# PROJECT SCOPING REPORT

# FOR

# CITY OF NEW ORLEANS
# HYDROLOGIC & HYDRAULIC DRAINAGE STUDY
# WEST END NEIGHBORHOOD


PREPARED FOR

City of New Orleans

PREPARED BY

Digital Engineering & Imaging, Inc.
527 West Esplanade Avenue, Suite 200, Kenner, LA 70065

IN COLLABORATION WITH

Wingate Engineers, LLC.
2378 Prentiss Avenue, New Orleans, LA 70122

Civil Design & Construction, Inc.
3251 Southern Pacific Road, Port Allen, LA 70767

Batture, LLC.
5110 Freret Street, New Orleans, LA 70115



digital engineering
DIGITAL ENGINEERING & IMAGING, INC.

SEPTEMBER 2024

# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

digital engineering

SECTION 1

# BACKGROUND & PURPOSE

CITY OF NEW ORLEANS: WEST END H&H DRAINAGE STUDY

# 1. Project Purpose and Background

## 1.1 Project Purpose

The City of New Orleans, Office of Resilience and Sustainability (ORS) has contracted Digital Engineering & Imaging, Inc. (DE) to perform a hydrologic & hydraulic (H&H) drainage study in the West End neighborhood. In collaboration with Wingate Engineers, LLC, Batture, LLC, and Civil Design & Construction, Inc., the DE Team analyzed flood risk and potential mitigation strategies, including subsurface drainage conveyance improvements and potential green infrastructure opportunities. The study area consists of approximately 455.5 acres of subdivided land and is bounded by Lake Marina Avenue (North), Pontchartrain Boulevard (East), North Frontage Road (South), and 17th Street Canal (West). A map showing the limits of the study area is shown in **Figure 1**. The study area consists of a generally flat subdivided area consisting of primarily single-family residential homes and multi-family apartments.


*Figure 1 – West End Study Area*

To develop a comprehensive H&H drainage study of the study area, the DE Team established an implementation strategy, which consisted of the following tasks:

1. Task 1: Data Collection, Gap Analysis, and Infrastructure Survey
2. Task 2: Existing Conditions Model Update, Calibration and Production Runs
3. Task 3: Project Scoping and Alternative Analysis
4. Task 4: Project Report
5. Task 5: Project Management

Data Collection under Task 1 consisted of collecting and organizing various data types to be utilized in modeling, surveying and project scoping for potential solutions to reduce flood inundation within the study area. Once the data was collected, the DE teams reviewed all data to identify potential gaps within the available data and developed an infrastructure survey to collect that additional data necessary to complete the scope of work. The infrastructure survey consisted of conducting survey of major drainage structures within the study area, which included but was not limited to top-of-castings, invert elevations, and drainage structure sizes.

The DE Team utilized data collected under Task 1 to develop a modeled representation of the existing drainage system utilizing Environmental Protection Agency (EPA) Stormwater Management Model's (SWMM) software. The existing drainage system was calibrated to multiple historical rainfall events to best-fit the current capacity of the drainage system to handle a wide variety of potential flooding events. Once completed, the DE Team developed rainfall hyetographs for the 1-, 10-, and 25-year, 24-hour duration rainfall events utilizing National Oceanic and Atmospheric Administration (NOAA) Atlas 14 rainfall totals with a National Resource Conservation Service (NRCS, formerly SCS) Type III rainfall distribution for water quantity evaluations. Model Simulations for each rainfall hyetograph were completed to determine the current drainage capacity and develop potential project solutions to the study area.

Project Scoping and Alternative Analysis consisted of identifying specific areas of improvements determined by H&H modeling analysis of the existing conditions model results, assessment of the current condition of roadway infrastructure and future planned roadway infrastructure improvements to the study area. Proposed drainage improvements were analyzed on their capacity to have a greater chance of reducing flooding the New Orleans' Level of Service roadway flooding requirements (Maximum of 6 inches of flooding during a 10-year, 24-hour storm.) The DE Team considered constructable, innovative green stormwater infrastructure (GSI) solutions to reducing flood risk in the study area. The DE Team prepared a 10% Conceptual Level-of-Effort plan set and Engineer's Opinion of Probable Construction Cost Estimate of the potential project solutions considered in this study.

Lastly, The DE Team compiled all analyses of the existing drainage system, drainage model results, and project solutions into a Final H&H Study Report. The Final H&H Study Report documents the Engineer's preferred solution, assumptions used, potential limitations of the models and the study developed, and a path forward on implementing the preferred solution.

## 1.2 Background

The City of New Orleans, founded nearly 300 years ago, throughout its long history has been heavily influenced by its most crucial asset and neighbor, water. New Orleans is a consolidated city-parish to Orleans Parish, which is geographically situated in the southeastern part of Louisiana. City of New Orleans encompasses a total area of approximately 350 square miles, 170 square miles of land area and 180 square miles of water. Orleans Parish is the 3rd most populous parish in Louisiana. A map showing the limits of Orleans Parish and the approximate location of the West End H&H Study Area in southeast Louisiana is shown on **Figure 2**.

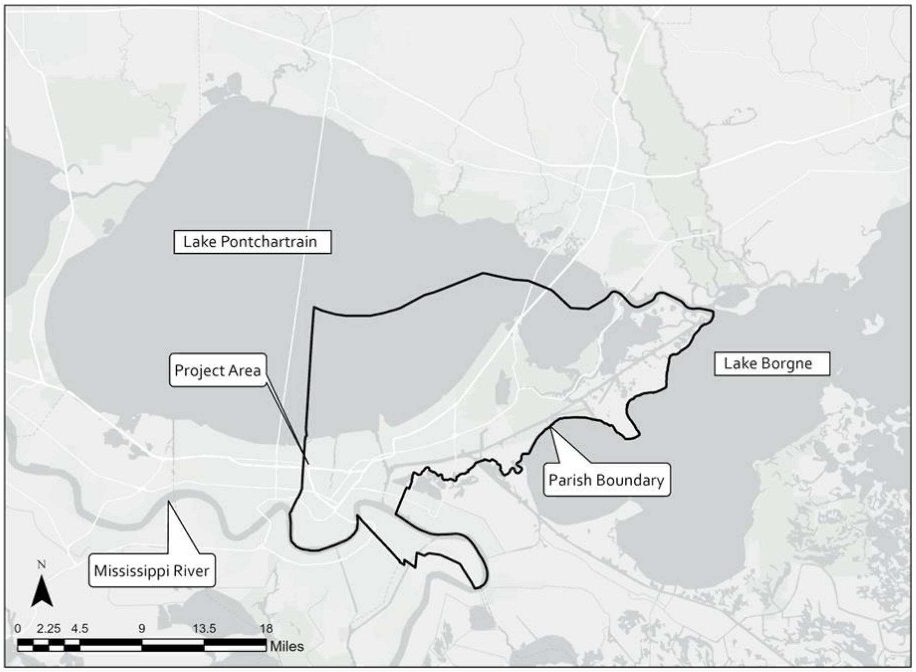



*Figure 2 – Orleans Parish Boundary Map*

The City of New Orleans is a coastal city bounded by the Lake Pontchartrain and Lake Borgne and is separated into four (4) polders by the Mississippi River, the Inner Harbor Navigational Canal and the Gulf Intercoastal Waterway. The southeastern part of Louisiana is also considered a subtropical climate and is considered one of the wettest regions of the U.S. New Orleans receives an average of 62.5 inches of rainfall per year, and 100% of runoff must be pumped out of the city. Just as the City of New Orleans benefits economically from its geographic location, it also must endure intense storms, hurricanes, and flooding due to being located below sea level.

The land on which the City of New Orleans and the Greater New Orleans area is built consists of a loamy alluvial floodplain. The City of New Orleans is protected by two (2) levee systems: (1) The Hurricane and Storm Risk Reduction System (HSDRRS) and (2) the Mississippi River Levee System (MRL). These two levee systems have protected the city from devastating storm surges and high river events but prevent soil recharge and has caused the city to settle further below sea-level (defined as subsidence). A topography map showing the elevation relative to Mean Sea Level for the City of New Orleans on the Eastbank is shown on **Figure 3**. Much of the Greater New Orleans Metropolitan Area and our study area is considered below sea level. A Typical Section of the City of New Orleans on the Eastbank is provided on **Figure 4**. The City of New Orleans has been able to persevere for over 300 years by developing and sustaining an intricate web of conventional drainage infrastructure to move water away from its communities. This delicate web of infrastructure is a combination of the following:

- Levees (Protection from Storm Surge & High River Level Conditions)
- Spillways (Protection from High River Level Conditions)
- Subsurface Drainage Pipe & Catch Basins (Move water below surface & push downstream)
- Drainage Canals & Subsurface Drainage Box Culverts (Move & Store Water from Communities)
- Drainage Pump Stations (Move Large Volumes of Water over Levee System to empty Drainage Canals & Subsurface Drainage Box Culverts)

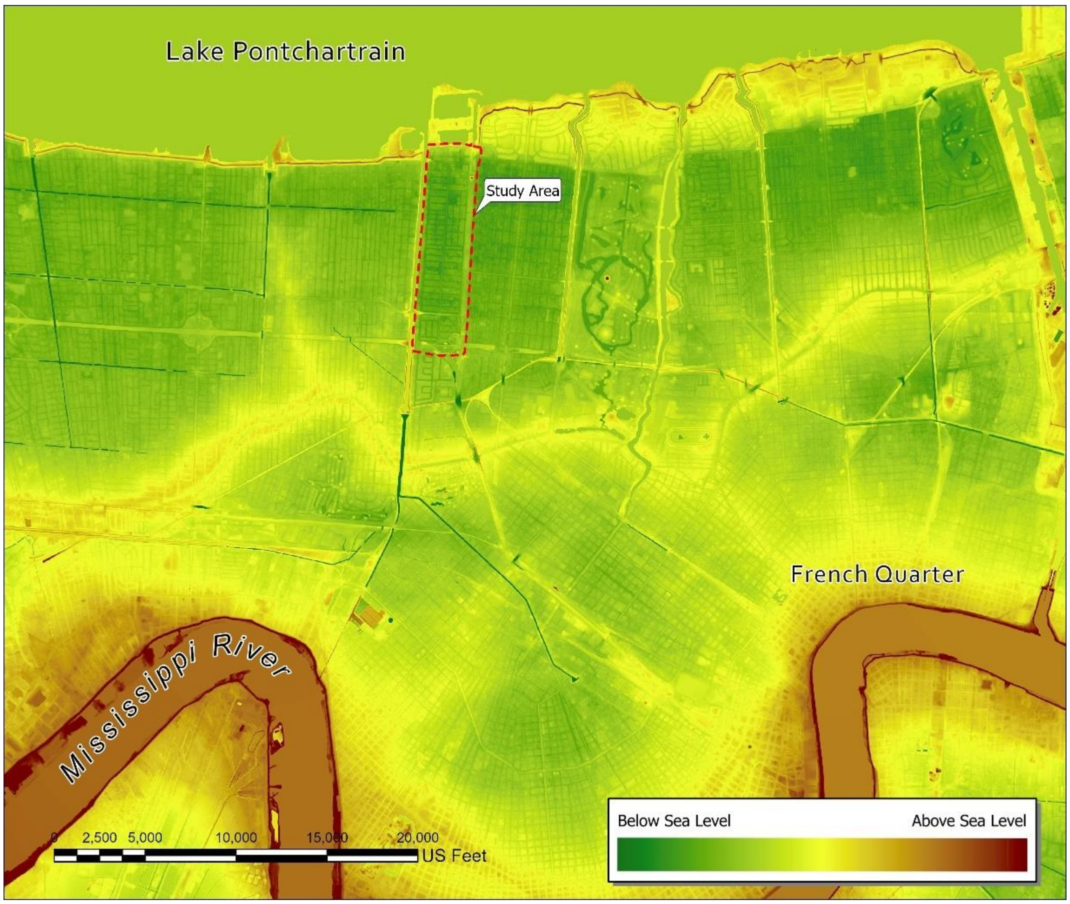



*Figure 3 – City of New Orleans (Topography Map)*

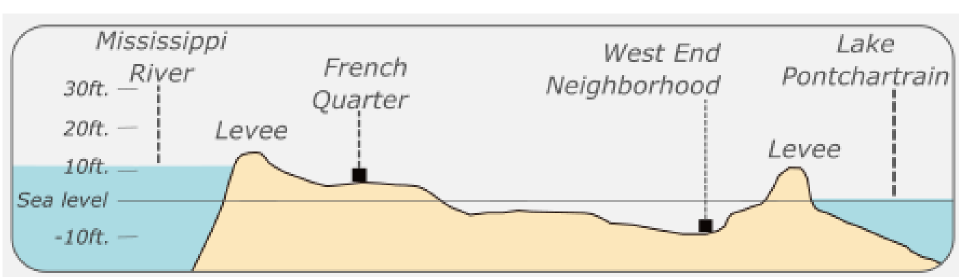



*Figure 4 – Eastbank City of New Orleans (Typical Section)*

The United States Environmental Protection Agency (EPA) defines this traditional infrastructure approach that was built to protect the City of New Orleans as "Gray" Infrastructure. With rising risks for potential damage and loss of life due to global climate change, subsidence and an aging infrastructure, many local and national communities now acknowledge the need for studying multiple approaches to upgrading existing drainage systems. Recent storms, which brought sudden and heavy rainfalls to local communities have resulted in localized inundation and severe damage to property and disruption to the stability of its community.

The City of New Orleans' Office of Resilience and Sustainability (ORS) focuses on environmental stewardship and climate resilience in New Orleans. ORS leads the policy development, implementation, and outreach for many resilience-building projects throughout New Orleans. ORS is responsible for developing New Orleans' Resilience Strategy, Climate Equity Report, and Climate Action Plan as guides to do work across the economic, environmental, infrastructure, and social sectors. The H&H study of the West End neighborhood was performed in alignment with ORS's resilience building initiatives, seeking to mitigate climate change and address sudden and intense rainfall events by studying advanced approaches to improving the traditional gray infrastructure and integrating innovative green stormwater infrastructure solutions. A graphic of this new strategy to tackle flooding problems by layering multiple drainage approaches is shown on Figure 5.

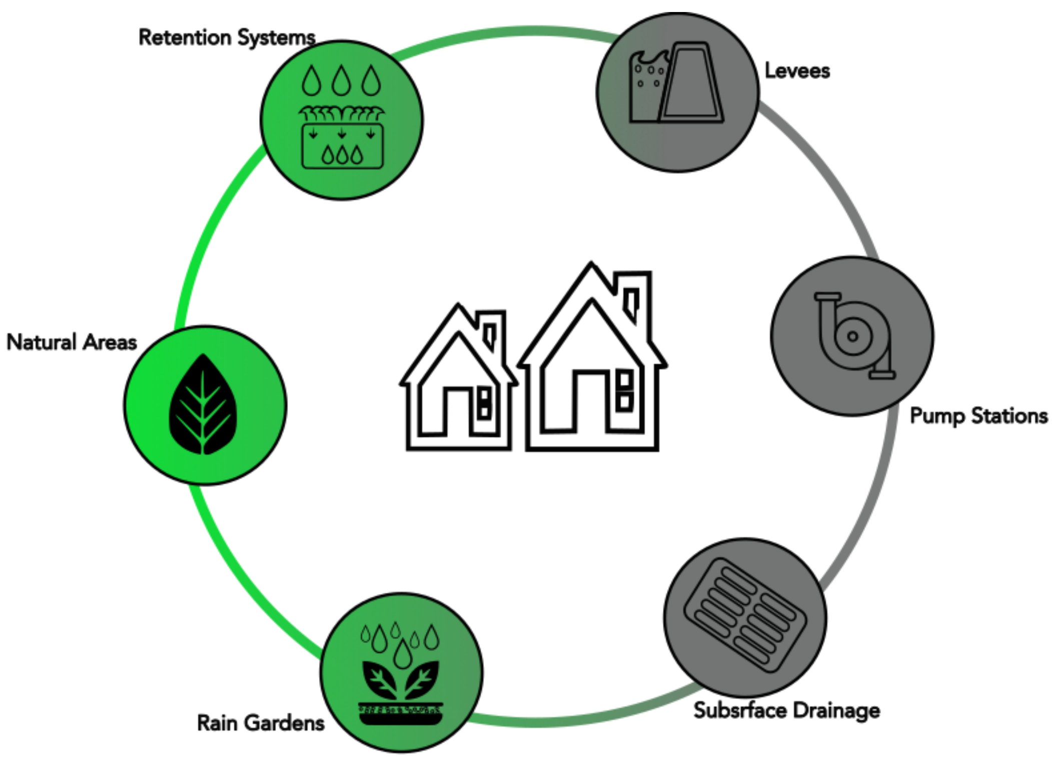



*Figure 5 – Layered Approach to Tackling Drainage Infrastructure*

SECTION 2

# DATA & METHODOLOGY

CITY OF NEW ORLEANS: WEST END H&H DRAINAGE STUDY

digital engineering

# 2. Methodology, Data Collection, and Data Gap Analysis

## 2.1 Methodology

The DE Team investigated historic rainfall events in the area, evaluated the cause of flooding, obtained rainfall data, and then determined the parameters required to replicate these flood events in a model of the study area. The hydraulic investigation included reviewing available existing drainage system information, obtaining missing topographic survey data of the current conditions of the existing drainage system, and incorporating this information into Geographic Information Systems (GIS) to visualize the study area.

The H&H Analysis for the study area and proposed improvements were performed using PC SWMM 2D (Storm Water Management Model) (Version 7.6), which is a software interface licensed by Computation Hydraulic Inc. (CHI). PC SWMM 2D is built upon the U.S. Environmental Protection Agency (EPA) SWMM 5 program by adding 2D modeling capability. SWMM model results were analyzed by the DE Team to determine peak Water Surface Elevations (WSE) for existing rainfall events and synthetic rainfall events throughout the study area. The goal is to use the data produced in the SWMM model results to evaluate the study area's existing drainage infrastructure and analyze potential drainage conveyance and green infrastructure solutions in the study area.

The approach of the development, calibration, and validation of the SWMM-based model is shown in Figure 6, which breaks the model development into two (2) major sections: (1) Development of an Existing Conditions Model and (2) Analysis of Infrastructure Solutions. The DE Team performed a constructability analysis on potential solutions and developed an opinion of probable construction cost for each solution. The final step was to develop recommendations for the City of New Orleans on the preferred project alternative and how City of New Orleans might be able to implement the proposed alternative.

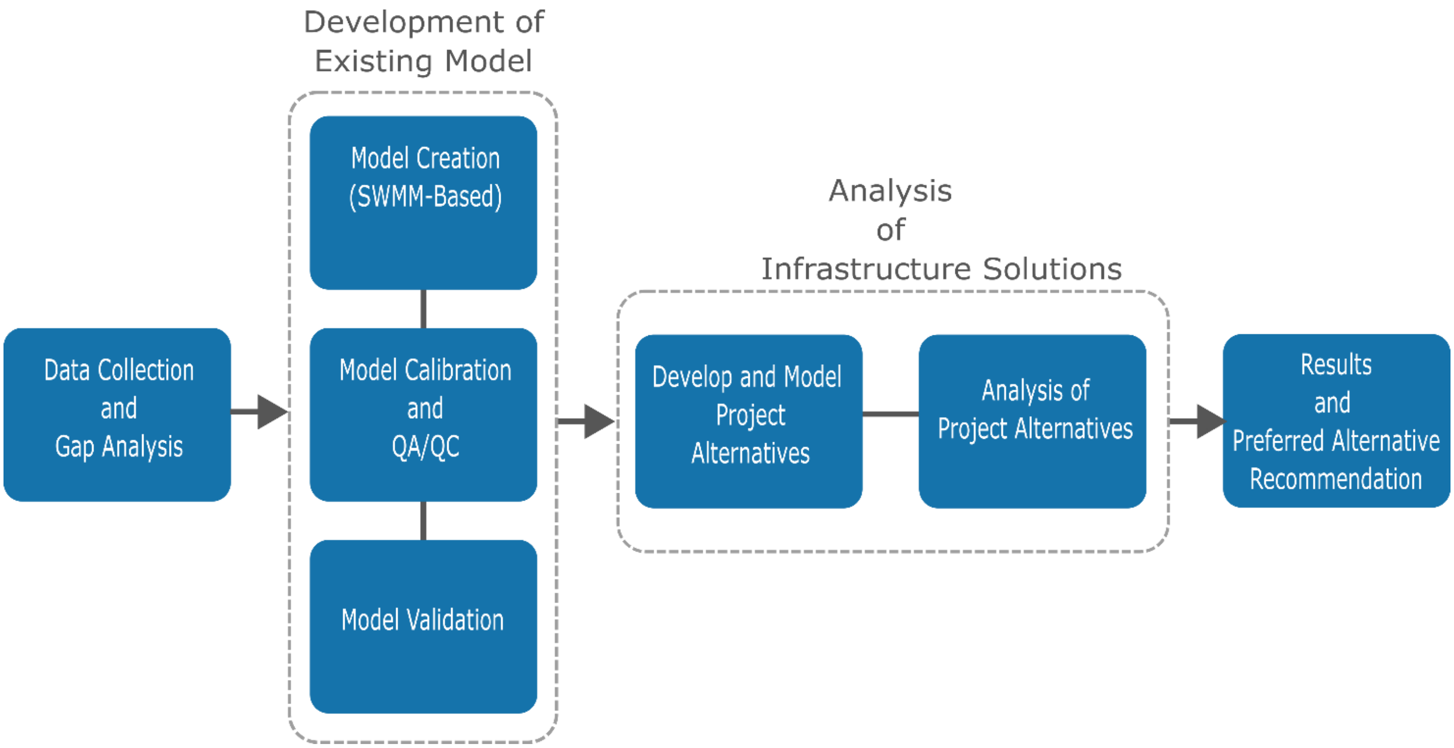



*Figure 6 – Model Development and Alternative Analysis Flowchart*

The DE Team used existing regional-wide models of the City of New Orleans drainage system developed by Sewerage & Water Board of New Orleans (SWBNO). The regional-wide models include a system of subsurface drainage infrastructure and drainage pump stations in the City of New Orleans, which represent the current drainage capacity for the entire city.

### 2.1.1 Existing Rainfall Events Analyzed (Model Calibration and Validation)

The DE Team referenced three (3) historical rainfall events to model the existing capacity of the drainage system and to model flood inundation observations.

The DE Team took the drainage model and calibrated it by fitting the model to the rainfall event. Accuracy of the model results simulated vs. historical observations was performed using rainfall distribution data and then checked against available recorded datasets collected by SWBNO, such as Drainage Pump Station suction depths. The DE Team selected the following historical rainfall events to calibrate and validate the model:

- July 10-11, 2019 (48-Hour Event): Calibration Rainfall Event
- September 4-5, 2023 (48-Hour Event): Validation Rainfall Event No. 1
- December 1-2, 2023 (48-Hour Event): Validation Rainfall Event No. 2

Total rainfall distributions over the 48-hour duration for the three (3) historical rainfall events is shown on **Table 1**.

*Table 1 – Historical Rainfall Event Totals*

| Historical Rainfall Event | Total Rainfall (inches) | Location |
|---|---|---|
| July 10-11, 2019 (48-Hours) | 2.50" | DPS 12 |
| September 4-5, 2023 (48-Hours) | 5.43" | DPS 7 |
| December 1-2, 2023 (48-Hours) | 5.12" | DPS 12 |

<u>July 10-11, 2019 Rainfall Event (Calibration Event)</u>

According to the 2022 Storm Water Master Plan Report developed for SWBNO, the city of New Orleans received nearly 9 inches of rain in some neighborhoods primarily between the hours of 6:30am and 9:30am. The intense rainfall in such a short period of time inundated the SWBNO drainage pump stations with storm water that backed up and caused severe street flooding in various areas. A figure of the rainfall distribution at DPS 12 of the July 10-11, 2019 rainfall event is shown on Figure 7.

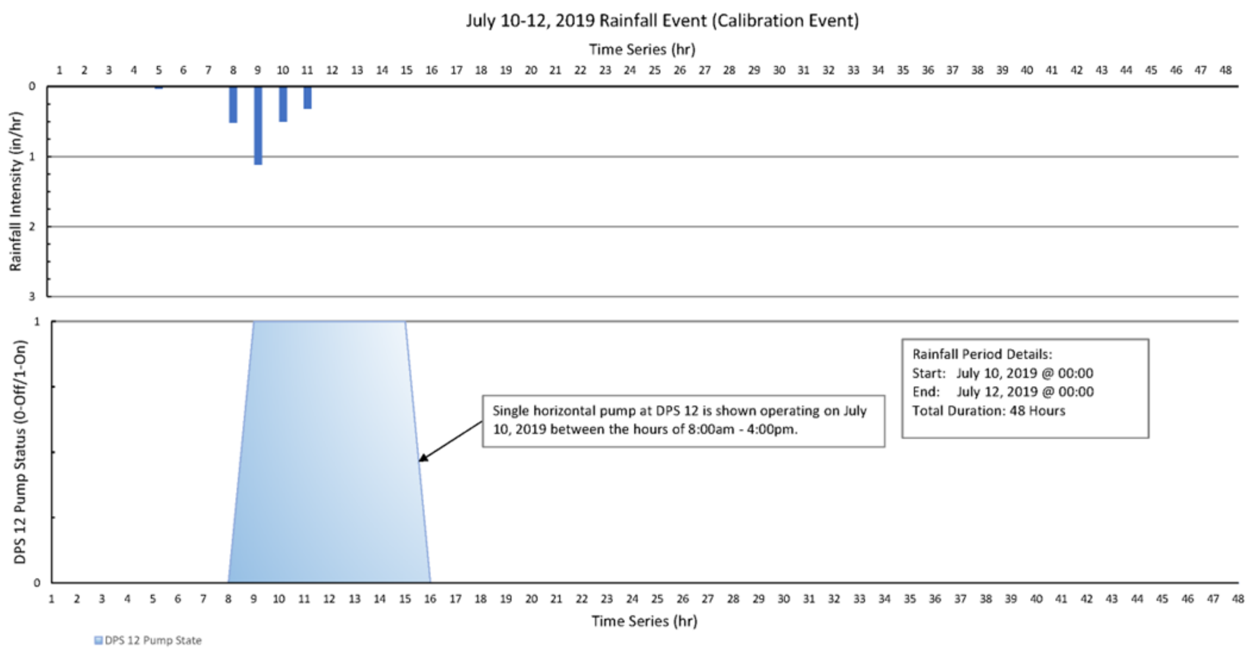



*Figure 7 – Calibration Rainfall Hyetograph (July 10-11, 2019)*

Figure 8 shows a map from the September 2019 report on the July 10-11, 2019, model simulations that displays the total precipitation in inches for July 10, 2019, across Orleans Parish.

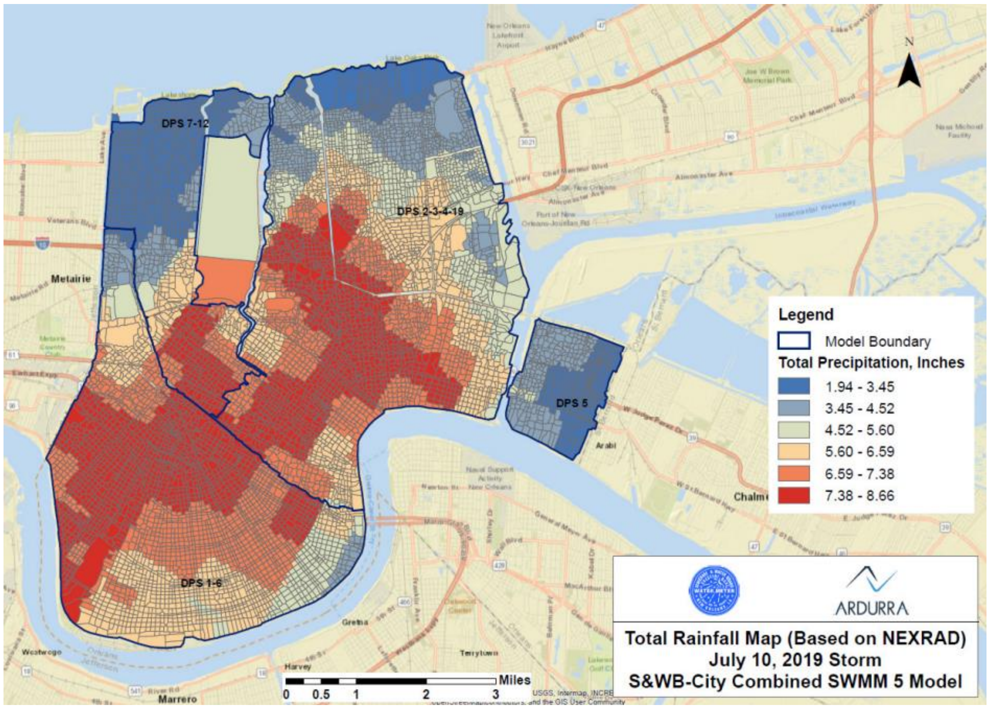



*Figure 8 – July 10-11, 2019, Rainfall Distribution across New Orleans Eastbank*

Figure 9 is a rainfall distribution graph of the rain gage data collectors in Orleans Parish inside and nearby the West End study area. Figure 9 shows that the West End study area saw significantly less rainfall than other portions of the city for the July 10-11, 2019 historical rainfall event. The area received similar flood inundation to areas that received more total precipitation.

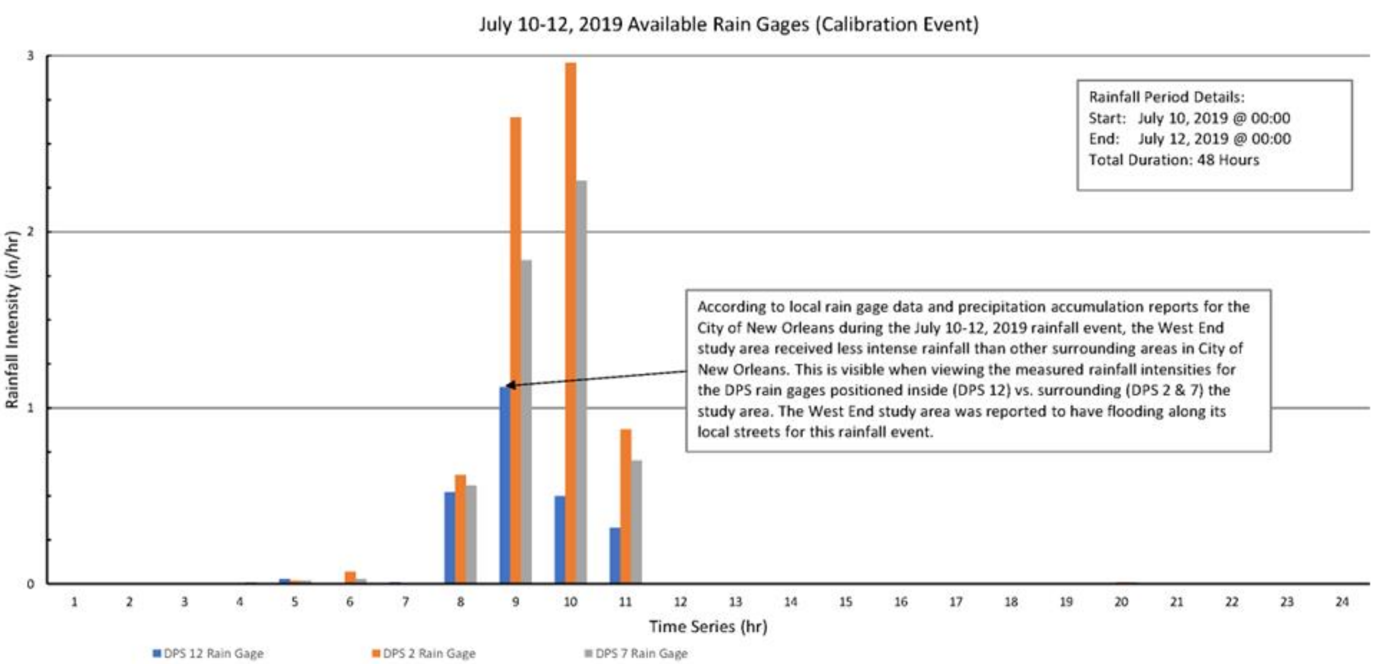



*Figure 9 – Rain Gage Recorded Data (July 10-11, 2019)*

September 4-5, 2023 Rainfall Event (Validation Event No. 1)

Heavy rainfall occurred on September 4, 2023, between the hours of 2:00pm – 4:00pm through parts of Jefferson Parish and Orleans Parish. The highest amount of rainfall detected by local rain gages was at DPS 7, located southeast of the West End study area near the intersection of Orleans Ave. and I-610, which received greater than 6 inches of rainfall. The DE Team utilized the September 4-5, 2023 recorded rainfall data to complete a validation of the model results observed in the West End study area. A figure of the rainfall distribution over September 4-5, 2023 and recorded operating status of the pump station at Drainage Pump Station (DPS) 12 during the rainfall event is shown on **Figure 10**.

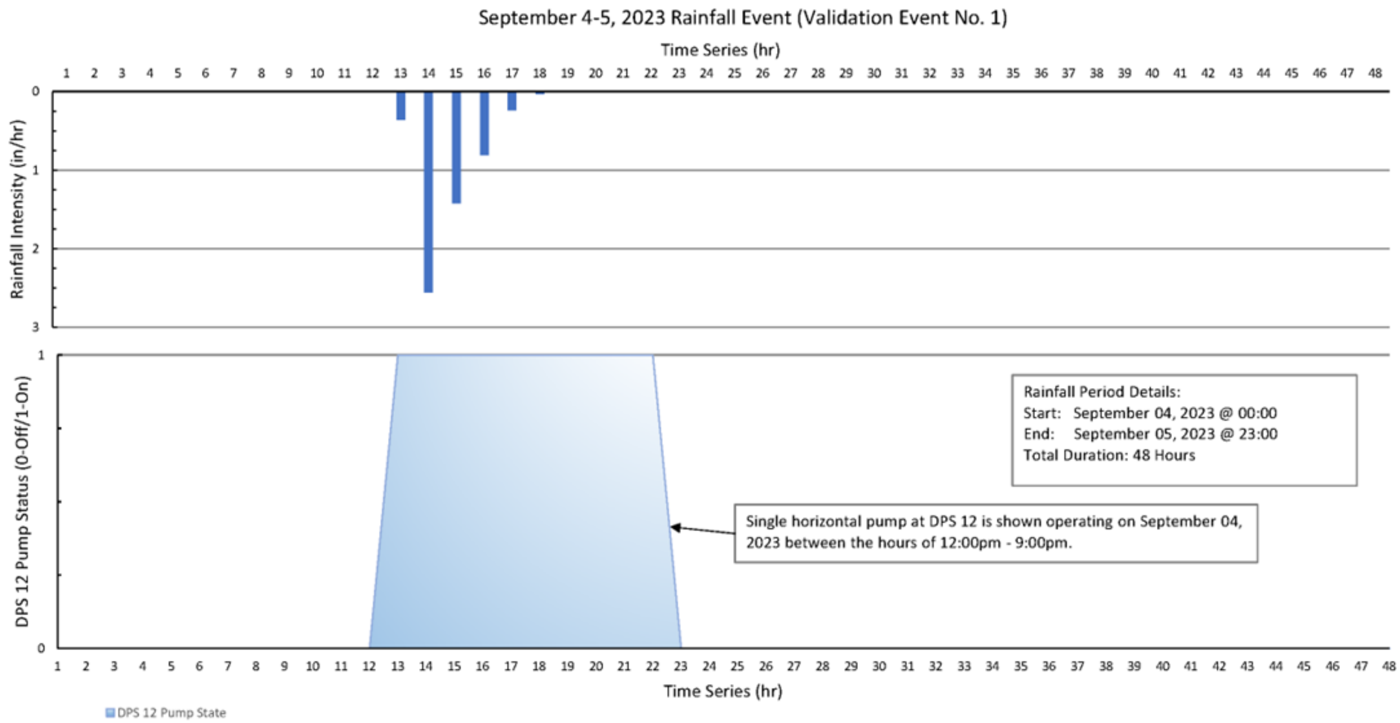



*Figure 10 – Validation Event No. 1 Rainfall Hyetograph (September 4-5, 2023)*

December 1-2, 2023 Rainfall Event (Validation Event No. 2)

Heavy rainfall and street flooding occurred between December 1st and December 2nd of 2023. Several rain gages throughout the city reported rainfall between 3 to 5 inches. The DE Team utilized the December 1-2, 2023 recorded rainfall data to complete a validation of the model results observed in the West End study area. A figure of the rainfall distribution over December 1-2, 2023 and recorded operating status of the pump station at Drainage Pump Station (DPS) 12 during the rainfall event is shown on **Figure 11**. SWBNO Turbines No. 4 and No. 5, which generate and feed power to the SWBNO-operated drainage pump stations across the City of New Orleans, went offline on the morning of December 2, 2023. Due to the temporary power loss, the following drainage pump stations were reported to be affected:

- Drainage Pump Stations 1, 2, 6, and 7 were reported to be running at a reduced capacity.

- Single pump at Drainage Pump Station 12 was down for three (3) hours, but crews were able to divert power to the pump station just after 9am.

As a result of this loss of power, SWBNO reported localized street flooding in the areas of Carrollton, Mid City, Central City, Broadmoor, Lakeview, and West End.

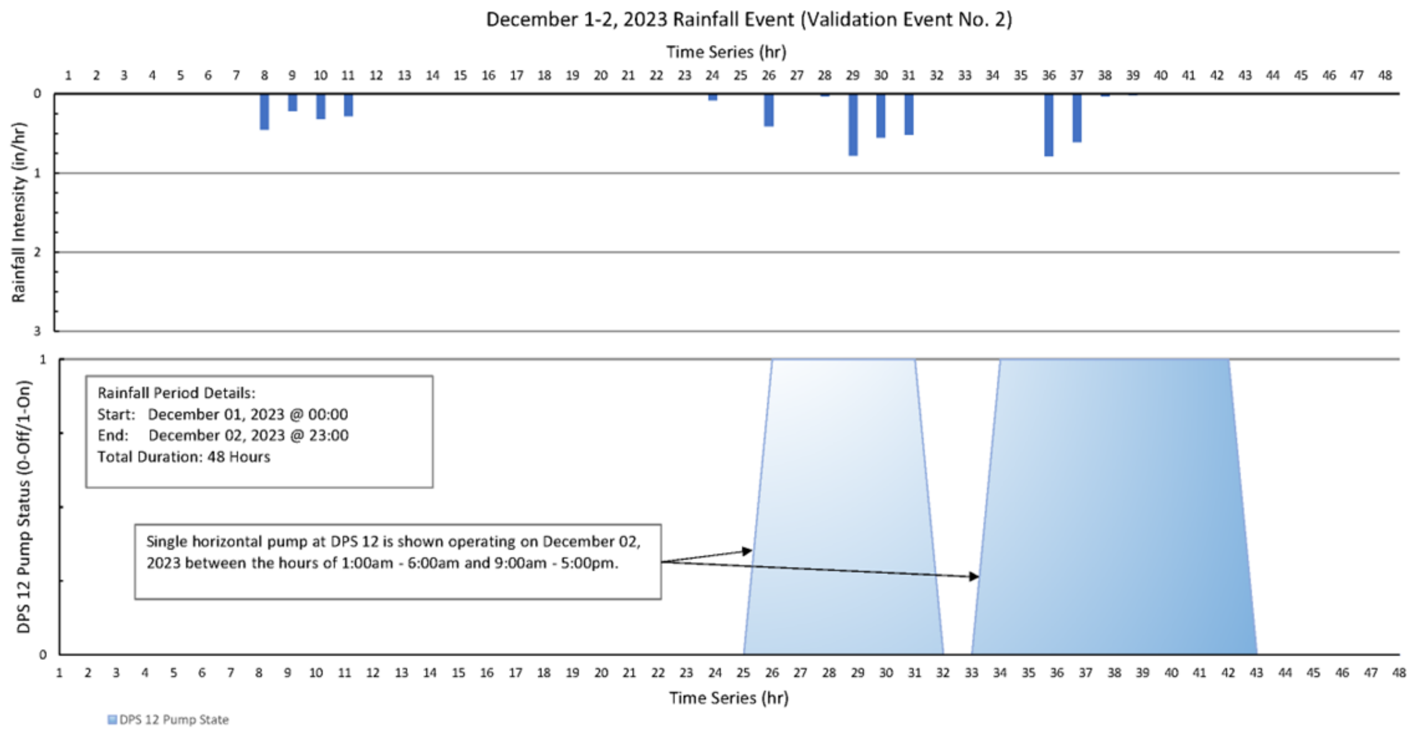



*Figure 11 – Validation Event No. 2 Rainfall Hyetograph (December 1-2, 2023)*

### 2.1.2 Model Simulations Analyzed (Design Rainfall Events Studied)

The DE Team modeled three (3) design rainfall events for the West End study area: 1-, 10-, and 25-year design storms. The 24-hour precipitation depths used in these design storms were obtained from NOAA Atlas 14 and are:

- 1-Year, 24-Hour Design Storm: 4.64"
- 10-Year, 24-Hour Design Storm: 8.31"
- 25-Year, 24-Hour Design Storm: 10.5"

A rainfall distribution is used to account for the varying intensities during a storm. The Soil Conservation Service (SCS) developed rainfall distributions using the National Weather Services (NWS) data for four (4) climatic regions in the United States. A Type III rainfall distribution, which is specified for Southeast Gulf Coast Region. **Figure 12** shows the cumulative rainfall distribution used for the West End study area.

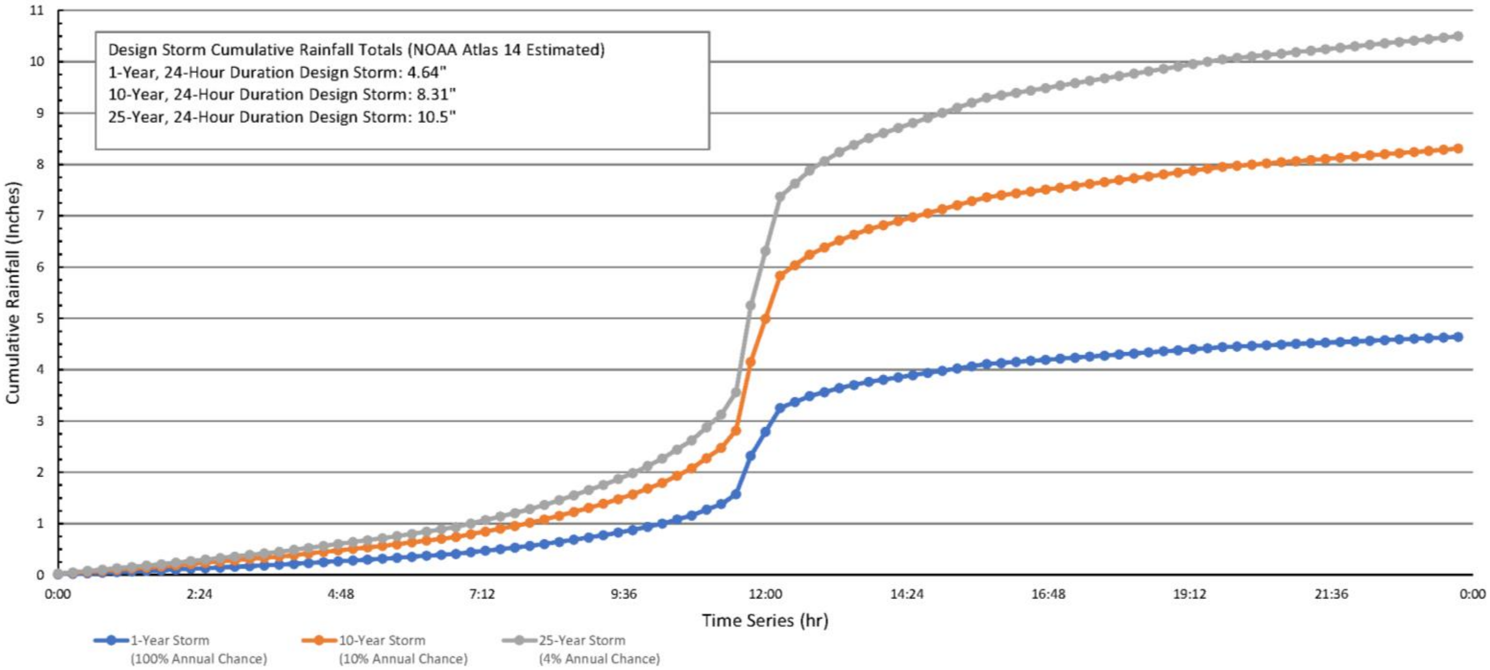



*Figure 12 – West End Study Area – SCS Type III Cumulative Rainfall Distribution*

## 2.2 Data Collection and Data Gap Analysis

### 2.2.1 Initial Data Collection

The DE team coordinated with the City of New Orleans Department of Public Works (DPW) and (SWBNO) to collect Geographic Information Systems (GIS) data to assist in the development of an H&H model of the project area. Department of Public Works was able to provide the following GIS data to the DE team:

- Project Boundary
- Building Footprints
- Street Centerlines
- Edge of Roadway and Sidewalk Pavements
- Drainage Structures w/ Top of Casting (Catch Basins, Drain Manhole, etc.)
- Drainage Pipe Culverts w/ Pipe Dimensions (Box Culverts, Drainage Pipe, etc.)
- Pump Stations
- General Vicinity/Location of other utilities structures and lines (Water, Sewer, etc.)
- Roadway condition Assessment (PASER)
- Joint Infrastructure Recovery Request (JIRR) projects with phase numbers
- Curbed/Non-curbed streets
- Right-of-Way (ROW) widths from the center line data
- Tree data that includes size and condition

In 2023, DPW completed a Light Detection and Ranging (LiDAR) point cloud survey of all structures within the roadway Right-of-Way in the project area. DE utilized the data collected to develop a GIS database of all roadway structures with a high-level of accuracy to the location and elevation (Elevations provided in the LiDAR dataset are in the North

American Vertical Datum of 1988 (NAVD88)) of these structures (manholes, catch basins, fire hydrants, etc.). The DE project team then updated the location of subsurface drainage structure pipe. the DE Team provided DPW with an updated GIS database as part of the final deliverable.

Additionally, SWBNO provided the DE team with the following data:

- Rainfall Gage Data in 15-minute Intervals
- Drainage Pump Station On/Off Records
- Drainage Pump Station Stage Data at Suction Basin
- Survey Validations for Datum Conversion Needs for Gage Data at Drainage Pump Stations
- GIS Database of Drainage Structures
- Unit Sheets (Electronic PDF) of DPW & SWBNO Utilities in Study Area

The DE Team also collected several other governmental agency databases, which were used to develop and calibrate existing drainage characteristics observed during the H&H drainage study of the study area. The following are a list of the datasets collected for the study area:

- Digital Elevation Model (DEM) using LSU Atlas LiDAR Database
- National Agriculture Imagery Program (NAIP) Imagery (Georeferenced Aerial Imagery)
- U.S. Department of Agriculture's National Resources Conservation Service (NRCS) Soil Survey Database
- U.S. Geological Survey (USGS) National Land Cover Database (NLCD) Impervious Area

As part of the data collection and analysis scope, the DE Team received the itemized drawings below and evaluated the project plans for available information that can be used in developing the study area's H&H SWMM model.

*Table 2 – Available Study Area Data – Recent Project Plan Production*

| Contract No. | Location | Construction Completion |
|---|---|---|
| DPW215 | Fleur de Lis Phase I (Veterans – I-610), | Jun 2008 |
| DPW058 | Fleur de Lis Phase II (Veterans – Harrison Ave) | Mar 2011 |
| DPW059 | Fleur de Lis Phase III (30th St – Hammon Hwy) | Feb 2019 |
| JIRR RR3 Program RR193 | West End Group A | Oct 2021 |
| JIRR RR3 Program RR194 | West End Group B | Nov 2022 |
| JIRR RR3 Program RR231 | West End Group C, F and G (RR195/RR198/RR199) | In Design |
| JIRR RR3 Program RR232 | West End Group D and E (RR196/RR197) | In Design |

The DPW bond projects (DPW215, DPW058, DPW059) included full topographic survey for the limits of their work but excluded invert elevations within the main Fleur de Lis drainage box canal. The Joint Infrastructure Recovery Request (JIRR) Roadway Recovery Program (RR3) projects include several categories of work in the construction project plan sets and each category includes either topographic-only survey without utility structure inverts, or complete topographic survey with utility structure inverts. The JIRR scope of work determined by the DE Team and the typical level of associated survey are:

*Table 3 – JIRR Scope of Works & Associated Survey*

| Scope of Work Category | Associated Survey |
|---|---|
| Non-Paving Incidentals | Minimal Survey, no drainage upgrades |
| Incidental Road Repairs | Topographic Survey excluding drainage infrastructure, no drainage upgrades |
| Patch Mill/Overlay | Topographic Surveys with some drainage infrastructure top of castings, no drainage upgrades |
| Patch Concrete | Topographic Surveys with some drainage infrastructure top of castings, no drainage upgrades |
| Full Reconstruction | Full Topographic Survey with drainage infrastructure, drainage upgrades to the 10% AEP event via Rational Method Analysis |

In instances where the scope of work for a given block is full reconstruction and the status of the roadway project is "Construction Complete", the study area's H&H SWMM model included the new drainage sections and profiles from the plans as part of the existing conditions model. In instances where the scope of work for a given block is full reconstruction and the status of the roadway project is "In Design", then the new H&H SWMM model included the new drainage sections and profiles from the plans as part of select project alternatives models.

Lastly, the DE Team considered the progress of roadway improvements being implemented through City of New Orleans Joint Infrastructure Recovery Request (JIRR) program, which seeks to restore damaged infrastructure from Hurricane Katrina and other significant storm events. As shown in Figure 13, the DE Team classified the current status of roadway improvements throughout the West End study area. Sections of roadway were classified based on if improvements were proposed, and if those improvements were implemented by the time of this study or are considered for future improvements. The DE Team considered proposed drainage solutions that would complement the ongoing effort of City of New Orleans to upgrade its roadway infrastructure.


*Figure 13 – JIRR Status of Roadway Improvements in West End (As of 2024)*

### 2.2.2 Field Site Visits and Roadway Assessment

The DE Team completed a field site survey to assess the condition of roadway blocks within the study area. This field assessment involved visual observation of roadway conditions based on the current surface quality, considered cracks, potholes, and other signs of wear to the existing pavement surface. The DE Team also visually observed and noted differential settlement due to potential subsurface conditions that might endanger the structural integrity of the roadway surface. Supplemental field site surveys were completed shortly after typical rainfall storm events, to further assess drainage efficiency to convey water into its subsurface drainage system. The DE Team collected field site survey notes and then determined an overall condition of the roadway block by block by grading a city block one of the following grades:

- 3 – Poor Condition: The roadway shows visible signs of wear or cracking throughout the entire roadway section. Sections of the road have been chipped off or are damaged and in need of repair. Around utility manholes, such as drainage catch basins and sewer manholes, the roadway has clearly settled several inches below the structure top castings and has begun to crack and cause drivers to have to navigate around the structure.

- 2 – Fair Condition: The roadway is beginning to show visible signs of wear or cracking. Differential settlement along the road is beginning to be shown but has not caused significant damage to the roadway pavement surface.
- 1 – Good Condition: The roadway shows no visible signs of wear or cracking. It is visually apparent that the roadway was replaced within the last 1-5 years.

The DE Team visually inspected several manhole structures and found the drainage system throughout the West End area to be generally clean and operable. The DE Team used field site survey observations and data provided by SWBNO to understand where potential project solutions could be implemented and where future roadway improvements are proposed to be completed. A list of the overall condition of the roadway block by block is shown on Table AE1 provided in Appendix E.

### 2.2.3 Regional City of New Orleans H&H Models

The DE team received two citywide (2) H&H models developed for SWBNO, which are commonly referred to as the comprehensive citywide models in this report. The models were developed with Environmental Protection Agency (EPA) SWMM software. Some of the existing drainage structures represented in the citywide models are:

- Levees (Protection from Storm Surge & High River Level Conditions)
- Subsurface Drainage Pipe & Catch Basins (Move water below surface & push downstream)
- Drainage Canals (Move & Store Water from Communities)
- Regional & Local Drainage Pump Stations (Move large volumes of water away from residential communities and over the levee system to empty drainage canals.)

The DE Team was provided with two (2) reports developed by Ardurra on the citywide modeling effort: (1) a 2019 report analyzing the July 10, 2019 rainfall event and (2) 2022 Stormwater Master Plan report on the development of the citywide models and calibration/validation to several recorded historical rainfall events. The 2019 report is an evaluation of the citywide models simulating historical rainfall and flooding that occurred to the city of New Orleans caused by the July 10-11, 2019 rainfall event. According to the report, intense rainfall from this event "caused significant flooding and some areas remained flooded for a period of several hours."

Due to the size and complexity of the entire Orleans Parish drainage system, SWBNO elected to separate drainage basins into separate models with the goal to reduce model instability and improve on reliability observed during model simulations. The West End study area is located and detailed within the two (2) H&H models, which are as follows:

- Citywide Model (DPS 1-6)
- Citywide Model (DPS 7-12)

The DPS 1-6 Citywide Model provides a detailed model representation of the drainage system for all areas that drain by gravity to Drainage Pump Stations Nos. 1 & 6 and are pumped beyond the levee protection system for Orleans Parish. Only the southern portion of the West End study area is detailed in the DPS 1-6 Citywide Model. An overview of the DPS 1-6 Citywide Model is shown on **Figure 14.** Some of the communities that are detailed in this model and drained to DPS 1 & 6 are:

- Old Metairie and Old Jefferson (Jefferson Parish)
- West End (Southern portion only), Hollygrove, Carrollton, Broadmoor, Central City, Uptown (Orleans Parish)

The DPS 7-12 Citywide Model provides a detailed model representation of the drainage system for all areas that drain by gravity to Drainage Pump Stations Nos. 7 & 12 and are pumped beyond the levee protection system for Orleans Parish. An overview of the DPS 7-12 Citywide Model is shown on **Figure 15**. Some of the communities that are detailed in this model and drained by DPS 7 & 12 are West End (northern portion only), Lakeview and Mid-City. The two citywide models were created with the North American Vertical Datum of 1988 (NAVD 88) and are projected to the Louisiana State Plane (NAD 1983, Louisiana South FIPS 1702).

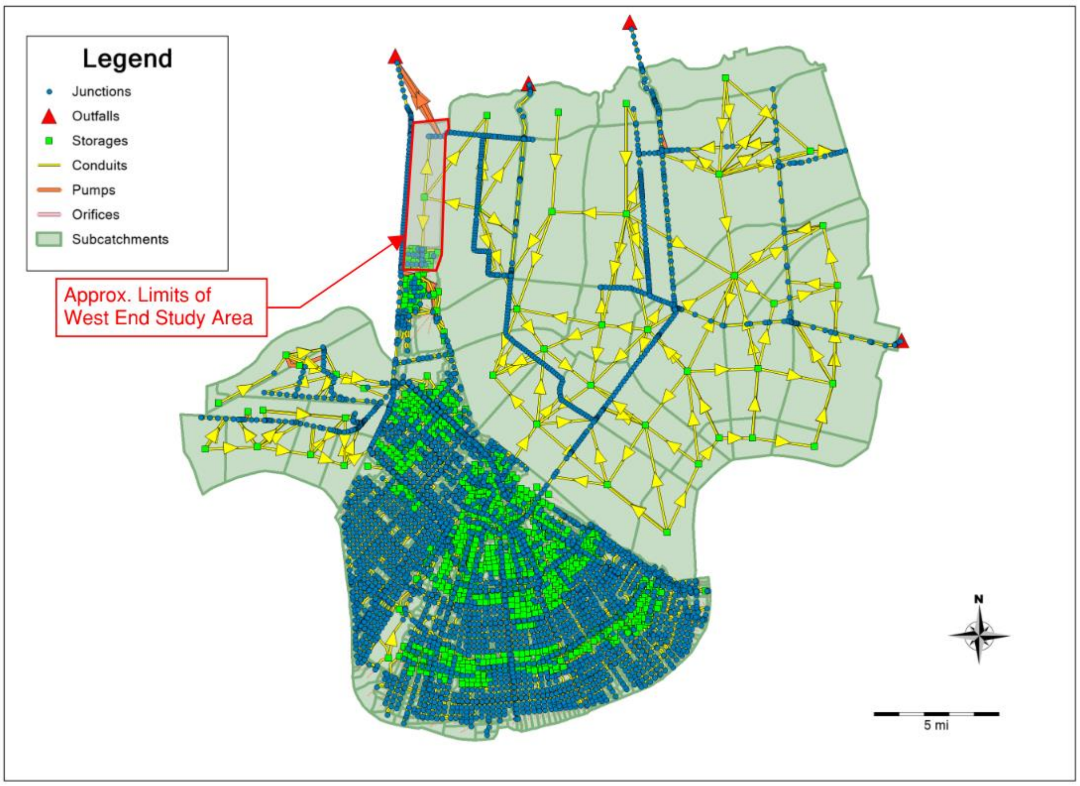



*Figure 14 - Citywide Models (DPS 1-6 Overview Snapshot)*

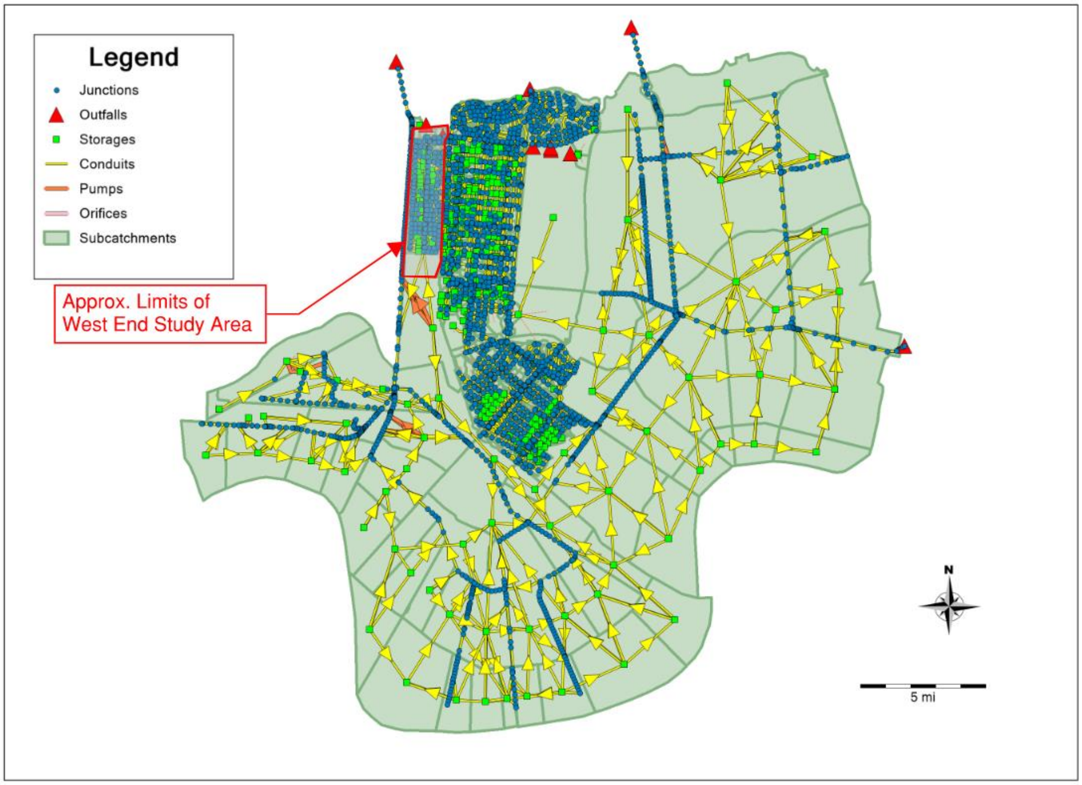



*Figure 15 - Citywide Models (DPS 7-12 Overview Snapshot)*

### 2.2.3 Data Gap Analysis

The DE Team completed a comprehensive review of all engineering and construction plans received by DPW and SWBNO through the data collection. The project team reviewed plans for availability of data that can be used in assisting in the development of the H&H model of the study area. As shown in Figure 16, street blocks were classified by the following:

- Street Topographic Survey Needed (Red)
- Structures Not Surveyed (Orange)
- Survey Available (Green)
- Not Yet Reviewed (Yellow)


*Figure 16 – Data Gap Analysis Results*

The data gap analysis was reviewed by the DE team and utilized to develop and implement a topographic survey of the areas where data is lacking and/or not available.

### 2.2.4 Topographic Survey

Utilizing information collected during the Data Gap Analysis, the DE Team collected survey data necessary to fill in gaps of missing infrastructure data to complete model set up and H&H model analyses. A map showing the approximate scope of survey completed is provided in **Figure 17**. The following topographic survey was collected by the DE Team:

- Approximate location of where drainage structures were surveyed to complete quality control of existing project as-built data and fill in missing survey data to develop a calibrated H&H model of the drainage system.
- Topographic Survey of the drainage ditch and asphalt roadway along Kenilworth St. between Fleur De Lis Dr. and W. Brooks St.

- Topographic Survey of Fleur De Lis Park, which was used to assist in the development of a calibrated H&H model of the drainage system and to assist in the development of project concepts in that vicinity.


*Figure 17 – Survey Scope of Work*

### 2.2.5 Green Stormwater Infrastructure (GSI) Suitability Index

The DE Team collaborated with ORS and other consulting modeling firms in the development of a GSI Suitability Index to better understand the best location for potential green stormwater infrastructure solutions across the entire city. This is part of a larger effort by ORS to develop a spatial scoring tool that will use multiple weighted criteria to rank and score potential sites based on how closely they match the selected criteria. The DE Team engaged and collaborated with ORS and other modeling consultants that were developing similar H&H model studies of adjacent drainage basins to share valuable insights on how to assist ORS in the development of the GSI Suitability Index. At the time of preparing this West End H&H Study Report, the GSI Suitability Index was not finalized.

digital engineering

SECTION 3

# EXISTING SYSTEMS EVALUATION

CITY OF NEW ORLEANS: WEST END H&H DRAINAGE STUDY

# 3. Existing System Evaluation

## 3.1 Existing Drainage Characteristics

The study area consists primarily of single-family homes and a concentration of multi-family homes, condominiums, and apartment complexes found in the northern section of the study area, just north of New Orleans-Hammond Hwy. The study area is primarily linear in shape aligned north-south, which is divided in the center by a 2-way median-separated boulevard called Fleur De Lis Dr. There is an approximately 6.5-acre park space along Fleur De Lis Dr. between 38th St. and 40th St. called Fleur De Lis Park. In the approximate center of the study area is West Harrison Ave., a two-way single roadway, which fronts multiple commercial properties. Further south and in the southern section of the study area is Veterans Blvd., which is a major thoroughfare for the Greater New Orleans metro. A map of the study area is shown in **Figure 1**.

Within the median of Fleur De Lis Dr. is a drainage box culvert which drains the study area and is shown in **Figure 19**. Local streets within the study area drain into the drainage system toward the Fleur De Lis Dr. Drainage Box Culvert. The study area is drained primarily by two (2) manned drainage pump stations (DPS 6 & 7) outside of the study area and by an unmanned Drainage Pump Station (DPS 12) located within the study area: See **Figure 18.**

A majority of SWBNO Drainage Pump Stations are actively managed by personnel stationed at the Drainage Pump Station. SWBNO supplies power from Central Plant (SWBNO power complex at the Carrolton Water Treatment Plant) to the drainage pump stations across the city. This effort requires coordination of multiple pump stations before power can be transferred to a drainage pump station. DPS 12 is unmanned and is monitored remotely. According to SWBNO operation procedures specific to DPS 12, when water at the Drainage Box Culvert and the pump suction basin reaches a certain elevation, SWBNO staff mobilize to DPS 12 and manually operate the pump station as needed. DPS 12's 1,000 cfs pump is typically primed at 10.5' depth and takes approximately 10 minutes to load. Prime is broken at 8.5' depth. Because DPS 6, 7, & 12 drainage basins are interconnected, the maximum water surface elevations observed in the West End study area is impacted by the larger drainage basins. The DE Team used the following elevation data in development of the study area model:

- Top of Suction Basin: -0.43'
- Designed Flood Line Elevation: -9.43'
- Suction Basin Top of Bell: -13.43'
- Bottom of Suction Basin: -18.43'

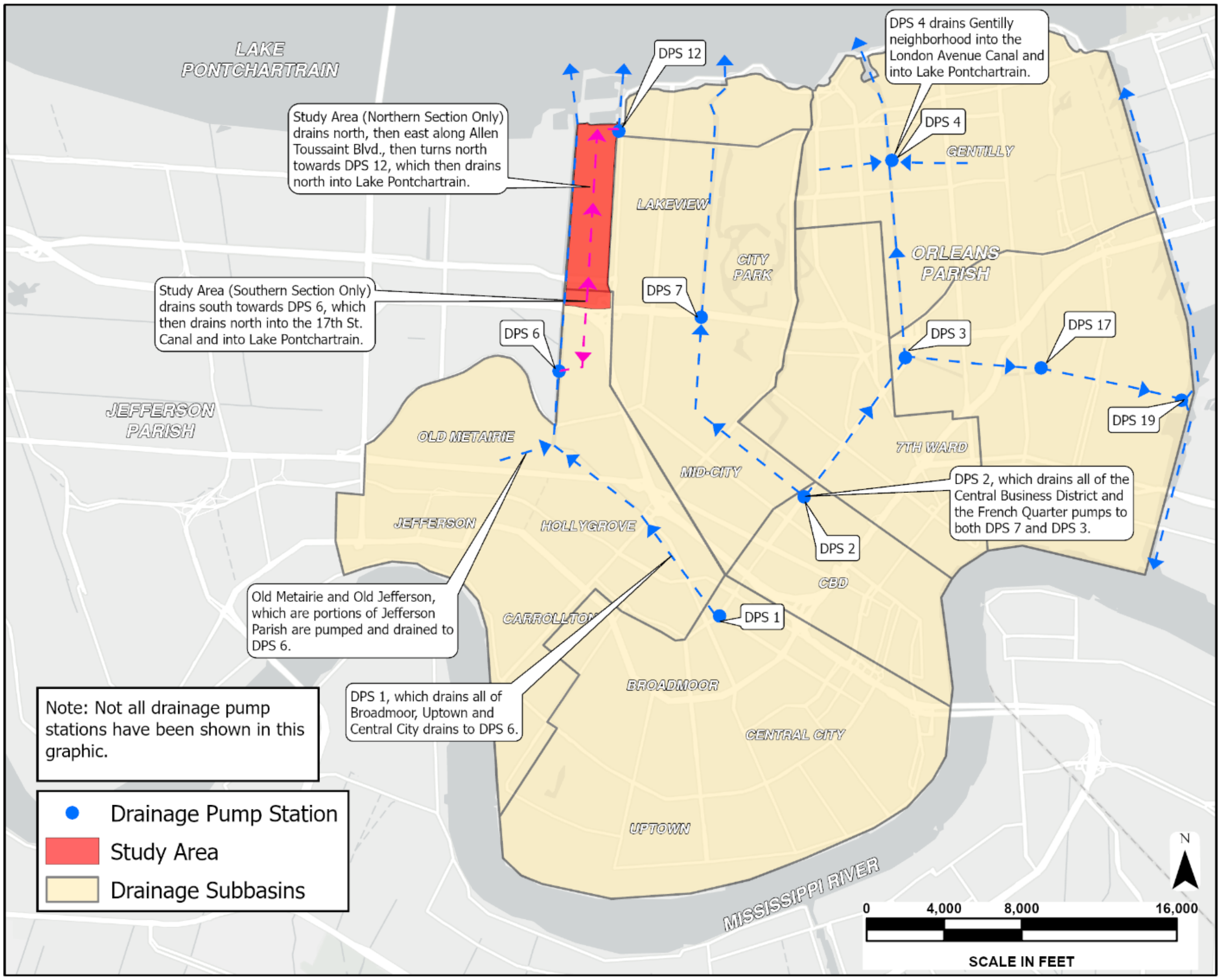



*Figure 18 – Drainage Pump Station Basins*

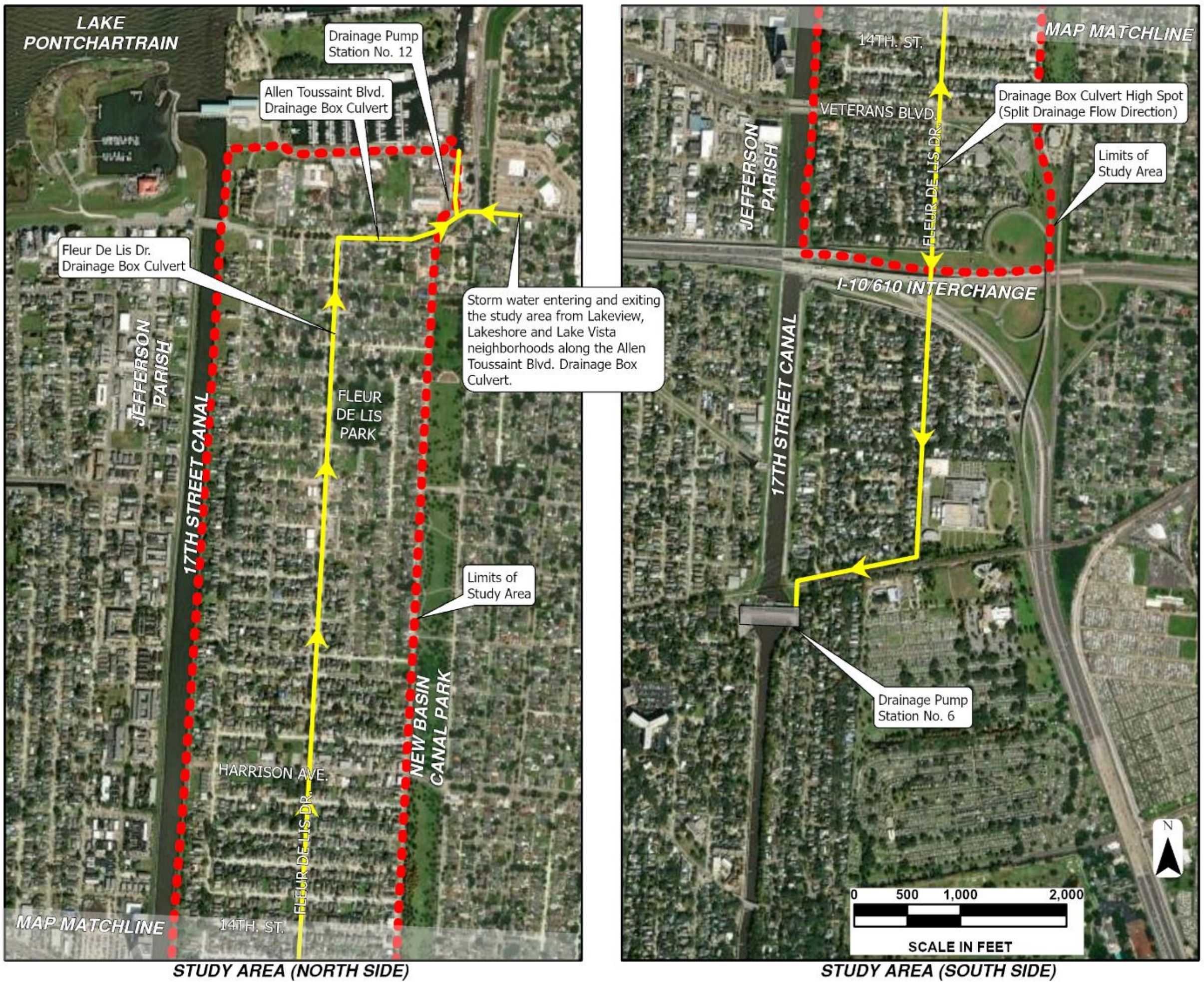



*Figure 19 – Study Area Drainage Characteristics*

The surface runoff path for drainage in the study area is relatively contained due to surrounding higher features: 17th St. Canal Levee (west), Lake Pontchartrain Levee Wall (north), New Basin Canal Park (right), I-10/I-610 interchange (south). For the existing subsurface drainage system, the DE Team determined that several outfall boundary conditions will be necessary for the subsurface drainage system.

A FEMA Floodplain Map is shown on **Figure 20**. This map shows that approximately 25.72% (117.16 acres) of the study area is within the AE Flood Zone, which has the potential of being flooded by a 1% Annual Chance Flood Event, which is commonly referred to as a 100-year flood event.


*Figure 20 – Study Area – FEMA Floodplain Map*

## 3.2 Evaluation of Regional H&H Models

### 3.2.1 Overview and Description

The citywide regional models developed for SWBNO was a region-wide model approach that consisted of 24 existing drainage pump stations that have a combined capacity of 50,000 cubic feet per second (cfs). The DE Team used results developed in the citywide regional models to develop the study area's SWMM model. Data and results were also used by the DE Team to calibrate and validate the results observed in the study area model.

### 3.2.2 Model Characteristics (Hydrology & Hydraulics)

For the two (2) Citywide Models (DPS 1/6 and DPS 7/12), the infiltration parameters were defined using the Horton soil infiltration method. The soils characteristics for the West End study area are shown on Figure 21, which was collected from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The following soil types and percentage of study area were discovered in the West End study area:

- AE (13.1%): Allemands Muck (0 to 0.2 percent slopes, Drained)
- An (2.40%): Aquents (Dredged)
- AT (0.90%): Aquents (Dredged, Frequently Flooded)
- Ha (34.2%): Harahan Clay (0 to 1 percent slopes)
- Ke (49.0%): Kenner Muck (Drained)
- W (0.30%): Water

Table 4 presents the soil parameters assigned to each subcatchment, based on the dominant hydrological soil group (HSG) identified in each area.


*Figure 21 – West End Study Area NRCS Soil Types Map*

*Table 4 – Global Soil Parameters in Citywide Models*

| Soil HSG | Max. Infiltration Rate (in/hr) | Min. Infiltration Rate (in/hr) | Decay Rate (1/sec x $10^{-4}$) | Dry Time (Days) | Soil Storage (in) |
|---|---|---|---|---|---|
| A | 12.0 | 1.00 | 5.56 | 1.0 | 5.4 |
| B | 9.0 | 0.50 | 5.56 | 1.0 | 4.0 |
| C | 6.0 | 0.25 | 5.56 | 1.0 | 3.0 |
| D | 4.0 | 0.10 | 5.56 | 1.0 | 1.3 |

Additional parameters were selected according to data received within the Citywide models. The subcatchment parameters are as follows and are shown in Table 5:

- Imperviousness (Imperviousness is defining the separation of pervious and impervious areas in a subcatchment.)
- Overland Roughness (Overland Roughness, defined by using Manning's Roughness coefficients, indicates the resistance of the land surface to the movement of water.)
- Depression Storage (Also called the initial abstraction, depression storage only affected the runoff from rainfall and is the initial amount of water that enters and remains on the ground until it evaporates.)

*Table 5 – Hydrology Parameters in Citywide Models*

| Parameter | Model Values |
| --- | --- |
| Impervious (%) | 33% (Initial) |
| Manning's Roughness<br>(Overland Roughness) | N (Impervious) – 0.013<br>N (Pervious) – 0.2 |
| Initial Abstraction<br>(Depression Storage) | Dstore Impervious (in) – 0.05<br>Dstore Pervious (in) – 0.1 |

A map showing the subcatchment areas from the two (2) citywide models overlaying the West End study area is shown on Figure 22. The DE Team re-delineated the subcatchments for the West End study area north of Veterans Blvd using the current LiDAR data. The subcatchments south of Veterans Blvd were re-used from the DPS 1-6 citywide model A map showing the subcatchments used in developing the West End study area model is shown as Figure 24. The DE team used Geographic Information Systems (GIS) tools available to incorporate hydrologic model subcatchment parameters from the DPS 1-6 and DPS 7-12 citywide modes into the West End study area model:

- Direct spatial distribution of DPS 1-6 model subcatchment data to model subcatchments transferred into the West End study area model.
- Spatially weighted distribution of DPS 7-12 model subcatchment data to model subcatchments delineated and generated by the DE Team in the West End study area model.

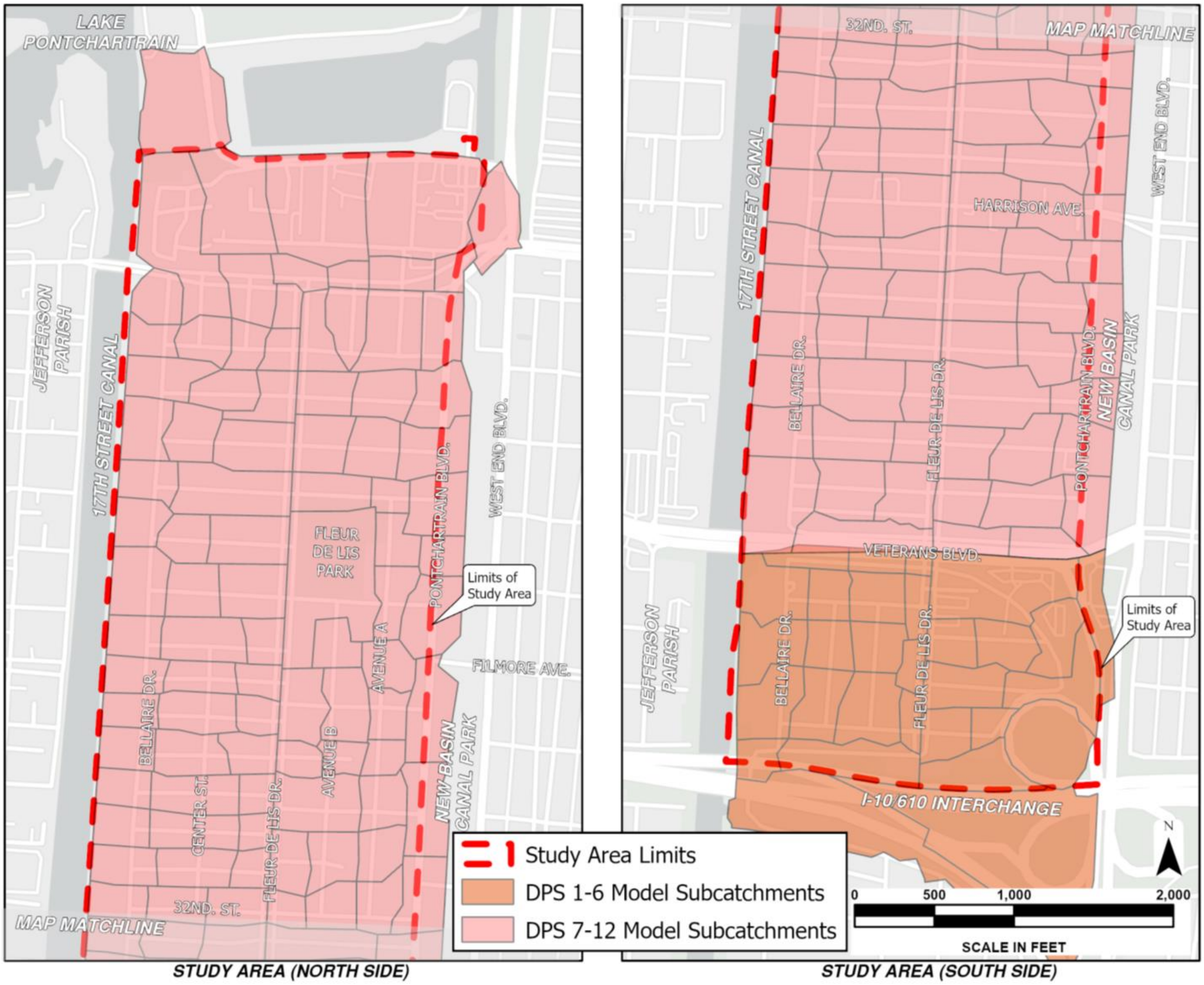



*Figure 22 - Citywide Models (Subcatchments Overlaying Study Area)*

The citywide models used storage curves and overflow links to simulate street flooding during rainfall events. Nodes where this flooding occurs, these nodes are replaced with storage area, where excess rainfall is stored at a volume defined by the storage curves. Water impounded in these storage areas is then routed using links representing overland flow and generally represents a typical street cross-section. A snapshot of the DPS 7-12 citywide model showing the utilization of both the Storage Node and overflow links is shown in Figure 23. Both conceptual approaches of adding storage nodes and overflow links are considered acceptable approaches by the engineering community to develop 1D models that simplify otherwise complex 2D modeling practices. However, double-counting of storage between the storage areas and the overland flow links must be accounted for.

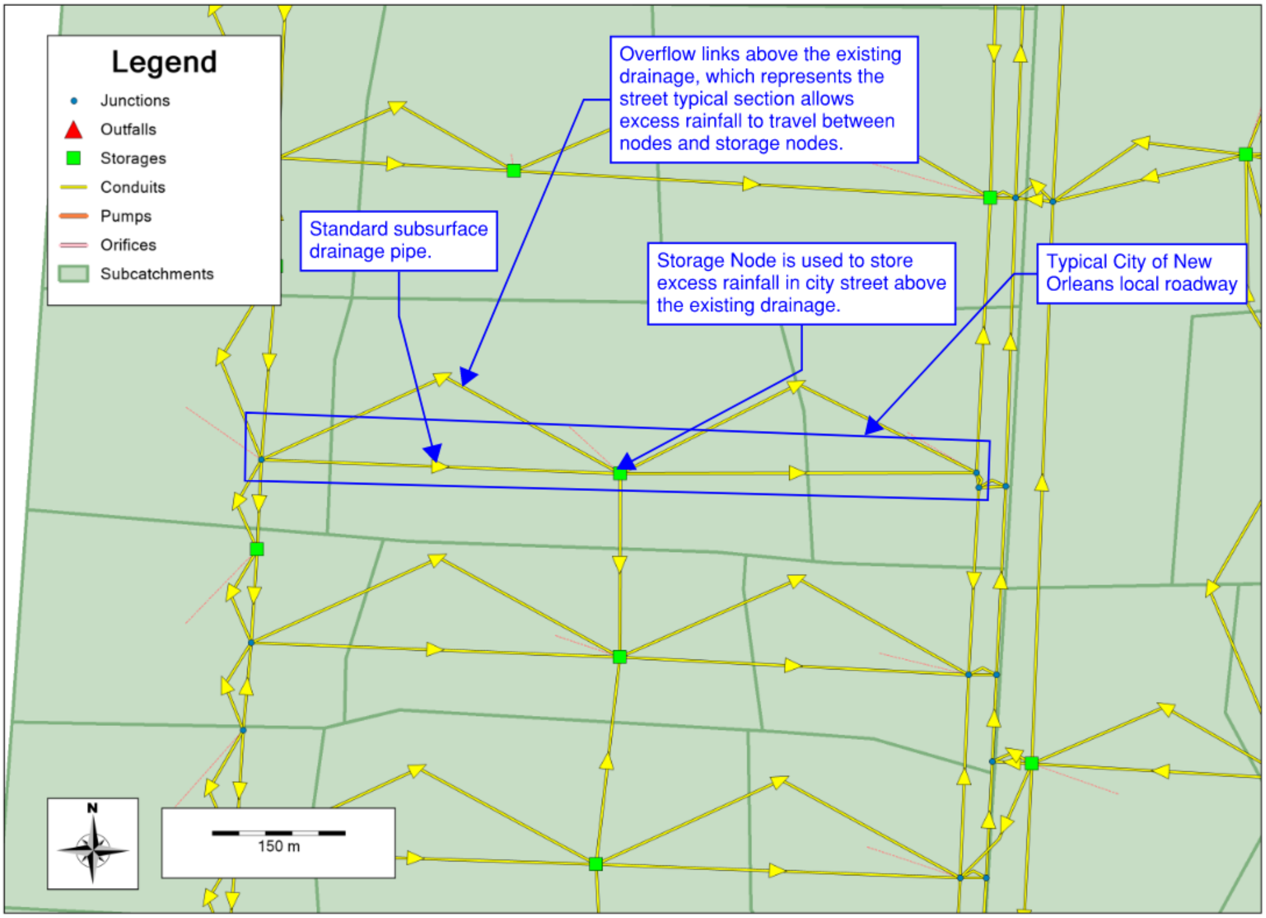



*Figure 23 – Citywide Models (Snapshot of 1D Subsurface Modeling Practices)*

### 3.2.3 Model Performance

The DE Team analyzed the two (2) citywide models for the 1-, 10-, 25-year design storms. Model simulation results for the three (3) design storms were successful in operation. Figure AE1 in Appendix E shows continuity error results from the model simulation of the two (2) citywide models, which were reported as insignificant.

To compare model results from the DPS 1-6 and DPS 7-12 models, the DE Team ran a 10-Year design storm event and compared pump run times and total volume pumped (million gallons) out at several different drainage pump stations. Results from this analysis are shown in Table 6. Excluding DPS 7, all other drainage pump stations pumped similar volumes of excess rainfall volume for each site. In the DPS 1-6 model, DPS 7 pumped only 926 million gallons (MG) of water. However, DPS 7 in the DPS 7-12 model pumped 610 MG (316 MG difference). Upon further analysis, the DE Team determined that peak flows at DPS 7 are similar and therefore acceptable for the purpose of this study of West End.

*Table 6 – Citywide Model Results*

| Drainage Pump Station | DPS 1-6 Citywide Model | | DPS 7-12 Citywide Model | |
|---|---|---|---|---|
| | Pump Run Times (hrs) | Total Volume Pumped (MG) | Pump Run Times (hrs) | Total Volume Pumped (MG) |
| DPS 1 | 22.75 | 1030 | 27.75 | 1100 |
| DPS 2a | 2.25 | 216 | 45.5 | 251 |
| DPS2b | 2.55 | 84.7 | 0.5 | 73.3 |
| DPS 3 | 22.2 | 720 | 28.5 | 609 |
| DPS 6 | 39.3 | 1940 | 24.5 | 1920 |
| DPS 7 | 16.1 | 926 | 24.5 | 610 |
| DPS 12 | 20.3 | 319.6 | 22.2 | 318 |
| TOTAL | 5236.3 | - | 4881.3 | - |

## 3.3 West End Model Development

### 3.3.1 Model Setup

The DE Team used several data sources discussed in the Data Collection, Data Gap Analysis and Infrastructure Survey tasks to develop a model representing the existing drainage system in the West End study area. The following components were reviewed by the DE Team to develop the West End study area model:

- Hydrology Characteristics (Subcatchments)
- Hydraulic Characteristics (Model Geometry)
- Two-Dimensional (2D) Overland Flow Characteristics
- Model Boundary Characteristics
- Drainage Pump Station (DPS) 12 Characteristics (Pump Parameters)

### 3.3.2 Hydrology Characteristics (Subcatchments)

The DE Team utilized the citywide regional models subcatchment database and existing utility unit sheets of the existing drainage system to develop subcatchments areas for the West End study area. A figure of the existing drainage system's subcatchment areas is shown on **Figure 24**.

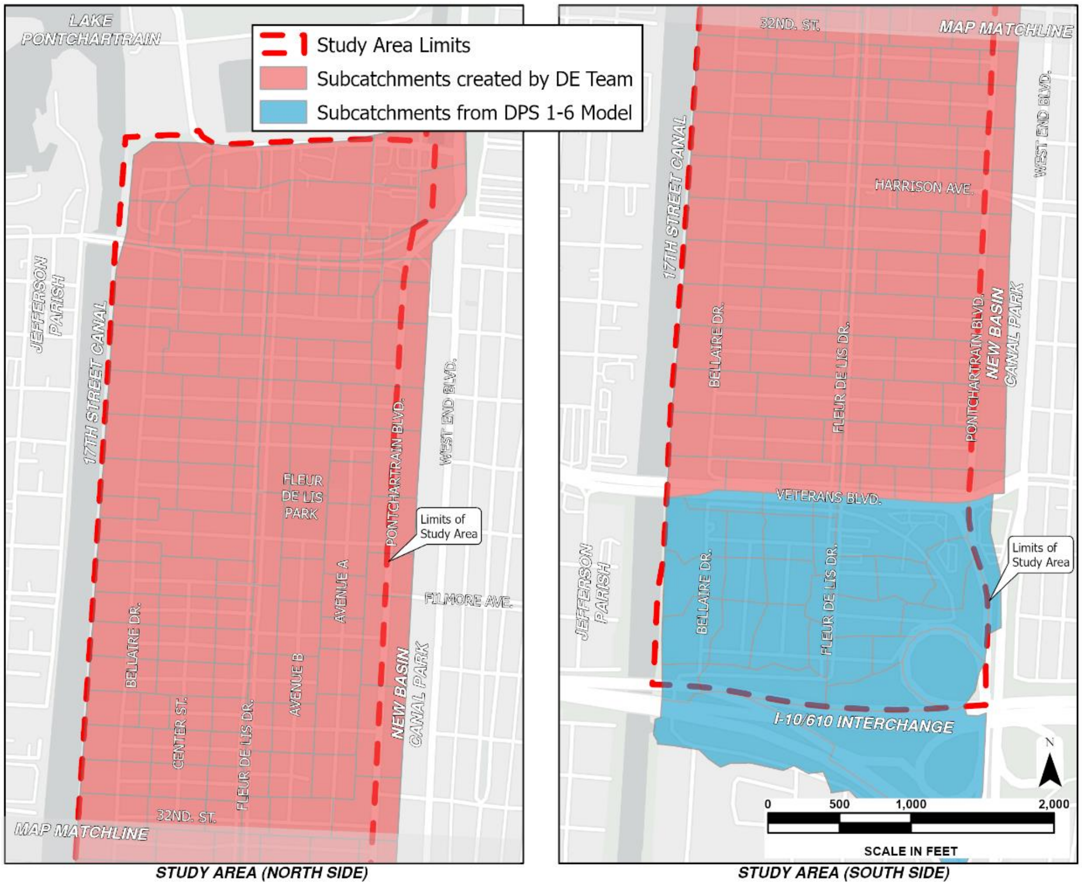



*Figure 24 – West End Study Area Model (Subcatchments)*

### 3.3.3 Hydraulic Characteristics (Model Geometry)

A schematic of the critical model elements of the West End study area is shown in Figure 25. All existing drainage system data represented in SWMM model was reviewed and adjusted if needed.

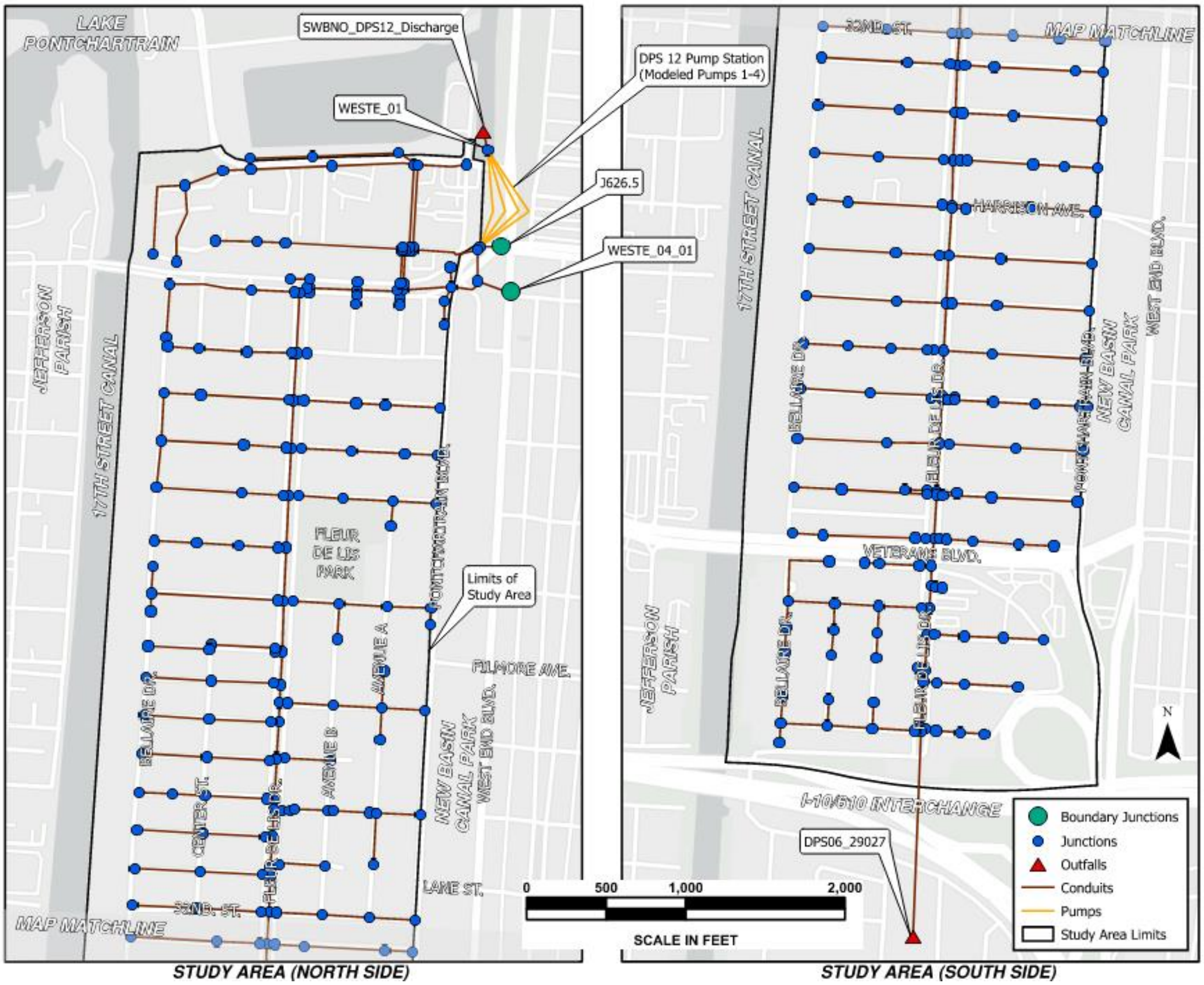



*Figure 25 – West End Study Area Model (Model Elements & Boundary Condition Elements)*

Figure 26 shows the typical sections of the major subsurface drainage box culvert through the system: (1) Allen Toussaint Blvd. Drainage Box Culvert and (2) Fleur De Lis Dr. Drainage Box Culvert.

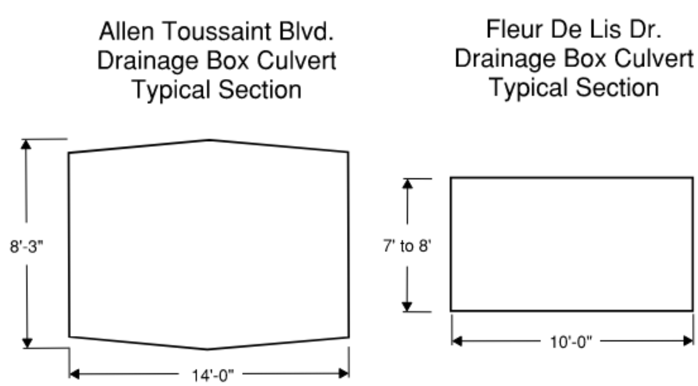



*Figure 26 – West End Study Area Model (Fleur De Lis Drainage Box Culvert Cross Section)*

Figure 27 profiles the major subsurface drainage box culvert from the most southern portion of the West End study area along Fleur De Lis Dr. and Hammond Hwy.

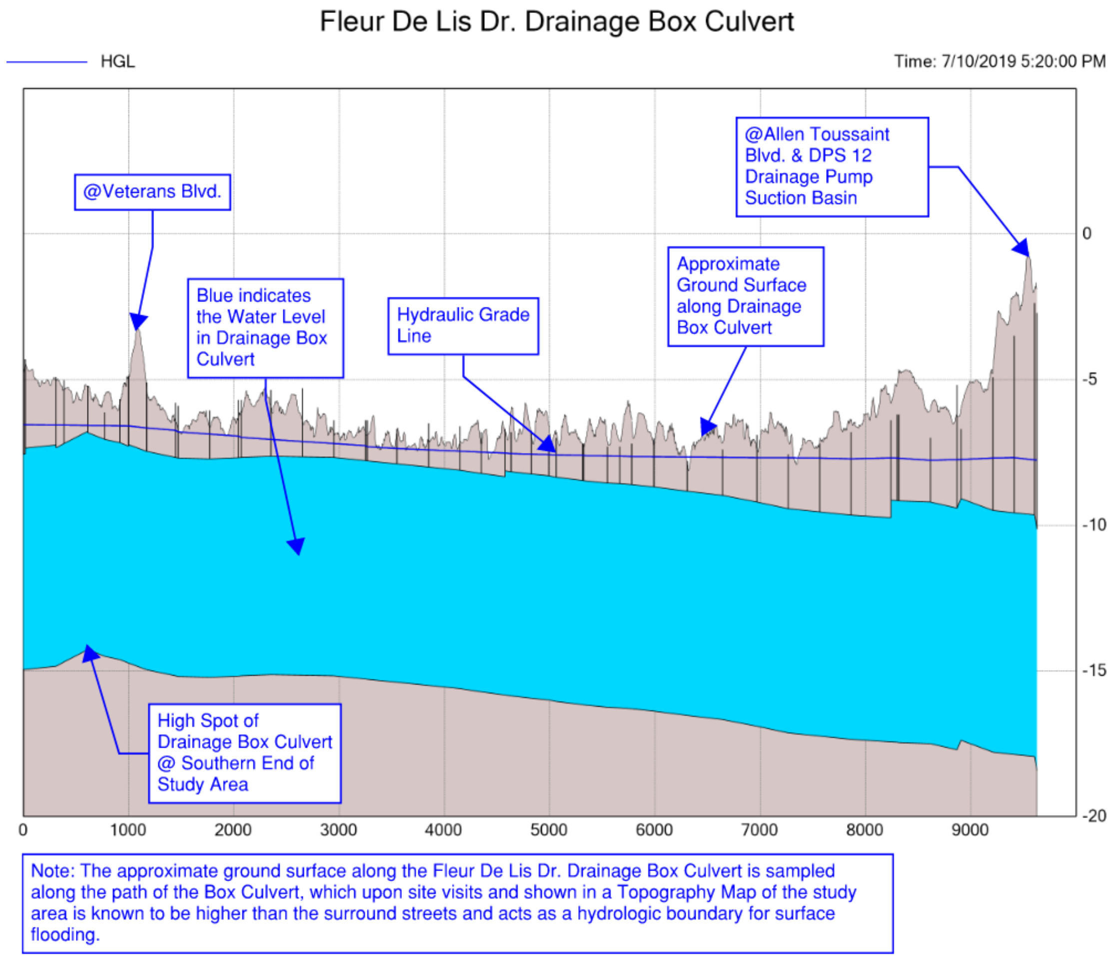



*Figure 27 – West End Study Area Model (Fleur De Lis Drainage Box Culvert Profile)*

### 3.3.4 Two-Dimensional (2D) Overland Flow Characteristics

The DE Team developed a 2D mesh using the Digital Elevation Model (DEM) for the study area. As indicated in Figure 28, several characteristics within the study area are observed:

- The median where Fleur De Lis Dr. Drainage Box Culvert is higher ground elevation than the surrounding streets. (Approximately 2.16' higher in some cases according to ground surface LiDAR data.) The median above the drainage box acts as a barrier that divides the neighborhood hydrologically.
- Fleur De Lis Park is lower ground elevation compared to the surrounding streets and areas. (Approximately 3.27' lower in some cases according to ground surface LiDAR data.)
- Vacant empty land parcels along W. Harrison Ave. between Bellaire Dr. and Fleur De Lis Dr. is lower ground elevation compared to the surrounding streets and areas. (Approximately 3.02' lower in some cases according to ground surface LiDAR data.)

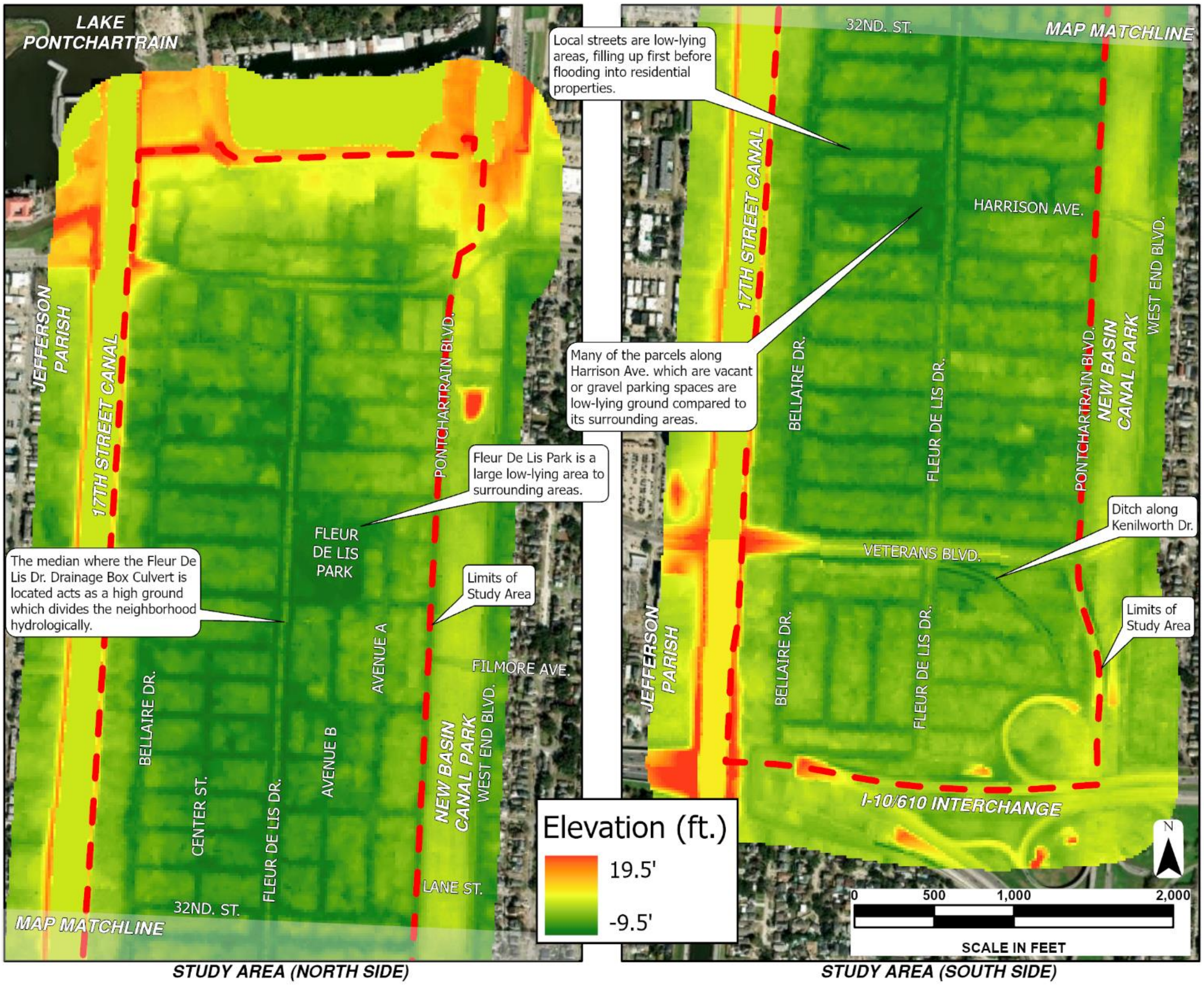



*Figure 28 – West End Study Area Topography Map*

To improve modeling stability and performance, the DE Team chose to simplify the model by not creating a 1D component of the Kenilworth ditch between Fleur De Lis Dr. and Pontchartrain Blvd. The Digital Elevation Model provides details of the ditch, which is transported into the West End model. No modeling loss was observed during model analyses from this modeling assumption.

To represent existing building slabs, the DE Team created obstructions within the model to inhibit water storage and conveyance. This allows the model to simulate realistic flooding events. The snapshot in **Figure 29** shows the developed 2D mesh with hexagonal/rectangularly shaped boundaries where surface flooding can be stored. In the snapshot, a randomly sampled rainfall event was simulated, and blue hexagons are shown which represent the depth of the water surface sampled at that location. Darker hexagons represent a deeper maximum flood depth at that location sampled by the hexagonal shape. The snapshot also shows excess rainfall not collecting above the drainage box. Excess rainfall is shown to collect along the adjacent streets on either side of the Fleur De Lis Dr. drainage box.

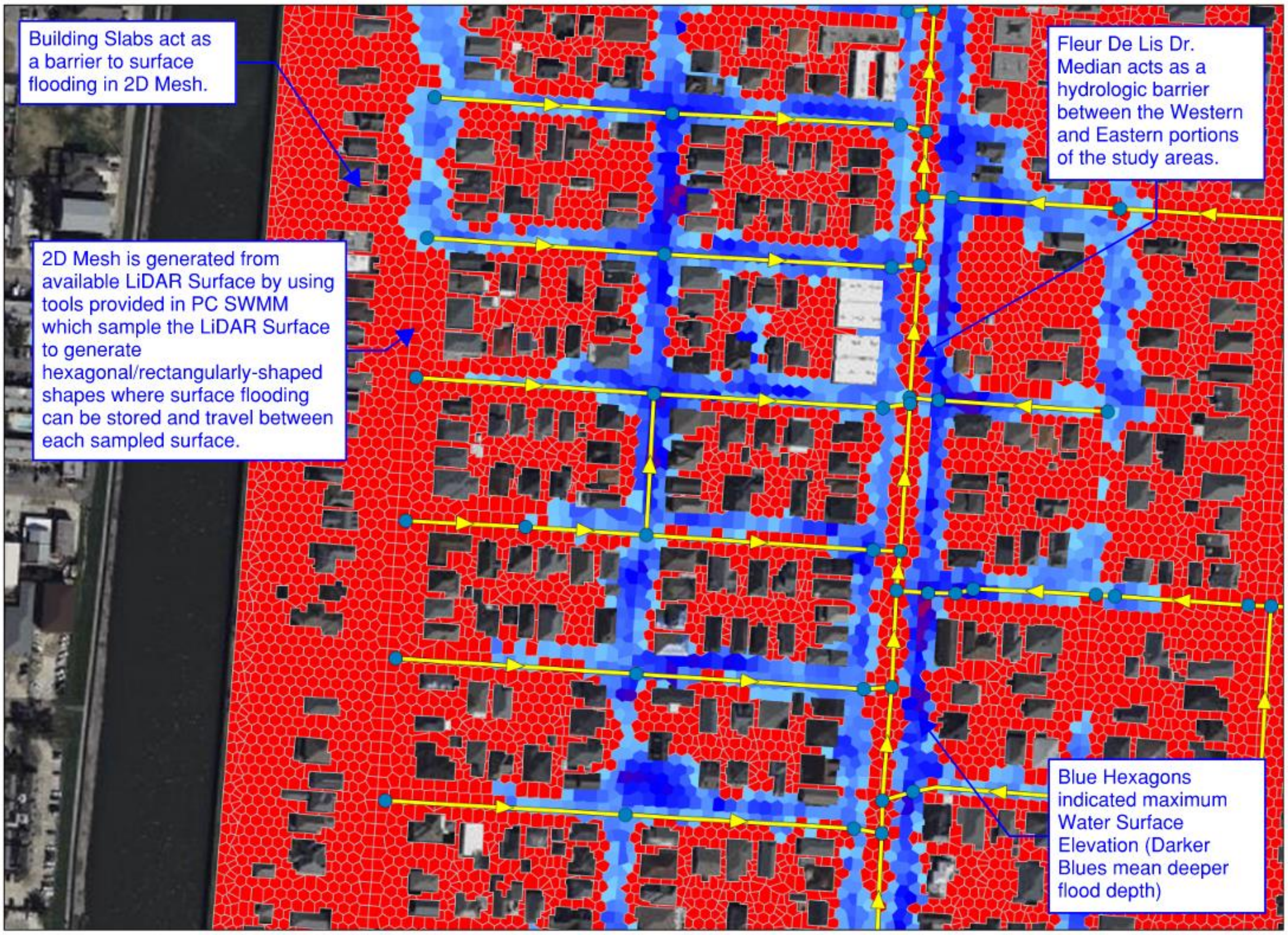



*Figure 29 – West End Study Area Model (Typical Snapshot of 2D Mesh Setup)*

### 3.3.5 Model Boundary Characteristics

The study area for this H&H Model Analysis of West End includes four (4) outfall boundary conditions, as shown on Figure 25. Two of the nodes are main outfalls for the study area and are represented as outfall nodes in the model. The other two remaining nodes are represented as junctions in the model and have inflow hydrographs attributed to them over a period during each rainfall event. The outfall boundary conditions are described as follows:

- SWBNO_DPS12_Discharge (Outfall No. 1): The outfall for all excess rainfall pumped through DPS 12 Drainage Pump Station and directly into Lake Pontchartrain. The outfall is set at a fixed elevation of 1' NAVD to simulate average Lake Pontchartrain elevations.
- DPS06_29027 (Outfall No. 2): The outfall that represents the southern connection to the remaining DPS 1-6 model basin. The outfall is set with a stage hydrograph,

to simulate the head condition that might be observed at that location during studied rainfall events.

- J626.5 (Boundary Junction No. 1): The outfall boundary for all drainage passing through this point along the Allen Toussaint Blvd. Drainage Box Culvert. The outfall is set with an inflow hydrograph over a period, to simulate the conveyance of water that might be overserved at that location during studied rainfall events.
- WESTE_04_01 (Boundary Junction No. 2): The outfall boundary for all drainage passing through this point that connects a small drain line along West End Blvd. to the West End study area. The outfall is set with an inflow Hydrograph.

Outfall No. 2 is modeled as a stage hydrograph that represents the elevation of the water surface over a period at that location. The DE Team considered the reliance of model conditions based on drainage capacity at DPS 6, which was excluded from this study. A snapshot of the DPS 1-6 citywide model set up to develop this stage hydrograph is shown on Figure 30. The DE Team completed model simulation for the West End study area using both conditions, the results from this study are shown in Figure 31. The DE Team chose to go with a stage hydrograph at Outfall No. 2 due to the stability in model water surface elevations. The Stage Hydrograph used at Outfall No. 2 for the model calibration event is shown on Figure 31.

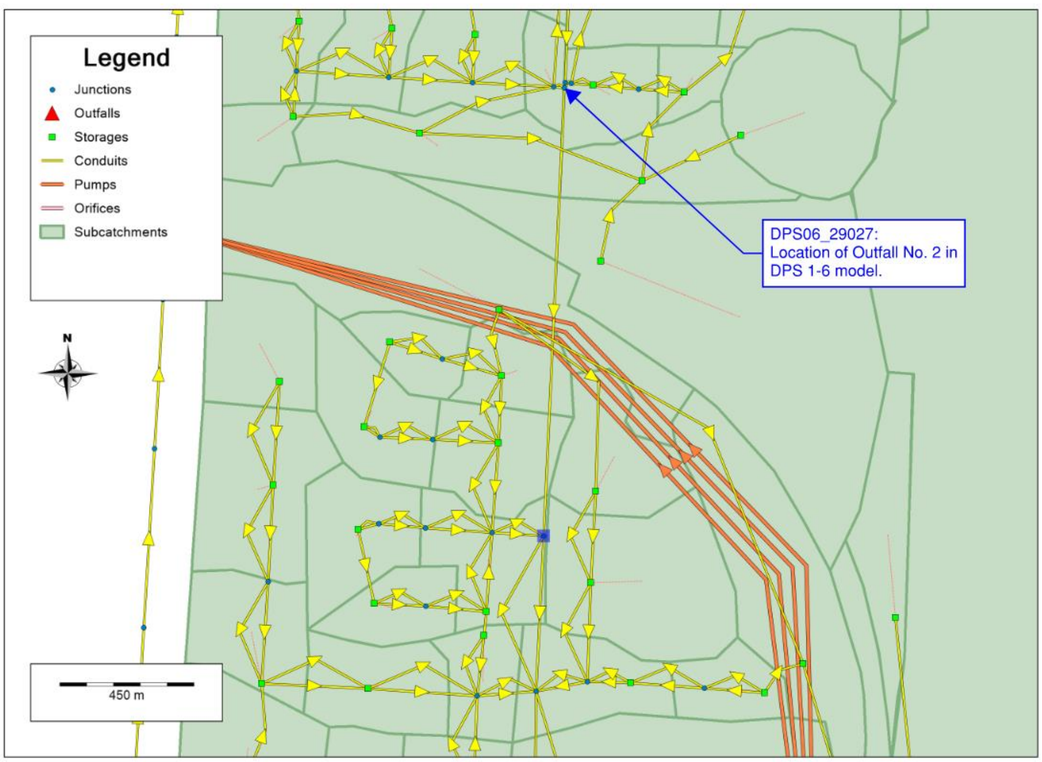



*Figure 30 – DPS 1-6 Citywide Model – Snapshot of Outfall No. 2 Boundary Setup*

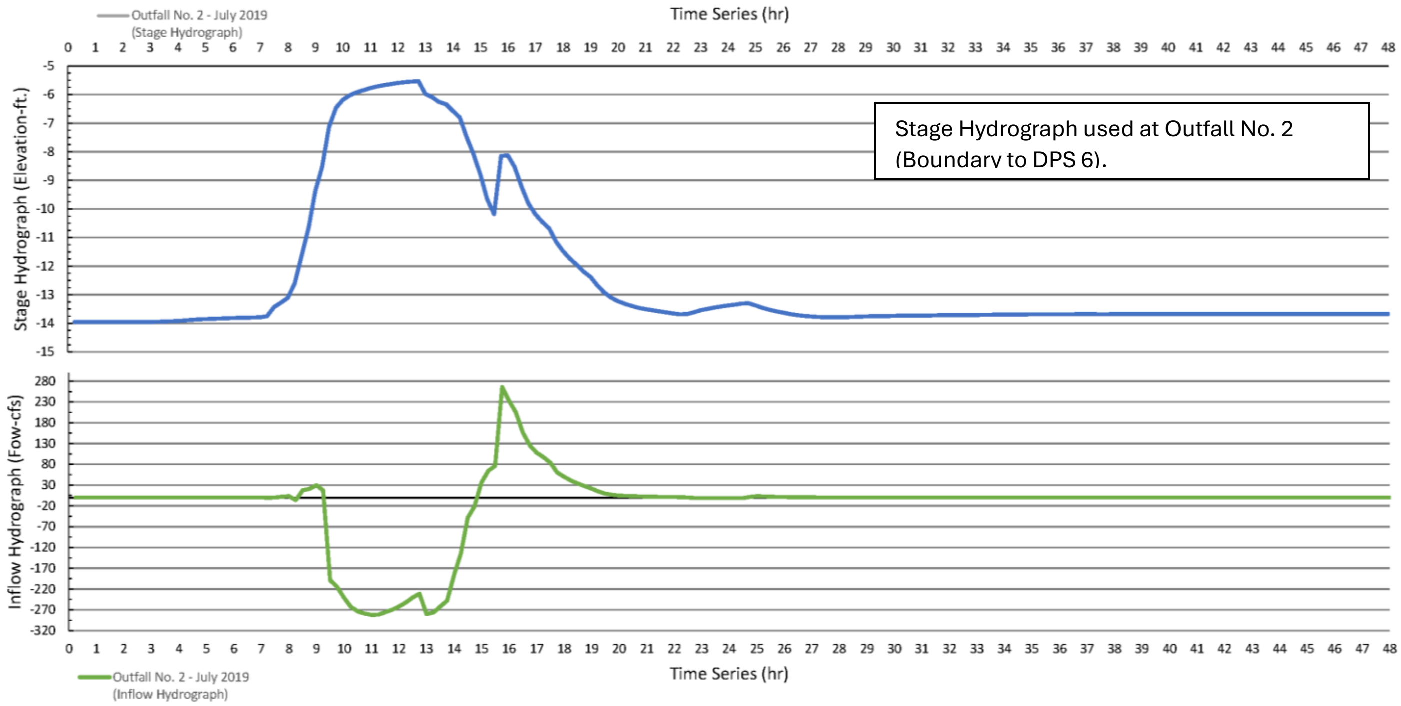



*Figure 31 – Outfall No. 2 Boundary Type Comparison*

Boundary Junctions No. 1 & 2 are modeled as inflow hydrographs that represent the flow that passes through those two locations. This is to model the inflow influence impact to the West End study area model, which can be pulled from the larger DPS 7-12 model results. A snapshot of the DPS 7-12 citywide model set up to develop these two (2) inflows hydrographs is shown on Figure 32. Due to the proximity of Boundary Junction No. 1 to the DPS 12 drainage pump station, the DE Team used an inflow hydrograph instead of a stage hydrograph. The flow movement at this location in the Allen Toussaint Blvd. Drainage Box Culvert is modeled more accurately when using an inflow hydrograph and has a major impact in the drainage patterns for the study area. Boundary Junction No. 2 has a small influence into the West End study area and transfers excess rainfall into the model, therefore an inflow hydrograph at this point in the study was used.

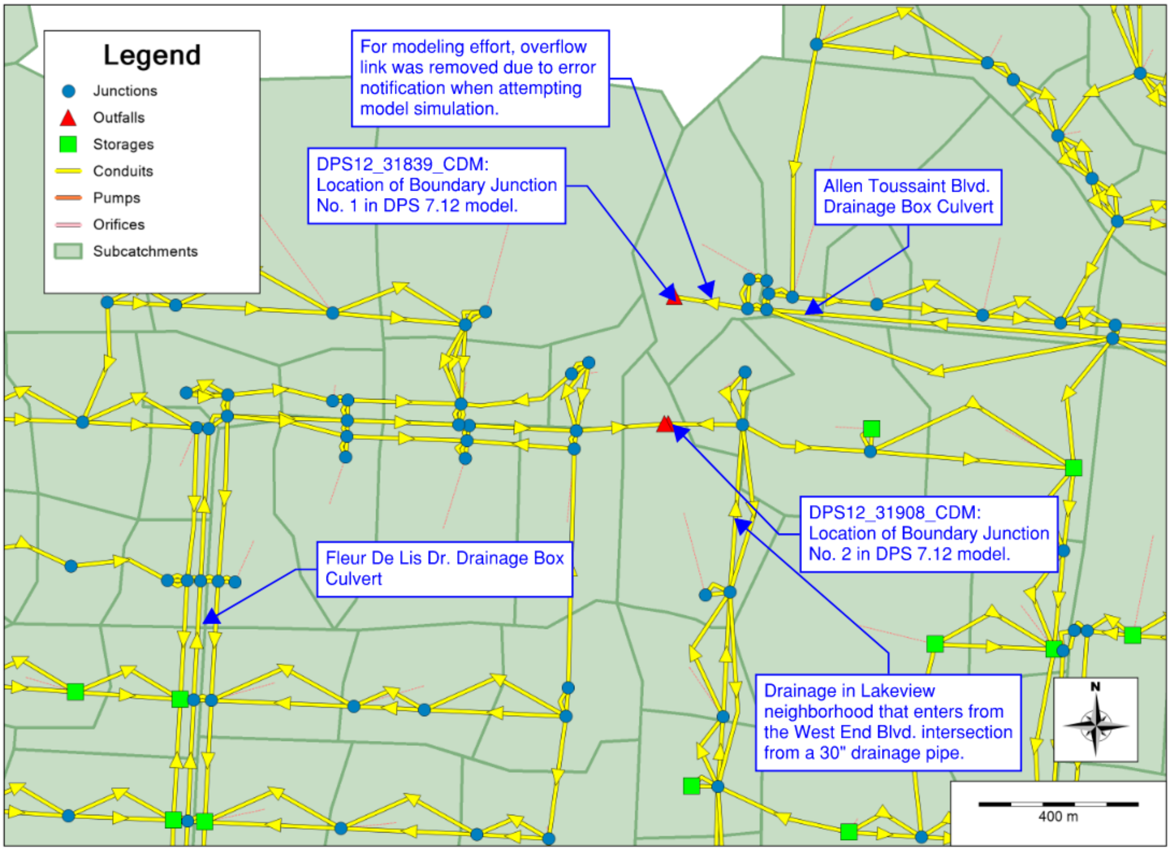



*Figure 32 – DPS 7-12 Citywide Model – Snapshot of Boundary Junctions 1 & 2 Setup*

Utilizing the citywide regional models, the DE Team ran and collected data for the four (4) outfall boundaries for the following model simulations:

- July 10-11, 2019
- September 4-5, 2023
- December 1-2, 2023
- 1-Year Design Storm
- 10-Year Design Storm
- 25-Year Design Storm

The rainfall hyetograph, inflow hydrographs, and stage hydrographs for the two (2) rainfall events are shown in the two following figures. **Figure 33** shows outfall boundary information for the calibration rainfall event (July 10-11, 2019). **Figure 34** shows outfall boundary information for the 10-Year Design Storm event.

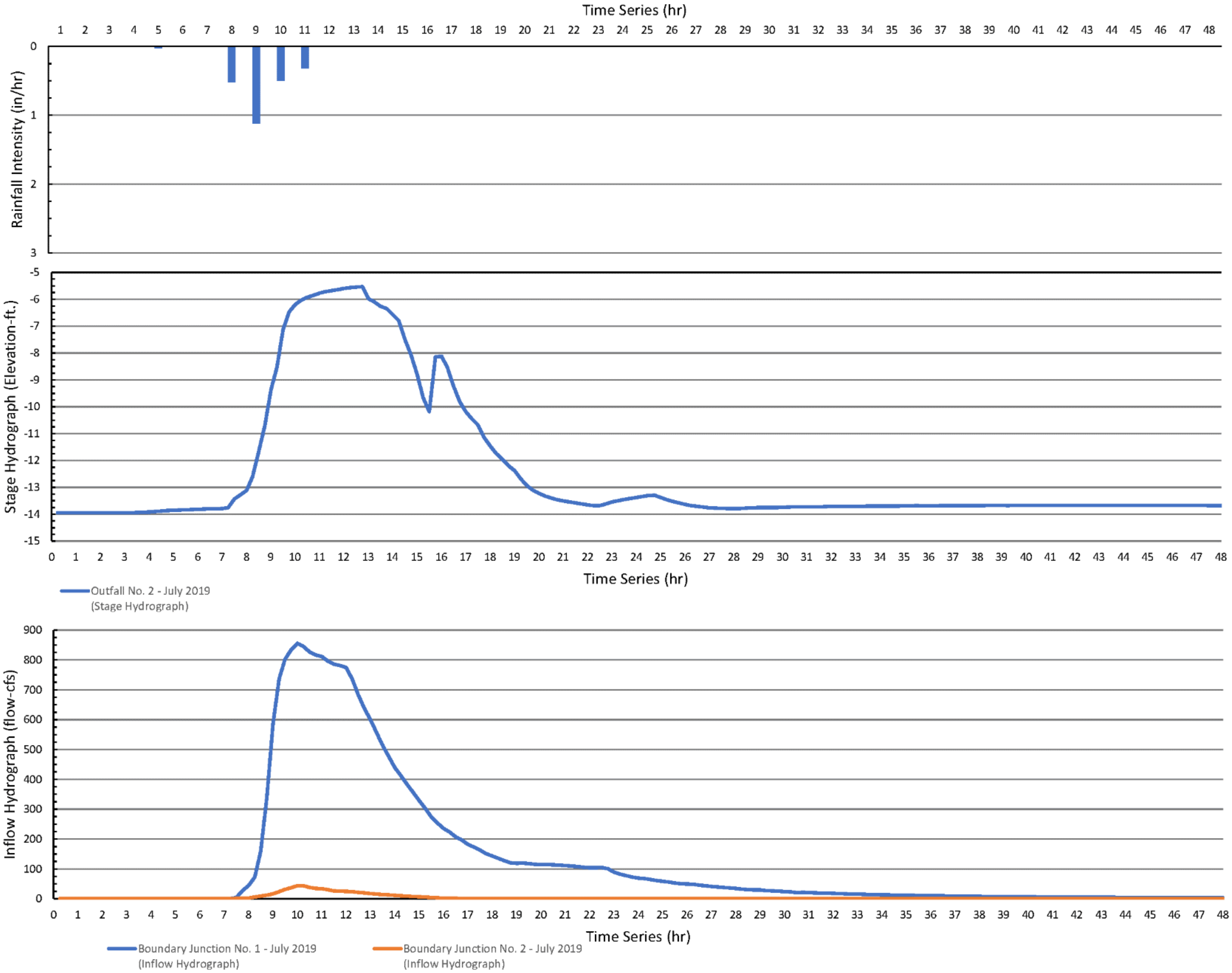



*Figure 33 – Outfall Boundary Conditions (July 10-11, 2019 Rainfall Event)*

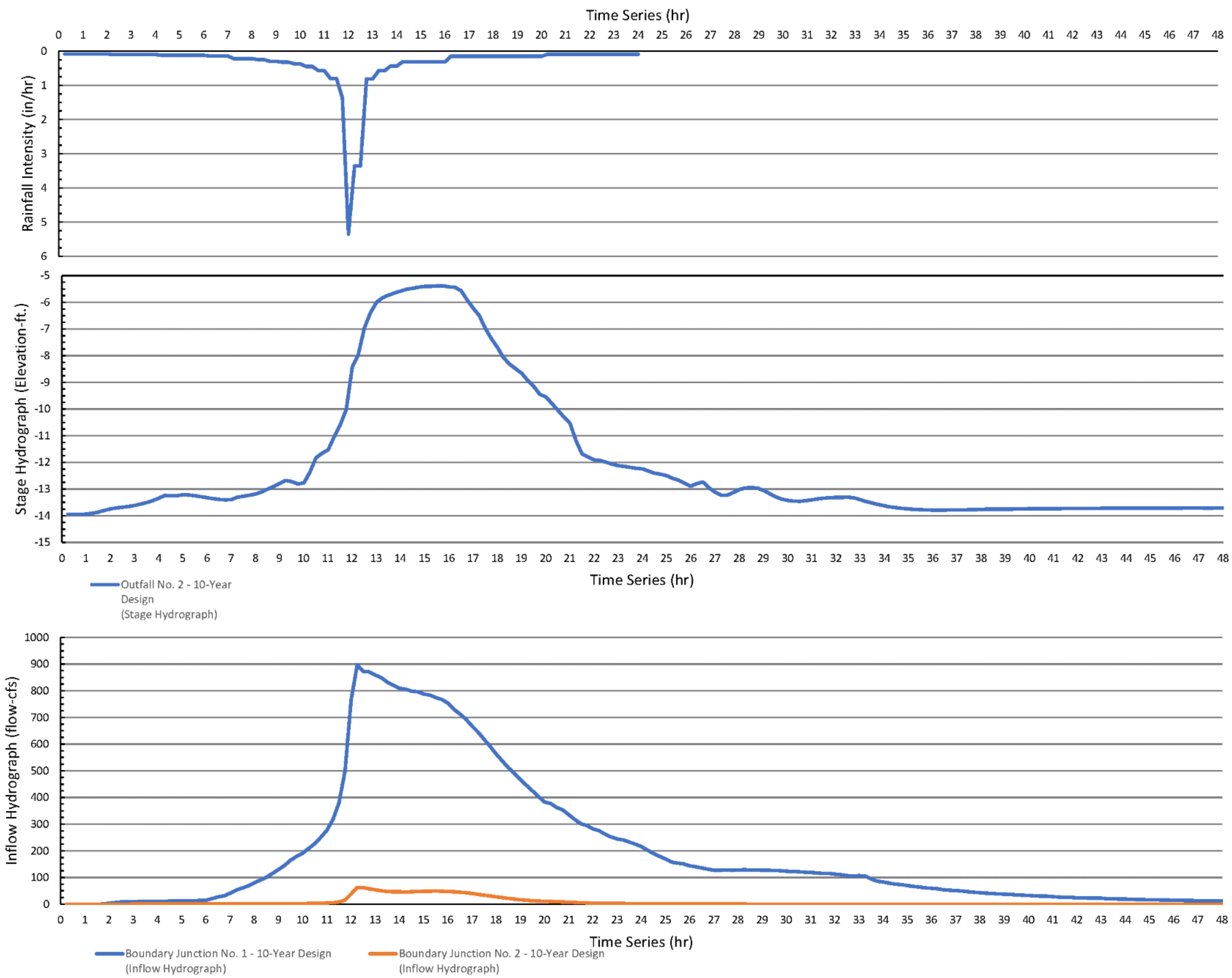



*Figure 34 – Outfall Boundary Conditions (10-Year Design Rainfall)*

### 3.3.6 Drainage Pump Station (DPS) 12 Characteristics (Pump Parameters)

The DE Team elected to model the operation of DPS 12 into the West End study area SWMM model. Model parameters and the initial set up were formatted according to DPS 7-12 citywide regional model. Within the DPS 7-12 citywide model, DPS was set up as a pump station with a total capacity of 1,200 cfs. The DPS 7-12 citywide model has the single pump station split into four (4) pumps with a capacity of 300 cfs each.

The DE Team consulted with SWBNO staff personnel to review the current model pump parameters and determine if revisions were necessary. According to SWBNO staff personnel, DPS 12 is a single horizontal drainage pump with a maximum flow capacity of approximately 1,000 cfs. The pump station at DPS 12 is manually operated but unmanned by staff, which means a SWBNO personnel would need to travel to DPS 12 and manually turn on the pump station during rainfall events. Additionally, SWBNO personnel also informed the DE Team that an "ideal" operating procedure at DPS 12 is that the pump is typically primed 10.5' depth, and takes approximately 10 minutes to load. Lastly, the pump station's prime is broken at 8.5'. The DE Team also reviewed Engineering As-builts of the construction/rehabilitation of DPS 12 to gain an understanding of the operational capacity at DPS 12. Lastly, the last completion of maintenance to DPS 12 and its pumping equipment was not known to the DE Team, therefore the DE Team assumed a 10% reduction of pumping capacity to DPS 12. Taking SWBNO personnel knowledge of the operation of DPS 12 Drainage Pump Station and the data provided in the SWBNO citywide regional models, the DE Team utilized the following pump characteristics of DPS 12 within the West End Study Area model:

- Pump 1 (300 cfs): Turn on 11', Turn off at 9'
- Pump 2 (300 cfs): Turn on 11', Turn off at 9'
- Pump 3 (300 cfs): Turn on 11', Turn off at 9'
- Total Pumping Capacity: 900 cfs
- Suction Basin Invert Elevation: -18.43'
- 10 minutes to load pump at DPS 12.

The pump station curve for all three (3) 300 cfs pumps is shown in **Figure 35,** which also shows the parameters for when each pump is started and shut down at depth above the suction basin invert elevation (-18.43'). Pump Station model parameters were estimated and adjusted according to SWBNO personnel knowledge of the operation of DPS 12 Drainage Pump Station.

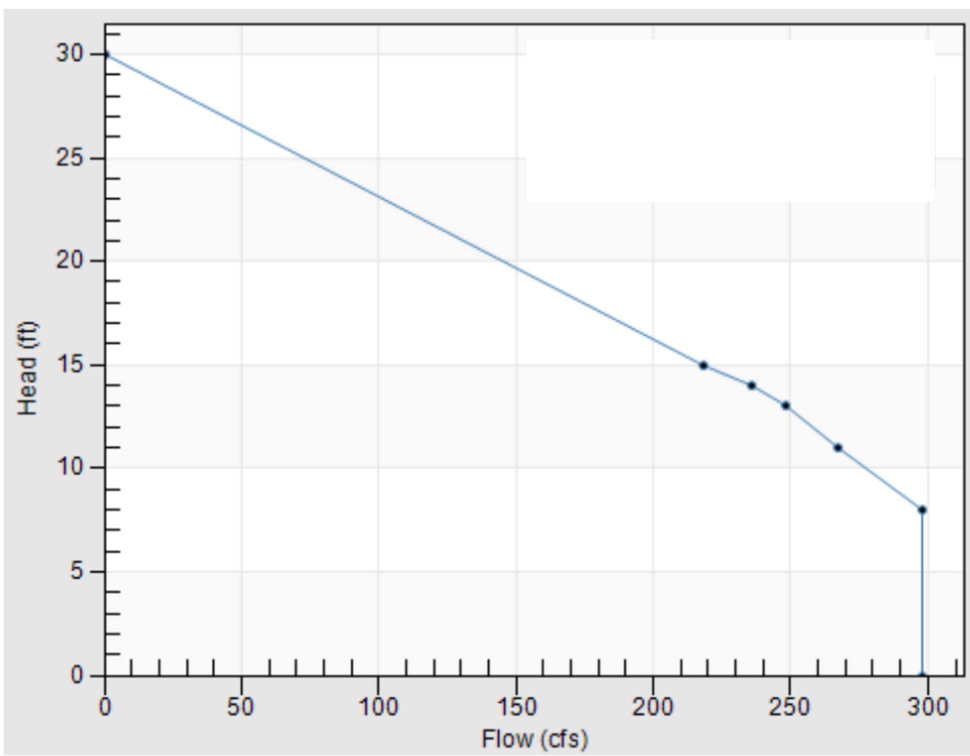



*Figure 35 – West End Study Area Model (DPS 12 Pump Curve and Characteristics)*

To provide stability within the West End study area SWMM model, the DE Team used pump controls and two (2) dummy pumps. The pump control rules are shown on **Figure AE2** in **Appendix E**, and the function for each one is as follows:

- Rule No. 1: If the Pump Control "Dummy" pump is set off, then all three (3) pumps will not run. This ensures pumps turn on at the correct pumping operational situation.
- Rule No. 2: If the Pump Control "Dummy" pump is set on, then all three (3) pumps will run. This ensures pumps turn on at the correct pumping operational situation.
- Rule No. 3: This pump control requires the pumps to remain off for a minimum of 1 hour before turning on. This is built to prevent model instability.
- Rule No. 4: This rule was only applied to the Validation Event No. 2 to simulate loss of power to DPS 12 and other pump stations throughout City of New Orleans. The loss of power resulted in the loss of pumping capacity at DPS 12 for approximately 3 hours.

## 3.4 Model Results (Existing Conditions)

### 3.4.1 Calibration Event (July 10-11, 2019)

Results of the existing conditions model for the West End study area are shown in **Figure 36**, where maximum inundation depths are displayed across the study area for the calibration event (July 10-11, 2019). Inundation results for the calibration rainfall event appear to be concentrated in the low-lying areas, such as the local streets, Kenilworth Dr. ditch, W. Harrison Ave. empty parcels, and Fleur De Lis Park. Throughout the calibration of the West End study area model, the DE Team ran several iterations and compared the results to confirm modeling assumptions would match realistic events. Results from each of the runs showed that by changing the outfall boundary conditions, specifically Outfall Boundary No. 2 and Boundary Junction No. 1 would influence the capability to create similar flood events that might have occurred in during the calibration event. As part of model calibration, the DE Team looked at several nodes, pump operations, and drainage profiles to compare results in the model to data received by SWBNO personnel and data pulled from the two (2) citywide models. The results from these are shown in **Figure 36, Figure 37**, and **Figure 38**, which are described showing the following:

- **Figure 36**: Flood Inundation Depths in West End Study Area for Calibration Rainfall Event (Existing Conditions)
- **Figure 37**: Fleur De Lis Dr. Drainage Box Culvert Profile Max HGL Observed for Calibration Event
- **Figure 38**: DPS 12 Pump Station On/Off Times for Calibration Event (SWBNO Collected Data vs. West End H&H Model)

Results shown on **Figure 37** of the Maximum hydraulic grade line (HGL) of the drainage pipe profile of Fleur De Lis Dr. show results where the top of ground surface above the box culvert is not submerged, which correlates with results shown on **Figure 36** of the maximum water surface depth inundation map results for the July 10-11, 2019 rainfall event. Model simulation results of the DPS 12 operation compared to the recorded data by SWBNO are shown on **Figure 38**, which line up within an hour of each other. Model simulation results of the operation of DPS 12 show the pump operations to last longer than recorded. Model runs developed for this historical rainfall events results in continuity error of -0.1% for surface runoff and -7% for flow routing. Results shown on Figure 37 of the Maximum HGL of the drainage pipe profile of 26th St. from Bellaire Dr. to Pontchartrain Blvd., which represents the capacity to convey water through the subsurface drainage system and is inundated for the calibration rainfall event.


STUDY AREA (NORTH SIDE)

STUDY AREA (SOUTH SIDE)

Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 36 – West End Study Area – Inundation Map (July 10-11, 2019 - Existing Conditions)*

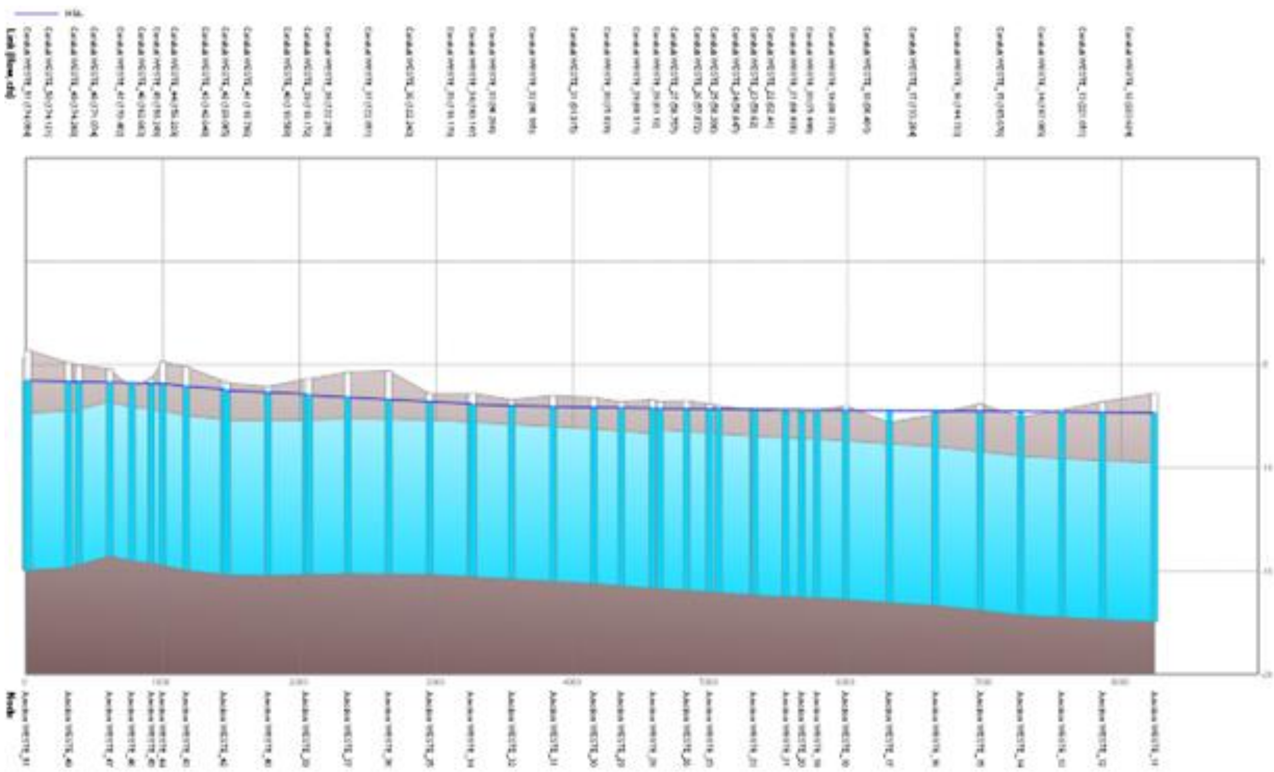


*Figure 37 – West End Study Area – Fleur De Lis. Dr. Drainage Box Culvert Max HGL Profile (July 10-11, 2019)*

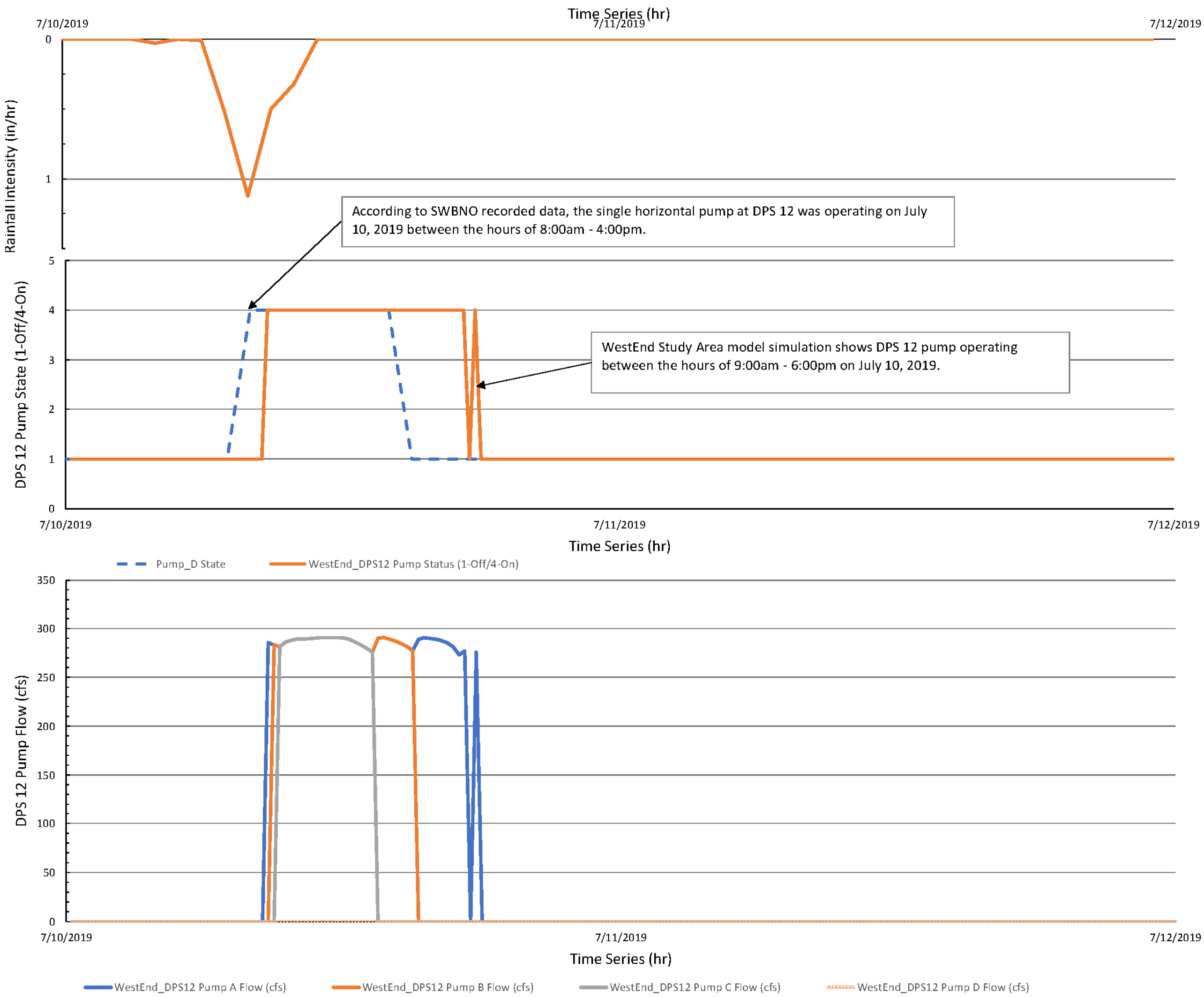



*Figure 38 – West End Study Area – DPS12 Pump On/Off Times (July 10-11, 2019)*

### 3.4.2 Validation Event No. 1 (September 4-5, 2023)

Results of the existing conditions model for the West End study area are shown in Figure 39, where maximum inundation depths are displayed across the study area for Validation Event No. 1 (September 4-5, 2023). Peak WSE during the model simulation matched WSE observed at DPS 12. Additionally, DPS 12 pump run times during the model simulation matched pump run times observed at DPS 12. Results of the model simulation results compared to data recorded by SWBNO are shown in Figure 40. Model runs developed for this historical rainfall event result in continuity error of -0.07% for surface runoff and -1.9% for flow routing.


Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 39 – West End Study Area – Inundation Map (September 4-5, 2023 - Existing Conditions)*

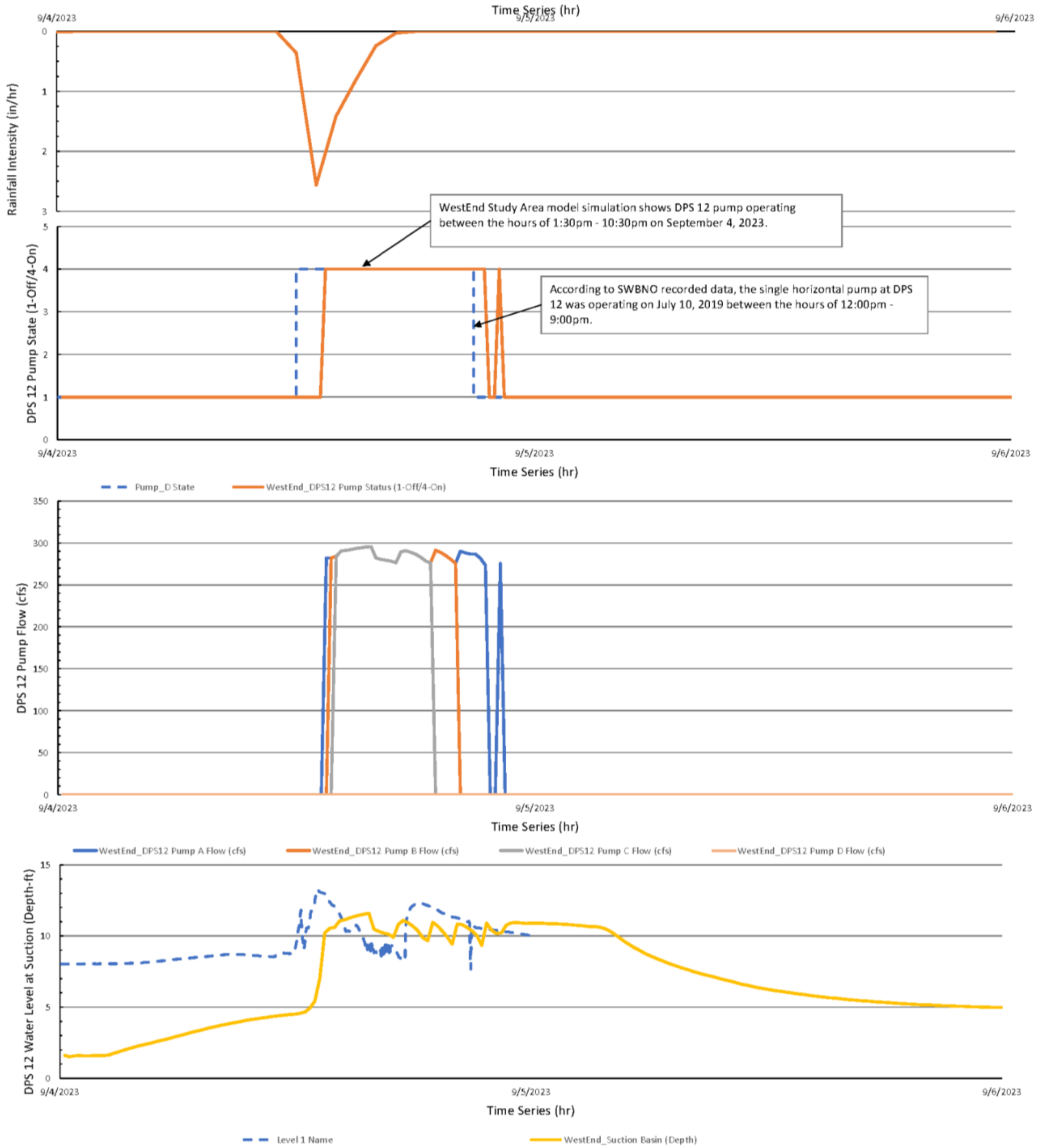



*Figure 40 – West End Study Area – DPS12 Pump On/Off Times (September 4-5, 2023)*

### 3.4.3 Validation Event No. 2 (December 1-2, 2023)

Results of the existing conditions model for the West End study area are shown in **Figure 41,** where maximum inundation depths are displayed across the study area for Validation Event No. 1 (September 4-5, 2023). Results of the model simulation results compared to data recorded by SWBNO are shown in **Figure 42**. Images of the flood depths during this rainfall events result in continuity error of -0.1% for surface runoff and 0.7% for flow routing. As shown on Figure 42, power was loss at DPS 12 for nearly 3 hours. As a result of this, the depth observed at DPS 12 suction basin increased approximately 4' during this loss of power.


*Figure 41 – West End Study Area – Inundation Map (December 1-2, 2023 - Existing Conditions)*

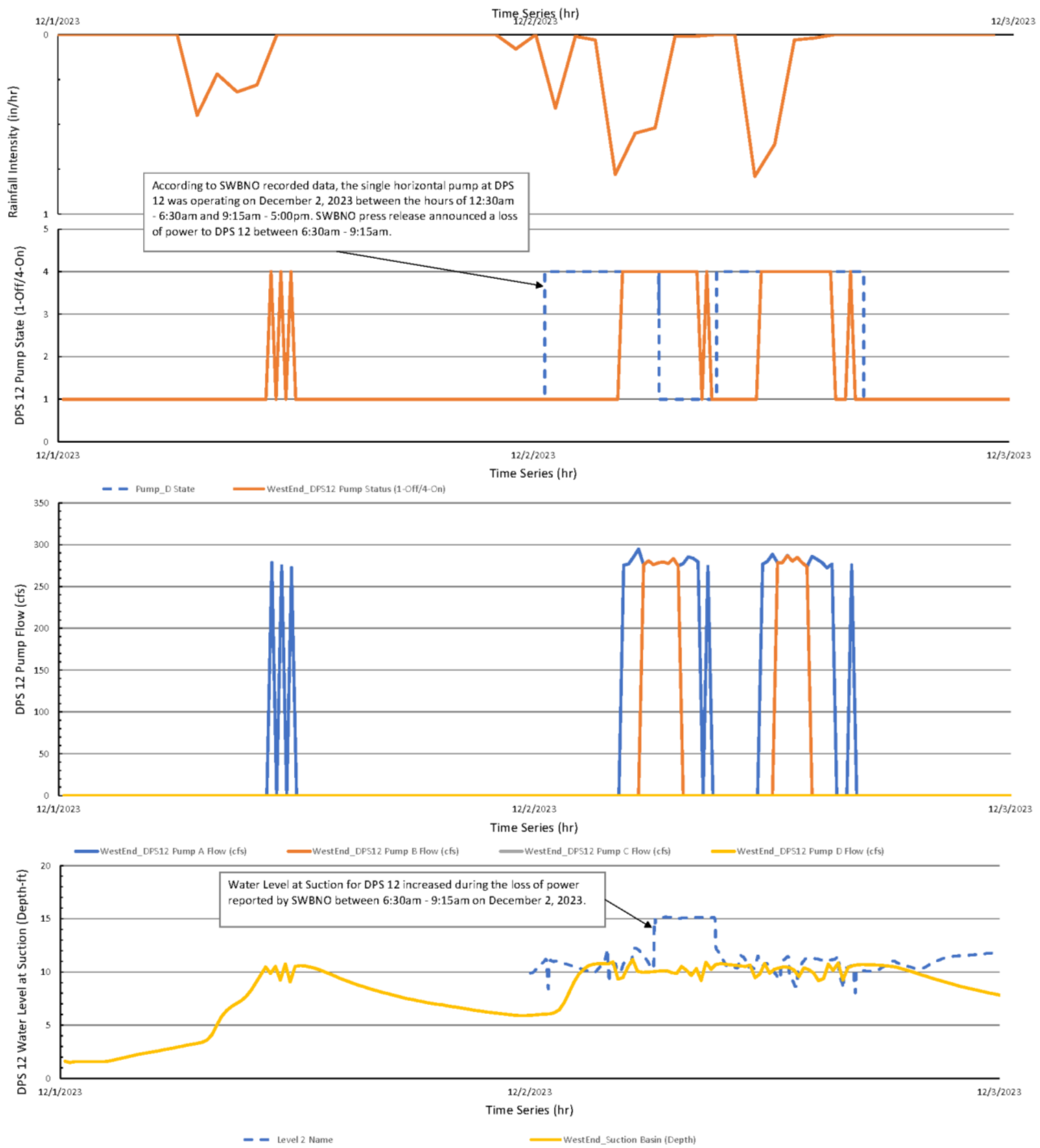
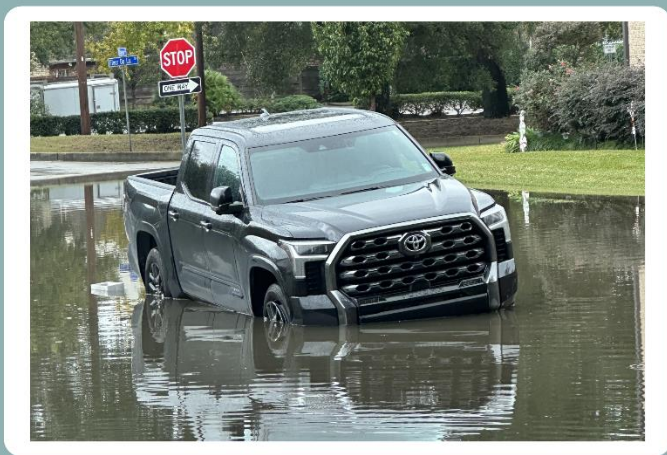
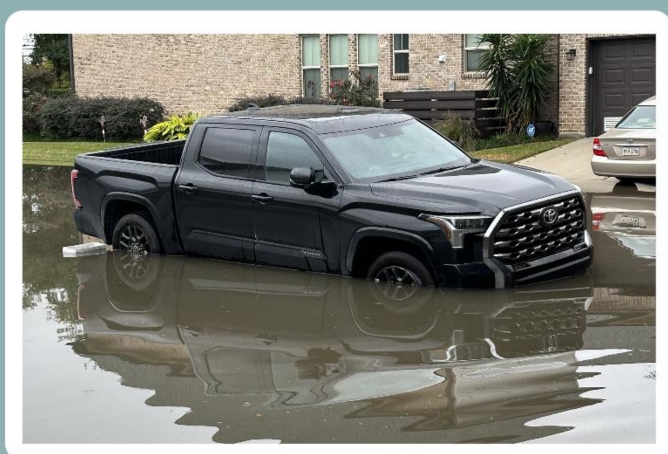



*Figure 42 – West End Study Area – DPS12 Pump On/Off Times (December 1-2, 2023)*

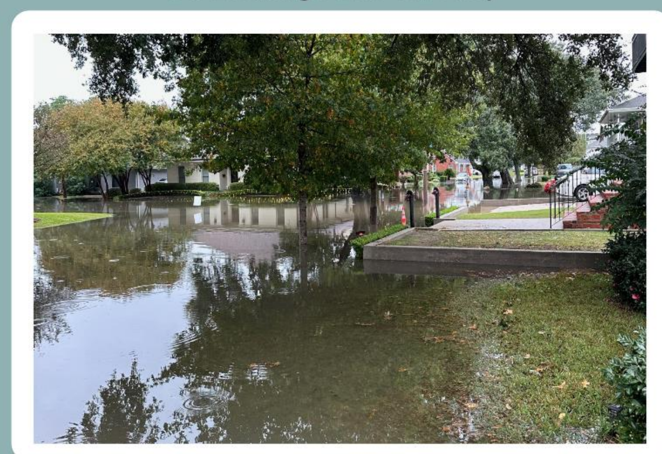



Flooding at Fleur De Lis Dr. & Sharon Dr.
(Photo taken around 8:00am on 12/2/2023)


Flooding at Fleur De Lis Dr. & Harrison Ave.
(Corner Left - No flooding above Fleur De Lis. Dr. Drainage Box Culvert)



Flooding at Fleur De Lis Dr. & Sharon Dr.
(Photo taken around 8:00am on 12/2/2023)



Flooding at Sharon Dr. & Marcia Ave.
(Photo taken around 8:00am on 12/2/2023)

*Figure 43 – West End Study Area – Photos of Flooding (December 1-2, 2023)*

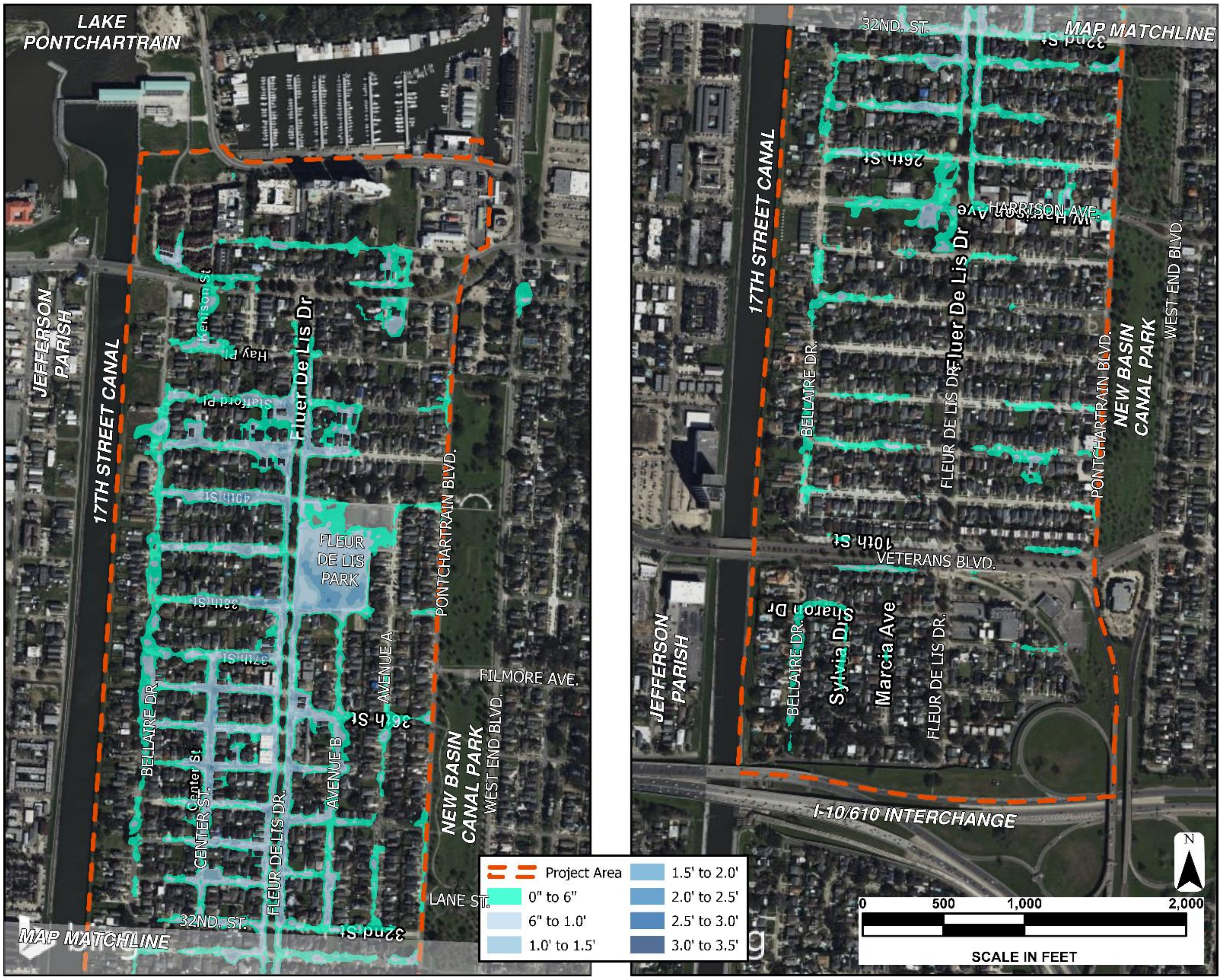
### 3.4.4 Model Simulations (1-, 10-, 25-Year Design Rainfalls)

The DE Team analyzed the existing drainage conditions and proposed infrastructure solutions to the study area by utilizing three (3) rainfall design storm scenarios, which are as follows:

- 1-Year, 24-Hour Design Storm: 4.64"
- 10-Year, 24-Hour Design Storm: 8.31"
- 25-Year, 24-Hour Design Storm: 10.5"

The DE Team analyzed and recommended proposed infrastructure solutions based on their capability to reduce/mitigate flooding during a 10-Year design storm event. Model results of the existing conditions for the West End study area are shown in Figure 44 through Figure 46, where maximum inundation depths are displayed across the study area for the 1-year, 10-year, and 25-year design storm, respectively. Model runs developed for this design storm events result in the following continuity error:

- 1-Year Continuity Error
    - Surface Runoff: -0.1%
    - Flow Routing: -0.8%
- 10-Year Continuity Error
    - Surface Runoff: -0.1%
    - Flow Routing -1.7%
- 25-Year Continuity Error
    - Surface Runoff: -0.1%
    - Flow Routing -2.6%




**STUDY AREA (NORTH SIDE)**

**STUDY AREA (SOUTH SIDE)**

Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 44 – West End Study Area – Inundation Map (1-Year Design Storm - Existing Conditions)*


**STUDY AREA (NORTH SIDE)**

**STUDY AREA (SOUTH SIDE)**

Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 45 – West End Study Area – Inundation Map (10-Year Design Storm - Existing Conditions)*


***STUDY AREA (NORTH SIDE)*** ***STUDY AREA (SOUTH SIDE)***

Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 46 – West End Study Area – Inundation Map (25-Year Design Storm - Existing Conditions)*

### 3.4.5 Model Volumetric Analysis

The DE Team performed a volume takeoff of the West End study area, including DPS 12, using the 10-yr storm event as a facsimile for the West End study area general behavior. During a 10-yr design storm, 1,460-acre-ft of water volume flows into the West End study area. The local runoff directly from the West End study area is 311-ac-ft and only accounts for 23% of this total volume. DPS6, via the Fleur de Lis Drainage Box Culvert (approximately 10'x10'), deposits 480-ac-ft, or 33% of the total volume. Additionally, the Lakeview Neighborhood, via the Allen Toussaint box canal (approximately 10'x10') drains another 630-ac-ft of runoff into this area. The final 20-ac-ft is local drainage from the West End Blvd 54" storm system. The duration of the 10-yr synthetic storm was 48-hours and during this time only 44% of the total water volume was evacuated from the neighborhood. While the model shows there is no remaining surface water after 48-hrs, stages in the subsurface system remain 4-ft feet above the model starting conditions. DPS 12 drains 615-ac-ft within the first 48-hr period and after this the water stages in the local basin remain below the DPS 12 operating range. An additional 25-ac-ft drains by gravity into the DPS 6 intake basin and no flow was observed flowing back into the Allen Toussaint box, which is connected to DPS7. It is anticipated that beyond the 48-hr period, the water flow in the Allen Toussaint and Flour de Lis box canals would become bi-directional and remaining water (820-ac-ft) would drain by gravity to DPS 6 and/DPS 7. Further investigation of the water volumes after 48-hours is inconsequential to potential infrastructure solutions being performed in this study and their performance so was not further studied.

## 3.5 Model Limitations

The West End PC-SWMM model is subject to several key limitations as discussed:

- Calibration Boundaries. The basis of the West End SWMM model is a combination of small portions of the Citywide 1-6 SWMM and Citywide 7-12 SWMM models. These two models were calibrated for their specific areas of interest and purpose. As the West End study area straddles the boundary overlapping portions of these two models, the study area model inherits some level of uncertainty. The key assumption for this study is that the stage boundary at DPS 6 from the DPS 1-6 model and the inflow hydrographs at Allan Tousant from the DPW 7-12 model exclude any correlation and behave as calibrated from their source models.
- DPS 12 Pump Operations. Another key fundamental piece of the West End SWMM model is that DPS 12 can commence operation at the programmed water levels obtained from SWBNO. In reality, DPS 12 is unmanned, remotely powered, and manually operated. Outside variables such as departure and arrival time of operators, power requests, and delivery and successful startup of the pump station are not considered in this model and may have significant impacts on the proposed solutions herein.
- Impacts of Adjacent Basins on West End. One of the key findings of this study is that the West End area water levels are highly influenced by the intake stages at DPS 6 and the inflow hydrographs into DPS 12 from Allen Tousant (which in turn is influenced by the intake stages at DPS 7). The boundary conditions for this study assume that proposed solutions and/or changes in the operation of DPS 12 do not impact these boundary conditions. Both of these boundary conditions originate from areas outside of the West End study area and thus were not evaluated within this model.
- Impact of West End Proposed Alternates on Adjacent Basins. Similar to the previous paragraph, some of the proposed solutions in this study may result in higher inflows from the adjacent areas. This does highlight a risk that some benefits shown in West End may not materialize. Conversely, there may be unreported benefits to the Lakeview and Carrollton areas resulting from the proposed solutions herein.

- Circular Dependency in Station 12 Operations Modeling and Water Surface Elevations. Pump Station 12 has no notable intake basin and its operations within the SWMM model are highly sensitive to water levels at the intersection of the Fleur de Lis and Allen Toussant box culverts. The results of this configuration are that very minor changes in water surface elevations within the system may slightly alter the modeled pump run times of DPS 12 by minutes or even seconds. These slight variations in model pump run times can vary the water surface elevations by several tenths of a foot in the immediate vicinity of the pump station. Due to potential feedback loop of Station 12 on water surface elevations and visa versa, these effects can be magnified in an antagonistic relationship. Therefore, results in the immediate vicinity of DPS 12 require additional engineering judgement and may need to be dismissed as beyond the resolution of the model at this location. This negative feedback influence on the results self-mitigates with distance from the pump station.

digital engineering

SECTION 4

# ALTERNATIVES EVALUATION

CITY OF NEW ORLEANS: WEST END H&H DRAINAGE STUDY

# 4. Alternatives Analysis

## 4.1 Overview

The DE Team was tasked with determining alternatives for proposed improvements to address the drainage problems within the West End neighborhood. This task involved the development of conceptual-level project alternatives, which would be analyzed for flood risk reduction and constructability. Alternative solutions would be input into the validated SWMM model for analysis of water surface reduction.

## 4.2 Observations of Flood Risk Areas in Study Area

To review a project alternative for constructability, the DE Team ran a hot spot analysis of the flood inundation observed during a 10-year design rainfall within the study area to review a project alternative for constructability. From this analysis, the DE Team determined several "hot spots" within the study area shown in **Figure 47** of where proposed solutions may be implemented to produce the maximum number of benefits.

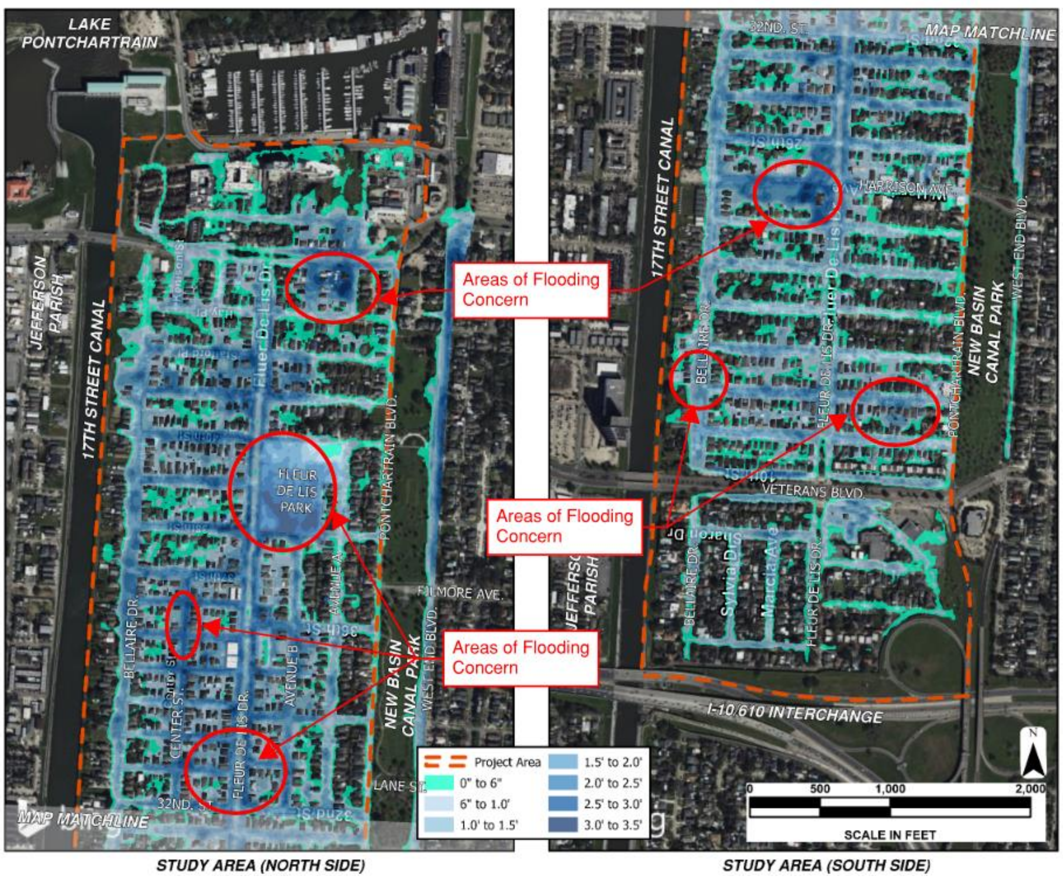



*Figure 47 – West End Study Area Hot Spot Analysis (10-Year Design Rainfall)*

## 4.3 Infrastructure Solutions to Consider in Study Area

The DE Team was tasked to consider both gray and green infrastructure improvements when determining project alternatives. Green infrastructure solutions suggested in EPA's Green Streets Handbook provide benefits to the community that go beyond just capturing stormwater runoff.

The benefits can range from better air quality, better water quality, and heat reduction to improved community health and aesthetics. Green infrastructure assists with the filtration, absorption, and transpiration of water, which help protect our waterways from harmful chemicals, bacteria, and pollutants. Furthermore, green infrastructure helps mitigate subsidence and recharge the groundwater by allowing water to infiltrate into the soil. The DE Team investigated multiple potential improvements to the project area. These infrastructure solutions considered are as follows:

Gray Infrastructure: Upsizing Existing Drainage Pipe Infrastructure

A standard solution to increase the collection of stormwater runoff is by upsizing the existing drainage pipes. Removing undersized drainage pipes and replacing them with larger diameter pipes allows the system to maximize the total flow of stormwater out of a specific area. A concern on upgrading drainage conveyance within a low-lying community is the negative impact it may have on areas being studied. Drainage Conveyance upgrades provide an opportunity for flood backwater impacts to travel upstream, which can worsen flooding in these low-lying areas. An impact proposed improvements may have on a community is determined through detailed H&H model analysis.

Green Infrastructure: Bioretention Cells

A bioretention cell is a shallow surface depression that utilizes vegetation and permeable soils to retain and filter surface runoff and pollutants. The total volume of runoff and peak discharges are reduced by infiltration by the soils and by interception, uptake, and evapotranspiration by the plants.

Green Infrastructure: Stormwater Curb Extensions & Green Intersections

Stormwater curb extensions are modified traffic-calming devices that cause the curb to protrude into the existing roadway to lower traffic speed and capture stormwater runoff from roadways and/or sidewalks. By putting the curb into the roadway, the width of the intersection’s entries is narrowed, allowing for a larger capture radius. The curb extensions are filled with a bioretention soil mix that allows vegetation to thrive and stormwater runoff to infiltrate, acting as storage. The vegetation absorbs and cleans the runoff, stopping any chemicals are pollutants from contaminating the surrounding ground and waterways. One issue with stormwater curb extensions is that they are inefficient for high traffic areas. For these cases, bioretention cells can be installed at intersections to provide the same benefits. These are sometimes called Green Intersections.

Green Infrastructure: Infiltration Trenches

Infiltration trenches are excavated linear areas that exploit permeable layers of stone and sand to slowly filter surface runoff into the existing drainage system. Using an impermeable membrane, surface runoff is guided into a perforated pipe at the bottom of the trench to push surface runoff back into the existing system. Stone and sand layers trap pollutants to produce higher quality discharges. This system requires pretreatment or regular maintenance to remove suspended solids.

Green Infrastructure: Modular Subsurface Retention Systems

Modular Subsurface Retention Systems are a method of green infrastructure that aims to capture and contain large amounts of surface runoff while slowly releasing that same runoff back into the existing stormwater drainage system. With the goal of taking stress off of the existing drainage system, modular subsurface retention systems are an innovative way optimize available underground space to store and clean stormwater runoff. These systems can be placed in open-field environments and under roadways, as they have the ability to distribute weight to support vehicle traffic loads.

Green Infrastructure: Permeable Pavement

Permeable pavement is a paving system that allows runoff to infiltrate void spaces instead of becoming surface runoff. Runoff will then be forced into the existing ground below, where, typically, an underdrain will capture the surface runoff and guide it into the existing drainage system. The soil beneath the permeable pavement allows the runoff to be filtered before it enters the system. A couple of concerns with permeable pavement are its low resistance to heavy/constant traffic volumes and its impact that sediment loads have on its efficiency. These concerns require frequent maintenance to ensure its an efficient method of drainage.

## 4.4 Development of Project Alternatives & Constructability Analysis

### 4.4.1 Overview

The project team determined five (5) alternatives for the West End neighborhood. A sixth alternative was composed from all of the five separate alternatives and combined into one. Locations for these alternatives were determined by using the existing conditions model and noting constructable areas of the neighborhood with the largest amounts of inundation. Each alternative has the goal of reducing water surface elevation to alleviate flooding within the neighborhood. All the alternatives include components of green infrastructure methods to accomplish this goal. For each alternative, an engineer's opinion of probable construction cost estimate was developed utilizing the conceptual level-of-effort plans. Proposed costs include project delivery costs to design and implement each proposed alternative studied. For Alternative 5, project delivery cost also includes the cost for City of New Orleans to acquire privately-owned empty lots along W. Harrison Ave. A total of each alternative is in **Table 7**.

*Table 7 – Engineer's Opinion of Probable Construction Cost for Project Alternatives*

| Alternative | Estimated Construction Cost Opinion ($) |
|---|---|
| Alternative No. 1 | $11,266,671.75 |
| Alternative No. 2 | $8,736,081.63 |
| Alternative No. 3 | $12,764,274.97 |
| Alternative No. 4 | $14,977,895.31 |
| Alternative No. 5 | $6,825,796.62 |
| Total (Alternative No. 6) | $53,695,813.03 |

### 4.4.2 Constructability Analysis

The DE Team also considered the constructability of potential green stormwater infrastructure (GSI) solutions in the study area. One of the constraints for implementing larger GSI solutions is the need for available land area to capture and store stormwater. The study area is a fully developed subdivision, with the only available land being a large park called Fleur de Lis Park and unused lots along W. Harrison Ave. Large scale GSI solutions can be focused in these areas. Fleur de Lis Park is owned by the Orleans Parish School Board and is not currently in-use for school operations. The unused lots on W. Harrison Ave. are privately owned, requiring land purchasing.

The implementation of GSI within the Right of Way was also considered when designing alternatives. Solutions can vary, but the most common solutions are bio-retention cells, curb extensions, permeable pavement, and infiltration trenches. Each method not only provides relief to the existing infrastructure from an excessive amount of surface runoff, but also acts as a means of beautification for the community.

The DE Team considered areas of the West End neighborhood where alternative implementation would cause the least amount of inconvenience to the residents, although this is unavoidable in specific circumstances. For example, some alternatives will require the relocation/replacement of other utilities such as water and sewer or relocation of water and sewer services from residential homes in the neighborhood. Most of the roadways that will need to be excavated for purposes of utility relocation, addition, and reconstruction will be in low-traffic residential areas.

After weighing the results from the hot spot analysis, the condition of the roadway and considering the City of New Orleans capital improvement plan to tackle improvements within the study area, the DE Team further refined potential GSI solution into several possible solutions in the study area which are as follows:

1. Proposed Subsurface Retention System at Fleur De Lis Park
2. Proposed Subsurface Retention System along Center St. within the limits of the roadway surface between 32$^{nd}$ St. and 37$^{th}$ St.
3. Proposed curbed extensions with bioretention cells and permeable pavement intersections dispersed throughout the study area on local streets only that do not see pass through traffic.
4. Proposed Bioretention Cells and a condensed roadway along Bellaire Dr. between 10$^{th}$ St. and 28$^{th}$ St.
5. Proposed Subsurface Retention System at W. Harrison Ave. in the empty privately owner lots west of Fleur De Lis Dr.
6. Proposed Improvements along 14$^{th}$ St. Between Fleur De Lis Dr. and Pontchartrain Blvd.

Improvements to 14$^{th}$ St. were determined to be unrealistic due to the recent completion of a full reconstruction project in the last 10 years. Allocating money to GSI improvements on this street would be an inefficient use of funds, so an improvement along this street was ruled out. The other hot spots in the neighborhood were better candidates for full reconstruction due to the current poor condition of the roadways and unknown conditions of the existing subsurface utilities, such as drain lines, sewer gravity lines, and water lines. Roadways such as Center St. and Bellaire Dr. fall under this category of poor-quality pavement and unknown condition of subsurface utilities. As well as GSI implementation on these streets, full reconstruction was factored into the constructability analysis.

### 4.4.3 Evaluation of Alternative based on Cost

For each alternative, all green infrastructure methods listed in the constructability section were considered. For some alternatives, only one method of green infrastructure was possible. For example, Alternative No. 2's only available option was permeable pavement, with the width of the right-of-way being thin.

Certain roadways require full reconstruction to give passage for implementing the proposed green infrastructure methods. Full reconstruction encompasses the removing and replacing of the current travel lanes and all structures tied to it and the removing and replacing all subsurface utilities directly beneath the reach of the roadway. Bellaire Dr. is a roadway proposed for full reconstruction due to its poor roadway condition. As part of the design, the project team proposed a reduction of Bellaire Dr. roadway width from 42' wide to the CNO DPW standard local roadway width of 26'. The reduction of roadway width to 26' wide would reduce the cost of replacing the traffic pavement and existing utilities to about $2,100.00 per linear foot for portland cement concrete pavement roadway.

When evaluating Center St., modular subsurface retention systems were initially considered to be the preferred method of GSI. After further investigation and analysis, this method became impractical due to the overall complexity of implementation around existing utilities. Implementation along Center St. would drive a higher cost per cubic foot of storage, estimated to be about an additional $12.00 per cubic foot of storage. The alternative option, infiltration trenches and permeable pavement, is a much more realistic option, as it provides a similar amount of runoff storage at a cheaper price than the modular subsurface retention system.

### 4.4.4 Alternative No. 1 – Fleur De Lis Park Subsurface Retention System

In this alternative, the objective was to increase runoff storage wherever possible to impede upstream flow into the existing drainage system. To complete this, subsurface runoff storage will be added in Fleur de Lis Park to relieve the existing box culvert of a portion of the stormwater runoff it receives upstream. The gray infrastructure includes increasing the diameter of drain lines surrounding the subsurface storage to guide as much water out of the existing drainage system and into the subsurface storage as possible. Over time, the subsurface storage will slowly release the runoff it holds back into the existing system, via . These upgrades will require removing and replacing concrete and asphalt roadways, removing and replacing concrete walks and drives as necessary, selectively removing and replacing trees and park equipment, and offsetting any existing subsurface utilities effected by the installation of the subsurface retention. For this alternative, the following streets and improvements are being proposed:

- 38th St. (Fleur de Lis Dr. to Avenue B)
    - Replace 141 linear feet of 30" Reinforced Concrete Pipe with 42" Reinforced Concrete Pipe.

- 40th St. (Fleur de Lis Dr. to Avenue A)
  - Replace 180 linear feet of 24" Reinforced Concrete Pipe with 180 linear feet of 42" Reinforced Concrete Pipe.
- Fleur De Lis Dr. at 39th St.
  - Install 18" discharge pipe for subsurface retention system into Fleur De Lis Dr. drainage box culvert with a inline check valve.

The following Green Infrastructure improvements are proposed in Alternative No. 1:

- Modular Subsurface Retention System:
  - Installation of a 177,934 cubic foot Modular Subsurface Retention System in the southwest corner of Fleur de Lis Park that will require the installation of 47 linear feet of 42" Reinforced Concrete Pipe and 60 linear feet of 18" Reinforced Concrete Pipe.
  - Installation of a 133,734 cubic foot Modular Subsurface Retention System in the northwest corner of Fleur de Lis Park that will require the installation of 21 linear feet of 42" Reinforced Concrete Pipe.
  - Installation of a 135,961 cubic foot Modular Subsurface Retention System in the northeast corner of Fleur de Lis Park that will require the installation of 287 linear feet of 36" Reinforced Concrete Pipe.

A figure representing these improvements is shown in Figure 48. A schematic displaying the operation of a Modular Subsurface Retention System is shown in

Figure *49*. Conceptual drawings were prepared for Alternative No. 1 and are provided in Appendix C.

In developing the model for Alternative No. 1, the following assumptions were applied:

- Drainage Conveyance improvements to the three (3) subsurface retention systems in Fleur De Lis park include increasing drainage line diameter along 38th St. and 40th St. at Fleur De Lis Dr.
- Alternative No. 1 subsurface retention system was modeled by utilizing three (3) storage nodes with approximately 6.5' of retention and resulted in 447,629 cubic feet of subsurface stormwater capacity at Fleur De Lis Park.
- There is a single 18" Reinforced Concrete Pipe (RCP) outfall with an inline check valve proposed to be installed to prevent backflow at the outfall of the subsurface retention system.

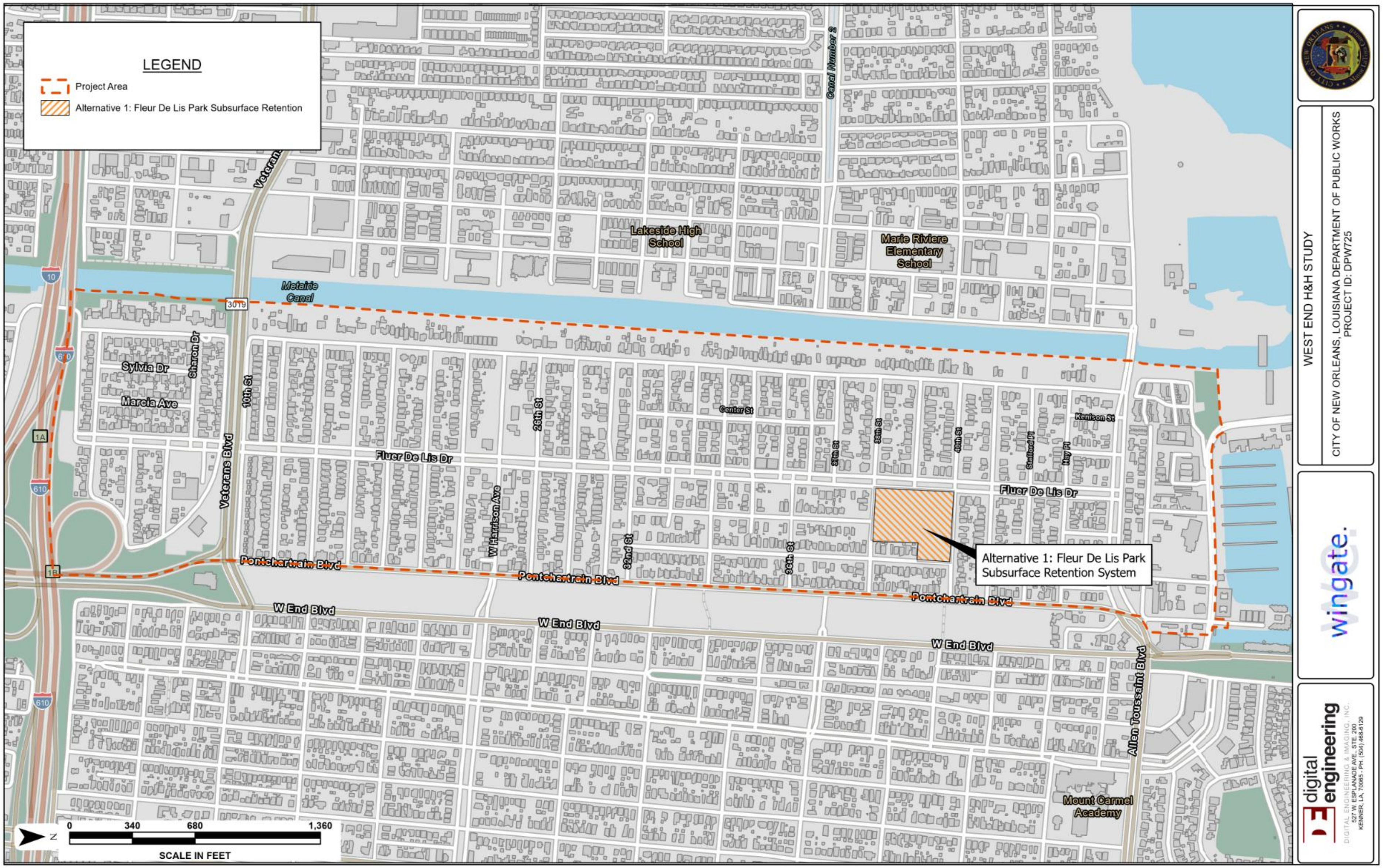



*Figure 48 – Proposed Project Alternative No. 1 Improvements*

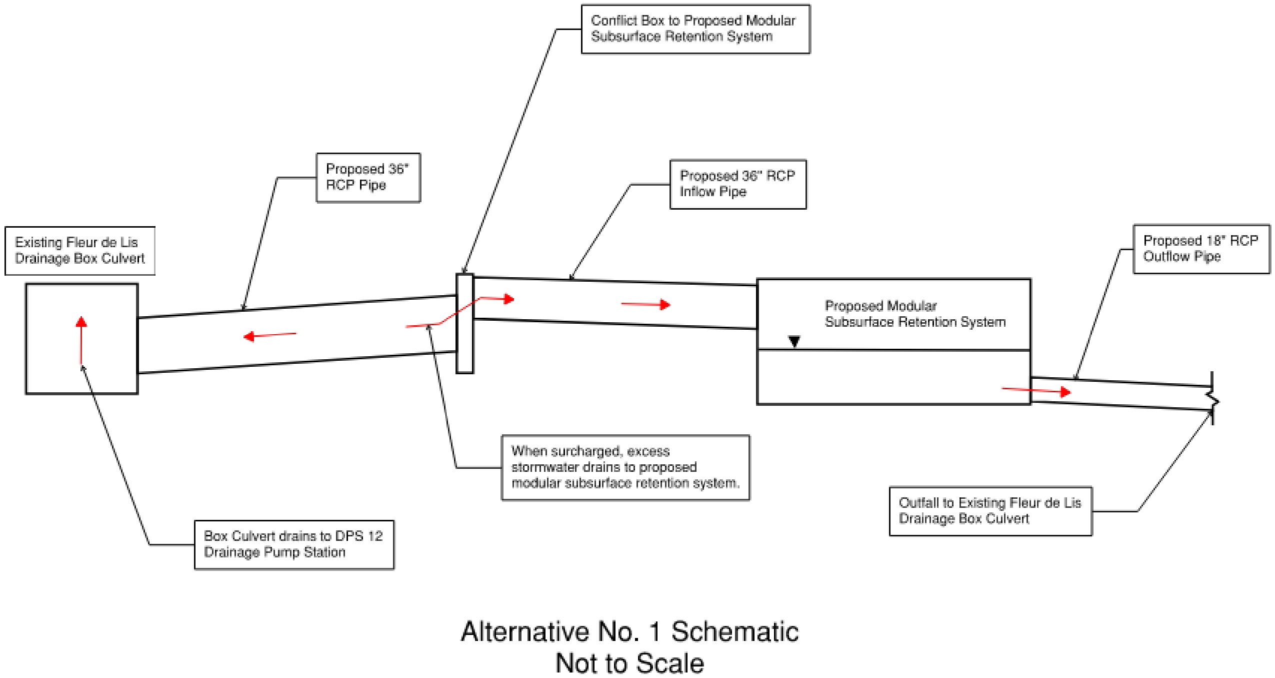



*Figure 49 – Schematic of Proposed Subsurface Retention System*

Compared to the existing conditions model for a 10-year design rainfall event, the average maximum water surface elevation for Alternative No. 1 decreased by approximately 0.30 feet with a maximum decrease of 1.67 feet. The decrease in the maximum water surface elevation (Max WSE) for Alternative No. 1 is caused by the increased subsurface retention system. Comparison results of the maximum water surface elevation near the proposed improvements for a 10-Year Design Storm are as follows:

- Fleur De Lis Dr. at 38th St.: Max WSE reduced by 0.32' (11.03%) to -6.00'
- Fleur De Lis Dr. at 40th St.: Max WSE reduced by 0.32' (12.40%) to -6.00'
- 40th St. at Avenue A: Max WSE reduced by 0.32' (39.51%) to -5.97'
- 38th St. at Avenue A: Max WSE reduced by 0.32' (72.73%) to -5.98'

A map showing the 10-Year Design Storm Inundation for Alternative No. 1 is shown on

Figure *50*. A map showing the flood risk reduction observed if Alternative No. 1 proposed improvements were implemented to the study area in Figure 51.


Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 50– 10-Year, 24-Hour Design Storm Inundation Map (Alternative No. 1)*


Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 51 – 10-Year, 24-Hour Design Storm Flood Risk Reduction Map (Alternative No. 1)*

### 4.4.5 Alternative No. 2 – Center St. Green Infrastructure Solutions

In this alternative, the goal was to increase the collection of stormwater runoff on Center St. by method of permeable pavement. As stormwater collects on the roadway, it gravity flows onto a strip of permeable pavement, which allows the runoff to seep through the cracks in the pavement. Underneath the pavement, an infiltration trench with course stone has voids that guides water into a perforated pipe, which is tied into the existing drainage system. The course stone also assists with filtering out pollutants from entering our waterways. These upgrades will require removing and replacing asphalt and concrete roadways, removing and replacing concrete walks and drives where necessary, and offsetting existing subsurface utilities. The following Green Infrastructure improvements are proposed in Alternative No. 2.

- Permeable Pavement:
  - Installation of 14 Permeable Pavement systems on the east and west sides of Center St. from 32nd St. to 37th St. A total length of 2,800 linear feet of permeable pavers with an infiltration trench proposed to be installed below.

A figure representing these improvements is shown in **Figure 52**. A typical section of Permeable Pavement is shown in

**Figure** *53*. Conceptual drawings were prepared for Alternative No. 2 and are located in Appendix D.

In developing the model for Alternative No. 2, the following assumptions were applied:

- Drainage upgrades included the installation of infiltration trenches above a permeable pavement surface and were designed as Low Impact Development (LIDs) in the model.

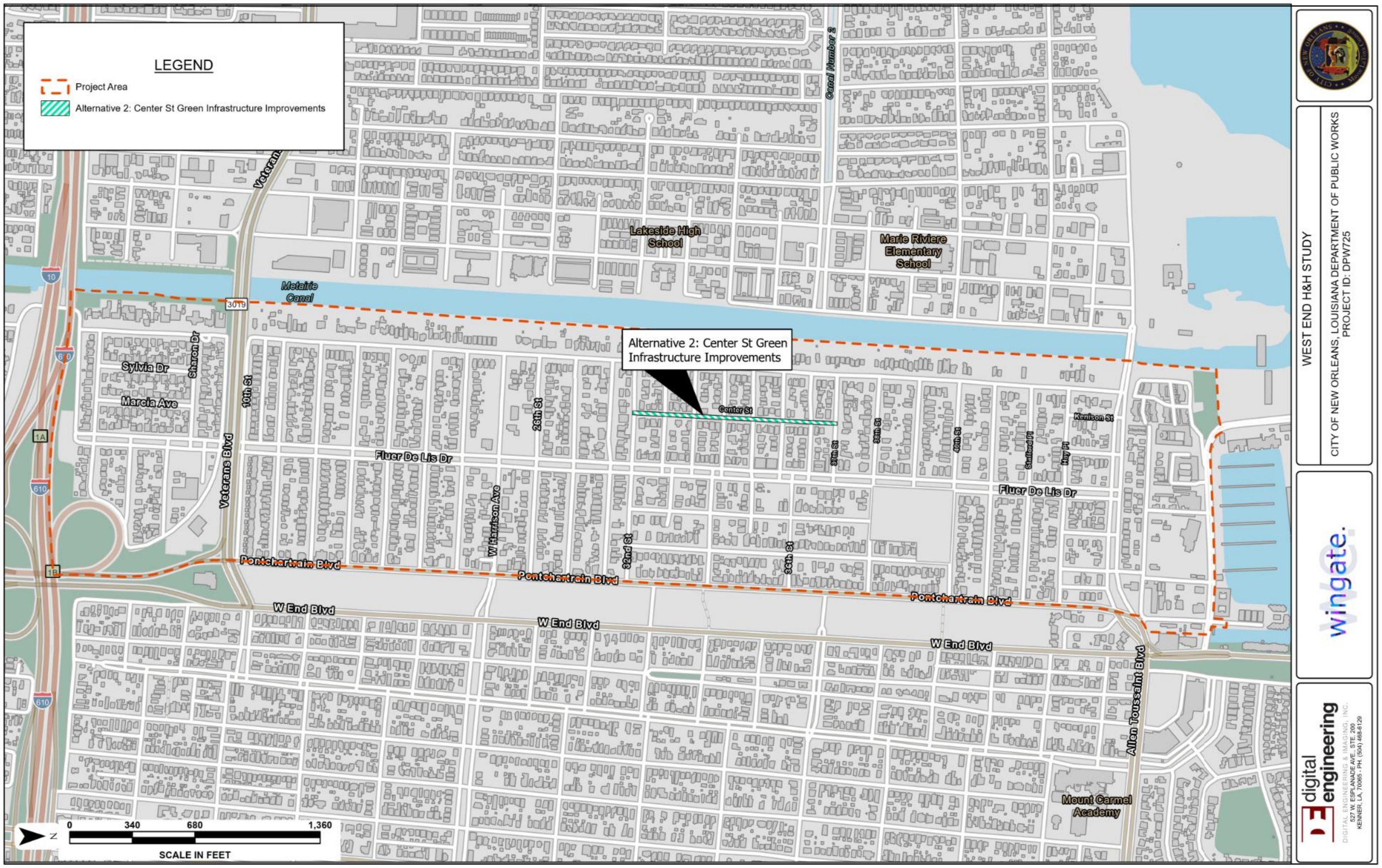



*Figure 52 – Proposed Project Alternative No. 2 Improvements*

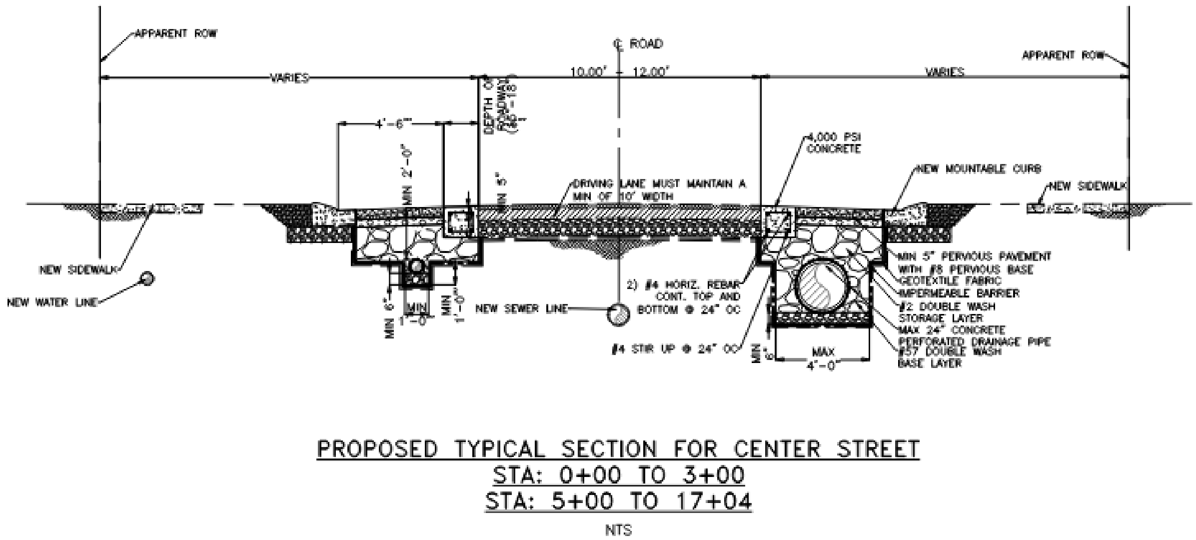



*Figure 53 – Typical Section of Project Alternative No. 2 – Center St.*

Compared to the existing conditions model for a 10-year design rainfall event, the average maximum water surface elevation for Alternative No. 2 decreased by approximately 0.00 feet with a maximum decrease of 0.13 feet. The decrease in the maximum water surface elevation (Max WSE) for Alternative No. 2 is caused by the increased subsurface retention system. Comparison results of the maximum water surface elevation near the proposed improvements for a 10-Year Design Storm are as follows:

- Center St. (32nd St. to 37th St.): Max WSE was not reduced.
- Bellaire Dr. (32nd St. to 37th St.): Max WSE was not reduced.

A map showing the 10-Year Design Storm Inundation for Alternative No. 2 is shown on Figure 54. A map showing the flood risk reduction observed if Alternative No. 2 proposed improvements were implemented to the study area in Figure 55.


Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

Figure 54 – 10-Year, 24-Hour Design Storm Inundation Map (Alternative No. 2)


**STUDY AREA (NORTH SIDE)**

**STUDY AREA (SOUTH SIDE)**

Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 55 – 10-Year, 24-Hour Design Storm Flood Risk Reduction Map (Alternative No. 2)*

### 4.4.6 Alternative No. 3 – Dispersed Green Infrastructure Improvements

In this alternative, the objective was to collect ponding surface runoff and divert it into a retaining system. This goal will be completed by inserting bioretention cells in the corners of T-intersections and four-way intersections. Adding these bioretention cells will not only collect surface runoff, but also will include landscaping to accomplish beautification. Permeable bioretention soil and highly rooted plants will absorb part of the runoff, filtering it in the process, while also allowing evapotranspiration. Base course stone beneath the soil will allow the surface runoff to infiltrate into the ground. Permeable Pavement will be placed within the confines of the intersection, allowing surface runoff to filter through its cracks, seeping into the soil layers beneath. These upgrades will require removing and replacing existing concrete and asphalt roadways and removing and replacing existing concrete walks, drives, and ramps. For this alternative, the following green infrastructure methods will be utilized:

- <u>Bioretention Cells:</u>
  - Installation of thirty (30) bioretention cells at intersections along Sharon Dr., Bellaire Dr., Hay Pl., and Avenue B. A total length of 1,688 linear feet of bioretention is proposed to be installed.
- <u>Permeable Pavement:</u>
  - Installation of eleven (11) permeable pavement systems at intersections along Sharon Dr., Bellaire Dr., Hay Pl., and Avenue B. A total length of 2,260 linear feet of permeable pavers with an infiltration trench underneath.

A figure representing these improvements is shown in Figure 56. A typical section of a Dispersed Intersection, including Bioretention Cells and Permeable Pavement, is shown in

Figure 57. Conceptual drawings were prepared for Alternative No. 3 and are located in Appendix D.

In developing the model for Alternative No. 3, the following assumptions were applied:

- Drainage upgrades included the installation of permeable pavement intersections that have undrain to a traditional drainage system and were designed as Low Impact Development (LIDs) in the model.
- Additionally, intersection included curb extensions that were bioretention cells that have underdrain to a traditional drainage system and were designed as Low Impact Development (LIDs) in the model.
- infiltration trenches above a permeable pavement surface and were designed as Low Impact Development (LIDs) in the model.

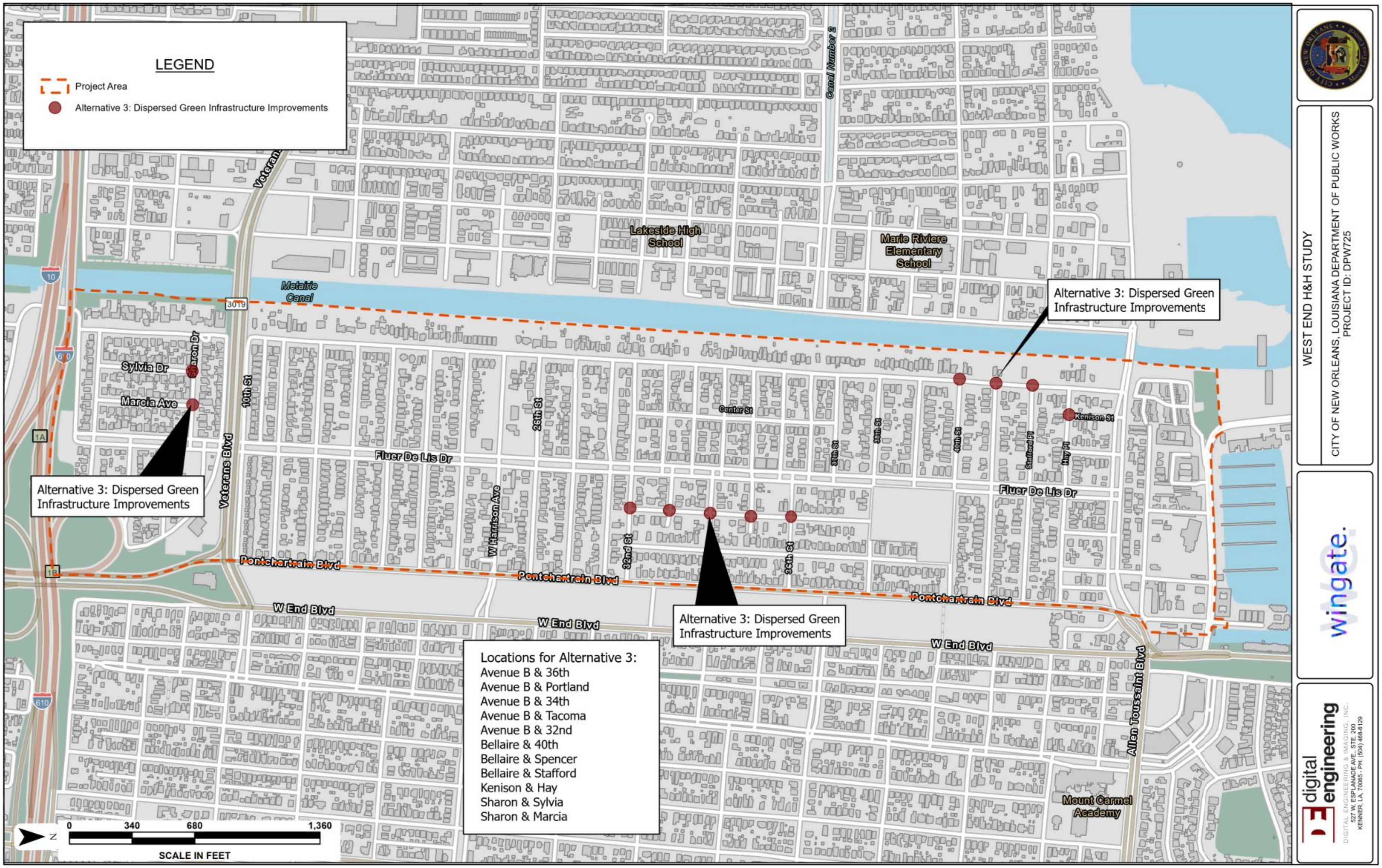



*Figure 56 – Proposed Project Alternative No. 3 Improvements*

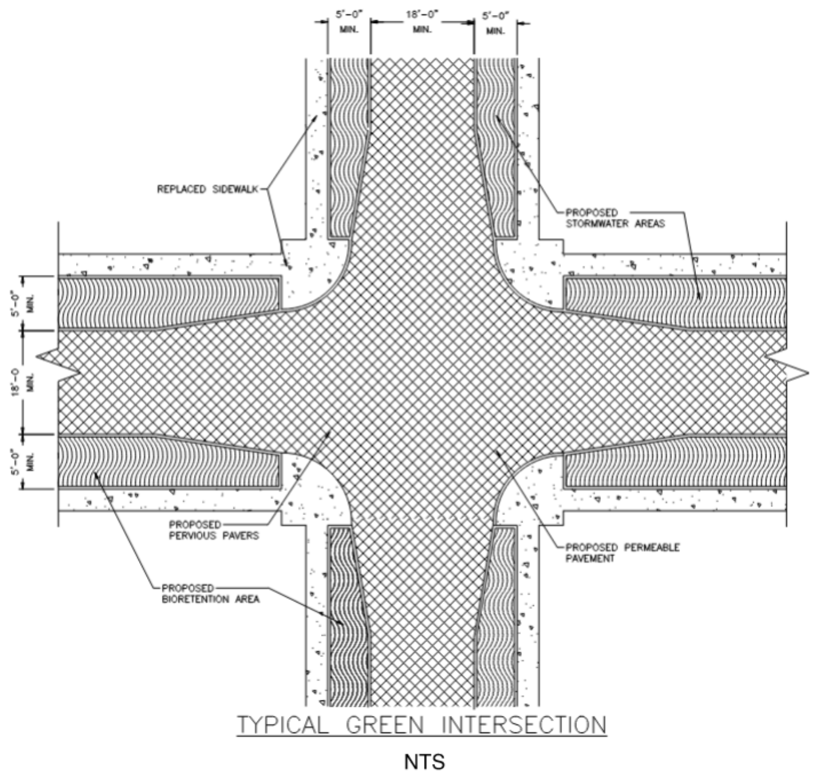



*Figure 57 – Schematic Plan View of Project Alternative No. 3 (Curb Extension & Permeable Pavement Intersections)*

Compared to the existing conditions model for a 10-year design rainfall event, the average maximum water surface elevation for Alternative No. 3 decreased by approximately 0.00 feet with a maximum decrease of 0.37 feet. The decrease in the maximum water surface elevation (Max WSE) for Alternative No. 3 is caused by the increased subsurface retention system. Comparison results of the maximum water surface elevation near the proposed improvements for a 10-Year Design Storm are as follows:

- Bellaire Dr. & Stafford Dr.: Max WSE was not reduced.
- Avenue B & 36th St.: Max WSE was not reduced.
- Sharon Dr. & Sylvia St.: Max WSE was not reduced.

A map showing the 10-Year Design Storm Inundation for Alternative No. 3 is shown on Figure 58. A map showing the flood risk reduction observed if Alternative No. 3 proposed improvements were implemented to the study area in Figure 59.


Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 58 – 10-Year, 24-Hour Design Storm Inundation Map (Alternative No. 3)*


Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 59 – 10-Year, 24-Hour Design Storm Flood Risk Reduction Map (Alternative No. 3)*

### 4.4.7 Alternative No. 4 – Bellaire Dr. Green Infrastructure Improvements

In this alternative, the objective was to create a connective solution to capture stormwater runoff from sidewalks and roadways and release it into the existing drainage system. The method of choice was infiltration trenches. The mulch and bioretention media guide water to a drain inlet that is tied into the existing drainage system. This method allows for storage and beautification. Plants and media capture and filter surface runoff as it flows through the system. To complete this objective, the upgrades will require removing and replacing concrete roadways, removing and replacing concrete walks and drives, and offsetting existing subsurface utilities. For this alternative, the following methods of green infrastructure will be implemented:

- Infiltration Trenches:
  - Installation of forty-two (42) infiltration trenches along both sides of Bellaire Dr. A total length of 1,824 linear feet of infiltration trenches is proposed to be installed.

A figure representing these improvements is shown in Figure 60. A typical section of an Infiltration Trench is shown in Figure 61. Conceptual drawings were prepared for Alternative No. 4 and are located in Appendix D.

In developing the model for Alternative No. 4, the following assumptions were applied:

- Drainage upgrades included the installation of bioretention cells with an underdrain to a traditional drainage system and were designed as Low Impact Development (LIDs) in the model.

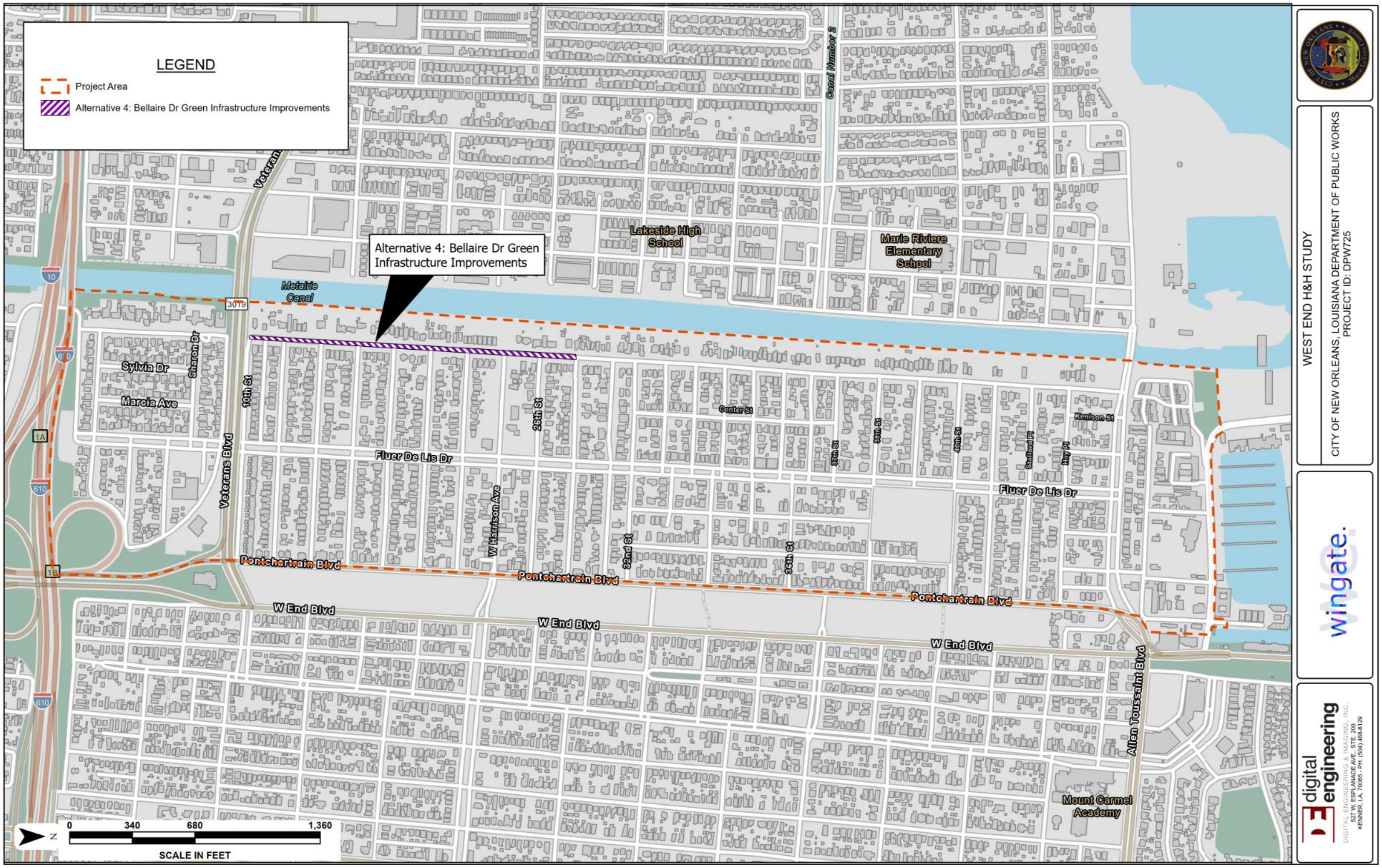



*Figure 60 – Proposed Project Alternative No. 4 Improvements*

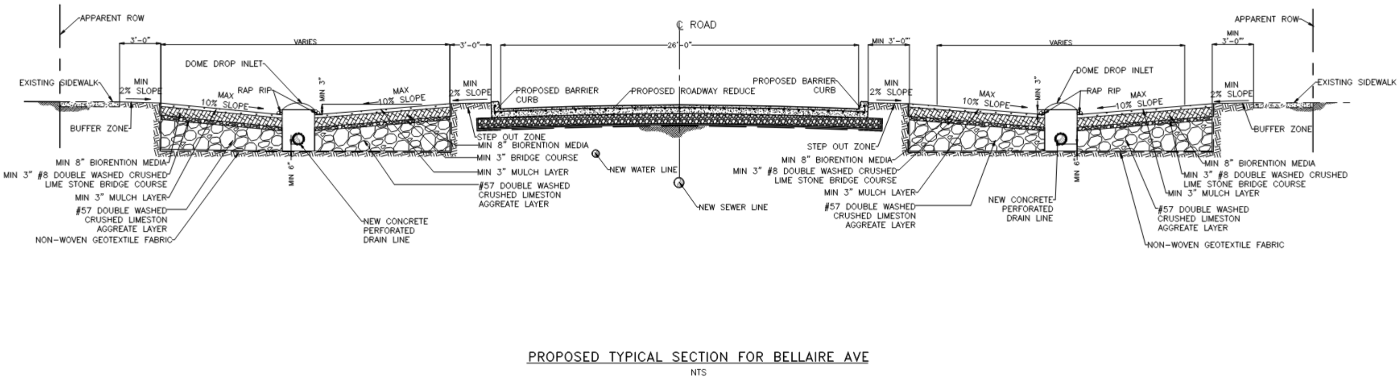



*Figure 61 – Typical Section of Project Alternative No. 4*

Compared to the existing conditions model for a 10-year design rainfall event, the average maximum water surface elevation for Alternative No. 4 decreased by approximately 0.00 feet with a maximum decrease of 0.37 feet. The decrease in the maximum water surface elevation (Max WSE) for Alternative No. 4 is caused by the increased subsurface retention system. Comparison results of the maximum water surface elevation near the proposed improvements for a 10-Year Design Storm are as follows:

- Bellaire Dr. & 12$^{th}$ St.: Max WSE was not reduced.
- Bellaire Dr. & 16$^{th}$ St.: Max WSE was not reduced.
- Bellaire Dr. & 22$^{nd}$ St.: Max WSE was not reduced.
- Bellaire Dr. & 26$^{th}$ St.: Max WSE was not reduced.

A map showing the 10-Year Design Storm Inundation for Alternative No. 4 is shown on Figure 62. A map showing the flood risk reduction observed if Alternative No. 4 proposed improvements were implemented to the study area in Figure 63.

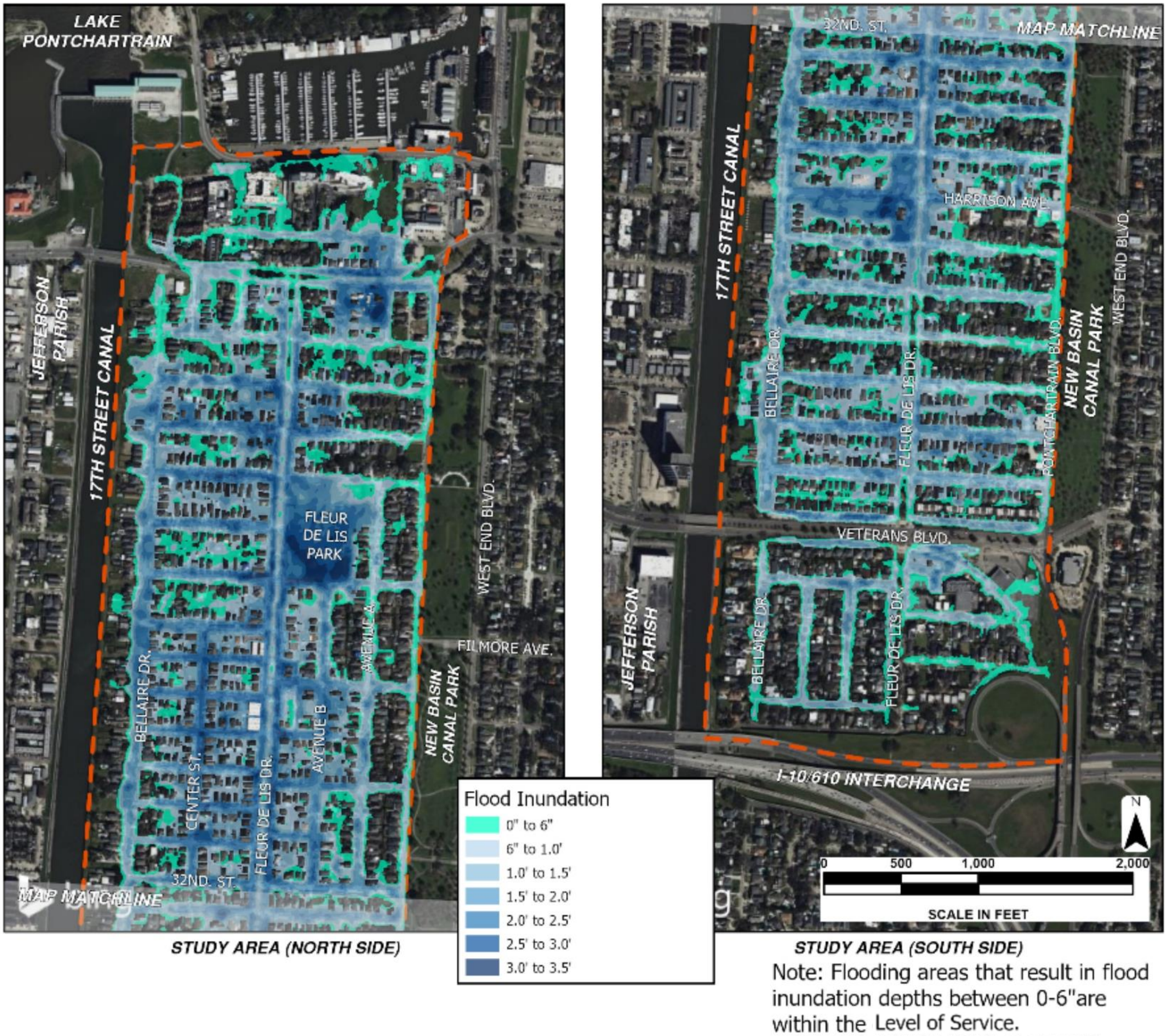



*Figure 62 – 10-Year, 24-Hour Design Storm Inundation Map (Alternative No. 4)*


*Figure 63 – 10-Year, 24-Hour Design Storm Flood Risk Reduction Map (Alternative No. 4)*

### 4.4.8 Alternative No. 5 – Harrison Ave. Subsurface Retention System

In this alternative, the objective was to convey surface runoff into storage that slowly releases back into the existing system. Similar to Alternative No. 1, Alternative No. 5 will include Modular Subsurface Retention Systems to attract runoff and convert it to storage. The Retention Systems will then slowly release all the stored runoff back into the existing drainage system. These upgrades will require removing and replacing concrete walks and drives as necessary and offsetting existing utilities. For this alternative, the following green infrastructure concepts will be implemented:

- Modular Subsurface Retention System:
- Installation of a 158,360 cubic foot Modular Subsurface Retention System south of W Harrison Ave. that will require the implementation of 25 linear feet of 42" Reinforced Concrete Pipe and 47 linear feet of 42" Reinforced Concrete Pipe.
- Installation of 42,040 cubic foot Modular Subsurface Retention System on the northeast side of W Harrison Ave. that will require the implementation of 38 linear feet of 18" Reinforced Concrete Pipe and 47 linear feet of 42" Reinforced Concrete Pipe.

A figure representing these improvements is shown in Figure 64. A typical section of the Modular Subsurface Retention System proposed for Alternative No. 5 is shown in

Figure 65. Conceptual drawings were prepared for Alternative No. 5 and are located in Appendix D.

In developing the model for Alternative No. 5, the following assumptions were applied:

- Drainage Conveyance improvements to the two (2) subsurface retention systems in Fleur De Lis park include increasing drainage line diameter along W. Harrison Ave. at Fleur De Lis Dr.
- Alternative No. 5 subsurface retention system was modeled by utilizing two (2) storage nodes with approximately 6.5' of retention and resulted in 200,400 cubic feet of subsurface stormwater capacity at Fleur De Lis Park.
- There are two (2) 18" Reinforced Concrete Pipe (RCP) outfalls with an inline check valve proposed to be installed to prevent backflow at the outfall of the subsurface retention systems.

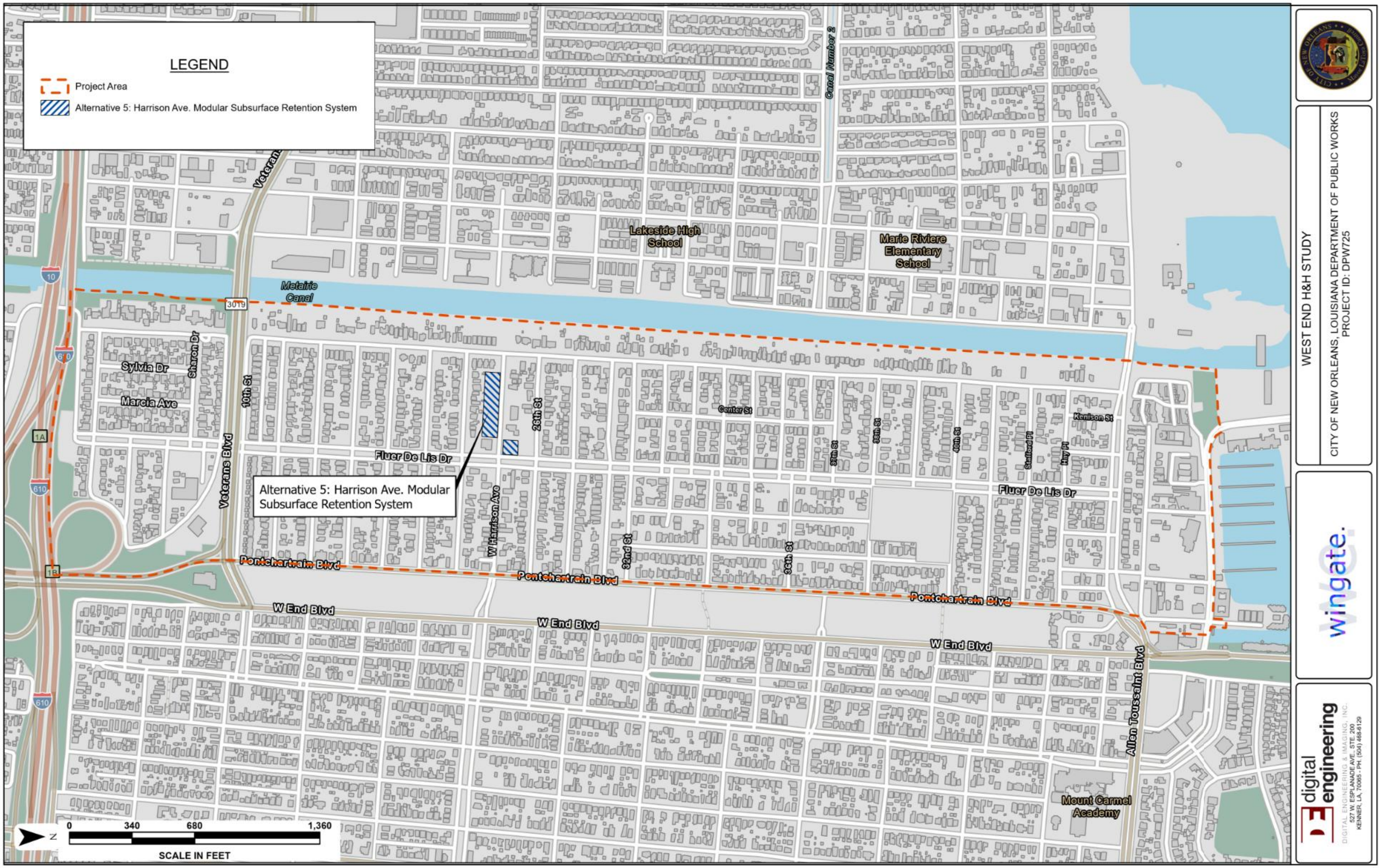



*Figure 64 – Proposed Project Alternative No. 5 Improvements*

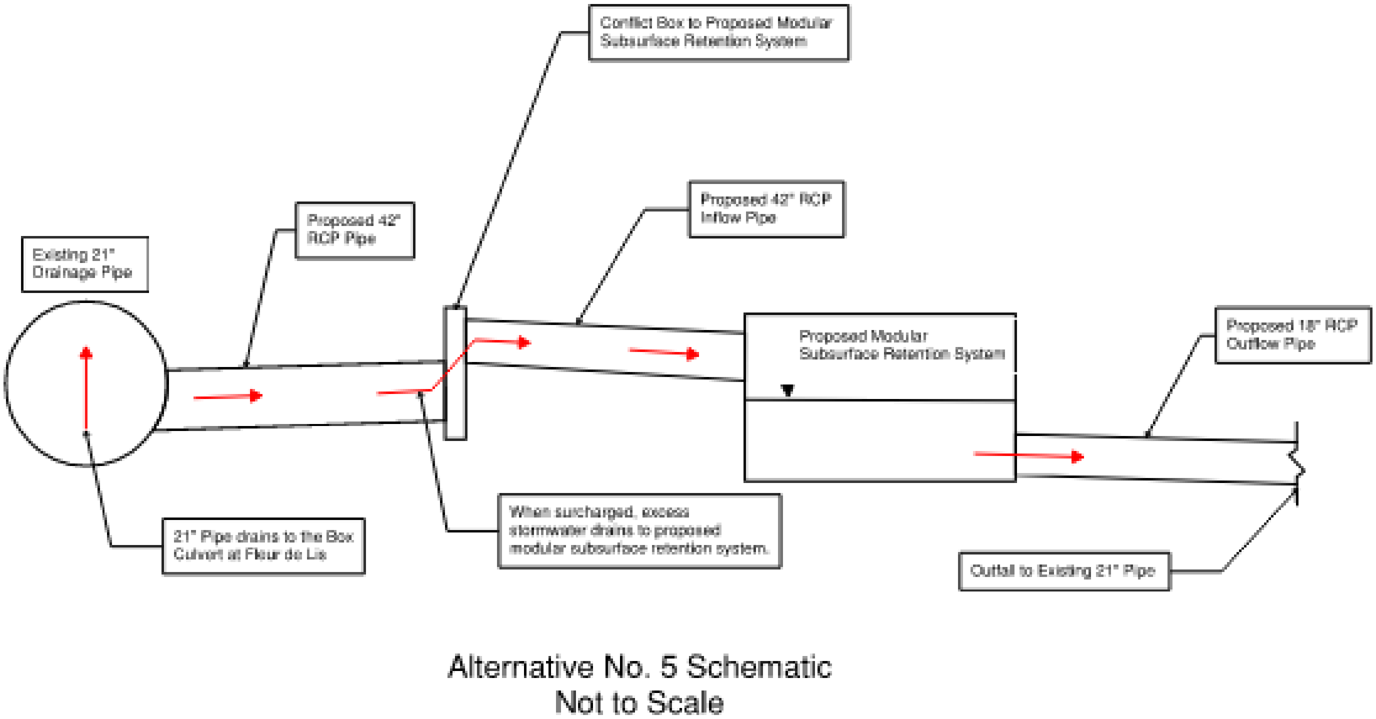



*Figure 65 – Schematic Section of Project Alternative No. 5*

Compared to the existing conditions model for a 10-year design rainfall event, the average maximum water surface elevation for Alternative No. 5 decreased by approximately 0.29 feet with a maximum decrease of 1.69 feet. The decrease in the maximum water surface elevation (Max WSE) for Alternative No. 5 is caused by the increased subsurface retention system. Comparison results of the maximum water surface elevation near the proposed improvements for a 10-Year Design Storm are as follows:

- Harrison Ave. & Fleur De Lis Dr.: Max WSE reduced by 0.29' (38.67%) to -5.94'
- Harrison Ave. & Bellaire Dr.: Max WSE reduced by 0.29' (16.76%) to -5.94'

A map showing the 10-Year Design Storm Inundation for Alternative No. 5 is shown on Figure 66. A map showing the flood risk reduction observed if Alternative No. 5 proposed improvements were implemented to the study area in Figure 67.


Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 66 – 10-Year, 24-Hour Design Storm Inundation Map (Alternative No. 5)*


STUDY AREA (NORTH SIDE)

STUDY AREA (SOUTH SIDE)

Note: Flooding areas that result in flood inundation depths between 0-6"are within the Level of Service.

*Figure 67 – 10-Year, 24-Hour Design Storm Flood Risk Reduction Map (Alternative No. 5)*

### 4.4.9 Alternative No. 6 – All Alternatives Combined

In this alternative, all of the proposed green infrastructure improvements in the West End neighborhood will be implemented. Although this alternative will give the neighborhood the most relief from flooding and stormwater runoff issues, it will cause the most inconvenience for the residents, as multiple street closures and construction sites will be required in the area. Also, access to several parts of the neighborhood will be limited as a result of this proposed alternative. A figure representing these improvements is shown in Figure 68.

In developing the model for Alternative No. 6, the following assumptions were applied:

- All proposed improvements in Alternatives No. 1-5 are incorporated into the Alternative No. 6 and in the model.

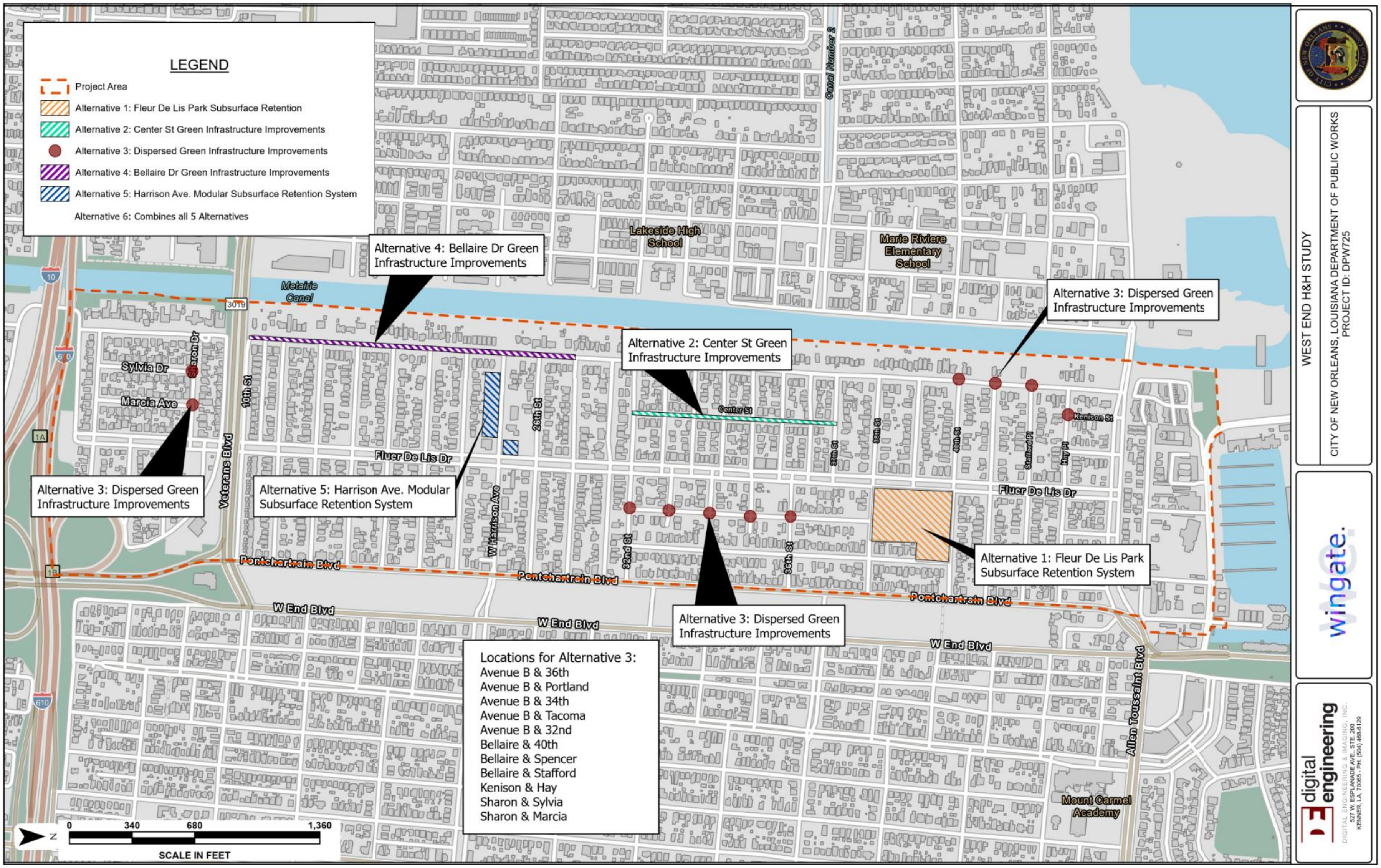



*Figure 68 – Proposed Project Alternative No. 6 Improvements*

Compared to the existing conditions model for a 10-year design rainfall event, the average maximum water surface elevation for Alternative No. 6 decreased by approximately 0.29 feet with a maximum decrease of 1.67 feet. The decrease in the maximum water surface elevation (Max WSE) for Alternative No. 6 is caused by the increased subsurface retention system. Comparison results of the maximum water surface elevation near the proposed improvements for a 10-Year Design Storm are as follows:

- Bellaire Dr. & Stafford Dr.: Max WSE reduced by 0.31′ (19.86%) to -5.98′
- Avenue B & 36th St.: Max WSE reduced by 0.32′ (17.01%) to -5.98′
- Sharon Dr. & Sylvia St.: Max WSE reduced by 0.11′ (6.13%) to -5.59′
- Bellaire Dr. & 12th St.: Max WSE reduced by 0.24′ (12.62%) to -5.87′
- Bellaire Dr. & 16th St.: Max WSE reduced by 0.24′ (13.23%) to -5.88′
- Bellaire Dr. & 22nd St.: Max WSE reduced by 0.31′ (21.87%) to -5.96′
- Bellaire Dr. & 26th St.: Max WSE reduced by 0.31′ (15.12%) to -5.96

A map showing the 10-Year Design Storm Inundation for Alternative No. 6 is shown on Figure *69*. A map showing the flood risk reduction observed if Alternative No. 6 proposed improvements were implemented to the study area in Figure 70.

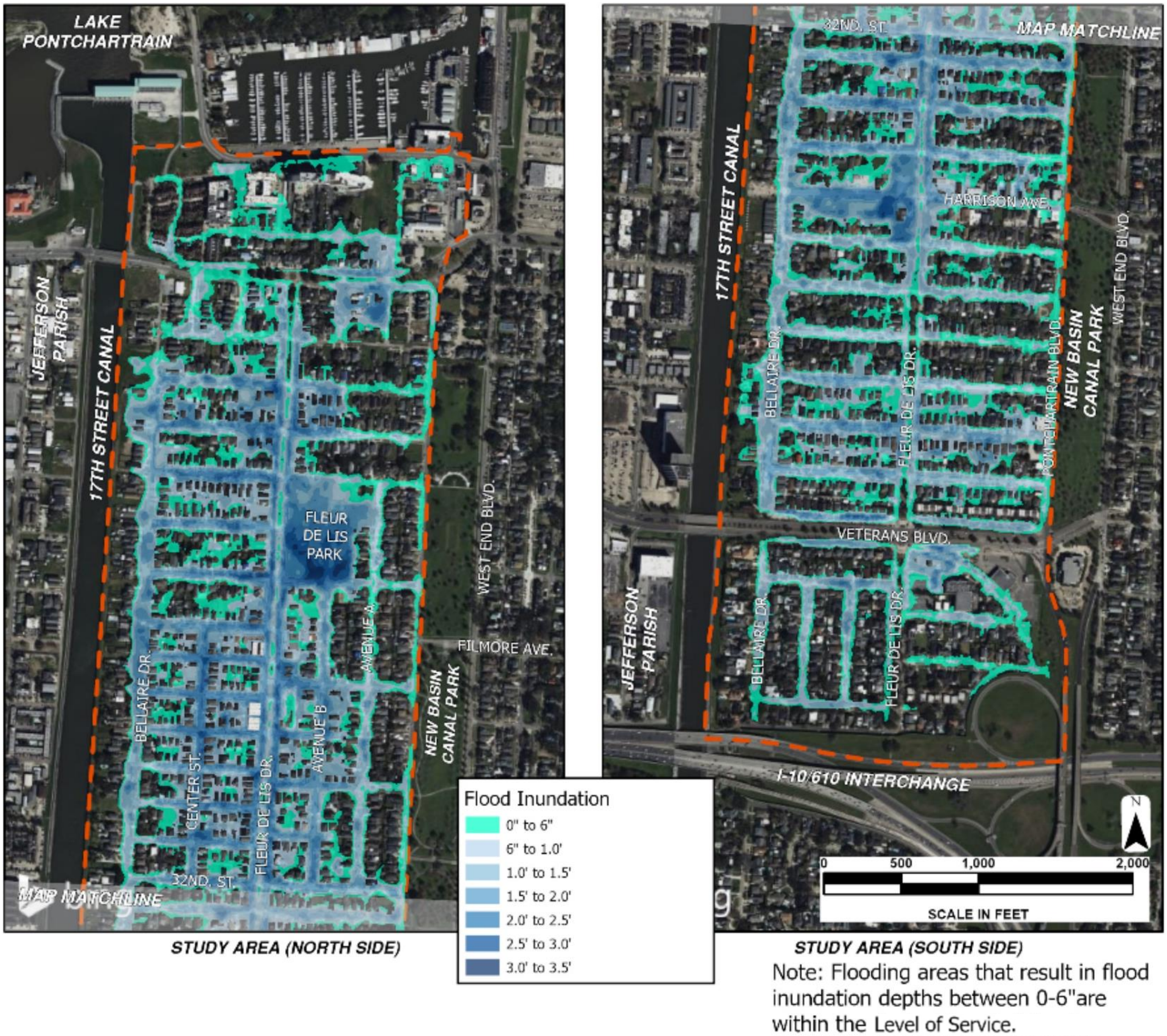



*Figure 69 – 10-Year, 24-Hour Design Storm Inundation Map (Alternative No. 6)*


*Figure 70 – 10-Year, 24-Hour Design Storm Flood Risk Reduction Map (Alternative No. 6)*

### 4.4.10 Model Findings and Limitations Observed

Flood Inundation Maps for all three (3) Model simulations for each of the six (6) project alternatives in provided as Appendix B. All proposed alternatives reduce the maximum water surface elevation relative to the existing conditions model. Alternative No. 6 reduces it the most, followed by Alternative No. 1 and Alternative No. 5. The reduction to the maximum water depth observed at the storage nodes between Alternative No. 2, Alternative No. 3, and Alternative No. 4 was negligible.

SECTION 5
# RECOMMENDATIONS
CITY OF NEW ORLEANS: WEST END H&H DRAINAGE STUDY

# 5. Recommendations

## 5.1 Preferred Solution

The DE Team considered all six (6) project alternatives in the selection of a preferred project solution for implementation in the West End study area. While the DE Team utilized a solution's impact in reducing flood risk as a major decision factor, the potential positive impact to the community and how it can address other City of New Orleans' needs was also considered. The impacts utilized by the DE Team to analyze all six (6) project alternatives are listed as follows:

- Reduce Flood Risk
- Risk Reduction: Increase Storage Capacity
- Risk Reduction: Incorporate New Green Spaces
- Reduce Urban Heat Impact
- Other Infrastructure Benefits: Civil Infrastructure Upgrades
- Other Infrastructure Benefits: Recreational & Community Opportunities
- Implementation Measure: Cost
- Implementation Measure: Schedule
- Beautification to Public Spaces

Each project alternative was evaluated for its performance in each criteria mentioned above which are shown on Error! Reference source not found.. Alternatives No. 1 & 5 reduce flood risk in the s tudy area. Alternative No. 1 is a proposed solution within an existing City of New Orleans park space, which could be tied with recreational improvements to enhance the park's benefits to the community, such as installation of playground and community spaces. To implement Alternative No. 5, the empty lots along W. Harrison Ave. would need to be acquired. Alternatives No. 2-4 propose infrastructure solutions throughout the West End study area along sections of streets that require immediate roadway repairs due to their current condition. Many of the proposed construction costs for these three (3) alternatives were due to the need to completely reconstruct the roadway. The DE Team recommends moving forward with Alternative No. 1 as a priority potential solution to reduce flood risk in the study area. Additionally, the DE Team recommends the City of New Orleans consider Alternative No. 5 as a potential solution to reduce flood risk in the study area, so long as it finds it viable to purchase the empty lots located along Harrison Ave. Alternatives No. 2-4 should be considered for implementation should the City of New Orleans identify the other civil infrastructure, such as water, sewer, and roadway infrastructure, priority for implementation.

*Table 8 – Project Alternatives Analysis Matrix*

| Scoring Criteria | Alt. 1 | Alt. 2 | Alt. 3 | Alt. 4 | Alt. 5 | Alt. 6 |
|---|---|---|---|---|---|---|
| Reduce Flood Risk | ✓ | | | | ✓ | ✓ |
| Risk Reduction: Increase Storage Capacity (CUFT) | 450,000 | 10,000 | 50,000 | 80,000 | 200,000 | 790,000 |
| Improve Public Green Spaces | ✓ | | ✓ | ✓ | ✓ | ✓ |
| Reduce Urban Heat Impact | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Civil Infrastructure Upgrades | | ✓ | ✓ | ✓ | | ✓ |
| Recreational & Community Opportunities | ✓ | | | | | ✓ |
| Implementation Measure: Cost | $11,266,671.75 | $8,736,081.63 | $12,764,274.97 | $14,977,895.31 | $6,825,796.62 | $53,695,813.03 |
| Implementation Measure: Schedule | 24 months | 24 months | 24 months | 24 months | 36 months | 48 months |
| Beautification to Public Spaces | ✓ | | ✓ | ✓ | ✓ | ✓ |

* Storage Capacity are approximate quantities.

## 5.2 Implementation

The DE Team considered all six (6) project alternatives in the selection of a preferred project solution for implementation. Each project alternative was evaluated for its performance in each criteria mentioned above which are shown on Error! Reference source not found.. The DE Team r ecommends to City of New Orleans to investigate potential grant funding opportunities for implementation of Alternatives No. 1 & 5, such as the FEMA Building Resilient Infrastructure & Communities (BRIC) program. Additional data may be necessary to submit for grant funding opportunities, which may include the following:

- Develop Benefit-Cost-Ratio for Proposed Solutions
- Study Proposed Solutions Potential benefit to the Community
- Engage with Community by Public Engagement Meeting on Project Solution
- Study the Recommended Project Solutions' Impact to Disadvantaged Communities

digital engineering

SECTION 6

# REFERENCES SOURCED

CITY OF NEW ORLEANS: WEST END H&H DRAINAGE STUDY

## 6. References Sourced


EPA (2021). Green Streets Handbook. Retrieved from https://www.epa.gov/sites/default/files/2021-04/documents/green_streets_design_manual_feb_2021_web_res_small_508.pdf

EPA (2023). Reduce Urban Heat Island Effect. Retrieved from https://www.epa.gov/green-infrastructure/reduce-urban-heat-island-effect#:~:text=Trees%2C%20green%20roofs%2C%20and%20vegetation,releasing%20moisture%20into%20the%20atmosphere.

Louisiana State University Department of Geography & Anthropology, Atlas Lidar, Retrieved from: https://maps.ga.lsu.edu/lidar2000/.

National Oceanic and Atmospheric Administration (NOAA), National Centers for Environmental Information. Retrieved from: https://www.ncdc.noaa.gov/cdo-web/.

State of Louisiana Department of Development and Transportation, 2011 Hydraulics Manual.

Sewerage & Water Board of New Orleans Press Release for December 2, 2023 loss of power to DPS 12. Retrieved from https://www.swbno.org/PressReleases/Details/4794.

Sewerage & Water Board of New Orleans Stormwater Master Plan, 2022.

Sewerage & Water Board of New Orleans July 10, 2019 Rainfall Event Modeling and Mapping. Retrieved from https://www.swbno.org/documents/Reports/July%2010%202019%20Rainfall%20Event%20Modeling%20Report.pdf.

City of New Orleans Department of Public Works General Specifications for Street Paving, 2015 edition. Retrieved from https://nola.gov/nola/media/DPW/Construction%20Engineering%20Resources/dpw-general-specifications-final-jan-4-2016.pdf.

Severe flooding in New Orleans' Lakeview neighborhood near Fleur De Lis Drive. Retrieved from https://www.wafb.com/video/2023/12/02/severe-flooding-new-orleans-lakeview-neighborhood-near-fleur-de-lis-drive/.