.

This plan represents a comprehensive assessment of our city's flood risks, combining local knowledge, cutting-edge hydrologic and hydraulic modeling, and community input to develop practical, effective solutions. Through this process, we have identified key factors contributing to flooding, such as aging drainage infrastructure and our region's unique low-lying topography. More importantly, the GSMP provides a roadmap for addressing these challenges through targeted capital improvement projects, innovative green infrastructure, and policy recommendations that will shape a stronger, more resilient Gretna.

Our city cannot tackle these challenges alone. The success of this plan depends on collaboration between local leaders, engineers, state and federal partners, and—most importantly—you, the residents of Gretna. Your voices have been instrumental in shaping this plan, and your continued engagement will be critical as we move from planning to implementation. By working together, we can secure funding, prioritize projects, and make informed decisions that will benefit our city for generations to come.

The Gretna Stormwater Master Plan is more than a document—it is a commitment to a safer, stronger future. Through its implementation, we will protect our homes, enhance our infrastructure, and ensure that our city remains a vibrant and thriving place to live, work, and raise a family.

Thank you for your support and partnership in building a flood-resilient Gretna.

Sincerely,

Belinda C. Constant

Mayor, City of Gretna

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Source: City of Gretna

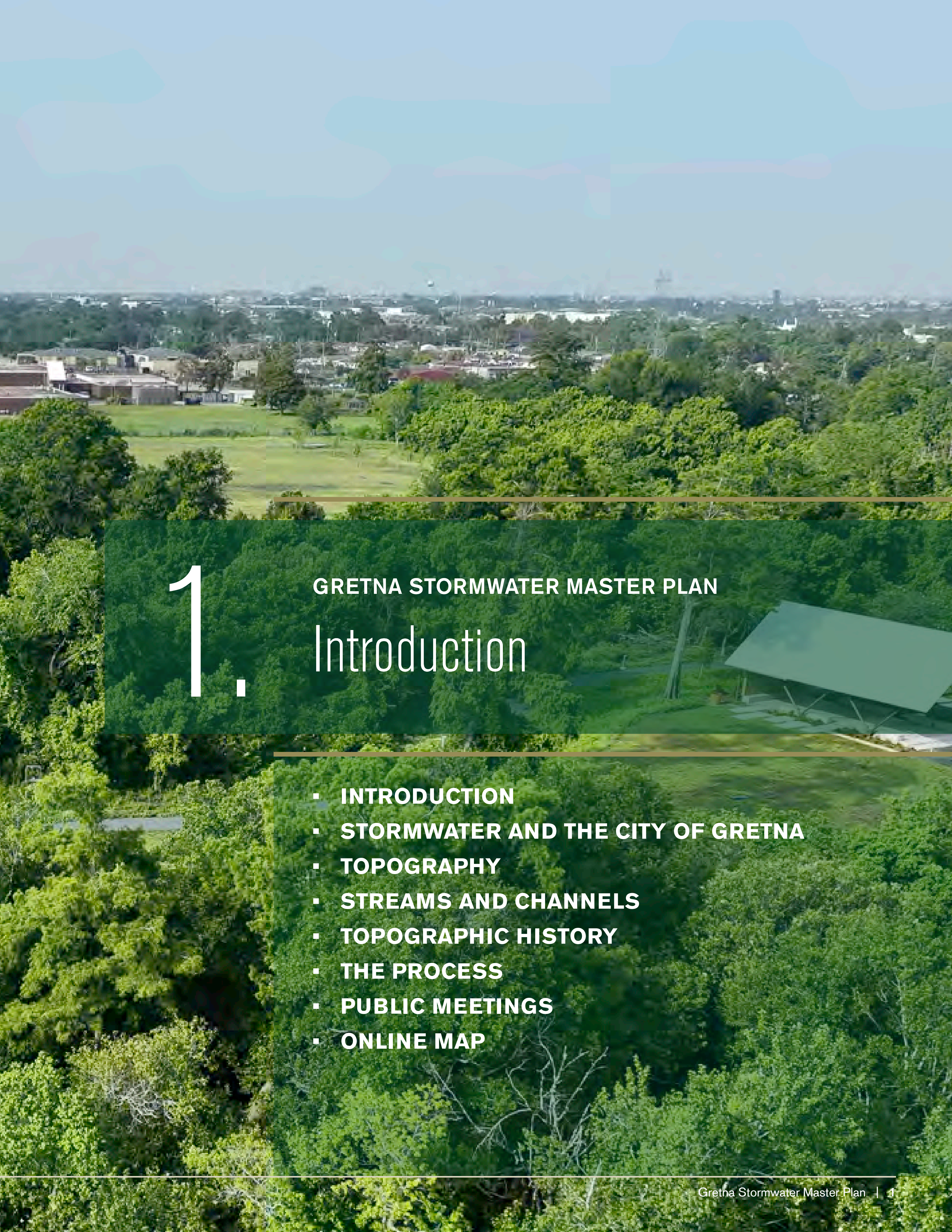
Executive Summary

The Gretna Stormwater Master Plan (GSMP) is a comprehensive assessment of flood risk in the City of Gretna, Louisiana, aimed at identifying and implementing effective flood mitigation solutions. The plan integrates local knowledge, publicly available data, and advanced hydrologic and hydraulic modeling to evaluate existing flood hazards and propose strategies to reduce risk. Through detailed analysis, the GSMP highlights key drivers of flooding in Gretna, including high impervious surface coverage, low-lying topography, and aging drainage infrastructure. The plan also emphasizes the importance of public engagement, incorporating feedback from residents and city officials to ensure the model accurately reflects real-world flooding conditions.

The GSMP outlines a range of flood risk reduction solutions, including capital improvement projects, green infrastructure initiatives, and policy recommendations. Among the key proposed projects are the Gretna Green Distributed Green Infrastructure Network, Stumpf Boulevard Drainage Improvements, and the Priority Elevation Program, which aims to mitigate flood damage to high-risk structures. Additionally, the plan evaluates funding opportunities through federal and state programs, ensuring that proposed solutions are financially viable. A benefit-cost analysis was conducted for each project to determine its effectiveness and feasibility in reducing flood risk across the city.

Looking forward, the implementation of the GSMP will require a coordinated effort between city officials, engineers, and the community. By prioritizing data-driven solutions and leveraging available funding sources, Gretna can significantly enhance its stormwater management system, reducing flood risks and improving long-term resilience. The plan also includes recommendations for updating stormwater regulations and continuing public engagement efforts. With a strategic and proactive approach, the GSMP provides a clear roadmap for building a more flood-resilient Gretna, safeguarding its residents, businesses, and infrastructure from future storm events.

| Source: City of Gretna



1.

GRETNA STORMWATER MASTER PLAN

Introduction

1. Introduction

GRETNA, LOUISIANA

GRETNA STORMWATER MASTER PLAN

Flood risk is an existential and economic threat communities face around the globe. The City initiated the Gretna Stormwater Master Plan (GSMP) to assess flood risk and proactively develop solutions to reduce risk.

The GSMP presents a science and evidence-based assessment of flood risk in the City and identifies implementable solutions to reduce it, including capital projects, codes and ordinances, and programmatic solutions.

Figure 1. Gretna's streets flooded after heavy rains during Hurricane Isaac in August of 2012.
Source: City of Gretna

Stormwater and the City of Gretna

Today, Gretna lies within the East of Harvey Basin, a levee and pump system which contains all land from the Harvey Canal in the west to the Jefferson-Orleans Parish line in the east, and from the Mississippi River in the north to the Gulf Intracoastal Water Waterway in the south. The levees to the north protect the area against Mississippi River flooding. Levees to the south protect against coastal flooding, storm surge and wave action. Intense rainfall events within the protected area are, therefore, the most critical source of flood risk in the City, and the only one which the City has some control of. The City relies on its network of storm drain inlets, underground pipes, and open and closed channels to convey water away from buildings and roadways to the receiving streams which eventually flow to the pump stations.

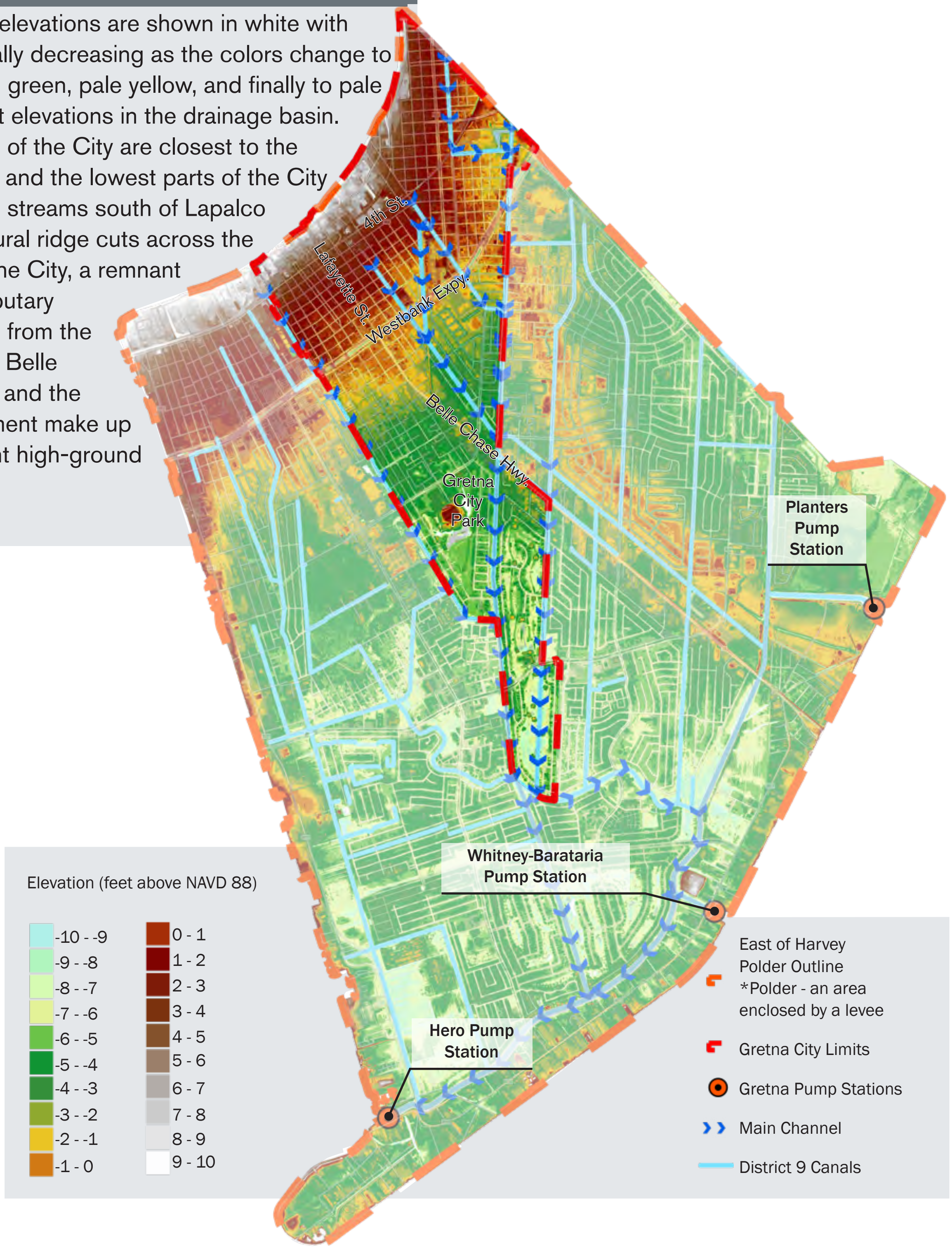
The primary drivers of flood risk in the City during intense rainfall are large percentage of impervious surface cover, low-lying topography, poor land slope, and high density of assets (buildings, vehicles, etc.). The stormwater pipe network can effectively handle small, low intensity rain events, but intense or prolonged rainfall leads to street flooding. The streets act as the "channel of last resort" when the pipe network is overwhelmed; stormwater flows along the streets until it can enter a channel or inlet that is not already overwhelmed. The relative height of streets, railroad alignments, and other high-ground features contribute to the location and depth of flooding.

Figure 2. During the Great Crevasse in 1891 a breach inadvertently created in the Mississippi River levee grew to more than 1000 feet, flooding much of Gretna and Algiers.
Source: gretnala.com

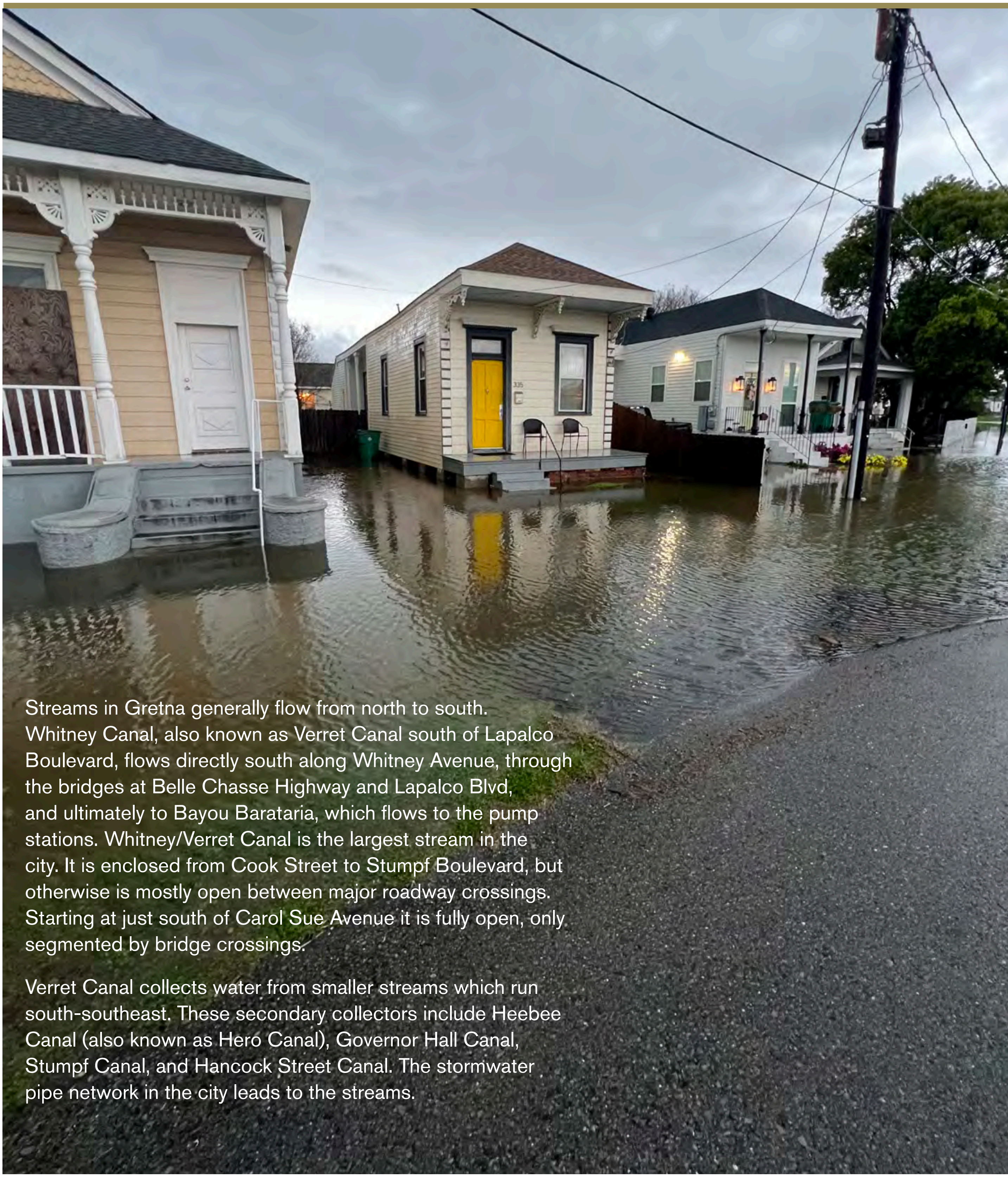
Topography

Figure 3. REGIONAL WATERSHED MAP

The highest land elevations are shown in white with elevations gradually decreasing as the colors change to grey, red, orange, green, pale yellow, and finally to pale blue at the lowest elevations in the drainage basin. The highest parts of the City are closest to the Mississippi River, and the lowest parts of the City are closest to the streams south of Lapalco Boulevard. A natural ridge cuts across the northern part of the City, a remnant of a former distributary stream branching from the Mississippi River. Belle Chasse Highway and the parallel rail alignment make up another prominent high-ground feature.



Streams and Channels

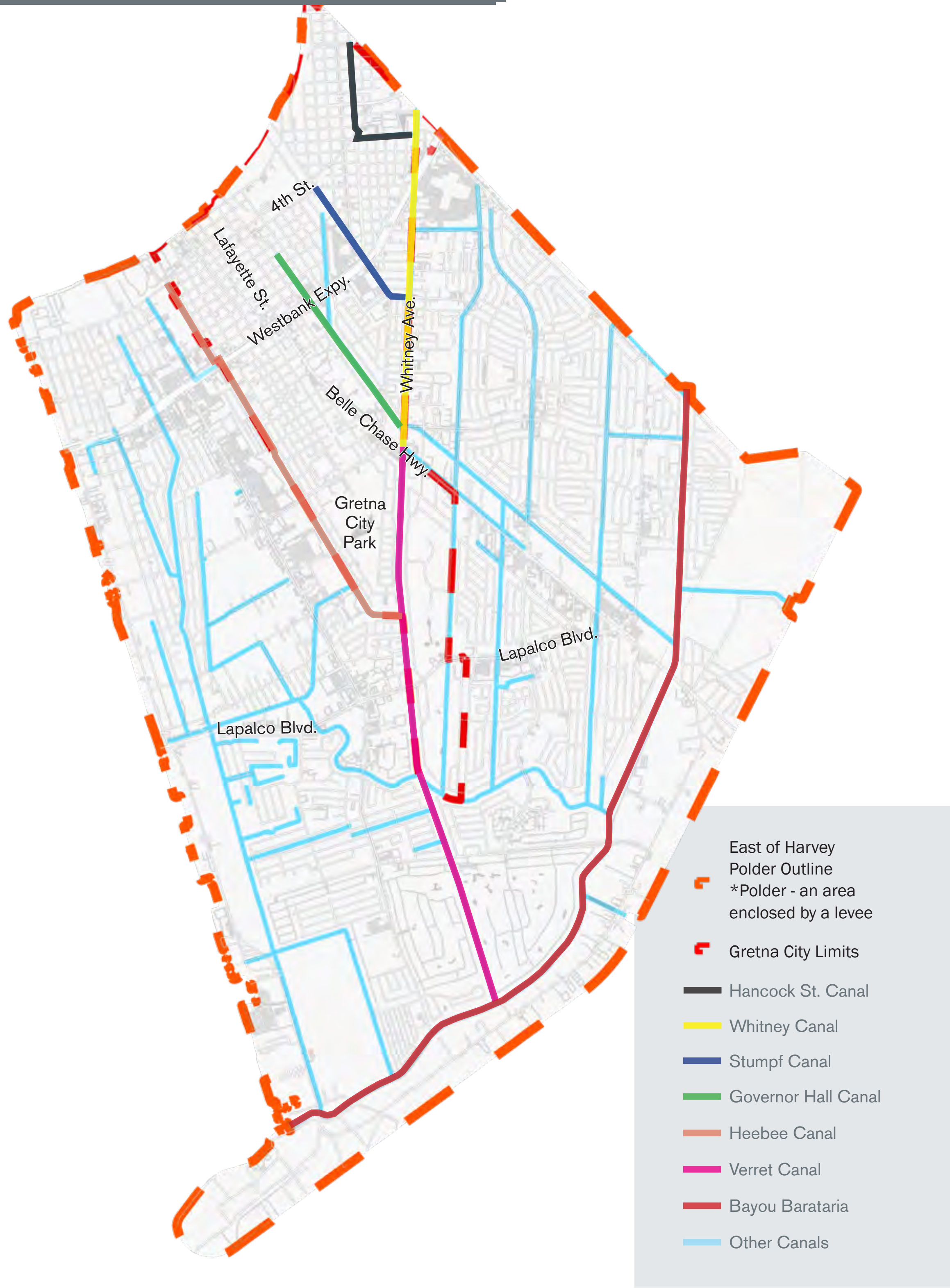


Streams in Gretna generally flow from north to south. Whitney Canal, also known as Verret Canal south of Lapalco Boulevard, flows directly south along Whitney Avenue, through the bridges at Belle Chasse Highway and Lapalco Blvd, and ultimately to Bayou Barataria, which flows to the pump stations. Whitney/Verret Canal is the largest stream in the city. It is enclosed from Cook Street to Stumpf Boulevard, but otherwise is mostly open between major roadway crossings. Starting at just south of Carol Sue Avenue it is fully open, only segmented by bridge crossings.

Verret Canal collects water from smaller streams which run south-southeast. These secondary collectors include Heebee Canal (also known as Hero Canal), Governor Hall Canal, Stumpf Canal, and Hancock Street Canal. The stormwater pipe network in the city leads to the streams.

Figure 4. Neighborhood flooding in Gretna, LA.

Figure 5. **Primary Drainage Channels un and near Gretna**



Topographic History

Much of the land which makes up the City of Gretna is low-lying. Before construction of the Mississippi River levee in the early 20th century and the levees which comprise the Hurricane and Storm Damage Risk Reduction System, most of the area which now makes up the City was a tidally flooded wetland. Figure 7 shows a United States Geological Survey topographic map from 1891 with the modern city limits superimposed.

Roads, homes, and businesses were generally confined to the highest, driest ground near the Mississippi River in the northern parts of the City. Construction of the levees enabled the wetland area to be drained. Development filled in the lower areas over time, placing assets at higher risk and more prone to riverine flooding.

Figure 6. Old Gretna (Mechanikham-Gretna Historic District)
Source: City of Gretna

Figure 7. HISTORIC USGS MAP

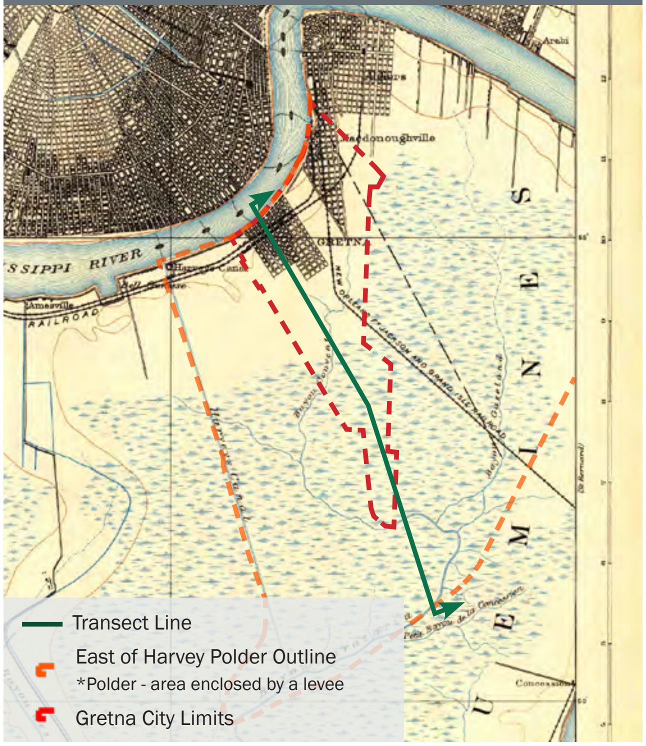


Figure 8. CURRENT USGS MAP

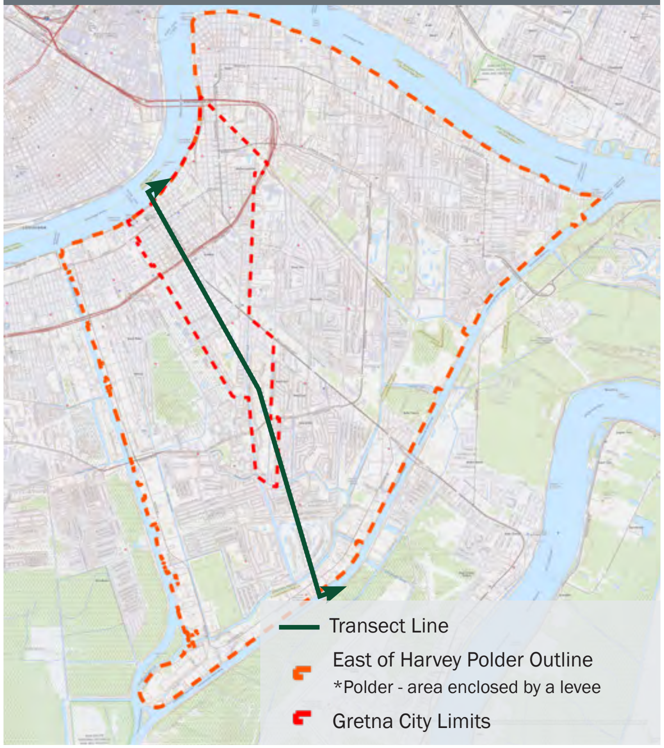


Figure 9. TRANSECT - HISTORICAL

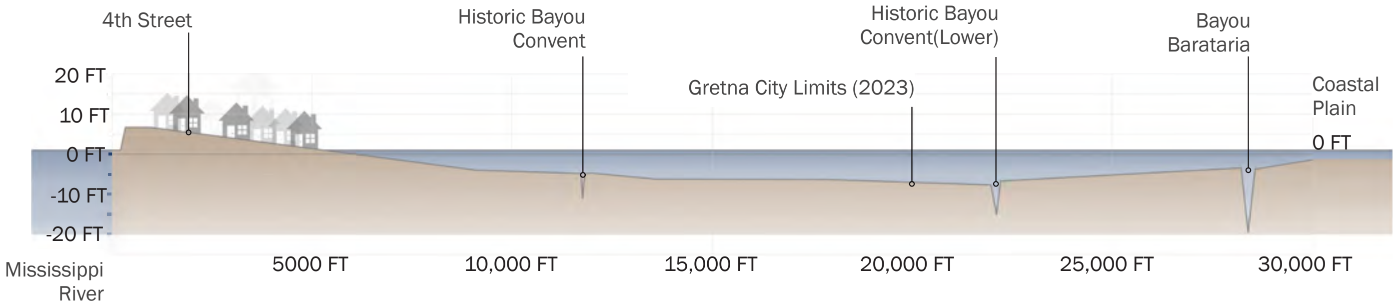
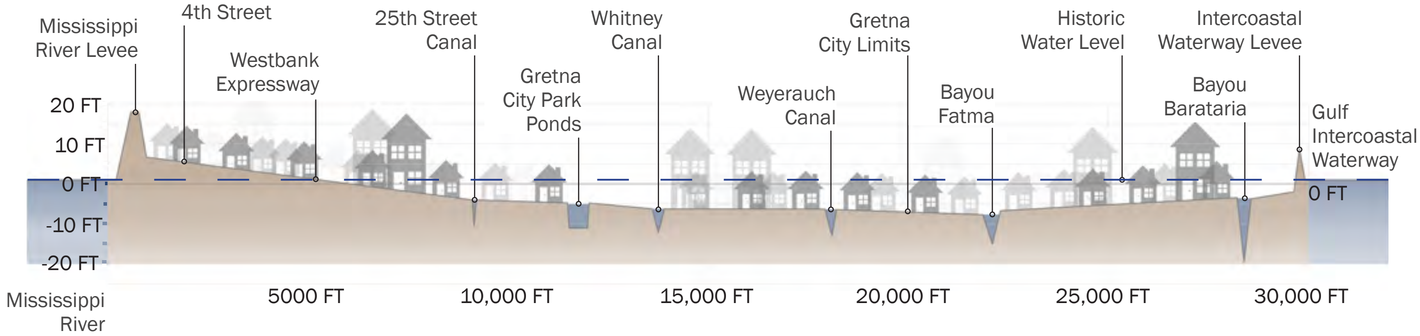


Figure 10. TRANSECT - CURRENT



*Subsidence from 1890 to 2021 not accounted for in this illustration.

The Process

ENGAGE

The GSMP engaged with members of the public at the beginning, middle, and end of the planning process. Those who live and work in the City are more aware of the reality of flood risk because they have experienced it. Throughout the GSMP, members of the public, elected officials, and City staff members helped identify and confirm issues, validated the GSMP model results, and helped shape proposed solutions.

PLAN

The goal of the middle portion of the planning process was to create a comprehensive portrayal of flood risk in the City. First, information was gathered from multiple sources to build an inventory of existing assets and drainage structures. This information was used to develop a comprehensive hydrologic and hydraulic (H&H) model to simulate drainage and flood levels. H&H model results were used to estimate the location and cost of damage due to flooded buildings and vehicles. H&H and damage results were used to confirm existing issues, identify other potential hazards, and prioritize areas for intervention. An overview of the modeling and hazard analysis process is shown in Figure 11.

Figure 11. Risk Assessment Tools Provide Insight, More in Chapter 3

IMPLEMENT

Capital projects and other solutions were developed to address the highest priority issues with the goal of reducing flood risk across the city. Potential funding pathways were identified for proposed solutions. An evaluation of the city's stormwater-related ordinances and codes was performed. Ultimately, the planning process culminated in actionable recommendations on stormwater management in the city.

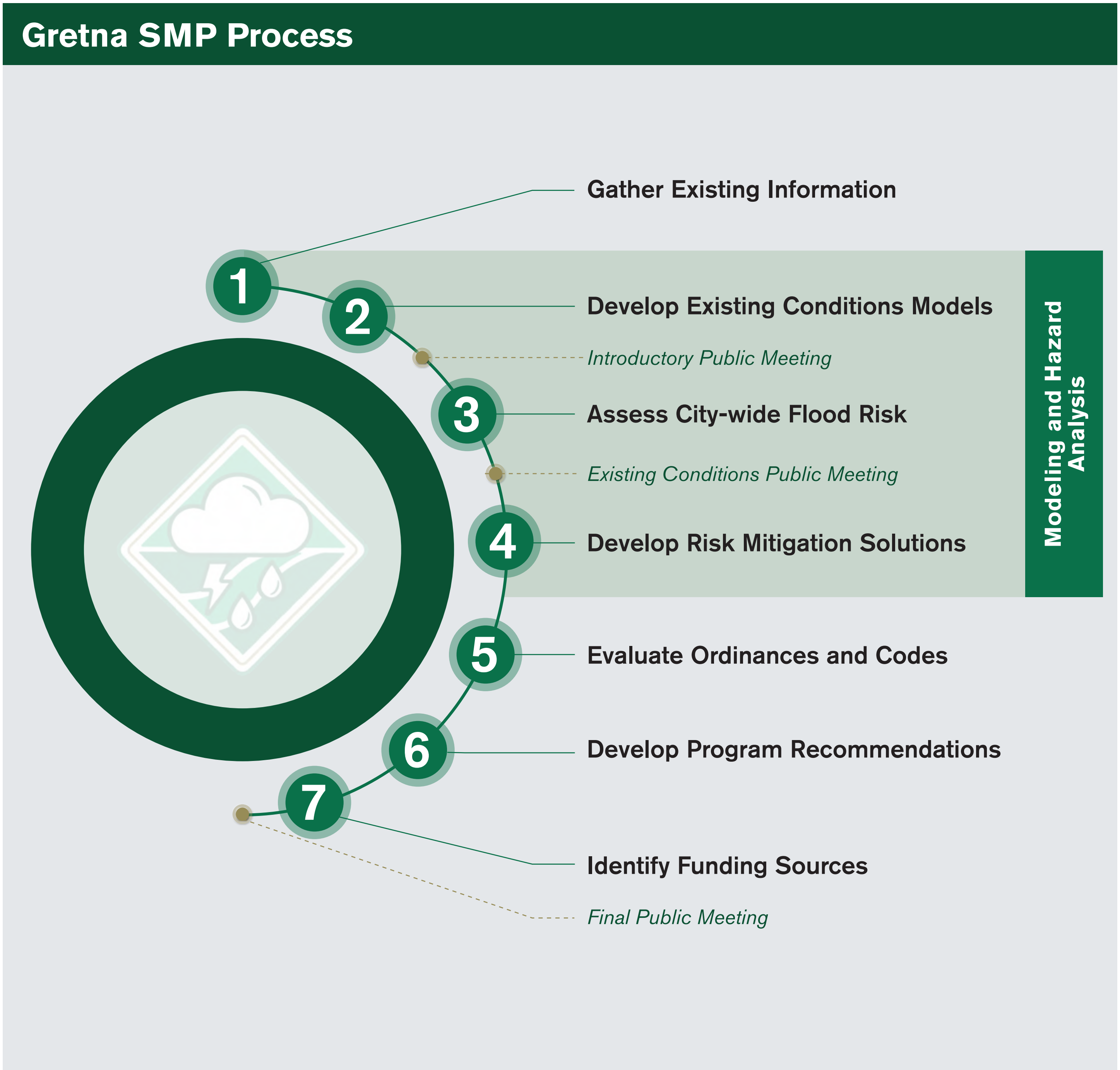


Figure 12. Progression of the Gretna Stormwater Master Plan

Public Meetings

Three public meetings were part of the GSMP process. The goals of the public engagement meetings were to inform city residents of the GSMP's progress and outcomes, to solicit feedback and input on flood prone areas, and to tell the story of the history of flooding within the City. The first meeting was held on October 18, 2023, at the Mel Ott Multipurpose Center. It introduced the SMP and described the physical characteristics of Gretna's drainage system. Project summary boards were created to help the public visualize and see aspects of the ongoing project. The boards displayed the goals of the project, the historical and existing terrain and ecology of the City, detailed figures of the existing subsurface drainage system, and preliminary model results. The boards were on display at the meeting, and members of the SMP team were present to discuss the plan and answer questions residents had on the project.

The second public meeting was held after H&H and damage modeling was completed, allowing for displays of preliminary project concepts. The SMP team attended the yearly Council District public meetings on August 15th and August 20th of 2024 to give a brief presentation of the SMP. By presenting at the Council District meetings, the GSMP team maximized engagement and provided a convenient option for residents to learn about the project. Visualization boards were on display at the end of the Council District meetings and SMP presentations. Members of the team were again available to discuss the plan, answer questions, and obtain feedback from residents.

The public meetings were crucial in the development of the plan and model, as resident input is a reliable way to understand how the drainage system is currently operating. Receiving input on model results also provided validation of the model and help strengthen modeling outcomes.

Online Map

CSRS, the modeling consultants hired by the City of Gretna to assist with creation of this plan, created an online map for public input accessible from computers, tablets, and smartphones. Residents of Gretna were invited to provide input to the SMP team via the online map. The "User Feedback" option allowed residents to provide information about past or recent flooding they have observed. It also allowed upload of a photo to accompany the description of an observed issue. The SMP team received online map input throughout the engagement process. Feedback was used to support the model results and conclusions.

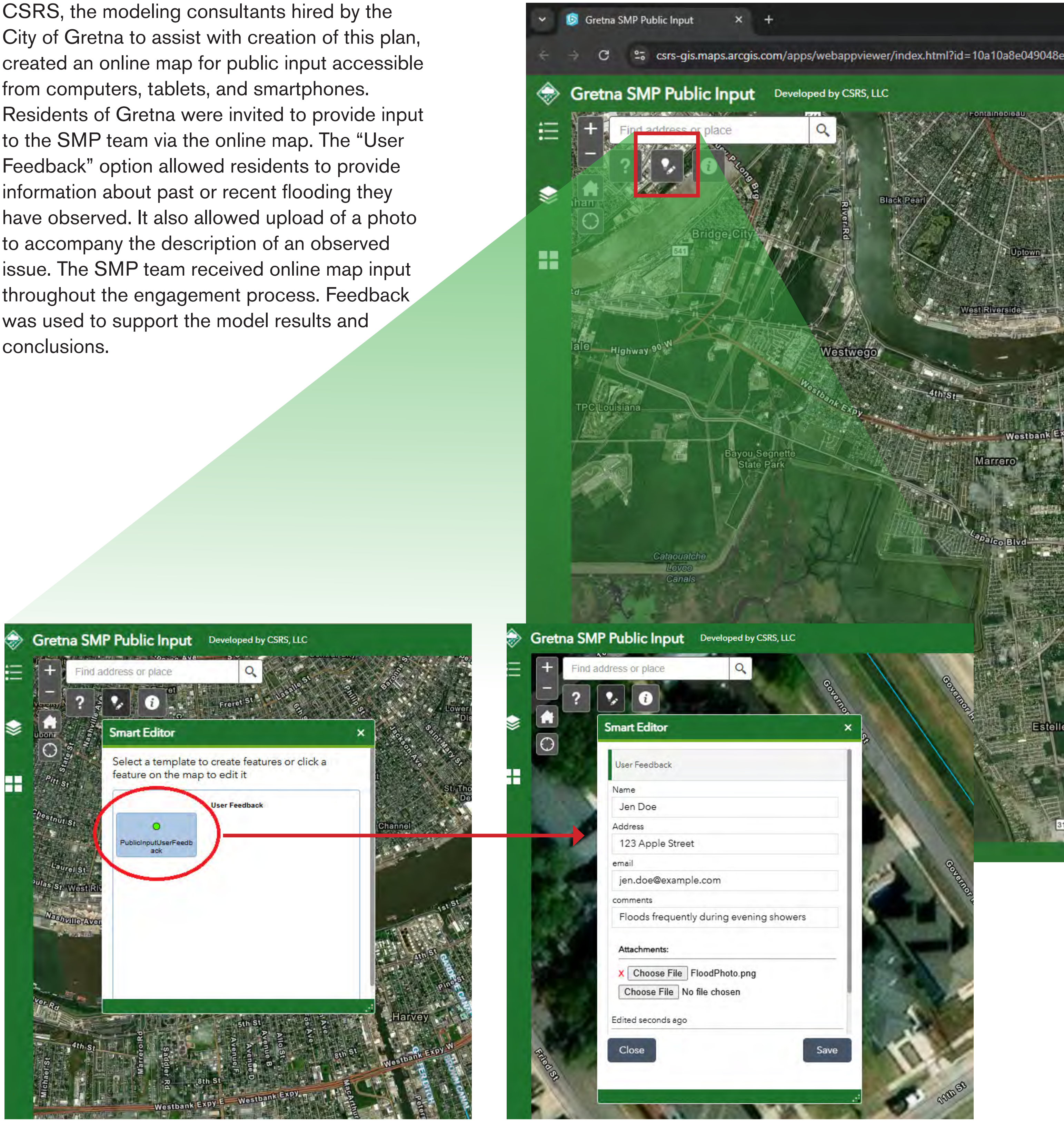
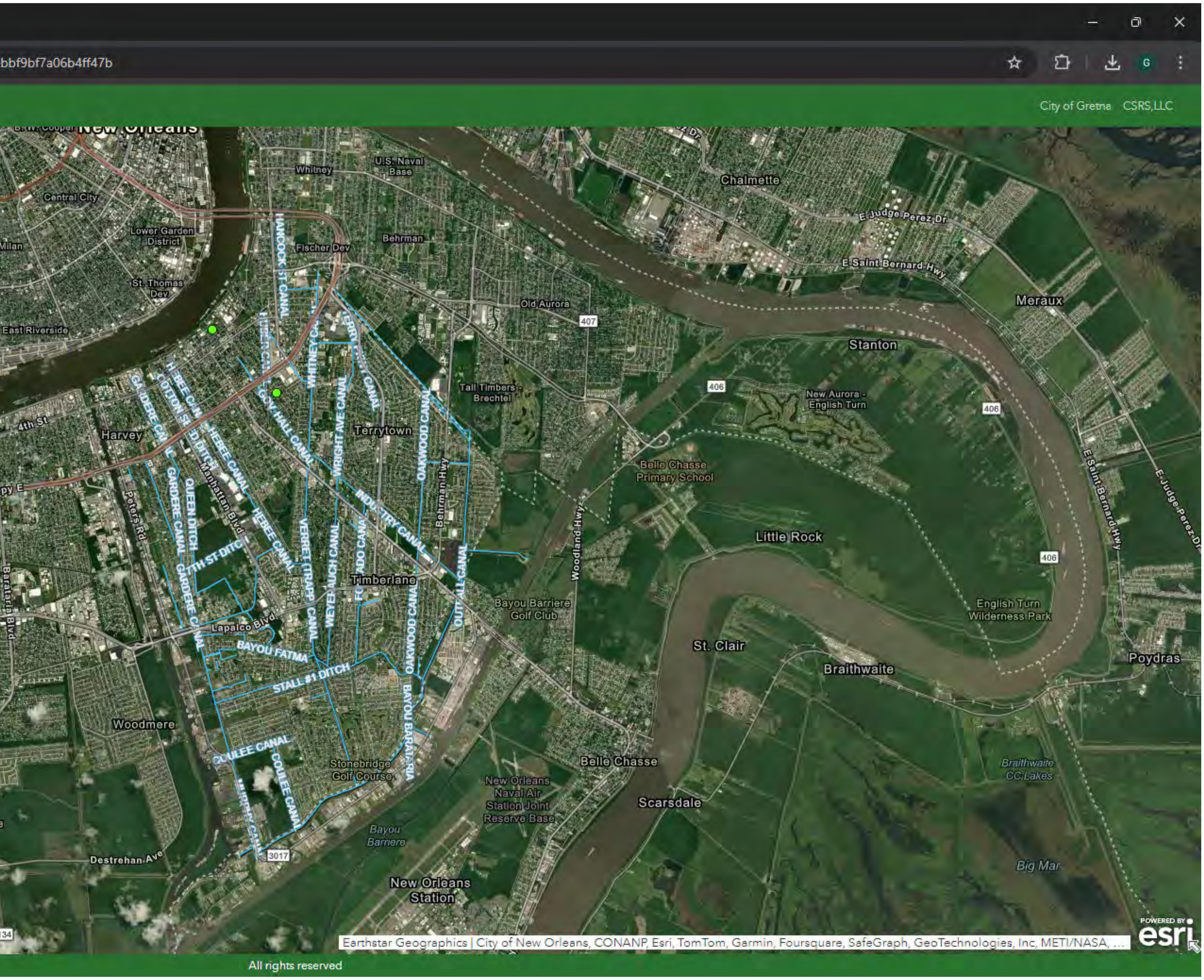


Figure 13. GSMP Public Engagement Mapping Tool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Chalmette
E Judge Perez Dr
E Saint Bernard Hwy
Meraux
Old Aurora
Stanton
HANCOCK ST CANAL
Harvey
4th St
Terrytown
Tall Timbers - Brechtel
New Aurora - English Turn
Belle Chasse Primary School
Little Rock
WHITNEY C...
WRIGHT AVE CANAL
OAKWOOD CANAL
INDUSTRY CANAL
GARDERE CANAL
QUEEN DITCH
HEBEE CANAL
VERRET (TRAPP) CANAL
WEYERAUCH CANAL
Timberlane
Bayou Barriere Golf Club
English Turn Wilderness Park
Lapalco Blvd
BAYOU FATMA
STALL #1 DITCH
OAKWOOD CANAL
BAYOU BARATARIA
St. Clair
Braithwaite
Poydras
Woodmere
COULEE CANAL
Stonebridge Golf Course
Belle Chasse
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Gretna City Hall

| *Source: City of Gretna*

GRETNA STORMWATER MASTER PLAN

2. Data Collection

- **INTRO**
- **THE DRAINAGE SYSTEM**
- **THE SURFACE**
- **CLIMATE CHANGE**
- **RAINFALL**
- **HYDRAULIC AND HYDROLOGIC METHODOLOGY**
- **MODEL VALIDATION**

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2. Data Collection

GRETNA, LOUISIANA

GRETNA STORMWATER MASTER PLAN

Intro

Detailed, accurate data of existing conditions is essential to analyze existing risk. Therefore, discussion of the Gretna Stormwater Master Plan model begins with describing the input data used. To estimate flood levels, information is needed on existing ground elevations, stormwater infrastructure, surface cover type, and soil infiltration rates. Federal and state agencies host information online for public use. Further, the City of Gretna keeps an internal database of geographic information. The GSMP utilized publicly available information and information already in the City's possession wherever possible.

Ground elevations, ground cover/land use, and the location, size, and physical properties of the pipe and channel system were gathered and organized at the beginning of the GSMP. The two main components of the model are the drainage system (including the subsurface pipes network and main channels) and the land surface.

Figure 14. Street view of a canal and tracks just north of Westbank Expy.
Source: google.com

The Drainage System

Survey of the subsurface pipe network is a time-consuming and expensive process. Fortunately, Gretna previously collected an inventory of all drainage structures in the City. The subsurface drainage system was surveyed by Compliance EnviroSystems, LLC (CES) in 2022 and 2023 during a project which identified and cleared debris and blockages from the pipe network. CES surveyed and digitized around 10,800 catch basins or manholes and 9,200 connecting pipes during the effort.

As the intent of CES's survey was maintenance, the pipe network dataset needed significant validation and adjustment. The model development team groomed the dataset and corrected missing connections, missing pipe sizes and material types, and inaccurate location data with reasonable assumptions according to nearby measured data and aerial imagery. CSRS was unable to validate the elevations information collected by CES, therefore, the GSMP team used the inlet depths CES measured and ground elevations from United States Geological Survey (USGS) Light Detection And Ranging (LiDAR) topographic data to estimate the bottom elevation of each junction, also known as the invert elevation. The team also consulted Gretna's city engineer, David Boyd, P.E. at Burke-Kleinpeter, Inc. (BKI), for assistance with resolving data gaps.

Main channels were generally not included in CES's database. The GSMP team was able to obtain the Jefferson Parish East of Harvey Basin Hydraulic (SWMM) Model from the "Comprehensive Stormwater Modeling in Jefferson Parish for LOMR Support" study by RPS. The 1-dimensional (1D) hydraulic model contained information for main channels, both open and covered, throughout the East of Harvey Basin. This information was used to define main channels in the GSMP model.

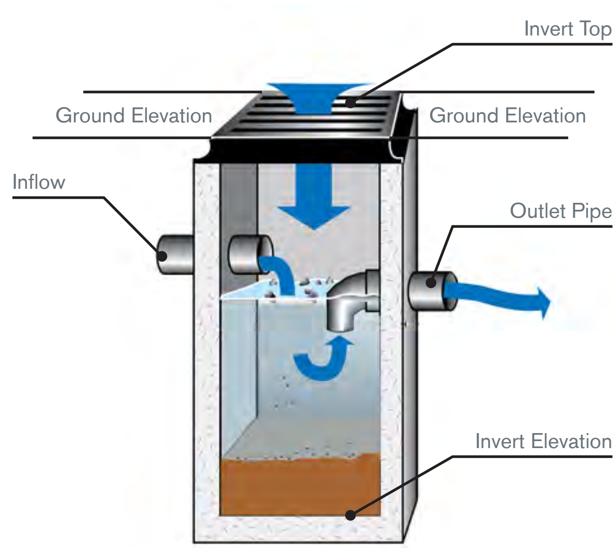


Figure 15. Storm Drain Inlet Diagram
| *Source: portland.gov*

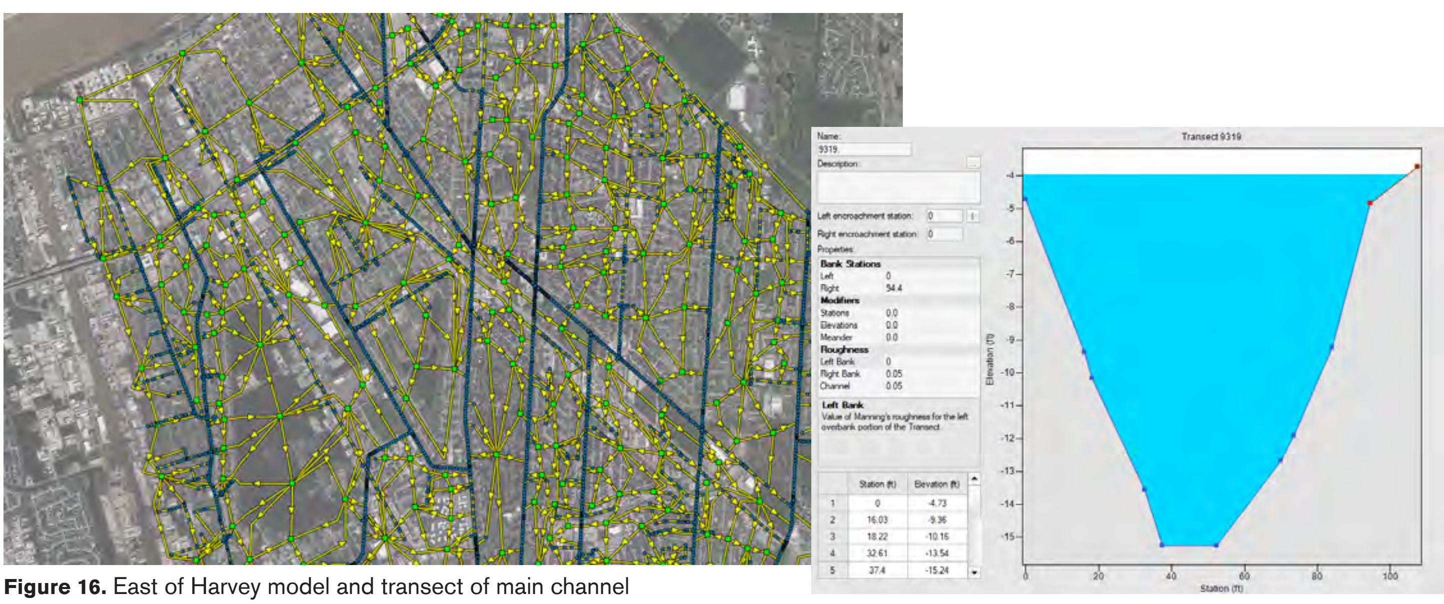


Figure 16. East of Harvey model and transect of main channel

Figure 17. CES Pipes and Junctions

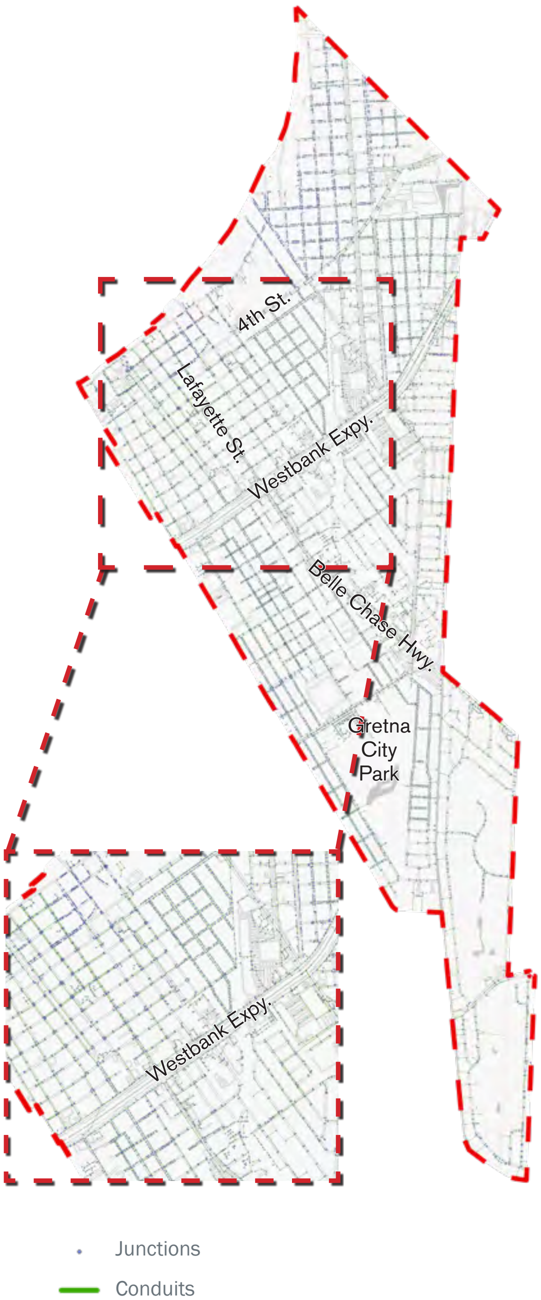
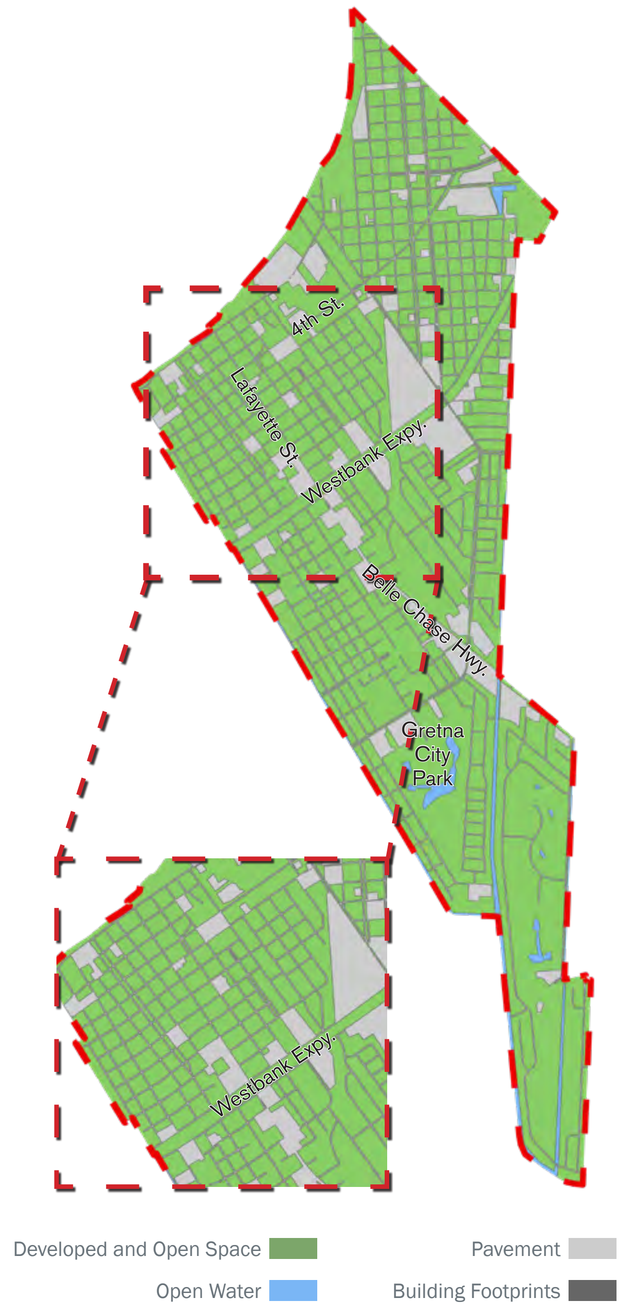


Figure 18. East of Harvey Polder Line

The Surface & Data Collection Figures

Figure 19. **LiDAR Topography**

Figure 20. **Land Cover**



During a rain event, stormwater collects on rooftops, yards, and streets before flowing into the stormwater pipe network. When the pipe network is overwhelmed, stormwater flows over the ground following the lowest topography to the outfall. Therefore, an accurate surface model is key to developing a comprehensive understanding of flood risk.

Figure 21. USDA Hydrologic Soil Groups

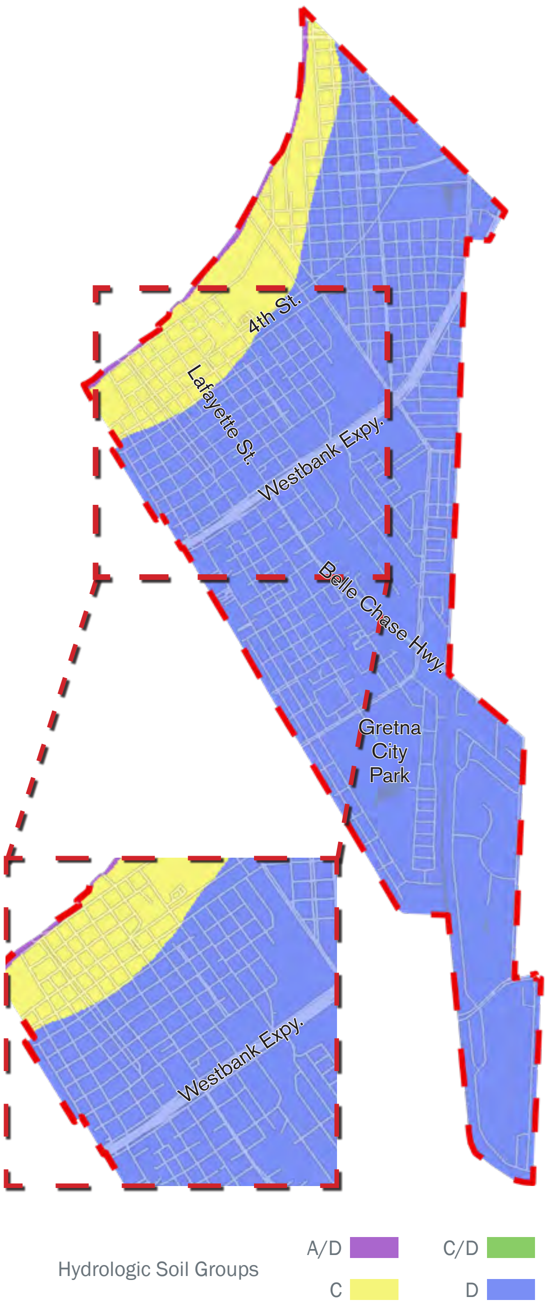


Figure 22. Building Footprint

Climate Change

The GSMP modeling effort accounts for climate change by incorporating increases in total rainfall depth for each return interval, reflecting trends in increasing global average temperatures and the frequency and intensity of rain events detailed in Table 1 and shown on Figure 23. The Intergovernmental Panel on Climate Change (IPCC) Annual Report 5 (AR5) Representative Concentration Pathways 6.0 (RCP6.0) scenario maximum statistic estimates an 11% annual increase in rainfall totals by 2065 for both the Central North America and Eastern North America regions. Because of Gretna's location, the Central North America and Eastern North America regions are the most applicable.

The AR5 report document includes estimated increases for a range of scenarios. The RCP6.0 scenario maximum statistic was chosen as it lies in the upper midrange of estimates in AR5. As climate change projections evolve with better methods and up-to-date data, the city should consider updating future flood risk estimates. Note that Annual Report 6 was published in 2023 during the development of the Gretna SMP, however, rainfall increase statistics were not yet available. The Gretna SMP team incorporated this information by increasing the total rainfall amount for each return period storm event by 11%, as per AR5. Increases were rounded up to the nearest 0.5 inch.

Source: istockphoto.com

Rainfall

One essential factor affecting flood risk is the frequency and intensity of rainfall events that an area experiences. The National Oceanic and Atmospheric Administration (NOAA) hosts data on the intensity, duration, and frequency of storm events that an area is expected to receive based on measurements of past events.

The GSMP team gathered storm event total rainfall depths for the 6-hour duration events from the NOAA Atlas 14 (NA14) dataset and temporally distributed based on NA14's quartile one, 10% distribution. Table 1 shows the total depths. Figure 23 shows the rainfall intensity-duration plots for all storms.

Return Period	Annual Exceedance Probability	NA14 Precipitation Depth (in)	Existing Conditions Precipitation Depth (in)	Climate Change Precipitation Depth (in)
1-year	100%	3.44	3.5	4.0
2-year	50%	3.93	4.0	4.5
5-year	20%	4.92	5.0	6.0
10-year	10%	5.93	6.0	7.0
25-year	4%	7.59	8.0	9.0
50-year	2%	9.08	9.0	10.0
100-year	1%	10.08	11.0	13.0

Table 1. Rainfall Frequency & Rainfall Depth

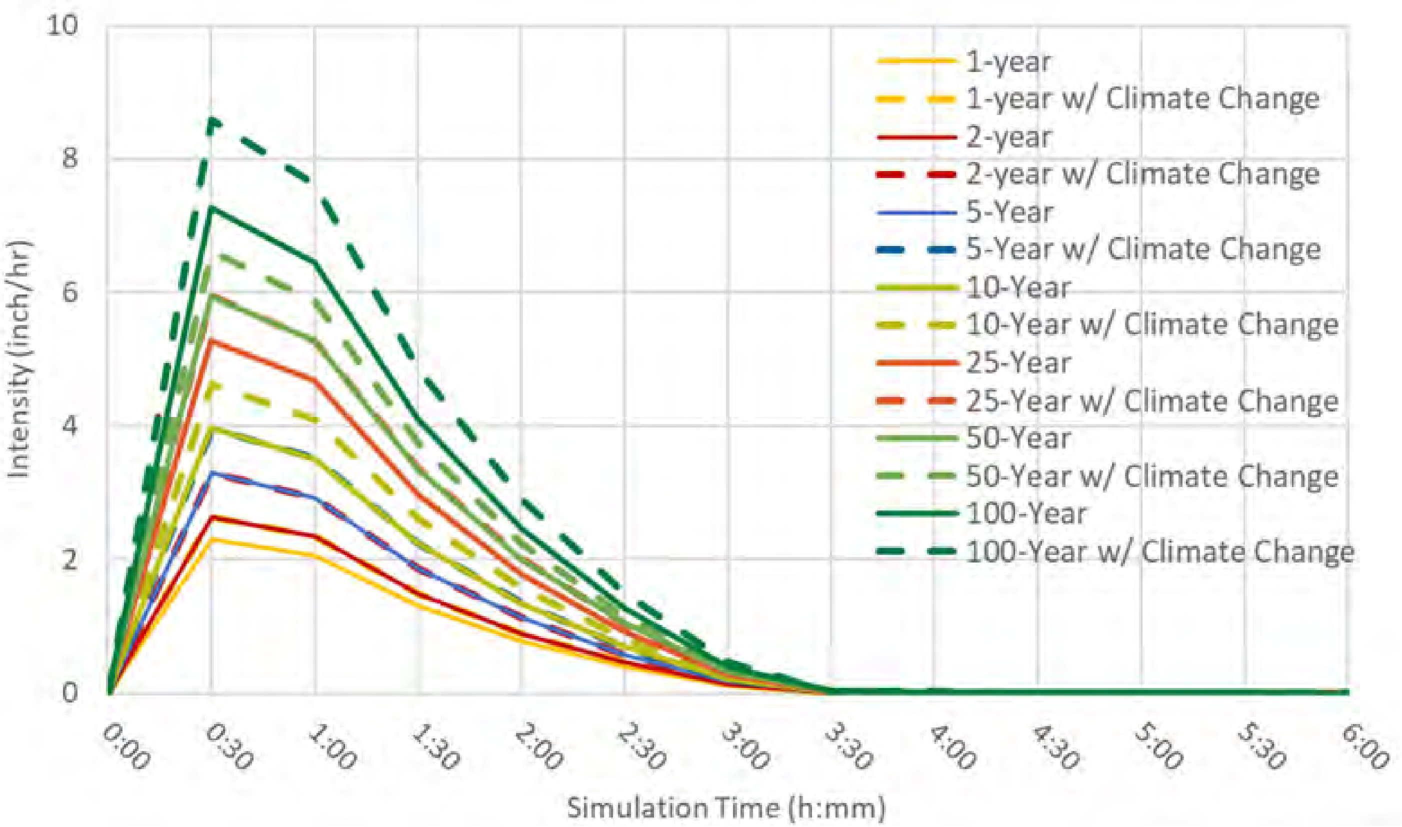


Figure 23. Duration functions

Hydrologic and Hydraulic Methodology

HYDRAULIC METHODOLOGY

The Computational Hydraulics International (CHI) Personal Computer Storm Water Management Model (PCSWMM) was used to simulate the hydrologic and hydraulic (H&H) response of the city under various rainfall events. It is a hydraulic modeling program built upon the Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) computational engine. Using PCSWMM enabled the GSMP team to use a combined 1-dimensional-2-dimensional (1D-2D) approach to model the depth and flow of runoff in streets and open spaces (2D regime) and the collection of runoff into pipes and channels (1D regime) in response to rainfall. The 2D computational mesh was developed to simulate ground features during a rainfall event, modeling the flow direction, the speed at which water flows over land, and the rate at which water is absorbed into the ground. The subsurface system was modeled as a 1D pipe network that connects with the 2D ground mesh and transports stormwater to the main channels. For open channels, model approach splits the channel flow between regimes: water below the channel top bank elevation is in the 1D domain, and water above the bank elevation is in the 2D domain. Computation options were adjusted and tested to improve model accuracy and efficiency. Test simulations were performed to identify stability issues. After an acceptable degree of stability was achieved, the model was validated against existing H&H studies, Repetitive Loss and Severe Repetitive Loss properties, and feedback from the city.

Mesh spacing was refined to better capture the street and channel features. Mesh spacing for channel was set based on the width of the channel from bank-to-bank. Building footprints were input as obstructions. This causes the 2D mesh to exclude the building footprint area which prevents water from flowing through them. The terrain or digital elevation model (DEM) determines 2D surface elevations in the hydraulic model. The 2D mesh can be seen in Figure 25.

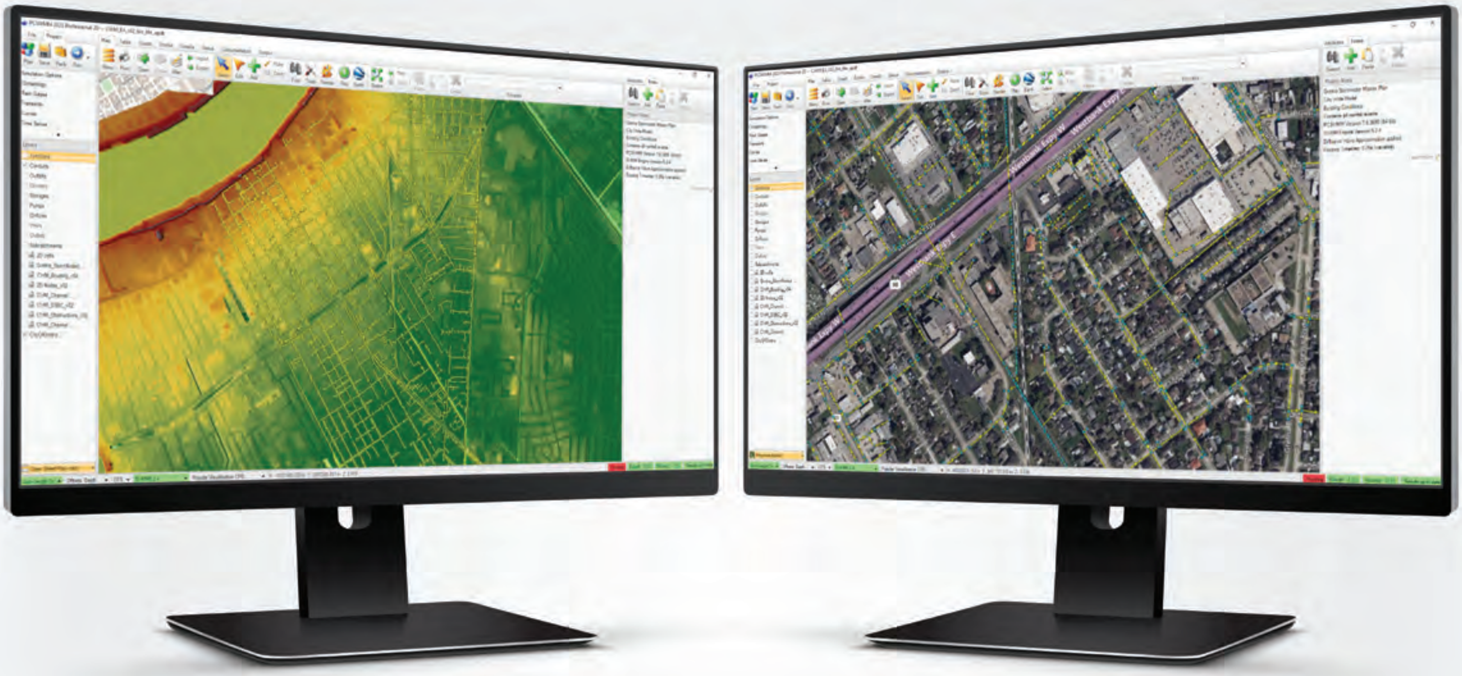


Figure 24. Example desktop images of CHI PCSWMM software at work.
Source: pcswmm.com

To model the land cover for this area, CSRS utilized roadway and channel centerline GIS datasets provided by the City of Gretna which were sufficient to define a land cover layer with more detail than the typically used National Land Cover Dataset (NLCD). Three land cover types were assigned: 1) Pavement, 2) Developed, Open Space, and 3) Open Water. The land cover layer is shown below in Figure 26. Pavement was developed using road way centerlines, Open Water was developed by using channel centerlines and pond locations, and Developed nad Open Space designations were assigned to everything that did not fall into the previous two categories.

The 2D mesh Manning's roughness (n) values affect the speed at which water flows over land in the model. 2D mesh Manning's n values were assigned based on land cover type. A portion of rainfall infiltrates into the ground in real systems. The rate at which water is absorbed into the ground, known as the infiltration rate, is determined by the physical properties of the surface and of the soil in place. Surface roughness values and infiltration rates ("seepage rates" in PCSWMM) are assigned in 2D conduits in PCSWMM.

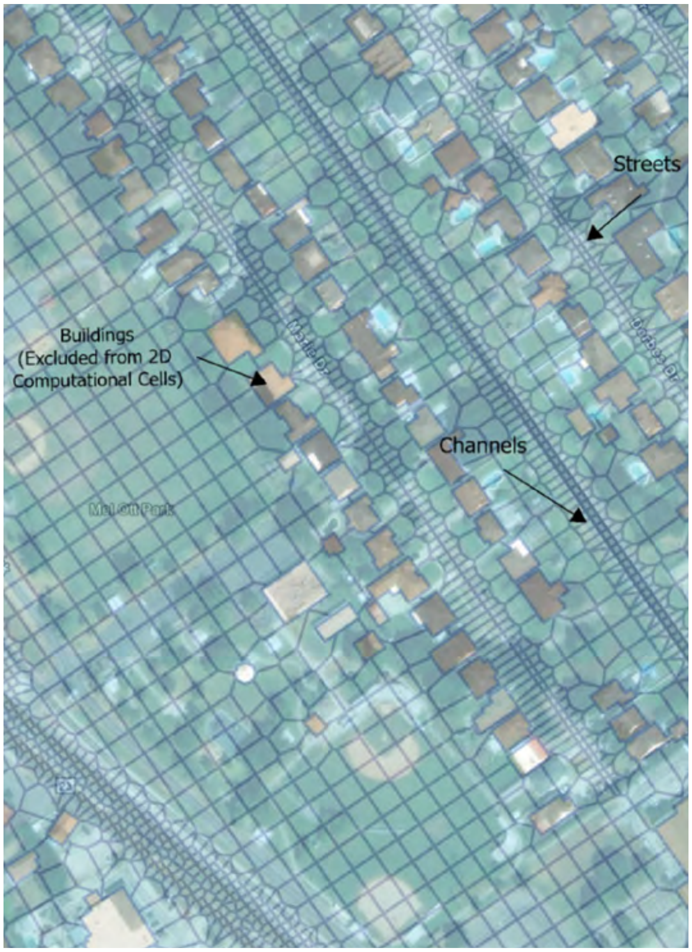


Figure 25. H&H model 2D mesh

Figure 26. GSMP Land Cover Layer

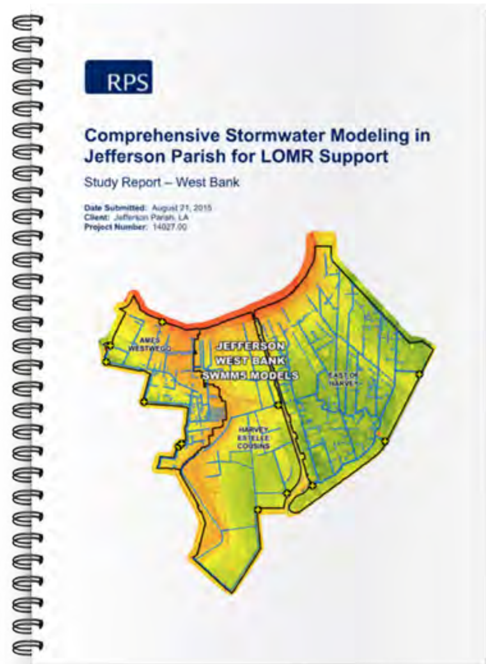
Hydrologic and Hydraulic Methodology

The enclosed drainage system was surveyed by Compliance EnviroSystems, LLC (CES) as discussed in the previous chapter; however, before incorporating this database into the city-wide model, it was essential to verify the accuracy, reliability, and completeness of the data. Where survey data was incomplete or missing, reasonable assumptions were made for the location, size, shape, and material type of subsurface conduits, catch basins, and manholes based on nearby surveyed data and a review of aerial and street-level imagery. Manning's roughness values of pipes were assigned based on the USDOT Urban Drainage Design Manual 2013 values for each conduit material type.

The open channel system required special modeling techniques in the 1D-2D combined approach. The Gretna SMP team implemented open channels as 1D conduits with transects containing channel cross-sectional geometry according to the methodology in the PCSWMM guidance from CHI.

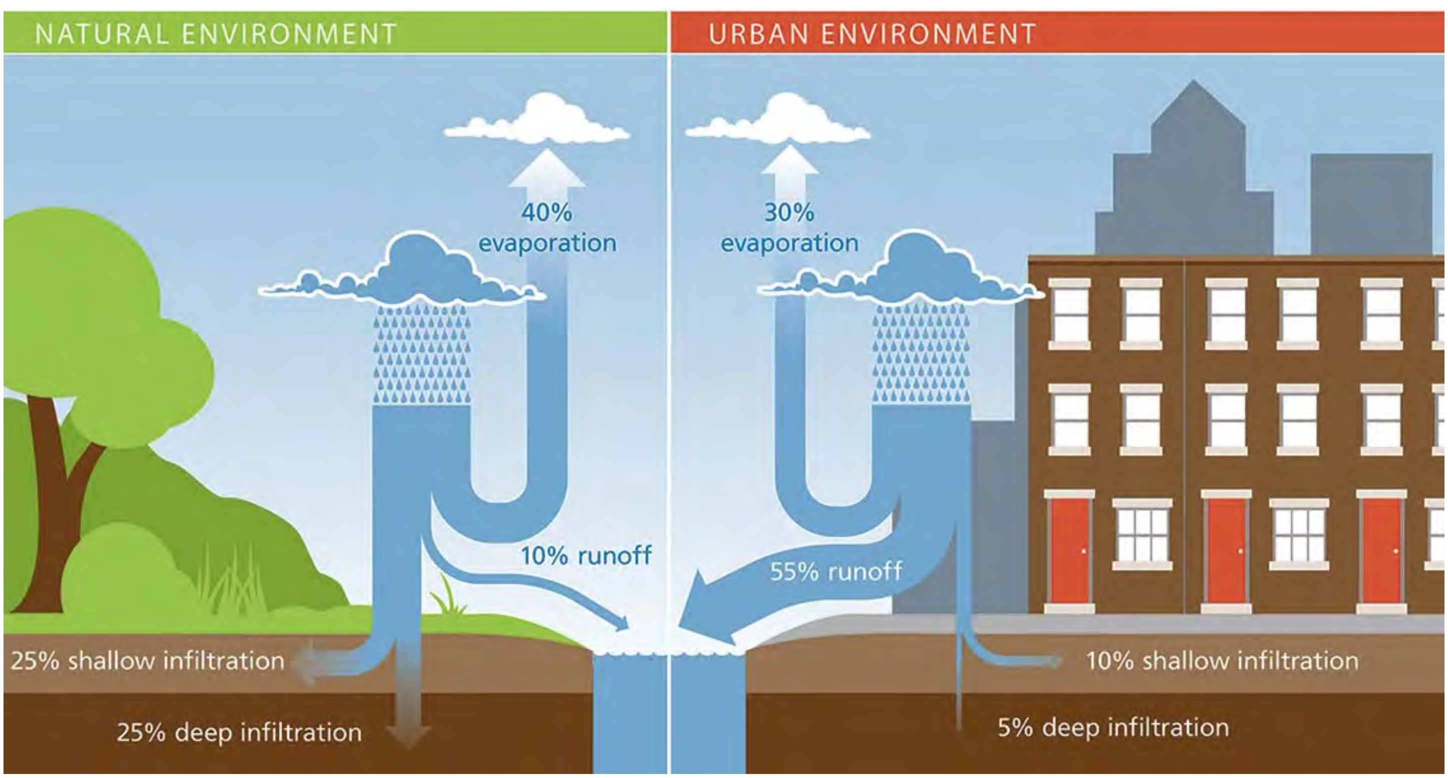
Source: clemson.edu

Station elevation data for channels across the city was available from the East of Harvey Basin SWMM model developed by RPS and BCG Engineering & Consulting Inc. for the "Comprehensive Stormwater Modeling in Jefferson Parish for LOMR Support" project owned by Jefferson Parish. The GSMP team used transect data and channel invert elevation data from this model as the base dataset for implementing main channels.



HYDROLOGIC METHODOLOGY

Hydrology in general is the study of Earth's water cycle. Hydrology in the GSMP model consists of the estimation total stormwater runoff volume in a simulated storm event. A hydrologic method combining temporal and volumetric analysis was utilized to create rainfall inputs for the unsteady hydraulic analysis. The total rainfall depths for the 6-hour duration were obtained from the National Oceanic and Atmospheric Administration Atlas 14 (NA14) after a sensitivity analysis was performed on similar sizes and types of models for the East Baton Rouge Stormwater Master Plan. Without accounting for losses, full synthetic rainfall was applied directly to the 2D mesh. Seven design storm events were identified for use in the GSMP and are detailed in the previous chapter.



Source: Philadelphia Water Department, water.phila.gov

Hydrologic and Hydraulic Methodology

The Intergovernmental Panel on Climate Change (IPCC) Annual Report 5 (AR5) Representative Concentration Pathways 6.0 (RCP6.0) scenario forecasts an 11% annual rainfall increase by 2065 in Central and Eastern North America, climate change effects were integrated into the modeling by projecting increased rainfall depths, The SMP team applied this 11% increase to future rainfall estimates across various return intervals. This adjustments were made to Gretna's flood risk assessments and can also be seen in the previous chapter.

Rainfall inputs were applied directly to the 2D mesh and the building subcatchments. Building subcatchments were needed to incorporate runoff from the rooftops since 2D mesh excludes building footprints. Building footprints were assumed to be impervious and were set to flow out to the nearest storm drain or manhole.

Since the City of Gretna is part of a larger watershed, the interaction of Gretna and adjacent areas must be considered. This is accomplished through the application of boundary conditions at the outflow locations of the GSMP model (rainfall inputs may also be called boundary conditions).

On the northside of the model, the 2D outfalls border the city limits along Donner Canal, and a 1D outfall is located on Donner Canal at its confluence with the Racetrack detention pond to simulate exchanges to the reach of Donner Canal beyond the city limits. Both the 1D and 2D outfalls use stage hydrographs from the Orleans Parish Ardurra (DPS 13) model

Figure 27. The Gulf Intracoastal Waterway

for each design storm event. The southern boundary also utilizes both 1D and 2D outfalls. The 2D outfalls here border the city limits along Hebee/Hero Canal continuing to its confluence with Whitney/Verret Canal, along Verret Canal to its confluence with Bayou Fatma, along Bayou Fatma to its confluence with Bayou Barataria, then northward to Belle Chasse Highway. A 1D outfall is located on Verret Canal at its confluence with Bayou Fatma to simulate outflow to the reach of Verret Canal beyond the city limits. An additional 1D outfall is located where Bayou Fatma meets the city limits for the same purpose. Both the 1D and 2D outfalls use stage hydrographs taken from the Jefferson Parish East of Harvey model for each design storm event. All the outfalls in the northern and southern locations use this approach to incorporate backwater effects from areas downstream of the City.

Model stability was assessed throughout model development. The stability of a hydraulic model is indicated by the size and frequency of computation errors during a simulation. A key indicator of model stability is routing error. Routing error occurs when the solution solver fails to converge for a given model component during calculations for a time step. Total routing errors of less than 1% were accepted for GSMP simulations.

Model Validation

Figure 28. Model Validation: Simulated flood depths

Reliable observed data is key to model calibration and validation. The GSMP team encountered a lack of observed data for the city; therefore, a direct calibration of the model could not be performed. The model was instead validated through comparison to existing studies and through visual inspection by members of the city staff and administration. Two existing studies, the FEMA Flood Insurance Study and the "Comprehensive Stormwater Modeling in Jefferson Parish for LOMR Support" project, were used for validating the GSMP model. Both studies employed 1-dimensional modeling and focused on major canals and conveyance features but did not include storm drains outside the canals. Preliminary GSMP model results were presented to city staff and administration, including the mayor, council members, Floodplain Administrator, Superintendent of Environmental Affairs, and the Superintendent of Parks and Parkways, among others. City personnel verified that the model showed flooding at locations of known issues.

Once existing conditions were finalized, maximum water surface elevations (WSEs) were exported from the GSMP model and the East of Harvey (EOH) model. Maximum WSEs were compared to test for the validity of the GSMP existing conditions. The GSMP model generally had lower depths and WSEs near channels than the EOH model, though the results were within 1 foot. This is because the EOH model is fully 1D and does not directly simulate overland flow nor does it directly account for storage of water in pipes or on the surface.

The GSMP model flood extents and flood elevations for the 100-year event were compared to the FEMA base flood zone (Zones A and AE) and base flood elevations. The GSMP model generally had lower peak water surfaces in main channels due to the model setup differences discussed above. The combined 2D surface and 1D subsurface storm drain system utilized for the GSMP model holds significant water volume during peak flooding. The comparisons did not necessitate adjustments to the GSMP model. After validation was completed via the above method, a severe storm event occurred that allowed the Gretna SMP team to further validate the model. This serve weather event occurred on February 3rd, 2024. City staff captured videos and photos as evidence of flooding during and after the rainfall. Following investigation, the precipitation intensity for this event was determined to be 3.5 inches over 12 hours. The SMP team simulated this event using the GSMP model with gauge-corrected radar rainfall estimates data. The GSMP compared model outputs to the flooding shown in the videos and photos, including flooding in both streets and canals. The analysis indicated that the SMP model closely matched the observed flooding depths shown in the videos for the February 3rd event. An example comparisons made for this storm event can be seen in Figures 28-30.

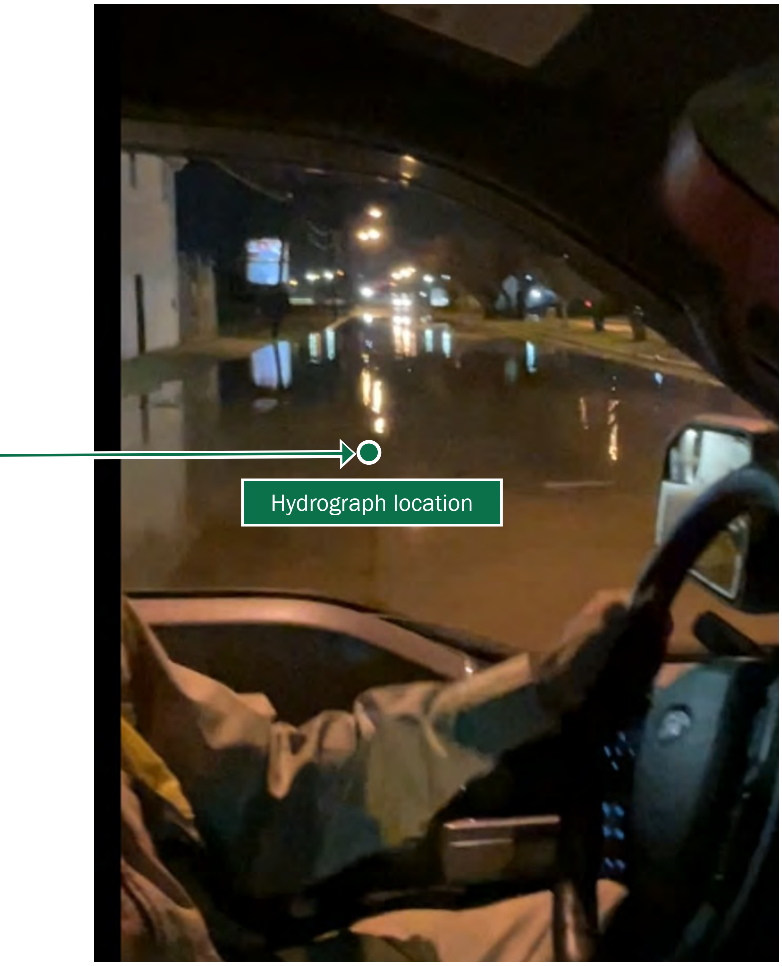


Figure 31. Model Validation: Images of real flooding

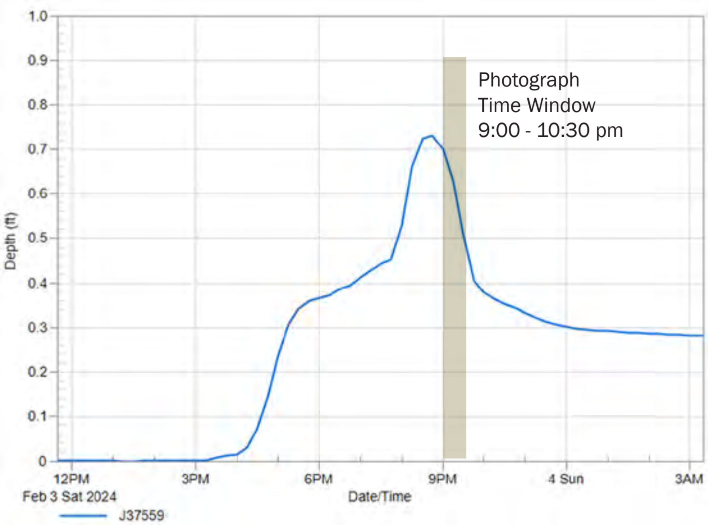
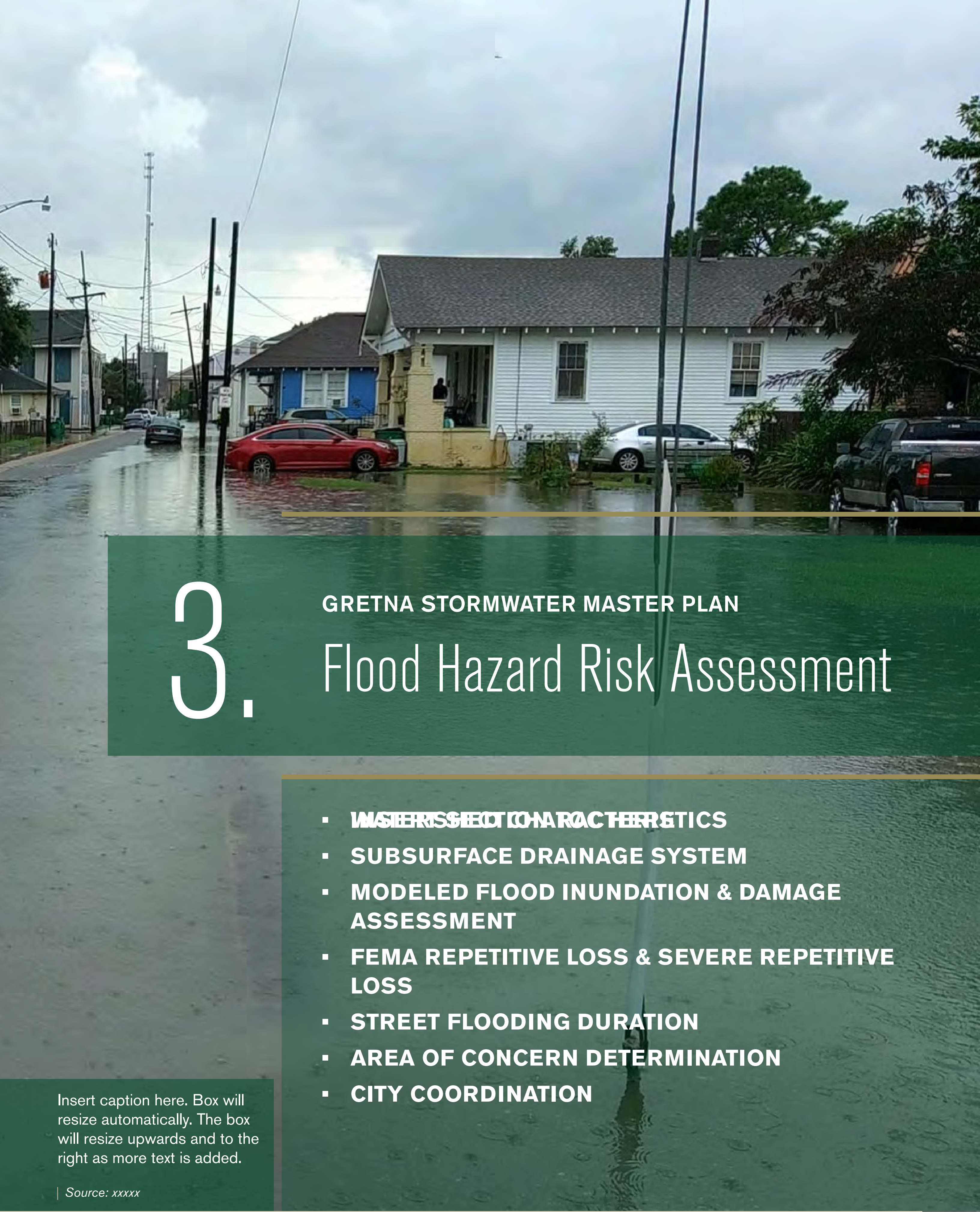


Figure 30. Model Validation: Simulated depth hydrograph

Flooding Along 3rd Street in Gretna During an Extreme Event

| *Source: City of Gretna*



3.

GRETNA STORMWATER MASTER PLAN

Flood Hazard Risk Assessment

- WATERSHED CHARACTERISTICS
- SUBSURFACE DRAINAGE SYSTEM
- MODELED FLOOD INUNDATION & DAMAGE ASSESSMENT
- FEMA REPETITIVE LOSS & SEVERE REPETITIVE LOSS
- STREET FLOODING DURATION
- AREA OF CONCERN DETERMINATION
- CITY COORDINATION

Insert caption here. Box will resize automatically. The box will resize upwards and to the right as more text is added.

| *Source: xxxxx*

3. Flood Hazard Risk Assessment

GRETNA, LOUISIANA

GRETNA STORMWATER MASTER PLAN

Watershed Characteristics

Figure 33. Planter

Figure 34. Whitney-Barataria

Figure 35. Model Validation: Images of real flooding

The City of Gretna is situated in the East of Harvey Basin, an area enclosed by levees located south and west of the Mississippi River, north of the Gulf Intracoastal Waterway, and east of the Harvey Canal. The City of Gretna comprises approximately 5.4 square miles within Jefferson Parish. Gretna features maximum and minimum elevations ranging from 10 feet to -10 feet (NAVD88 Geoid 12A), respectively. The city slopes gently from north to south, with its highest point at the Mississippi River Levee and descending towards its lowest areas near the Timberlane Neighborhood. Gretna is predominantly developed with man-made, concrete lined channels. This characteristic alone leads to higher rates of stormwater runoff during high intensity events. Water that is captured by the subsurface system is collected and routed to these drainage canals throughout the city. Once in the drainage canals, the water travels south and west towards the Gulf Intracoastal Waterway and Harvey Canal. The key drainage canals are Whitney, Verret, Hero, Governor Hall, and Hancock Canals, which ultimately discharge into the Harvey Canal and Gulf Intracoastal Waterway via three pumping stations. These pumping stations are Planters Pump Station located on Bypass Rd, Engineers Pump Station located on Engineers Rd, and the Hero Canal Pump Station located between Bayou Rd and Concord Rd.

Modeled Flood Inundation & Damage Assessment

A flood damage assessment was conducted for the City of Gretna using the Personal Computer Stormwater Management Model (PCSWMM) and Hydrologic Engineering Center Flood Impact Analysis (HEC-FIA) programs to evaluate structural and content damages across various storm events. The assessment used storm events for the 2-, 5-, 10-, 25-, 50-, and 100-year return intervals. Maps of the maximum depth from the PCSWMM model are the primary input for the HEC-FIA damage simulation along with the location and elevation of structures. The City of Gretna provided a building footprints layer which included information on structure type/use. The structure type information was verified, and first-floor elevations and structure replacement values were added to the dataset. Structure values had to be applied and were estimated by categorizing structure type and building footprint square footage.

Figure 36. Existing conditions 100-year storm simulated maximum food depth

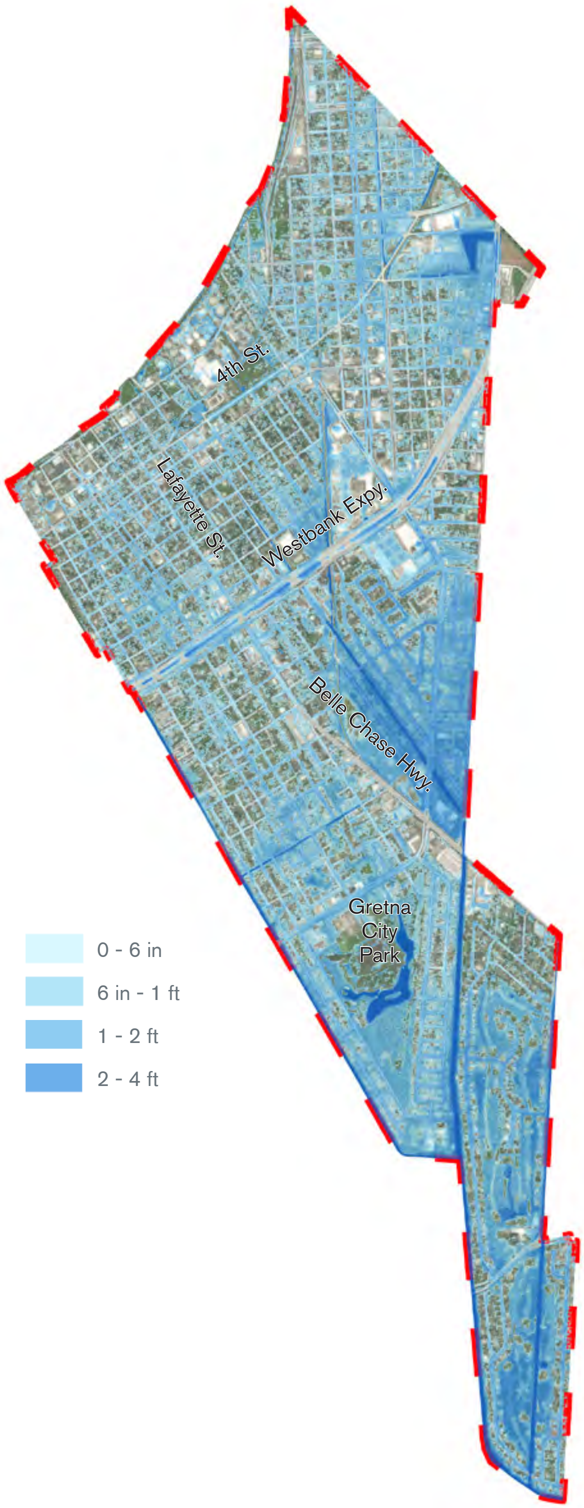
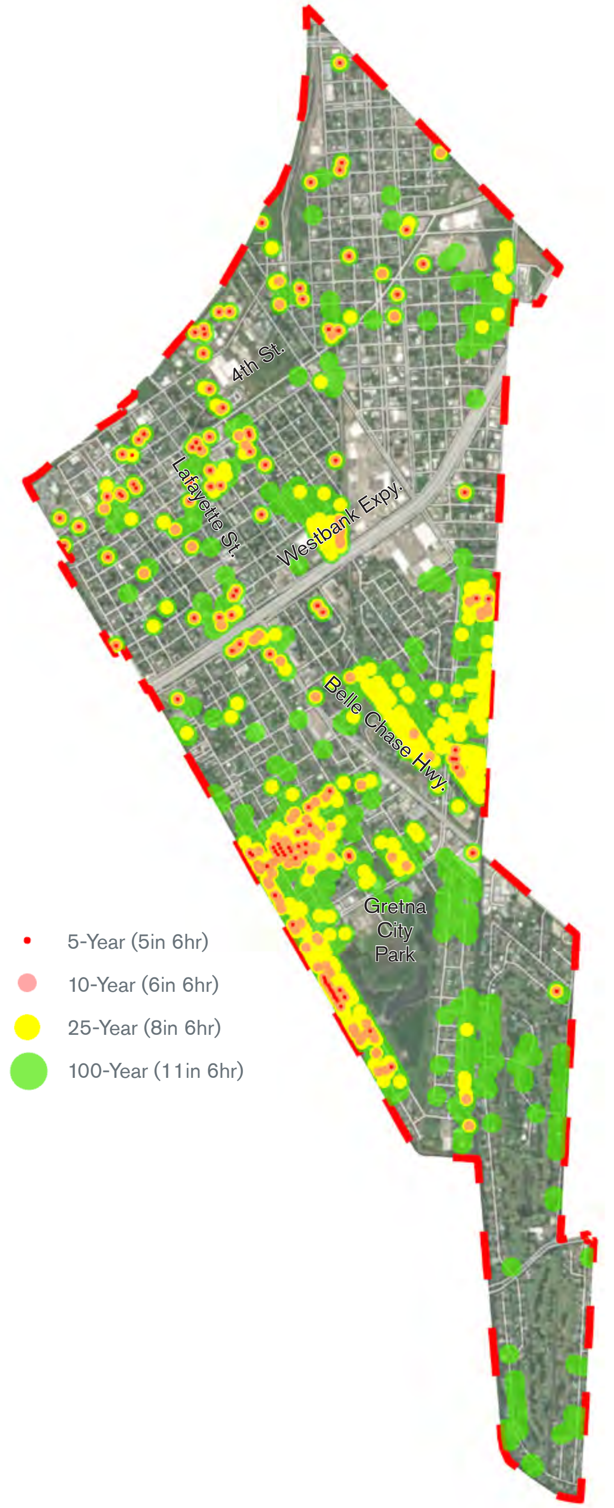


Figure 37. Existing conditions simulated structure flooding

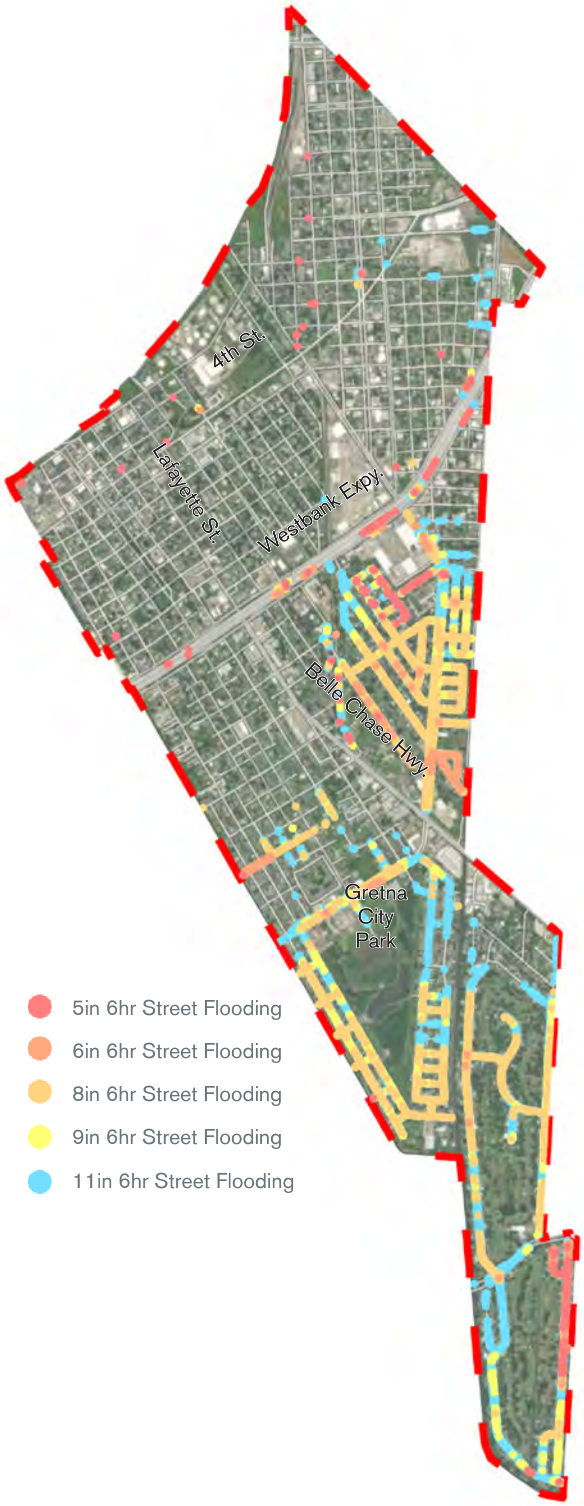


Concentrations of simulated flooded structures were key for identifying high-risk areas. Hydraulic modeling results estimate damages to private and public property ranging from $15 million from a 1-year event to $170 million from a 100-year event under the current conditions. The distribution of the simulated flooded structures city-wide from the 5-, 10-, 25-, and 100-year events can be seen in Figure 35 of the and neighborhood distributions can be seen in subsequent figures 40-55. The assessment also considered climate change impacts, showing increased total damages due to higher rainfall amounts in future scenarios compared to current conditions. An 11% increase was applied to the total rainfall amount for each return period storm event per Annual Report 5 (AR5) provided by Intergovernmental Panel on Climate Change (IPCC).

Street Flooding Duration

During intense storm events, flooded streets can result in detours for emergency response vehicles, limit the mobility of residents, inhibit recovery efforts, and delay the community's return to normal function. The flood model results for each storm event were used to identify areas where water is likely to remain present and deep for a significant period after a rain event. The analysis mapped locations where water remained at a depth of 1 foot or greater after the end of a simulated rainfall event as shown in Figure 36. The areas most prone to street flooding are in the central and southern portions of the City, along the internal canals, surrounding Gretna City Park and the Timberlane Country Club. As the rainfall intensity increases, the extent and duration of street flooding expands.

Figure 38. Existing conditions simulated street flooding



FEMA Risk Information

Figure 39. FEMA flood zone AE (Special flood hazard area)

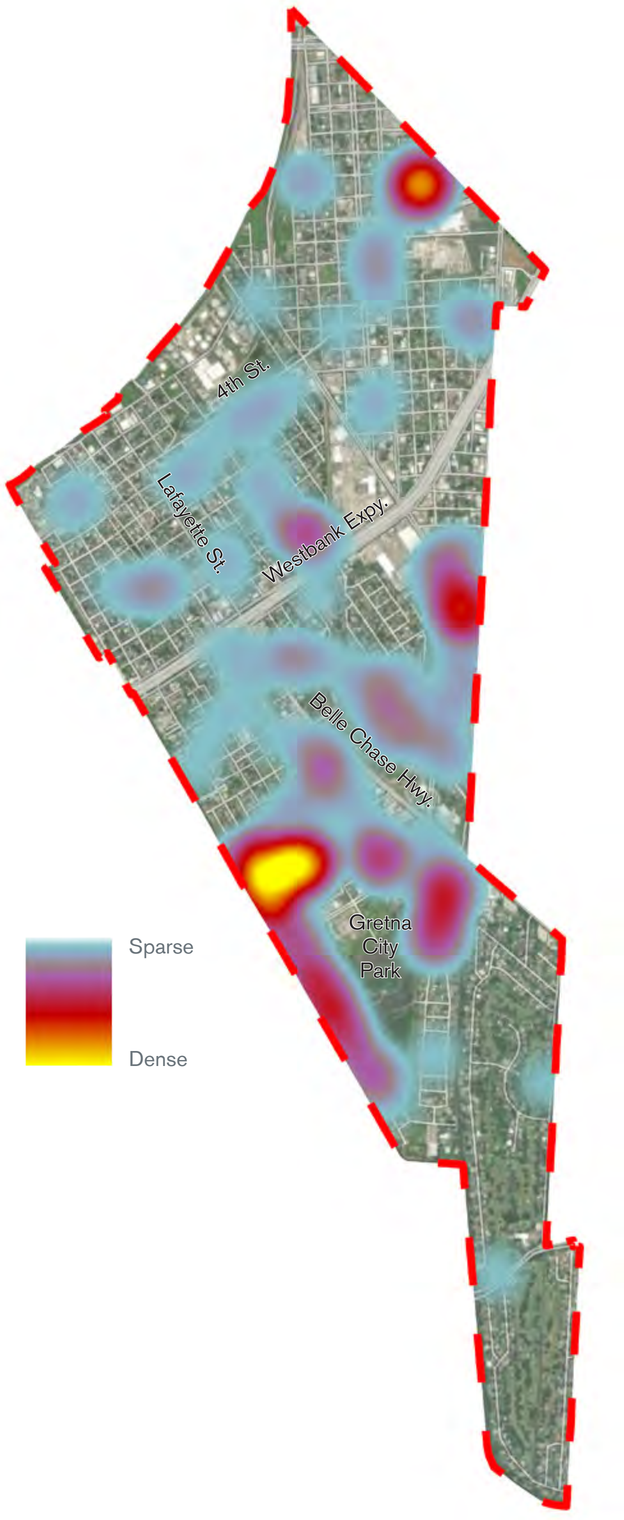
FLOOD ZONES, REPETITIVE LOSS & SEVERE REPETITIVE LOSS

The City of Gretna participates in the National Flood Insurance Program (NFIP). Administered by the Federal Emergency Management Agency (FEMA), the NFIP maintains flood studies for participating communities which affect flood insurance rates for individual properties. FEMA flood zones are generally based on H&H modeling. Flood Zones A and AE, shown on Figure 37 are areas likely to flood in a 100-year storm event. FEMA flood zones provided an additional point of validation for the GSMP flood model.

FEMA Risk Information

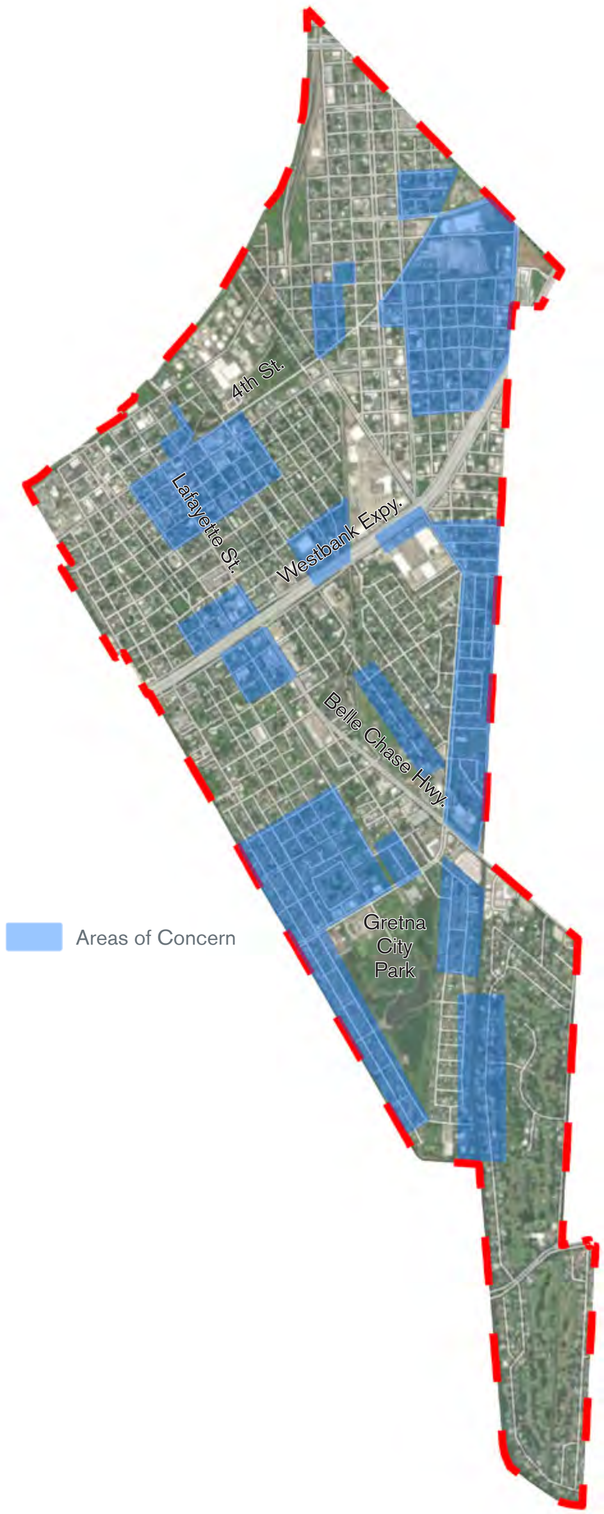
Both the NFIP and Flood Mitigation Assistance (FMA) program identify repetitive loss (RL) and severe repetitive loss (SRL) loss properties based the frequency and size of insurance claims and claims payments for flood-related losses. Due to the sensitive nature of the data, data points for RL and SRL are presented as a heat map in Figure 38. The GSMP team referenced RL and SRL property locations to confirm the accuracy of the flood model and to improve the identification of high-risk areas. Generally, the southwestern portion of the city contains more repetitive loss structures.

Figure 40. Density of repetitive loss and severe repetitive loss properties



Area of Concern Determination & City Coordination

Figure 41. GSMP areas of concern



Once the data points for the RL/SRL, simulated flooded structures, and the roadway flooding were analyzed, the areas that are prone to frequent flooding could be properly identified. The areas of concern were determined by analyzing the distribution of simulated flooded structures, the density of RL/SRL properties, and roadway flooding during and after rainfall events. The FEMA flood zones were also taken into consideration. Any areas that had a large overlap of the multiple data points were considered an "area of concern," and determining these areas allowed for a more focused analysis in flood mitigation measures.

Following CSRS's initial analysis, a charette was held with members of Gretna's staff to review the modeling methodology, preliminary results, and preliminary areas of concern. Input from city officials on recent and planned flood mitigation projects and their local knowledge of historic flood patterns informed updates to the model and revisions to areas of concern affected by flooding. A subsequent charette reviewed final model results and confirmed that identified areas of concern effectively reflect existing flood risk in Gretna. In total, 19 preliminary areas of concern were identified, and these areas of concern can be seen in Figure 39. The Flood Risk Reduction Project Analysis phase of this project generated and evaluated solutions to address the locations identified in this section.

SIMULATED FLOODED STRUCTURES NEIGHBORHOOD

Bellevue

Figure 42. Bellevue 5-year flood event

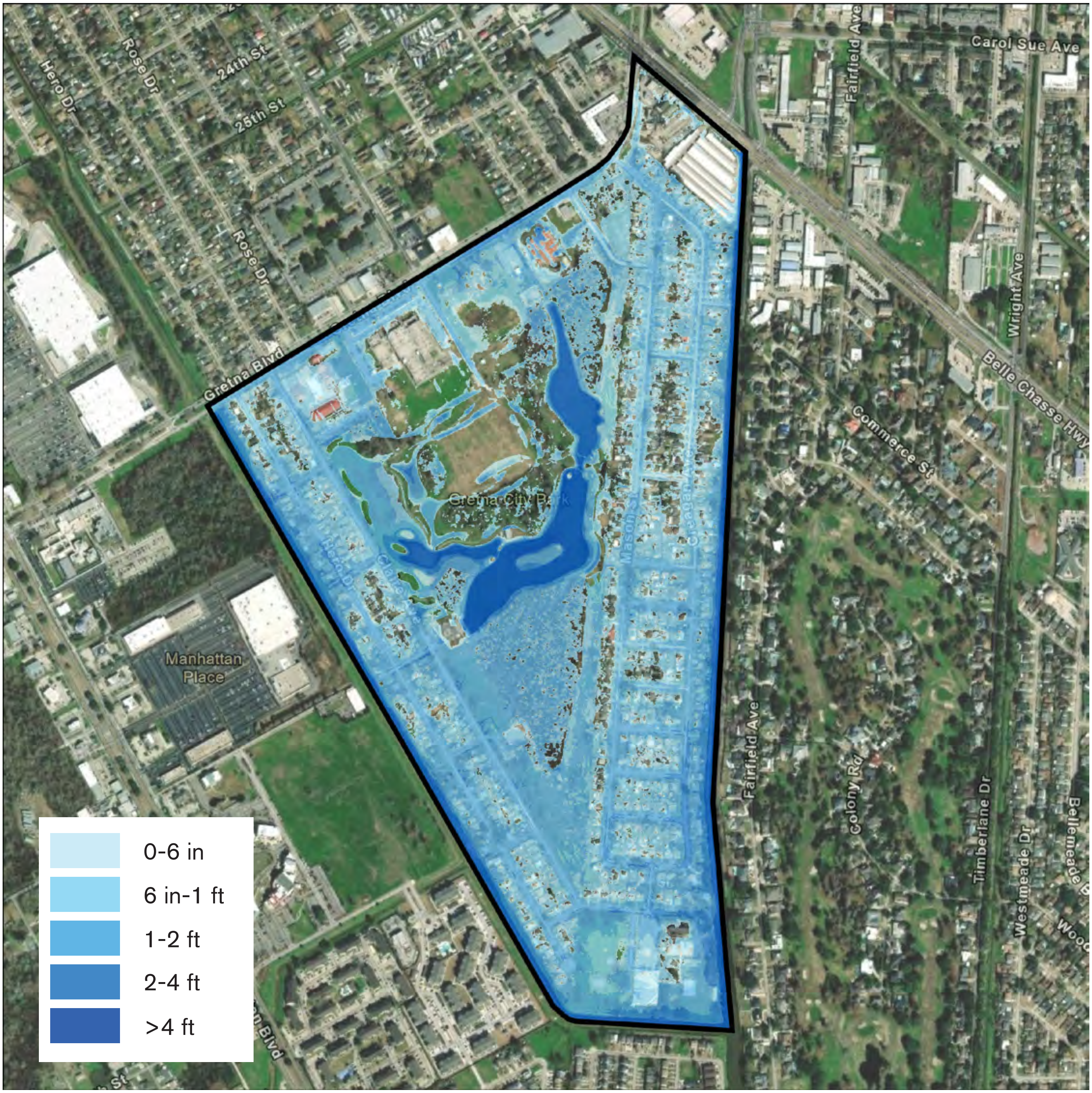


Figure 43. Bellevue 100-year flood event

SIMULATED FLOODED STRUCTURES NEIGHBORHOOD

Jonestown

Figure 44. Jonestown 5-year flood event

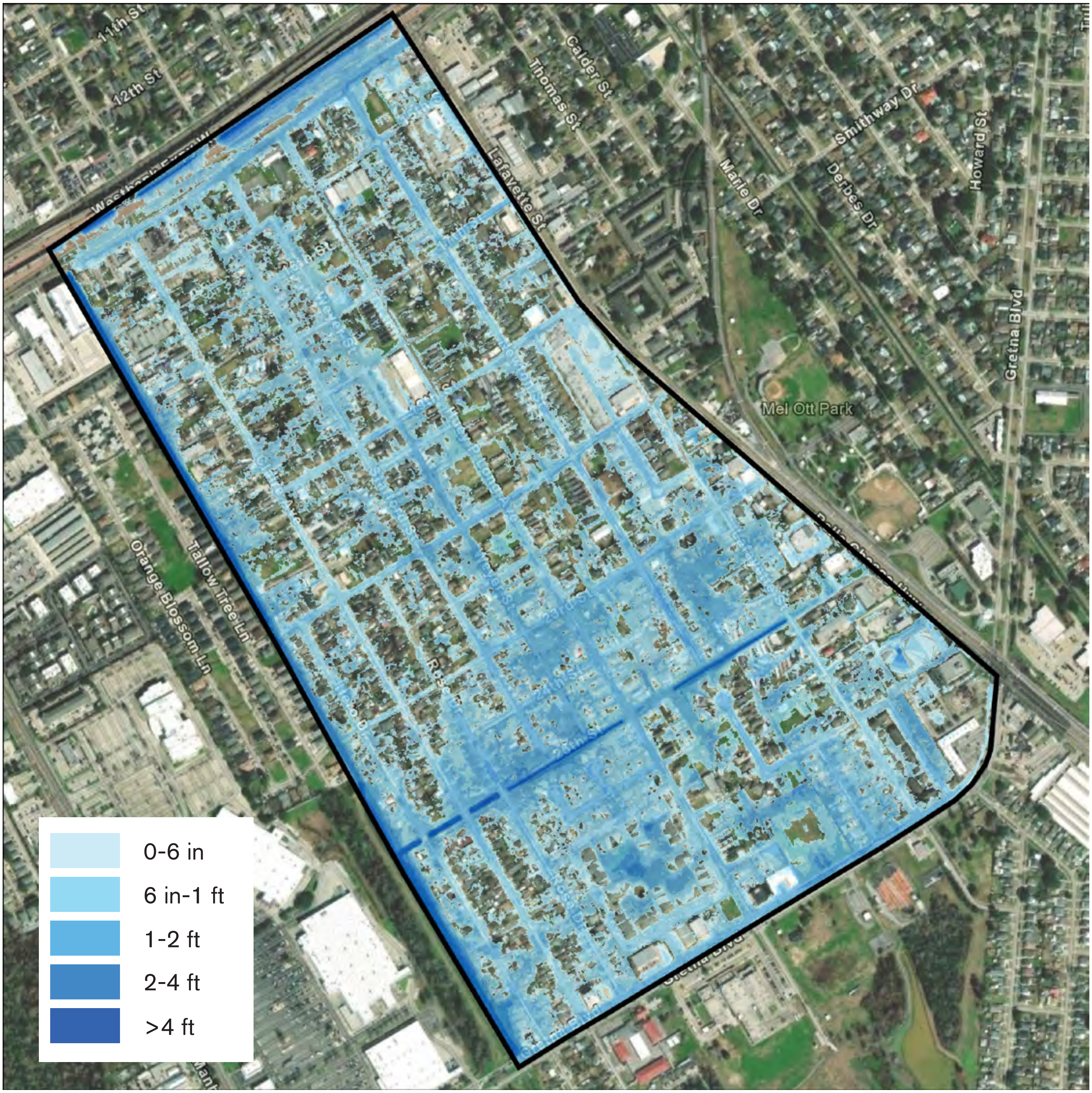


Figure 45. Jonestown 100-year flood event

SIMULATED FLOODED STRUCTURES NEIGHBORHOOD

McDonoghville

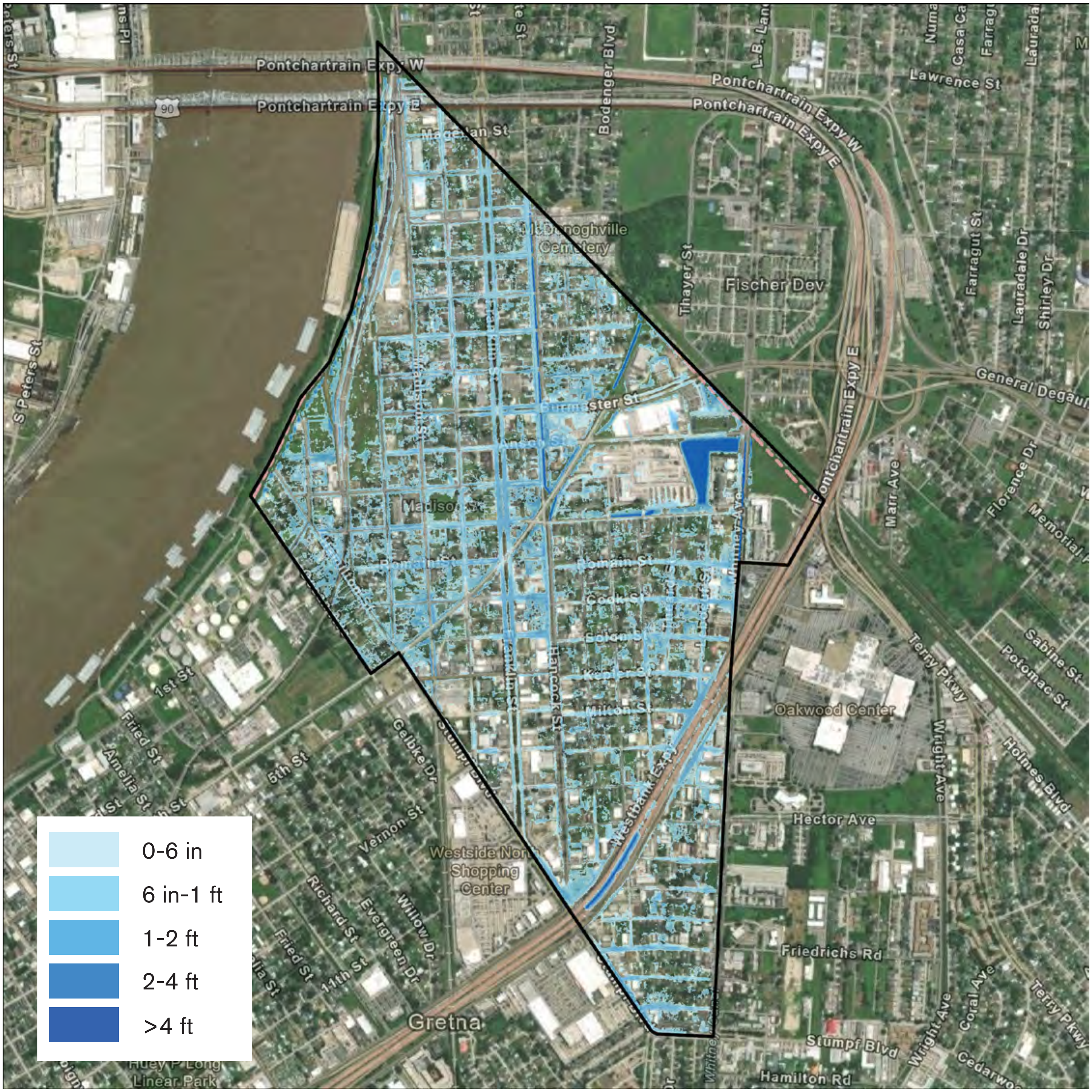


Figure 46. McDonoghville 5-year flood event

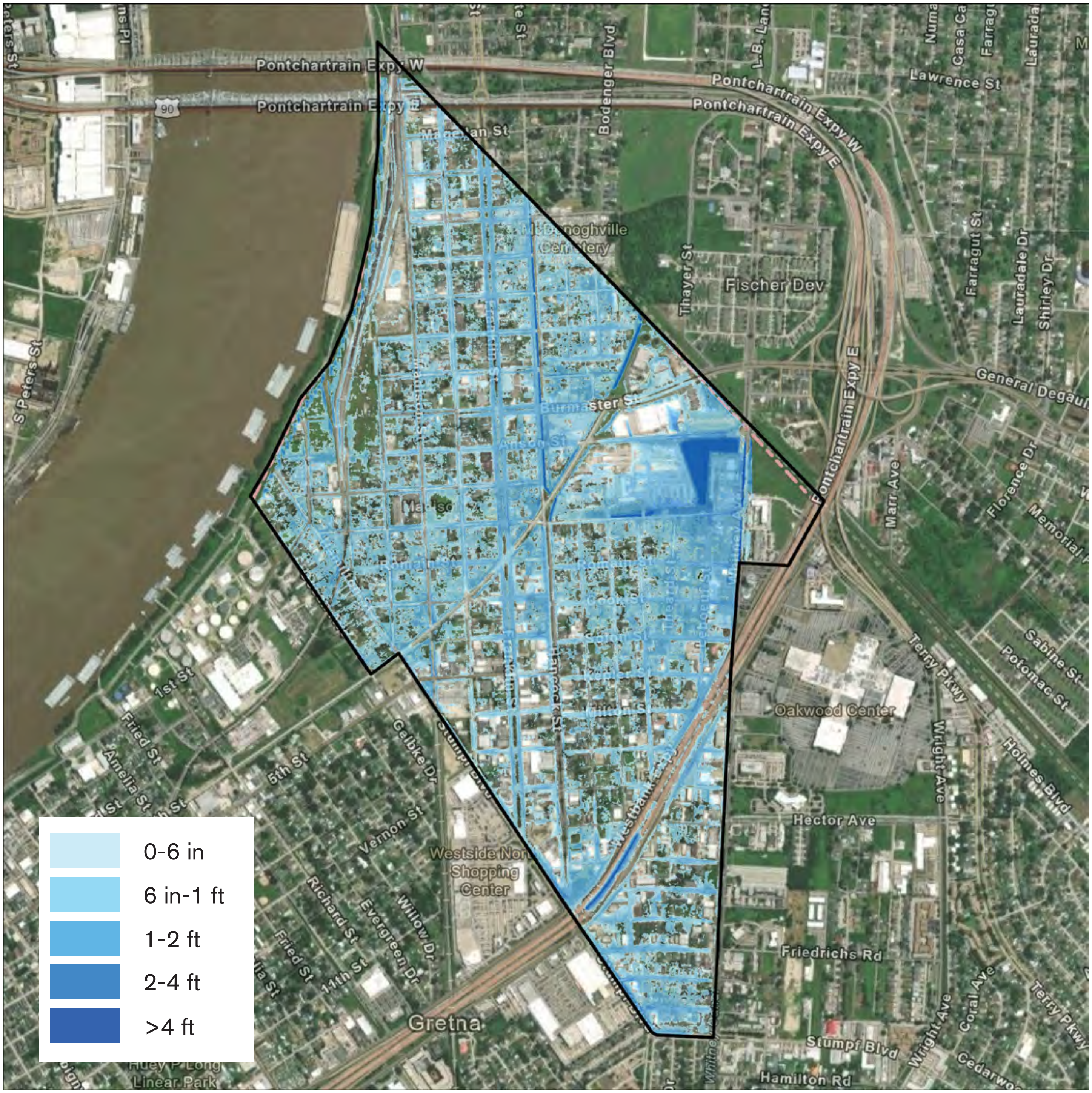


Figure 47. McDonoghville 100-year flood event

SIMULATED FLOODED STRUCTURES NEIGHBORHOOD

New Garden Park

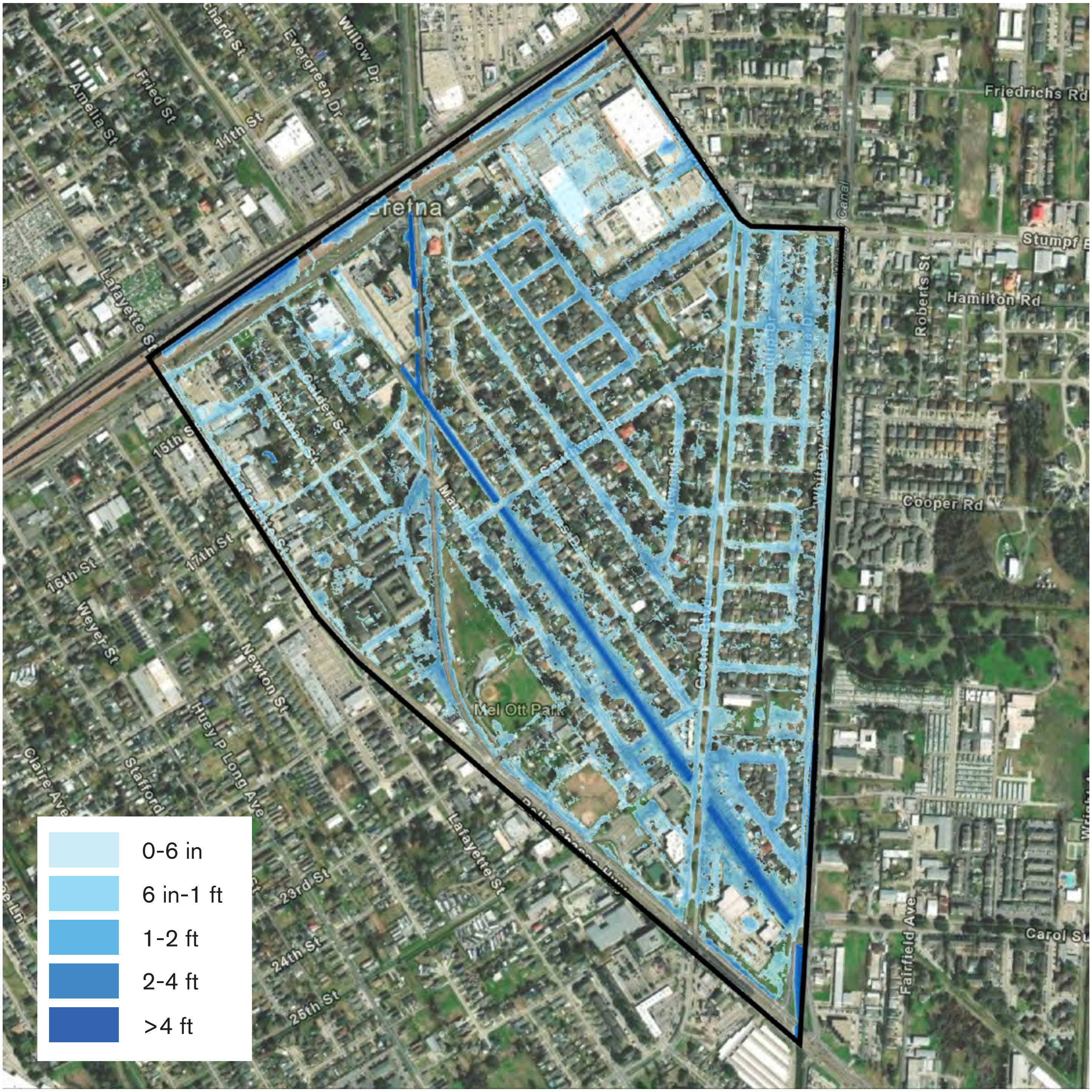


Figure 48. New Garden Park 5-year flood event

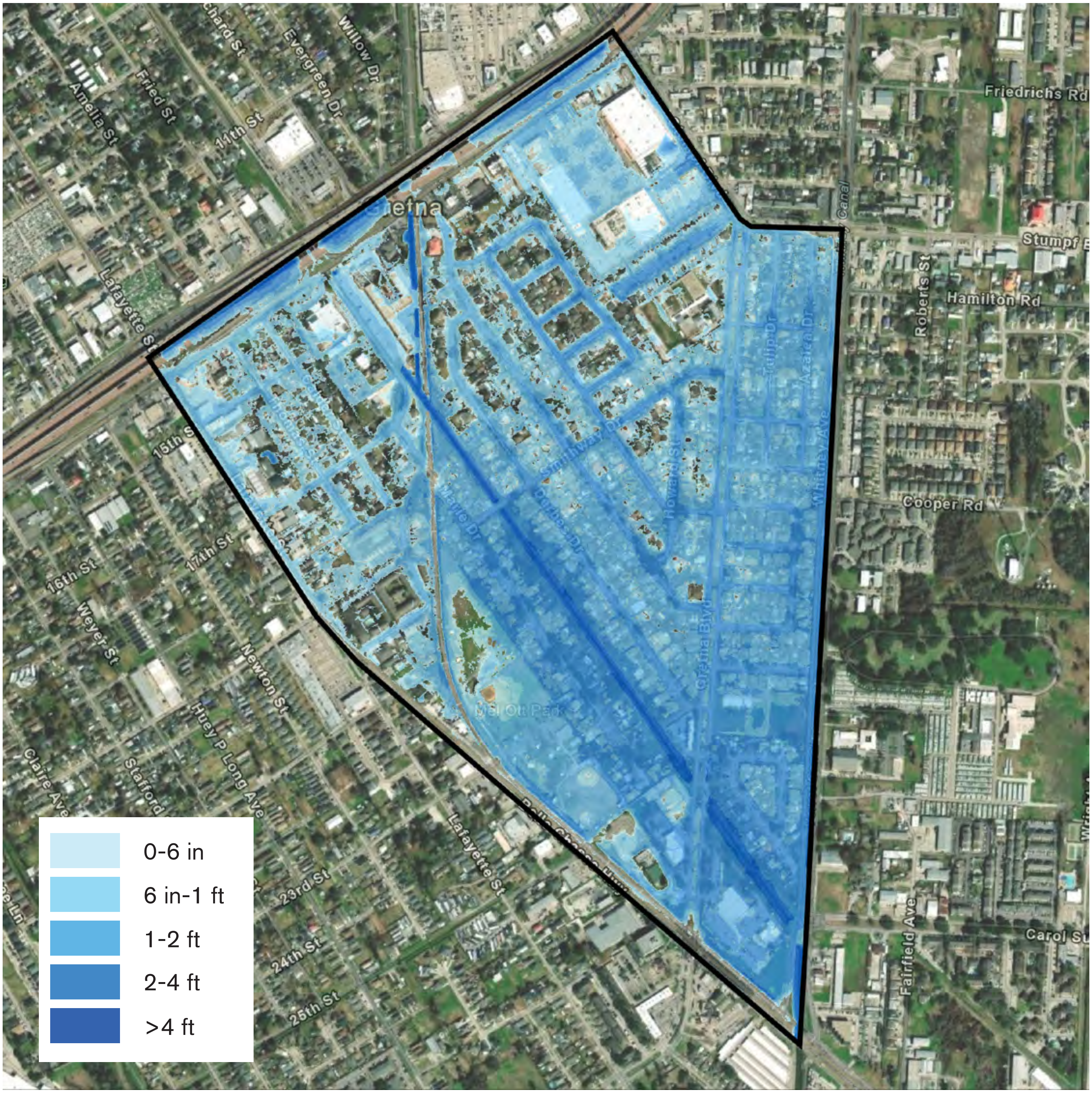


Figure 49. New Garden Park 100-year flood event

SIMULATED FLOODED STRUCTURES NEIGHBORHOOD

Old Gretna - Mechanickham

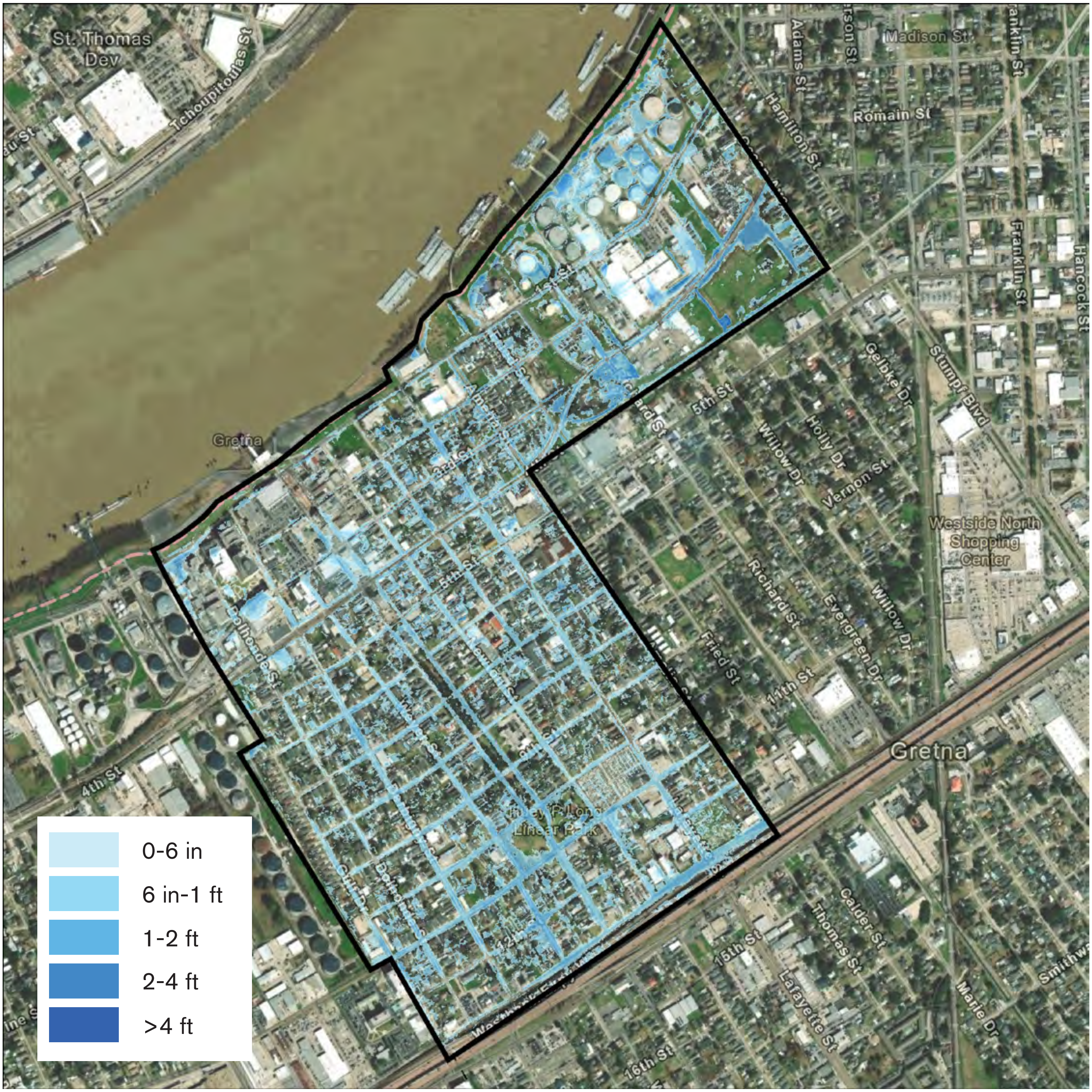


Figure 50. Old Gretna - Mechanickham Park 5-year flood event

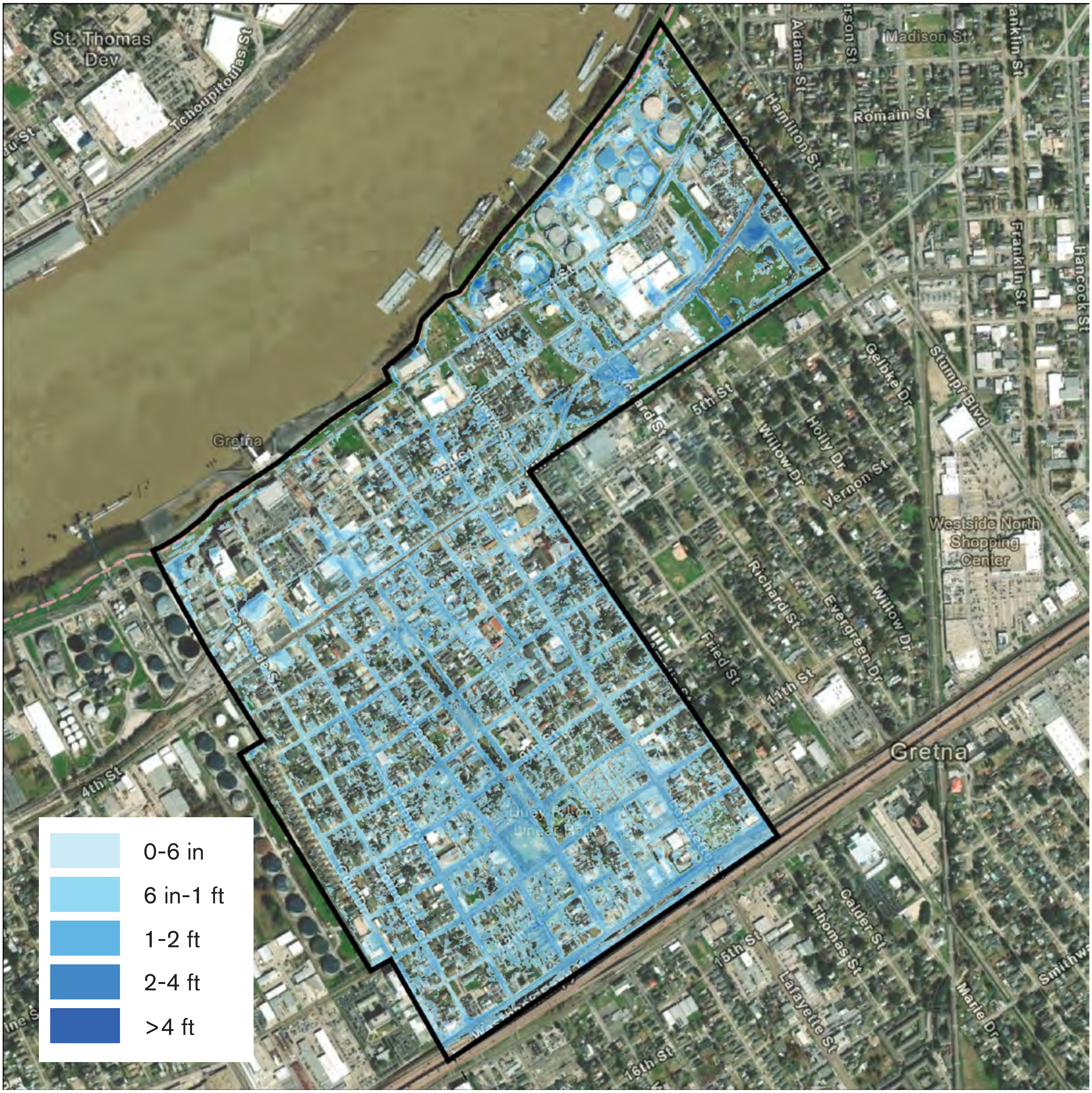


Figure 51. Old Gretna - Mechanickham 100-year flood event

SIMULATED FLOODED STRUCTURES NEIGHBORHOOD

Old Garden Park

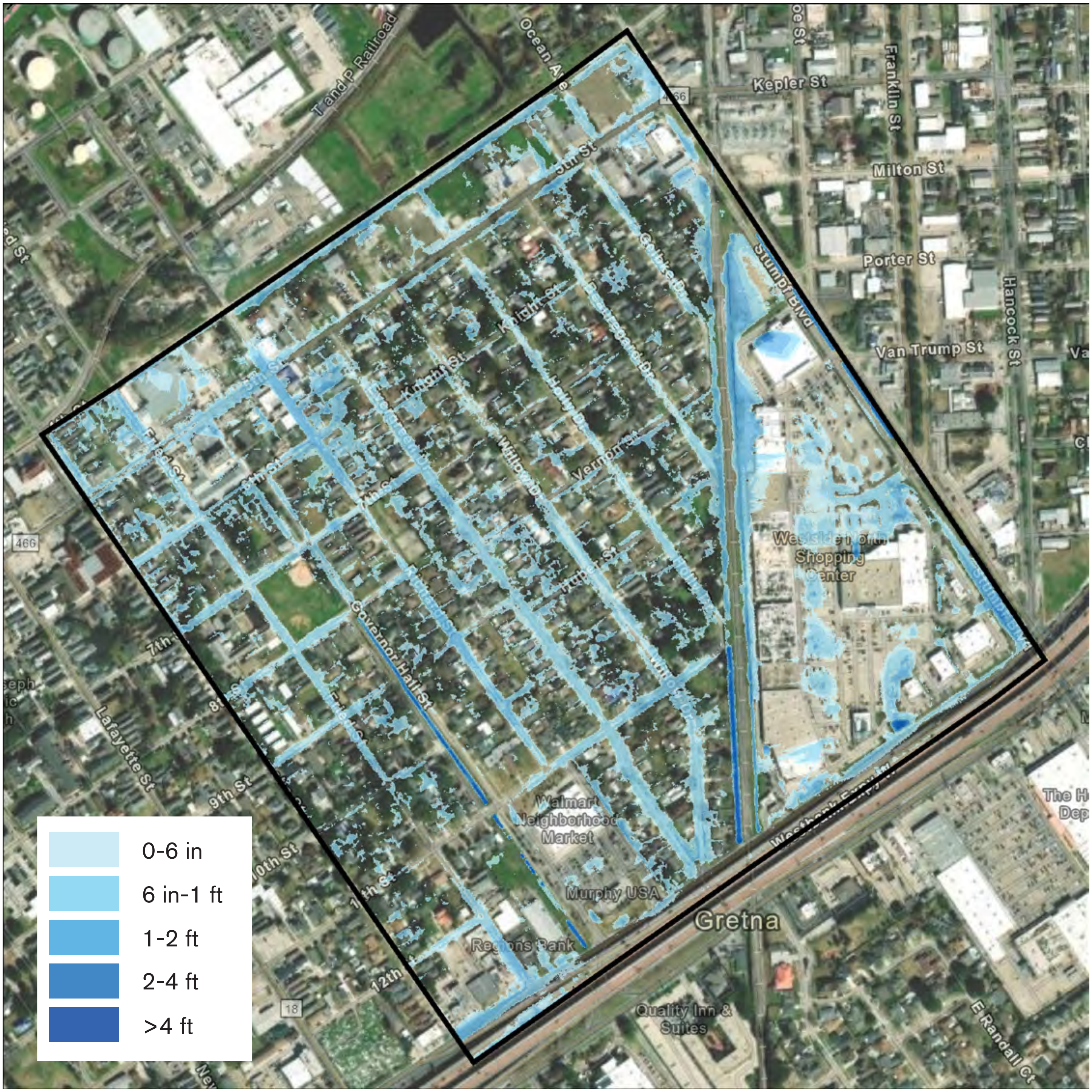


Figure 52. Old Garden Park 5-year flood event

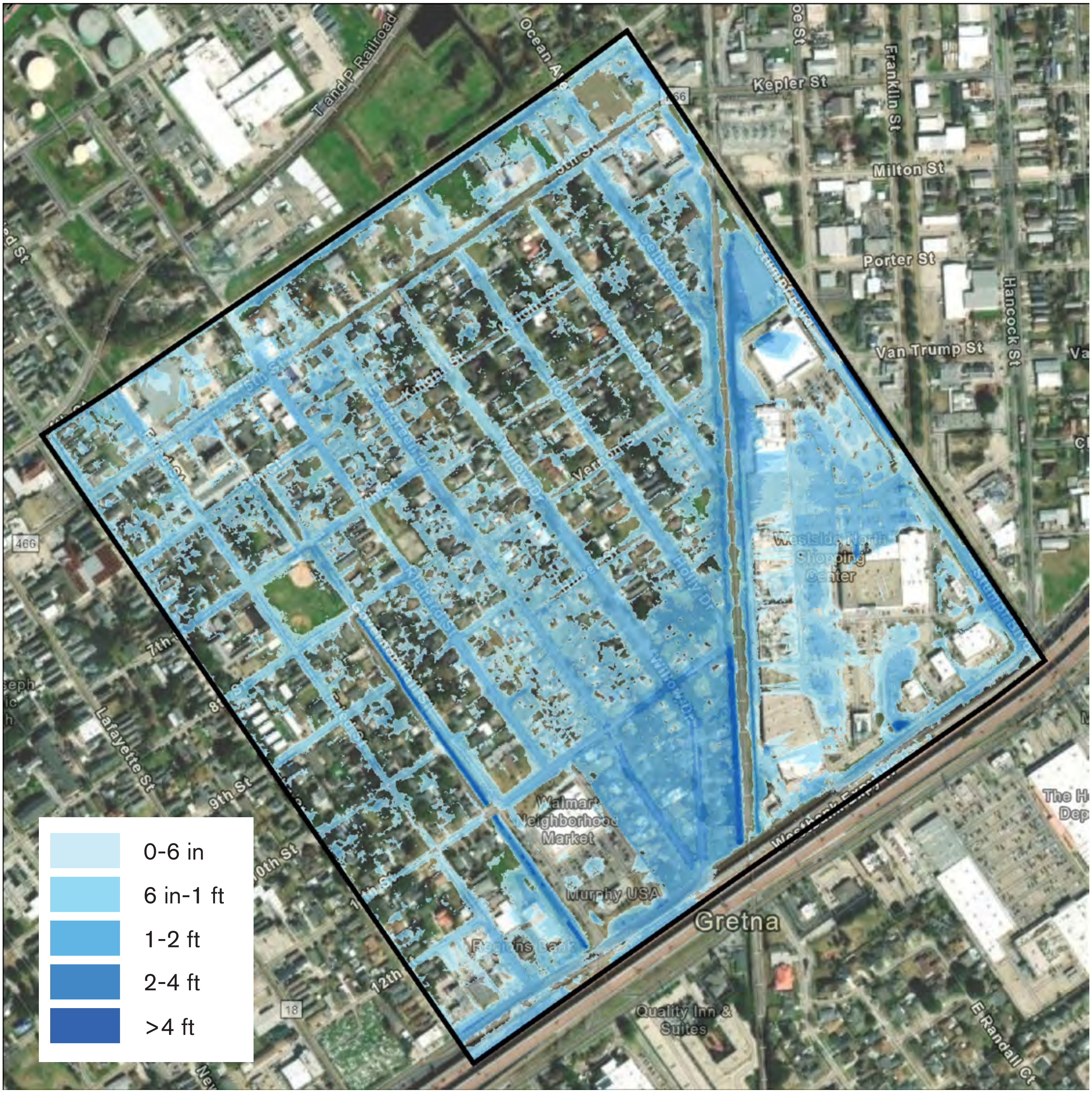


Figure 53. Old Garden Park 100-year flood event

SIMULATED FLOODED STRUCTURES NEIGHBORHOOD

Timberlane

Figure 54. Timberlane 5-year flood event

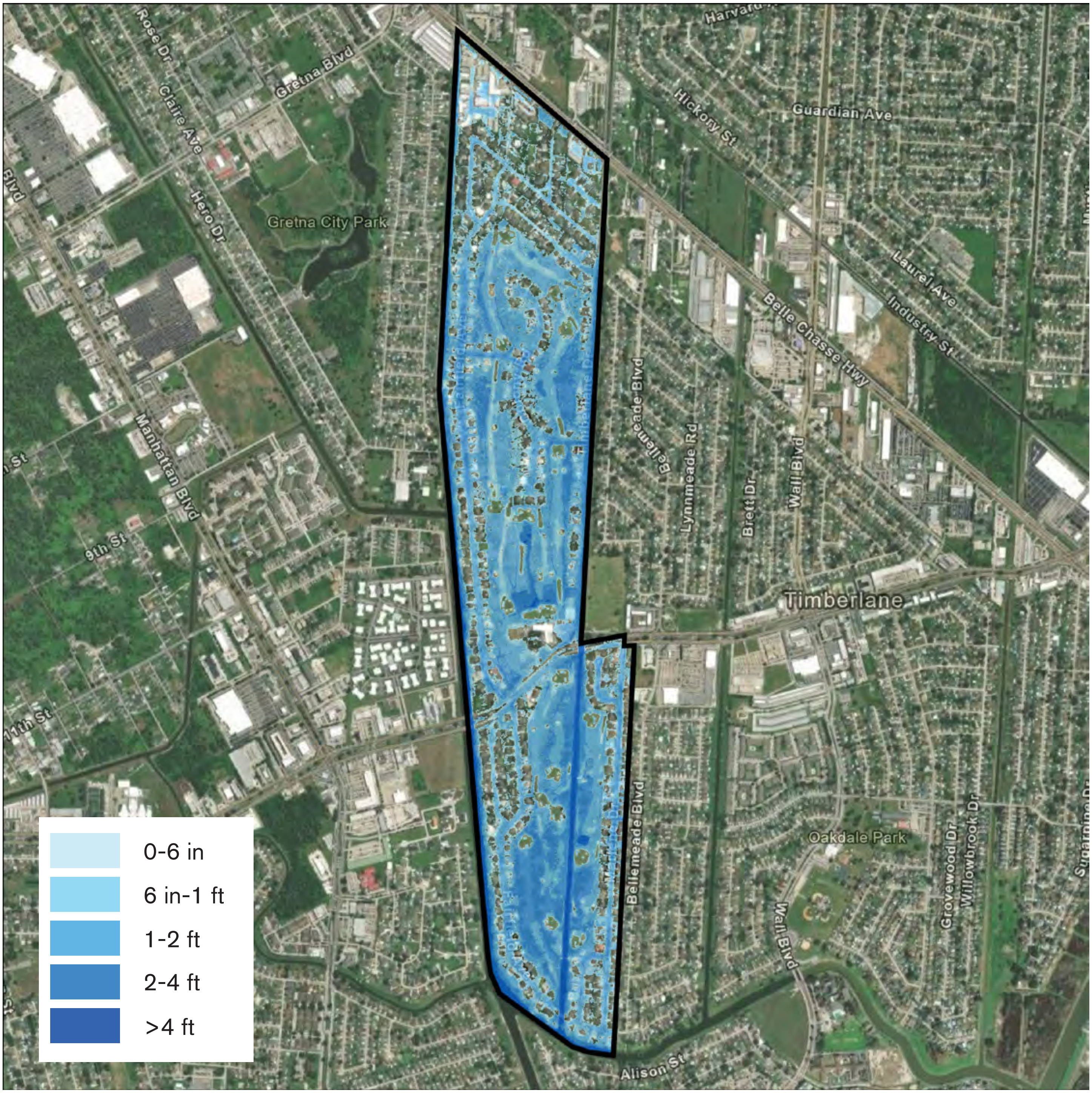


Figure 55. Timberlane 100-year flood event

SIMULATED FLOODED STRUCTURES NEIGHBORHOOD

City of Gretna

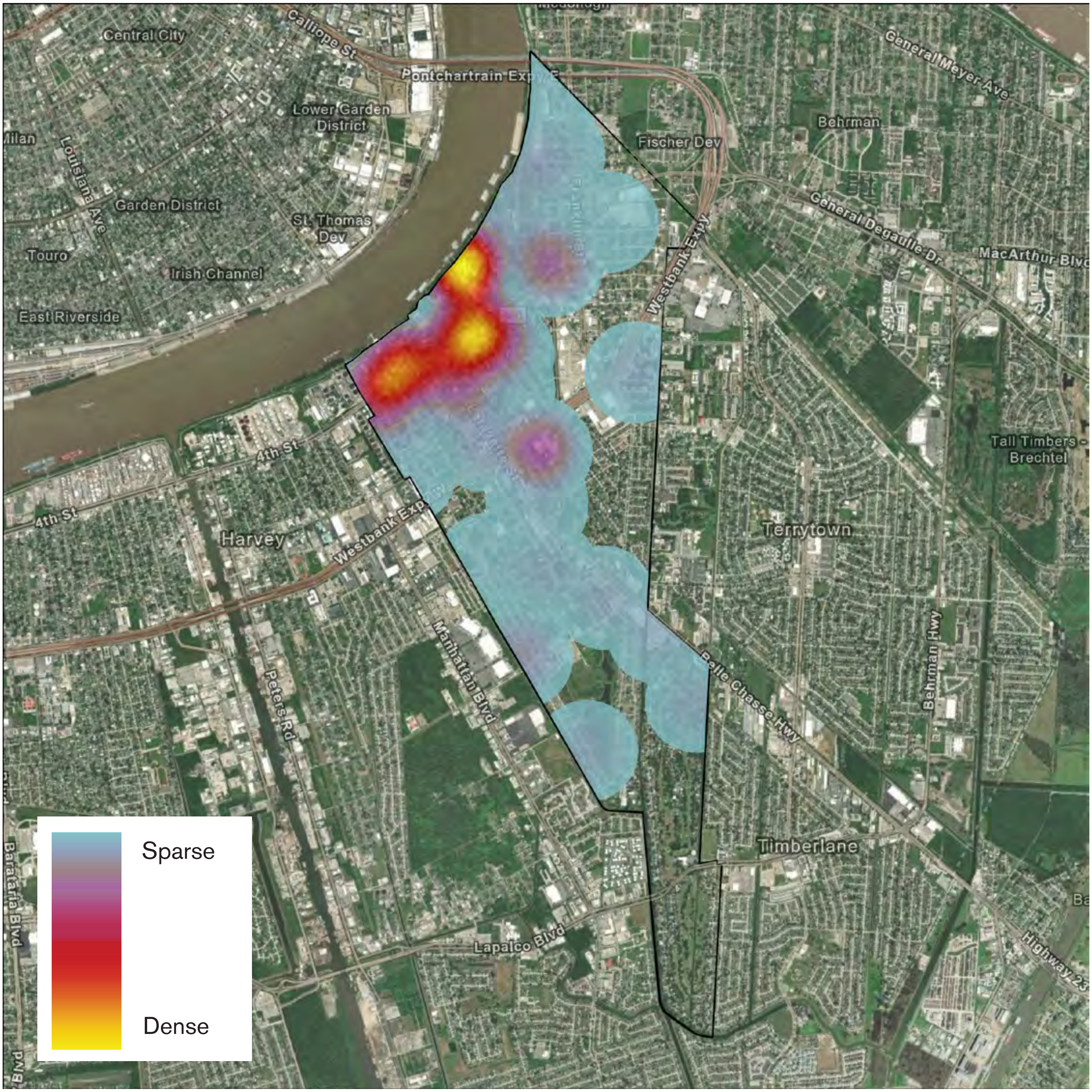


Figure 56. Density of Simulated Structure Damages - City of Gretna 5-Year

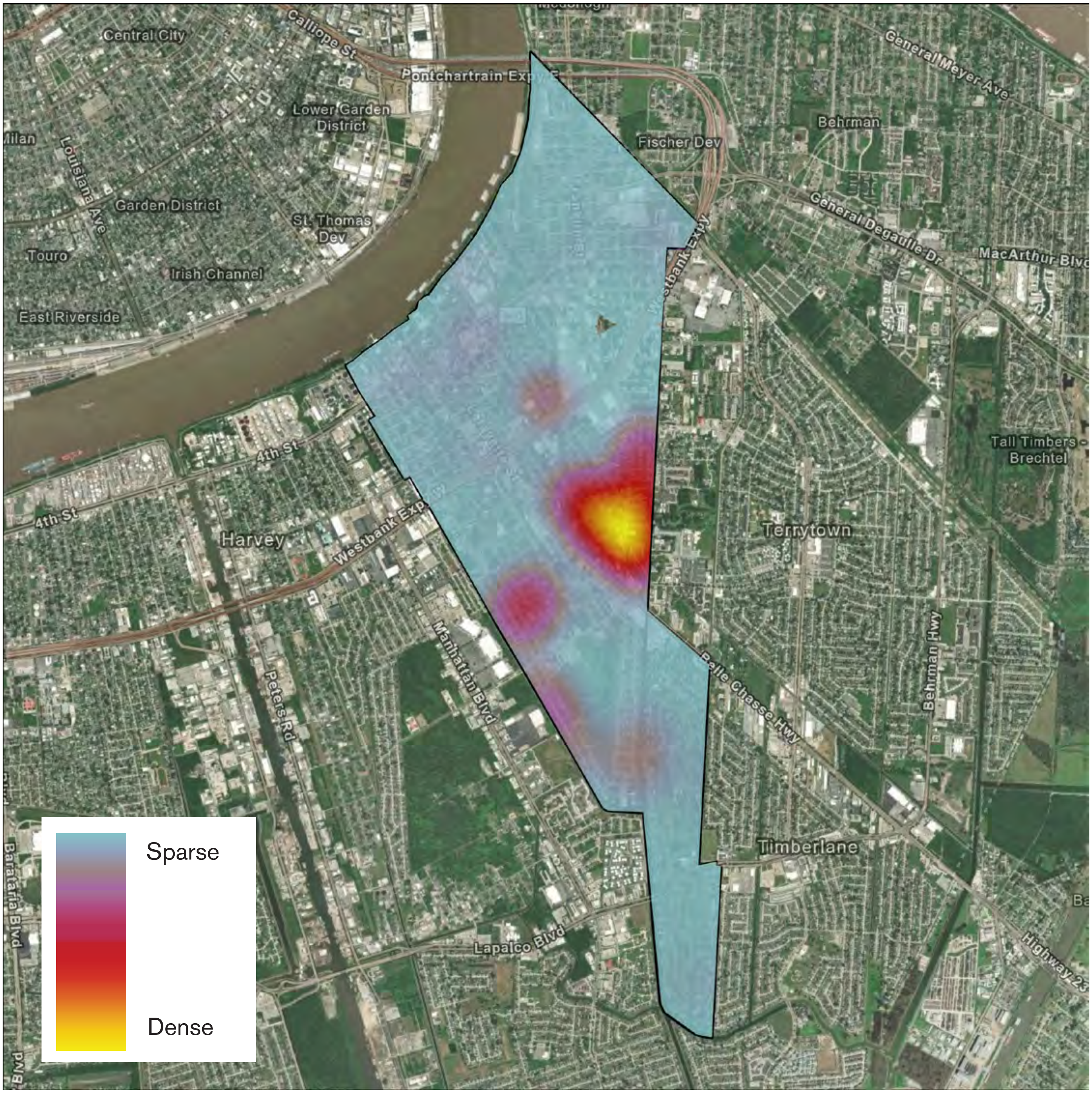


Figure 57. Density of Simulated Structure Damages - City of Gretna 100-Year

| Dana Brown and Associates

GRETNA STORMWATER MASTER PLAN

4. Priority Flood Risk Reduction Projects

4. Priority Flood Risk Reduction Projects

GRETNA, LOUISIANA

GRETNA STORMWATER MASTER PLAN

Introduction

Once the flood hazard risk assessment was completed using the existing conditions model, CSRS presented the results to the City of Gretna. The discussion that followed confirmed that results were valid and reflected real conditions during intense storm events. Discussion about the mitigation measures continued, with the City highlighting two funded projects that are substantially designed: drainage improvements to 5th Street and the addition of a pump station and control structure on the 25th Street Canal at its confluence with Hancock Canal. The City and CSRS agreed that proposed solutions in the GSMP should be evaluated as if these two projects are already constructed. This way, ensuring recommendations are prioritized based on the additional benefit they provide beyond the currently funded projects. CSRS utilized plans produced by BKI to add the 5th Street and 25th Street projects to the existing conditions model to create the "interim conditions" model. The interim conditions model was used as the without project condition throughout risk reduction measure analysis.

Five (5) proposed solution concepts were discussed with the City and were approved to proceed to testing their viability in reducing flood risk. These concepts included: the Gretna Distributed Green Infrastructure Network BRIC & FMA Application (See methodology report for more details), New Garden Park Green Infrastructure Implementation, "Proposed solution to 2nd and Friend", Stumpf Boulevard Diversion & Drainage Improvements, and Non-Structural Solutions. The five projects were then input into the interim condition model and their results were compared to pre-project conditions.

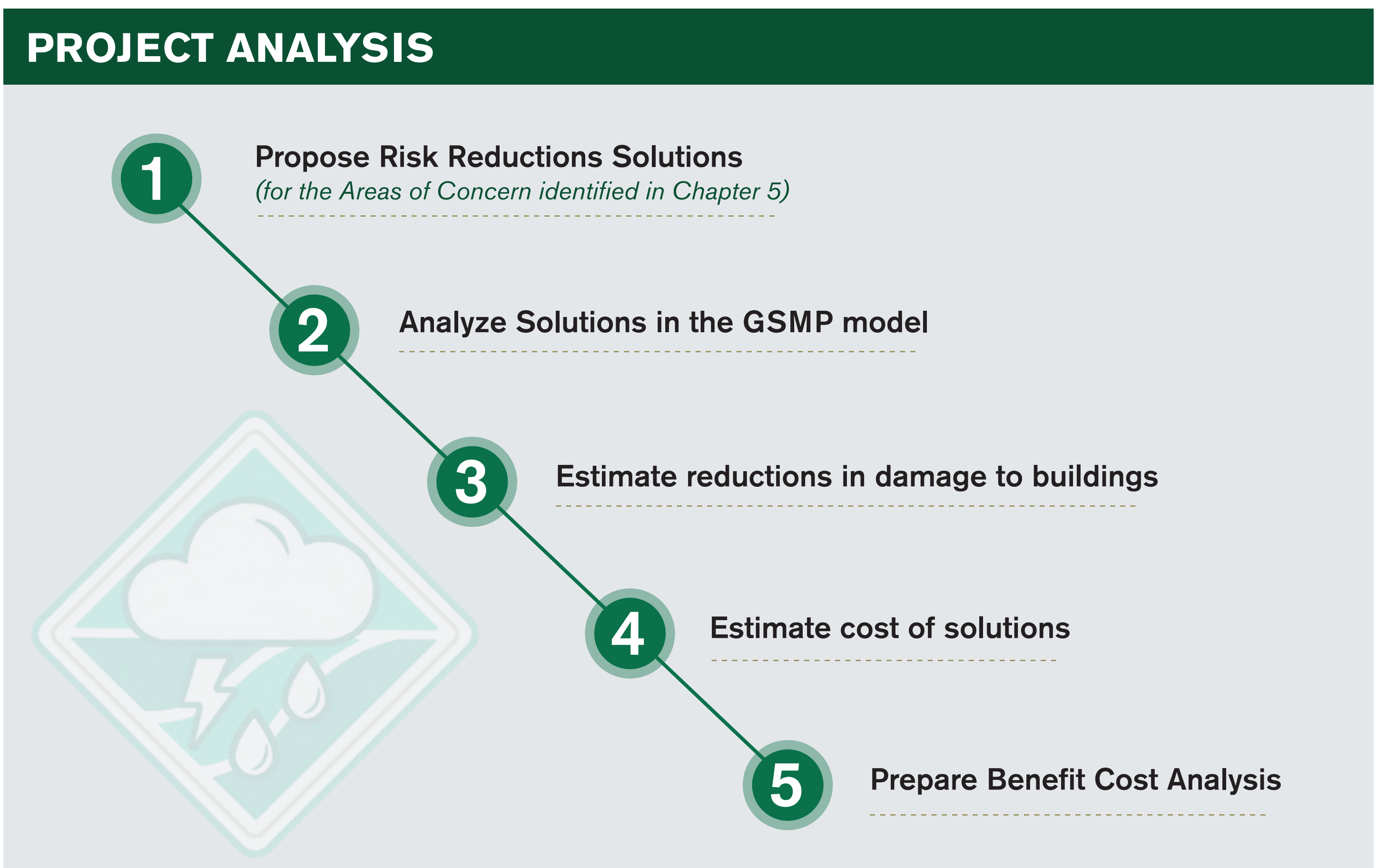


Figure 58. Progression of Project Analysis

Current Projects

As mentioned above, City of Gretna had two (2) projects substantially designed and fully funded at time of analysis. These were added to the existing conditions PCSWMM model to create the "interim conditions" model. This was done so that proposed solutions are prioritized based on the additional benefit they provide beyond the currently funded projects.

LA 466: 5TH STREET IMPROVEMENTS

The first project is LA 466: 5th Street Improvements. This project is designed by BKI and spans from the intersection of 5th Street and Evergreen Drive to the intersection of Kepler Street and Franklin Street (Kepler Street and 5th Street are part of a single alignment). It incorporates the restructuring and resizing of subsurface pipes to more efficiently move water throughout this area. On the surface, there are plans for green infrastructure implementation to detain water in effort to reduce flooding on 5th Street and in the surrounding neighborhood. The green infrastructure of this project was not modeled for the interim condition due to the availability of plans at the time of analysis. As it would likely only add benefits due to additional storage, the interim conditions remain a valid comparison dataset. The green infrastructure should be incorporated into the GSMP model after final design/construction.

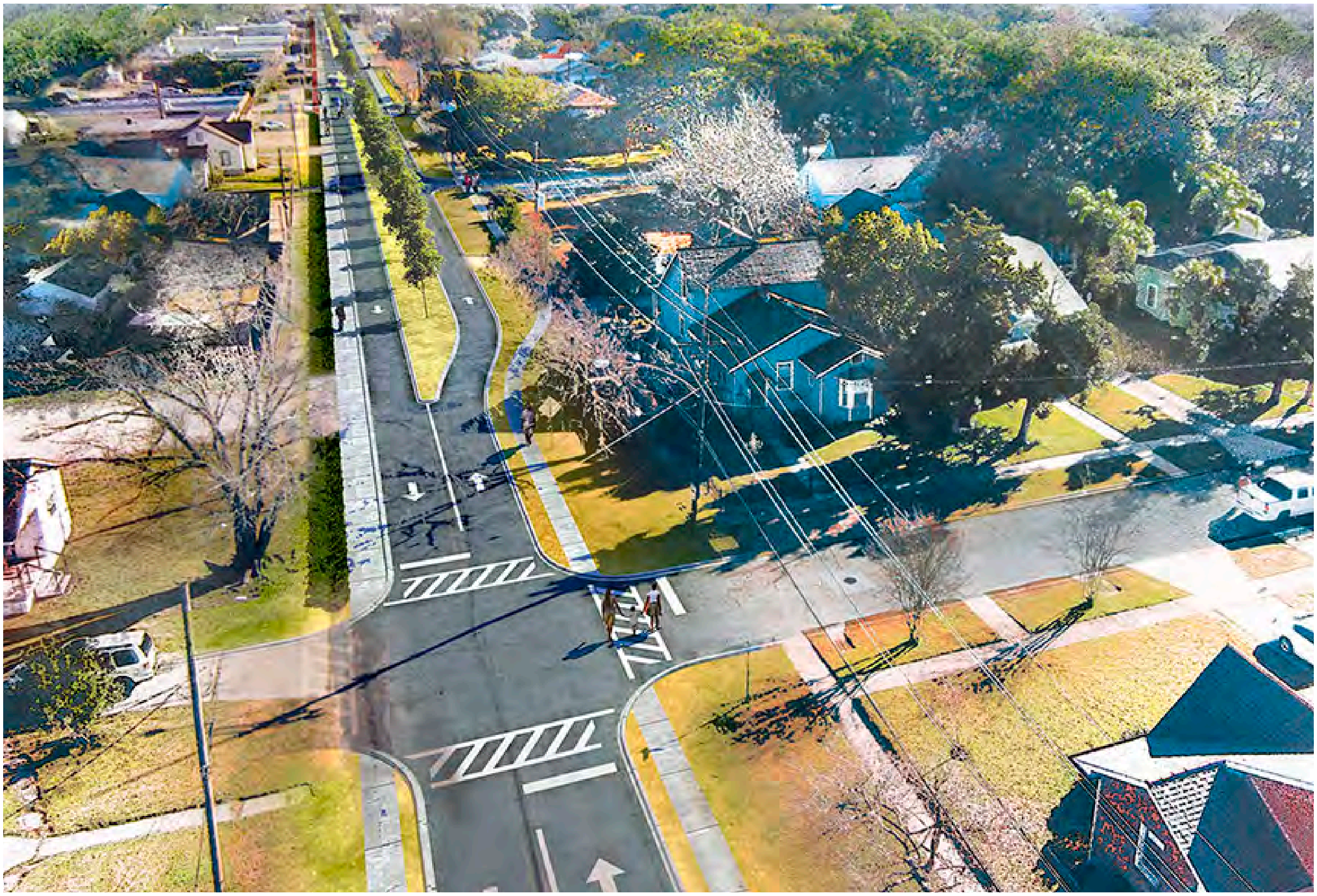


Figure 59. 5th Street Improvements Project Rendering
Source: Dana Brown and Associates

25TH STREET CANAL DRAINAGE IMPROVEMENTS PROJECT

The second project is the 25th Street Canal Drainage Improvements Project. It includes the implementation of a new pump station at the confluence of Hero Canal and 25th Street Canal designed by BKI. The plans also incorporate widening the 25th Street canal from Hero Canal to Rose Drive. The pump station will have three (3) pumps that can convey roughly 125 cfs each totaling 375 cfs of total conveyance. The 25th Street Pump Station project will add flap gates to the outfall culverts both upstream and downstream of the pump station at 23rd and 27th Street, respectively. This will help reduce the backflow from Hero Canal as water levels rise during larger storm events.

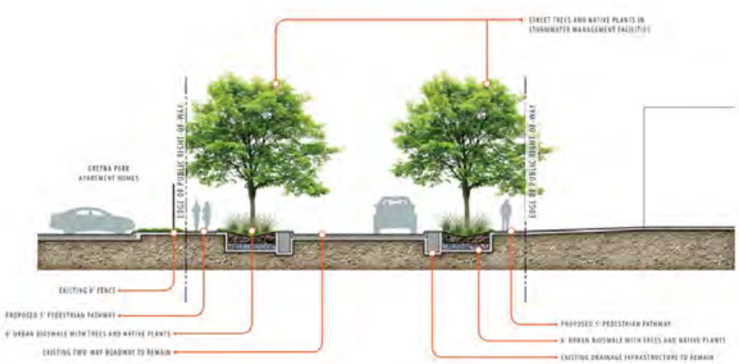
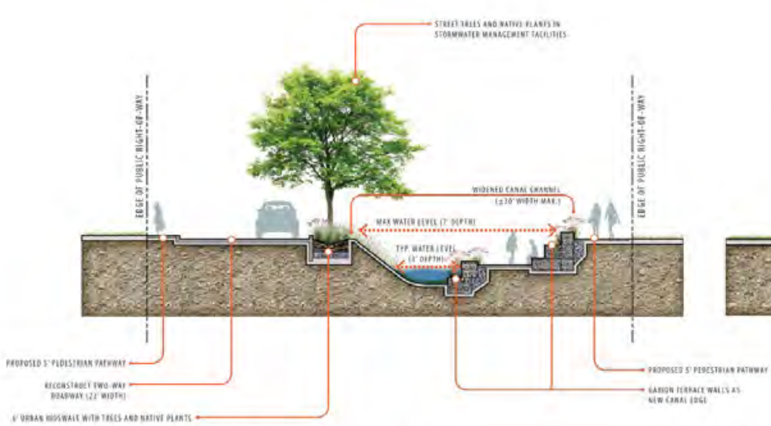


Figure 61. 25th Street canal Drainage Improvements Typical Section
| *Source: Dana Brown and Associates*

Figure 60. 25th Street Canal Drainage Improvements Greenways Layout
| *Source: Dana Brown and Associates*



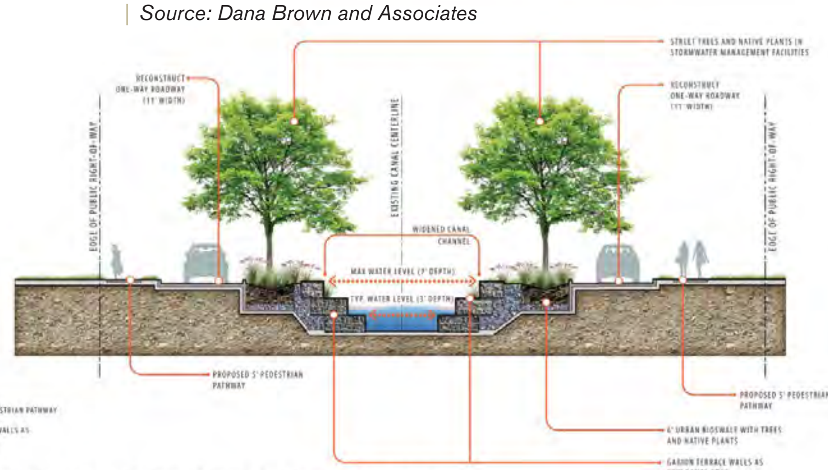


Figure 62. 25th Street canal Drainage Improvements Typical Section
| *Source: Dana Brown and Associates*

Gretna Stormwater Master Plan Projects

With existing risk assessed and the benefits of already-funded projects considered, the GSMP team identified priority flood risk reduction projects to address the areas of concern identified in Chapter 3. The following projects will contribute significantly to the reduction of flood reduction of flood damages in the City of Gretna.

Gretna Green Distributed GI Network

For the Gretna Green Distributed GI project, CSRS worked in conjunction with Dana Brown & Associates to develop Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA) applications in February 2024 that focused on green infrastructure solutions for the McDonoghville, Old Garden Park, and Old Gretna-Mechanickham neighborhoods. The green infrastructure practices that were implemented included bioswales, pervious pavers, engineered soils, channel improvements, and detention ponds. More information can be seen in Attachment 3 - Technical Memorandum, H&H Study, & Cost.

For Gretna Green GI, the calculations for the storage areas and storage depths, green infrastructure placement, and channel widening dimensions were all provided by Dana Brown and Associates, Inc. (DBA). CSRS took this information and implemented it into the PCSWMM model to obtain the results needed for a Benefit Cost Analysis (BCA). As the entire process was documented in the BRIC and FMA applications, please see Attachment 3.

The cost estimate for the Gretna Green GI project was developed by Dana Brown and Associates, Inc. (DBA). Maintenance will be more expensive in the short-term as the plants need time to establish roots. Once the plants are well established, annual maintenance costs will decrease significantly. Maintenance cost for Gretna Green GI was also provided by DBA.
All details pertaining to the cost estimate for this project can be seen in Attachment 3.

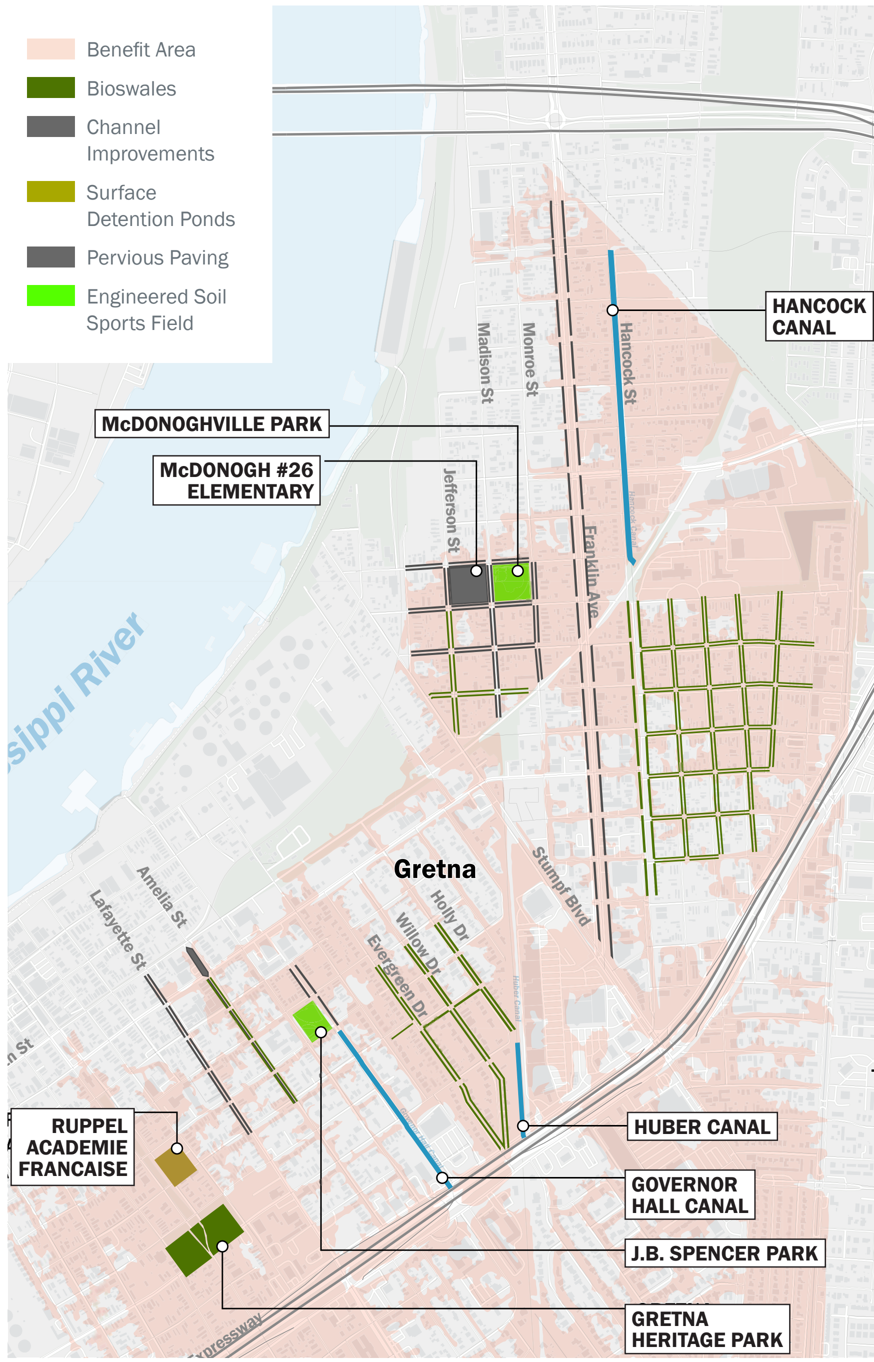


Figure 63. Gretna Green Project Layout
Source: Dana Brown and Associates

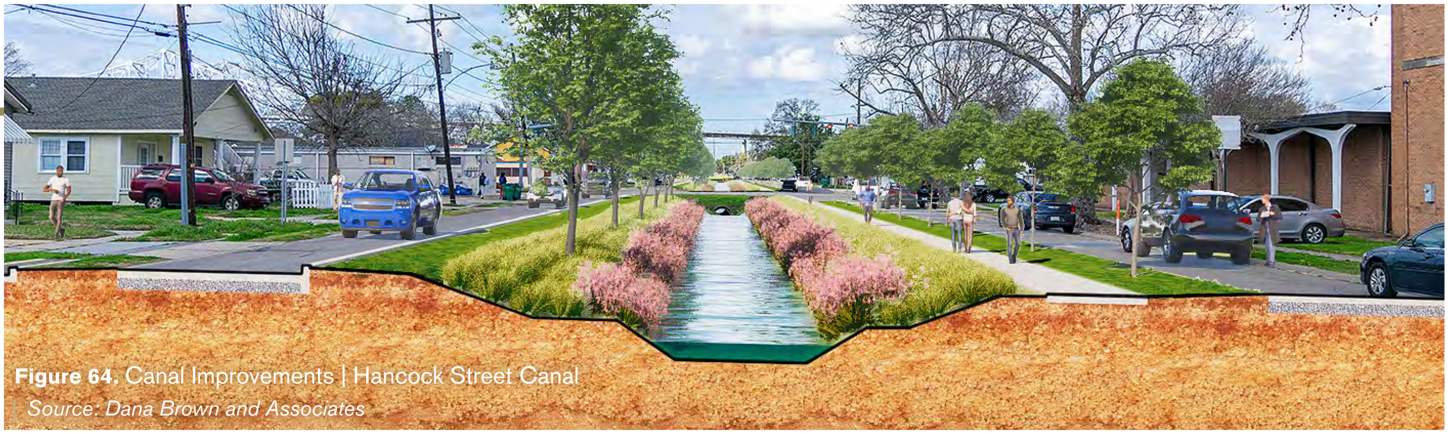


Figure 64. Canal Improvements | Hancock Street Canal
Source: Dana Brown and Associates

Figure 65. Pervious Paving | Franklin Street & Virgil Street
Source: Dana Brown and Associates

Figure 66. Bioswales | Holly Street
Source: Dana Brown and Associates

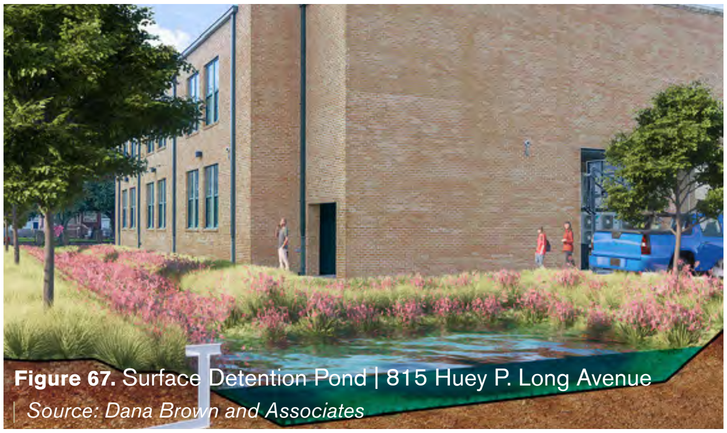


Figure 67. Surface Detention Pond | 815 Huey P. Long Avenue
Source: Dana Brown and Associates

Figure 68. Engineered Soils Sports Field | Governor Hall Street
Source: Dana Brown and Associates

Amelia Street to Stumpf Boulevard Improvements

When discussing which areas could benefit from stormwater mitigation, the Mayor and Councilman Hinyoub expressed their concerns about Fried Street near its intersection with 2nd Street along with Ocean Avenue and Hamilton Street near 4th Street. They reported a flood issue which includes deep, standing water on Fried Street and in residents' front yards just south of 2nd Street. They also reported water pooling on the north side of 4th Street between Amelia Street and Fried Street. Ocean Avenue and Hamilton Street were experiencing similar issues on the western side of each street just north of 4th Street. The City Engineer additionally provided design plans for drainage improvements along 5th Street near the Ocean & Hamilton issues. The improvements are included in the 5th Street Improvements project from LADOTD.

After an analysis of the hydraulics of the area, the GSMP team identified three actions to reduce flooding in these areas. The first recommendation is to ensure the 5th Street Improvements project is constructed without causing adverse flooding impacts. The GSMPM model should be used to test this project for impacts, and revisions should be requested to address any issues found. The Ocean Avenue and Hamilton Street areas drain southward though this area and share a common outfall with the section of 5th Street which will be improved. The next two recommended actions are the installation of two (2) detention ponds to directly address flooding in the problem areas. The first detention pond is located at Fried Street near its intersection with 2nd and 3rd Street, and the second pond is located just north of 4th Street and west of Ocean Avenue. The location and extents of the 5th Street Drainage Improvements project and each proposed detention pond can be seen in Figure 67.

To implement the two ponds into the model, CSRS assumed a 4.5 foot depth for the pond located along Fried Street and a 5-foot depth for the pond along 4th Street. This will create roughly 10,500 and 14,600 cubic yards (cuyd) of additional storage, respectively. Control structures at the downstream ends of both detention ponds will need to be put in place to help reduce the overflowing of the detention ponds. Plans for the 5th Street Drainage Improvements project were provided to CSRS and input into the model before the analysis of the ponds to ensure that the benefits of the projects complement one another.

Excavation is the primary driver of cost for the proposed detention ponds. A 30% contingency was included to incorporate other elements, such as the control structures , as they are defined in detailed design. The full cost estimate can be seen in Attachment 4: Cost Estimate – Amelia Street to Stumpf Boulevard Improvements.

For Amelia Street to Stumpf Boulevard Improvements, maintenance costs were determined by calculating 10% of the total construction costs - a standard practice for estimating costs. Annual maintenance was calculated by taking the total maintenance cost and dividing by the project life (50 years). Maintenance for this project would include upkeep by the City to keep the control structures free of blockage by debris or sediment.

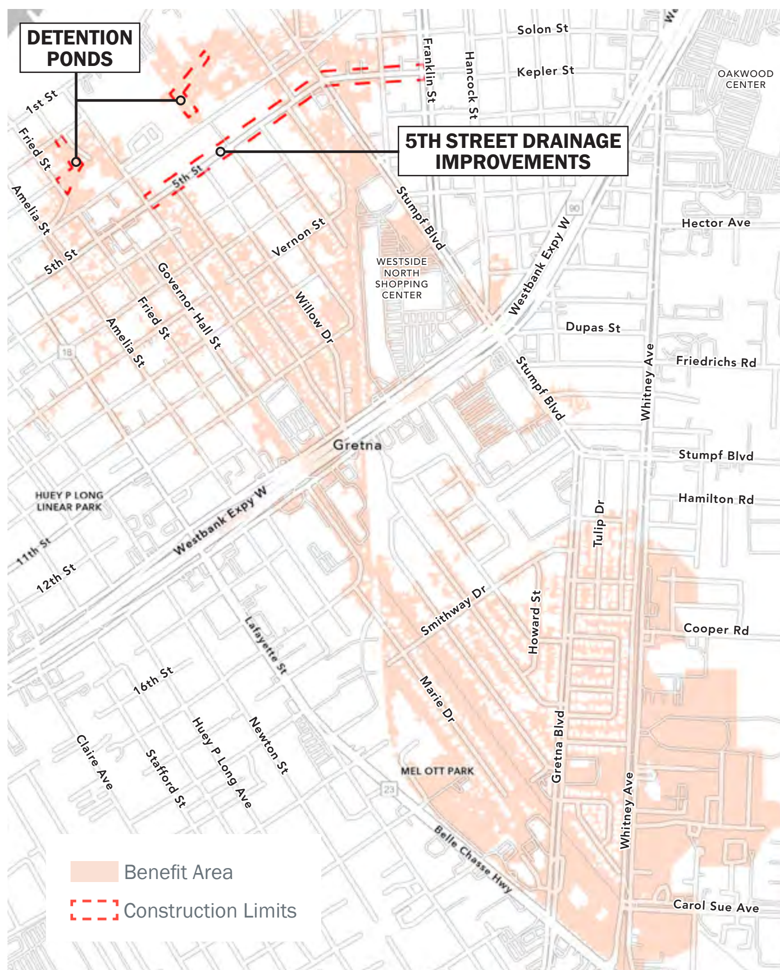


Figure 69. Amelia to Stumpf Project Layout

New Garden Park Green Infrastructure Implements

The New Garden Park Green Infrastructure Implementation project is designed to utilize green infrastructure in the New Garden Park neighborhood to mitigate flood risk similar to the Gretna Green GI project developed for the BRIC and FMA applications. The project itself uses four (4) types of green infrastructure to achieve this: bioswales, pervious pavers, engineered soils, and detention ponds. These types of green infrastructure are placed throughout the New Garden Park neighborhood, and detention ponds are proposed in areas already owned by the City of Gretna. More information can be seen about this project in Attachment 5: Project Summary Sheet – New Garden Park Green Infrastructure Implementation.

Because the New Garden Park Green Infrastructure Implementation project is very similar to the Gretna Green GI project, similar methods were used when implementing the project into the model. CSRS was able to use the data provided by DBA to estimate storage volumes for each proposed green infrastructure component. For bioswales, 3 feet of storage was modeled with 1-foot of freeboard, totaling 4 feet of total depth of storage. Pervious pavers were modeled with a total 4-foot depth of storage. Engineered soils were modeled with 1 foot of storage and were setup to be highly pervious. Lastly, detention ponds were modeled with 4 feet of storage. Green infrastructure implementation was considered for the entire area of New Garden Park. For more information refer to Attachment 5.

Surface area and depth of each green infrastructure implementation were considered when calculating the cost. From DBA's cost estimate, CSRS was able to determine a cost per square foot for four (4) of the green infrastructure implements required for this project: bioswales, pervious pavers, engineered soils, and detention basins. Once totals for the cost per square foot were determined, CSRS used in house tools to determine Engineering and Design Costs (EDC). The full cost estimate can be seen in Attachment 5.

Maintenance costs for New Garden Park Green Infrastructure Implementation projects will be more expensive in the short-term as the plants needs time to establish roots. Once the plants are well established, annual maintenance costs will decrease significantly. Maintenance costs for New Garden Park Green Infrastructure Implementation was calculated by using life-cycle maintenance costs per square foot of each intervention type from Gretna Green GI and multiplying them by the area of the New Garden Park GI components.

Figure 70. New Garden Park Green Infrastructure Layout

Stumpf Boulevard Drainage Improvements

The City of Gretna and the City Engineer had previously discussed the potential of adding subsurface drainage culverts that connect from Stumpf Boulevard to Whitney Canal. The three selected streets - Friedrichs, Hawkins, and Aquavit - are in a flood-prone area. The City reported that water flowing down Stumpf Boulevard continues onto Gretna Boulevard, exacerbating flooding in the New Garden Park neighborhood. More details on this project can be seen in Attachment 6: Project Summary Sheet - Stumpf Boulevard Diversion & Drainage Improvements.

To model the Stumpf Boulevard Diversion, three (3) twin 5'x3' concrete box culverts were input into the PCSWMM model. The culverts connected Stumpf Boulevard to Whitney Canal via Friedrichs, Hamilton, and Aquavit Street. This new connection to Whitney Canal allows Stumpf Boulevard to more quickly convey water to the canal. It reduces the overloading of Stumpf Boulevard that can occur during smaller storm events, and it reduces the surface flow down Gretna Blvd in larger events. For more information on this project refer to Attachment 6.

Figure 71. Stumpf Boulevard drainage improvements project location and benefit area

To develop a rough order of magnitude cost estimate for Stumpf Boulevard Diversion & Drainage improvements, CSRS utilized the latest bid history from the Department of Transportation and Development (DOTD) to determine the cost per linear foot of the to-be-installed culverts. CSRS used in-house tools to determine other components of the cost estimate such as pavement removal and replacement, removal of existing drainage pipes, and the installation of drainage structures (inlets, manholes, etc.). The full cost estimate can be seen in Attachment 6.

For Stumpf Boulevard Diversion & Drainage Improvements, maintenance was determined by taking 1% of the total construction costs. Annual maintenance was calculated by taking the total maintenance cost and dividing by the project life (50 years). Maintenance for this project would include upkeep by the City to keep the culverts free of blockage by debris or sediment.

Priority Elevation Program

While flood damages can be mitigated through structural capital projects, some buildings will remain at risk. To address this, the GSMP teams identified residential buildings which should be prioritized for structure elevation. The GSMP model results were analyzed to identify which structures remain at risk of flooding in a 100-year storm event after all structural projects are implemented. 500 hundred structures remained at risk for this event out of 7,092 in the model. These structures were elevated to 1 foot above the modeled 100-year flood elevation, and the damage simulation was updated. For more information refer to Attachment 7 - Project Summary Sheet - Priority Elevation Program.

For the priority elevation solution cost estimate, Selecting Appropriate Mitigation Measures for Floodprone Structures (FEMA 551), Chapter 8 report were used, however, the latest report was from 2007. In order to make sure the cost per units were accurate, CSRS used an inflation calculator provided by the US Bureau of Labor Statistics to determine the percent change in inflation from 2007 to 2024. This calculation showed an inflation rate of approximately 53%. The priority elevation cost estimate also assumed that all affected, residential structures were slab-on-grade and the final unit cost was calculated to be $69/sqft. The full cost estimate can be seen in Attachment 7. No maintenance will be required by the city for elevations as the maintenance costs will fall solely on the property owner.

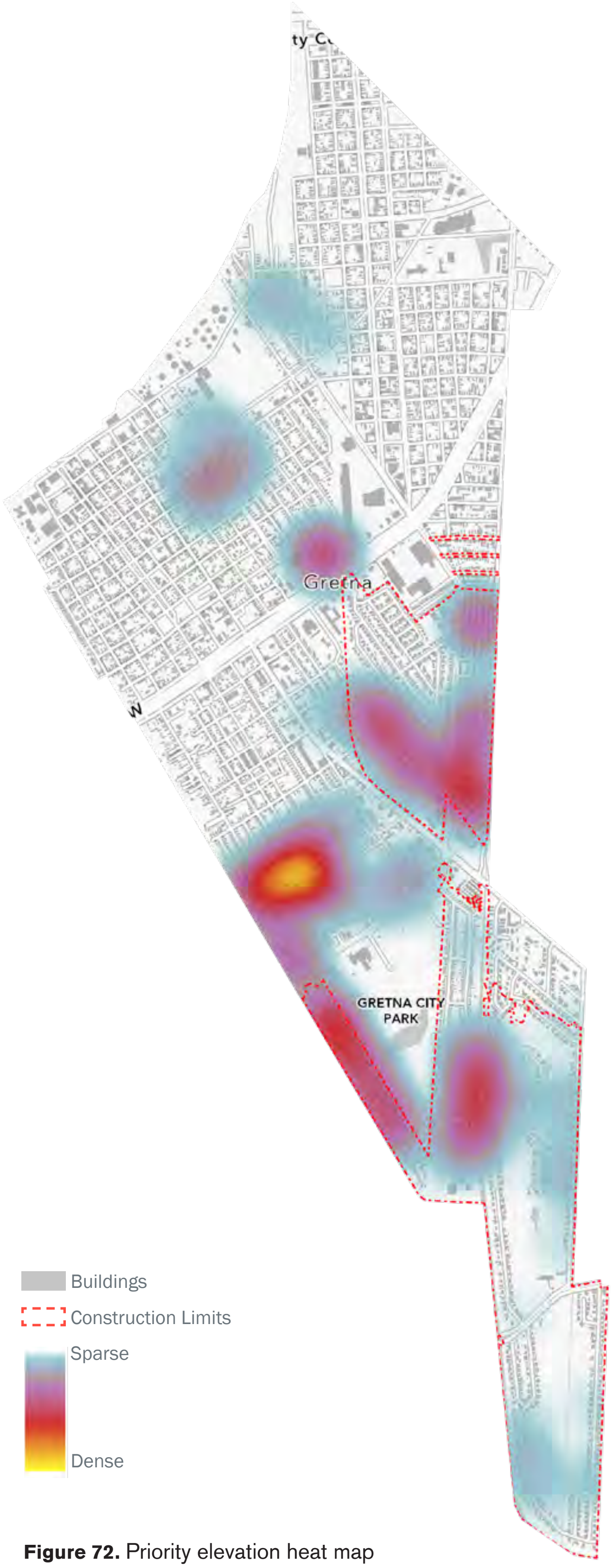


Figure 72. Priority elevation heat map

Benefit Cost Analysis (BCA)

For all projects, FEMA's BCA Toolkit V6.0 was used. Interim condition max depth rasters were exported from PCSWMM and input into HEC-FIA. HEC-FIA generated aggregate damages for both interim condition and post-project results. The damage values were input into the BCA toolkit. Ecological benefits were only considered for Gretna Green GI and New Garden Park Green Infrastructure Implementation due to Stumpf Diversion & Drainage Improvements being a gray infrastructure project. Social benefits were included for all projects. Social benefits were calculated by determining the number of affected residential structures and multiplying by the average persons per household. Additionally, the number of residents per household were multiplied to achieve the number of working residents, and these values were input into the BCA toolkit. Ecological benefits were determined by the total area of green infrastructure components in each project.

SUMMARY OF ALL PROJECTS

The below table details the project costs, benefits, and respective Benefit Cost Ratios (BCR) for each project. Each BCR is for a 3% discount rate and includes social and/or ecological benefits.

Priority	Project Name	Project Cost	Project Benefit	BCR	Funding Source	Notes
High	Gretna Green Distributed GI Network	$54,849,555	$76,030,899	**1.20**	Funded: FMA*	Identified for further review; $50M federal share with a $12M local match. Local Match was funded through: SFCP and CDBG-DR
High	Amelia Street to Stumpf Boulevard Improvements	$1,857,221	$4,926,472	**2.65**	FMA, HMGP*, CDBG-BR*, SFCP*	
High	Stumpf Boulevard Diversion & Drainage Improvements	$6,291,049	$11,862,356	**1.89**	FMA, HMGP, CDBG-DR, SFCP	Possible consolidation with the Amelia Street to Stumpf Boulevard Improvements Projects
Medium	New Garden Park Green Infrastructure Implementation	$72,412,618	$60,000,897	**0.83**	SFCP, CDBG-DR	Seek a phasing of scenarios and evaluate if any discrete phases have positive BCA
Medium	Priority Elevation Program	$79,665,844	$36,598,456	**0.46**	FMA and HMGP	Structures in the FEMA designated 100-yr floodplain and/or individual elevations whose BCR is at or exceeds a 1.00 would be prioritized for FEMA funding eligibility. All other affected structures would be driven by locally funded initiatives
Total Cost of Projects:		**$213,954,617**				

Table 2. Solution Benefit-Cost Summary
* Flood Mitigation Assistance (FMA), Hazard Mitigation Grant Program, Statewide Flood Control Program (SFCP), Community Development Block Grant-Disaster Recovery (CDBG-DR)

Benefit Cost Analysis (BCA)

RECOMMENDATIONS

Given the outcomes of the BCRs in the table above, CSRS recommends the following for each project:

Gretna Green Distributed Network GI: No further recommendation as this project was already approved for federal FMA grant funding.

2nd & Fried and 300 Block of 4th Street: It is recommended that similar analyses be performed in other areas within the city that are prone to nuisance flooding.

New Garden Park GI Implementation: Further analysis is recommended to help boost the BCR to be above a 1.00 required for FEMA funding. This may be done by selecting the highest impact-per-dollar components, and attempting the analysis with only these.

Stumpf Boulevard Diversion & Drainage Improvements: It is recommended that the City of Gretna proceeds in designing and constructing this project.

Priority Elevation Program: This is a program, not a project. It is recommended that the City of Gretna seek funding by means of federal or state programs.

Combined Structural Project: This analysis provides an understanding of the cumulative benefit of implementing these project solutions.

Source: City of Gretna

GRETNA STORMWATER MASTER PLAN

5. Plan Implementation

5. Plan Implementation

GRETNA, LOUISIANA

GRETNA STORMWATER MASTER PLAN

Introduction

Effective flood risk management requires constant oversight and review of public and private development as well as changing weather patterns. The implementation of specific programs can provide this oversight and review. This chapter provides an overview of two critical Codes & Ordinances and one program. The two Codes & Ordinances include Offsite Drainage Assessment (ODA) and Community Defined Flood Elevations (CDFE) while the critical Programs include a Flood Warning System (FWS). Offsite ODA utilizes the hydrologic and hydraulic model to assess the impacts and/or benefits of new development and infrastructure upgrades. The goal of ODA is to prevent increases in flood risk to the existing community as the community evolves. CDFE uses the existing SMP model's water surface elevations for regulating new or substantially improved building first floor elevations. The FWS integrates the stormwater model and real-time rainfall forecasts to estimate real-time and future flood levels ahead of and during a rainfall event. The goal of the FWS is to provide government officials and the public with the following:

- Enhanced Preparedness: Up to 48 hours of advance warning for likely flood events.
- Actionable Insights: Identify specific locations, depths, and durations of potential flooding.
- Operational Efficiency: Improve staging of emergency response efforts.
- Public Safety: Provide residents with precise, location-specific flood warnings to safeguard lives and property.
- Community Rating System Points: Can potentially provide 300+ CRS points which can reduce NFIP flood insurance premiums for residents.

Figure 73. The Recently Improved Gretna City Park Ponds Provide Stormwater and Water Quality Benefits

Offsite Drainage Assessment

New development is a sign of a growing community, but development can lead to increased flood risk if unmanaged. Building codes and floodplain management regulations provide a baseline mitigation of increased risk, however, the GSMP H&H model enables more robust analysis of new development. The Offsite Drainage Assessment (ODA) is a process which utilizes a high-detail hydraulic model to assess the effects of proposed developments on adjacent properties and the floodplain. The GSMP model is fit for this use as it covers all areas of the City.

An ODA can be incorporated into the development permit cycle. It would include the below steps:

1. Initial assessment/screening to determine whether an ODA is required based on the size and location of a development
2. Provision of a proposed grading plan and hydraulic structures by the applicant to the City
3. Addition of the proposed grading plan and hydraulic structures to the H&H model to create proposed conditions
4. Comparison of existing and proposed offsite flood levels
5. Memorandum to report findings

The ODA can be performed by a consultant with the capabilities to use the model or qualified personnel on staff with the City. The program can be funded through an additional fee to developers of properties requiring an ODA. The fee can be adjusted according to the type of proposed development (e.g., residential, small-scale commercial, large-scale commercial). Table 3 below shows municipalities which currently have an ODA program with details on how it is administered.

The initial assessment or screening to determine the need for an ODA should be based on the location of a property with respect to the areas that significantly convey or store stormwater. A "conveyance zones" map can be produced based on GSMP model results to clearly mark these areas. Figure 72 shows example conveyance zones from East Baton Rouge Parish.

An ODA program mitigates risk in 2 ways. First, it deters property owners and developers from proposing construction in areas that are vital to conveyance of stormwater. Second, it helps to minimize the impact of development in these areas. An ODA Program can minimize increases in risk while allowing the community to grow.

Name	Fee to Applicant	Consultant or In-house	Conveyance Zones
City of Central, LA	Yes	Consultant	Yes
City/Parish of East Baton Rouge	No	Consultant	Yes
Ascension Parish	Yes	Consultant	No

Table 3. Existing ODA programs in Louisiana municipalities

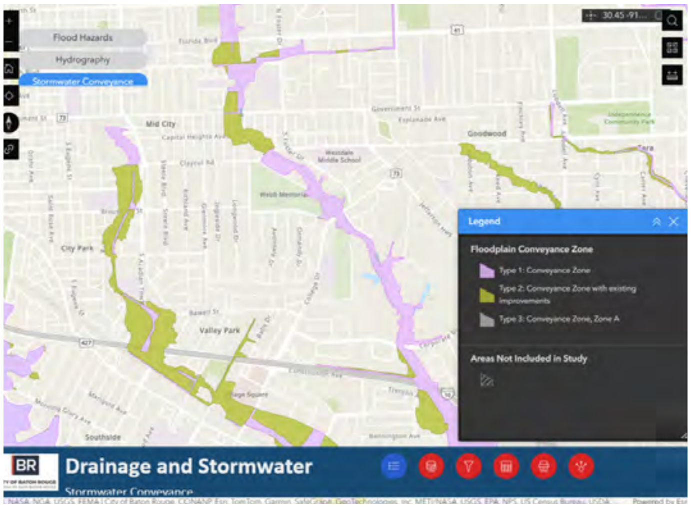


Figure 74. East Baton Rouge Parish conveyance zones

Flood Warning System

The Flood Warning System (FWS) is an essential tool in mitigating the impacts of real flood events. The GSMP H&H model can be used to tailor the FWS to the specific hydraulic and hydrologic conditions of the City. The forecasts can be hosted live online to provide up to 48 hours advance warning of projected flooding. The system would use real-time rainfall forecasts from NOAA or another trusted source to directly model flooding due to projected rainfall. Figure 73 shows the website for the FWS CSRS developed for the City of Central, LA, including a forecasted inundation map and water surface elevation hydrograph.

Precise flood forecasting empowers individuals and businesses to evacuate and/or relocate valuable or critical items and equipment and install or activate flood-proofing systems, mitigating damage and reducing recovery costs. It enhances the efficiency of emergency management by providing actionable data. This allows municipalities to block roads, deploy rescue teams, stage equipment, and activate flood response programs. By minimizing flood damage, flood forecasting can significantly reduce the financial burden of post-disaster repairs, cleanup, and recovery efforts. The increased availability of real-time flood risk information fosters greater awareness of flood risks among residents, promoting the development of preparedness plans and resilience-building activities within communities. The FWS can also incorporate flood warnings sent to residents as soon as flooding is projected. The FWS can potentially qualify for 300+ Community Rating System (CRS) points which can contribute to discounted NFIP flood insurance premiums for residents.

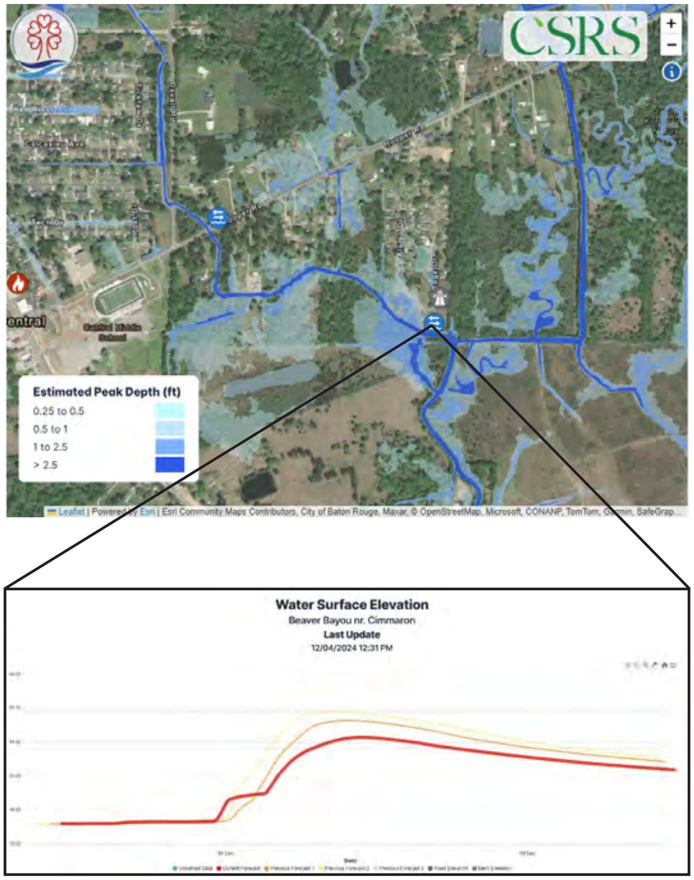


Figure 75. City of Central flood warning System “Early Flows” by CSRS

Community Defined Flood Elevation

When the GSMP existing conditions modeling was completed, the question arose: how do the FEMA Flood Insurance Rate Maps (FIRMs) compare to the results of this modeling? The FEMA FIRMs show Base Flood Elevations (BFE) and Special Flood Hazard Areas (SFHA) and are based on an 1%-annual-exceedance-probability (1% AEP), otherwise known as the "100-year", event. The City of Gretna's model outputs can be used to compare to the FIRMs, specifically ones that closely match the 1% AEP event, according to NOAA Atlas 14. Doing this can determine if the use of the FEMA maps is leading to underestimates of flood risk in some areas and overestimates in others. The Community Defined Flood Elevations and Special Flood Hazard Areas (CDFE/SFHA or just CDFE) can be developed as remedy to this. A similar process was developed as a part of East Baton Rouge's (EBR) Stormwater Master Plan and is shown in Figure 74.

The CDFE can provide an estimate of flood risk based on the latest available data from the GSMP. Revisions to the Codes and Ordinances for Gretna could be proposed to include the CDFE as a supplement to the FEMA BFE and SFHA for determining first floor elevation and fill mitigation requirements. The CDFE would help guide more resilient development based on a more accurate estimate of current and future flood risk. The CDFE map is intended to supplement FEMA FIRM information when determining first floor elevation and fill mitigation requirements. The accuracy of the CDFE map is dependent upon the quality and calibration of the Stormwater Master Plan models. The modeled water surface elevation at any location is dependent on the model components in the vicinity of that location. Therefore, the user should consider relative model resolution when viewing the map. Additionally, as significant improvements are made to Gretna's models in the future, the CDFE map would be updated to reflect these. Updates would be proposed to the city to incorporate this map as described above.

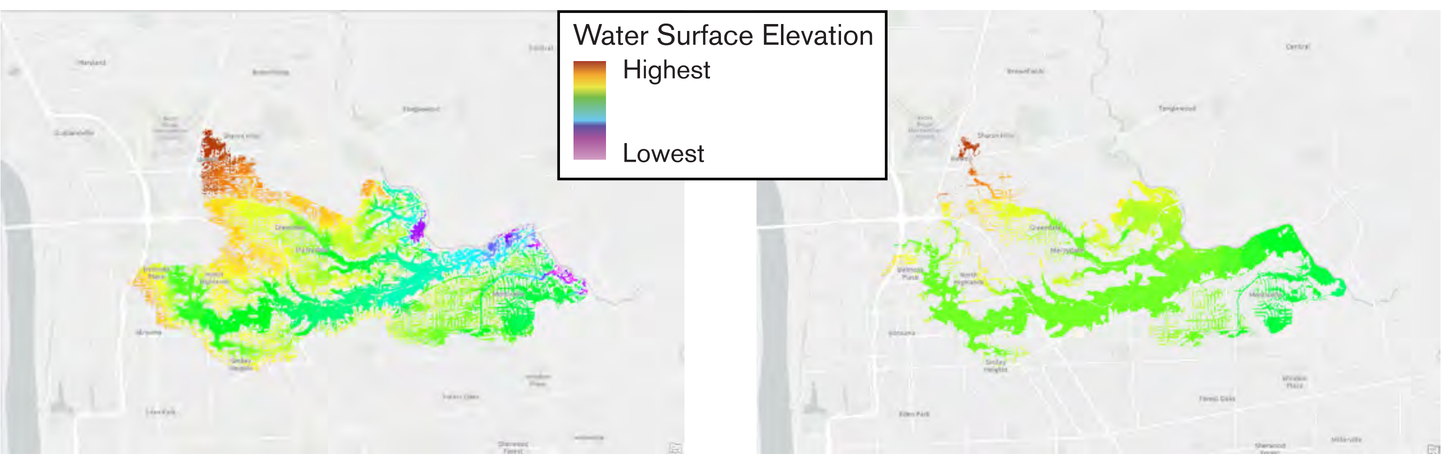


Figure 76. Raw Model Output (Left) and Final CDFE (Hurricane Creek/Engineer Depot Canal in EBR for Example)

Conclusion

The Gretna Stormwater Master Plan (GSMP) represents a decisive step forward in addressing the city's long-standing and growing flood risk. By integrating advanced modeling tools, extensive data collection, and community engagement, the GSMP delivers a clear-eyed assessment of existing vulnerabilities and presents a robust, actionable strategy to enhance stormwater resilience citywide.

From evaluating watershed characteristics and climate change impacts to identifying repetitive flood loss areas and designing cost-effective mitigation projects, this plan translates complex challenges into achievable solutions. The proposed projects and green infrastructure initiatives are rooted in technical rigor and informed by local experience. Furthermore, the emphasis on codes & ordinance evaluation, program development, and diverse funding opportunities ensures that the GSMP is not just visionary, but practical and implementable.

Ultimately, the success of this plan relies on sustained collaboration between city leadership, technical partners, and residents. As Gretna moves from planning to action, the GSMP provides a foundational blueprint for reducing flood damage, improving infrastructure performance, and enhancing community safety and quality of life—today and for future generations.

| *Source: City of Gretna*

A.

GRETNA STORMWATER MASTER PLAN

Appendix A

INSERT SECTION TOC HERE

- **ATTACHMENT 1:** Modeling Methodology
- **ATTACHMENT 2:** Flood Hazard Risk Assessment
- **ATTACHMENT 3:** Technical Memorandum & H&H Report
- **ATTACHMENT 4:** Cost Estimate and Benefit Cost Analysis: Amelia Street to Stumpf Boulevard Improvements
- **ATTACHMENT 5:** Project Summary Sheet - New Garden Park Green Infrastructure Implementation
- **ATTACHMENT 6:** Project Summary Sheet - Priority Elevation Program
- **ATTACHMENT 7:** Project Summary Sheet – Stumpf Boulevard Diversion & Drainage Improvements

ATTACHMENT 1

Modeling Methodology

GRETNA, LOUISIANA

1. Introduction

This document describes the methodology used to develop and implement the hydrologic and hydraulic (H&H) models for the City of Gretna Stormwater Master Plan (SMP). It covers the methodology from the initial data collection and acquisition through to the model application for the risk and damage assessments. The results of the modeling effort are demonstrated in subsequent appendices. *Figure 1* shows the process of developing the existing conditions model for the Gretna SMP project.

Figure 1: Development Process

2. Hydraulics & Hydrology

2.1. Hydraulics Methodology

The Computational Hydraulics International (CHI) Personal Computer Storm Water Management Model (PCSWMM) was used to simulate the hydrologic and hydraulic response of the city under various rainfall events. It is a hydraulic modeling program built upon the Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) computational engine. EPA SWMM is a 1-dimensional (1D) link-node model with unsteady state capabilities. CHI PCSWMM adds a methodology for modeling 2-dimensional (2D) surface flow (e.g., water flowing in streets or through yards and open space). This system enabled the Gretna SMP team to use a combined 1D-2D approach to model the depth and flow of runoff in streets and open spaces (2D regime) and the collection of runoff into pipes and channels (1D regime) in response to rainfall.

The major components of the model are the 2D computational mesh, the subsurface system, and the open channel system. Terrain, soils, and land cover layers were developed in ArcGIS Pro and applied in PCSWMM. The model went through a quality assurance/quality control (QA/QC) process to correct input errors. Computation options were adjusted and tested to improve model accuracy and efficiency. Test simulations were performed to identify stability issues. After an acceptable degree of stability was achieved, the model was validated against existing H&H studies, Repetitive Loss and Severe Repetitive Loss properties, and feedback from the city, as detailed below.

2.2. 2-D Computational Mesh & Digital Elevation Model

The 2D computational mesh utilized a base square cell size of 45 x 45 feet within the city. Mesh spacing was refined to better capture the street and channel features. Street mesh size was set to 15x15 feet to cover the width of a street with 2 cells (on average). Mesh spacing for channel was set based on the width of the channel from bank-to-bank. Building footprints were input as obstructions. This causes the 2D mesh to exclude the building footprint area preventing water from flowing through them. The 2D mesh can be seen in *Figure 2*.

The terrain or digital elevation model (DEM) determines 2D surface elevations in the hydraulic model. The Gretna SMP DEM was based on the publicly available 2021 USGS GNO LiDAR dataset. A notable feature, the Gretna City Park project, was not captured in the LiDAR as it was constructed after the LiDAR was collected as shown in *Figure 3*. The park was incorporated into the DEM by merging the post-project site surface elevation model for the park, including pond bottom elevations, into the base DEM. The Gretna City Park surface model was provided to CSRS by Batture, LLC.

Figure 2: 2D Mesh

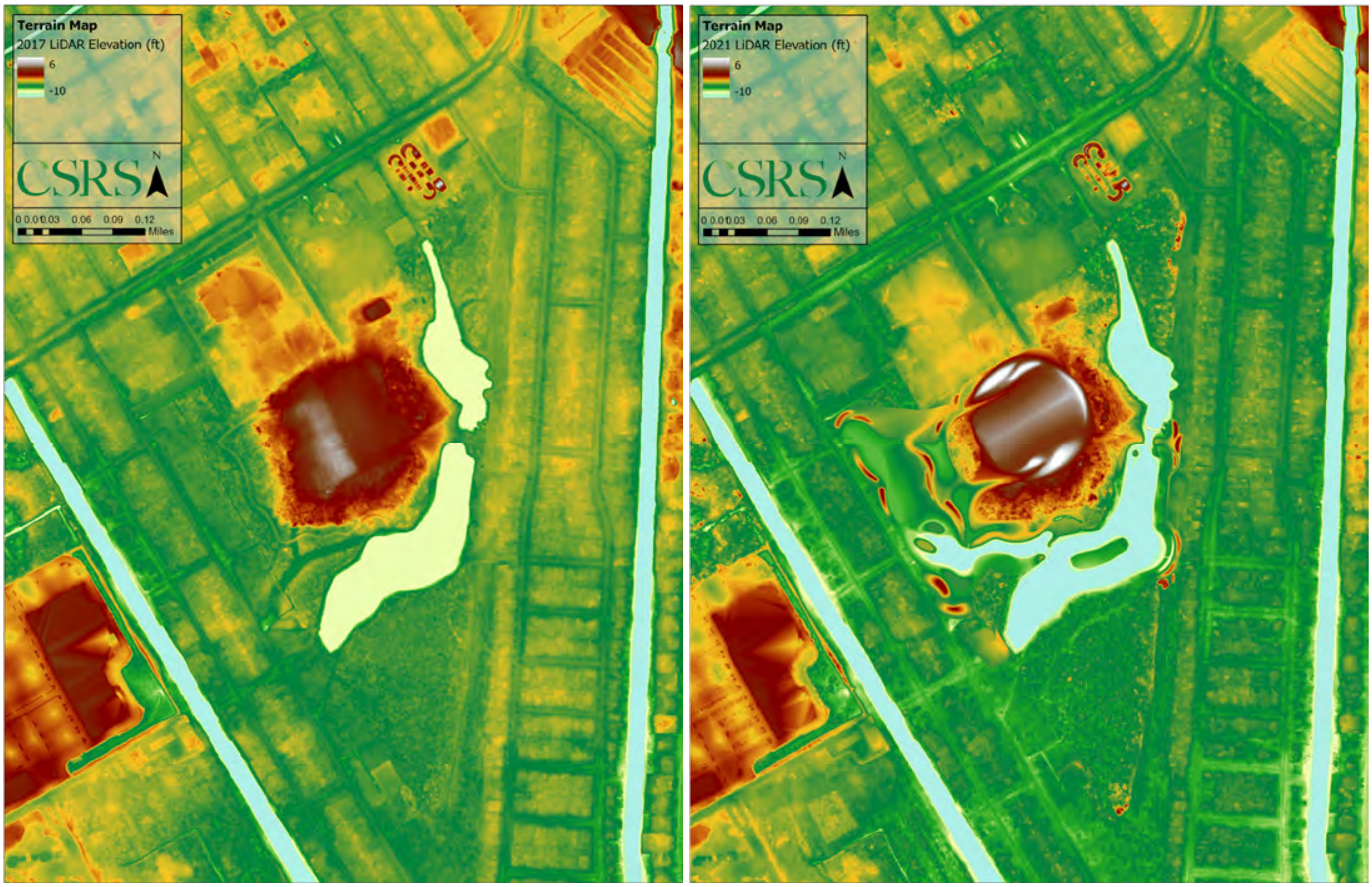


Figure 3: Terrain Maps Before and After Park Addition

2.3. Land Cover, Roughness, and Soils

The City of Gretna is mostly developed with buildings, roadways, and pavement. The National Land Cover Database (NLCD) gridded land cover dataset is typically used to define the land cover types due to its availability to the public; however, the city provided roadway and channel centerline GIS datasets which were sufficient to help define a more detailed land cover layer.

The Gretna SMP land cover layer was created by buffering roadway and channel centerlines. Off-street paved areas and ponds with standing water were manually defined based on review of aerial imagery. Three land cover types were assigned: 1) Pavement, 2) Developed, Open Space, and 3) Open Water. The land cover layer is shown in Figure 4*.*

The 2D mesh Manning's roughness (n) values affect the speed at which water flows over land in the model. 2D mesh Manning's n values were assigned based on land cover type. Surface roughness values are implemented in 2D conduits in PCSWMM. *Table 1* shows the roughness values.

A portion of rainfall infiltrates into the ground in real systems. The rate at which water is absorbed into the ground, known as the infiltration rate, is determined by the physical properties of the surface and of the soil in place. Infiltration rates are assigned as “seepage rates” in 2D conduits in PCSWMM. The United States Department of Agriculture (USDA) identifies a range of hydrologic soil groups, each group with unique properties. The Gretna SMP team reviewed the gridded Soil Survey Geographic (gSSURGO) 2020 dataset available from USDA to characterize Gretna’s soils. The predominant hydrologic soil group in the city is Type D, as shown in *Figure 5* . Type D soils have slow infiltration rates which impede the downward movement of water and the slow rate of groundwater transmission. Open spaces in the land cover layer were given an infiltration rate of 0.14 inches per hour (in/hr) based on Table 7-1 of *Chapter 7 Hydrologic Soil Groups* of *Part 630 Hydrology* of the Natural Resources Conservation Service (NRCS) *National Engineering Handbook*. Soils beneath open water areas were assumed to be saturated, therefore, they were given an infiltration rate of 0.01 in/hr. Infiltration does not occur in paved areas, therefore, these were given an infiltration rate of 0 in/hr. *Table 1* shows the infiltration rates for each land cover type.

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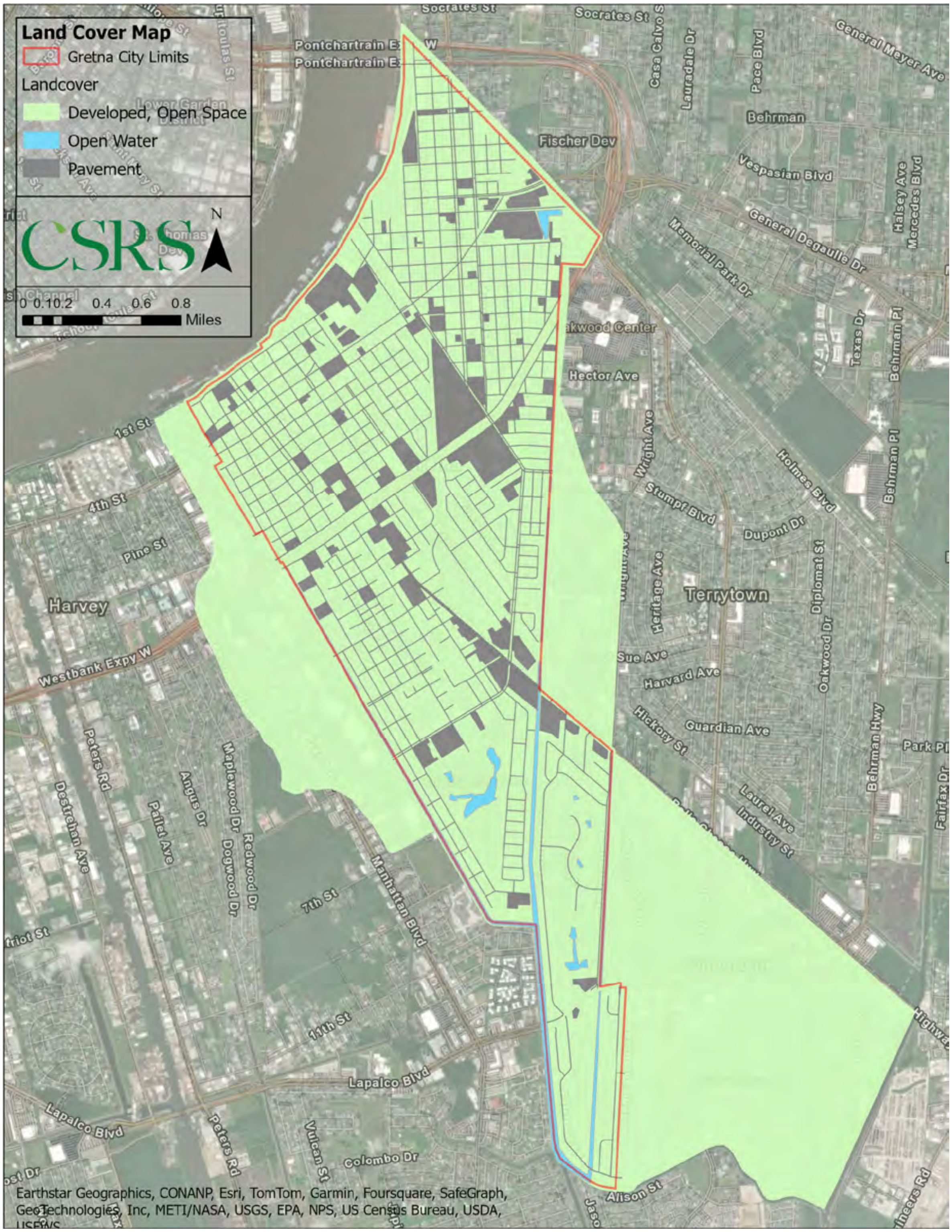

Figure 4: Landcover Map

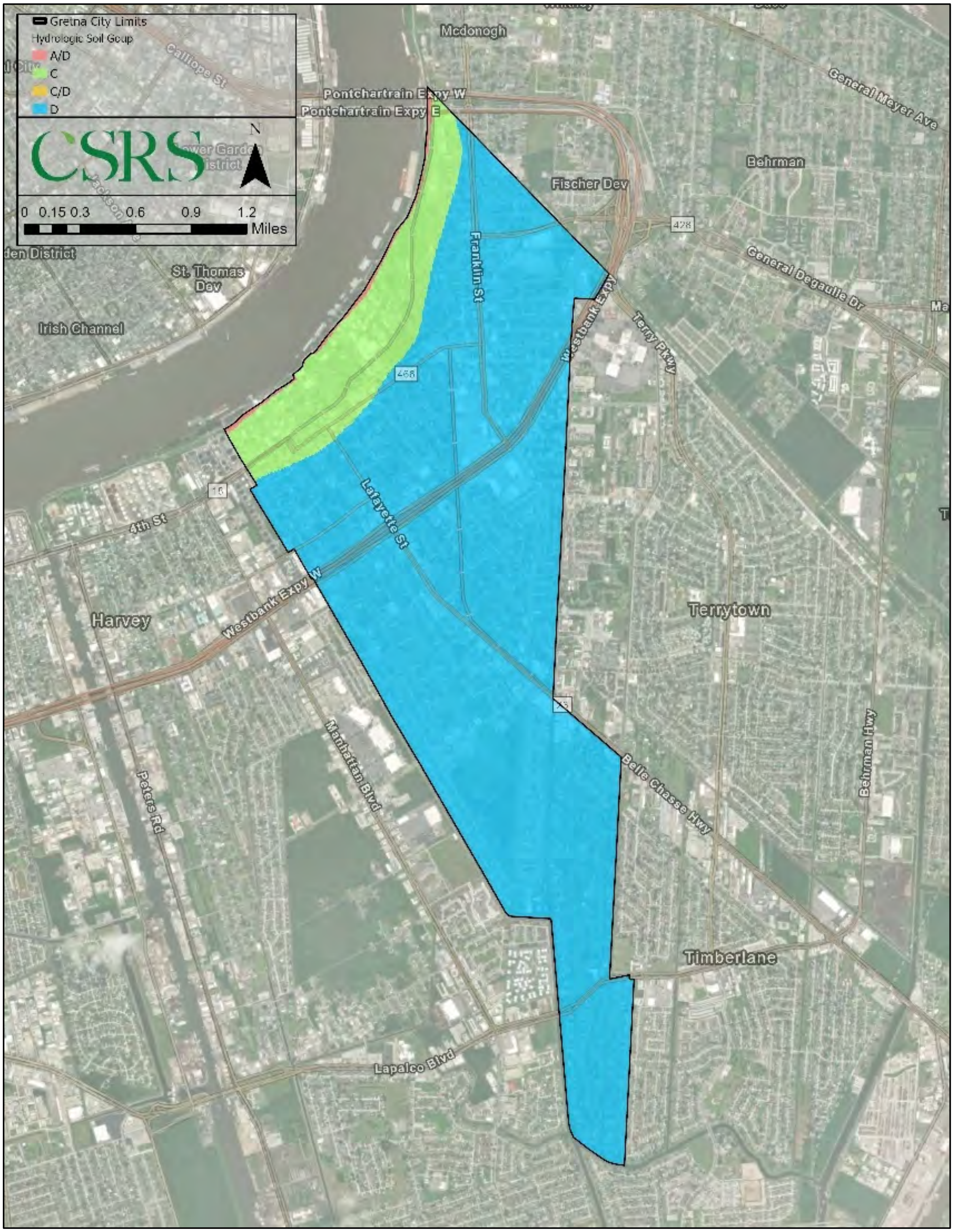

Figure 5: Soils Map

Table 1: Roughness Values, Soil Types, and Seepage Rates for Land Cover Types

PCSWMM 2D Grid Hydraulic Roughness	Manning's Value	Infiltration Rate
Open Water	0.01	0.14
Impervious Area, Roads, Roofs	0.012	0
Open Space	0.04	0.14
Buildings	Blocked	0

2.4. Subsurface Drainage System

The enclosed drainage system was surveyed by Compliance EnviroSystems, LLC (CES); however, before incorporating this database into the city-wide model, it was essential to verify the accuracy, reliability, and completeness of the data. Some inlets and pipes (subsurface conduits) were not well defined due to in-the-field issues including excess debris, clogging, and restricted access. Where survey data was incomplete or missing, reasonable assumptions were made for the location, size, shape, and material type of subsurface conduits, catch basins, and manholes based on nearby surveyed data and a review of aerial and street-level imagery. CSRS also consulted Gretna's city engineer, David Boyd, P.E. at Burke-Kleinpeter, Inc., for assistance with resolving data gaps.

Simulation run times and stability are directly affected by the number and length of conduits (both 1D and 2D). Short conduits, especially those shorter than 15 feet (cf., CHI Water Support) can significantly impact simulation stability. The Gretna SMP team set a lower limit on the diameter and length of subsurface conduits to be included in the model. Subsurface conduits with a diameter smaller than 8 inches or a length shorter than 15 feet were generally excluded from the model to maximize stability and minimize simulation times.

Manning's roughness of pipes was assigned based on the USDOT Urban Drainage Design Manual 2013 values for each conduit material type. *Table 2* shows the Manning's n-values chosen for each material in the final geometry.

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Table 2: Roughness Values for Conduits in 1D system

PCSWMM 1D Conduit Material Type	Manning's n-Value
Brick	0.014
Cast Iron	0.013
Clay Tile	0.013
Concrete	0.013
CMP	0.023
Ductile Iron	0.014
Fiberglass	0.010
Plastic/Steel	0.017
Polyethylene	0.017
Polypropylene	0.017
PVC	0.010
Reinforced Plastic	0.017
Steel	0.013
Vitrified Clay	0.012

2.5. Open Channel System

The open channel system required special modeling techniques in the 1D-2D combined approach. A 2D approach for open channels was forgone as each 2D cell in PCSWMM contains only one elevation. Capturing complex channel geometries in 2D would require very small cells. Smaller cells lead to longer simulation times and more instability. Therefore, the Gretna SMP team implemented open channels as 1D conduits with transects containing channel cross-sectional geometry according to the methodology in the PCSWMM guidance from CHI. Station elevation data for channels across the city was available from the East of Harvey basin SWMM model developed by RPS and BCG Engineering & Consulting Inc. for the "Comprehensive Stormwater Modeling in Jefferson Parish for LOMR Support" project owned by Jefferson Parish. The Gretna SMP team used transect data and channel invert elevation data from this model as the base dataset for implementing main channels.

In the selected approach, channel flows below the bank elevation are handled in the 1D domain (in open channel conduits with transect data). Channel flows above the bank elevation are handled in the 2D domain (in the 2D cells). Transect elevation data and 2D cell elevation data were adjusted to ensure volume was not counted in both domains. Channel transect data was truncated so that the highest elevation in the transect was equal to the bank elevation. 2D cell invert elevations "above" main channels were adjusted to equal the bank elevation. *Figure 6* illustrates the relationship between the 1D and 2D systems for the channels.

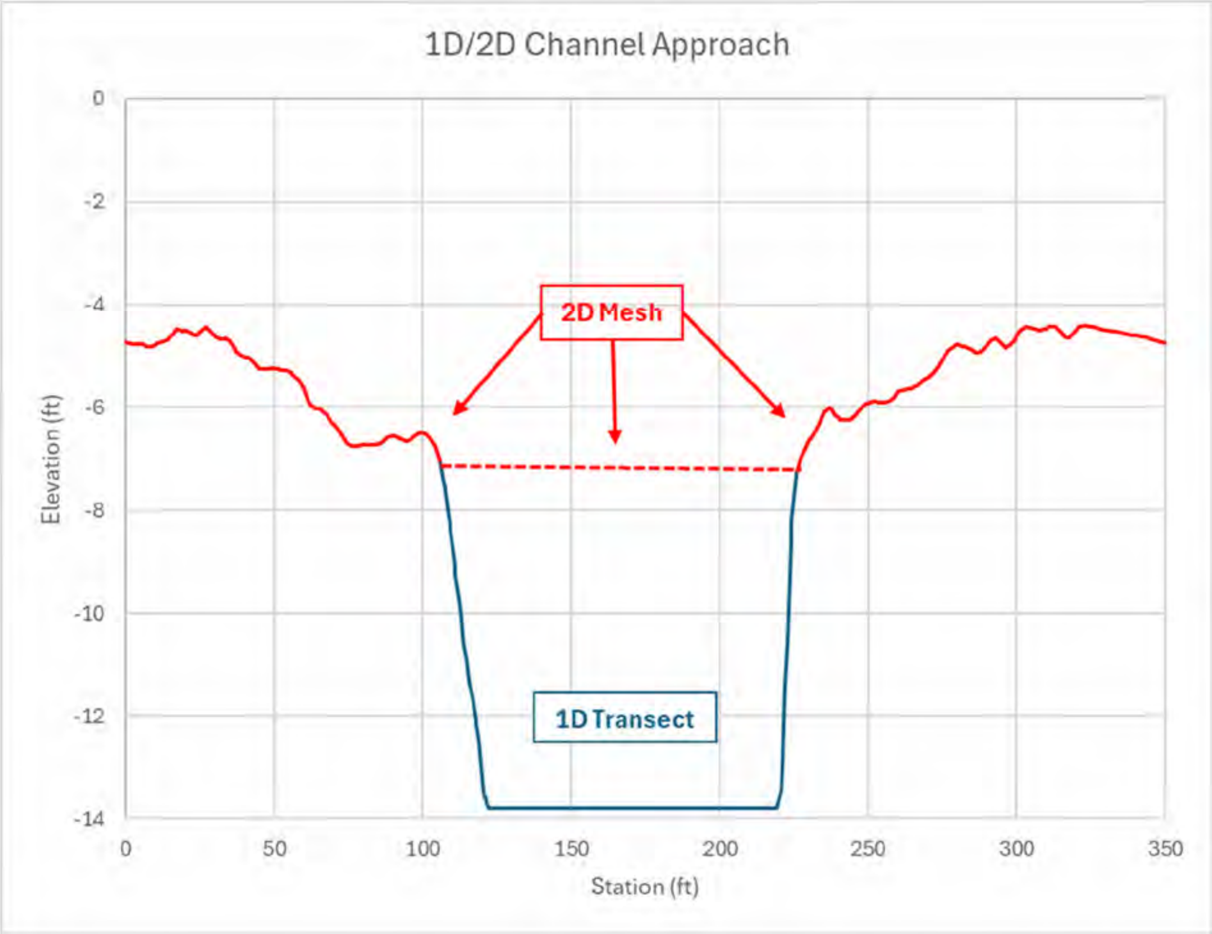


Figure 6: 1D/2D Relationship for Main Channels

2.6. Hydrology Methodology

A temporal- and volumetric-based hydrologic method was used to develop hydrologic inputs for an unsteady hydraulic analysis. Rainfall hyetographs were developed for eleven return intervals and applied directly to the H&H model. Losses due to infiltration and ponding were explicitly accounted for in the model as detailed in subsequent sections.

2.6.1. Existing Conditions Precipitation

Full probabilistic rainfall hyetographs (without accounting for losses) were applied directly to the 2D mesh nodes and building footprint subcatchments. The total rainfall depths for the 6-hour duration were obtained from the National Oceanic and Atmospheric Administration Atlas 14 (NA14) and temporally distributed based on NA14's quartile one, 10% distribution. This duration and temporal distribution were chosen as a result of a sensitivity analysis performed on similar sizes and types of models for the East Baton Rouge Stormwater Master Plan. (*Appendix D of the East*

Baton Rouge Stormwater Master Plan, Flood Risk Reduction Approach Methodology, Section 2.2.1 Hydrology [HNTB]).

The NA14 6-hour rainfall depths for return intervals are provided in *Table 3* below. The 90% confidence interval for NA14 precipitation frequency estimates has wide bounds. Therefore, precipitation depths were rounded to the nearest whole number before applying the distribution for readability purposes.

Table 3: Storm Return Intervals and Precipitation Depths

Return Period	Annual Exceedance Probability	NA14 Precipitation Depth (in)	Modeled Precipitation Depth (in)
1-year	100%	3.44	3.5
2-year	50%	3.93	4.0
5-year	20%	4.92	5.0
10-year	10%	5.93	6.0
25-year	4%	7.59	8.0
50-year	2%	9.08	9.0
100-year	1%	10.8	11.0

2.6.2. Accounting for Climate Change

Climate change is incorporated in the Gretna SMP modeling effort through increases in total rainfall depth for each return interval based on trends in increasing global average temperatures and the frequency and intensity of rain events detailed in *Table 4*. Incremental and accumulated rainfall hyetographs can be seen in Figure 7 and Figure 8, respectively. The Intergovernmental Panel on Climate Change (IPCC) *Annual Report 5 (AR5)* Representative Concentration Pathways 6.0 (RCP6.0) scenario maximum statistic estimates an 11% annual increase in rainfall totals by 2065 for both the Central North America and Eastern North America regions. Because of Gretna's location, the Central North America and Eastern North America regions are the most applicable. The *AR5* report document includes estimated increases for a range of scenarios. The RCP6.0 scenario maximum statistic was chosen as it lies in the upper midrange of estimates in *AR5*. As climate change projections evolve with better methods and up-to-date data, the city should consider updating future flood risk estimates. Note that *Annual Report 6* was published in 2023 during the development of the Gretna SMP, however, rainfall increase statistics were not yet available. The Gretna SMP team incorporated this information by increasing the total rainfall amount for each return period storm event by 11%, as per AR5. Increases were rounded up to the nearest 0.5 inch.

Table 4: Gretna SMP Climate Change Precipitation Depths

Return Period	Annual Exceedance Probability	Existing Conditions Precipitation Depth (in)	GSMP Climate Change Precipitation Depth (in)
1-year	100%	3.5	4.0
2-year	50%	4.0	4.5
5-year	20%	5.0	6.0
10-year	10%	6.0	7.0
25-year	4%	8.0	9.0
50-year	2%	9.0	10.0
100-year	1%	11.0	13.0

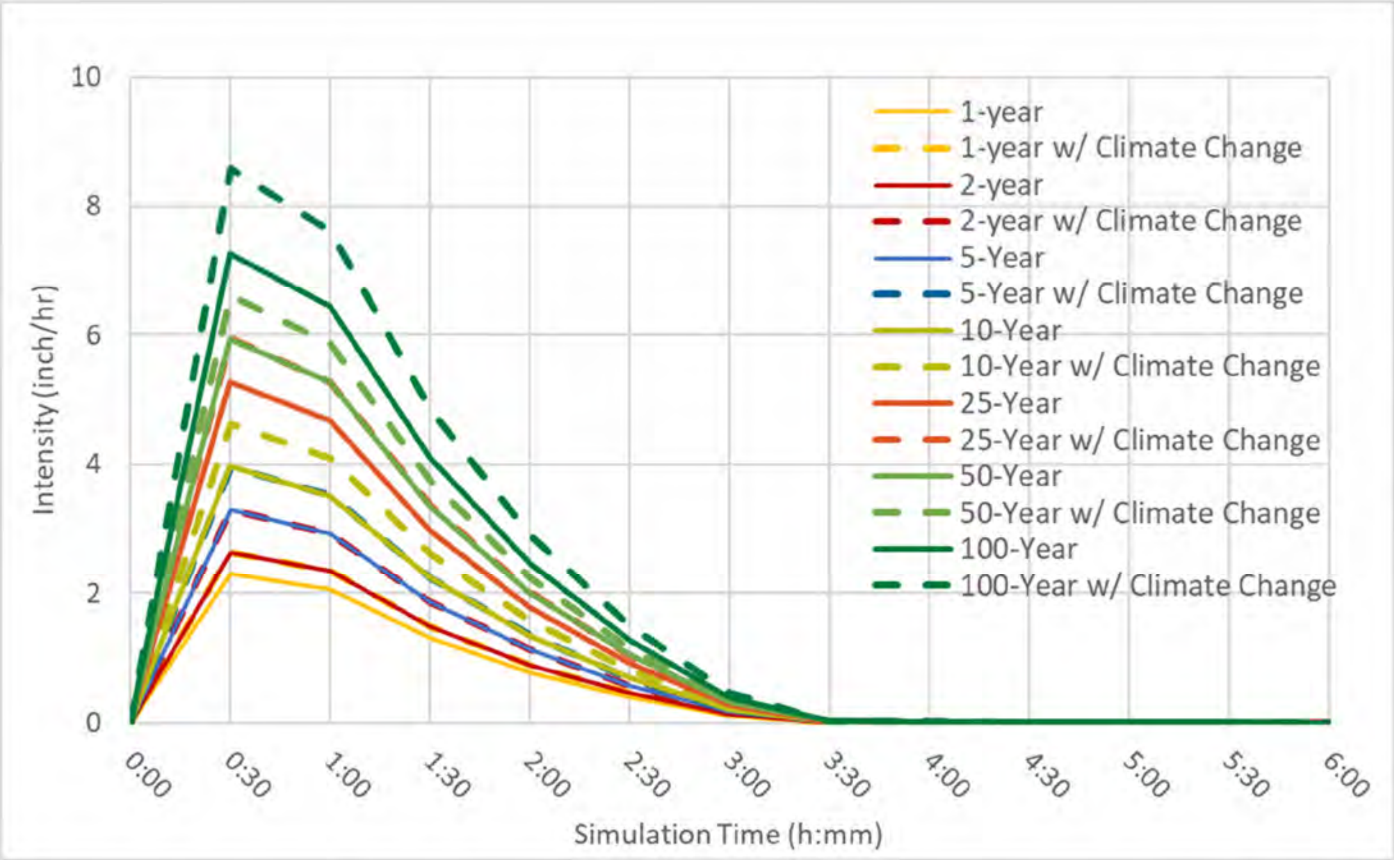


Figure 7: Gretna SMP Incremental Rainfall Hyetographs

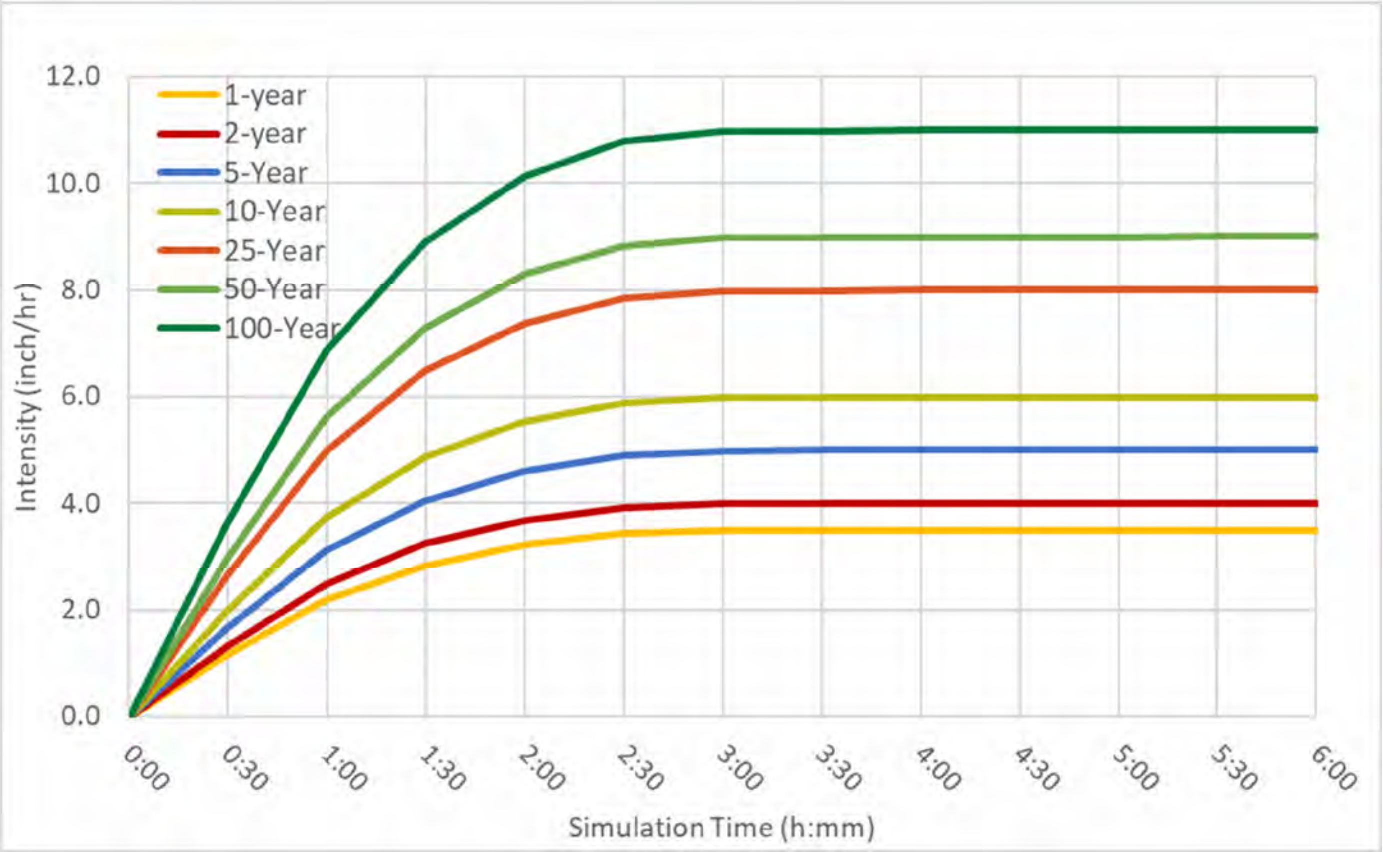


Figure 8: Gretna SMP Accumulated Rainfall Hyetographs

2.7. Boundary Conditions

2.7.1. Precipitation Input

The probabilistic rainfall hyetographs described in the Hydrology section above were applied to both subcatchments (buildings) and 2D junctions in accord with the “direct inflow to nodes” approach detailed in the PCSWMM guidance from CHI. The 2D junction inflows were calculated by converting rainfall units from inches per time interval to feet per time interval. Each 2D junction received a scale factor equal to the area of the corresponding 2D cell in square feet. The result is an inflow in cubic feet per time interval for each 2D junction.

The 2D mesh excludes building footprints. Therefore, in order to incorporate runoff from the rooftops, building footprints were included in the model as subcatchments with rainfall hyetographs directly applied and assumed to be impervious. Building subcatchments were set to flow out to the nearest 2D node.

2.7.2. Northern Boundary

The northern boundary utilizes both 1D and 2D outfalls. The 2D outfalls border the city limits along Algiers Canal starting at Rupp Street, crossing Burmaster St, and continuing to its confluence with Whitney Canal as shown in *Figure 9*. A 1D outfall is located on Algiers Canal at its confluence with the Racetrack detention pond to simulate exchanges to the reach of Algiers Canal beyond the city limits. Both the 1D and 2D outfalls are taken from the Jefferson Parish Ardurra (DPS 13) model for each design storm event detailed in *Figure 10*. This approach enables the model to incorporate backwater effects from areas upstream of the city.

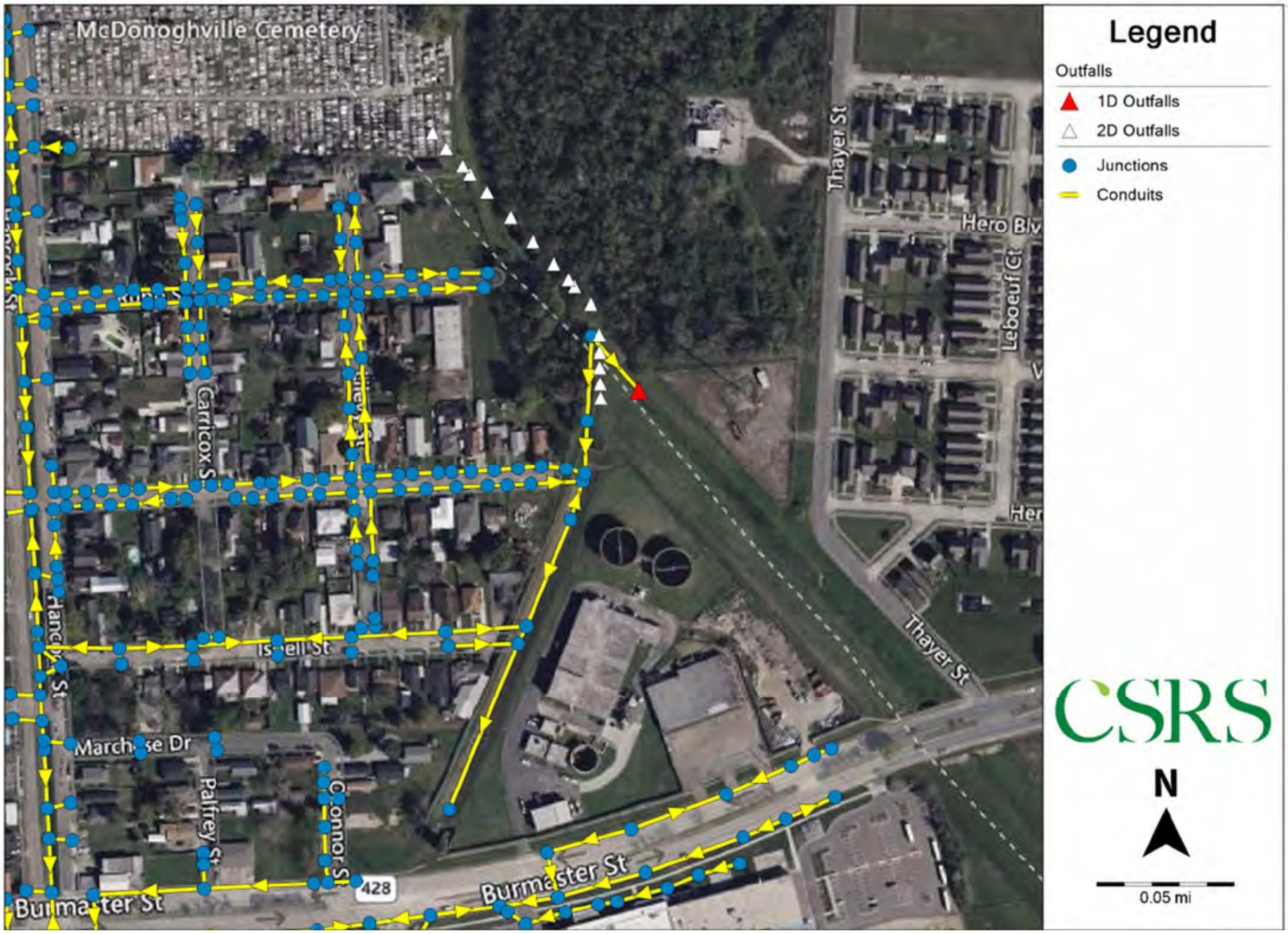


Figure 9: Upstream Outfalls in Northeast Model

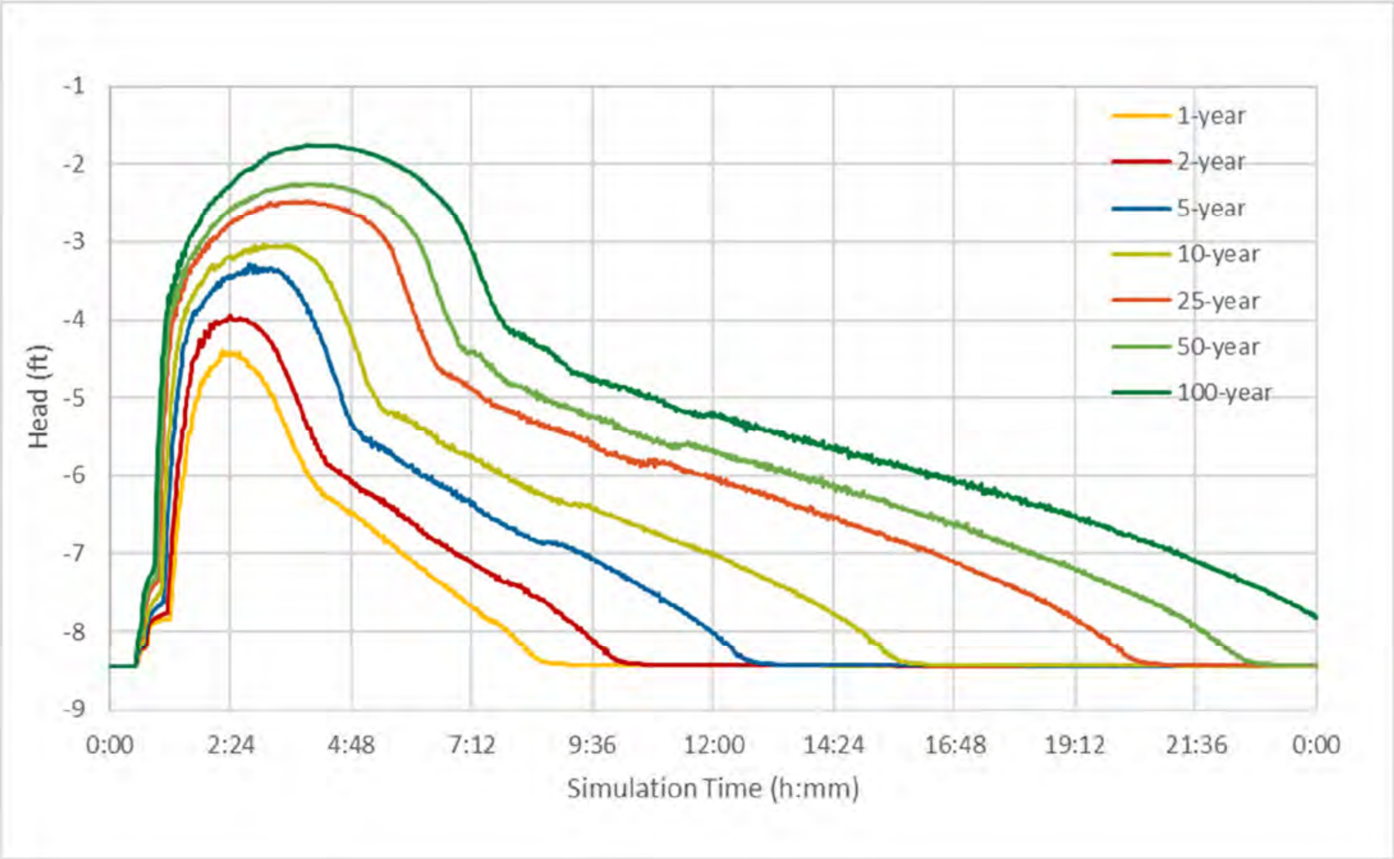


Figure 10: North 1D Boundary Outfall Stage Hydrograph

2.7.3. Southern Boundary

The southern boundary utilizes both 1D and 2D outfalls. The 2D outfalls border the city limits along Hebee Canal starting at 32nd Street, continuing to its confluence with Verret Canal, along Verret Canal to its confluence with Bayou Fatma, along Bayou Fatma to its confluence with Bayou Barataria, then northward to Belle Chasse Highway as shown in Figure 11. A 1D outfall is located on Verret Canal at its confluence with Bayou Fatma to simulate outflow to the reach of Verret Canal beyond the city limits. An additional 1D outfall is located where Bayou Fatma meets the city limits for the same purpose. Both the 1D and 2D outfalls use stage hydrographs taken from the

Jefferson Parish EOH model for each design storm event as shown in

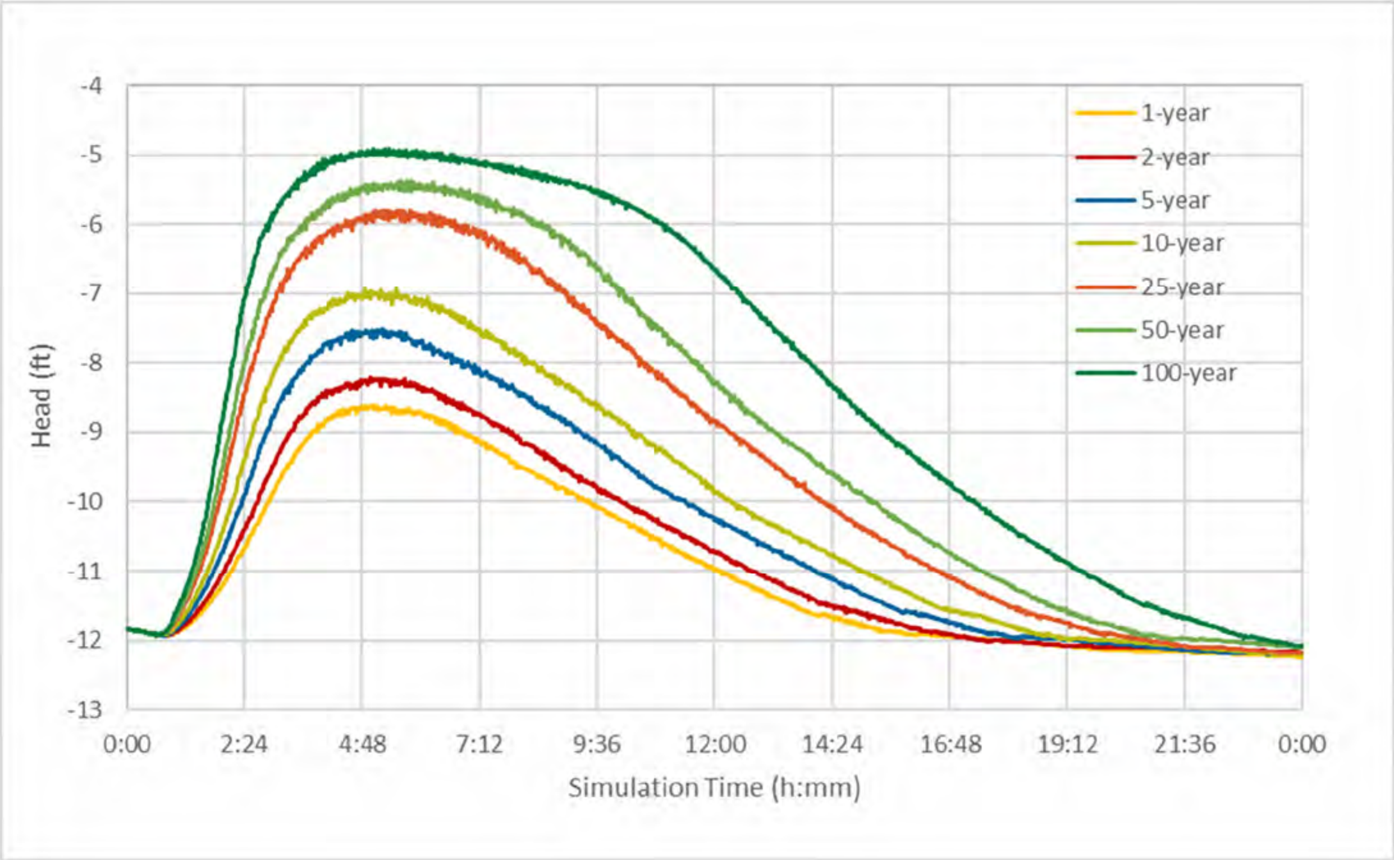


Figure 12. This approach enables the model to incorporate backwater effects from areas downstream of the city.

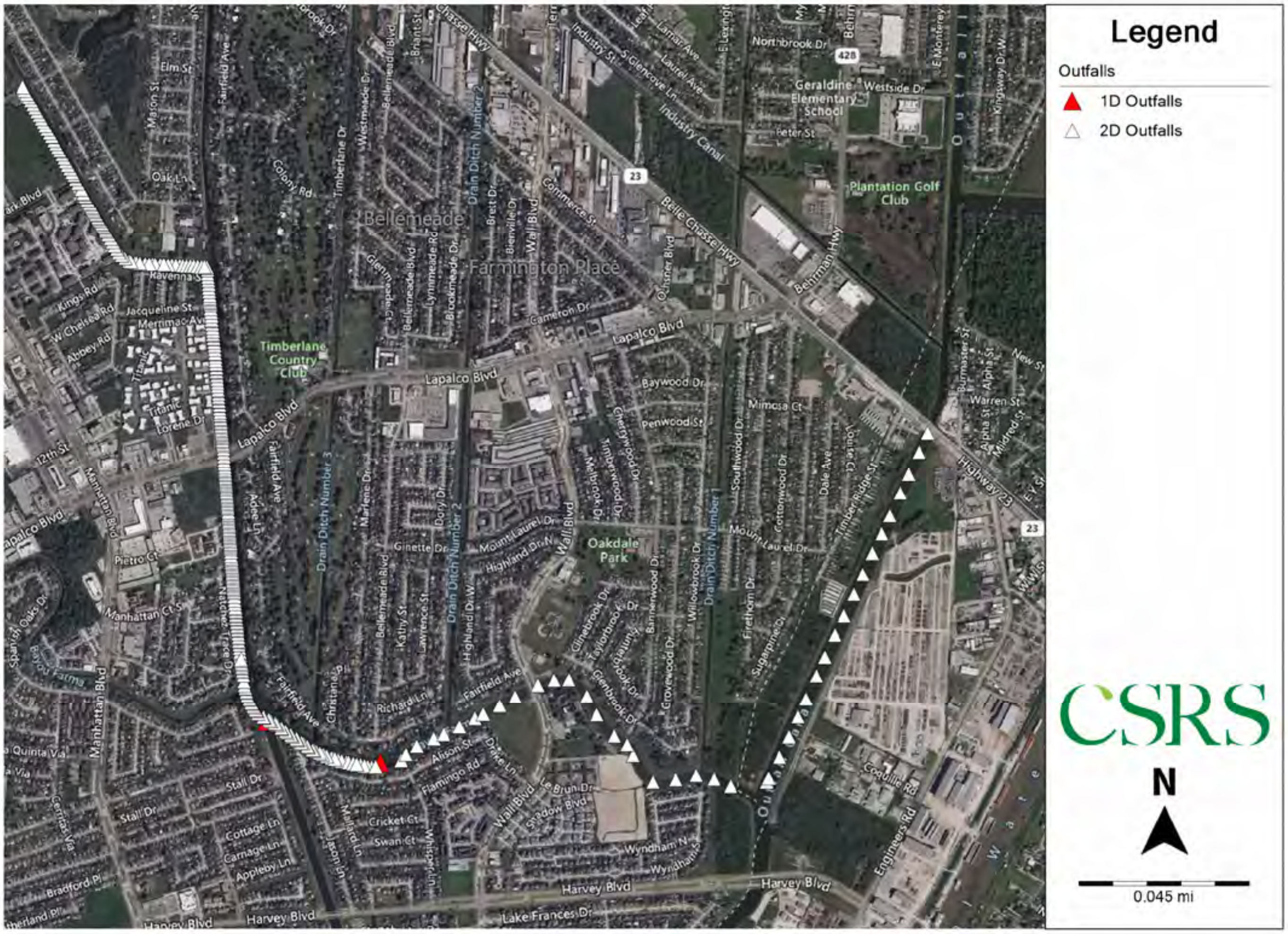


Figure 11: South Boundary Outfalls

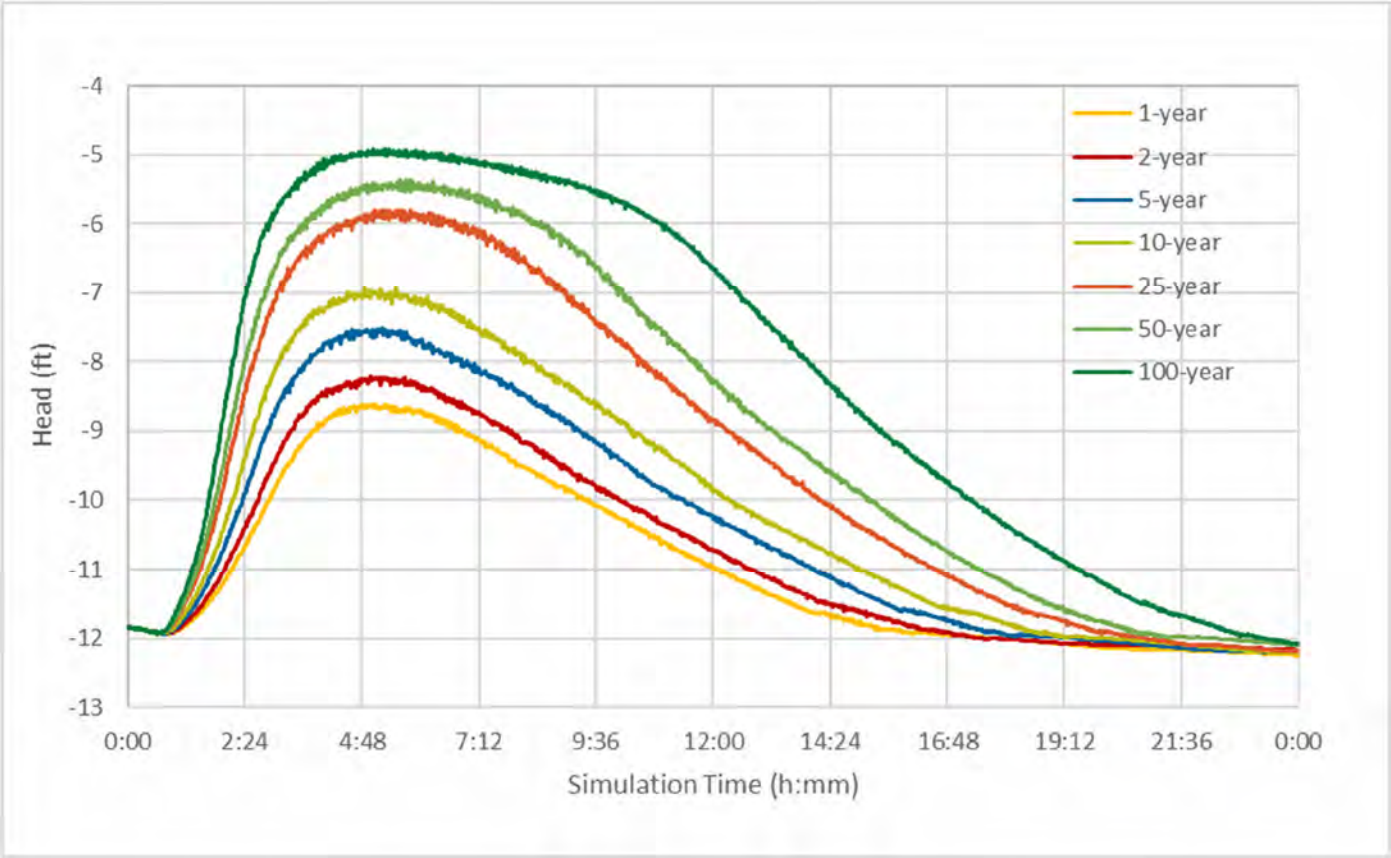


Figure 12: South 1D Boundary Outfall Stage Hydrograph

2.8. Computation Methods

The selected computation methods are shown in *Table 5*. The time step was selected to balance run time with stability. The Horton Infiltration Model enabled the direct application of infiltration rates to 2D conduits.

Table 5: Computation Methods Setup in PCSWMM

Parameter	Setup
SWMM Engine Version	5.1.015
Process Model(s)	Rainfall/Runoff; Flow Routing
Infiltration Model	Horton
Routing Method	Dynamic Wave
Routing Time Step	5 second
Normal Flow Criterion	Slope & Froude
Force Main Equation	Hazen-Williams
Surcharge Method	Extran
Minimum Variable Time Step	0.25* seconds

2.9. Model Stability

Model stability was assessed throughout model development. The stability of a hydraulic model is indicated by the size and frequency of computation errors during a simulation. A key indicator of model stability is routing error. Routing error occurs when the solution solver fails to converge for a given model component during calculations for a time step. Total routing errors of less than 1% were accepted for GSMP simulations. The following methods were used to encourage model stability:

- Excluding especially short conduits
- Avoiding mesh spacings smaller than 15 feet
- Adjusting the mesh angle to align with the orientation of streets and streams
- Connecting manholes to the 2D surface with a small orifice to allow surcharge
- Employing an adaptive time step

The final setup of the 2D mesh, 1D junctions, 1D conduits, and computation options produced a stable model. Routing errors are less than 0.1% for all simulated storm events.

3. Model Validation

Reliable observed data is key to model calibration and validation. The Gretna SMP team encountered a lack of observed data for the city; therefore, a direct calibration of the model could not be performed. The model was instead validated through comparison to existing studies and through visual inspection by members of the city staff and administration.

Two existing studies were used for comparative validation: the FEMA Flood Insurance Study and the "Comprehensive Stormwater Modeling in Jefferson Parish for LOMR Support" project owned by Jefferson Parish. Both studies used 1-dimensional models, HEC-RAS in the case of the FEMA study and EPA-SWMM in the Jefferson Parish study. Both studies focused on major canals and conveyance features. Neither included storm drains outside of major enclosed canals. Flood extents for the 100-year flood from the FEMA Flood Insurance Rate Map (FIRM) and 100-year water surface elevations from the Jefferson Parish study report were compared to GSMP model outputs. Generally, the peak water surface of the GSMP model was slightly lower than the existing studies in the main canals and higher in the streets. The differences in the canals did not exceed one foot. The difference is likely due to the inclusion of the 2D surface and 1D subsurface storm drain system in the GSMP model. A non-negligible volume of water resides in these model components during the flood peak. As the 1D models from FEMA and Jefferson Parish do not have these components, it is reasonable that more water is shown in the canals in these. The comparison did not imply the need for adjustments to the GSMP model.

Preliminary GSMP model results were presented to city staff and administration, including the mayor, council members, Floodplain Administrator, Superintendent of Environmental Affairs, and the Superintendent of Parks and Parkways, among others. City personnel verified that the model generally showed flooding at locations of known issues.

Computations were completed for the 5-, 10-, 25-, 50-, and 100-year events for both the existing conditions model and the EOH model. Max water surface elevations (WSEs) were exported from both and compared to test for the validity of the existing conditions. The EOH model generally had higher depths and WSEs than the existing conditions model. This is because the EOH model is a 1D model and does not contain the complex overland, 2D flow or consider any of the surface or subsurface storage the existing condition model contains.

4. Damage Modeling

The H&H model provides information on flood levels throughout the city. Damage modeling goes beyond the H&H model to estimate the impact of simulated floods in terms of the cost to repair or replace damaged structures. HEC-FIA (Hydrologic Engineering Center - Flood Impact Analysis) was used to model structure flooding and estimate damages.

4.1. HEC-FIA

HEC-FIA takes in maximum depth from the H&H model results, the DEM used for the model, and a database of building structures for the city. It calculates simulated flood levels in structures and applies depth-damage functions (DDF) to estimate the percentage of loss or damage in a given scenario on a structure-by-structure basis. It calculates damage in dollars by multiplying each building's percentage of loss by a building-specific estimated replacement value. The building structure database is discussed in detail below.

4.1.1. Structure Database (Buildings)

The City of Gretna provided a building footprints layer which included information on structure type/use. The structure type information was verified, first-floor elevations and structure replacement values were added to the dataset as described below. Structure values had to be applied and were estimated by categorizing structure type and building footprint square footage.

Structure Type

Structures from the building footprint were assigned one of the following ten classifications:

- Apartment
- Church
- Industrial Storage Tank*

- Medical
- Mobile
- Office
- Parking Garage*
- Resident
- School
- Store

  *Damages were not calculated for industrial storage tanks or parking garages.

First-Floor Elevations

The first floor elevations represent the elevation of the structure's slab and determine what depth the structure will begin to flood. To determine these values, elevation certificates that verify the first-floor elevations for structures were provided but Forerunner. However, the database provided by Forerunner did not have first-floor elevations for all structures present within the City of Gretna, so the remaining structures' first-floor elevations needed to be estimated. First-floor elevations were estimated based on an assumed first-floor offset above the 2021 USGS GNO LiDAR ground elevations. The standard deviation of LiDAR elevations within each footprint was calculated. Structures with elevation standard deviations of less than 0.5 feet used the minimum LIDAR elevation within the footprint as the ground elevation. Those with standard deviations greater than 0.5 used the average elevation within the footprint as the ground elevation. The first-floor offsets were assigned on a neighborhood-by-neighborhood basis using Google Earth Streetview to assess a sample of streets within each neighborhood.

The default DDFs in HEC-FIA were applied to each respective structure classification. According to the *HEC-FIA User's Manual (December 2019), Pages 8-24 (8.6.3)*, the depth-damage curves are from EGM 04-01 *US Army Corps of Engineers' Generic Depth-Damage Relationships (2003)* and the HAZUS database. The industrial storage tank and parking garage classifications were not assigned a replacement value or DDF in the analysis and do not contribute to simulated damages. Water depth results from the 5-, 10-, 25-, 50-, and 100-year event H&H simulations were input as inundation data.

Structure Replacement Value

The structure inventory used for this analysis was provided by the City of Gretna. These replacement values are a set price for how much it would cost to repair the structure after flooding occurs. Each building footprint was assigned a structure value based on the square footage of the structure and relevant cost per square foot from 2023 RS Means data.

For this analysis, car damage was also incorporated into the structure database. The percentage of household vehicle ownership in Gretna from the *U.S. 2022 Census Bureau S2504* was averaged across all structures classified as residential within HEC-FIA. Vehicle values determined by the *US Army Corps of Engineers' Final Report, Depth-Damage, Relationships for Structures, Contents, Vehicles, and CSVR, Donaldsonville (2003)* were adjusted for inflation from 2006 to 2023 using the *Bureau of Labor Statistics Consumer Price Index (November 2023)*. After adjusting for inflation, the average vehicle value used was $32,500.

The resultant max water depths for both the existing and proposed conditions models, the emergency planning zones (EPZ), and the structure inventory were used to run the FIA tool. Once completed, the aggregated results detail the damages calculated for the structures, the contents of the structures, and the vehicular damages.

5. Summary of Model Application

The hydraulic models developed for the Stormwater Master Plan were used to estimate flood depths and elevations from various return interval storm events. This analysis estimated flooded areas within the City of Gretna to help identify the areas of highest risk. Additionally, the model and model results were used to help determine which areas to consider for flood mitigation projects. Areas that are likely to flood will yield a higher benefit-cost when mitigating the flooding as demonstrated in the Flood Hazard Risk Assessment Appendix. Future use of the models can help provide a flood warning system. If the City knows a severe weather event is approaching that is similar to a modeled return interval, preventative measures can be communicated and put in place for areas that are prone to flooding in that event. This will increase resilience to flood damage in the City.

ATTACHMENT 2

Flood Hazard Risk Assessment

GRETNA, LOUISIANA

GRETNA STORMWATER MASTER PLAN

Existing Conditions Flood Hazard Assessment

A flood hazard risk assessment (FHRA) of the existing flooding conditions in the City of Gretna was performed to identify areas of concern and to quantify structure & content damage associated with flooding within the City. From there, flood mitigation projects will be identified to target the areas of greatest potential benefit. Areas of concern were identified by coordinating the historical flooding data recorded by the City and the hydraulic model results.

1.1. Watershed Characteristics

The City of Gretna lies within the East of Harvey Basin. The East of Harvey Basin, shown in *Figure 1*, is the area bound by levees south and west of the Mississippi River, north of the Gulf Intracoastal Waterway, and east of the Harvey Canal. The City of Gretna covers approximately 5.4 square miles (~3,500 acres), all falling within Jefferson Parish and the East of Harvey Basin. The city limits were used for evaluation for the FHRA. The city includes mostly incorporated areas and is generally developed. Elevations within the City of Gretna range from 10 feet to -10 feet (NAVD88 Geoid 12A). Gretna has a slight slope from north to south starting at its highest at the Mississippi River Levee and sloping downward to the Timberlane Neighborhood. The Whitney and Verret Canals (Whitney Canal is the northernmost canal and confluences and turns into Verret once it crosses Belle Chasse Highway) are the main drainage artery of the city flowing North to South. Other notable drainage canals include Hero Canal, Governor Hall Canal, and Hancock Canal. Verret Canal eventually confluences with Bayou Fatma in the south and flows towards pumping stations which pump the water into the Harvey Canal and Gulf Intracoastal Waterway. The model bounds and terrain can be seen in *Figure 2* and a map of the neighborhoods can be seen in *Figure 3*.

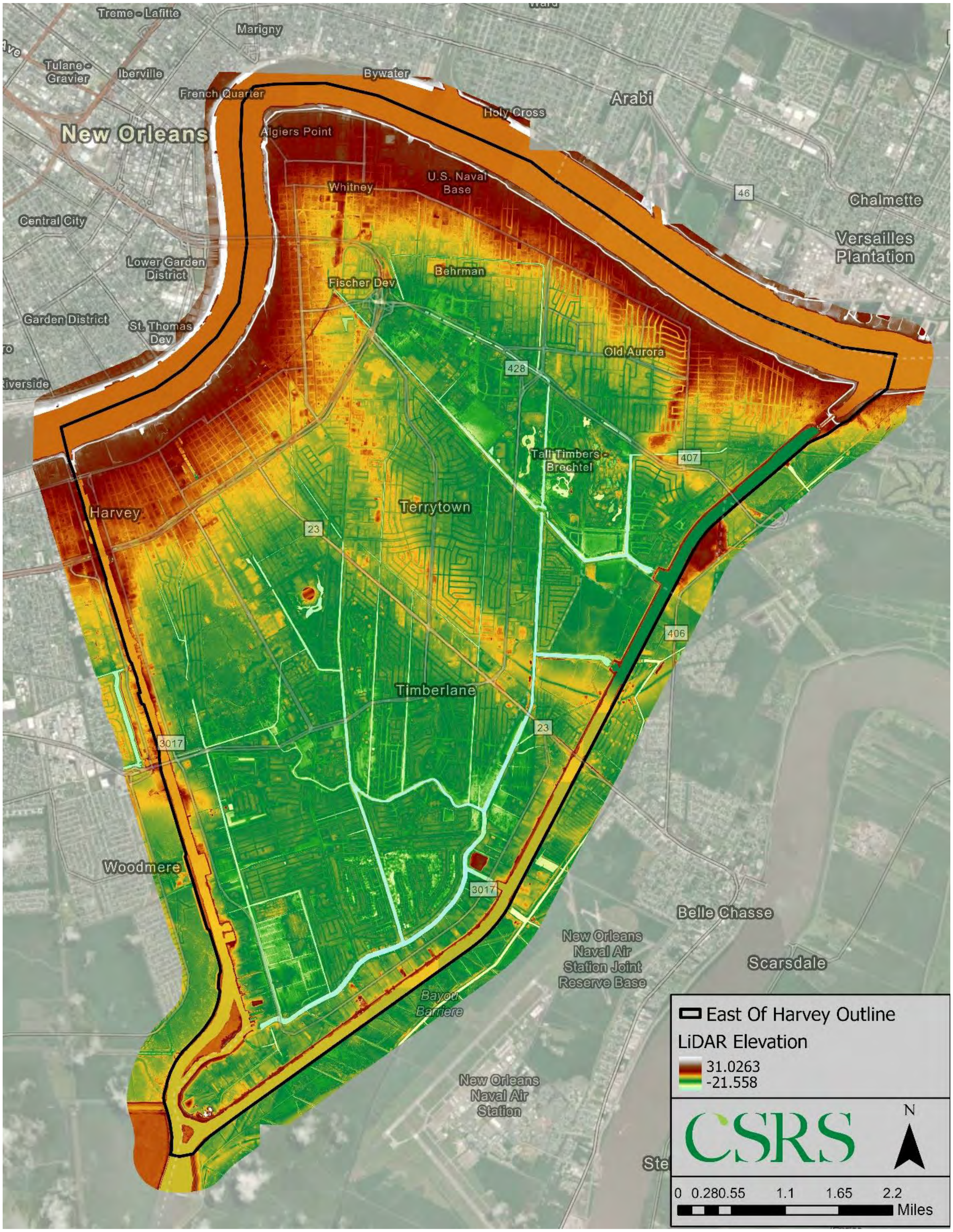


Figure 1: East of Harvey Basin Extents

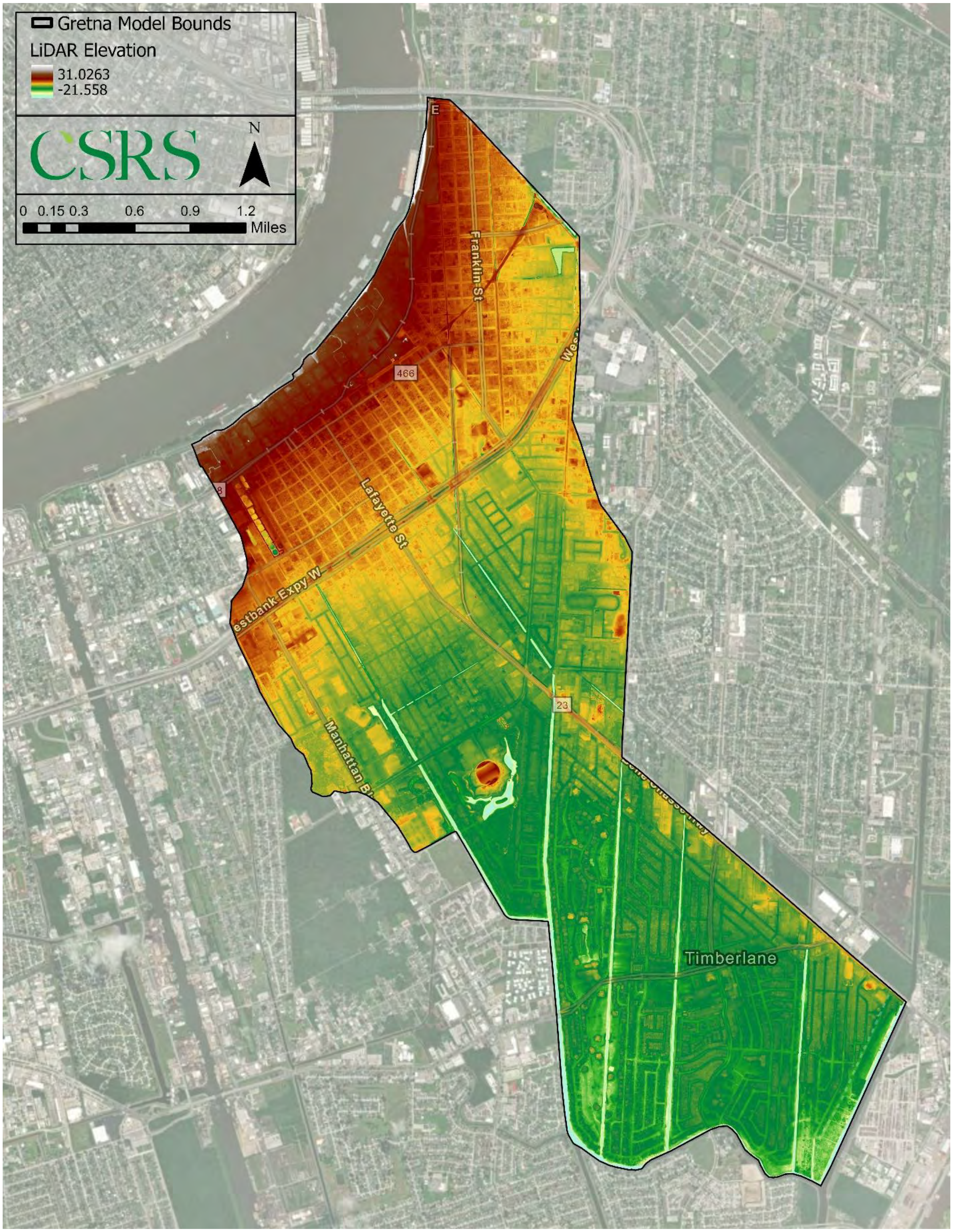


Figure 2: Model Bounds and LiDAR

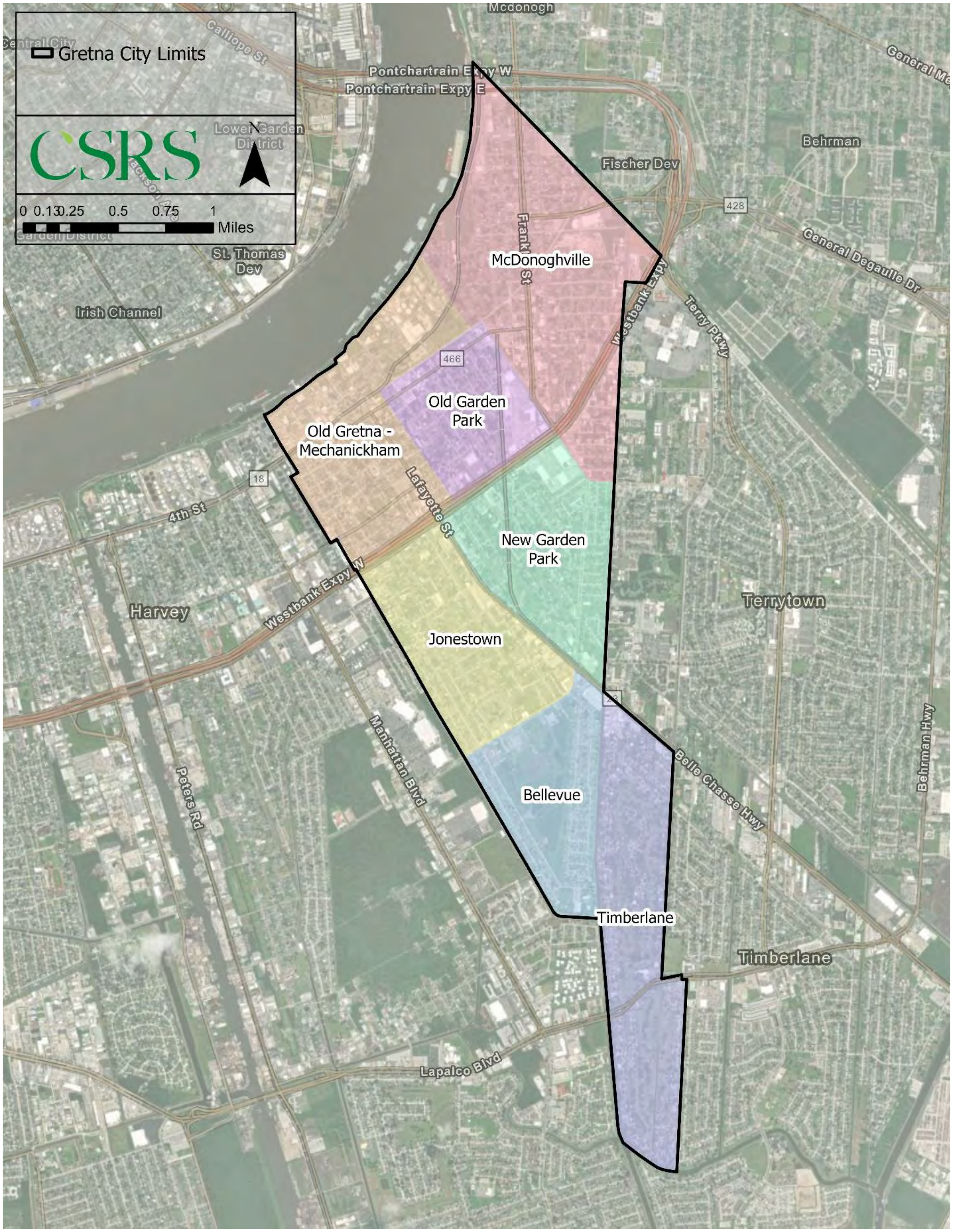


Figure 3: City of Gretna Neighborhoods

1.2. Modeled Flood Inundation & Damage Assessment

A flood damage assessment was performed for the City of Gretna. Structural damages were quantified for seven design storm events (1-, 2-, 5-, 10-, 25-, 50-, and 100-year storm events) using HEC-FIA, a software program developed by the U.S. Army Corps of Engineers (USACE) in collaboration with the Risk Management Center (RMC) and the Engineering Research and Design Center (ERDC). HEC-FIA determines both building and contents damages based on depth-damage curves specified by building type. Details on the damage modeling methodology and the structure inventory can be found in the methodology report.

Using the developed methodology, monetary damages for each structure within the city were identified. The location and value of structure damages from the FIA results served as an essential reference for the areas of concern. As mentioned in the Methodology report, section 2.6.2, climate change is incorporated in the Gretna SMP modeling. The total damage for simulations related to the existing events and climate changing events are illustrated in *Figure 4*. As expected, the total damage increased comparing the climate changing results with the existing condition results. This increase in damages is a result of an increase in the total rainfall amount for each return interval storm event for the with climate change scenario.

Hydraulic modeling results estimate damages ranging from \$15 million from a 1-year event to \$170 million from a 100-year event. These damages are distributed throughout the city with the most concentrated areas located along Whitney Canal, Stumpf Canal, and 25th Street. These concentrations of damages are due to a high density of mostly residential structures located in flood prone areas. The 100-year flood extent can be found in *Figure 5.*

The structure damage map for the existing condition is shown in *Figure 6*, and this map only includes the 5-, 10-, 25-, and 100-year events and shows damages that are greater than 0-feet.

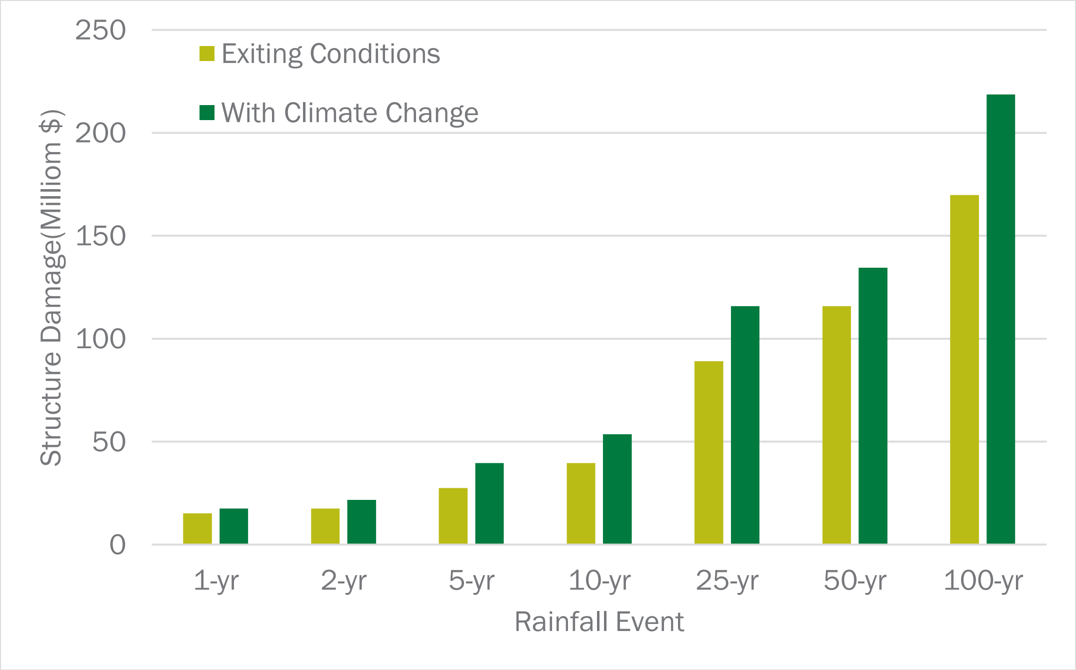


Figure 4: Total Damages for Simulated 6-Hour Events and 6-Hour Climate Change Events in Gretna (1-, 2-, 5-, 10-, 25- 50-, and 100-year)

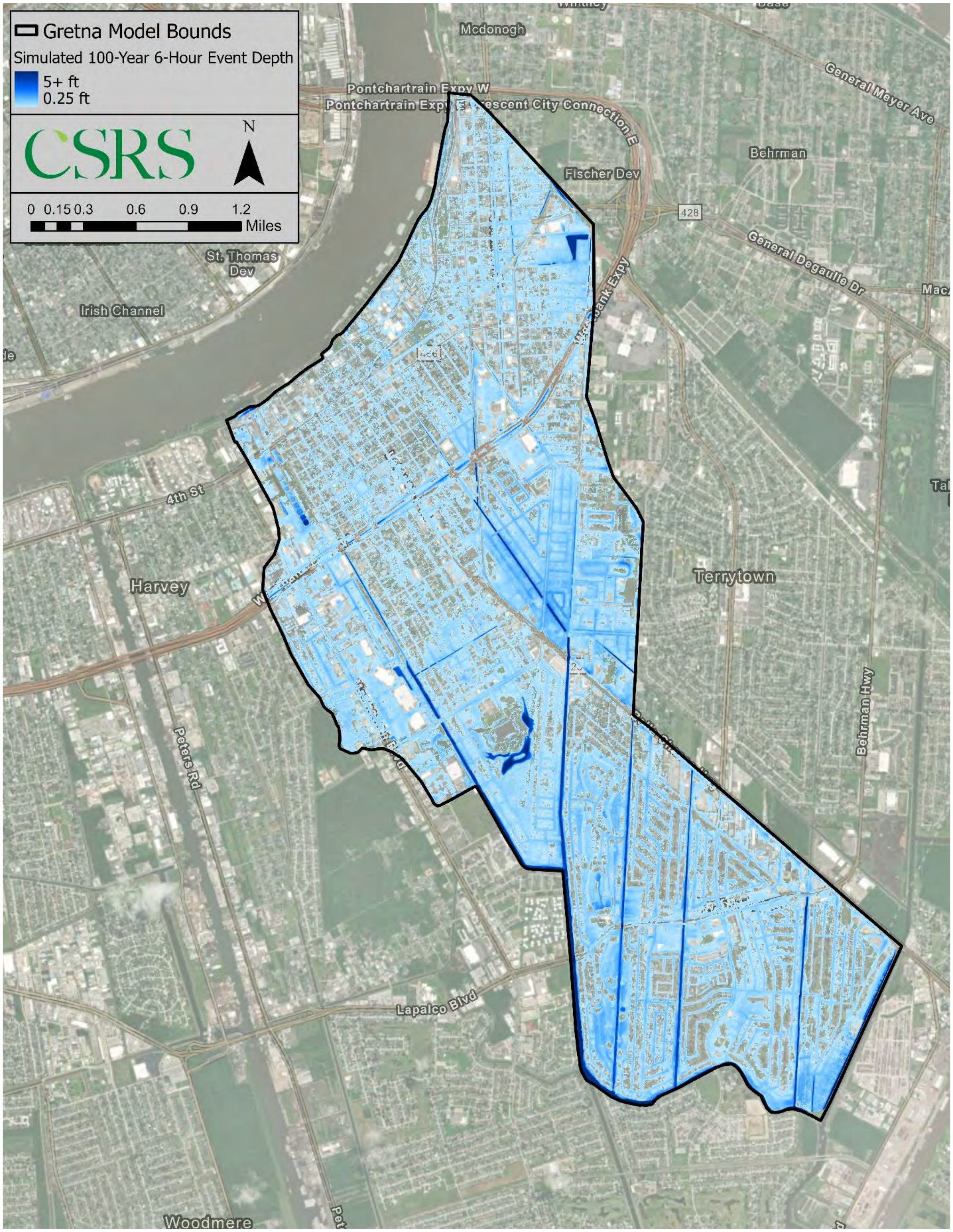


Figure 5: 100-yr 6-hour Storm Event Depths

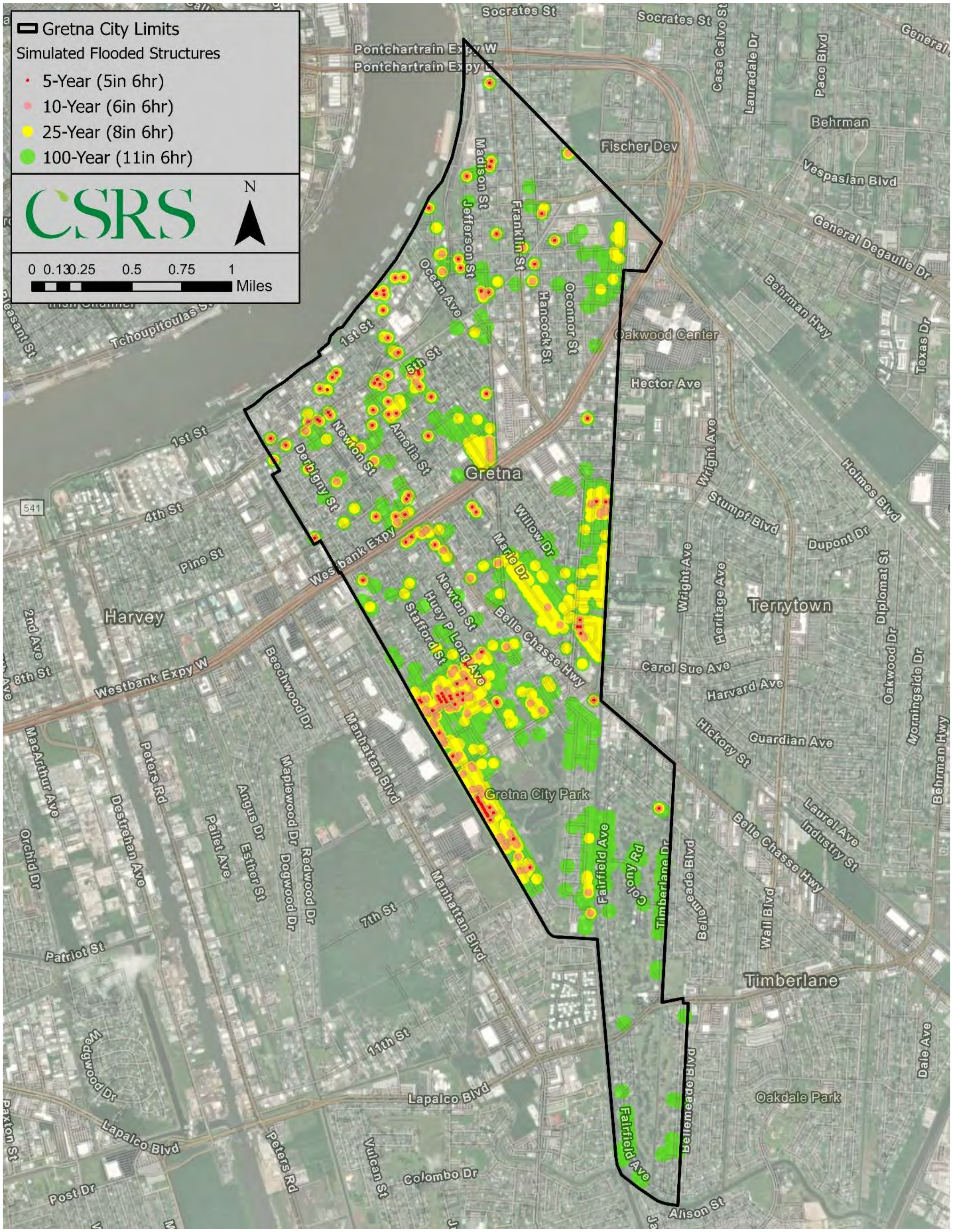


Figure 6: Structure Damages for Simulated 6-Hour Events in Gretna (5-, 10-, 25-, and 100-year)

1.3. FEMA Repetitive Loss & Severe Repetitive Loss

Both unmitigated repetitive loss (RL) and unmitigated severe repetitive loss (SRL) properties as defined by both the National Flood Insurance Program (NFIP) and Flood Mitigation Assistance (FMA) grant program were mapped.

NFIP SRL properties are those that have had four or more claims of more than $5,000 (including buildings and contents payments) or at least two claims that cumulatively exceed the building's value (building payments only). FMA SRL properties are those that have had four or more separate claims payments (includes building and contents payments) have been made under flood insurance coverage with the amount of each such claim exceeding $5,000, and with the cumulative amount of such claims payments exceeding $20,000, or at least two separate claims payments (building payments only) have been made under such coverage, with the cumulative amount of such claims exceeding the market value of the insured structure.

NFIP RL properties are those that have had two or more claims of more than $1,000 paid by the National Flood Insurance Program (NFIP) within any rolling 10-year period, since 1978; or two or more claims (building payments only) that, on average, equal or exceed 25 percent of the market value of the property. FMA RL properties are those that have had incurred flood-related damage on two occasions, in which the cost of the repair, on average, equaled or exceeded 25 percent of the market value of the structure at the time of each such flood event; and at the time of the second incidence of flood-related damage, the contract for flood insurance contains increased cost of compliance coverage.

Although data points are not documented in this report due to the sensitive nature of the data, RL and SRL data were utilized as criteria for assessing risk areas. The southwestern portion of the city contains the highest concentration of repetitive loss structures.

1.4. FEMA Special Flood Hazard Areas

As displayed in *Figure 7,* the area is comprised primarily of two flood zones, Zone AE and Shaded Zone X. AE flood zones are areas that present a 1% annual chance of flooding according to FEMA studies. Areas in Shaded Zone X are determined to be with reduced flood risk due to a levee. The northern portion of the city contains most of the Shaded Zone X areas, as these are areas of higher elevation. Downstream and southern areas make up most of the Flood Zone AE locations.

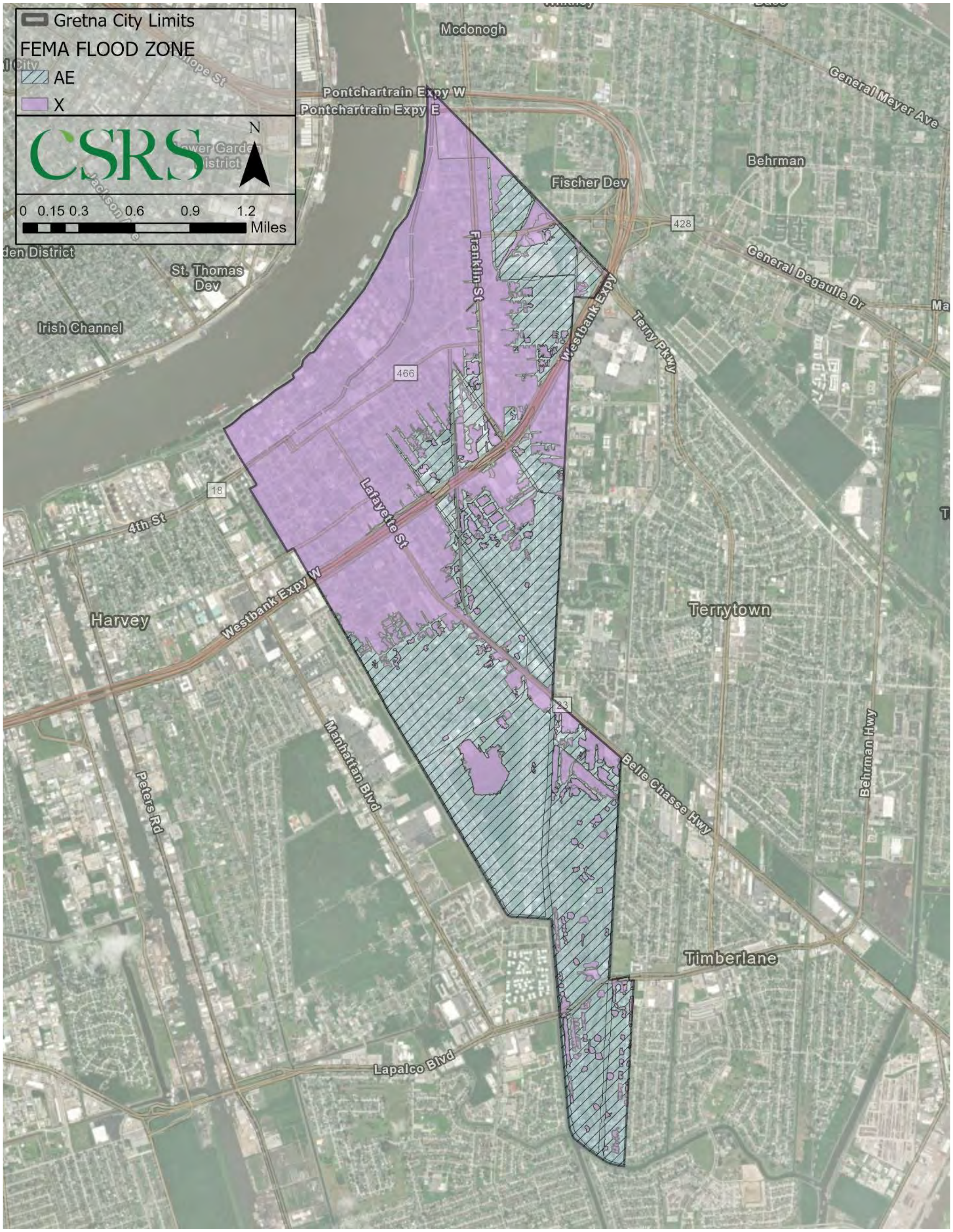


Figure 7: FEMA Flood Hazard Map for the City of Gretna

1.5. Critical Infrastructure

Critical infrastructure is identified as infrastructure that is crucial to the safety and health of the public, this includes:

- Fire Stations
- Police Stations
- Municipal Facilities
- Museum
- City Halls
- Schools
- Hospitals

Critical infrastructure that is flooded cannot operate in its standard role or capacity resulting in a loss of social or economic function and slower emergency response times, potentially leading to a loss of life or property during storm events. Additionally, areas such as community centers cannot be used as emergency shelters when they are inundated or damaged due to flooding from storm events. Flooded critical infrastructure locations, along with a heat map of 10-Year event structure damages, are shown in *Figure 8*.

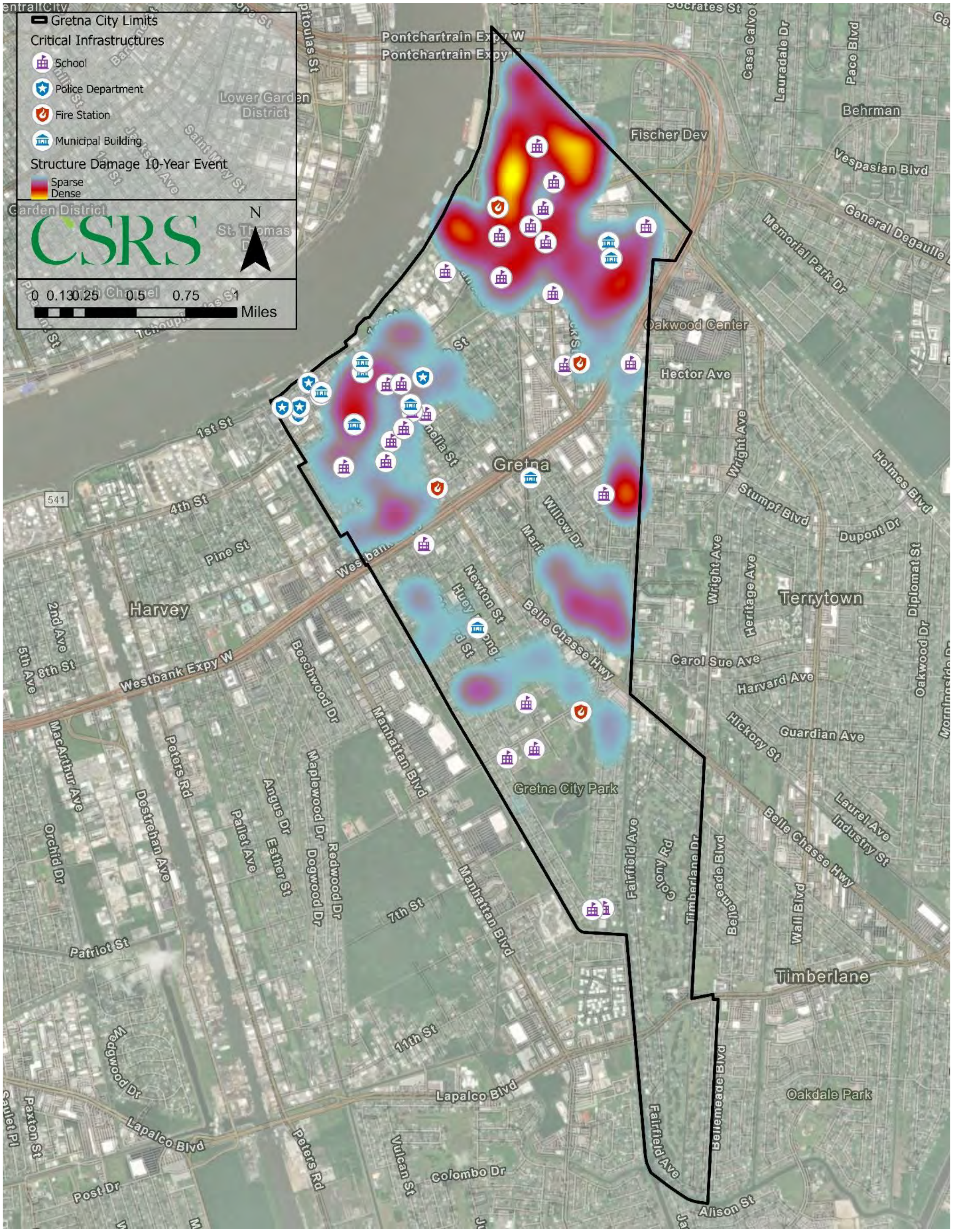


Figure 8: Flooded Structure Damages in the Gretna Area

1.6. Street Flooding Duration

Flooded streets result in detours for emergency responses, limit the mobility of residents, inhibit recovery efforts, and delay the return to normal community function. To identify locations of flooded streets during and after the rainfall event, street flooding maps were generated by setting a depth tolerance of 1 foot. The depth tolerance was set in order to yield this map focusing on the worst street flooding issues. Street flooding locations were observed throughout the city. The worst street flooding is seen in the central and southern portions of the city, along the internal canals, surrounding Gretna City Park and the Timberlane Country Club. The resulting street flooding map can be seen in *Figure 9.* In *Figure 9*, each colored point indicates a flooded segment of the street from the simulation results, with a maximum flooding depth greater than 1 foot. Since these points are overlaid from lighter rainfall events to heavier rainfall events, it can be observed that as the rainfall intensity increases, the extent of street flooding expands.

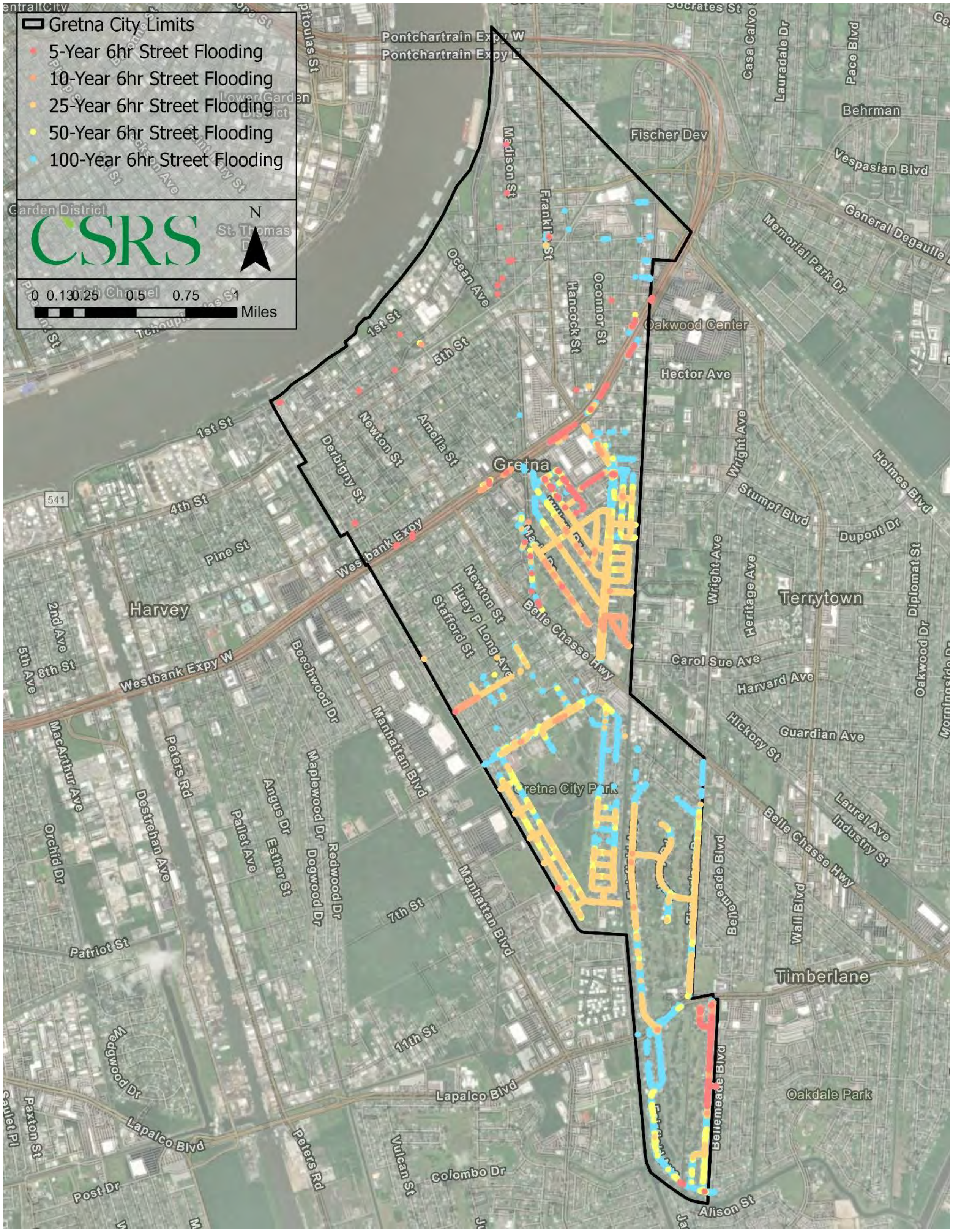


Figure 9: Street Flooding for Simulated 6-Hour Events in Gretna (5-, 10-, 25-, and 100-year)

1.7. Area of Concern Determination & City Coordination

The areas of concern were determined by analyzing the distribution of the simulated damages of structures in combination of the density of RL/SRL properties. Roadway flooding was also taken into account when determining the areas of concern. Following CSRS's initial analysis, a charette was held with members of the staff of Gretna, the mayor, and members of the city council to review the modeling methodology, preliminary results, and preliminary areas of concern. Gretna's staff and elected officials provided their knowledge of recently completed and/or currently scheduled flood mitigation projects along with their on-the-ground understanding of historic flood risk to confirm the areas of concern. The model was updated to reflect their inputs, and areas of concern were revised to include priority nuisance flooding locations. Following the finalization of the model results, an additional charette was held to review the final results and areas of concern. The results and areas of concern were found to sufficiently represent existing flood risk and issues in the City of Gretna. In total, 19 preliminary areas of concern were identified and can be seen in *Figure 10*. These areas of concern represent concentrated flood damage, each resulting from a single source or multiple sources of flooding. The Flood Risk Reduction Project Analysis phase of this project generated and evaluated solutions to address the locations identified in this section.

Figure 10: Final areas of concern for the City of Gretna

ATTACHMENT 3

Technical Memorandum & H&H Report

GRETNA, LOUISIANA

1. Overview

This technical memorandum describes the data and methodology used to complete a benefit-cost-analysis (BCA) for proposed risk reduction and water quality improvements for the City of Gretna. These proposed projects are located on the riverside of the Westbank Expressway in the Old Gretna-Mechanickham, Old Garden Park, and McDonoghville neighborhoods. Repetitive and severe repetitive loss properties validate hydraulic and hydrologic simulations of existing conditions which show Gretna experiences pluvial flooding in localized areas throughout the city. To reduce this flooding, a mixture of green infrastructure (GI) and traditional infrastructure solutions are proposed on the river-side of the Westbank Expressway to store excess precipitation runoff near the source. This includes distributed bioswales, pervious pavers, engineered soil sports fields, channel improvements, and one detention basin. The proposed solutions were evaluated using Computational Hydraulics International's (CHI) PCSWMM software to identify optimal placement and maximum benefit within the affected areas. Figure 1 shows an overview of the PCSWMM model in the area near the project. Figure 2 shows the proposed concepts.

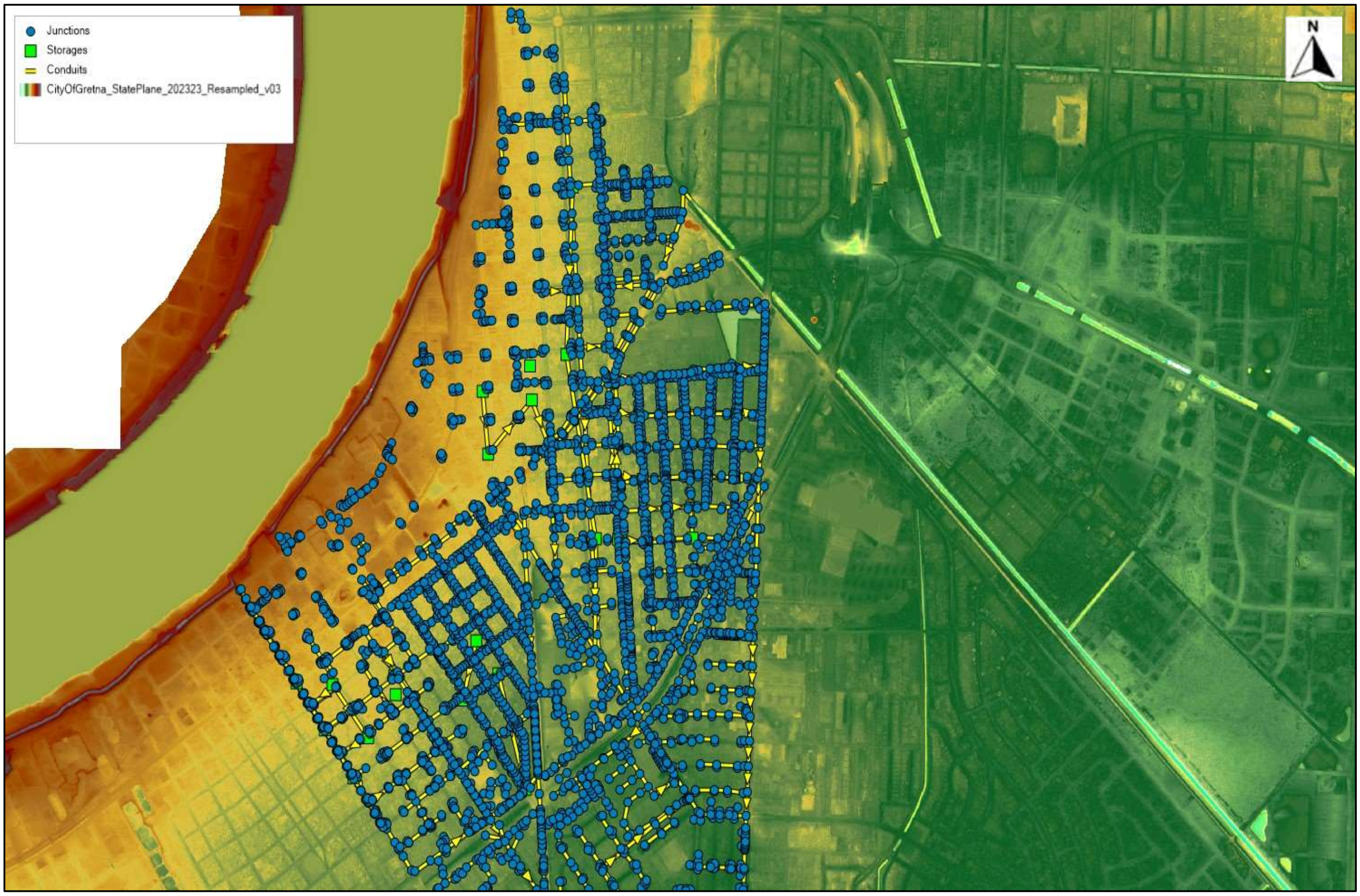
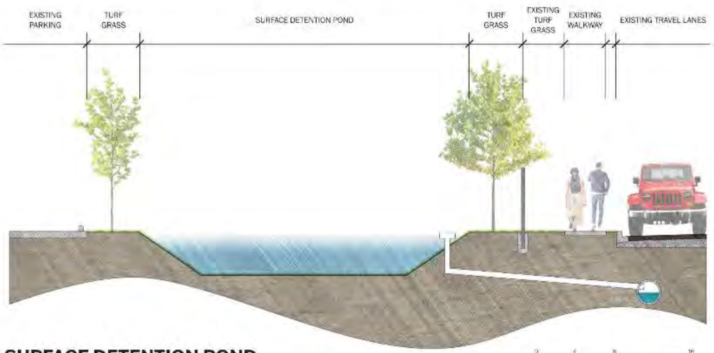


Figure 1: PCSWMM Model



SURFACE DETENTION POND

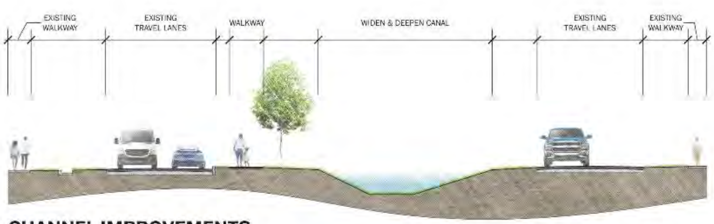
TYPICAL SECTION

EXISTING OPEN LAND AREAS ARE EXCAVATED TO DETAIN WATER. PIPE CONNECTIONS TO THE MUNICIPAL DRAINAGE SYSTEM ALLOW THEM TO RECEIVE STORMWATER DURING A STORM AND DISCHARGE IT BACK INTO THE PIPES AFTERWARDS.

BIOSWALES

TYPICAL SECTION

SHALLOW, LINEAR SWALES ARE PLANTED WITH NATIVE PLANTS THAT CAPTURE, DETAIN, AND CONVEY STORMWATER RUNOFF. STORMWATER IS FILTERED BY THE NATIVE PLANTINGS AND HIGHLY PERMEABLE SOILS TEEMING WITH MICROBES, WHICH BIOLOGICALLY REMOVE WATER POLLUTANTS.



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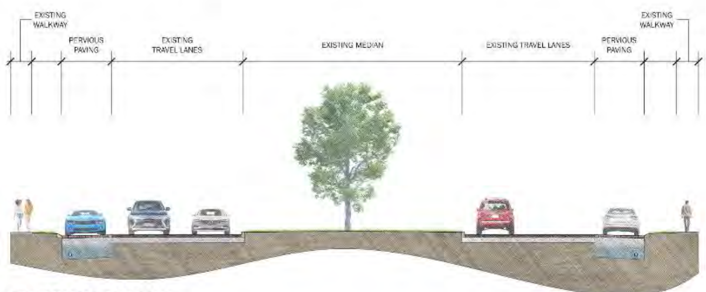

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EXISTING PARALLEL PARKING ALONG SELECT STREETS AND PARKING STALLS IN SELECT LOTS ARE RECONSTRUCTED WITH PERVIOUS CONCRETE PAVERS TO REDUCE STORMWATER RUNOFF, TO ALLOW INFILTRATION INTO THE AGGREGATE AND SUBDRAINS BELOW, AND TO DETAIN STORMWATER BEFORE DISCHARGING INTO THE MUNICIPAL DRAINAGE SYSTEM.

ENGINEERED SOIL SPORTS FIELDS

TYPICAL SECTION

EXISTING SPORTS FIELDS ARE EXCAVATED AND RECONSTRUCTED WITH SOILS THAT ARE HIGHLY PERMEABLE AND PROVIDE STORMWATER STORAGE CAPACITY. HARDY TURF GRASS PLANTED ON THE FIELDS DRAIN STORMWATER QUICKLY INTO THE SOIL AND SUBDRAINS, ALLOWING THE TURF TO DRY MORE QUICKLY AND BE READY FOR SPORTS PLAY.

Figure 2: Proposed Solution Concept Sckethes by Type

1.1. Software

FEMA's BCA Toolkit Version 6.0.0 was used to determine the Benefit-Cost Ratio (BCR) for the proposed mitigation activities. The following section describes the detailed methodology used to calculate the BCR. While following the FEMA BCA Reference Guide and Supplement, this analysis uses engineering assessment and statistical determinations of likely occurrences and their associated damages during the expected events. The Professional Expected Damages option was used within the BCA Toolkit to prepare this BCA. PCSWMM was used for hydrologic and hydraulic modeling. HEC-FIA was used to calculate structure and content damages from simulated flooding results.

1.2. Historic and Modeled Events

In accordance with the FEMA BCA Reference Guide and Supplement, historical loss data and/or expected losses associated with specific flood events can be used to estimate benefits in the BCA. Historical precipitation data was not used in this analysis. Model results were validated by FEMA repetitive loss and severe repetitive loss claim concentrations. A large portion of the city flooded in 2005 from Hurricane Katrina. In order to reduce the possibility of misrepresenting historic flooding that was mitigated, analysis focused on properties flooded after 2005. The 5-year, 10-year, 25-year, 50-year and 100-year events were simulated to determine building losses, content losses, displacement costs, and loss of function. Simulated flood depths were imported into HEC-FIA to calculate damages. Calculated damages were input into the Toolkit as "Professional Expected Damages" using the frequency relationship option. This approach is consistent with FEMA's professional expected damages approach, as detailed in the FEMA BCA Reference Guide.

1.3. Proposed Mitigation Action

To ensure that the proposed improvements are in compliance with available regulations and guidance, CSRS completed a Hydrologic and Hydraulic (H&H) Study to aid in project design. This study was done with the intention of evaluating the existing hydraulic behavior of the City of Gretna to determine a proposed design that would provide adequate flood relief for affected properties. Incorporation of permeable pavers, bioswales, channel improvements, engineered soil sport fields, and one detention basin were considered for implementation within the study area. Sizing, placement, and volume of the proposed mitigation measures were determined by Dana Brown & Associates. Results of the H&H Study can be found in the *H&H Report*, Appendix A.

2. Project and Maintenance Costs

The project cost was input as a single amount into the BCA Toolkit. See Table 1 below for a summary of the costs. The estimate values below were generated by Dana Brown & Associates (DB&A) and are detailed in the cost take off included with the grant application. Construction costs were calculated by unit costs for each component. Unit costs were sourced from local 2022 and 2023 construction bid items. For items without available local bid line items, unit costs were sourced from R.S. Means. Maintenance costs were established by consultation with DB&A landscape architects and were based on existing City and regional projects with similar components.

Table 1: Mitigation Project Capital and Maintenance Costs

Mitigation Activity	Project Cost	Annual Maintenance Cost
Gretna Green Distributed GI Network	$54,849,555	$694,016

3. Project Useful Life

In *FEMA Economic Benefit Values for Green Infrastructure (July 2022), page 21*, Table 4, FEMA identifies the project useful life (PUL) for a range of GI components. The shortest PUL for components included in the proposed solution was 30 years (for pervious pavers). As such, analyses used a 30-year PUL for the mitigation project.

4. Determining Recurrence Intervals

Analyses used recurrence intervals from the H&H Study to model expected impacts. Recurrence intervals analyzed in the H&H Study are based on NOAA Atlas 14's point precipitation values taken for the city. A sensitivity analysis was performed using the H&H model to identify which storm duration (1-hour, 6-hour, 24-hour, etc) produced the greatest risk. Based on the results of the analysis, the 6-hour storm duration values were used for the 5-, 10-, 25-, 50-, and 100-year return interval events.

5. Determining Physical Damages and Displacement Costs

Because of the proximity of various structures to the natural drainage areas, structural damage has been frequently reported after heavy rain and storm events. The effectiveness of flood mitigation was assessed for each of the return intervals mentioned on a structure-by-structure basis using the H&H model outputs and a damage model in HEC-FIA.

5.1. Structure Inventory

The City of Gretna building footprint database was used to determine the square footage of each structure identified in the benefit area. Each building footprint was assigned a structure value based on the square footage of the structure and relevant cost per square foot from 2023 RSMeans data for residential structures and 2020 RSMeans data for commercial structures due to the availability of data at time of analysis. Elevation certificates were supplied by the city to ensure accurate first floor elevations where available. Where elevation certificates were not available, first floor elevations were estimated based on an assumed first floor offset above the 2021 USGS GNO LiDAR ground elevations. The standard deviation of LiDAR elevations within each footprint were calculated. Structures with elevation standard deviations of less than 0.5 feet used the minimum LIDAR elevation within the footprint as the ground elevation. Those with standard deviations greater than 0.5 used the average elevation within the footprint as the ground elevation. The first floor offsets were assigned on a neighborhood-by-neighborhood basis using Google Earth Streetview to assess a sample of streets within each neighborhood.

5.2. Damage Modeling Using HEC-FIA

HEC-FIA version 3.1 was used to determine structure damages, content damages, and vehicular damages based on simulated depths of flooding. Structures from the building footprint were assigned one of the following ten classifications:

- Apartment
- Church
- Industrial Storage Tank*
- Medical
- Mobile
- Office
- Parking Garage*
- Resident

- School
- Store

  **Damages were not calculated for industrial storage tanks or parking garages.*

The default depth-damage functions (DDFs) in HEC-FIA were applied to each respective structure classification. According to the *HEC-FIA User's Manual (December 2019), Page 8-24 (8.6.3)*, the depth-damage curves are from EGM 04-01 *US Army Corps of Engineers' Generic Depth-Damage Relationships (2003)* and the HAZUS database. The industrial storage tank and parking garage classifications were not assigned a replacement value or DDF in the analysis and do not contribute to pre-post damages. Water depth results from the 5-, 10-, 25-, 50-, and 100-year event H&H simulations were input as inundation data.

Percentage of household vehicle ownership in Gretna from the *U.S. 2022 Census Bureau S2504* was averaged across all structures classified as residential within HEC-FIA. Vehicle values determined by the *US Army Corps of Engineers' Final Report, Depth-Damage, Relationships for Structures, Contents, Vehicles, and CSVR, Donaldsonville (2003)* were adjusted for inflation from 2006 to 2023 using the *Bureau of Labor Statistics Consumer Price Index (November 2023)*. After adjusting for inflation, the average vehicle value used was $32,500.

5.3. Displacement Costs

Displacement costs were calculated using September 2023 GSA lodging and meal & incidentals (M&IE) values for New Orleans of $136 per diem and $74 per diem, respectively (2023 New Orleans, Louisiana Federal Per Diem Rates, GSA.gov). These values were multiplied by the number of days of displacement for each benefitted residential structure to yield the displacement cost for each. The number of displaced days was estimated using the assumption of 45 days of displacement per foot of flooding above the first floor inside a residential structure. This assumption was applied using a continuous linear function. Depths of flooding above the first floor were taken from HEC-FIA results for each of the pre-project and post-project scenarios. **Tables 2** and 3 below identify the total damages and displacement costs calculated for each simulated return interval.

5.4. Summary Costs Before and After Mitigation Project

Table 2: Building, Content, and Displacement Costs Calculated Before Mitigation Project

Recurrence Interval (yr)	Total Structure Damages	Total Content Damages	Total Vehicle Damages	Total Displacement Costs	Total Cost
5.0	$7,740,787	$4,295,331	$77,199	$326,773	$12,440,091
10.0	$16,281,155	$7,884,095	$217,222	$922,478	$25,304,950
25.0	$38,347,820	$16,959,544	$654,209	$2,889,196	$58,850,769
50.0	$60,121,202	$32,032,787	$999,100	$4,968,971	$98,122,060
100.0	$75,289,106	$36,637,592	$1,775,536	$7,805,526	$119,258,863

Table 3: Building, Content, and Displacement Costs Calculated After Mitigation Project

Recurrence Interval (yr)	Total Structure Damages	Total Content Damages	Total Vehicle Damages	Total Displacement Costs	Total Cost
5.0	$5,207,087	$2,792,743	$63,579	$266,615	$8,330,024
10.0	$10,975,358	$5,042,496	$166,651	$708,286	$16,892,791
25.0	$23,847,214	$9,555,824	$454,928	$1,875,672	$35,733,639
50.0	$44,446,517	$21,682,011	$781,590	$3,659,287	$70,569,405
100.0	$46,711,286	$20,256,123	$1,087,566	$4,409,732	$73,905,703

6. Social Benefits

Social Benefits were assessed based on all residential structures benefited across all simulated return intervals. Households in Gretna have an average of 2.16 people according to the U.S. Census Bureau, 2018-2022 American Community Survey 5-Year Estimates. According to the same source, 58% of residents are employed. The number of residents per household was multiplied by the number of benefitted residential structures, then the percentage of employed persons was applied to find the number of workers affected, as shown in Table 4 below.

Table 4: Total Social Benefits Summary

Category	Value
Benefitted Residential Structures	2,413
Number of Residents	5,212
Workers affected	3,023
Total Social Benefit	**$39,141,844**

7. Ecosystem Benefits

Ecosystem benefits were assessed based on the total acreage where land use will be enhanced due to the proposed mitigation efforts. The total acreage calculated was 26.3 for all proposed solutions. This includes a combination of the green infrastructure, channel improvements, and detention basin within the study area. More details concerning the ecosystem benefits can be found in the BCA Report submitted with this application.

8. Results

The benefit-cost ratio (BCR) for the Gretna Green Distributed GI Network and the total project cost is listed in Table 5 below. Costs included in the determination of the BCR cover maintenance costs over the PUL of the mitigation alternative. This BCR is considered a conservative, high-level estimate as additional benefits, i.e., inundation of roadways, damages to the surrounding areas, and health impacts, are not included in this analysis. The total project BCR is shown in Table 5 below. The mitigation project is a cost-effective solution. To understand the BCA calculations in more depth, see the BCA Report submitted with this application.

Table 5: Gretna Green Distributed GI Network BCA Results

Discount Rate	Benefits (B)	Costs (C)	BCR (B/C)
7%	$76,030,899	$63,461,628	1.20
3% (For BRIC and FMA only)	$97,409,180	$68,452,575	1.42

Gretna Green Distributed Green Infrastructure Network H&H Report

FEMA Non-Disaster Hazard Mitigation Assistance Programs

Jefferson Parish, Louisiana

1. Introduction

This report presents the hydrologic and hydraulic analysis and mitigation strategy performed to assess the City of Gretna drainage area and identify a solution to reduce the risk of flooding for streets, repetitive loss structures, and other flood-prone properties in the surrounding areas. After examining existing conditions model results, the following green infrastructure (GI) improvements in certain areas within the City of Gretna, north of the Westbank Expressway were identified to reduce the risk of flooding to help protect the community, including the severe repetitive and repetitive loss structures, shown in *Figure 1*:

1. Old Garden Park East
    - Bioswales
    - Governor Hall Canal channel improvements
    - Huber Canal channel improvements
2. Mechanickham/Old Garden Park
    - Pervious pavers
    - Engineered soil sports field
3. West McDonoghville
    - Pervious Pavers
    - Engineered soil sports field
    - Bioswales
4. Old Mechanickham South
    - Bioswales
    - Surface Detention
    - Pervious pavers
5. East McDonoghville
    - Bioswales
    - Hancock Canal channel improvements
6. Franklin Street
    - Pervious pavers

All of the above-mentioned GI improvements will have a depth of four (4) feet with the exception of the engineered soil locations at Madison Street Park and Ruppel Academy which will have a depth of one (1) foot total with 0.5 feet consisting of fiber soils and the other 0.5 feet consisting of sand. The total cost of the proposed alternative is estimated to be $54,849,555. Please refer to Technical Memorandum Gretna Green Distributed GI Network for benefit cost specifics of the proposed alternative.

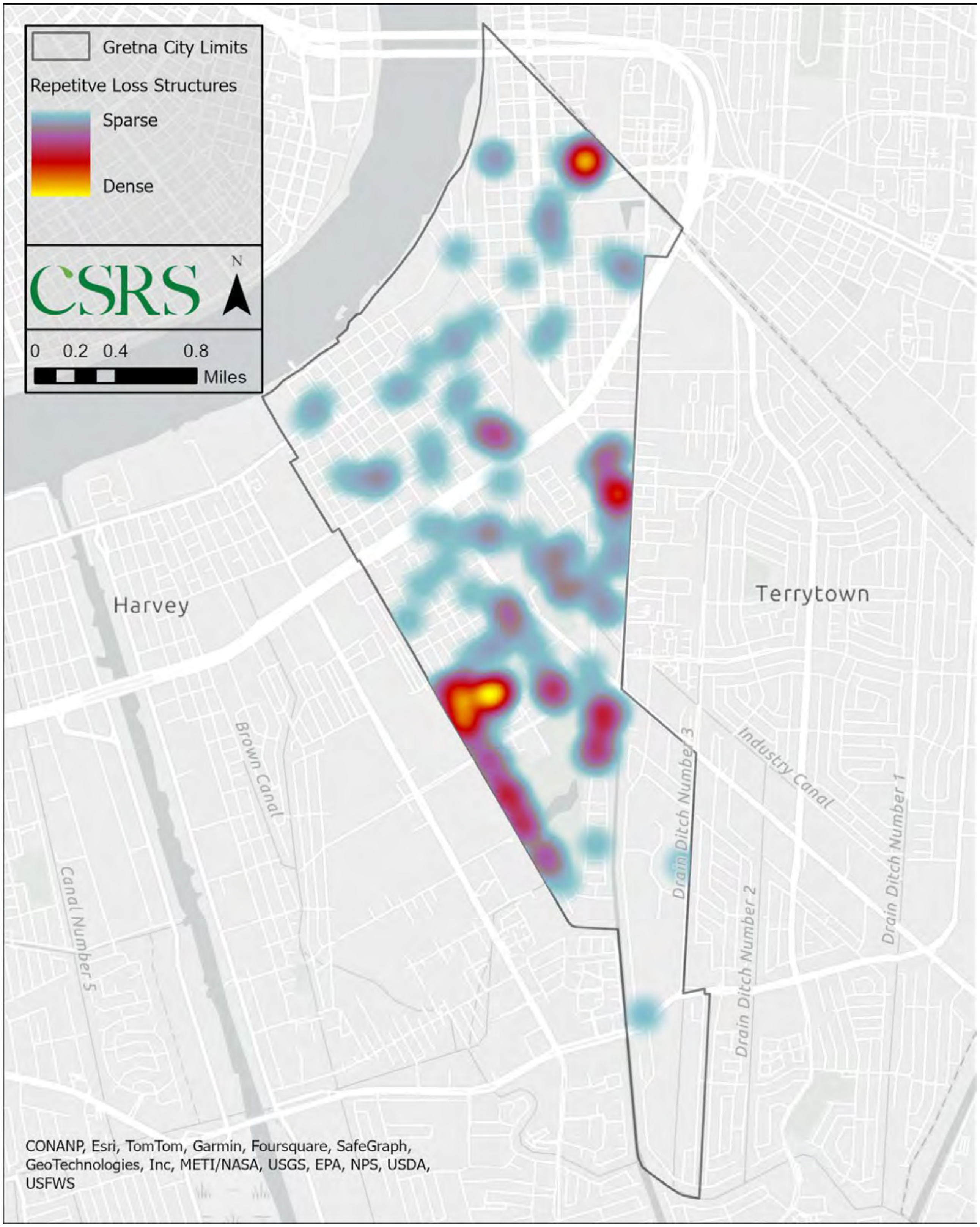


Figure 1: Heat Map of Repetitive Loss Structures

2. Hydrologic & Hydraulic Analysis Approach

Hybrid 1-Dimensional/2-Dimensional PCSWMM simulations (PCSWMM 5.1.015) were run for the hydrologic and Hydraulic analysis and rain-on-grid precipitation was used based on incremental rainfall hyetographs. Precipitation depths were based on NOAA Atlas 14 point-precipitation values for a 6-hour storm duration and temporally distributed in accordance with the NOAA Temporal Distribution Quartile 1 10^{th} Percentile described NOAA Atlas (2014). The 5-, 10-, 25-, 50- and 100-year events were modeled for the existing and proposed conditions to identify the benefits to flood-prone structures. The 5-, 10-, 25-, 50- and 100-year events corresponds to 5 inch, 6 inch, 8 inch, 9 inch, and 11 inch rainfall, respectively within a 6-hour storm duration. The GI solutions were modeled using in-house PCSWMM tools to simulate designed storage volumes that were calculated and provided by Dana Brown & Associates Inc. *Figure 2* shows the existing subsurface system for the City of Gretna and *Figure 3* shows the proposed green infrastructure practices implemented to reduce flood risk in the area.

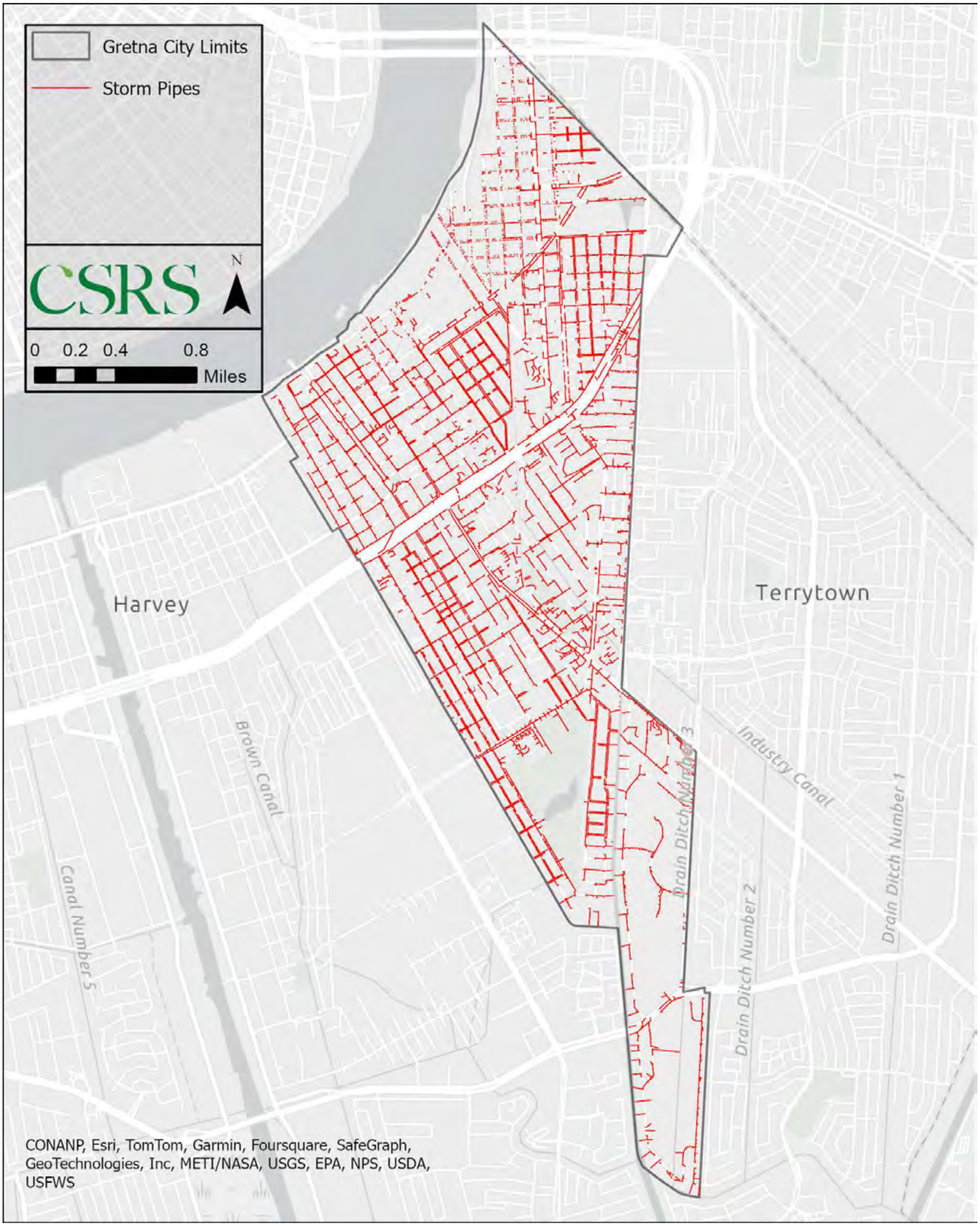
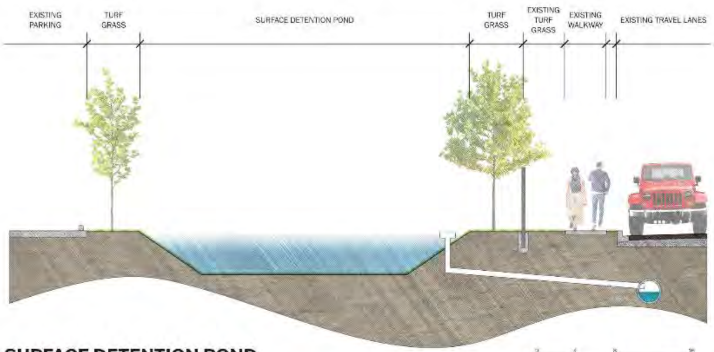


Figure 2: Subsurface Drainage System



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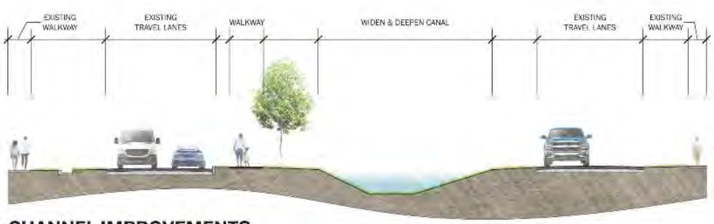

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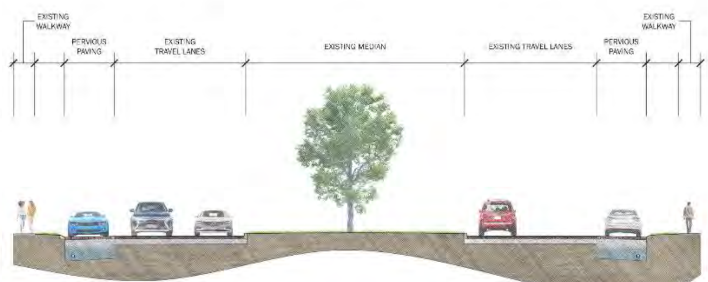

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Figure 3: Proposed Solutions

3. Flood Risk Mitigation

The effectiveness of flood risk mitigation was assessed for properties in the region using the Benefit-Cost-Analysis (BCA) determined with the FEMA BCA Toolkit (v6.0). The methodology for this process is described in the Technical Memorandum Gretna Green Distributed GI Network provided. The Benefit-Cost-Ratio (BCRs) was developed using the 5-, 10-, 25-, 50- and 100-year event existing and proposed conditions results.

The existing model as well as repetitive loss structures aided in the determination and verification of flood-prone areas and the source of the flooding. It was determined that several areas within McDonoghville and Gretna north of the Westbank Expressway will benefit from the implementation of GI as a means to mitigate stormwater flooding. These GI improvements included pervious pavers, bioswales, surface detention, engineered soils, and channel improvements. The proposed features were then investigated to determine the maximum benefit of these GI solutions once implemented. The final proposed geometric features described earlier in this report were modeled in the PCSWMM project scenarios.

Figures 4 through *8* show the benefited areas and the water surface benefit in feet for the 5-, 10-, 25-, 50- and 100-year events, respectively. These figures show that there will be a significant benefit to many surrounding properties across the city.

Figure 4: 5-YR Water Surface Benefit Map

Figure 5: 10-YR Water Surface Benefit Map

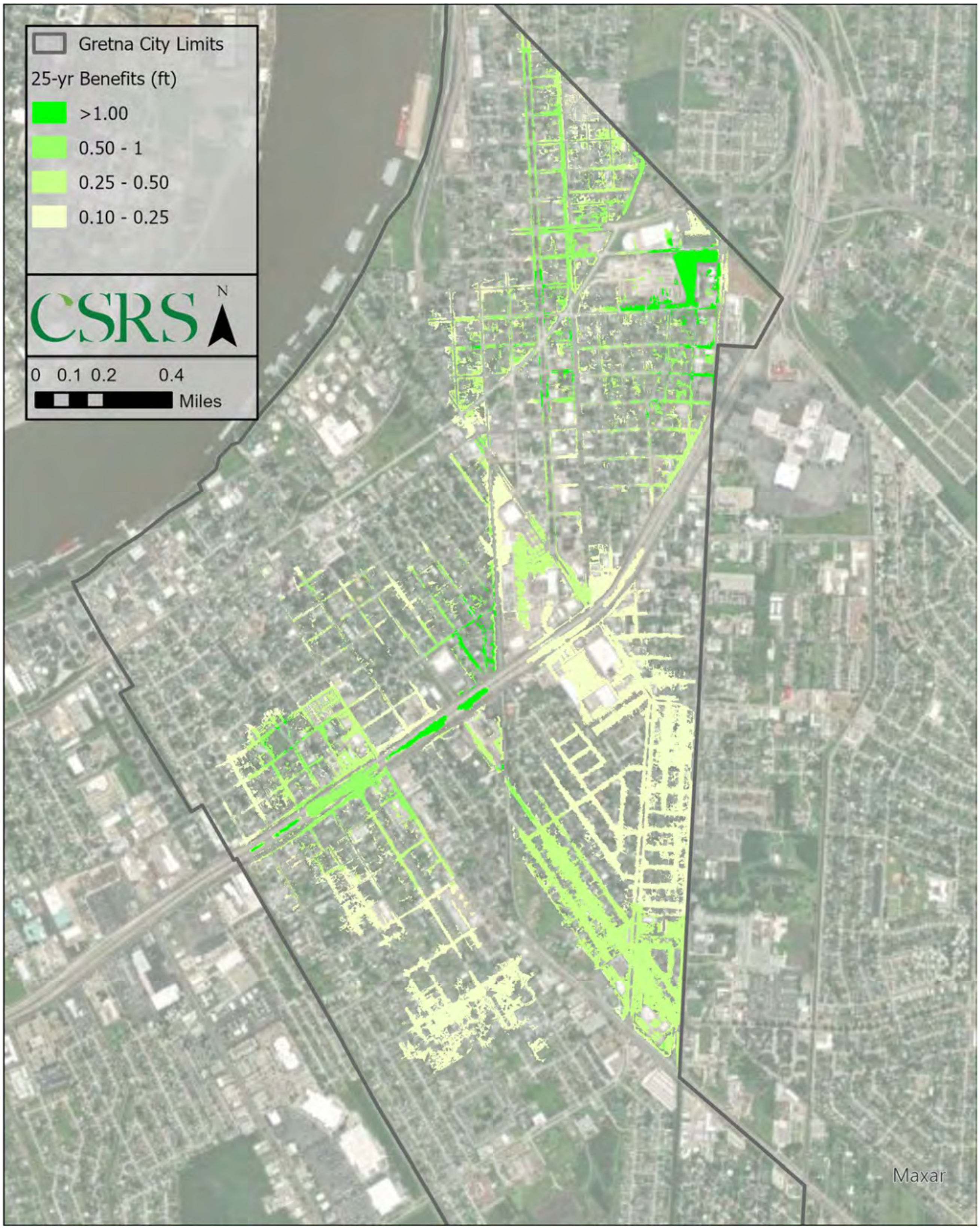

Figure 6: 25-YR Water Surface Benefit Map

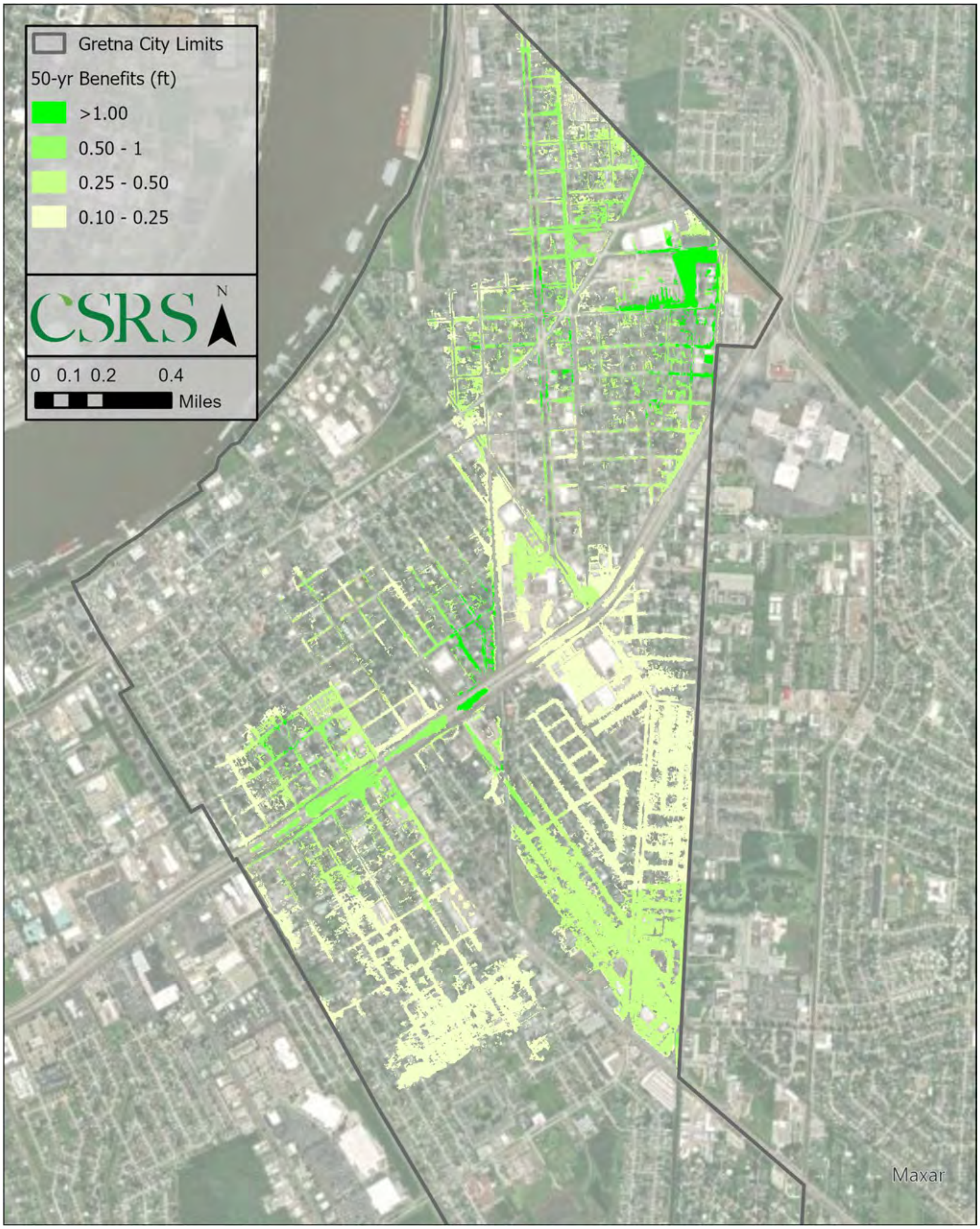

Figure 7: 50-YR Water Surface Benefit Map

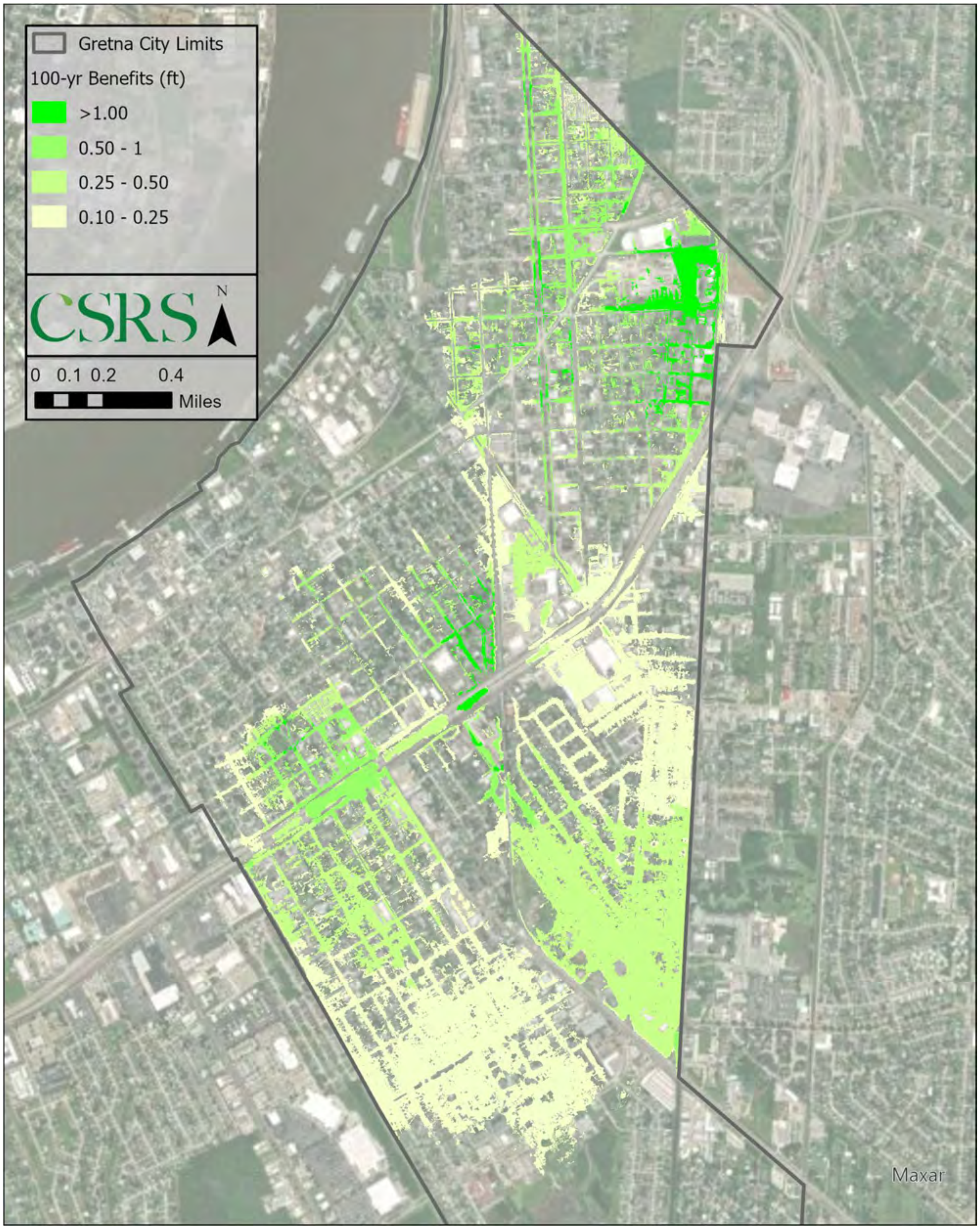

Figure 8: 100-YR Water Surface Benefit Map

4. Conclusions

This analysis was done to determine a mitigation solution for flood-prone structures for the City of Gretna's drainage area. Based on the results and the associated BCR shown in the Technical Memorandum Gretna Green Distributed GI Network, implementation of the proposed green infrastructure features that are described in this report would substantially reduce flood risk for a significant number of Gretna residents.

ATTACHMENT 4

Cost Estimate and Benefit Cost Analysis

Amelia Street to Stumpf Boulevard Improvements

GRETNA, LOUISIANA

Estimated Project Budget

The estimated project budget is detailed in the cost breakdown below.

ESTIMATED PROJECT BUDGET				
CONSTRUCTION COST ESTIMATE				
Description	*Quantity*	*Unit of Measure*	*Cost per Unit*	*Costs*
Excavation (Fried Detention)	**10,469**	**CUYD**	**$18**	**$188,447**
Excavation (4th St. Detention)	**14,660**	**CUYD**	**$18**	**$263,883**
Mobilization	**1**	**% of Construction**	**5%**	**$22,617**
DESIGN SERVICES ESTIMATE				
RW/Serv. Acquisition	**1**	**% of Land Costs**	**3%**	**$32,670**
H&H Analysis	**1**	**% of Construction**	**3%**	**$14,248**
Engineering Services	**1**	**% of Construction**	**7%**	**$33,246**
Construction Services (CEI)	**1**	**% of Construction**	**5%**	**$23,747**
Project Management	**1**	**% of Construction**	**5%**	**$23,747**
Permitting and Environmental	**1**	**% of Construction**	**1%**	**$4,749**
LAND AQUISITION				
LAND COST	**1**	**ACRES**	**$1,089,000**	**$1,089,000**
Wetland Mitigation	**0**	**ACRES**	**$25,000**	**$0**
CONTINGENCY				
		% Sum Total Cost	**30%**	**$142,484**
TOTAL PROJECT COSTS			$1,838,839	
ESTIMATED ANNUAL MAINTENANCE (1% of Construction)			$950	
ESTIMATED PROJECT USEFUL LIFE			50 YEARS	

Benefit-Cost Analysis

Cost Effectiveness

Further details related to the BCA and BCR including breakdowns of the project benefits, BCR and social benefits can be seen in Attachment 1 - Benefit-Cost Calculator Report. The total project's benefits, cost and calculated BCR with the 3% discount rate allowed for FMA applications are $4.9M, $1.8M, and 2.65, respectively. The social benefits were calculated based on recent census data for the city and environmental benefits were calculated based on the acreage of the total amount of green infrastructure implements proposed. Because this area falls within a levee system, no sea level rise analysis was needed. Benefits occurring outside the city are not quantified.

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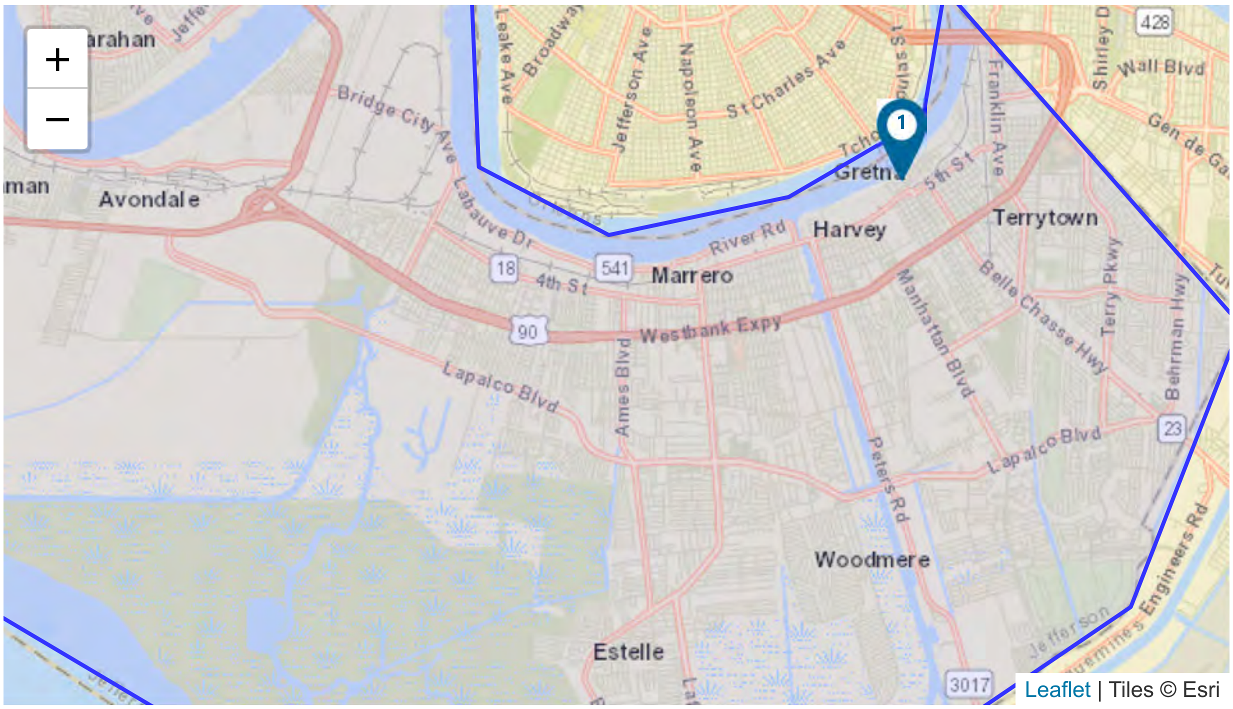
Benefit-Cost Calculator

V.6.0 (Build 20250602.0319 | Release Notes)

Benefit-Cost Analysis

Project Name: Gretna Amelia to Stumpf Mitigation



Map Marker ▲	Mitigation Title	Property Type	Hazard	Discount Rate (%)	Benefits (B)	Costs (C)	BCR (B/C)	
1	Floodwater Diversion and Storage @ Gretna, Louisiana_copy		DFA - Riverine Flood	3.1	$ 4,926,472	$ 1,857,221	2.65	!
TOTAL (SELECTED)					$ 0	$ 0	0.00	
TOTAL					$ 0	$ 0	0.00	

Property Configuration

Property Title:	Floodwater Diversion and Storage @ Gretna, Louisiana_copy
Property Location:	70053, Jefferson, Louisiana
Property Coordinates:	29.916960000000074, -90.06593999999996
Hazard Type:	Riverine Flood
Mitigation Action Type:	Floodwater Diversion and Storage
Property Type:	Residential Building
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Floodwater Diversion and Storage @ Gretna, Louisiana_copy

Discount Rate (%):	3.1% Use Default:Yes
Project Useful Life (years):	30
Project Cost:	$1,838,839
Number of Maintenance Years:	30 Use Default:Yes
Annual Maintenance Cost:	$950

Damage Analysis Parameters - Damage Frequency Assessment

Floodwater Diversion and Storage @ Gretna, Louisiana_copy

Year of Analysis was Conducted:	2025
Year Property was Built:	0
Analysis Duration:	10 Use Default:Yes

Professional Expected Damages Before Mitigation

Floodwater Diversion and Storage @ Gretna, Louisiana_copy

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
5	24,967,000	0	0	0	0	0	24,967,000
10	33,152,000	0	0	0	0	0	33,152,000
25	74,077,000	0	0	0	0	0	74,077,000
50	100,344,000	0	0	0	0	0	100,344,000
100	163,263,000	0	0	0	0	0	163,263,000

Annualized Damages Before Mitigation

Floodwater Diversion and Storage @ Gretna, Louisiana_copy

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
5	24,967,000	2,876,988
10	33,152,000	2,973,362
25	74,077,000	1,724,318
50	100,344,000	1,279,940
100	163,263,000	1,632,614
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	395,803,000	10,487,222

Professional Expected Damages After Mitigation

Floodwater Diversion and Storage @ Gretna, Louisiana_copy

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
5	24,460,000	0	0	0	0	0	24,460,000
10	32,045,000	0	0	0	0	0	32,045,000
25	72,194,000	0	0	0	0	0	72,194,000
50	98,878,000	0	0	0	0	0	98,878,000
100	161,870,000	0	0	0	0	0	161,870,000

Annualized Damages After Mitigation

Floodwater Diversion and Storage @ Gretna, Louisiana_copy

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
5	24,460,000	2,799,680
10	32,045,000	2,885,904
25	72,194,000	1,689,781
50	98,878,000	1,265,124
100	161,870,000	1,618,684
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	389,447,000	10,259,173

Ecosystem Services Losses Avoided

Floodwater Diversion and Storage @ Gretna, Louisiana_copy

Total Project Area (acres):	3.25
Percentage of Urban Green Open Space:	0.00%
Percentage of Rural Green Open Space:	0.00%
Percentage of Riparian:	0.00%
Percentage of Coastal Wetlands:	0.00%
Percentage of Inland Wetlands:	100.00%
Percentage of Forests:	0.00%
Percentage of Coral Reefs:	0.00%
Percentage of Shellfish Reefs:	0.00%
Percentage of Beaches and Dunes:	0.00%
Expected Annual Ecosystem Services Benefits:	$26,556

Benefits-Costs Summary

Floodwater Diversion and Storage @ Gretna, Louisiana_copy

Discount Rate (%):	3.1% Use Default:Yes
Total Project Benefits:	$4,926,472
Total Project Cost:	$1,857,221
Benefit-Cost Ratio:	2.65

ATTACHMENT 5

Project Summary Sheet

New Garden Park Green Infrastructure Implementation

GRETNA, LOUISIANA

Project Title
New Garden Park Green Infrastructure Implementation

Project Location
City of Gretna, Jefferson Parish, Louisiana (See attachment 1)

Description of Mitigation Need
A subset of the East of Harvey watershed was analyzed focusing on the City of Gretna, and flood risks were found within the southeastern half of the city. Within the New Garden Park neighborhood, there is space for significant green infrastructure improvements such as bioswales, pervious pavers, detention basins, and engineered soils. The construction of green infrastructure will result in flood risk reduction for the area immediately upstream of Whitney Canal and Belle Chasse Hwy and help the performance of the canal and connected subsurface pipes. Maps of the project location and terrain can be found in Attachment 1 and Attachment 2. Attachment 3 provides the existing FEMA flood map. As seen in Attachment 6, there are multiple existing homes in the benefit area that experience flooding during a 100-year rainfall event. For a 30-year project lifespan project, the estimated cost of the project is $72M, and estimated benefits are $60M resulting in a Benefit-Cost Ratio (BCR) of 0.83. Further details on FEMA Benefit Cost Analysis (BCA) can be found in Attachment 8.

Percentage of Population Affected
The percentage assumes 1253 affected households, with 2.16 persons per household, out of a total City of Gretna population of 17,590, will be positively impacted by the most substantial flood risk reduction benefits conveyed. Census Tract 254 and 257 in the New Garden Park, Bellvue, and McDonoghville neighborhoods contain 200 and 48 acres, respectively, that fall within the area of direct benefit. These areas of the population are disproportionately disadvantaged according to numerous metric designations, including CEJEST disadvantaged community designation, HUD Low-Moderate Income, high Social Vulnerability Index scores, high percentile rankings on the EPA's Environmental Justice Screening Tool and other ways of determining disadvantaged communities.

$$(1253*2.16)/17,590 = 0.15 = 15\%$$

Hazard Sources
Primary hazard source: Flooding
Secondary hazard Source: Tropical cyclone (hurricane/typhoon)
Tertiary hazard source: Severe storm

Project Scope of Work
Description of Proposed Activity
The proposed mitigation activity for the City of Gretna consists of a distributed network of green infrastructure (GI) facilities designed to capture and detain stormwater to reduce repetitive property losses in areas adversely impacted by flooding. The proposed nature-based solutions will provide additional benefits including improved water quality, mitigation of urban heat, enhanced pedestrian walkways to connect homes and transit, carbon sequestration and removal of other air pollutants, and additional public green space. The most substantial flooding and damages caused by storm events are clustered within several neighborhoods, including New Garden Park, Timberlane, Bellvue, Old Garden Park, and McDonoghville. New Garden Park is split into two (2) census tracts. Census Tract 253's population, accounting for 336 acres of the benefit area, includes 37% people of color, 17% living in poverty, and 17% with disabilities. Census Tract 254's population, accounting for 200 acres of the benefit area including the Bellevue neighborhood, includes 67% people of color, 21% living in poverty, and 10% with disabilities. Timberlane and Bellvue are split into two (2) census tracts, Census Tract 254 and Census Tract 255.02. Census Tract 255.02's population, accounting for 176 acres of the benefit area, includes 69% people of color, 17% living in poverty, and 8% with disabilities. Old Garden Park has two (2) census tracts, one (1) of which is included in

the benefit area. Census Tract 256's population, accounting for 38 acres of the benefit area, includes 41% people of color, 18% living in poverty, and 17% with disabilities. Lastly, McDonoghville has one (1) census tract, Census Tract 257, and its population, accounting for 48 acres of the benefit area, includes 88% people of color, 39% living in poverty, and 31% with disabilities. Social, environmental, and economic disparities are wider in disadvantaged neighborhoods where flood risk is elevated. To maximize the flood risk reduction benefits in the most impacted areas, nature-based solutions, primarily green infrastructure facilities, are proposed in strategic locations. The types of GI facilities in the network include: replacing impervious surfaces in walkways, on-street parking, and parking lots with pervious paving to reduce runoff and facilitate stormwater infiltration; bioretention cells to capture, detain, and filter water in rights-of-way; detention basins to reduce the rate of stormwater discharge into the municipal drainage system; and engineered soils to claim and store stormwater below the surface. Each GI facility is designed to have a discharge connection to the existing municipal drainage system.

Description of Benefit Area

The benefit area is widespread across the City and covers most of the New Garden Park neighborhood as well as covering parts of the Old Garden Park, McDonoghville, Timberlane, and Bellvue neighborhoods (see Attachment 5 – Benefit Area & Project Construction Limits). The primary area is quantified and captured in the BCA and all areas with reduced water surface elevations resulting from the project in the modeled storms. Any structure which showed a reduction in flood depth greater than 0.0 inches was counted for social benefit. The secondary benefit area is the entirety of the "drainage shed" defined by the outfall canals that inform the City of Gretna's municipal boundaries. In this area, the project will improve stormwater pollutant load filtration and water quality, for all discharged water into the Barataria Basin and the Gulf of Mexico, though these secondary impacts have not been quantified.

Benefits to Vulnerable Populations

The median income in Census Tract 254 and 257 falls within the 65th and 83rd percentile, respectively, of median income in the area. The northwestern section of the New Garden Park neighborhood, the entirety of the Bellvue neighborhood, and the northeastern section of the McDonoghville neighborhood contain disadvantaged residents who will receive the greatest flood risk reduction and additional benefits to disadvantaged groups from the implementation of green infrastructure. These efforts align with the Justice40 Initiative and EO 14008, to support communities at home against the already realized effects of climate change and to further the cause of environmental justice.

Maintenance

The City of Gretna Parks and Parkways will perform long-term maintenance required after project completion. Estimated long-term care and maintenance costs will not exceed $690,000 annually. Maintenance costs will be the most expensive in the first two years to ensure proper plant establishment. Maintenance cost includes: 1) periodic site inspections; 2) removal of invasive species and low-frequency mowing in upland grassland and reforested habitats; 3) removal of invasive species, assessment of diseases and pests, and removal of accumulated sediment in areas with wetland planting; and 4) removal of debris and inspection for all weirs, debris barriers culverts, riprap, and laterals.

Hydrologic and Hydraulic Analysis

Residual Risk

This project, as designed, is intended to address persistent flooding in multiple areas subject to routine flood losses. After project implementation, residual flood risk is expected to remain for precipitation events and flooding caused by severe storms and tropical cyclones. The structural damage that occurs in the 5-year storm event pre-mitigation action and post-mitigation is $25M and $23M, respectively, resulting in a 6% reduction in damages. For the 100-year storm events, the pre-mitigation action and post-mitigation is $162M and $140M, respectively, resulting in a 14% reduction in damages. Across all studied storm events (5-, 10-, 25-, 50-, and 100-year), the average structural damage comparing pre-mitigation action and post-mitigation yields a 15% reduction. Results of the 100-year event for the existing conditions and proposed conditions can be seen in Attachment 6 and Attachment 7 respectively.

Anticipated Future Conditions

Accounting for increased stormwater event frequency and intensity, the proposed project will reduce stormwater inundation within the region adjacent to and upstream of the Belle Chasse Hwy by implementing four types of green infrastructure (surface detention ponds, bioswales, engineered soil sports fields, and pervious paving). The inclusion of these four types of green infrastructure will allow for water to be temporarily stored, increase infiltration, and slow the flow of runoff to the main canals.

Hazard Mitigation Plan Alignment

This project will mitigate flood losses in the city of Gretna, Louisiana by increasing stormwater storage capacity and protecting repetitive and severe repetitive loss properties. The project involves a 5-step construction process that includes detaining and filtering runoff, absorbing surface runoff, increasing the carrying capacity for reaches of Hancock Canal, Huber Canal, Governor Hall Canal, and adding additional stormwater storage with a surface detention pond. The project is identified in the multi-jurisdictional Hazard Identification Risk Assessment and is consistent with the goals, objectives, and strategies outlined in the Mitigation Strategy. The proposed activity aligns with multiple mitigation action items put forth in the Hazard Mitigation Plan, Sections 5.3, page 280, Mitigation Goals and Section 5.4, page 280, Mitigation Strategies. The project was also identified in the City's adopted Watershed Master Plan (WMP)

Environmental/Land

The area is currently developed, cityscape, and is not a protected conservation or marsh area surrounded by urban developments. Preliminary due diligence of the project will be conducted to determine the presence of protected resources within the project area in accordance with acts and executive orders in the below table. Information obtained during the preliminary due diligence will be used to determine what permits or authorizations will be required for the project.

Environmental Considerations	*Agency Coordination*
National Historic Preservation Act (Historic Buildings & Structures and Archeological Resources)	**Louisiana State Historic Preservation Office Tribes with local interest**
Endangered Species Act and Fish and Wildlife Coordination Act	**US Fish and Wildlife Service Louisiana Department of Wildlife and Fisheries**
Section 401 and 404 Clean Water Act, Section 10 of Rivers and Harbors Act, and Executive Order 11990 (Protection of Wetlands)	**US Army Corps of Engineers Louisiana Department of Environmental Quality**
Executive Order 11988 (Floodplain Management)	**Federal Emergency Management Agency Local Floodplain Management Agency**
Coastal Zone Management Act	**Louisiana Department of Energy and Natural Resources Local governmental bodies**
Farmland Protection Policy Act	**Natural Resources Conservation Services**
Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (Hazardous and Toxic Materials)	**Louisiana Department of Environmental Quality US Environmental Protection Agency**
Executive Order 12898, Environmental Justice for Low Income and Minority Populations	**US Environmental Protection Agency**
Section 408 of the Clean Water Act (projects impacting federally authorized project i.e. levees)	**US Army Corps of Engineers Local levee districts**
Louisiana Department of Wildlife and Fisheries' Scenic Rivers (LRS title 56, Chapter 8, Part II)	**Louisiana Department Wildlife and Fisheries**
Rivers and Harbors Appropriation Act of 1899, Construction of bridges, causeways, dams, or dikes	**US Coast Guard**

Estimated Project Schedule

Schedule

The estimated start date is contingent upon award of funding. See below table for a more detailed anticipated timeline of execution of mitigation activities.

Task Name	Start Month	Task Duration (in Months)	Task Description
Award Announcements	1	1	Announcement if project is “identified for further review”
Phase I – Procurement of all pre-construction services (design, survey, etc.) and grant management services	1	2	Compliant procurement of all required services to advance construction plans.
Execution of Phase I award agreement	9	1	
Design and pre-construction activities	3	18	
Execution of Phase II award agreement	16	1	Following EHP
Procurement of Construction Contractor	16	2	
Construction	18	42	
Closeout	42	3	
Phase I+II Grant Management	3	42	

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Estimated Project Budget

The estimated project budget is detailed in the cost breakdown below.

ESTIMATED PROJECT BUDGET				
CONSTRUCTION COST ESTIMATE				
Description	*Quantity*	*Unit of Measure*	*Cost per Unit*	*Costs*
Bioswale	**331,204**	**SQFT**	**$74**	**$24,661,483**
Detention Basin	**234,466**	**SQFT**	**$18**	**$4,288,755**
Engineered Soils	**241,593**	**SQFT**	**$8**	**$1,858,408**
Pervious Paver	**175,562**	**SQFT**	**$90**	**$15,717,304**
Mobilization	**1**	**% of Construction**	**5%**	**$2,326,297**
DESIGN SERVICES ESTIMATE				
RW/Serv. Acquisition	**1**	**% of Land Costs**	**3%**	**$0**
H&H Analysis	**1**	**% of Construction**	**3%**	**$1,465,567**
Engineering Services	**1**	**% of Construction**	**7%**	**$3,419,657**
Construction Services (CEI)	**1**	**% of Construction**	**5%**	**$2,442,612**
Project Management	**1**	**% of Construction**	**5%**	**$2,442,612**
Permitting and Environmental	**1**	**% of Construction**	**1%**	**$488,522**
LAND AQUISITION				
LAND COST	**0**	**ACRES**	**$1,089,000.00**	**$0.00**
Wetland Mitigation	**142**	**ACRES**	**$25,000.00**	**$0.00**
TOTAL PROJECT COSTS			$59,111,219	
ESTIMATED ANNUAL MAINTENANCE (1% of Construction)			$687,429	
ESTIMATED PROJECT USEFUL LIFE			30 YEARS	

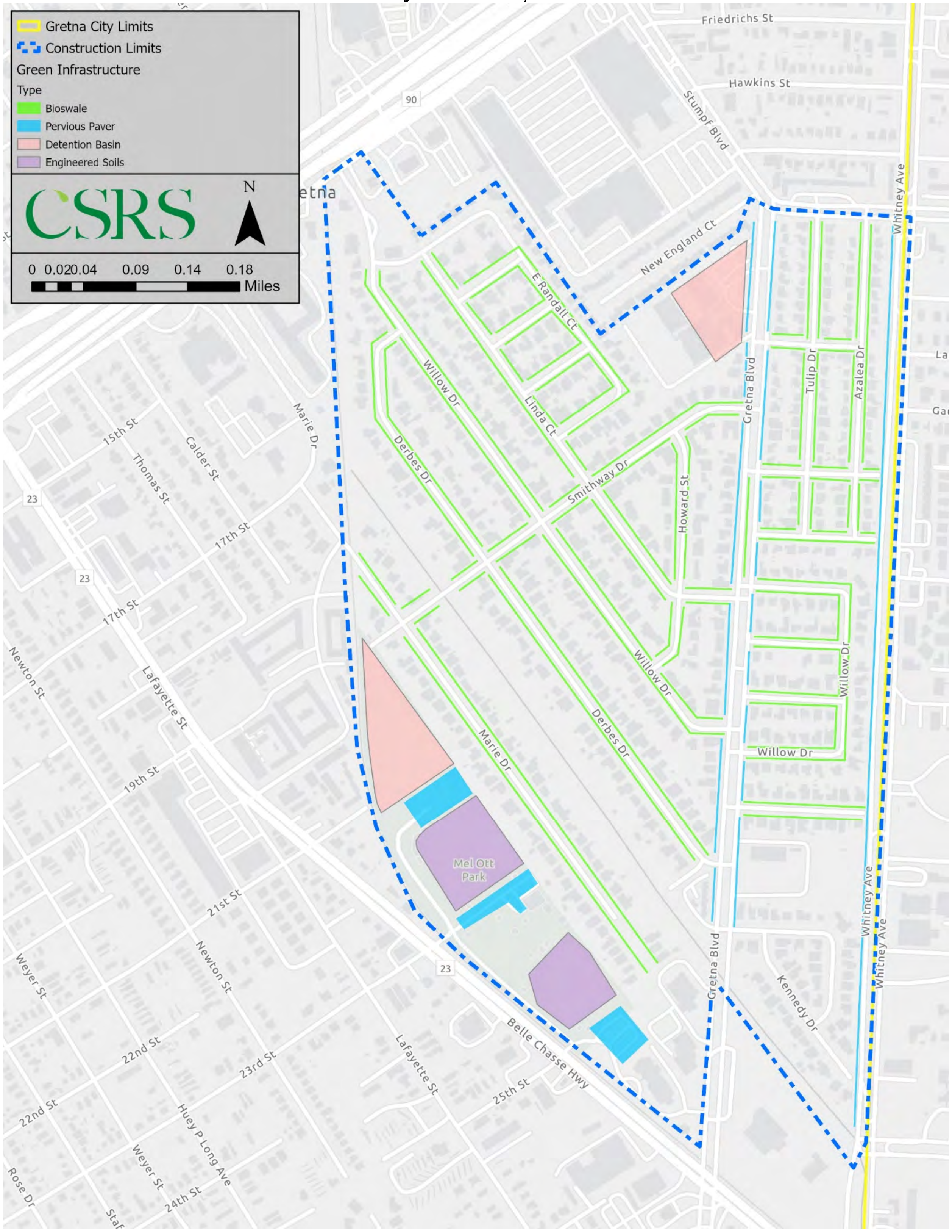
Benefit-Cost Analysis

Cost Effectiveness

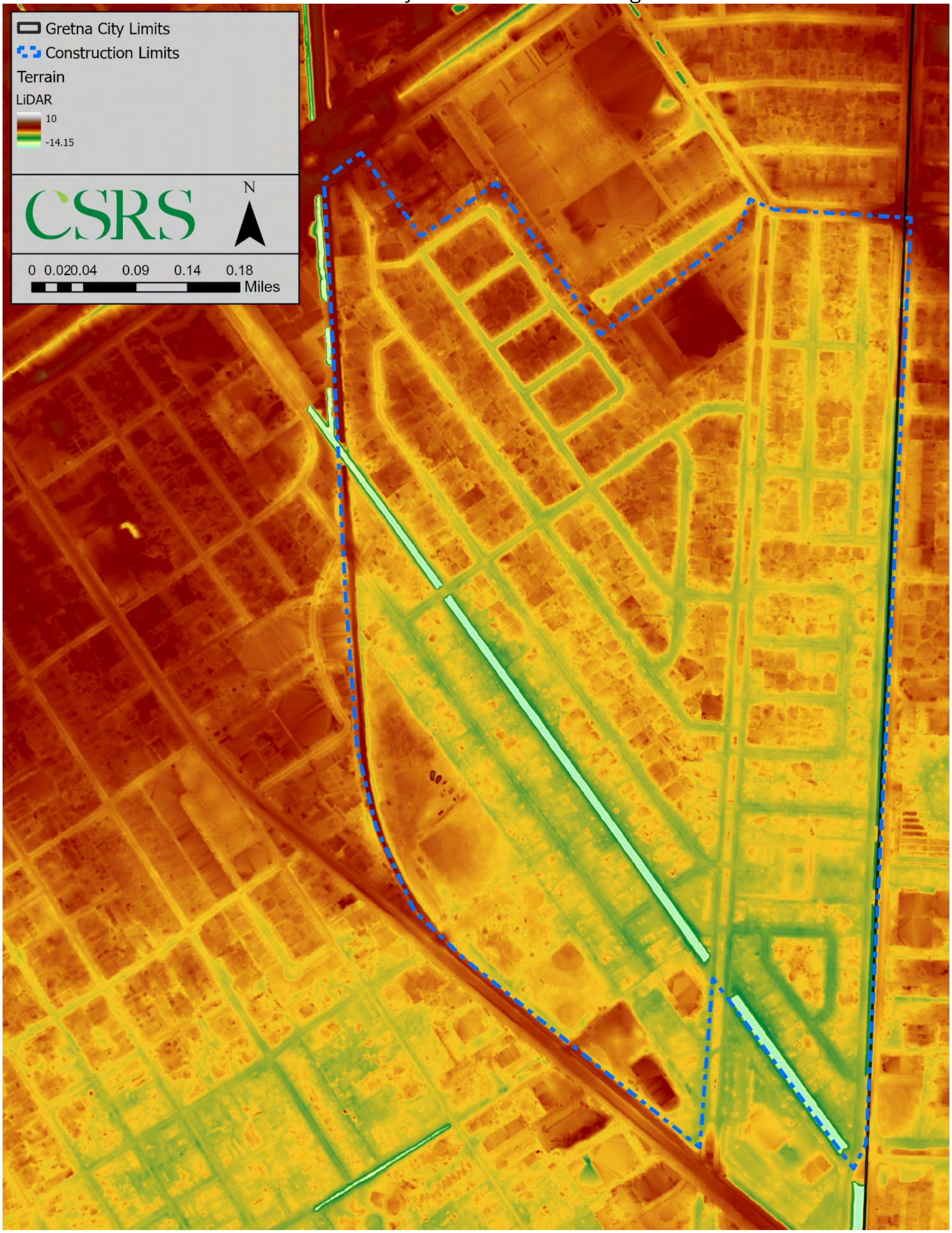
Further details related to the BCA and BCR including breakdowns of the project benefits, BCR, social benefits, and environmental benefits can be seen in Attachment 8 - Benefit-Cost Calculator Report. The total project's benefits, cost and calculated BCR with the 3% discount rate allowed for FMA applications are $60M, $72M, and 0.83, respectively. The social benefits were calculated based on recent census data for the city and environmental benefits were calculated based on the acreage of the total amount of green infrastructure implements proposed. Because this area falls within a levee system, no sea level rise analysis was needed. Benefits occurring outside the city are not quantified.

Attachments:

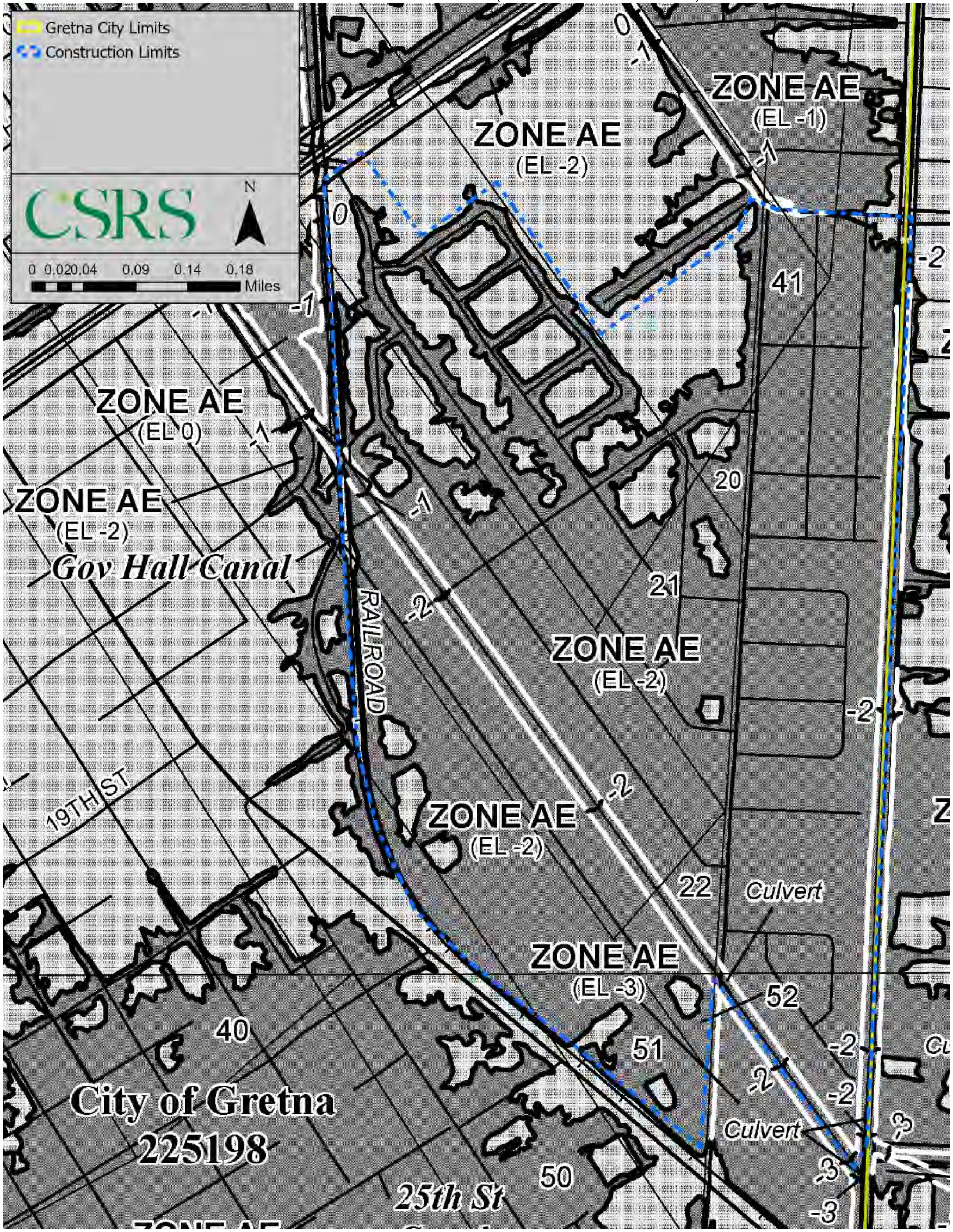
Attachment 1: Project Location/Construction Limits



Attachment 2: Project Location with Existing Terrain



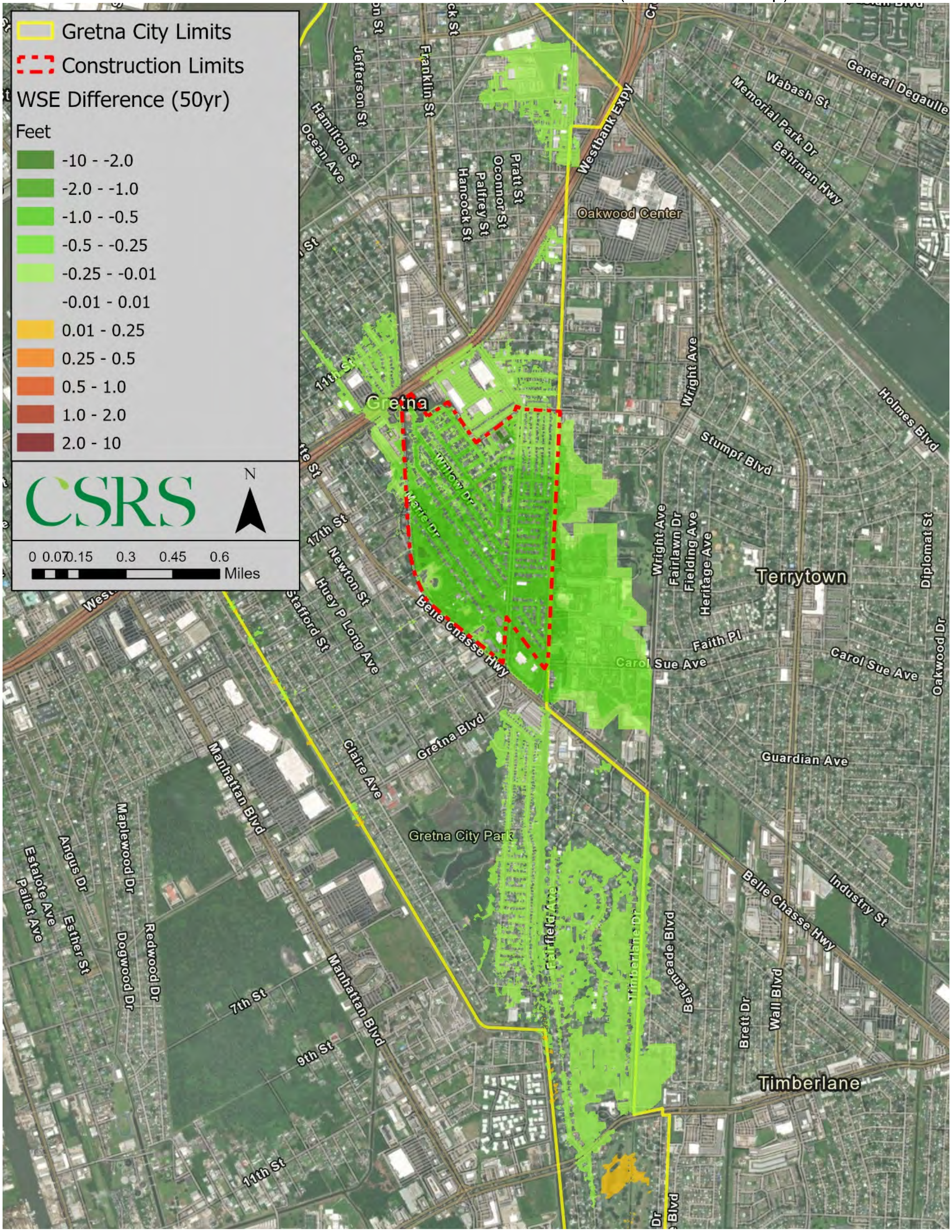
Attachment 3: FEMA FIRM (Panel 22051C0220F)



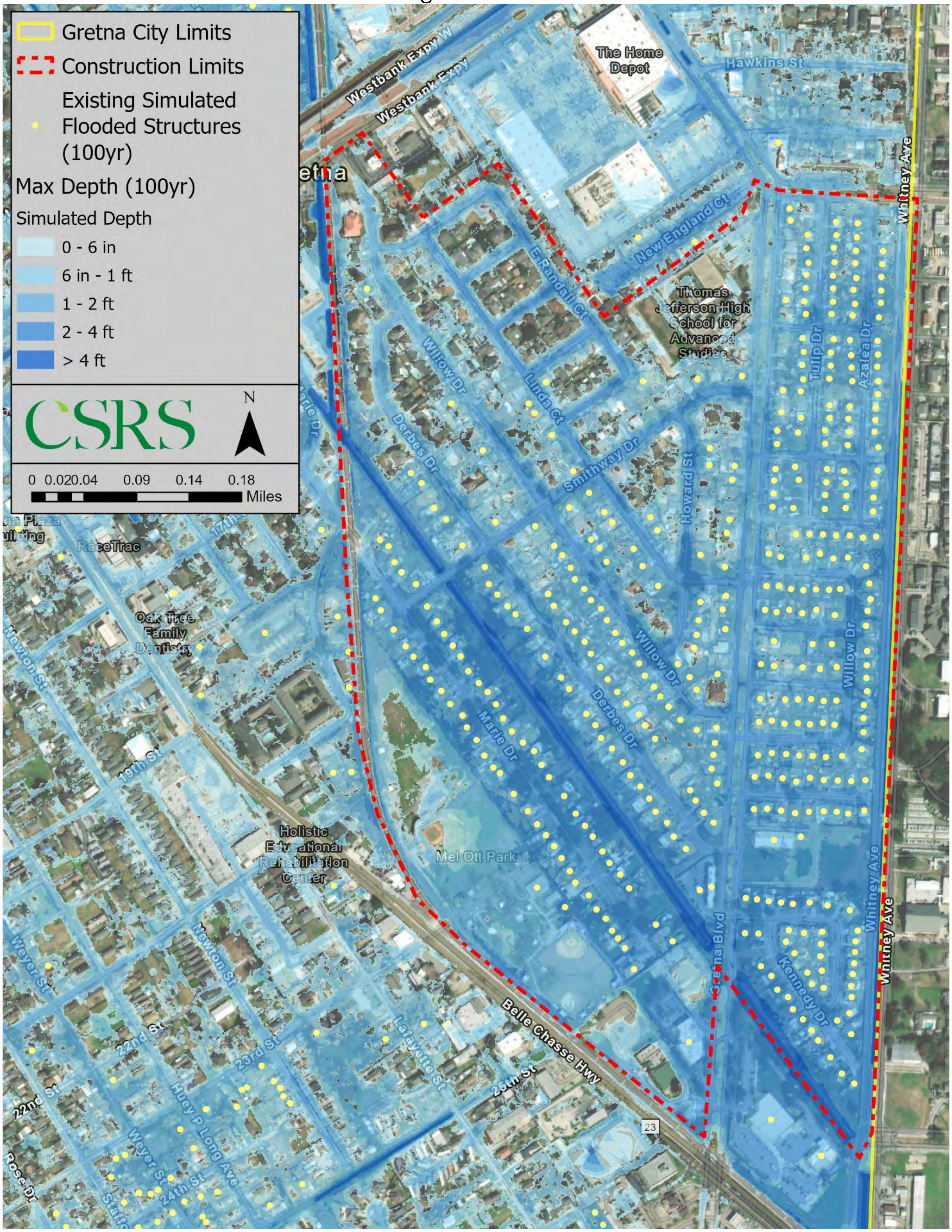
Attachment 4: FEMA FIS Profile with Project Location Marked

(No FIS profiles exist for this area of Jefferson Parish)

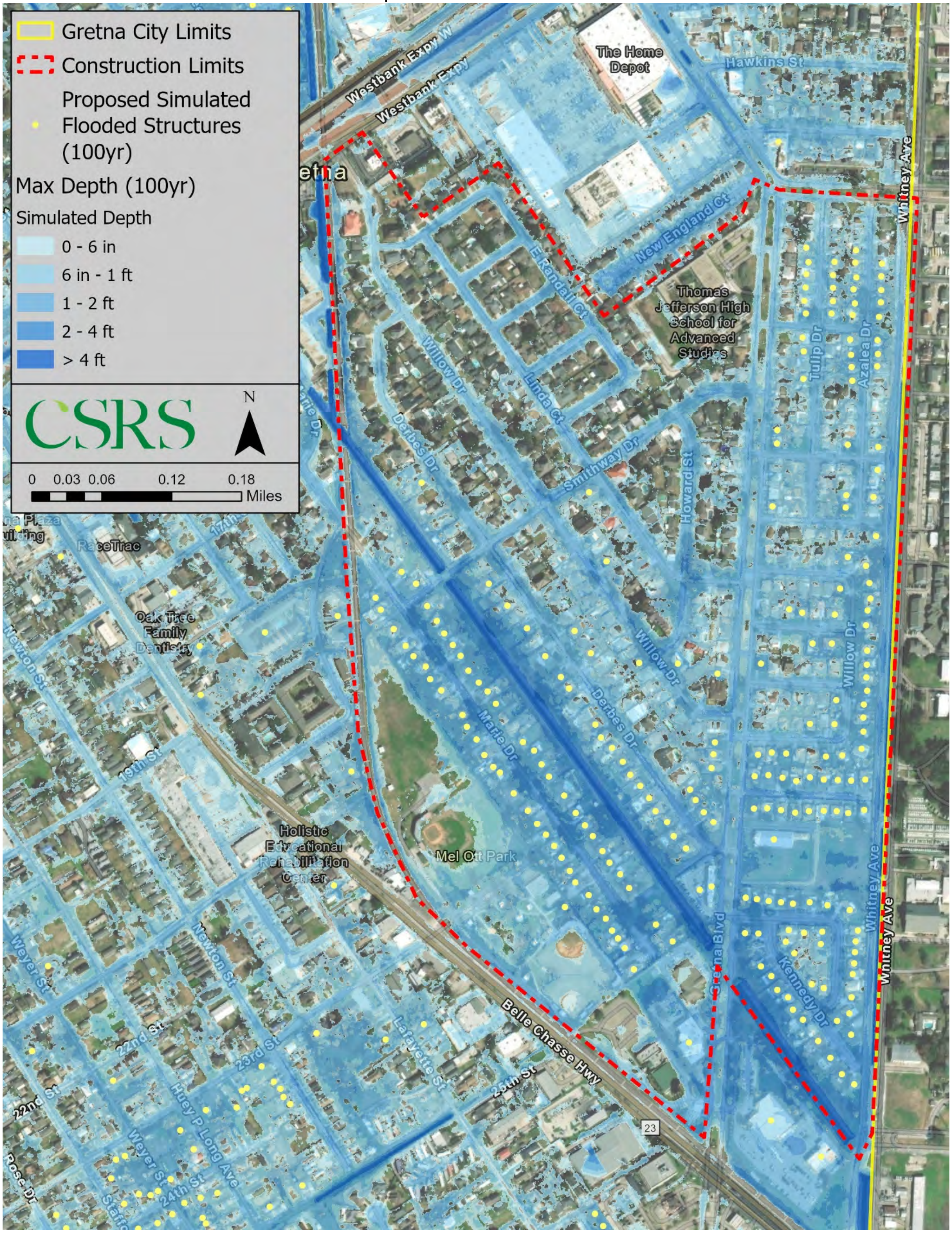
Attachment 5: Water Surface Elevation Reduction (Benefit Area Map)



Attachment 6: 100-Year Existing Flood Inundation with Affected Structures



Attachment 7: 100-Year Proposed Flood Inundation with Affected Structures



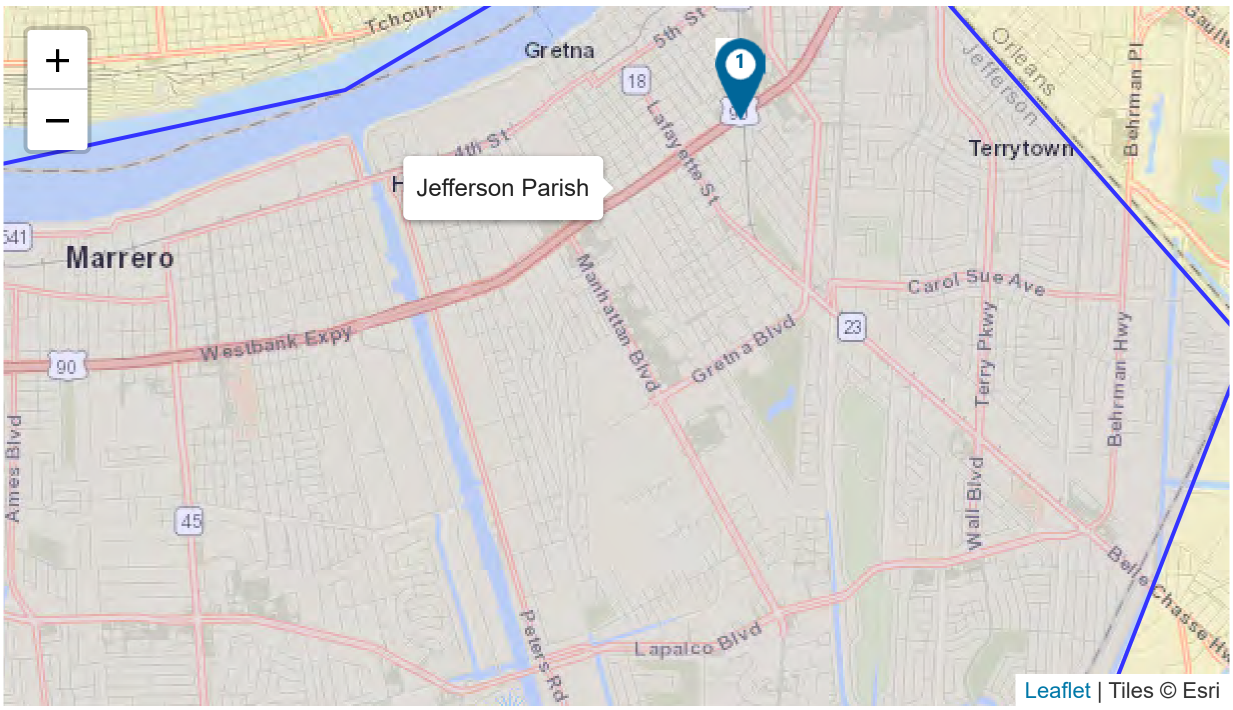
FEMA

Benefit-Cost Calculator

V.6.0 (Build 20240510.2248 | Release Notes)

Benefit-Cost Analysis

Project Name: Gretna New Garden Park Green Infrastructure



Map Marker ▲	Mitigation Title	Property Type	Hazard	Discount Rate (%)	Benefits (B)	Costs (C)	BCR (B/C)
1	Floodwater Diversion and Storage @ Gretna, Louisiana		DFA - Riverine Flood	3.1	$ 60,000,897	$ 72,412,618	0.83
TOTAL (SELECTED)					**$ 60,000,897**	**$ 72,412,618**	**0.83**
TOTAL					**$ 60,000,897**	**$ 72,412,618**	**0.83**

Property Configuration

Property Title:	Floodwater Diversion and Storage @ Gretna, Louisiana
Property Location:	70053, Jefferson, Louisiana
Property Coordinates:	29.912239, -90.051566
Hazard Type:	Riverine Flood
Mitigation Action Type:	Floodwater Diversion and Storage
Property Type:	Residential Building
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Floodwater Diversion and Storage @ Gretna, Louisiana

Discount Rate (%):	3.1% Use Default:Yes
Project Useful Life (years):	30
Project Cost:	$59,111,219
Number of Maintenance Years:	30 Use Default:Yes
Annual Maintenance Cost:	$687,429

Damage Analysis Parameters - Damage Frequency Assessment

Floodwater Diversion and Storage @ Gretna, Louisiana

Year of Analysis was Conducted:	2024
Year Property was Built:	0
Analysis Duration:	10 Use Default:Yes

Professional Expected Damages Before Mitigation

Floodwater Diversion and Storage @ Gretna, Louisiana

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
5	24,506,000	0	0	0	0	0	24,506,000
10	32,744,000	0	0	0	0	0	32,744,000
25	73,788,000	0	0	0	0	0	73,788,000
50	100,270,000	0	0	0	0	0	100,270,000
100	162,446,000	0	0	0	0	0	162,446,000

Annualized Damages Before Mitigation

Floodwater Diversion and Storage @ Gretna, Louisiana

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
5	24,506,000	2,832,710
10	32,744,000	2,949,239
25	73,788,000	1,720,317
50	100,270,000	1,276,263
100	162,446,000	1,624,444
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	393,754,000	10,402,973

Professional Expected Damages After Mitigation

Floodwater Diversion and Storage @ Gretna, Louisiana

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
5	23,377,000	0	0	0	0	0	23,377,000
10	28,653,000	0	0	0	0	0	28,653,000
25	55,183,000	0	0	0	0	0	55,183,000
50	80,549,000	0	0	0	0	0	80,549,000
100	139,654,000	0	0	0	0	0	139,654,000

Annualized Damages After Mitigation

Floodwater Diversion and Storage @ Gretna, Louisiana

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
5	23,377,000	2,588,090
10	28,653,000	2,385,827
25	55,183,000	1,333,407
50	80,549,000	1,060,613
100	139,654,000	1,396,526
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	327,416,000	8,764,463

Standard Benefits - Ecosystem Services

Floodwater Diversion and Storage @ Gretna, Louisiana

Total Project Area (acres):	24.4
Percentage of Urban Green Open Space:	0.00%
Percentage of Rural Green Open Space:	0.00%
Percentage of Riparian:	20.00%
Percentage of Coastal Wetlands:	0.00%
Percentage of Inland Wetlands:	80.00%
Percentage of Forests:	0.00%
Percentage of Coral Reefs:	0.00%
Percentage of Shellfish Reefs:	0.00%
Percentage of Beaches and Dunes:	0.00%
Expected Annual Ecosystem Services Benefits:	$341,029

Additional Benefits - Social

Floodwater Diversion and Storage @ Gretna, Louisiana

Number of Workers:	1,727
Expected Annual Social Benefits:	$21,697,830

Benefits-Costs Summary

Floodwater Diversion and Storage @ Gretna, Louisiana

Discount Rate (%):	3.1% Use Default:Yes
Total Standard Mitigation Benefits:	$38,303,067
Total Social Benefits:	$21,697,830
Total Mitigation Project Benefits:	$60,000,897
Total Mitigation Project Cost:	$72,412,618
Benefit Cost Ratio - Standard:	0.53
Benefit Cost Ratio - Standard + Social:	0.83

ATTACHMENT 6

Project Summary Sheet

Priority Elevation Program

GRETNA, LOUISIANA

Project Title
Gretna Priority Elevation Program

Project Location
Gretna, Louisiana, Jefferson Parish

Description of Mitigation Need
A subset of the East of Harvey watershed was analyzed focusing on the City of Gretna, and flood risks were found within the lowest elevations of the city located in the southernmost area. An analysis was performed to evaluate the residual risk of residential structures in Gretna after all other mitigation efforts were constructed. The analysis revealed that 500 residential structures across the city would still experience flooding during intense storm events after other mitigation efforts were implemented. Since there are no clear or cost-effective mitigation measures to reduce flood risk in these areas, raising residential homes is the most effective approach to increase flood risk resilience for them. A heat map proposed home elevations (project location) can be found in Attachment 1 and Attachment 2. Attachment 3 shows the project area to the existing FEMA flood zones. The residential structures that experience flooding during a 100-year rainfall event are indicated by the yellow points in Attachment 6, and the reduction of flooded structures due to home elevations can be seen in Attachment 7. For a 30-year project lifespan project, the estimated cost of the project is $77M, and estimated benefits are $37M resulting in a Benefit-Cost Ratio (BCR) of 0.46. Further details on FEMA Benefit Cost Analysis (BCA) can be found in Attachment 8.

Percentage of Population Affected
There are 500 residential structures with residual risk after the implementation of other mitigation actions. The percentage of affected population assumes 500 affected households, with 2.16 persons per household, out of a total City of Gretna population of 17,590, will be positively impacted by the most substantial flood risk reduction benefits conveyed. Residential structures that are a part of the Priority Elevation Program fall in all census tracts in the City of Gretna including five (5) disproportionally disadvantaged census tracts according to numerous metric designations, including CEJEST disadvantaged community designation, HUD Low-Moderate Income, high Social Vulnerability Index scores, high percentile rankings on the EPA’s Environmental Justice Screening Tool and other ways of determining disadvantaged communities.

$$(500*2.16)/17,590 = 0.12 = 6\%$$

Hazard Sources
Primary hazard source: Flooding
Secondary hazard Source: Tropical cyclone (hurricane/typhoon)
Tertiary hazard source: Severe storm

Project Scope of Work

Description of Proposed Activity
The proposed flood risk reduction improvements for the City of Gretna consist of raising the 500 homes across the city to reduce repetitive property losses in areas adversely impacted by flooding. Substantial flooding and damages caused by storm events are clustered within all neighborhoods in the City of Gretna including five (5) CJEST disadvantaged communities. To maximize the flood risk reduction benefits in the areas, only residential homes in this area were considered due to their higher risk of flooding. Social, environmental, and economic disparities are wider in disadvantaged neighborhoods where flood risk is elevated. The proposed improvements will provide the greatest flood risk reduction to disadvantaged groups within the disadvantaged neighborhoods. The proposal is to raise homes to one (1) foot above the water surface elevation of the 100-yr storm event. On average, the proposed 500 residential structures will be raised 1.7 feet with the minimum elevation being one (1) foot and the maximum elevation being 5.8 feet.

Description of Benefit Area

The benefits are quantified and captured in the BCA as all residential structures that would be affected by the 100-year storm event after other flood mitigation measures were put in place. The residential structures receiving benefit from the Priority Elevation Program are located in every neighborhood across the City of Gretna. The benefits seen from this project are reflected in the reduction of flooded structures.

Benefits to Vulnerable Populations

The residential structures receiving benefit from the Priority Elevation Program are located in every neighborhood across the City of Gretna. The table below summarizes the indicators of disadvantaged communities for each census tract. The proposed improvements will provide the greatest flood risk reduction and additional benefits to disadvantaged groups in the city. These efforts align with the Justice40 Initiative and EO 14008, to support communities at home against the already realized effects of climate change and to further the cause of environmental justice.

	Population Demographics				
Census Tract No.	**Disability**	**Below Poverty Level**	**Person of Color**	**Median Income (Percentile)**	**CJEST?**
251.02	8%	17%	69%	19th	No
253	17%	17%	37%	41st	No
254	10%	21%	67%	65th	Yes
255	15%	41%	81%	64th	Yes
256	17%	18%	41%	34th	No
257	31%	39%	88%	83rd	Yes
258	32%	22%	71%	66th	Yes
259	10%	21%	49%	73rd	Yes

Maintenance

Maintenance of the non-structural solution of raising homes would fall solely on the owner of the property.

Hydrologic and Hydraulic Analysis

Residual Risk

This project, as designed, is intended to address persistent flooding in multiple areas subject to routine flood losses. After project implementation, residual flood risk is expected to remain for precipitation events and flooding caused by severe storms and tropical cyclones. The structural damage that occurs in the 5-year storm event pre-mitigation action and post-mitigation is $20M and $18M, respectively, resulting in a 12% reduction in damages. For the 100-year storm events, the pre-mitigation action and post-mitigation are $105M and $76M, respectively, resulting in a 28% reduction in damages. Across all studied storm events (5-, 10-, 25-, 50-, and 100-year), the average structural damage comparing pre-mitigation action and post-mitigation yields a 22% reduction. Results of the 100-year event for the existing conditions and proposed conditions can be seen in Attachment 6 and Attachment 7 respectively.

Anticipated Future Conditions

Accounting for increased stormwater event frequency and intensity, the proposed project will reduce stormwater flooding of residential homes by raising homes. This results in homes with a higher finished floor elevation reducing the probability that water will flood the home.

Hazard Mitigation Plan Alignment

This project will mitigate flood losses in the city of Gretna, Louisiana by raising residential structures and protecting repetitive and severe repetitive loss properties. The project involves a construction process that includes identifying residential structures that are frequently affected and raising them one (1) foot higher than the water surface elevations recorded by the 100-year storm event. The project is identified in the multi-jurisdictional Hazard Identification Risk Assessment and is consistent with the goals, objectives, and strategies outlined in the Mitigation Strategy. The proposed activity aligns with multiple mitigation action items put forth in the Hazard Mitigation Plan, Sections 5.3, page 280, Mitigation Goals and Section 5.4, page 280, Mitigation Strategies. The project was also identified in the City's adopted Watershed Master Plan (WMP).

Environmental/Land

The area is currently developed, cityscape, and is not a protected conservation or marsh area surrounded by urban developments. Preliminary due diligence of the project will be conducted to determine the presence of protected resources within the project area in accordance with acts and executive orders in the table below. Information obtained during the preliminary due diligence will be used to determine what permits or authorizations will be required for the project.

Environmental Considerations	*Agency Coordination*
National Historic Preservation Act (Historic Buildings & Structures and Archeological Resources)	**Louisiana State Historic Preservation Office Tribes with local interest**
Endangered Species Act and Fish and Wildlife Coordination Act	**US Fish and Wildlife Service Louisiana Department of Wildlife and Fisheries**
Section 401 and 404 Clean Water Act, Section 10 of Rivers and Harbors Act, and Executive Order 11990 (Protection of Wetlands)	**US Army Corps of Engineers Louisiana Department of Environmental Quality**
Executive Order 11988 (Floodplain Management)	**Federal Emergency Management Agency Local Floodplain Management Agency**
Coastal Zone Management Act	**Louisiana Department of Energy and Natural Resources Local governmental bodies**
Farmland Protection Policy Act	**Natural Resources Conservation Services**
Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (Hazardous and Toxic Materials)	**Louisiana Department of Environmental Quality US Environmental Protection Agency**
Executive Order 12898, Environmental Justice for Low Income and Minority Populations	**US Environmental Protection Agency**
Section 408 of the Clean Water Act (projects impacting federally authorized project i.e. levees)	**US Army Corps of Engineers Local levee districts**
Louisiana Department of Wildlife and Fisheries' Scenic Rivers (LRS title 56, Chapter 8, Part II)	**Louisiana Department Wildlife and Fisheries**
Rivers and Harbors Appropriation Act of 1899, Construction of bridges, causeways, dams, or dikes	**US Coast Guard**

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Estimated Project Schedule

Schedule

The estimated start date is contingent upon award of funding. See below table for a more detailed anticipated timeline of execution of mitigation activities.

Task Name	*Start Month*	*Task Duration (in Months)*	*Task Description*
Award Announcements	**1**	**1**	**Announcement if project is "identified for further review"**
Phase I – Procurement of all pre-construction services (design, survey, etc.) and grant management services	**1**	**2**	**Compliant procurement of all required services to advance construction plans.**
Execution of Phase I award agreement	**9**	**1**	
Design and pre-construction activities	**3**	**18**	
Execution of Phase II award agreement	**16**	**1**	**Following EHP**
Procurement of Construction Contractor	**16**	**2**	
Construction	**18**	**42**	
Closeout	**42**	**3**	
Phase I+II Grant Management	**3**	**42**	

Estimated Project Budget

The estimated project budget is detailed in the cost breakdown below.

ESTIMATED PROJECT BUDGET				
CONSTRUCTION COST ESTIMATE				
Description	*Quantity*	*Unit of Measure*	*Cost per Unit*	*Costs*
Wood-frame building on piles, posts, or columns	**0**	**SQFT**	**$55**	**$0**
Wood frame on concrete or block foundation walls	**0**	**SQFT**	**$49**	**$0**
Brick walls	**0**	**SQFT**	**$66**	**$0**
Slab-on-grade	**1,102,065**	**SQFT**	**$69**	**$75,82,233**
CONTINGENCY				
		% Sum Total Cost	**5%**	**$3,793,612**
TOTAL PROJECT COSTS			$79,665,844	
ESTIMATED ANNUAL MAINTENANCE (1% of Construction)			$0	
ESTIMATED PROJECT USEFUL LIFE			30 YEARS	

Benefit-Cost Analysis

Cost Effectiveness

Further details related to the BCA and BCR including breakdowns of the project benefits, BCR, social benefits, and environmental benefits can be seen in Attachment 8 - Benefit-Cost Calculator Report. The total project's benefits, cost and calculated BCR with the 3% discount rate allowed for FMA applications are $36.5M, $79.6M, and 0.46, respectively. The social benefits were calculated based on recent census data for the city and environmental benefits were calculated based on the acreage of the total amount of green infrastructure implements proposed. Because this area falls within a levee system, no sea level rise analysis was needed.

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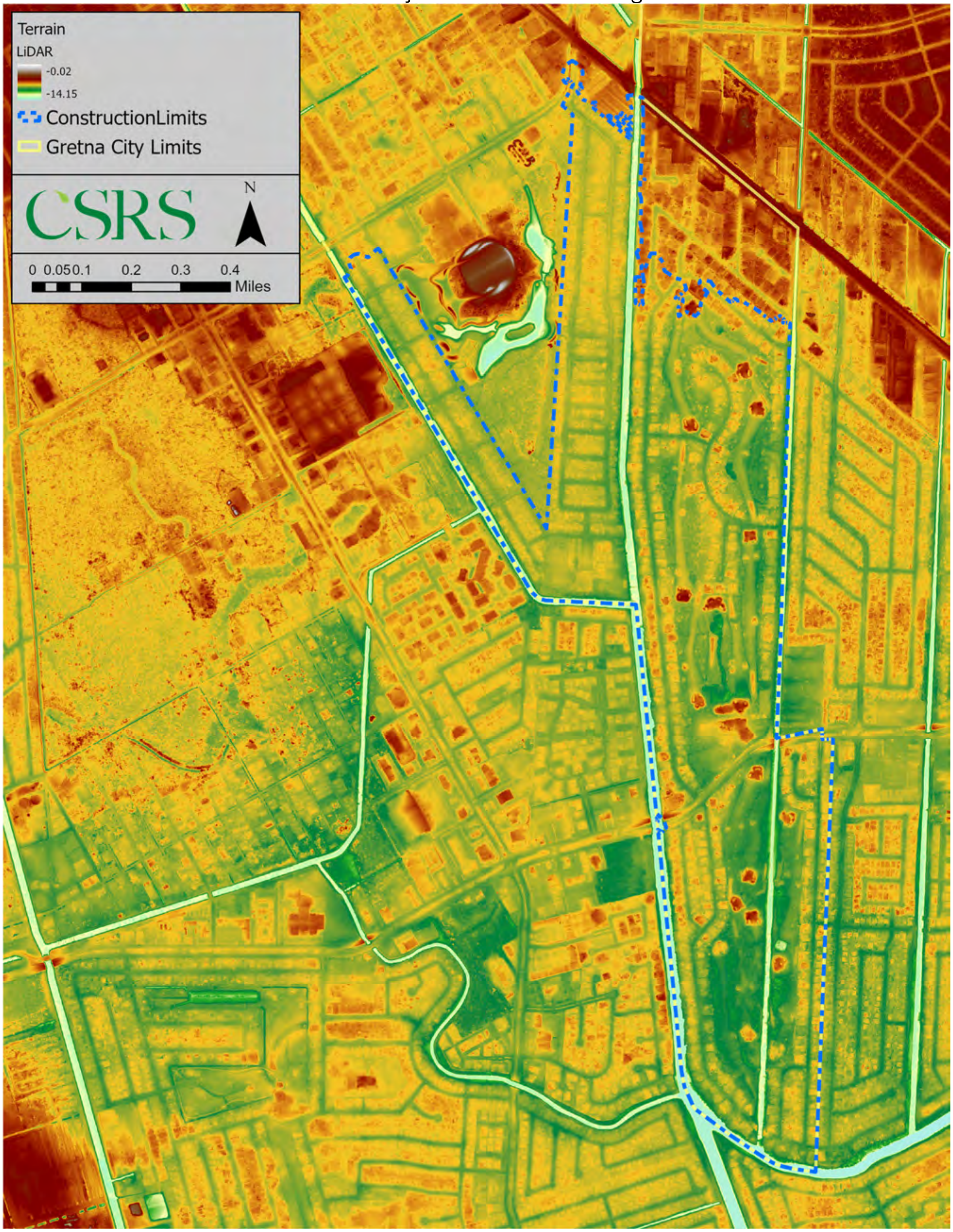
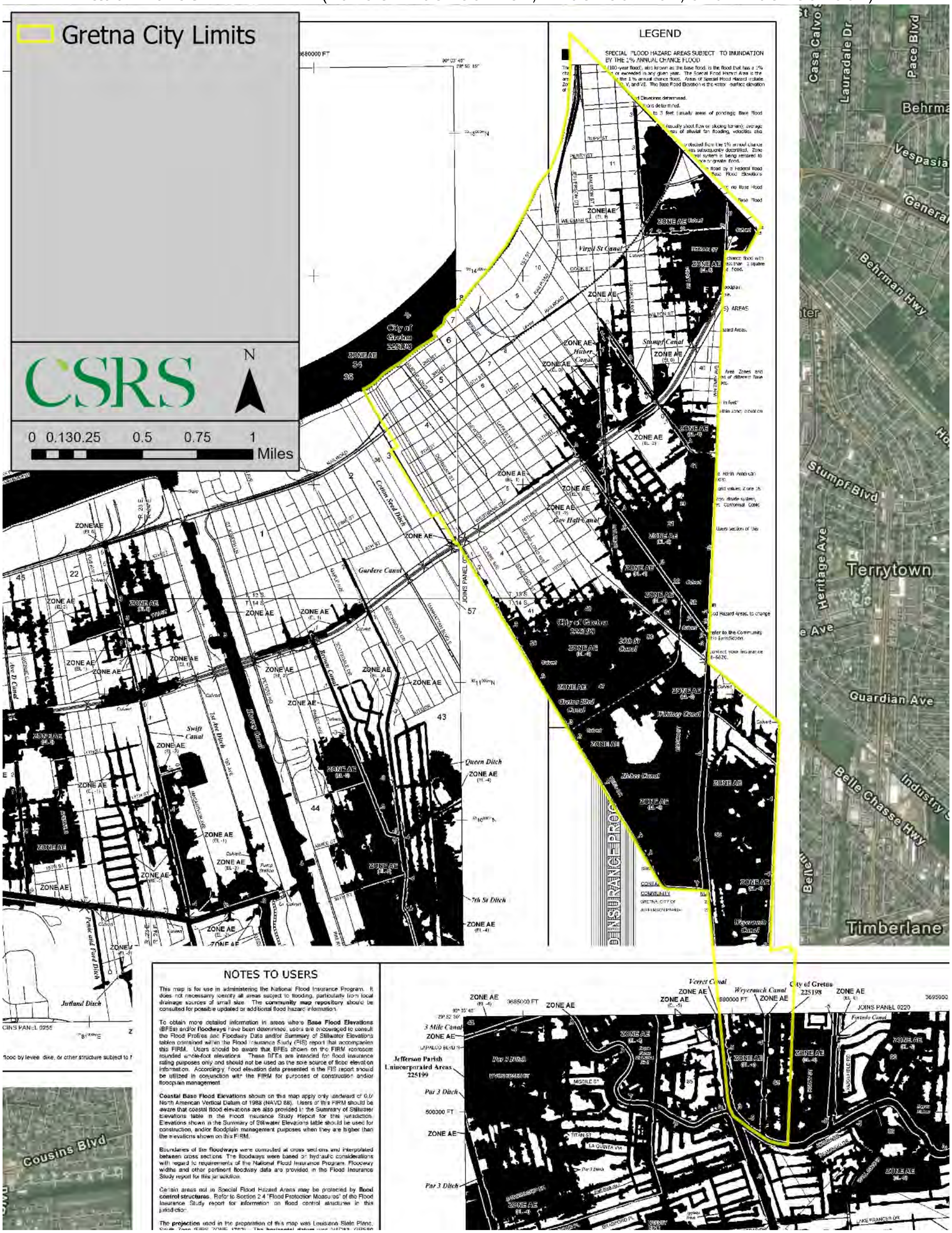
Attachments:

Attachment 1: Project Location/Construction Limits with Parcels

Attachment 2: Project Location with Existing Terrain



Attachment 3: FEMA FIRM (Panels 22051C0215F, 22051C0220F, and 22051C0260F)



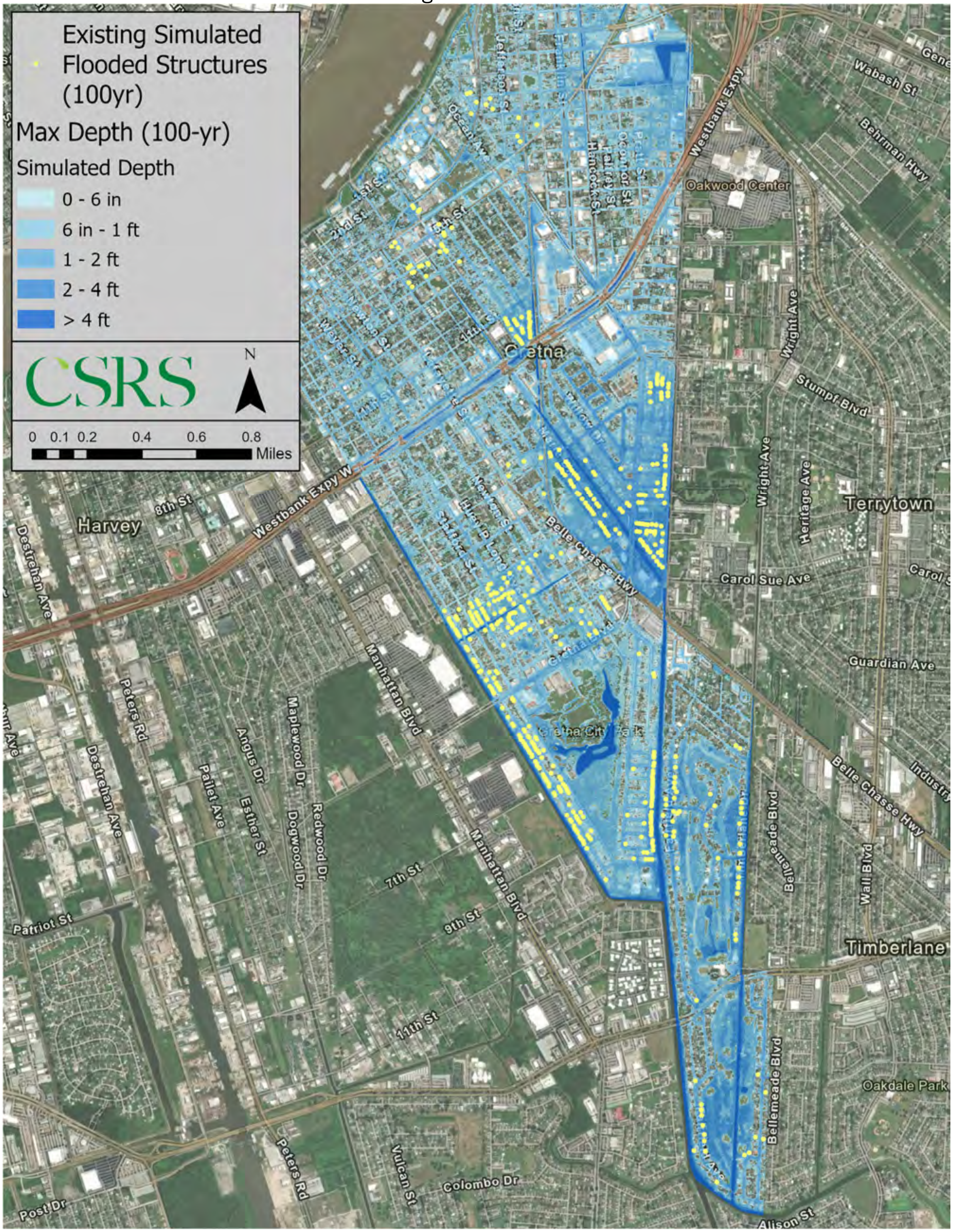
Attachment 4: FEMA FIS Profile with Project Location Marked

(No FIS profiles exist for this area of Jefferson Parish)

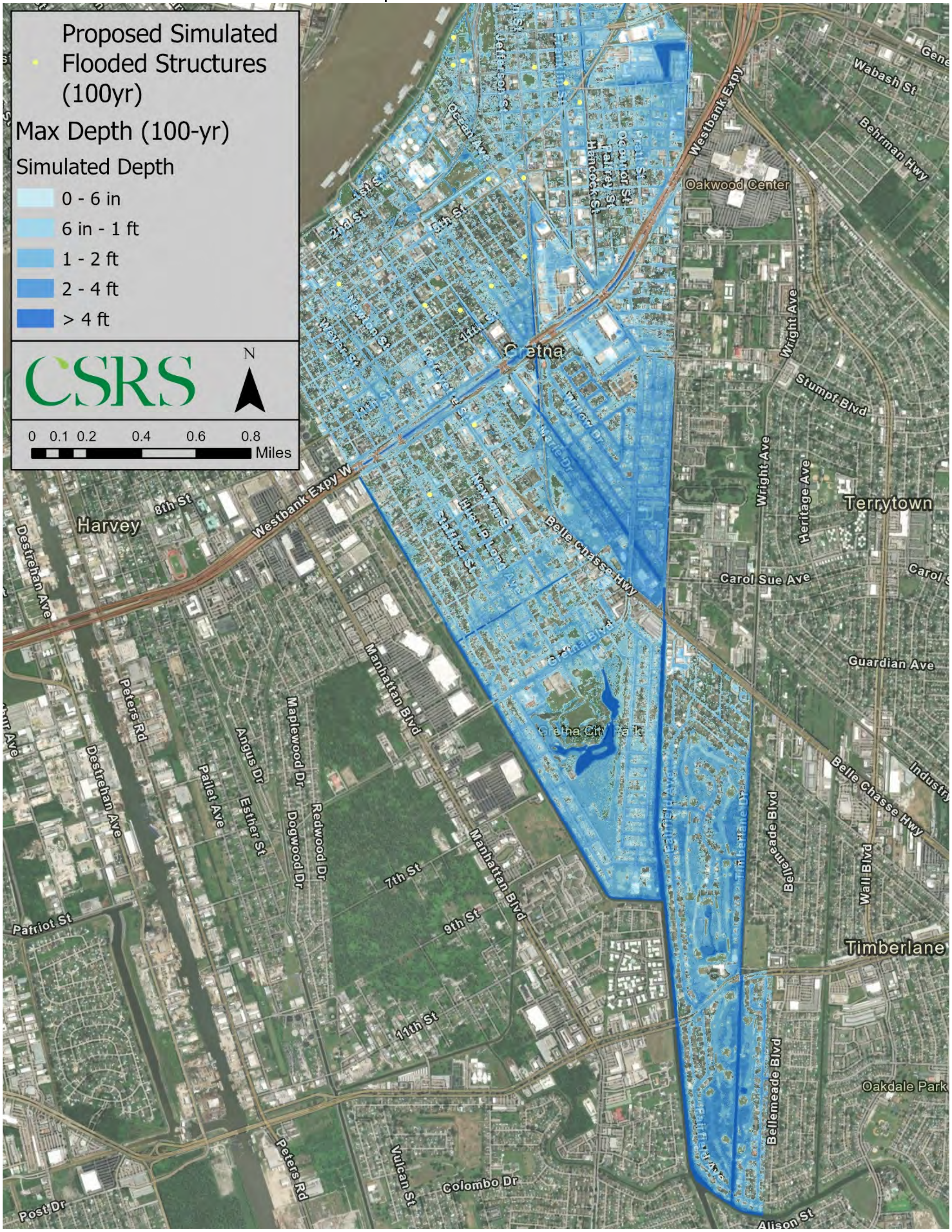
Attachment 5: Water Surface Elevation Reduction (Benefit Area Map)

(Benefits shown by reduction of flooded structures)

Attachment 6: 100-Year Existing Flood Inundation with Affected Structures



Attachment 7: 100-Year Proposed Flood Inundation with Affected Structures



Benefit-Cost Calculator

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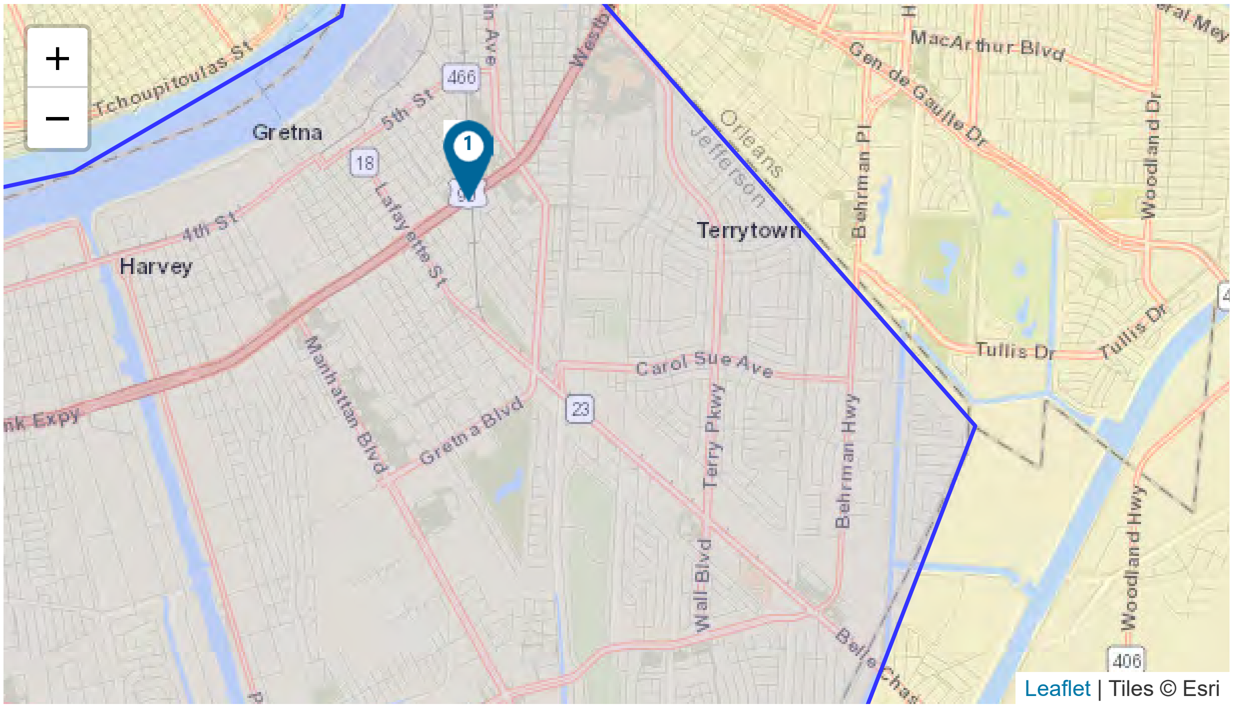
Benefit-Cost Analysis

Project Name: Gretna Non-Structural Solutions



Map Marker ▲	Mitigation Title	Property Type	Hazard	Discount Rate (%)	Benefits (B)	Costs (C)	BCR (B/C)
1	Elevation @ Gretna, Louisiana		DFA - Riverine Flood	3.1	$ 36,598,456	$ 79,665,844	0.46
TOTAL (SELECTED)					**$ 36,598,456**	**$ 79,665,844**	**0.46**
TOTAL					**$ 36,598,456**	**$ 79,665,844**	**0.46**

Property Configuration

Property Title:	Elevation @ Gretna, Louisiana
Property Location:	70053, Jefferson, Louisiana
Property Coordinates:	29.912239, -90.051566
Hazard Type:	Riverine Flood
Mitigation Action Type:	Elevation
Property Type:	Residential Building
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Elevation @ Gretna, Louisiana

Discount Rate (%):	3.1% Use Default:Yes
Project Useful Life (years):	30
Project Cost:	$79,665,844
Number of Maintenance Years:	30 Use Default:Yes
Annual Maintenance Cost:	$0

Damage Analysis Parameters - Damage Frequency Assessment

Elevation @ Gretna, Louisiana

Year of Analysis was Conducted:	2024
Year Property was Built:	0
Analysis Duration:	10 Use Default:Yes

Professional Expected Damages Before Mitigation

Elevation @ Gretna, Louisiana

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
5	20,534,000	0	0	0	0	0	20,534,000
10	23,601,000	0	0	0	0	0	23,601,000
25	42,052,000	0	0	0	0	0	42,052,000
50	58,289,000	0	0	0	0	0	58,289,000
100	105,071,000	0	0	0	0	0	105,071,000

Annualized Damages Before Mitigation

Elevation @ Gretna, Louisiana

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
5	20,534,000	2,201,415
10	23,601,000	1,890,209
25	42,052,000	990,186
50	58,289,000	782,591
100	105,071,000	1,050,699
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	249,547,000	6,915,100

Professional Expected Damages After Mitigation

Elevation @ Gretna, Louisiana

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
5	18,152,000	0	0	0	0	0	18,152,000
10	20,689,000	0	0	0	0	0	20,689,000
25	30,567,000	0	0	0	0	0	30,567,000
50	41,111,000	0	0	0	0	0	41,111,000
100	75,736,000	0	0	0	0	0	75,736,000

Annualized Damages After Mitigation

Elevation @ Gretna, Louisiana

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
5	18,152,000	1,937,903
10	20,689,000	1,508,855
25	30,567,000	708,982
50	41,111,000	557,995
100	75,736,000	757,352
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	186,255,000	5,471,087

Additional Benefits - Social

Elevation @ Gretna, Louisiana

Number of Workers:	689
Expected Annual Social Benefits:	$8,657,544

Benefits-Costs Summary

Elevation @ Gretna, Louisiana

Discount Rate (%):	3.1% Use Default:Yes
Total Standard Mitigation Benefits:	$27,940,912
Total Social Benefits:	$8,657,544
Total Mitigation Project Benefits:	$36,598,456
Total Mitigation Project Cost:	$79,665,844
Benefit Cost Ratio - Standard:	0.35
Benefit Cost Ratio - Standard + Social:	0.46

ATTACHMENT 7

Project Summary Sheet

Stumpf Boulevard Diversion & Drainage Improvements

GRETNA, LOUISIANA

Project Title
Stumpf Boulevard Diversion & Drainage Improvements

Project Location
Gretna, Louisiana, Jefferson Parish (see Attachment 1)

Description of Mitigation Need
A subset of the East of Harvey watershed was analyzed focusing on the City of Gretna, and flood risks were found within the southeastern half of the city. Stumpf Boulevard becomes overloaded by any storm greater than the 25-year storm event. Along Stumpf Boulevard near where subsurface piping intersects with Whitney Canal, three crossroads, Friedrichs, Hawkins, and Aquavit, provide an opportunity to divert stormwater from the overloaded subsurface conduit under Stumpf Boulevard. The construction of the stormwater diversion will result in flood risk reduction for the area immediately upstream of Whitney Canal and help the performance of the canal and connected subsurface pipes. Maps of the project location and terrain can be found in Attachment 1 and Attachment 2. Attachment 3 shows the effective FEMA flood insurance rate map (FIRM). FEMA does not provide any flood profiles for this area. As seen in Attachment 6, multiple homes in the benefit area are flooded during a 100-year rainfall event. For a 30-year project lifespan project, the estimated cost of the project is $6.3M, and estimated benefits are $12M resulting in a Benefit-Cost Ratio (BCR) of 1.89. Further details on FEMA Benefit Cost Analysis (BCA) can be found in Attachment 8.

Percentage of Population Affected
This proposed mitigation will affect approximately 6% of the population. This was calculated (see equation below) assuming 477 households, with 2.16 persons per household, out of a total City of Gretna population of 17,590, will be positively impacted by the most substantial flood risk reduction benefits conveyed. Census Tract 253 and 254 in the New Garden Park neighborhood contain 336 and 86 acres, respectively, that fall within the area of direct benefit. The northeast corner in the McDonoghville area has 55 residential homes that receive slight increases in water surface ranging from 0.12 inches to 0.24 inches due to more water diverted to Whitney Canal resulting in less flow from upstream. The residents falling within 86 acres of Census Tract 254 and the northeast corner of McDonoghville are disproportionately disadvantaged according to numerous metric designations, including CEJEST disadvantaged community designation, HUD Low-Moderate Income, high Social Vulnerability Index scores, high percentile rankings on the EPA's Environmental Justice Screening Tool and other ways of determining disadvantaged communities.

$$(477*2.16)/17,590 = 0.06 = 6\%$$

Hazard Sources
Primary hazard source: Flooding
Secondary hazard Source: Tropical cyclone (hurricane/typhoon)
Tertiary hazard source: Severe storm

Project Scope of Work

Description of Proposed Activity
The proposed mitigation activity for the City of Gretna consists of three (3) additional storm drains along Fredrichs, Hawkins, and Aquavit designed to divert stormwater to reduce repetitive property losses in areas adversely impacted by flooding. The most substantial flooding and damages caused by storm events are clustered within several neighborhoods, particularly New Garden Park and McDonoghville. New Garden Park and McDonoghville are split into two (2) census tracts. Census Tract 253's population, accounting for 336 acres of the benefit area, includes 37% people of color, 17% living in poverty, and 17% with disabilities. Census Tract 254's population, accounting for 86 acres of the benefit area, includes 67% people of color, 21% living in poverty, and 10% with disabilities. Social,

environmental, and economic disparities are wider in disadvantaged neighborhoods where flood risk is elevated. To maximize the flood risk reduction benefits in the areas, the storm drains were modeled in three strategic locations. The proposed activity is to replace existing pipes with two (2) 5'x3' reinforced concrete box (RCB) culverts for each of the streets; Each storm drain is designed to have a discharge connection to Whitney Canal.

Description of Benefit Area

The primary benefit area includes the portions of New Garden Park where Belle Chasse Hwy meets Whitney Canal and continues north through New Garden Park to where Stumpf Boulevard meets Whitney Canal in McDonoghville (see Attachment 5 – Benefit Area & Project Construction Limits). The primary benefit area is quantified and captured in the BCA as all areas with reduced water surface elevations resulting from the project in the modeled storms. Any structure which showed a reduction in flood depth greater than 0 inches was counted for social benefit.

Benefits to Vulnerable Populations

The median income in Census Tract 254 falls within the 65th percentile of median income in the area. The northwestern section of the New Garden Park neighborhood contains disadvantaged residents who will receive the greatest flood risk reduction and additional benefits to disadvantaged groups. These efforts align with the Justice40 Initiative and EO 14008 to support communities at home against the already-realized effects of climate change and to further the cause of environmental justice.

Maintenance

The City of Gretna Public Works will perform long-term maintenance required after project completion. Estimated long-term care and maintenance costs will not exceed $830 annually. The cost of the project includes yearly inspections and cleaning of debris or blockages.

Hydrologic and Hydraulic Analysis

Residual Risk

This project, as designed, is intended to address persistent flooding in multiple areas subject to routine flood losses. After project implementation, residual flood risk is expected to remain for precipitation events and flooding caused by severe storms and tropical cyclones. The structural damage that occurs in the 5-year storm event pre-mitigation action and post-mitigation is $25M and $23M, respectively, resulting in a 3% reduction in damages. For the 100-year storm events, the pre-mitigation action and post-mitigation are $162.4M and $161.9M, respectively, resulting in a 0.3% reduction in damages. Across all studied storm events (5-, 10-, 25-, 50-, and 100-year), the average structural damage comparing pre-mitigation action and post-mitigation yields a 1% reduction. In the northeastern area of the McDonoghville neighborhood, there is a maximum of 0.36-inch rise in WSE due to more water being preset in Whitney Canal downstream. Further analysis of a mitigation need is recommended for this area. Results of the 100-year event for the existing conditions and proposed conditions can be seen in Attachment 6 and Attachment 7, respectively.

Anticipated Future Conditions

Accounting for increased stormwater event frequency and intensity, the proposed project will diminish stormwater inundation by rerouting water flowing under Stumpf Boulevard to Whitney Canal. Whitney Canal conveys more water and can help move water to larger drainage basins and toward the pump stations located outside of the City. The three storm drains will allow for more efficient hydraulics and in turn diminish water surface inundation within the benefit area for higher intensity precipitation events with increased frequency.

Hazard Mitigation Plan Alignment

Implementation of the project is directly related to final authorization of FEMA non-disaster Hazard Mitigation Assistance (HMA) funds, completion of supporting design/engineering work, permitting by other government agencies, and all other pre-construction coordination required by the City of Gretna and any other interested parties.

The City of Gretna Mayor's Office and Planning Department will be responsible for all aspects of pre-award coordination and response to any requests for information (RFIs), post-award grant compliance and administration, project delivery, commissioning, and closeout. At this juncture, it is anticipated that project implementation will follow a traditional design-bid-build delivery approach. The City anticipates hiring contractors to support most grants compliance and administration activities as well.

Environmental/Land

The area is currently developed, cityscape, and is not a protected conservation or marsh area surrounded by urban developments. Preliminary due diligence of the project will be conducted to determine the presence of protected resources within the project area in accordance with acts and executive orders in the below table. Information obtained during the preliminary due diligence will be used to determine what permits or authorizations will be required for the project.

Environmental Considerations	*Agency Coordination*
National Historic Preservation Act (Historic Buildings & Structures and Archeological Resources)	**Louisiana State Historic Preservation Office Tribes with local interest**
Endangered Species Act and Fish and Wildlife Coordination Act	**US Fish and Wildlife Service Louisiana Department of Wildlife and Fisheries**
Section 401 and 404 Clean Water Act, Section 10 of Rivers and Harbors Act, and Executive Order 11990 (Protection of Wetlands)	**US Army Corps of Engineers Louisiana Department of Environmental Quality**
Executive Order 11988 (Floodplain Management)	**Federal Emergency Management Agency Local Floodplain Management Agency**
Coastal Zone Management Act	**Louisiana Department of Energy and Natural Resources Local governmental bodies**
Farmland Protection Policy Act	**Natural Resources Conservation Services**
Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (Hazardous and Toxic Materials)	**Louisiana Department of Environmental Quality US Environmental Protection Agency**
Executive Order 12898, Environmental Justice for Low Income and Minority Populations	**US Environmental Protection Agency**
Section 408 of the Clean Water Act (projects impacting federally authorized project i.e. levees)	**US Army Corps of Engineers Local levee districts**
Louisiana Department of Wildlife and Fisheries' Scenic Rivers (LRS title 56, Chapter 8, Part II)	**Louisiana Department Wildlife and Fisheries**
Rivers and Harbors Appropriation Act of 1899, Construction of bridges, causeways, dams, or dikes	**US Coast Guard**

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Estimated Project Schedule

Schedule

The estimated start date is contingent upon award of funding. See below table for a more detailed anticipated timeline of execution of mitigation activities.

Task Name	*Start Month*	*Task Duration (in Months)*	*Task Description*
Award Announcements	**1**	**1**	**Announcement if project is "identified for further review"**
Phase I – Procurement of all pre-construction services (design, survey, etc.) and grant management services	**1**	**2**	**Compliant procurement of all required services to advance construction plans.**
Execution of Phase I award agreement	**9**	**1**	
Design and pre-construction activities	**3**	**18**	
Execution of Phase II award agreement	**16**	**1**	**Following EHP**
Procurement of Construction Contractor	**16**	**2**	
Construction	**18**	**42**	
Closeout	**42**	**3**	
Phase I+II Grant Management	**3**	**42**	

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Estimated Project Budget

The estimated project budget is detailed in the cost breakdown below.

ESTIMATED PROJECT BUDGET				
CONSTRUCTION COST ESTIMATE				
Description	*Quantity*	*Unit of Measure*	*Cost per Unit*	*Costs*
Storm drain Installation (Hawkins)	1,033	EACH	$773	$798,733
Storm drain Installation (Aquavit)	831	EACH	$773	$642,083
Storm drain Installation (Fredrichs)	1,266	EACH	$773	$978,755
Pavement Removal and Installation	1	EACH	$1,183,056	$1,183,056
Drainage Structures (inlets, MH etc.)	22	EACH	$5,000	$110,064
Removal of Existing Pipe	1	EACH	$241,957	$241,957
Mobilization	1	% of Construction	5%	$197,732
DESIGN SERVICES ESTIMATE				
RW/Serv. Acquisition	1	% of Land Costs	3%	$0
H&H Analysis	1	% of Construction	3%	$124,571
Engineering Services	1	% of Construction	7%	$290,667
Construction Services (CEI)	1	% of Construction	5%	$207,619
Project Management	1	% of Construction	5%	$207,619
Permitting and Environmental	1	% of Construction	1%	$41,524
LAND AQUISITION				
LAND COST	0	ACRES	$1,089,000	$0
Wetland Mitigation	0	ACRES	$25,000	$0
CONTINGENCY				
		% Sum Total Cost	30%	$1,245,714
TOTAL PROJECT COSTS			$6,270,093	
ESTIMATED ANNUAL MAINTENANCE (1% of Construction)			$830	
ESTIMATED PROJECT USEFUL LIFE			50 YEARS	

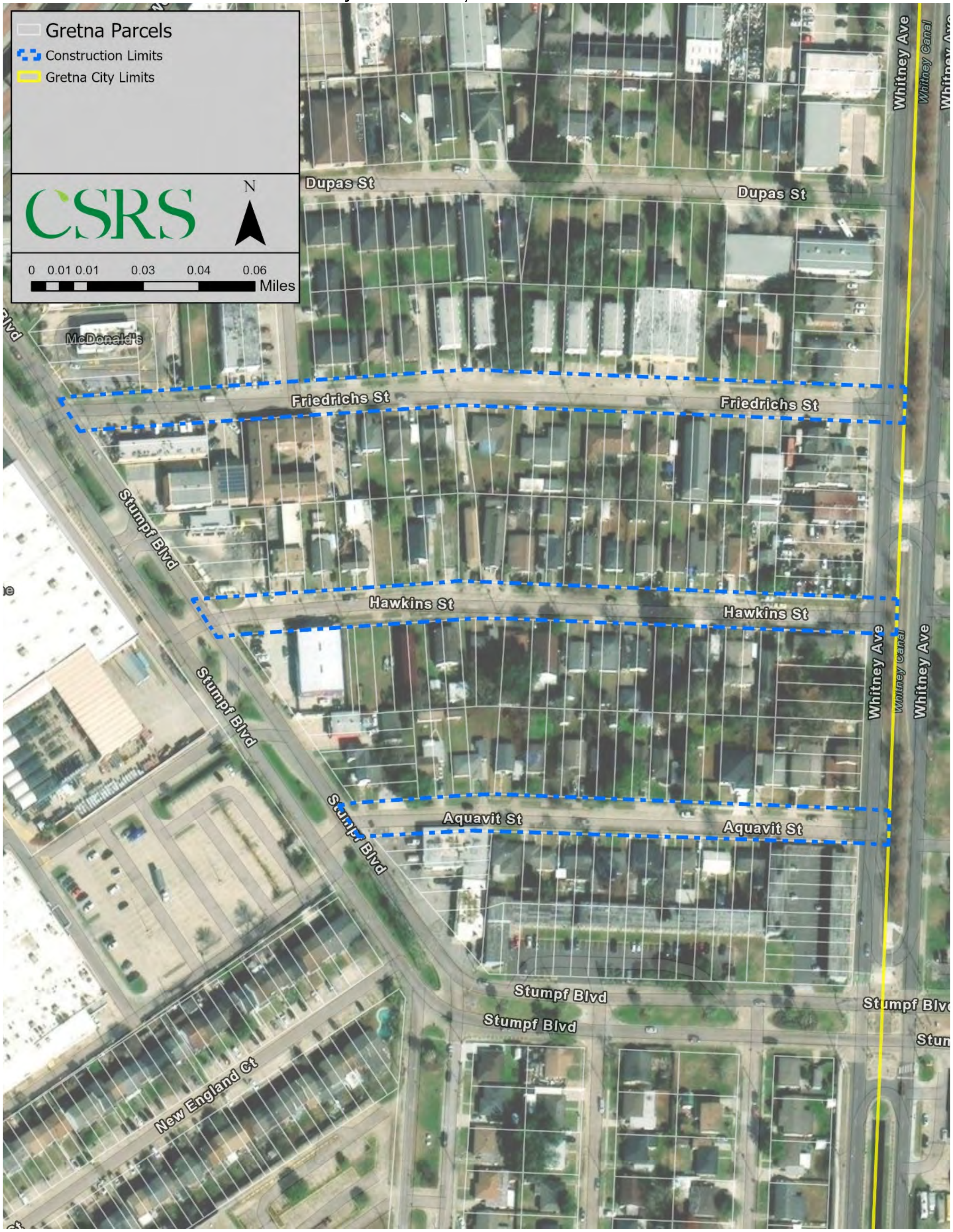
Benefit-Cost Analysis

Cost Effectiveness

Further details related to the BCA and BCR including breakdowns of the project benefits, BCR and social benefits can be seen in Attachment 8 - Benefit-Cost Calculator Report. The total project's benefits, cost and calculated BCR with the 3% discount rate allowed for FMA applications are $12M, $6.2M, and 1.89, respectively. The social benefits were calculated based on recent census data for the city and environmental benefits were calculated based on the acreage of the total amount of green infrastructure implements proposed. Because this area falls within a levee system, no sea level rise analysis was needed. Benefits occurring outside the city are not quantified.

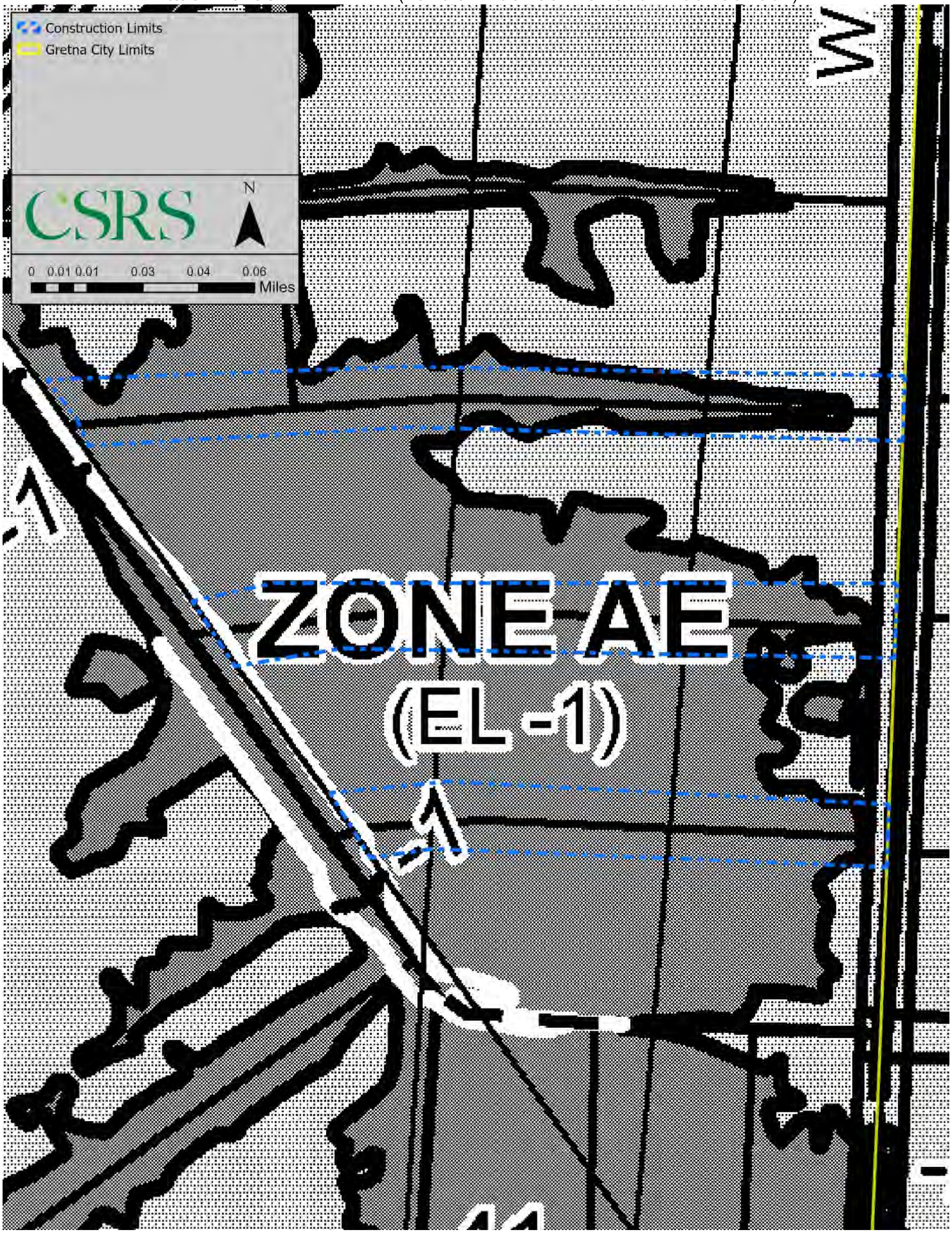
Attachments:

Attachment 1: Project Location/Construction Limits with Parcels



Attachment 2: Project Location with Existing Terrain

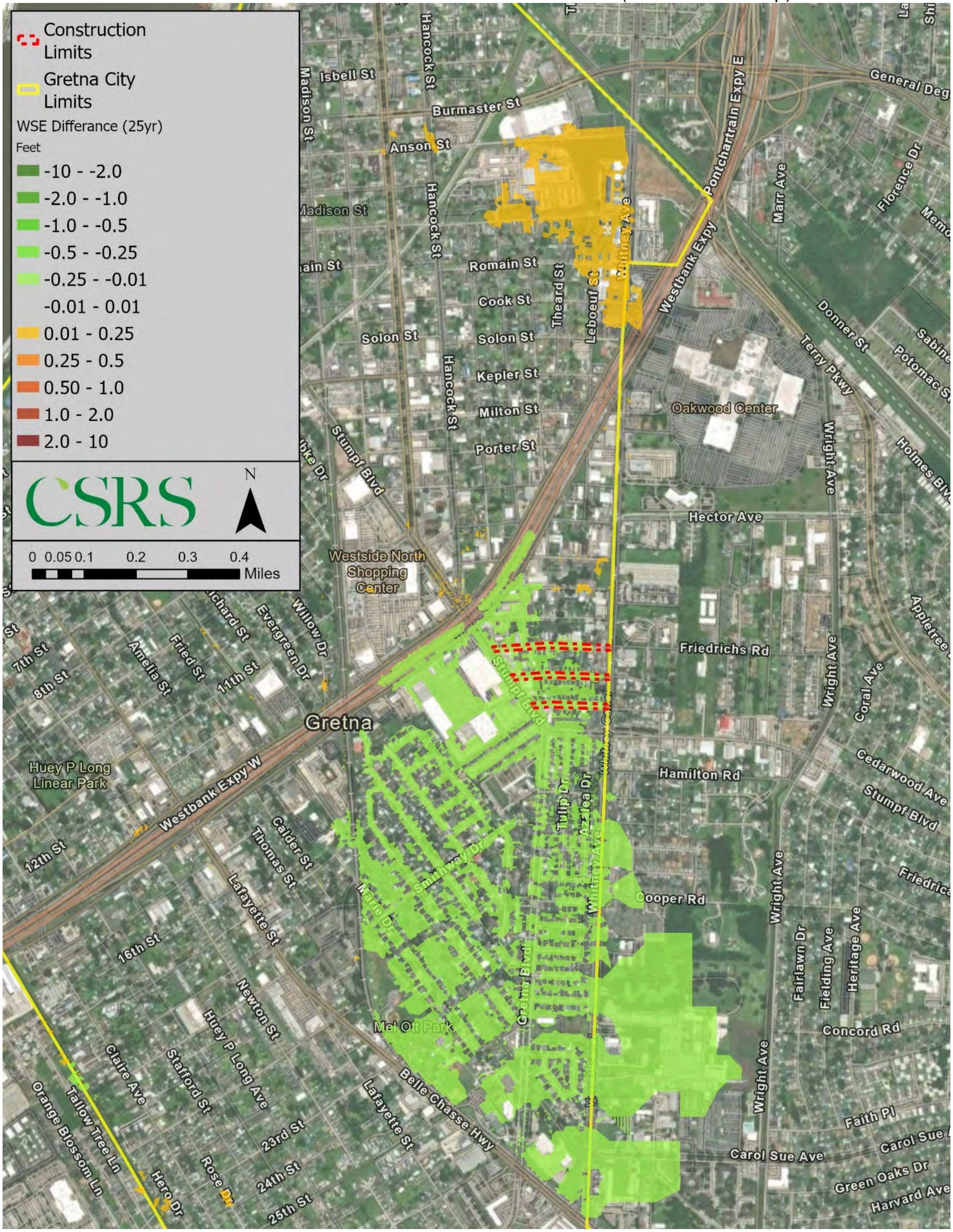
Attachment 3: FEMA FIRM (Panels 22051C0220F and 22051C0260F)



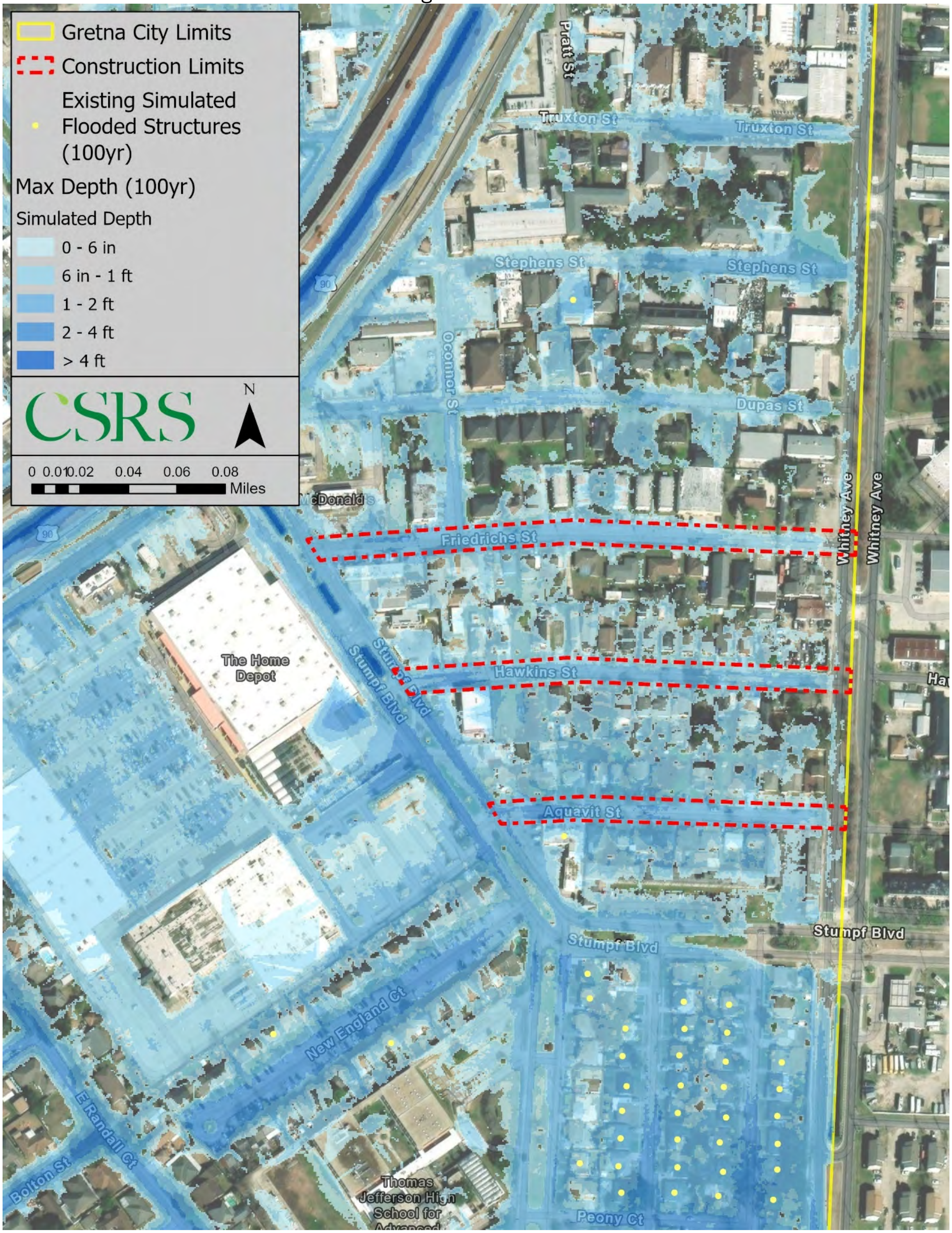
Attachment 4: FEMA FIS Profile with Project Location Marked

(No FIS profiles exist for this area of Jefferson Parish)

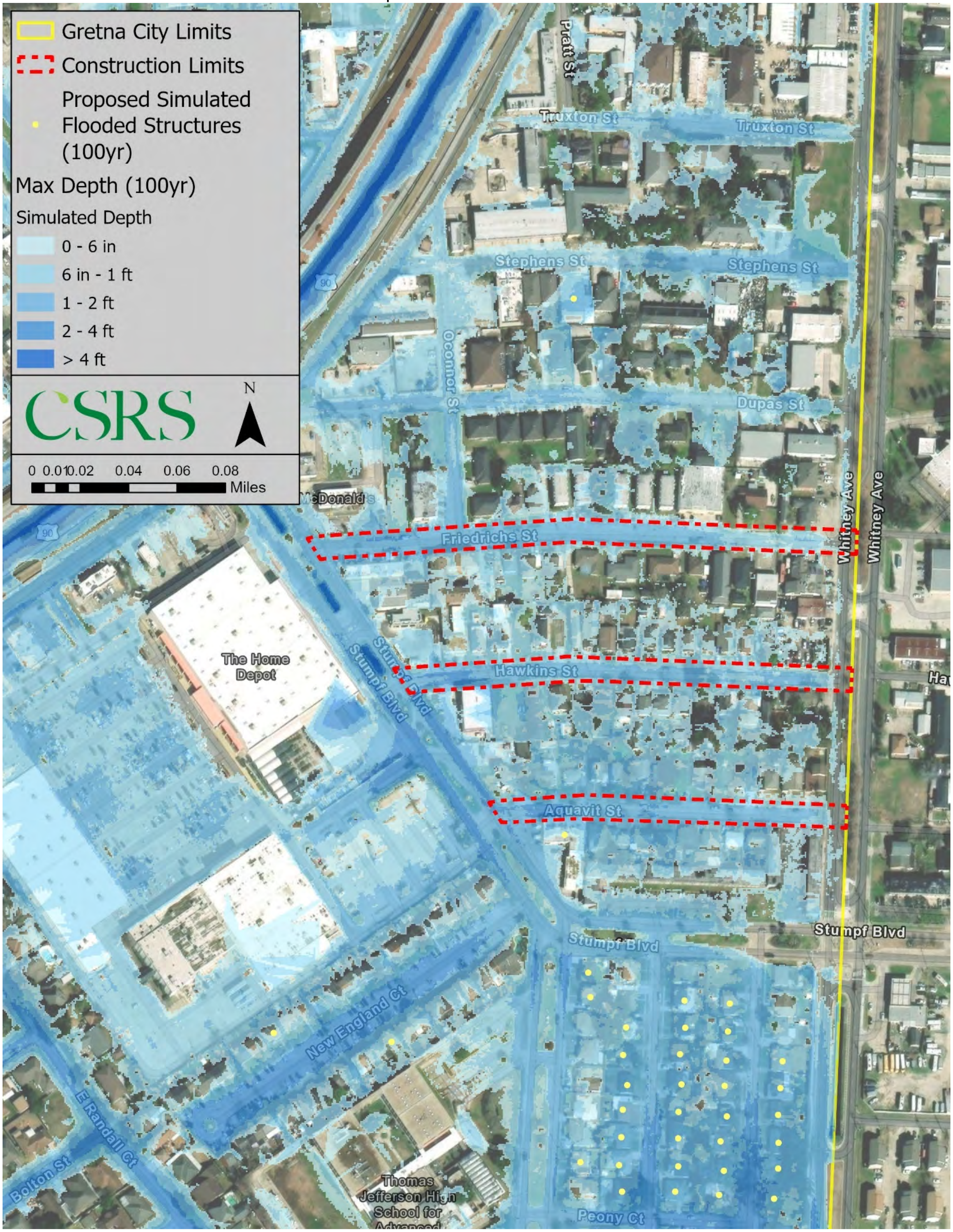
Attachment 5: Water Surface Elevation Reduction (Benefit Area Map)



Attachment 6: 100-Year Existing Flood Inundation with Affected Structures



Attachment 7: 100-Year Proposed Flood Inundation with Affected Structures



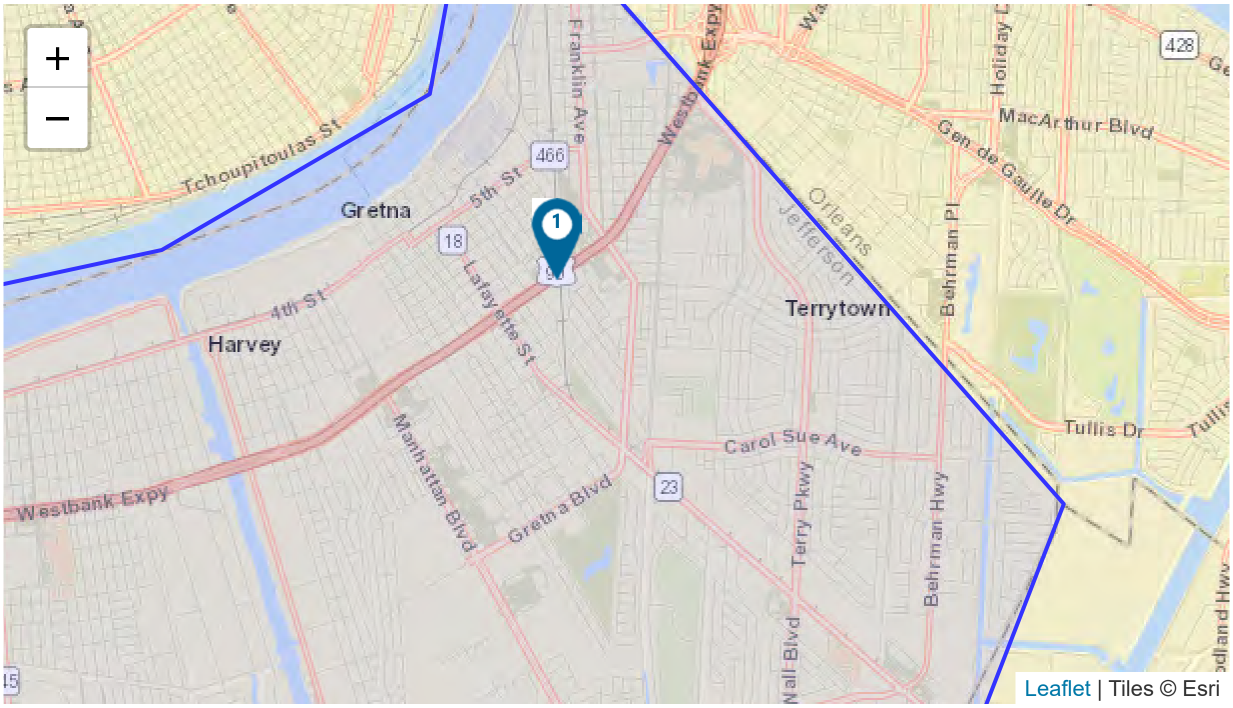
FEMA

Benefit-Cost Calculator

V.6.0 (Build 20240510.2248 | Release Notes)

Benefit-Cost Analysis

Project Name: Gretna Stumpf Diversion



Map Marker ▲	Mitigation Title	Property Type	Hazard	Discount Rate (%)	Benefits (B)	Costs (C)	BCR (B/C)
1	Drainage Improvement @ Gretna, Louisiana		DFA - Riverine Flood	3.1	$ 11,862,356	$ 6,291,049	1.89
TOTAL (SELECTED)					**$ 11,862,356**	**$ 6,291,049**	**1.89**
TOTAL					**$ 11,862,356**	**$ 6,291,049**	**1.89**

Property Configuration

Property Title:	Drainage Improvement @ Gretna, Louisiana
Property Location:	70053, Jefferson, Louisiana
Property Coordinates:	29.912239, -90.051566
Hazard Type:	Riverine Flood
Mitigation Action Type:	Drainage Improvement
Property Type:	Residential Building
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Drainage Improvement @ Gretna, Louisiana

Discount Rate (%):	3.1% Use Default:Yes
Project Useful Life (years):	50
Project Cost:	$6,270,093
Number of Maintenance Years:	50 Use Default:Yes
Annual Maintenance Cost:	$830

Damage Analysis Parameters - Damage Frequency Assessment

Drainage Improvement @ Gretna, Louisiana

Year of Analysis was Conducted:	2024
Year Property was Built:	0
Analysis Duration:	10 Use Default:Yes

Professional Expected Damages Before Mitigation

Drainage Improvement @ Gretna, Louisiana

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
5	24,506,000	0	0	0	0	0	24,506,000
10	32,744,000	0	0	0	0	0	32,744,000
25	73,788,000	0	0	0	0	0	73,788,000
50	100,270,000	0	0	0	0	0	100,270,000
100	162,446,000	0	0	0	0	0	162,446,000

Annualized Damages Before Mitigation

Drainage Improvement @ Gretna, Louisiana

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
5	24,506,000	2,832,710
10	32,744,000	2,949,239
25	73,788,000	1,720,317
50	100,270,000	1,276,263
100	162,446,000	1,624,444
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	393,754,000	10,402,973

Professional Expected Damages After Mitigation

Drainage Improvement @ Gretna, Louisiana

	OTHER	OPTIONAL DAMAGES			VOLUNTEER COSTS		TOTAL
Recurrence Interval (years)	Damages ($)	Category 1 ($)	Category 2 ($)	Category 3 ($)	Number of Volunteers	Number of Days	Damages ($)
5	23,670,000	0	0	0	0	0	23,670,000
10	31,982,000	0	0	0	0	0	31,982,000
25	73,165,000	0	0	0	0	0	73,165,000
50	100,202,000	0	0	0	0	0	100,202,000
100	161,988,000	0	0	0	0	0	161,988,000

Annualized Damages After Mitigation

Drainage Improvement @ Gretna, Louisiana

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
5	23,670,000	2,751,389
10	31,982,000	2,902,390
25	73,165,000	1,712,458
50	100,202,000	1,274,030
100	161,988,000	1,619,864
	Sum Damages and Losses ($)	Sum Annualized Damages and Losses ($)
	391,007,000	10,260,131

Standard Benefits - Ecosystem Services

Drainage Improvement @ Gretna, Louisiana

Total Project Area (acres):	0
Percentage of Urban Green Open Space:	0.00%
Percentage of Rural Green Open Space:	0.00%
Percentage of Riparian:	0.00%
Percentage of Coastal Wetlands:	0.00%
Percentage of Inland Wetlands:	0.00%
Percentage of Forests:	0.00%
Percentage of Coral Reefs:	0.00%
Percentage of Shellfish Reefs:	0.00%
Percentage of Beaches and Dunes:	0.00%
Expected Annual Ecosystem Services Benefits:	$0

Additional Benefits - Social

Drainage Improvement @ Gretna, Louisiana

Number of Workers:	657
Expected Annual Social Benefits:	$8,255,842

Benefits-Costs Summary

Drainage Improvement @ Gretna, Louisiana

Discount Rate (%):	3.1% Use Default:Yes
Total Standard Mitigation Benefits:	$3,606,514
Total Social Benefits:	$8,255,842
Total Mitigation Project Benefits:	$11,862,356
Total Mitigation Project Cost:	$6,291,049
Benefit Cost Ratio - Standard:	0.57
Benefit Cost Ratio - Standard + Social:	1.89

City of Gretna
Stormwater Master Plan

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