FINAL

FULLERWOOD NEIGHBORHOOD RESILIENCE AND DRAINAGE STUDY

Technical Memo

BLACK & VEATCH PROJECT NO. 418216

PREPARED FOR

The City of St. Augustine

28 JULY 2024

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1.0 Project Summary

The Fullerwood Neighborhood Resilience and Drainage Study (contract number 23029 (PW2023-01E)) was performed to help this low-lying coastal community located on the north side of the City of St. Augustine identify potential ways in which they could improve nuisance flooding in the area. This study focused on Fern Street, Althea Street, Atlantic Avenue, Seminole Drive, Beacon Street, Oak Street, and Oak Tree Lane - roadways that do not currently have existing drainage infrastructure and are facing increased nuisance flooding from typical rainfall events. The parcels have little natural slope and are bordered by marsh on the north and east sides.

A PCSWMM model was developed using local data such as a digital elevation model (DEM), soil type, rainfall, and future land use data to simulate neighborhood flooding during 5-year, 25-year, and 100-year rainfall events. The results of the existing conditions model showed flooding along neighborhood roadways and towards the rear of the parcels which was consistent with the flooding seen by residents and City staff.

Four stormwater mitigation alternatives were designed each incorporating different combinations of stormwater mitigation strategies. Alternative 1 utilizes three (3) outfalls, conveyance pipe, and inlets to divert stormwater from neighborhood roadways. Additionally, this alternative proposes road refurbishment through milling and overlay patching for most area roadways as well as road repaving in localized areas. Alternative 2 also utilized three (3) outfalls, conveyance pipe, and inlets to divert stormwater; however, this alternative also makes use of two (2) stormwater retention ponds and gutters. One of the proposed stormwater ponds would be located on property currently owned by the City but land for the second pond would need to be acquired. In contrast to Alternative 1, Alternative 2 proposes large sections of road be repaved to accommodate the proposed gutters. Alternative 3 combines ideas from Alternatives 1 and 2 and proposes three (3) outfalls, conveyance pipe, inlets, road refurbishment through milling and overlay patching, road repaving in localized areas, and a stormwater retention pond on a City-owned parcel. In addition, Alternative 3 proposes two swales be installed along property lines. Alternative 4 was designed using future rainfall amounts. Along with the three (3) outfalls, inlets, and conveyance pipe proposed by all the other alternatives, Alternative 4 proposes nearly all neighborhood roadways to be repaved, gutters to be installed, and a pump station to be furnished. The parcel owned by the City would be regraded slightly and turned into a pocket park for the neighborhood.

1.1 Recommended Alternative

To most accurately determine which of the four alternatives would provide the most value for the City and residents of Fullerwood, a benefit-cost ratio (BCR) was determined for each alternative. To do this, the depth-damage result was calculated for each parcel and summed for each alternative using the FEMA depth-damage equation. The BCR was then calculated by dividing by the money saved by implementing each alternative (the base condition depth-damage result minus the depth-damage result determined for each alternative) by the cost to implement each alternative. The largest ratio represents the greatest benefit to cost ratio and identifies the alternative that provides the most value. This analysis determined that Alternative 3 would give the City the greatest benefit in flood reduction per dollar spent on flood improvement. **Table 1-1** shows the benefit-cost ratio for each of the proposed design alternatives. Alternative 3 proposes two swales, one that begins at the proposed stormwater pond at the City owned parcel (1513300251) and runs northeast along parcel lines terminating in the marsh. The second swale begins behind 28 Atlantic Ave and runs northwest alone parcel lines terminating in the marsh. To construct these swales, easements would need to be procured. The timeline to secure these easements should be considered when drafting the project completion timeline. **Table 1-2** lists the parcel numbers and corresponding property addresses that will be impacted by the construction of the proposed swales.

Table 1-1 Benefit-Cost Ratio by Proposed Stormwater Mitigation Alternative

Alternative	Alternative Implementation Cost	Savings Incurred by Implementing Alternative	Benefit-Cost Ratio
Alternative 1	$1,411,867.60	$1,310,096.45	0.93
Alternative 2	$3,439,350.20	$1,294,309.82	0.38
Alternative 3	$1,671,412.60	$2,026,121.50	1.21
Alternative 4	$1,731,807.80	$796,732.90	0.46

Table 1-2 Parcels Impacted by Alternative 3 Swale Installation

SWALE	PIN	Parcel Address
ATLANTIC AVE	151170 0000	20 ATLANTIC AVE
ATLANTIC AVE	151150 0040	8 ALTHEA ST
ATLANTIC AVE	151150 0060	6 ALTHEA ST
ATLANTIC AVE	151200 0000	28 ATLANTIC AVE
SEMINOLE DR	151320 0200	12 FERN ST
SEMINOLE DR	151320 0210	30 SEMINOLE DR
SEMINOLE DR	151320 0200	12 FERN ST
SEMINOLE DR	151250 0001	0 SEMINOLE DR

2.0 Project Background

2.1 Existing Conditions

The Fullerwood neighborhood is located north of the City center and west of the Tolomato River. This resilience and drainage study focuses specifically on the properties along Seminole Drive, Fern Street, Althea Street, Oak Tree Lane, Oak Street, Atlantic Avenue, and Beacon Street. The neighborhood is generally low-lying, with roads typically at grade, leading residents to experience nuisance flooding after rainfall. Roadways and rights-of-way contain minimal to no drainage infrastructure. Residents have seen increased flooding and property damage. As such, the City has requested Black & Veatch to complete a drainage assessment for the Fullerwood neighborhood. It is important to note that this drainage study only focuses on nuisance flooding due to typical rainfall events. Although there are other events, such as high tides, nor'easters, storm surges, and hurricanes, these events were not included in the scope of flood concerns for this project. Below, **Figure 2-1** shows ponding typical of a rainfall event in the Fullerwood neighborhood. **Figure 2-2** below shows stormwater work orders and service requests called in by neighborhood residents from 2020 to 2023 overlaid onto a digital elevation model (DEM) for the Fullerwood neighborhood. This map helps illustrate some of the problem areas in the Fullerwood neighborhood. Brief descriptions of the work orders and service requests submitted can also be found in a table embedded in **Figure 2-2**. The DEM was obtained from the Florida Geographic Information Office and was flown from November 2018 to March 2019.

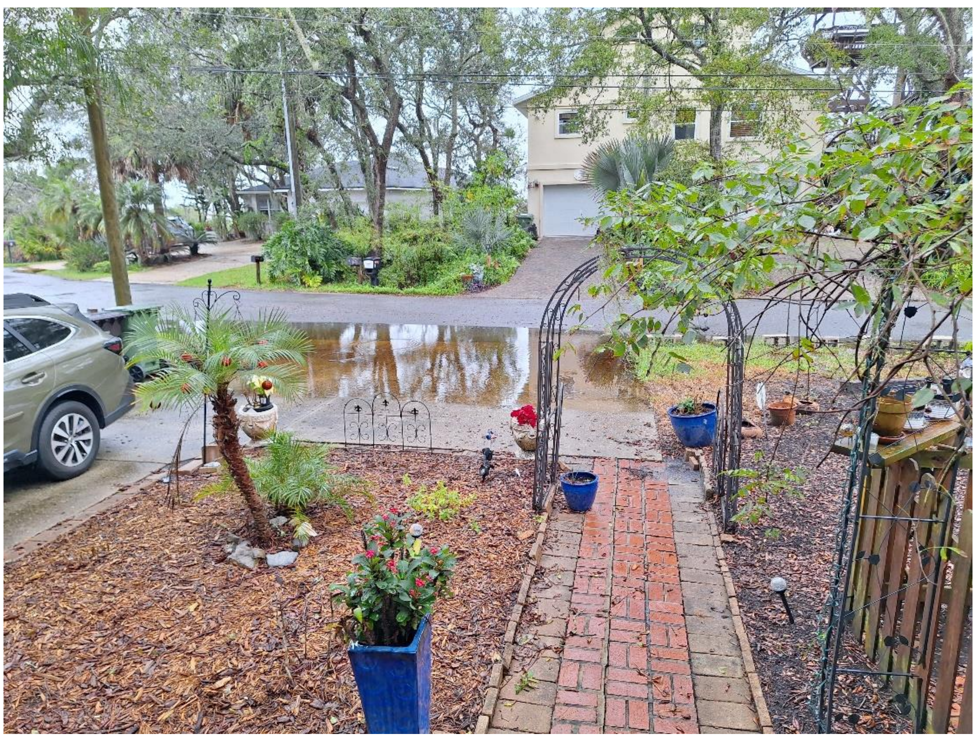
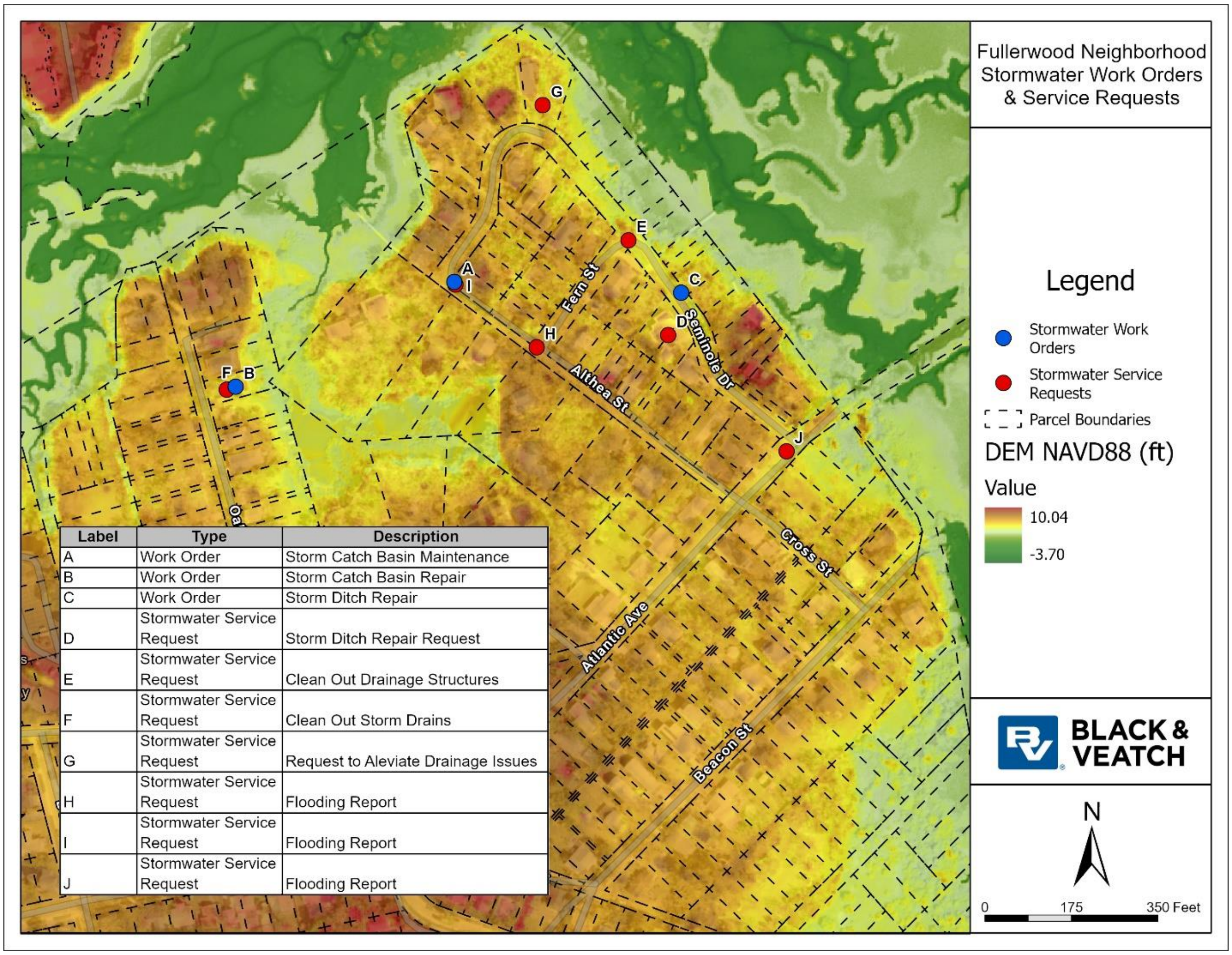


Figure 2-1 An Example of Flooding Seen in the Fullerwood Neighborhood



Label	Type	Description
A	Work Order	Storm Catch Basin Maintenance
B	Work Order	Storm Catch Basin Repair
C	Work Order	Storm Ditch Repair
D	Stormwater Service Request	Storm Ditch Repair Request
E	Stormwater Service Request	Clean Out Drainage Structures
F	Stormwater Service Request	Clean Out Storm Drains
G	Stormwater Service Request	Request to Aleviate Drainage Issues
H	Stormwater Service Request	Flooding Report
I	Stormwater Service Request	Flooding Report
J	Stormwater Service Request	Flooding Report

Figure 2-2 Stormwater Work Orders and Service Requests Submitted for the Fullerwood Neighborhood

Roads within the Fullerwood neighborhood do not have curb and gutter systems to convey water away from parcels, leaving standing water that can be present for extended periods. The neighborhood has three outfalls: Oak Street, Beacon Street, and Seminole Drive. The Oak Street outfall collects stormwater from two inlets at the north corners of 29 and 31 Oak Street. The area where these two inlets lie is a local minimum and is known to experience frequent nuisance flooding. The outfall then discharges into the marsh behind the homes on the east side of Oak Street between 35 and 31 Oak Street. The Beacon Street outfall collects stormwater from a single inlet in front of 33 Beacon Street, just before the intersection with Cross Street. The outfall discharges to an open drain on the easternmost end of Beacon Street, which finally terminates in the marsh. The Seminole Drive outfall collects water from an inlet at the bottom of the driveway at 25 Seminole Drive, which is then conveyed through an 8-inch PVC pipe to the marsh at the end of Seminole Drive. Below, **Figure 2-3** shows the existing sewer, potable water, and stormwater utilities along the streets within the Fullerwood neighborhood, and **Table 2-1** shows utility providers by Sunshine811 ticket area and number. **Figure 2-4** and **Figure 2-5** show detailed views of the existing stormwater utilities on Oak and Beacon Streets, respectively. The City installed the Seminole Drive outfall in May of 2024, and it is not yet mapped in GIS; however, photos are included in **Figure 2-6.** It should be noted that all four stormwater mitigation alternatives show this outfall as a proposed improvement as the outfall was installed at the time of their development.

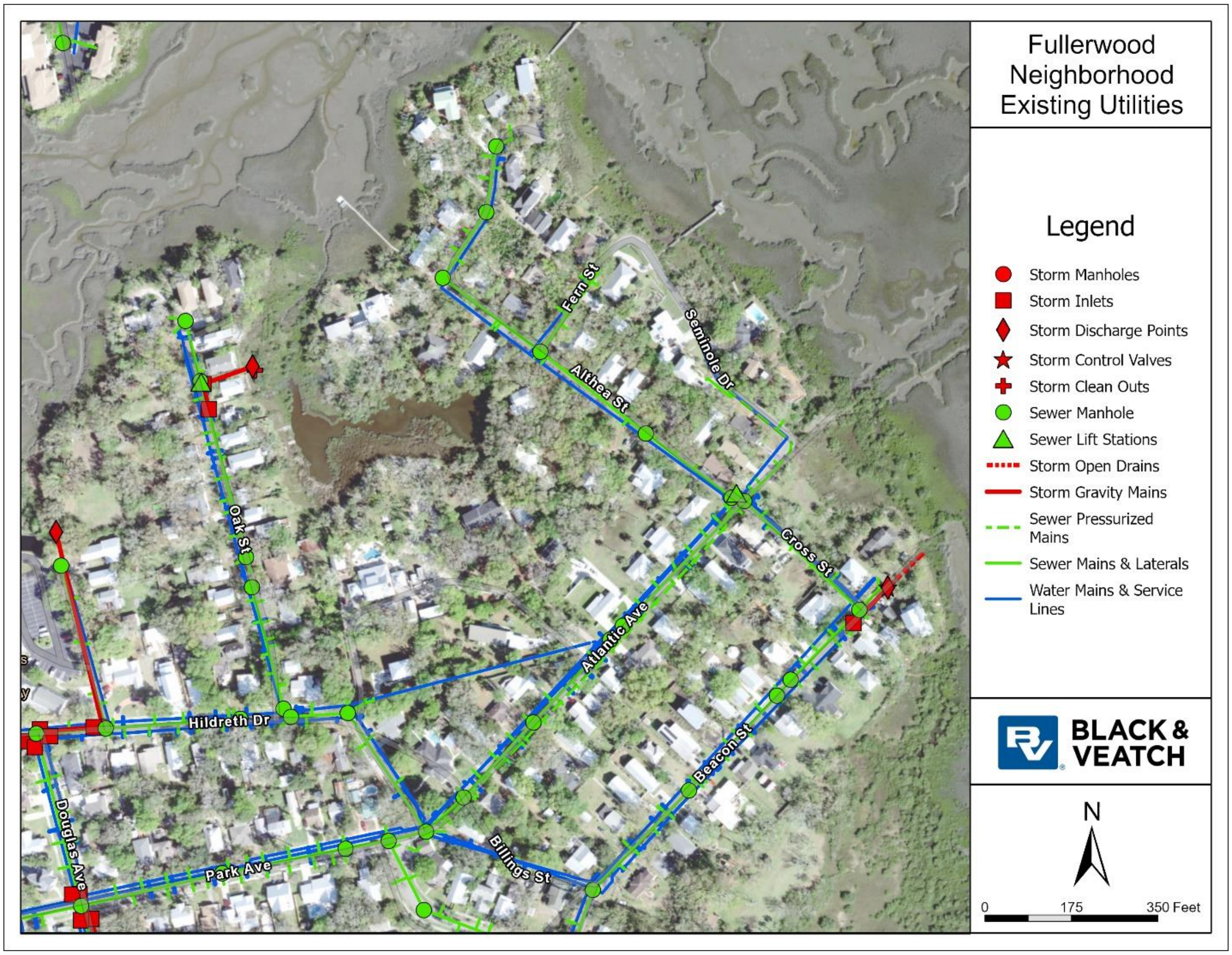


Figure 2-3 All Existing Sewer, Water, and Stormwater Utilities Within the Fullerwood Neighborhood

Table 2-1 Fullerwood Neighborhood Utilities as Reported by Sunshine811

Ticket No.	Ticket Type	Street	Telephone	Sewer/Water	Electric
136407230	Between Intersections	Oak Street	AT&T	CoSA	FPL
136407296	Street	Oak Tree Lane	AT&T	CoSA	FPL
136407508	Street	Atlantic Avenue	AT&T	CoSA	FPL
136407549	Street	Beacon Street	AT&T	CoSA	FPL
136407586	Between Intersections	Cross Street	AT&T	CoSA	FPL
136407781	Between Intersections	Althea Street	AT&T	CoSA	FPL

136407816	Between Intersections	Seminole Drive	AT&T	CoSA	FPL
136407832	Between Intersections	Fern Street	AT&T	CoSA	FPL
136407929	Street	Seminole Drive	AT&T	CoSA	FPL

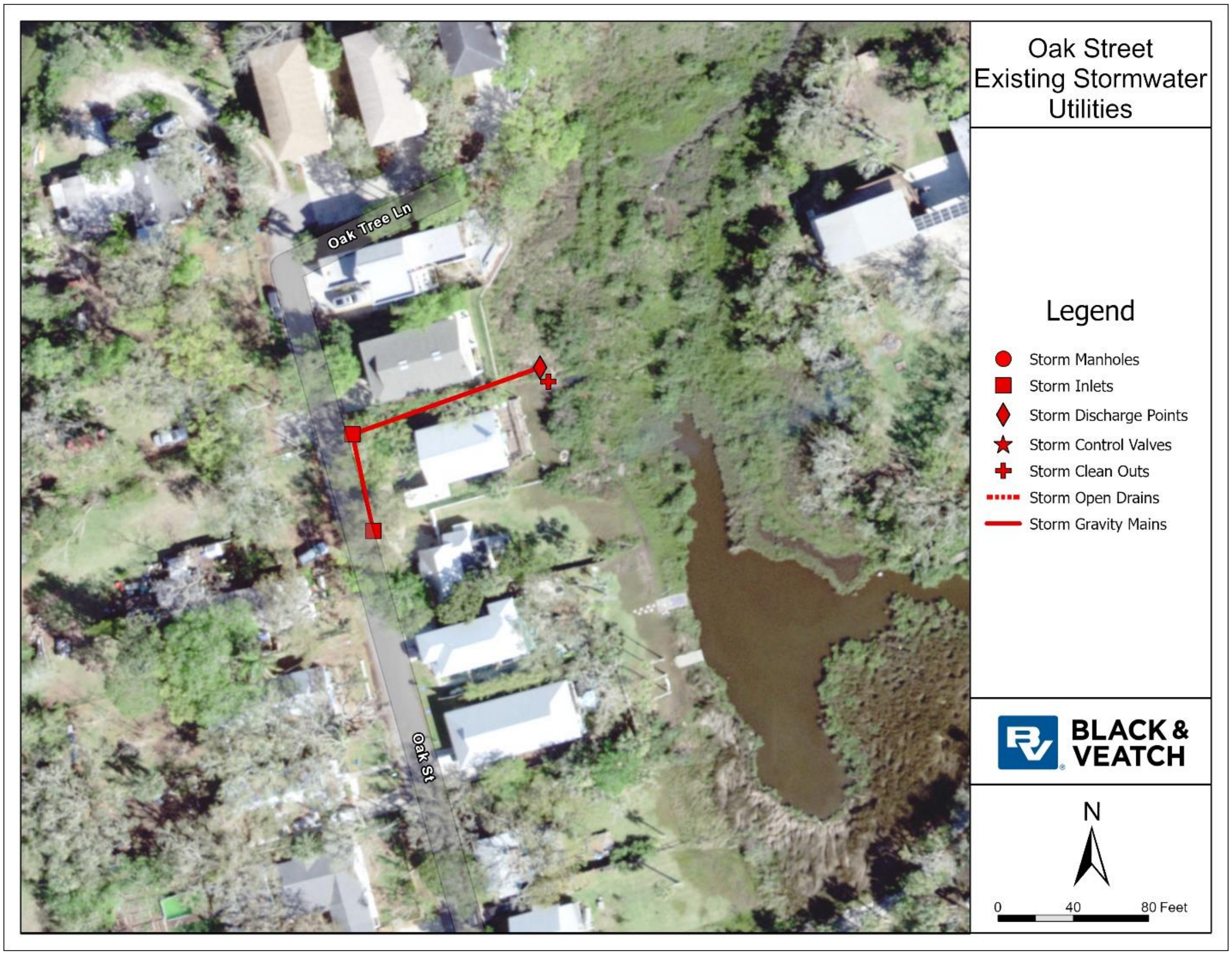


Figure 2-4 Existing Stormwater Utilities Along Oak Street

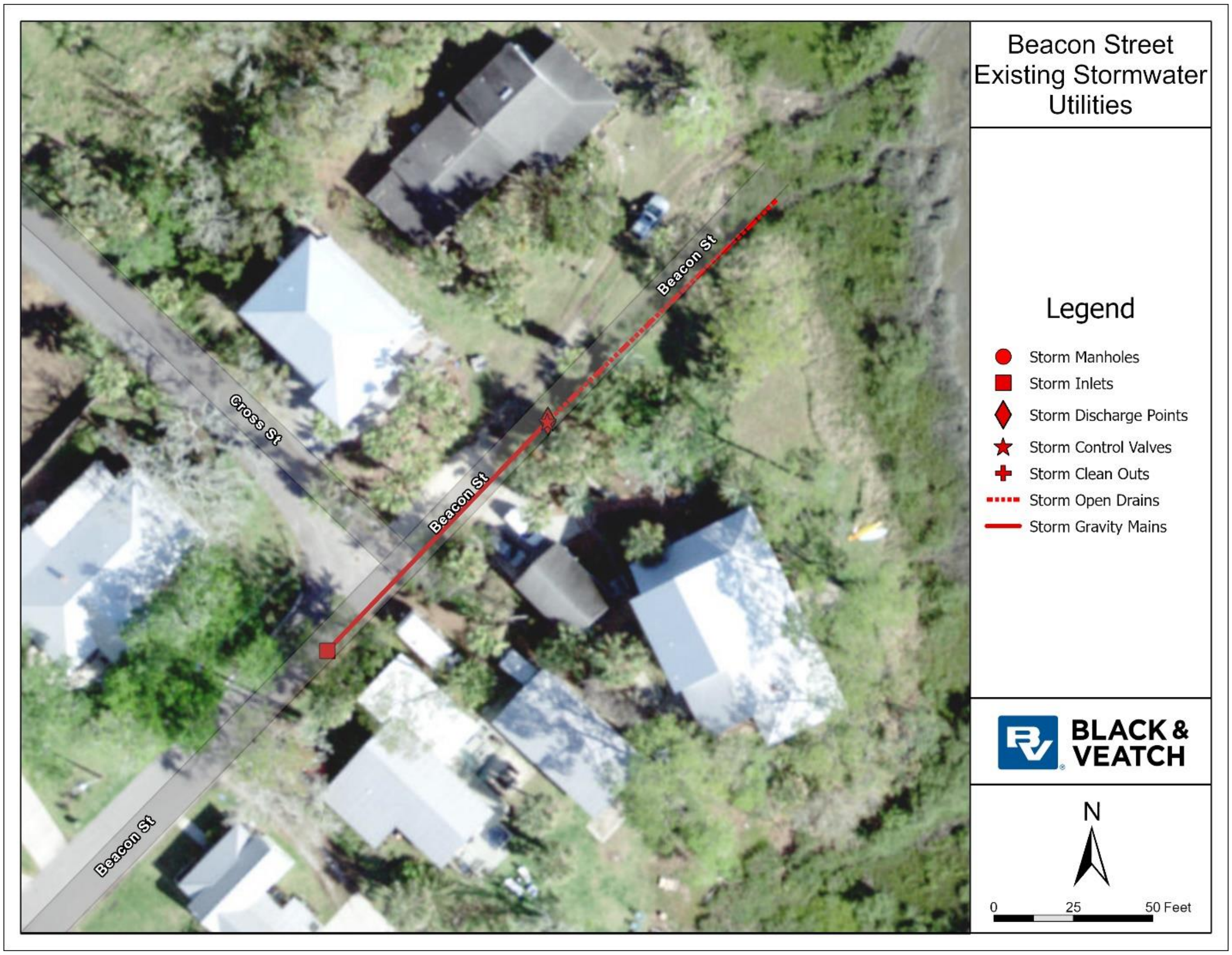


Figure 2-5 Existing Stormwater Utilities Along Beacon Street

Figure 2-6 Newly Installed Inlet, Conveyance Pipe, and Outfall at Seminole Drive

Generally, existing rights-of-way (ROW) widths within the Fullerwood neighborhood are limited and contain mostly sewer and potable water and sewer infrastructure. The largest ROW within the Fullerwood neighborhood runs along Beacon Street with a width of 43ft, while the smallest ROW runs along Althea Street and is 18ft across. It appears that Althea Street could be considered an alleyway that was repurposed into a roadway; during the evaluation of the alternatives, this will need to be considered as easements to install drainage features would be required. **Figure 2-7** below shows the approximate rights-of-way locations and widths along the Fullerwood neighborhood roadways.

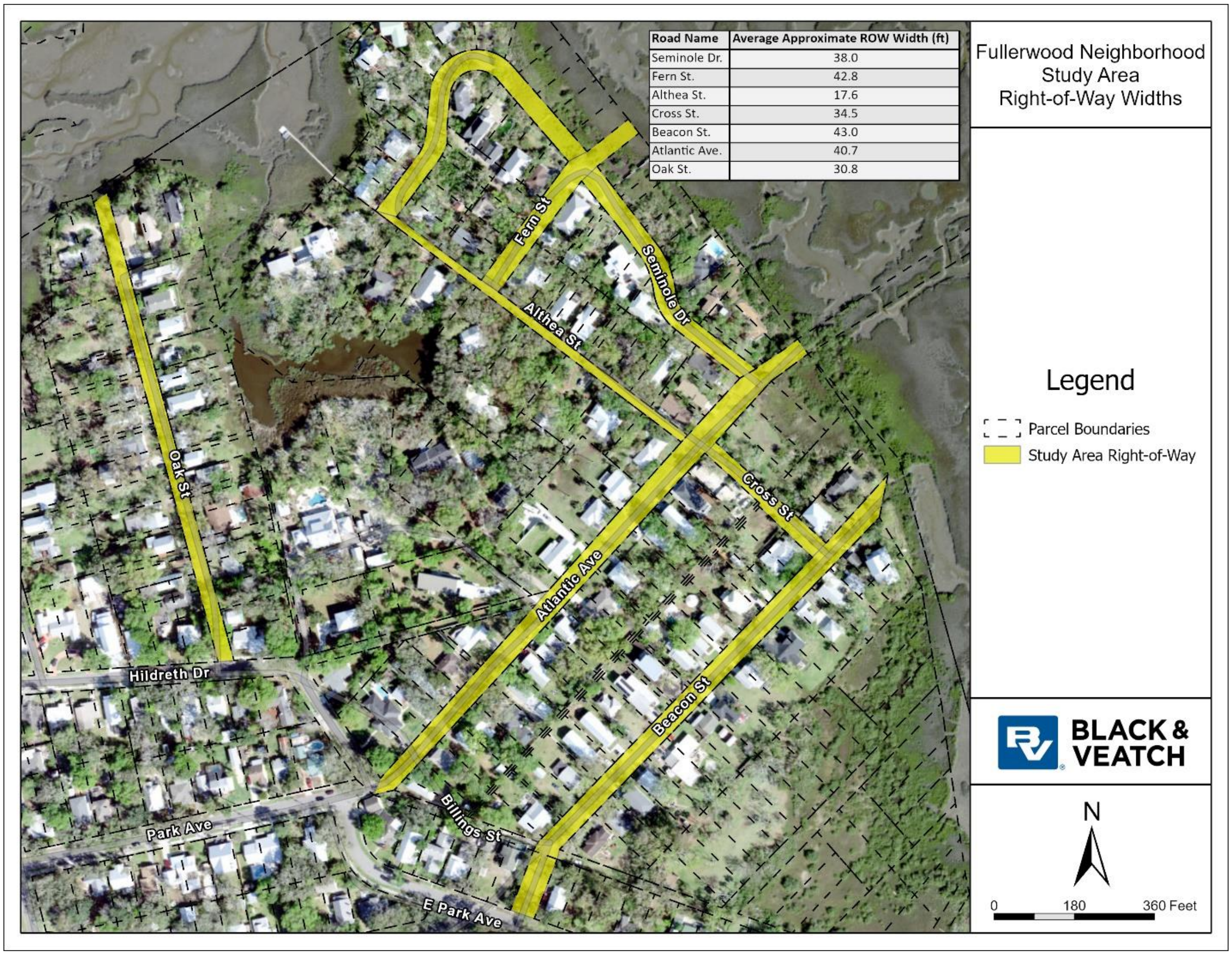


Figure 2-7 **Rights-of-Way Along Fullerwood neighborhood Roadways and Their Approximate Widths**

Coastal Barrier Resources System (CBRS) areas around the north and west sides of the Fullerwood neighborhood could present complications for future drainage structure installation. To encourage the conservation of coastal areas, CBRS areas were designated to reduce the loss of natural resources and property in these storm-prone areas. Federal funding, financial assistance, and the sale of NFIP flood insurance are prohibited in CBRS areas to deter landowners from developing in these sensitive regions. However, construction and development are not prohibited activities if the proper permits are obtained. If the City were interested in using these CBRS areas for stormwater drainage features, local funds would need to be obtained and utilized for construction. For this study, construction within CBRS areas is unnecessary when implementing the suggested drainage strategies. **Figure 2-8** below shows CBRS areas, the wetlands for the project, and surface waters within and adjacent to the Fullerwood neighborhood.

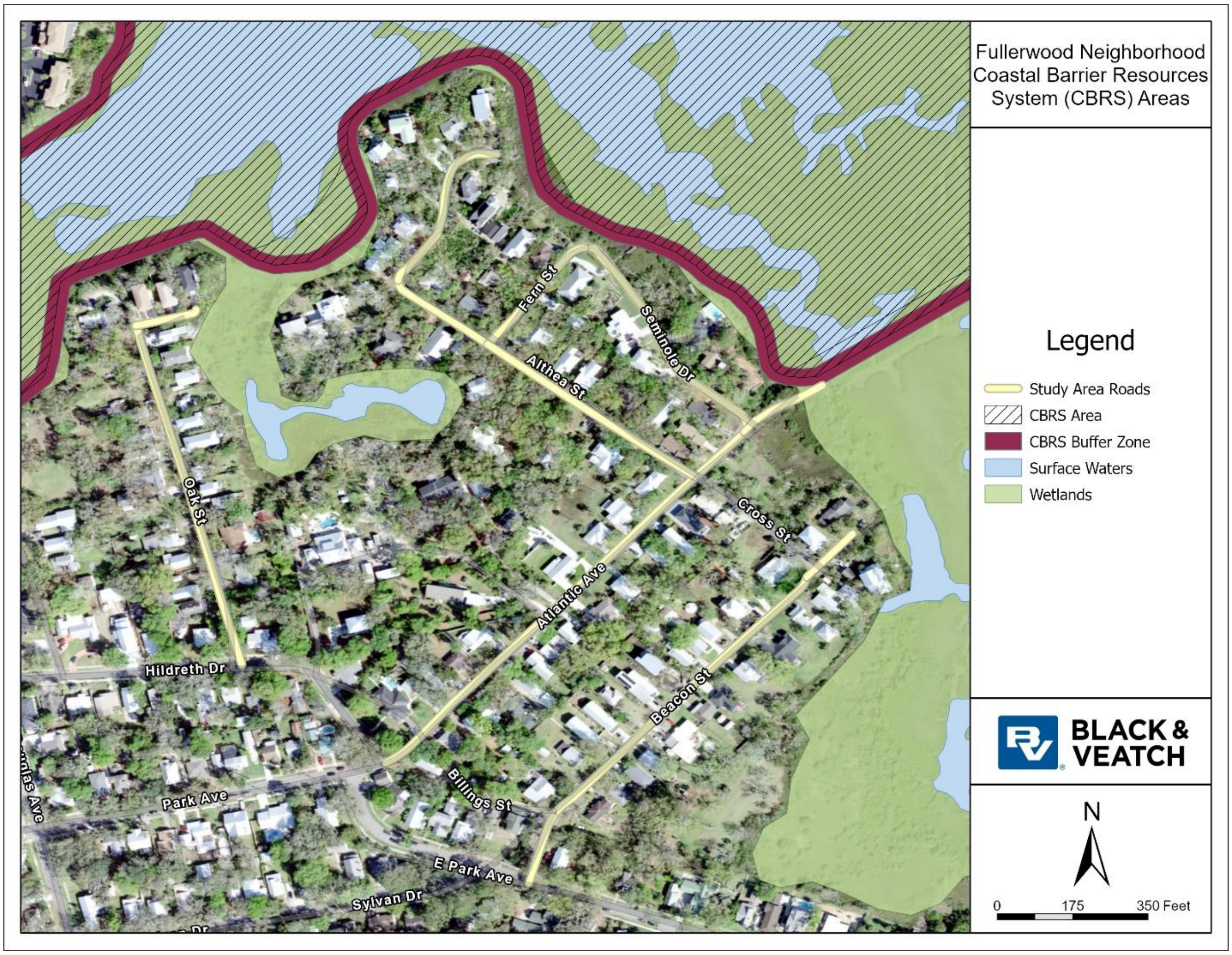


Figure 2-8 Coastal Barrier Resources Areas Adjacent to the Fullerwood Neighborhood

2.2 Data Collection

Data required to build the model were provided by many sources, including the City of St. Augustine (COSA), Jones Edmunds (JE), and the Army Corps of Engineers (USACOE), and additional data were sourced by Black & Veatch (BV). These datasets included light detection and ranging data (LiDAR), geographic information system (GIS) data, engineering standard details, engineering drawing sets, and St. Johns County property appraiser information. **Table 2-2** below summarizes the data utilized in this resilience and drainage study.

Table 2-2 Summary of Data Collected for the Fullerwood Neighborhood Resilience and Drainage Study

Data Type	Data File Name	Description	Data Source	Provided By
Excel	Cityworks Storm Data	Stormwater work orders and service requests	COSA	COSA
PDF	Flood Elevation Certificates	Each file is named by property address	COSA	COSA
PDF	Technical Publication SJ 91-3	24-hr rainfall distributions for surface water basins within the SJRWMD	St. Johns River Water Management District (SJRWMD)	BV
Report	South Davis Shores Resiliency Study	Flood and resiliency risk study	CDM Smith	COSA
Spatial	CoSA_DEM_Fullerwood	LiDAR for Fullerwood neighborhood	Florida Geographic Information Office	BV
Spatial	USDA Web Soil Survey_Fullerwood	Soil Types	United States Department of Agriculture (USDA)	BV
Spatial	Future_Land_Use	Future land use	St. Johns County	BV
Spatial	NOAA Digital Coast Impervious Area	Impervious Area	National Oceanic and Atmospheric Administration (NOAA)	BV
Spatial	COSA_GIS_Utility_042023	Existing utilities	COSA	COSA

Data Type	Data File Name	Description	Data Source	Provided By
Spatial	Parcel Boundaries	Paracel boundaries	St. Johns County	BV
Spatial	ICPR_Model_Basins	Model basins	JE	JE
Spatial	COSA_CriticalAssets	Surface waters and wetlands	JE	JE
Spatial	Flood_Elevation_Certificates_Fullerwood	Digitized flood elevation certificate locations and corresponding elevations	COSA	BV
Spatial	CAMAData	STRAP numbers and assessed home values	St. Johns Property Appraiser	BV
Spatial	USA SSURGO - Soil Hydrologic Group	Soil group by geography	Natural Resources Conservation Service (NRCS)	BV

3.0 Model Preparation

Using the Personal Computer Storm Water Management Model (PCSWMM), Black & Veatch (BV) created a hydrologic model for the Fullerwood neighborhood. Using this model, flooding for the design storm was analyzed, and various drainage technologies were then incorporated into the model to simulate their impact on flood levels. The following sections detail what data were obtained for inclusion in the initial conditions model, where they were taken from, and how they were utilized.

3.1 Existing Hydrologic Conditions

3.1.1 Soil Data

Soil data was obtained from the United States Department of Agriculture (USDA) Web Soil Survey. The Fullerwood neighborhood was determined to have two soil types represented by map unit symbols of 51, St. Augustine-Urban Land Complex, and 24, Pellicular silty clay loam, frequently flooded. St. Augustine-Urban Land Complex soil type typically has slopes of 0% to 2%, and the parent material is composed of sandy mine spoil or earthy fill. The natural drainage class is poorly drained, and water movement in the most restrictive layer is high. Pellicular silty clay loam, frequently flooded, has slopes of 0% to 1% and is found on tidal and marine marshes on coastal plains. While the soil is frequently flooded, it is not ponded, and the natural drainage class is very poorly drained. Using geospatial data provided by the USDA Natural Resources Conservation Service (NRCS), it was determined that the St. Augustine-Urban Land Complex soil belongs to soil group A while the Pellicular silty clay loam, frequently flooded, belongs to soil group D. The USDA NRCS defines soils in Group A as soils that consist of deep, well-drained sands or gravelly sands with high infiltration and low runoff rates and soils in Group D as soils with a very slow infiltration rate and high runoff potential. This group comprises clays with a high shrink-swell potential, soils with a high water table, soils with a clay pan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. As seen in Figure 3-1 Soil Types Found in the Fullerwood Neighborhood **Figure 3-1**, the soil in the Fullerwood neighborhood is predominantly St. Augustine-Urban Land Complex, soil group A. Considering that most, if not all, of the proposed stormwater improvements, will likely be constructed in St. Augustine-Urban Complex soil, the parameters of this soil type were used in the model. These parameters can be seen in **Table 3-1** below.

Table 3-1 Fullerwood Neighborhood Soil Parameters

St. Augustine-Urban Land Complex		
Parameter	**Value**	**Assumption**
Maximum Infiltration Rate	5 in/hr	Dry, sandy soil
Minimum Infiltration Rate	0.5 in/hr	Based on Group A soil
Decay constant	2.002/hr	Standard value
Drying Time	2.1 days	Standard value
Maximum Volume	4 in	Available capacity estimated at 4.6 inches
Pellicular Silty Clay Loam, Frequently Flooded		
Parameter	0.5 in/hr	Wet, loamy soil
Maximum Infiltration Rate	0.04 in/hr	Based on Group D soil
Minimum Infiltration Rate	2.002/hr	Standard Value
Decay constant	14 days	Due to the soil's high moisture content
Drying Time	10.5 in	Available capacity estimated at 11.5

These data were entered into SWMM and used to calculate the rate at which water infiltrates the soil and the volume of that infiltration using the Horton infiltration equation. This equation, seen below, was chosen because of its general regulatory acceptance and frequency of use in the project's geographical location.

$$f_t = f_{min} + (f_{max} - f_{min})e^{-kt}$$

Where:

f_t = the infiltration capacity of the soil (in/hr) at time, t

f_{min} = the minimum infiltration capacity (in/hr)

f_{max} = the maximum infiltration capacity (in/hr)

k = exponential decay constant (1/hr)

t = time (hr)

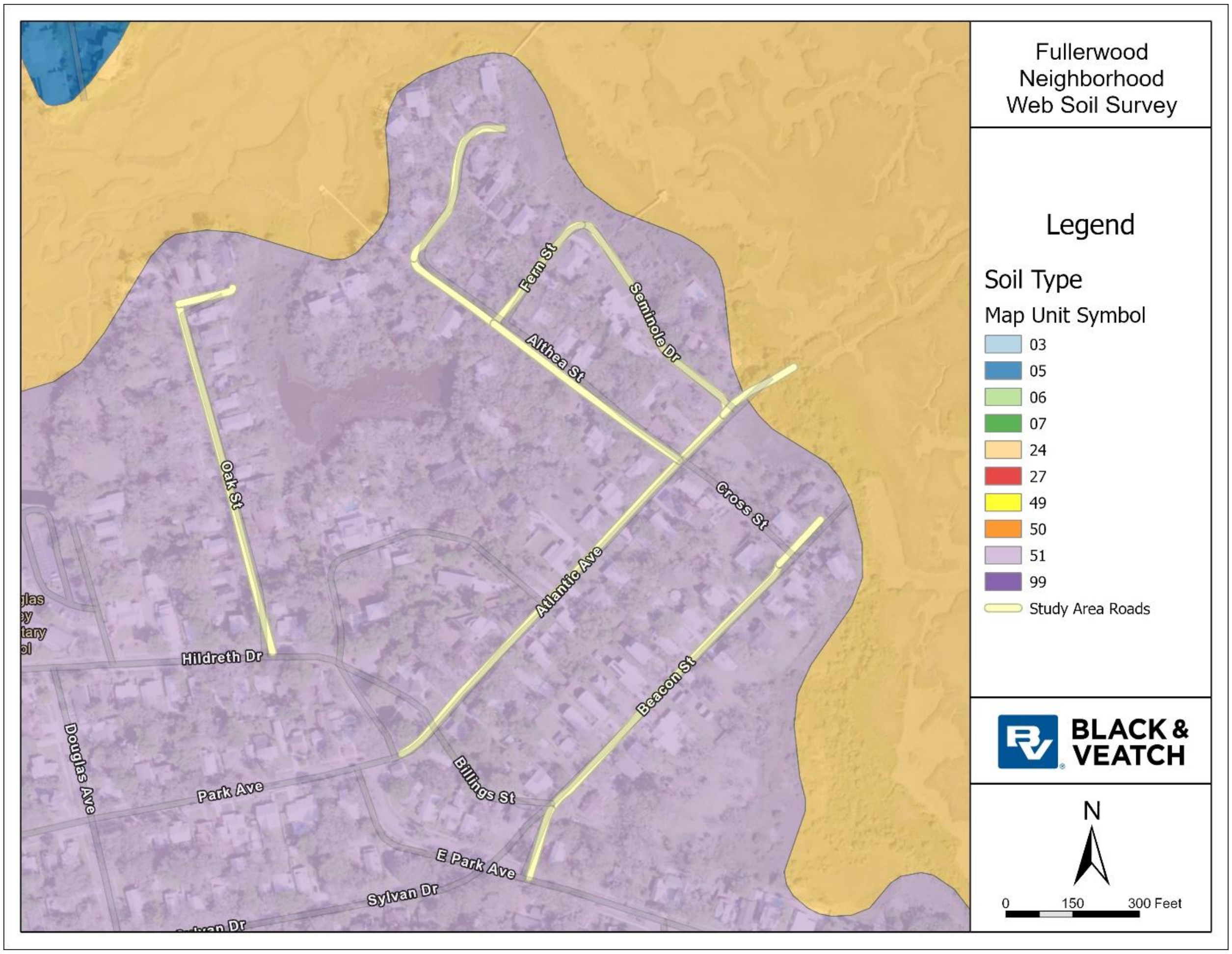


Figure 3-1 Soil Types Found in the Fullerwood Neighborhood

3.1.2 Rainfall

To simulate rainfall over the Fullerwood neighborhood, rainfall data from the St. Johns River Water Management District (SJRWMD) SJ 91-3 technical publications on the 24-hour rainfall distribution were used. The City of St. Augustine lies within the upper coastal basin, Hydrologic Unit IX (HU IX). With this data, stormwater runoff hydrographs were generated for each basin within the Fullerwood neighborhood. Next, NOAA Atlas 14 was used to obtain Point Precipitation Frequency Estimates for a 24-hour storm duration for each frequency. **Table 3-2** below shows the rainfall totals determined by NOAA Atlas 14 for storms of 5-year, 25-year, and 100-year frequencies.

Table 3-2 24-Hour Rainfall Totals for SWMM Model Storms from NOAA Atlas 14

Storm Frequency (Years)	24-hour Rainfall Total (Inches)
5	5.81
25	8.92
100	12.4

3.1.3 Future Rainfall

Future rainfall conditions were also considered a phase II or long-term fourth alternative to support the city's resilience efforts. Future rainfall used current rainfall totals from **Table 3-2** and the adjustment factors developed by the Florida International University (FIU) Sea Level Solutions Center. The adjustment value used was the CODEX Change Factor with the 50th percentile. **Table 3-3** includes the adjustment factor and future rainfall for the near-term scenario (2040-2069).

Table 3-3 24-Hour Rainfall Totals for SWMM Model Storms from NOAA Atlas 14

Storm Frequency (Years)	CODEX (50TH Percentile)	24-hour Rainfall Total (Inches))
5	1.15	6.65
25	1.22	10.85
100	1.27	15.78

3.1.4 Land Use & Impervious Area

The future land use for the Fullerwood neighborhood was taken from the City's 2040 Comprehensive Plan and consists of low-density residential and open land uses, as seen in **Figure 3-2**. The land use types in the Fullerwood neighborhood were further divided into land use descriptions for incorporation in the model. These include open land, pasture, golf course, agriculture, residential low-density, high-density residential and mixed-use, commercial/light industrial/institutional, heavy industrial and transportation, wetlands, and waterbodies. Abbreviations of these land use descriptions used in SWMM can be seen in **Table 3-4.** Once each basin's area has been assigned the appropriate land use descriptions, the following parameters are calculated: Manning's n for pervious and impervious areas, initial abstraction for pervious and impervious areas, and the percent of runoff routed to each land use description. Land use parameters used in the base conditions model can be seen below in **Table 3-5**.

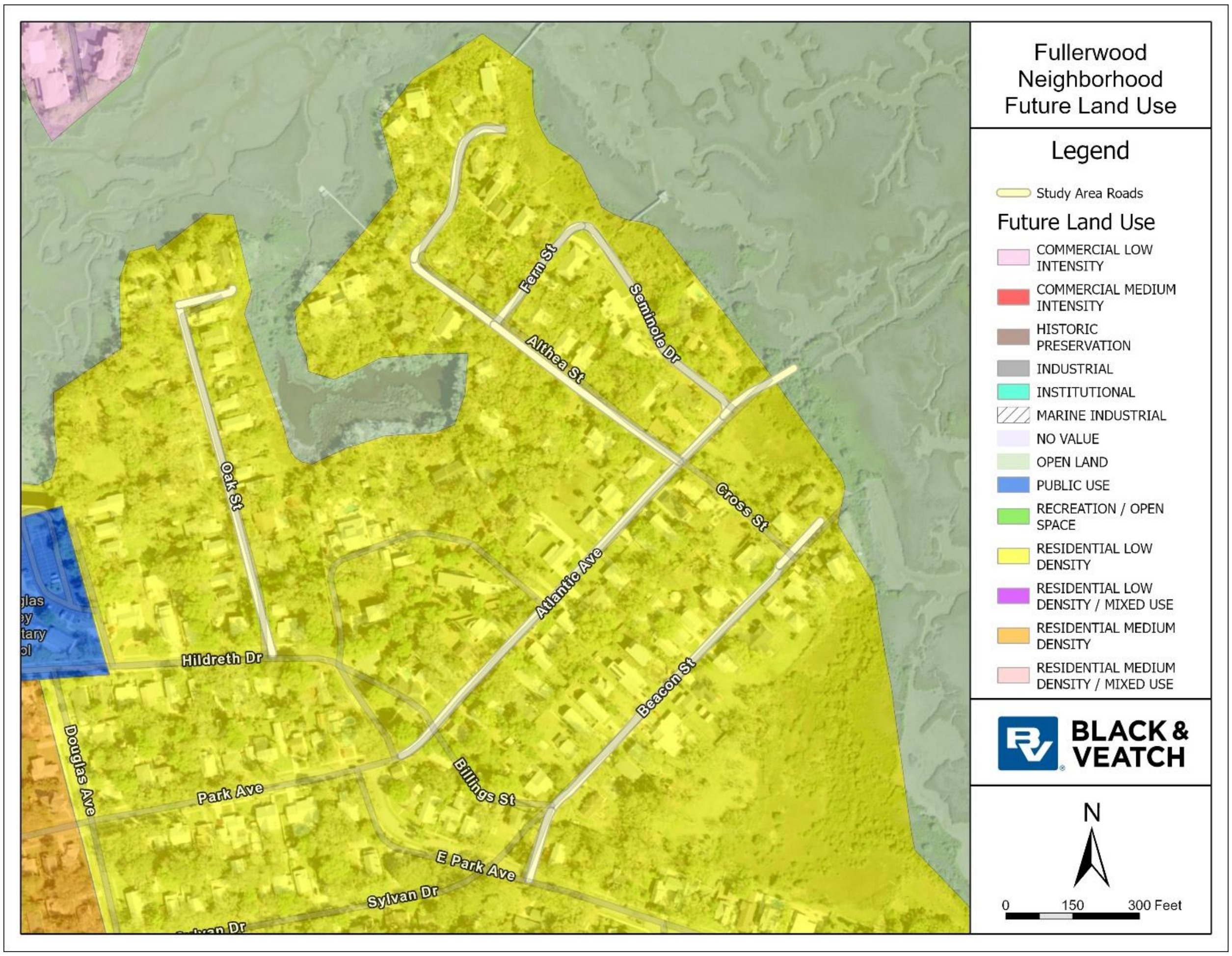


Figure 3-2 City of St. Augustine Future Land Use

Table 3-4 Land Use Descriptions and Their Abbreviations

Land Use Description	Land Use Code Abbreviation
Open Land	Open
Pasture	Past
Gold Course & Agriculture	Ag/GC
Residential Low Density	LDR
Medium Density Residential	MDR
High Density Residential & Mixed Use	HDR
Commercial, Light Industrial & Industrial	Comm
Heavy Industrial & Transportation	Hind
Wetlands	Wetland
Waterbodies	Water

Table 3-5 Land Use Parameters by Land Use Description Used in SWMM

	Parameters				
Land Use Description	**Impervious n**	**Pervious n**	**Impervious Abstraction**	**Pervious Abstraction**	**Routed (%)**
Low Density Residential	0.015	0.25	0.1	0.25	0.5
Open Land	0.015	0.4	0.1	0.25	0.8

3.1.5 Digital Elevation Model (DEM)

The topography data for the Fullerwood neighborhood Fullerwood neighborhood, as seen in **Figure 3-3**, was obtained from the Florida Geographic Information Office and flown in 2019. This DEM illustrates shows the low-lying, flat conditions present in the Fullerwood neighborhood as discussed in **Section 2.1**. This DEM was used to create inundation maps, basins, stage-area relationships, and overland flows.

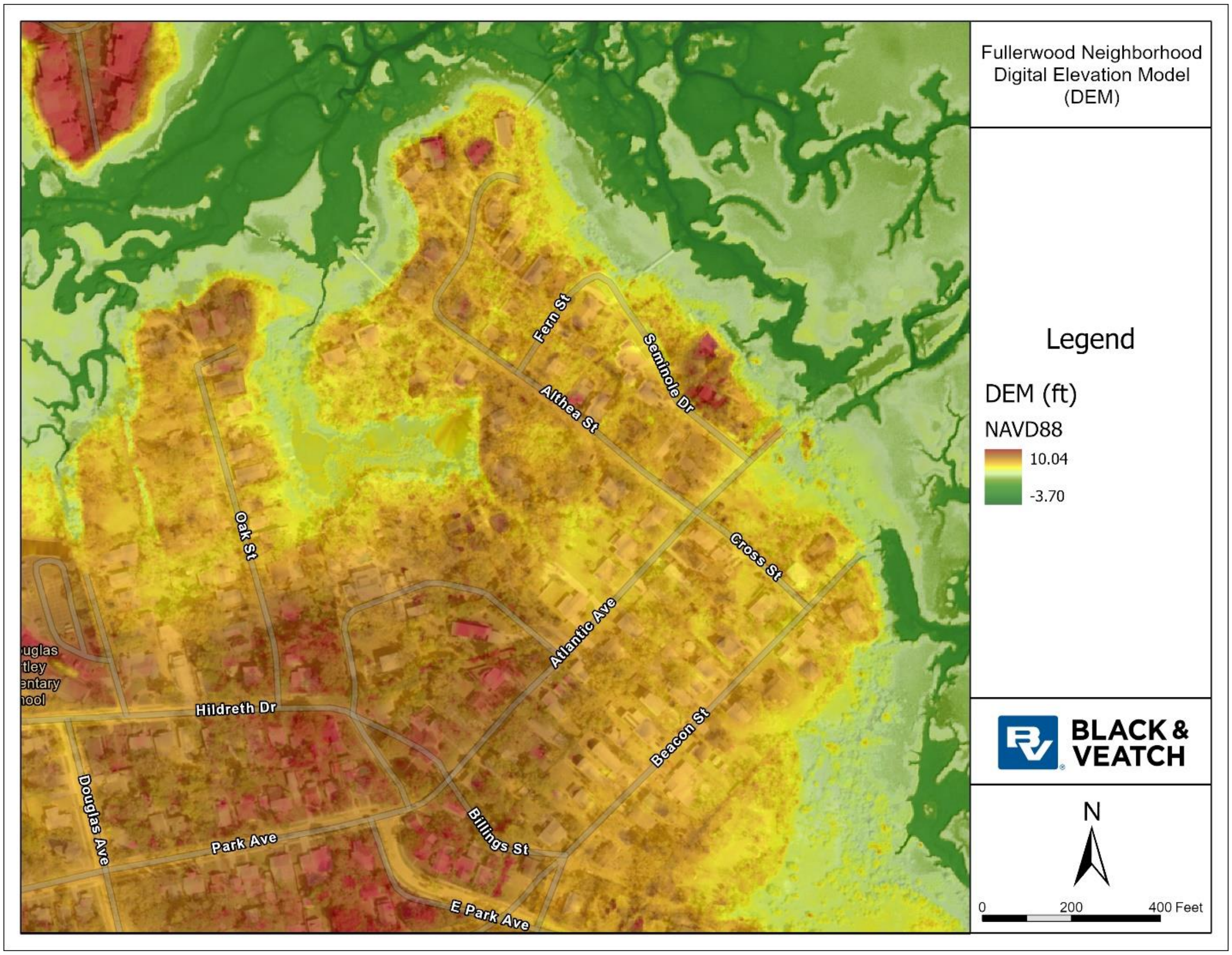


Figure 3-3 Fullerwood neighborhood Digital Elevation Model

3.2 Basin Delineation

The PCSWMM watershed delineation tool uses sequential computations of flow direction, flow accumulation, and stream definition based on a threshold and watershed delineation. For this delineation effort, a maximum watershed size was set to 3 acres to determine detailed flow path, discharge point, and basin delineation for the Fullerwood neighborhood was completed. PCSWMM completes its delineation by leveraging readily available data, including DEM and existing discharge points. The discharge point data is leveraged by utilizing the burn-in function, which develops a sink feature. Once the DEM and outlets are entered into PCSWMM's watershed delineation tool, like other tools available in GIS software, the following steps are completed: filling pits, calculating slope, flow direction, and flow accumulation. The next step was delineating the basins for the Fullerwood neighborhood to align with the Jones Edmunds (JE) basins. While JE basins did not extend to the Fullerwood neighborhood, BV used these basins as defined boundaries to ensure continuity across City projects. Parcel lines, roadways, and existing drainage flow paths largely drove basin delineation for the Fullerwood area. These drainage flow paths largely exist due to landscaping and driveways installed by homeowners. Both the JE and BV delineated basins can be seen in **Figure 3-4**.

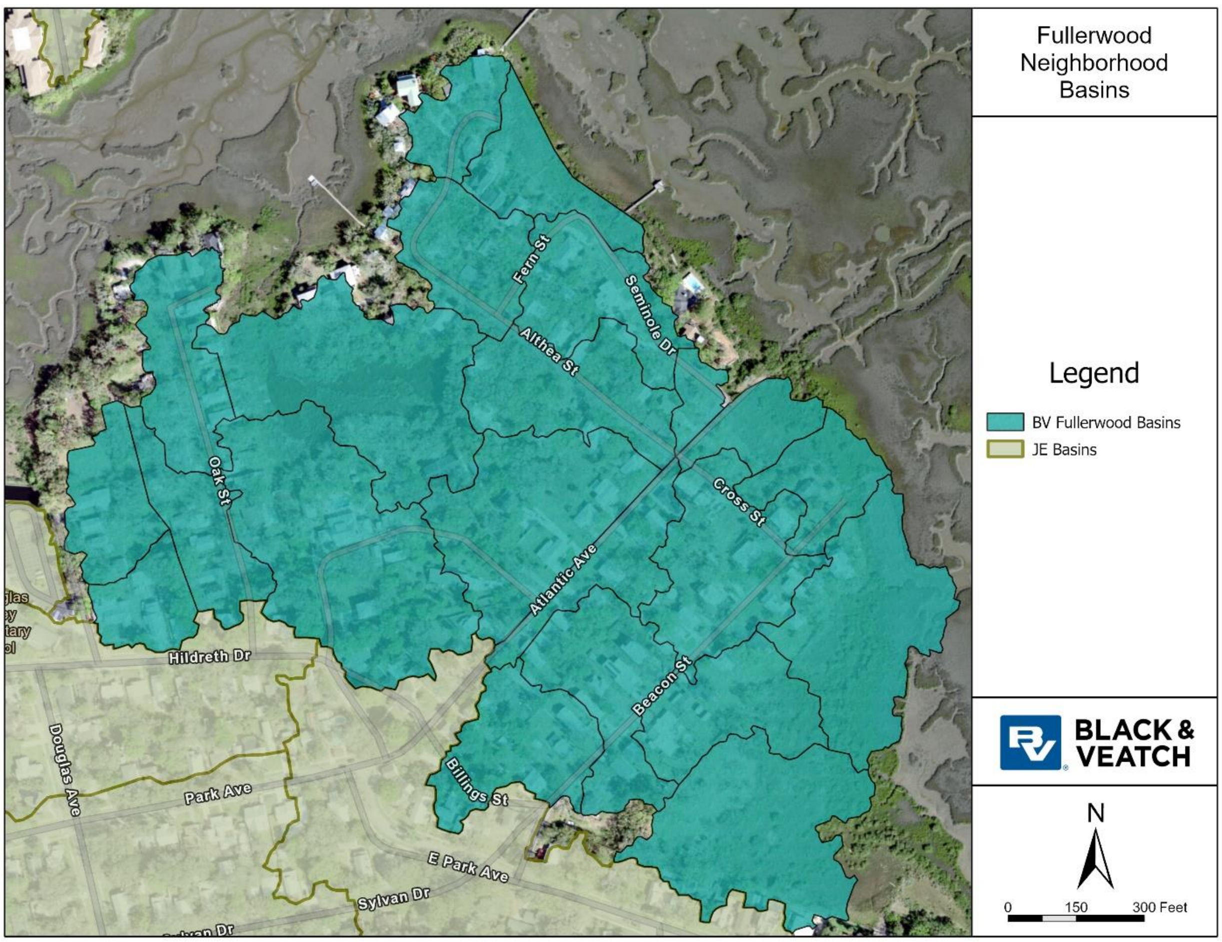


Figure 3-4 Fullerwood Neighborhood BV and JE Delineated Basins

3.3 Overland Flow Parameters

SWMM5 calculates the runoff overland flow using the physical parameters input for each storage catchment and a non-linear reservoir approximation (Manning's equation for a wide, shallow rectangular channel). SWMM5 does not require times of concentration (Tc) to be calculated externally as input. The overland flow hydraulic length (HL) is estimated from the weighted average travel length to the point of interest. The width of the overland flow path for sheet flow runoff is computed for every basin. To estimate this parameter for each basin, multiple flow path lengths were measured within each basin, and then the total sub catchment area was divided by the average of these flow path lengths.

The slope for each basin is determined by using the flow path lengths and the start and end-point elevations of each flow path determined for the basin. The average slope of the multiple flow paths is selected to represent the basin. Overland flow Manning's n values were estimated based on land use, as discussed in **Section 3.1.3**.

3.4 Hydraulic Network

The SWMM5 hydraulic model uses the node/link representation of the stormwater management system. For the study model, nodes are located at:

- The ends of culverts.
- At representative inlets in the stormwater management system.
- Each basin will represent stage storage and an interconnected system.

The study model contains 22 storages, four outfalls, and 39 conduits. Of the conduits, 3 represent closed conduits, 35 represent channel overflows and flow along the street. The model schematic is shown below in **Figure 3-5**. Model input parameter values for junctions, outfalls, and conduits are listed in **8.0Appendix A**.

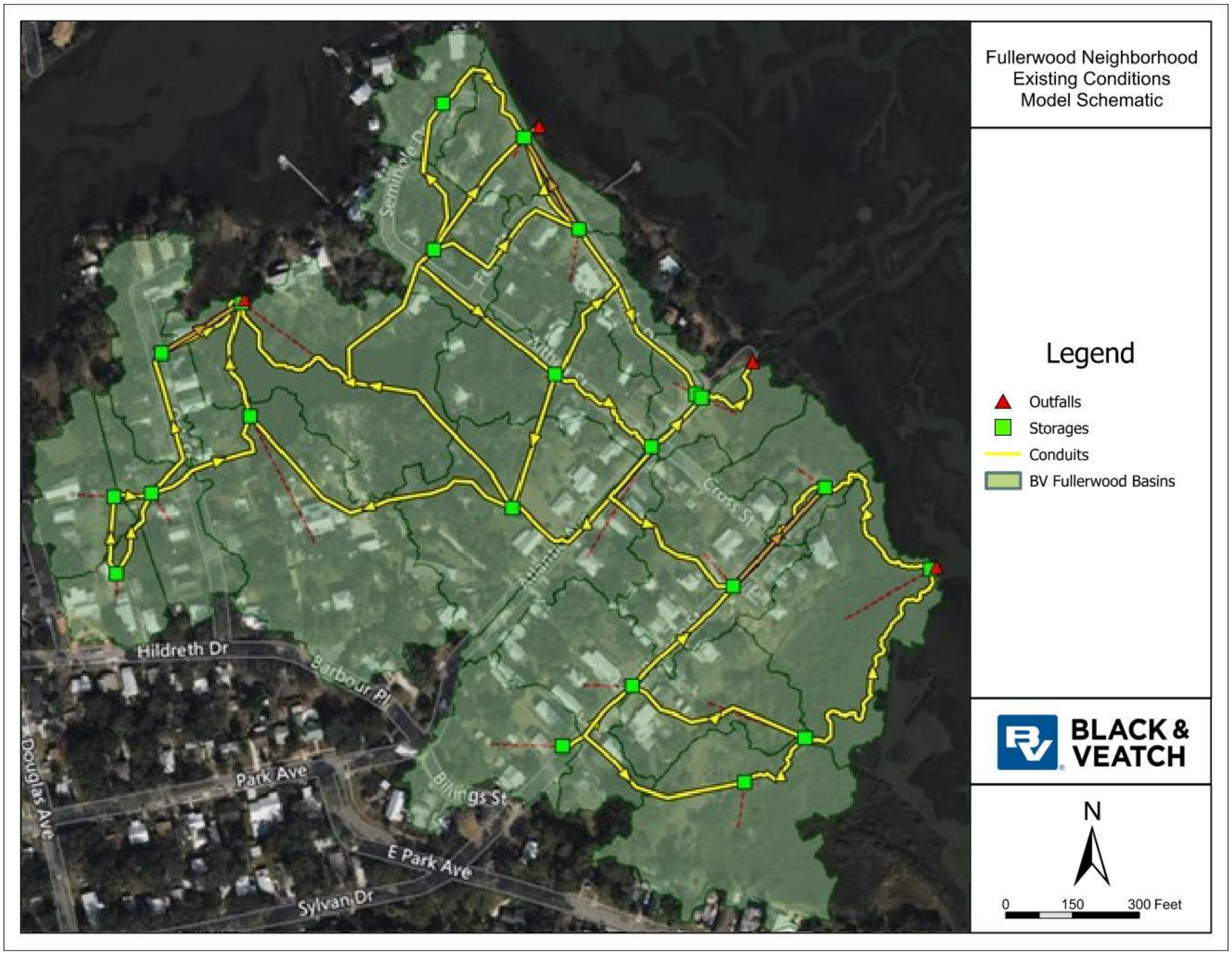


Figure 3-5 Existing Conditions Model Schematic

3.4.1 Stage-Area Storage

From the DEM and basin delineation effort, each basin was assigned to a storage node within the PCSWMM model to account for runoff storage and represent inundation within each basin. A spatial analysis utilizing GIS-based tools was leveraged to determine the stage storage relationship for each basin. Stage storage values were developed in the North American Vertical Datum of 1988 (NAVD 88) datum and are provided under **Appendix B** for reference.

3.4.2 Conduits and Structures

Hydraulic data for culverts, storm sewers, and channel cross sections were obtained from stormwater management system databases, field inspections, and review of structure location and the DEM. Data collected include elevation, length, geometry, surface roughness, and other pertinent features. The infrastructure location, size, and length were input into the Fullerwood neighborhood model based on the best available information. Closed conduit and culvert characteristics include length, slope (upstream and downstream invert elevations), width and depth, Manning's roughness coefficient, and inlet and outlet loss coefficients.

Overland flow conduits are generally used, when developing a 1-Dimensional Model, to avoid causing a "glass-wall" effect during model computation. Glass wall effect occurs when the conveyance system portion of the model is at capacity and the stage area node begins to mound up beyond what is reasonable in real-world conditions. To eliminate "glass walls" within a model, overland flow weirs can be deployed to ensure that adjacent nodes communicate when the conveyance system is inundated during storm events. This provides a higher degree of accuracy within the model and helps realistically represent the condition of swales within the basins. Overland flow weirs were developed at the basin boundaries delineated in **Figure 3-4** using GIS-based pre-processing tools. These conduits could represent swales, the road's centerline, pavement edge, drainage breaklines, and driveways.

The datum applied in the model is NAVD88. Inverts in nodes were set at or lower than the lowest connecting conduit invert. For closed conduits, entry losses were 0.35 for pipes and 0.50 for culverts. Exit losses are 0.25 for pipes and 1.0 at outfalls.

3.5 Boundary Conditions

Hydraulic boundary conditions are needed to simulate the tailwater effects of the project Fullerwood neighborhood. Coastal evaluations consider Stillwater conditions that account for surge conditions and represent cases with the lower occurrence, such as the 10-, 25-, 50-, and 100-year (i.e., the 10-percent,4-percent, 2-percent, and 1-percent annual chance) recurrence intervals. For the Fullerwood neighborhood, the same approach used by South Davis Shores for using the 1-year stillwater elevation was considered for all three rainfall events. In addition, the discharge conditions at the outfalls were set based on the stillwater elevation so that the Fullerwood neighborhood.

The Fullerwood neighborhood considered these stillwater elevations for the areas along the Tolomato River, as published by FEMA in the 2018 Flood Insurance Study (FIS). Using the predicted x-percent annual chance stillwater elevations and least square regression using a power curve, the present-day 1-year (100-percent chance) stillwater elevation is estimated to be 2.95 ft NAVD88. The FEMA FIS stillwater elevation predictions are based on recent advances in storm surge modeling. Additional documentation regarding the 2018 FEMA FIS is found on the FEMA Map Service Center website for St. Johns County, FL. Sea level rise is currently not considered for the Fullerwood neighborhood as the project was focused on local drainage challenges akin to the 5-year storm event and future rainfall conditions. With the Fullerwood Neighborhood being within the CBRS area, the Back-Bay study would not include an evaluation for this area, so a future enhancement to this study could include a coastal shoreline study to determine what improvements could be implemented by the City.

4.0 Model Results

The existing conditions modeling evaluation utilized the input parameters described in **Section** 3.0**3.0** for the design frequencies: 5-year, 25-year, and 100-year storms. The existing condition model results were used to prioritize improvements and identify flood-prone areas based on flood depth.

4.1 Peak Stages

Peak stages are the greatest elevation of water reached within each basin during the simulation of the associated design storm within the model. These peak stages enable the flood risks to be assessed within each basin and the Fullerwood neighborhood. Within the model, these peak storages are represented at storage nodes. Once the areas with the greatest flood risks have been determined, stormwater mitigation strategies can be proposed to manage flooding most efficiently within the Fullerwood neighborhood. **Table 4-1** below lists the peak stages for each of the three design storms as simulated in the model of the initial conditions for current and future rainfall amounts.

Table 4-1 Peak Stages in Each Sub Watershed by Design Storm

Sub Watershed Name	Storage Node	Current Rainfall			Future Rainfall		
		5-year Max. Depth (ft)	25-year Max. Depth (ft)	100-year Max. Depth (ft)	5-year Max. Depth (ft)	25-year Max. Depth (ft)	100-year Max. Depth (ft)
1	S_1	4.29	4.48	4.56	4.36	4.54	4.66
2	S_2	3.57	3.85	3.9	3.77	3.89	3.93
3	S_3	4.26	4.35	4.41	4.29	4.4	4.5
4	S_4	3.36	3.27	3.35	3.18	3.33	3.43
5	S_5	3.13	3.52	3.63	3.39	3.61	3.78
6	S_6	3.32	4.64	4.72	4.53	4.7	4.79
7	S_7	4.46	4.31	4.34	4.18	4.31	4.36
8	S_8	4.24	3.09	3.17	2.95	3.16	3.24
9	S_9	2.95	3.37	3.37	3.37	3.37	3.41
10	S_10	2.98	3.19	3.27	3.08	3.25	3.29
11	S_11	4.91	4.98	5	4.93	5	5.03
13	S_13	4.9	4.96	4.98	4.92	4.98	4.99
14	S_14	4.64	4.72	4.77	4.65	4.76	4.8
15	S_15	4.28	4.47	4.55	4.36	4.53	4.64
16	S_16	4.41	4.48	4.56	4.42	4.54	4.65
17	S_17	2.95	3.09	3.17	2.95	3.16	3.24
18	S_18	3.7	3.73	3.75	3.71	3.74	3.76
19	S_19	3.04	3.08	3.11	3.05	3.1	3.13

Sub Watershed Name	Storage Node	Current Rainfall			Future Rainfall		
		5-year Max. Depth (ft)	25-year Max. Depth (ft)	100-year Max. Depth (ft)	5-year Max. Depth (ft)	25-year Max. Depth (ft)	100-year Max. Depth (ft)
20	S_20	4.46	4.64	4.72	4.53	4.7	4.79
21	S_21	4.46	4.64	4.72	4.53	4.7	4.79
22	S_22	3.95	4.06	4.16	3.99	4.14	4.24
23	S_23	3.12	3.19	3.22	3.15	3.21	3.25

4.2 Flood Mapping

With the peak stages generated for each design storm, flood maps show which portions of the Fullerwood neighborhood would be flooded after a 5-year, 25-year, and 100-year storm, given current conditions. To do this, the maximum hydraulic grade line (HGL) at each of the 23 storage nodes was extracted for each design storm. This data was then uploaded into ArcGIS, and a raster was made using the HGL elevations for each design storm. Finally, the Fullerwood neighborhood elevation from the DEM was subtracted from the 5-year, 25-year, and 100-year storm raster, which produced the flood elevations across each basin. **Figure 4-1, Figure 4-2,** and **Figure 4-3** show the flood depth for the 5, 25, and 100-year storms, respectively. Future storm depths are provided for reference above and will be used for comparative purposes.

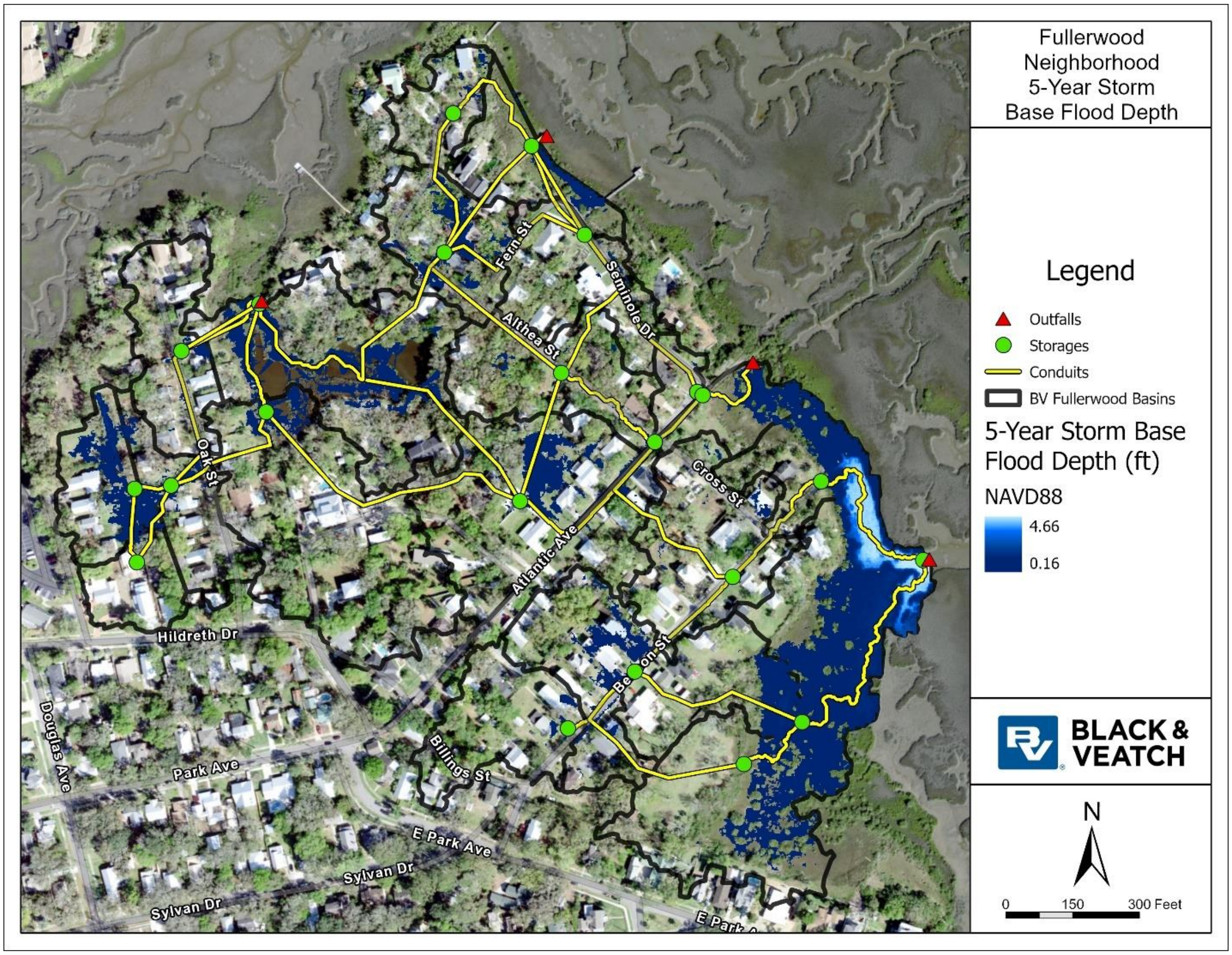


Figure 4-1 5-Year Storm Flood Depth

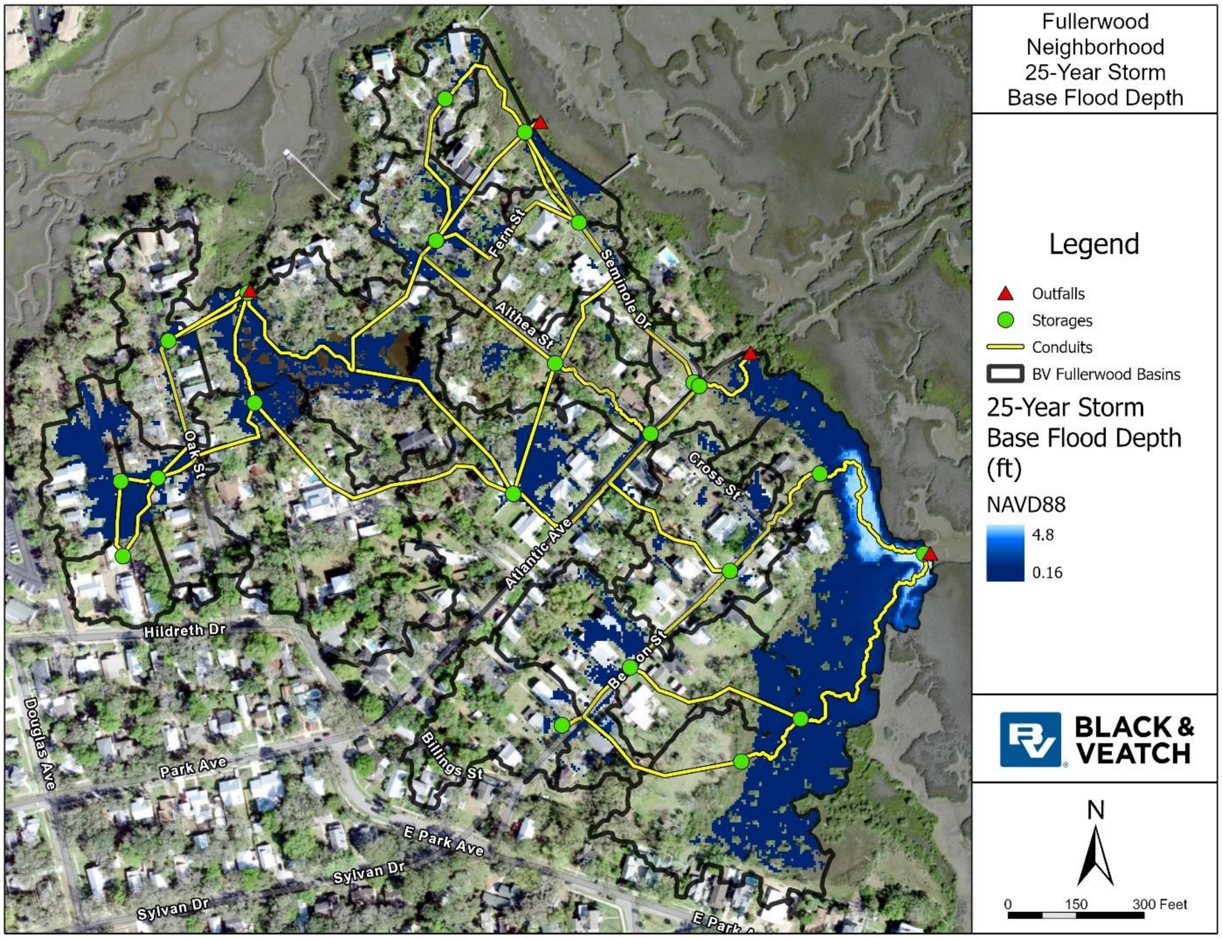


Figure 4-2 25-Year Storm Flood Depth

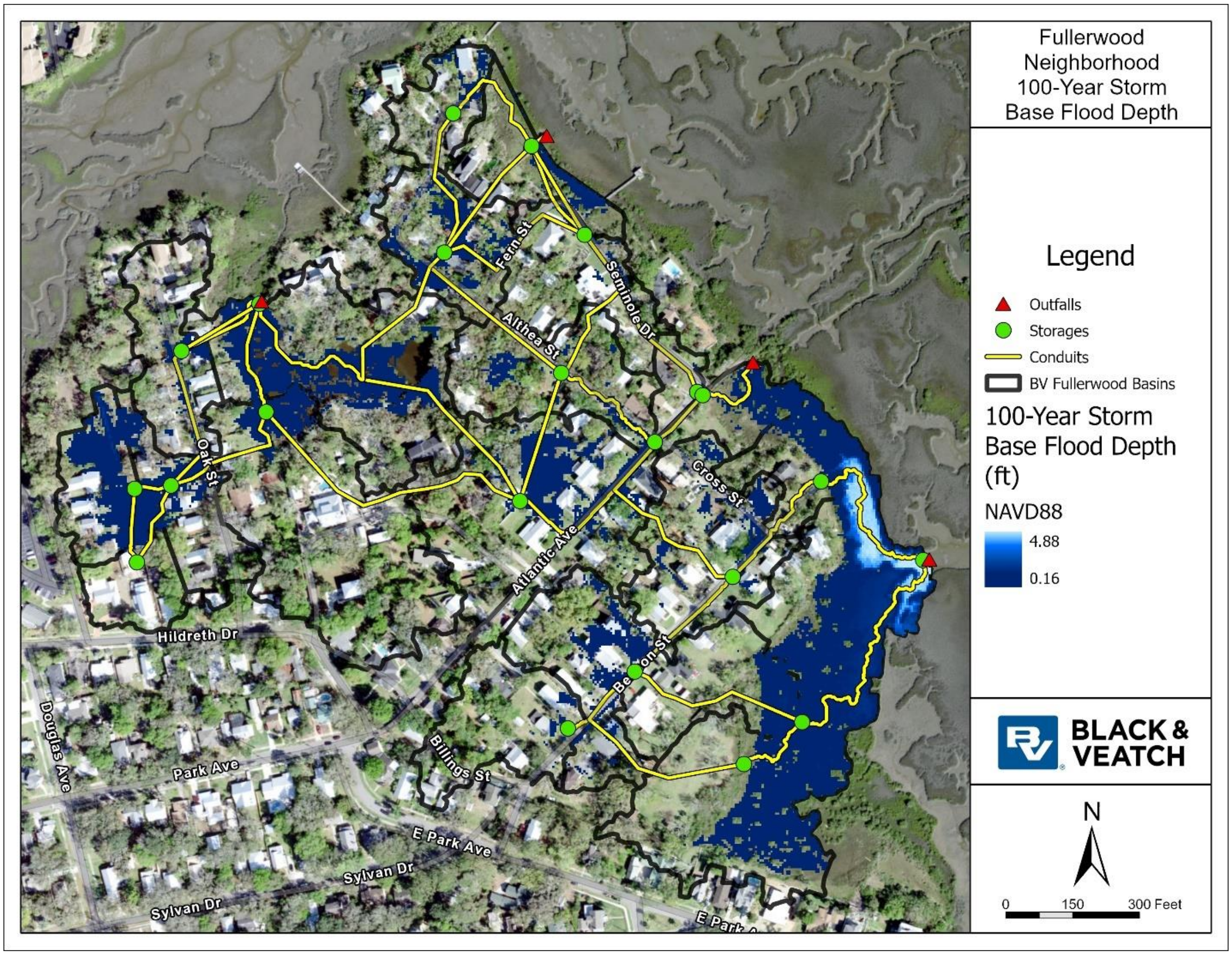


Figure 4-3 100-Year Design Storm Flood Depth

4.3 Model Observations and Validation

After reviewing the results across the different scenarios and in coordination with the City during the workshops (**Appendix C**), we found that the results agree with the documented flooding issues that have been occurring. Within the Fullerwood neighborhood, the following observations have been noted by City staff and appear within the existing conditions model:

- There are low-lying areas with pond water. Particularly at the intersections around the Fullerwood neighborhood.
- Homeowner properties do not have sufficient drainage in the rear of the property. This has caused low-lying properties to collect runoff from the adjacent properties and the streets.
- Oak and Beacon Street both include a drainage structure with a discharge feature. However, the beacon has had backflow prevention installed and generally appears to function as intended. Oak requires backflow prevention and slight modification due to recent infill development.
- Most drainage is near the city's current lift station at Atlantic Ave and Althea St. This Area would benefit from drainage structures to alleviate the local flooding issue.
- The ponding or “bird bath” areas throughout the Fullerwood neighborhood would require re-grading the roads.
- The city recently installed an outfall on Seminole Drive, as depicted in **Figure 2-6**, which, from initial modeling, can be confirmed to benefit the local drainage issues in the neighborhood.

5.0 Proposed Stormwater Mitigation Strategies

Listed below are strategies that the City could implement in various combinations to promote stormwater drainage in the Fullerwood neighborhood. Many of these stormwater strategies perform best when utilized together to address the nuisance flooding that is occurring most effectively. **Section 6.0** outlines three alternatives that combine these alternatives in different permutations to provide effective flood relief from nuisance flooding.

5.1 Swales and Gutters

Currently, none of the roadways within the Fullerwood neighborhood have curbs and gutters installed to convey stormwater. Adding a curb and gutter system is a simple but highly effective way to convey and manage stormwater. A drop curb and gutter system is recommended because the neighborhood is naturally low-lying with minimal slopes. Installing curbs and gutters will also help to elongate the lifespan of the roads, as water can break down and weaken asphalt over time, leading to cracks and potholes. In addition, swales could be installed in areas of Fullerwood that have adequate right-of-way widths. Swales can provide treatment to improve runoff quality and the quality of surrounding waterbodies. **Figure 5-1**and **Figure 5-2** show a standard detail of a swale and gutter, respectively.

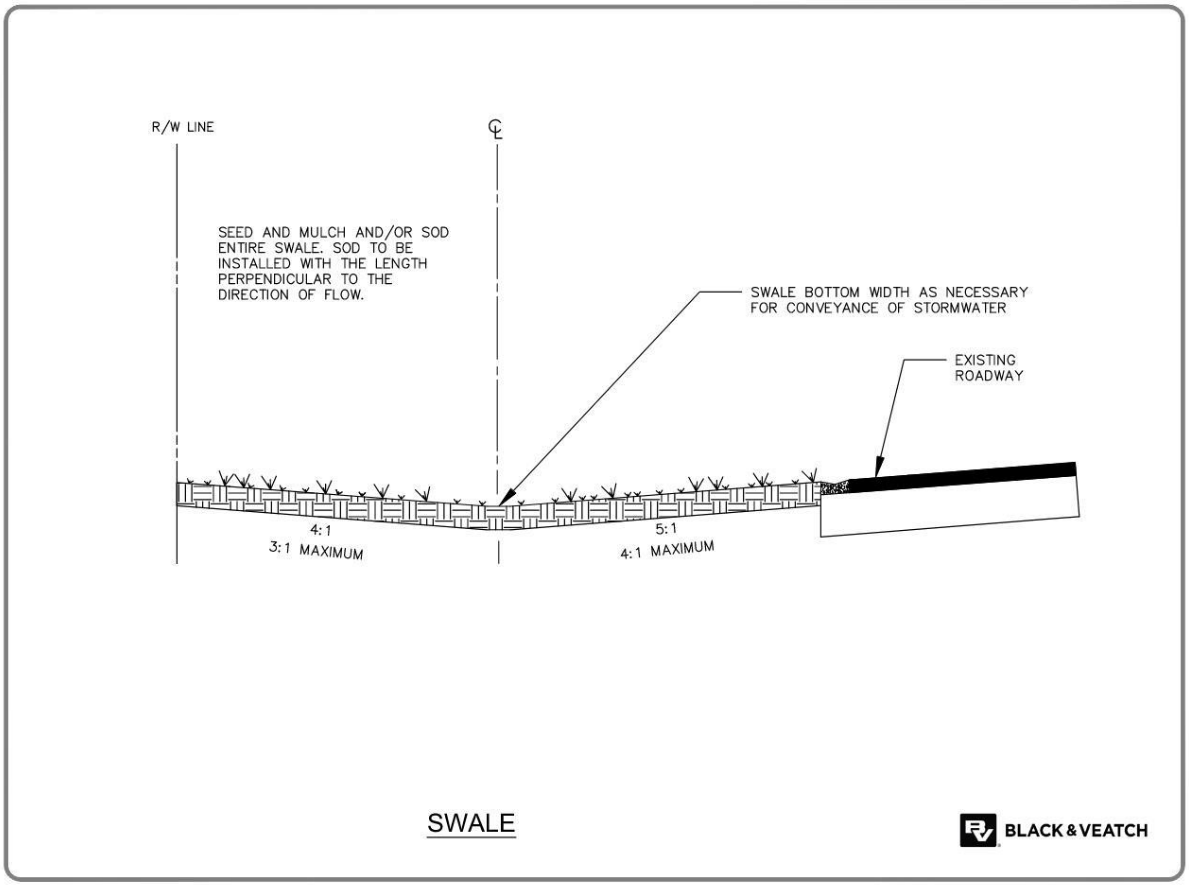


Figure 5-1 Standard Detail Depicting a Typical Roadside Swale Design

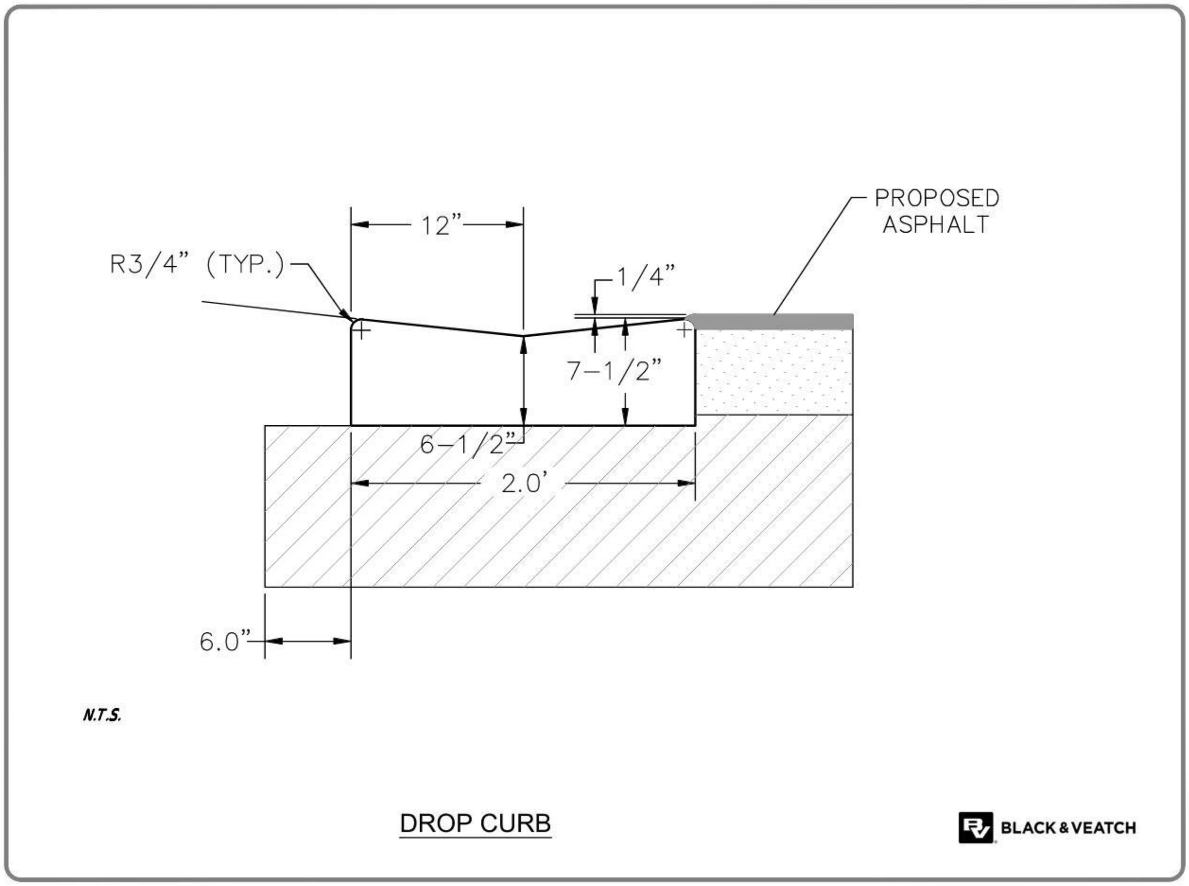


Figure 5-2 **Standard Detail Depicting a Typical Drop Curb and Gutter System**

5.2 Inlets and Conveyance Pipe

Stormwater inlets and conveyance pipes can be a good option for smaller rights-of-way and flatter areas where naturally occurring slopes cannot convey runoff. For these reasons, traditional grey infrastructure may be a good option for the Fullerwood area; however, the neighborhood’s low-lying nature and proximity to the water table may require special considerations during installation. Conveyance pipe must be installed with slopes sufficient to convey stormwater and properly sealed to manage infiltration from the water table. As described in the 2024 FDOT Drainage Design Manual, inlets should be placed at all low points and no more than 300’ apart unless spread calculations determine greater spacing is allowable. Conveyance pipes shall be a minimum of 18” in diameter, and maintenance access structures should be no more than 300’ apart. In addition to these requirements, roadway geometry, maintenance accessibility, and pedestrian and bicycle safety should be considered when determining inlet location and spacing. Below, standard details depicting a stormwater inlet curb box and a drop curb inlet can be seen in **Figure 5-3** and **Figure 5-4**, respectively. For the Fullerwood area, drop curbs may be a more suitable option than curb inlets, as the neighborhood is relatively flat, and curbs could prove to be a costly addition to the design.

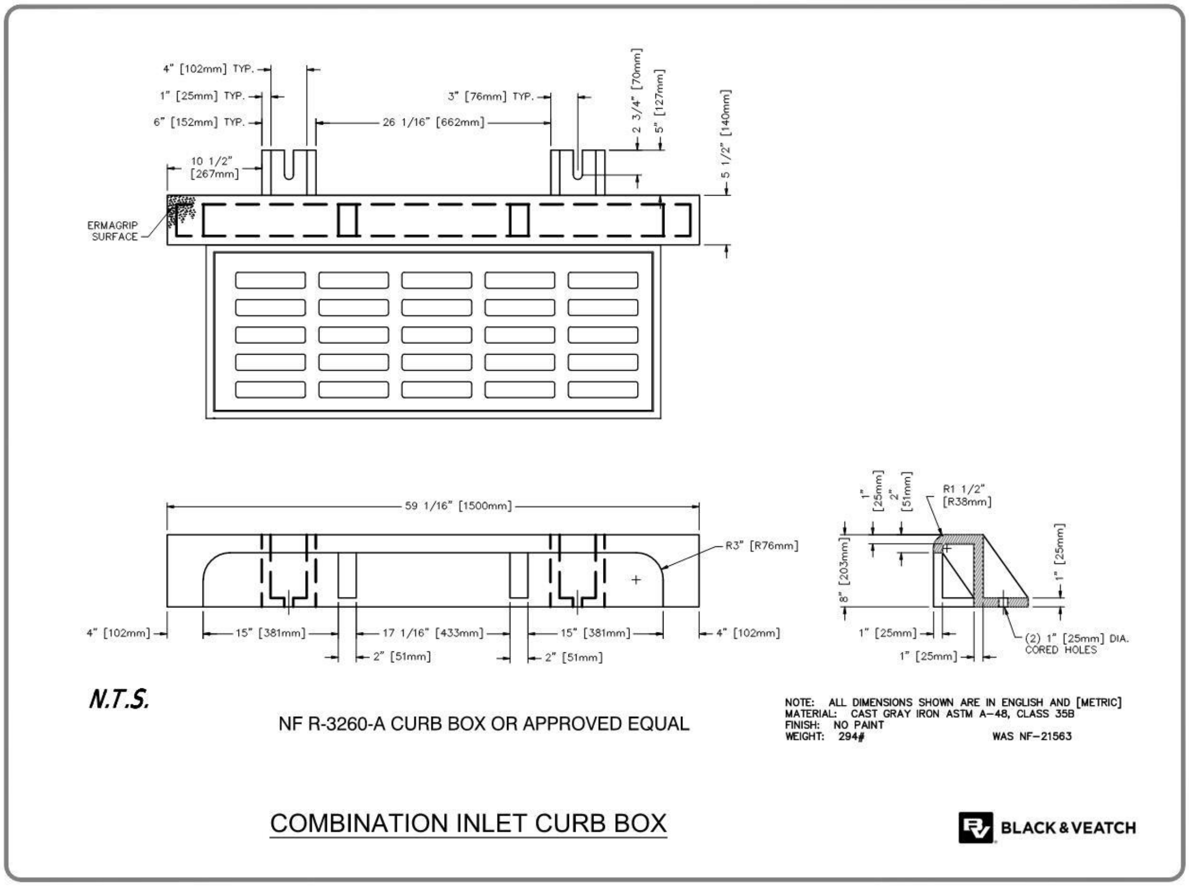


Figure 5-3 Standard Detail Depicting a Stormwater Inlet Curb Box

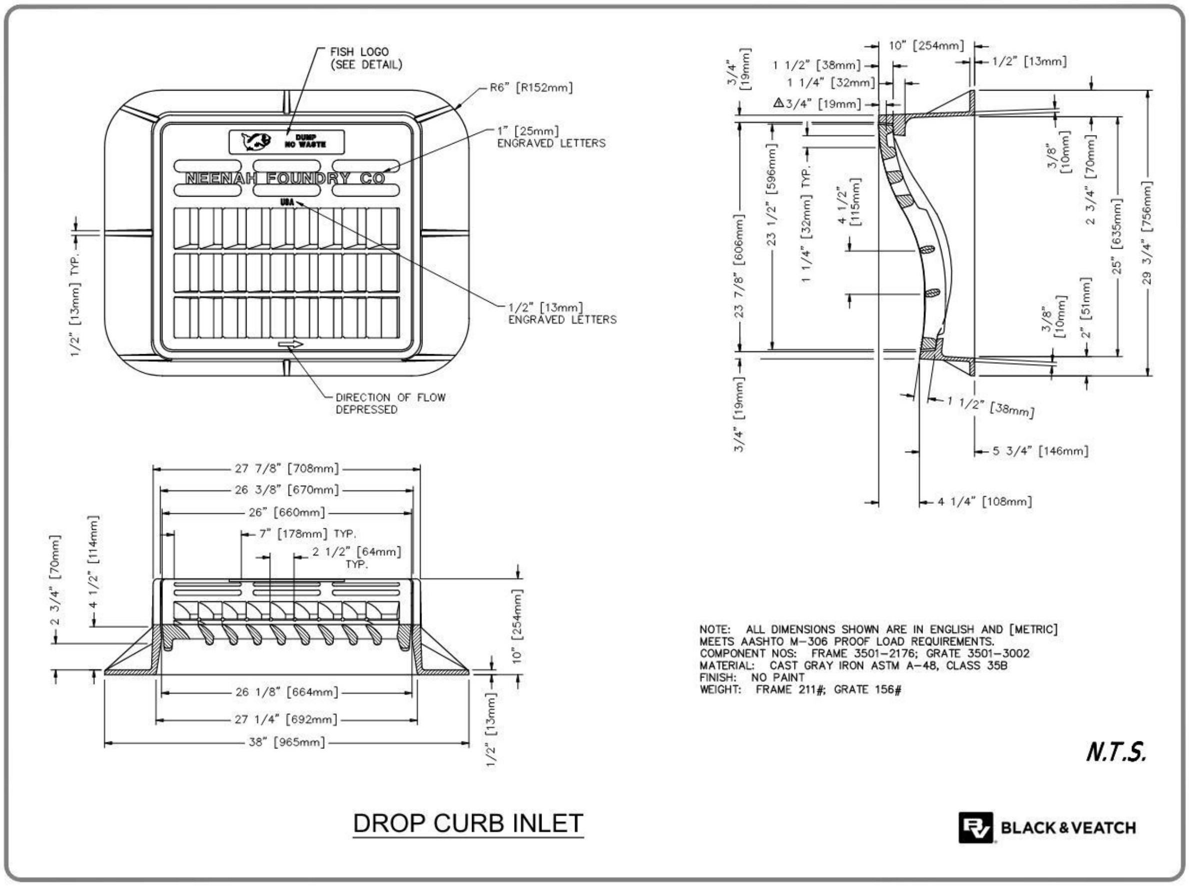


Figure 5-4 Standard Detail Depicting a Drop Curb Inlet

5.3 Stormwater Retention

A stormwater retention pond can serve multiple functions if implemented in the Fullerwood neighborhood. The pond will serve as the storage point for stormwater routed via inlets and conveyance pipes and will also provide water quality treatment. The pond should be designed to retain a permanent pool of water, only discharging during heavy rainfall once the stormwater reaches the orifice. During average rainfall events, the water retained in the pond will receive treatment as it percolates back into the ground. In addition, the pond may serve as a community recreation/nature park. A gravel path, benches, and native plantings could be installed to make the retention pond attractive to Fullerwood residents and wildlife alike and could function as a pocket park. The City could also use this park to install informative signs describing the stormwater improvements implemented in the neighborhood and their benefits. Currently, the City owns a parcel (1513300251) off Seminole Drive that would suit the construction of a stormwater retention pond/ neighborhood recreation park. Suppose the City wished to position a retention pond in a different location. In that case, three parcels (1509600000 and 1509500000 (2)) at Atlantic Avenue and Cross Street could be purchased for its construction. Below, **Figure 5-5** depicts a standard detail of a stormwater retention pond.

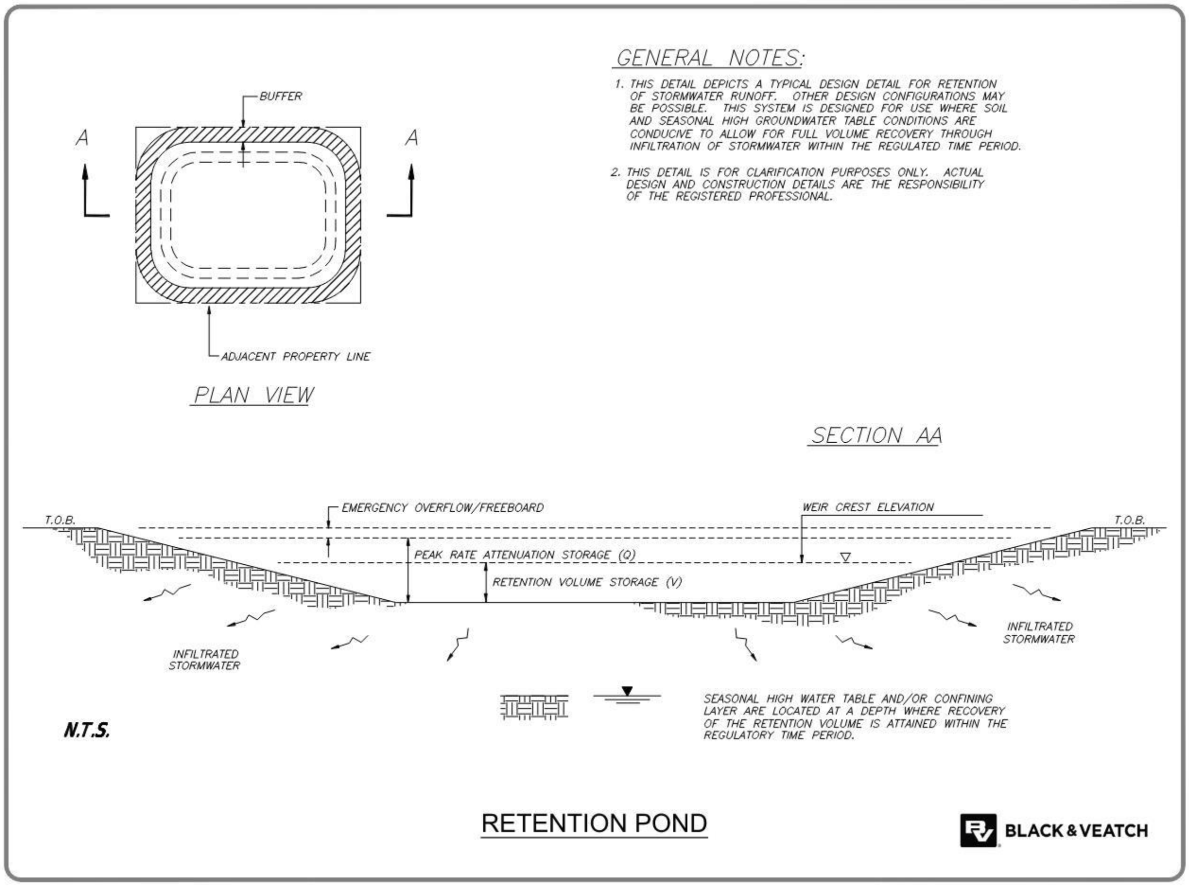


Figure 5-5 **Standard Detail Depicting a Typical Retention Pond Design**

5.4 Outfalls and Backflow Prevention

Once stormwater has been collected, outfalls may discharge the water into the marsh and away from Fullerwood roads and homes. To continue the program the City has implemented in the Davis Shores neighborhood, any new permitted outfalls should be fitted with backflow prevention valves, also known as tidal valves (https://www.citystaug.com/1005/City-Wide-Tide-Check-Valves). These valves allow stormwater to be discharged from the pipe but ensure that reverse flow from the marsh into the neighborhood is prohibited. The City is familiar with these types of valves. For example, the WaPro or Tideflex tidal valves could be utilized similarly to the valves installed on Seminole Drive. **Figure 5-6** and **Figure 5-7** below show standard details for an outfall design and a tidal check valve, respectively.

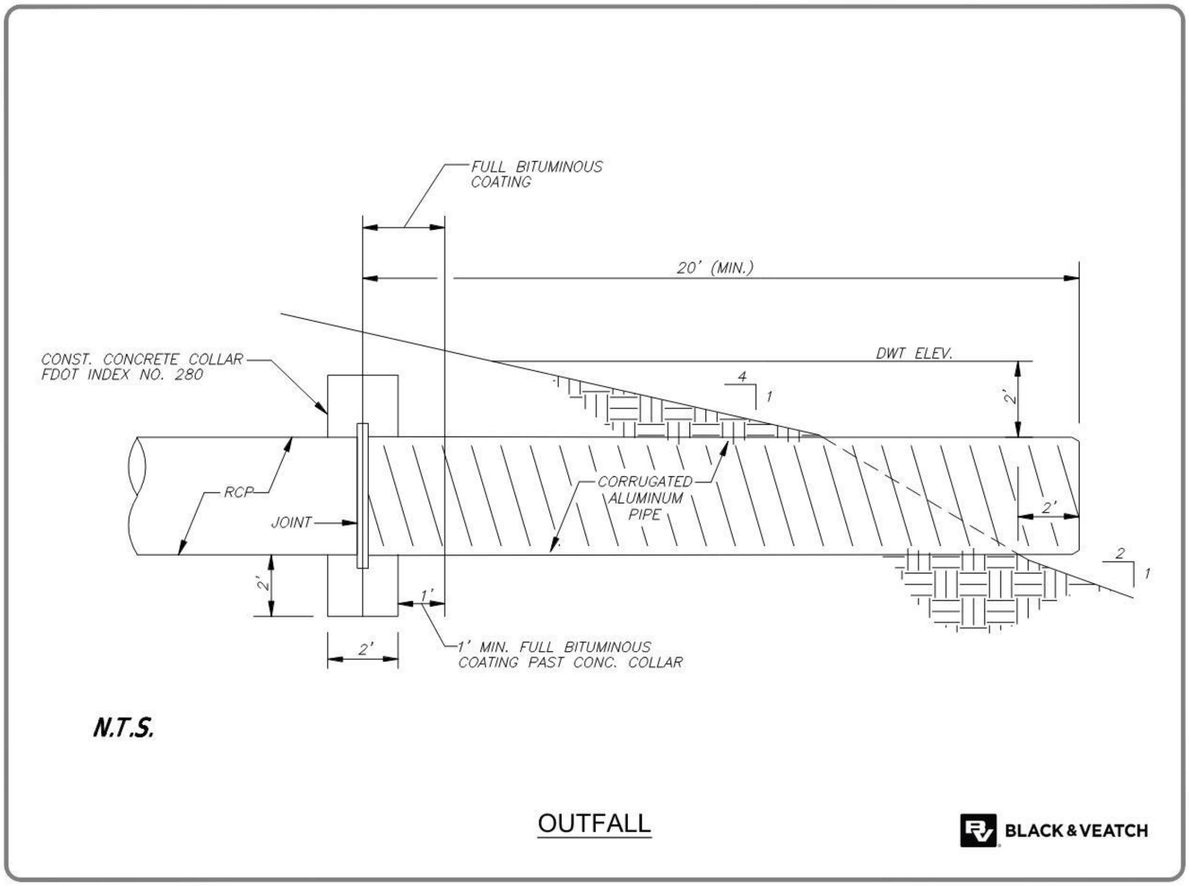


Figure 5-6 Standard Detail Depicting a Typical Outfall Design

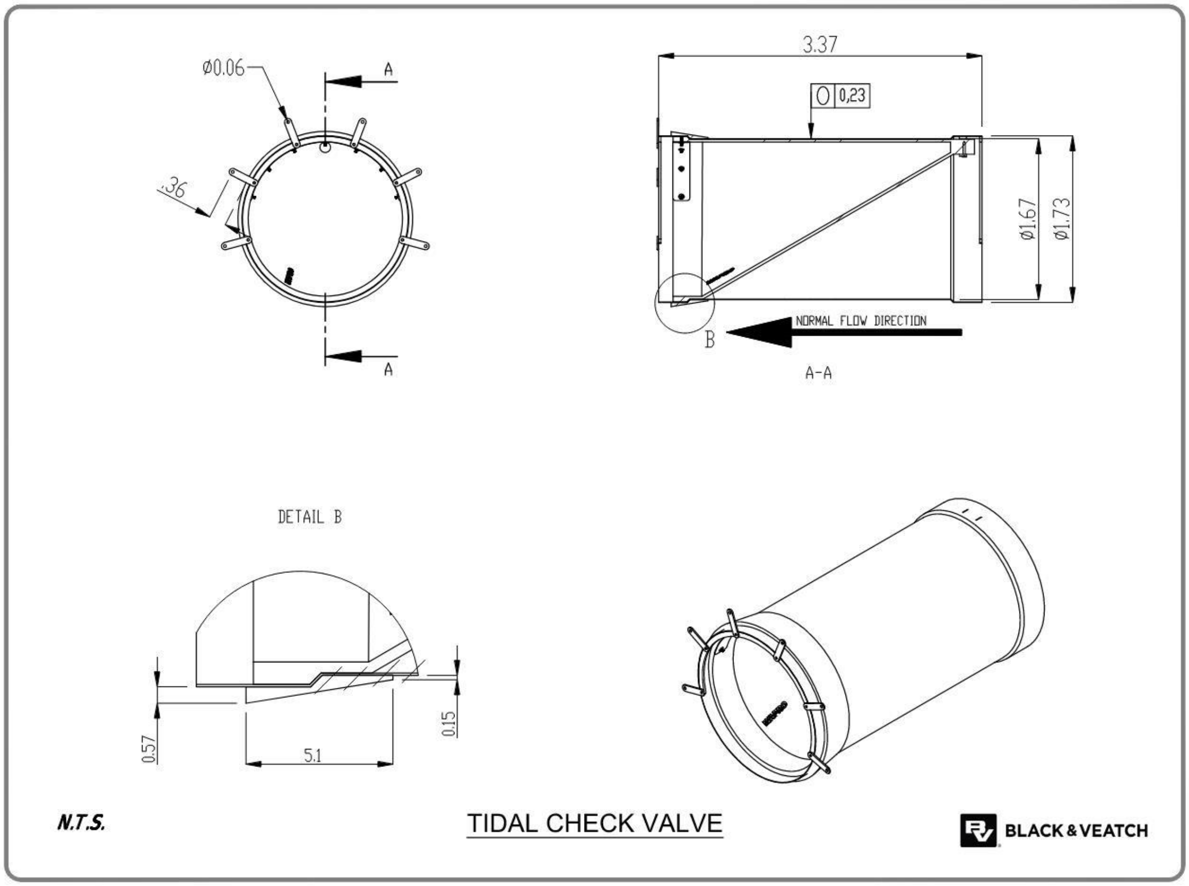


Figure 5-7 **Standard Detail Depicting a Tidal Check Valve**

5.5 Minor Berms and Road Regrading

In areas with appropriately sized rights-of-way, minor berms can be installed to slow or block stormwater and assist with diverting stormwater to swales or inlets. Berms are a low-cost, low-maintenance option that can be installed quickly. Additionally, regrading the roadways in the Fullerwood neighborhood would maximize the efficiency of the berms. Most existing roadways are relatively flat and do not have a pronounced crown. Regarding roads to enhance the slope, incorporating the previously mentioned drainage structures (inlets and conveyance pipe) will prevent ponding and birdbaths after rain showers. **Figure 5-8** and **Figure 5-9** below show standard details for a berm and roadway cross-section, respectively.

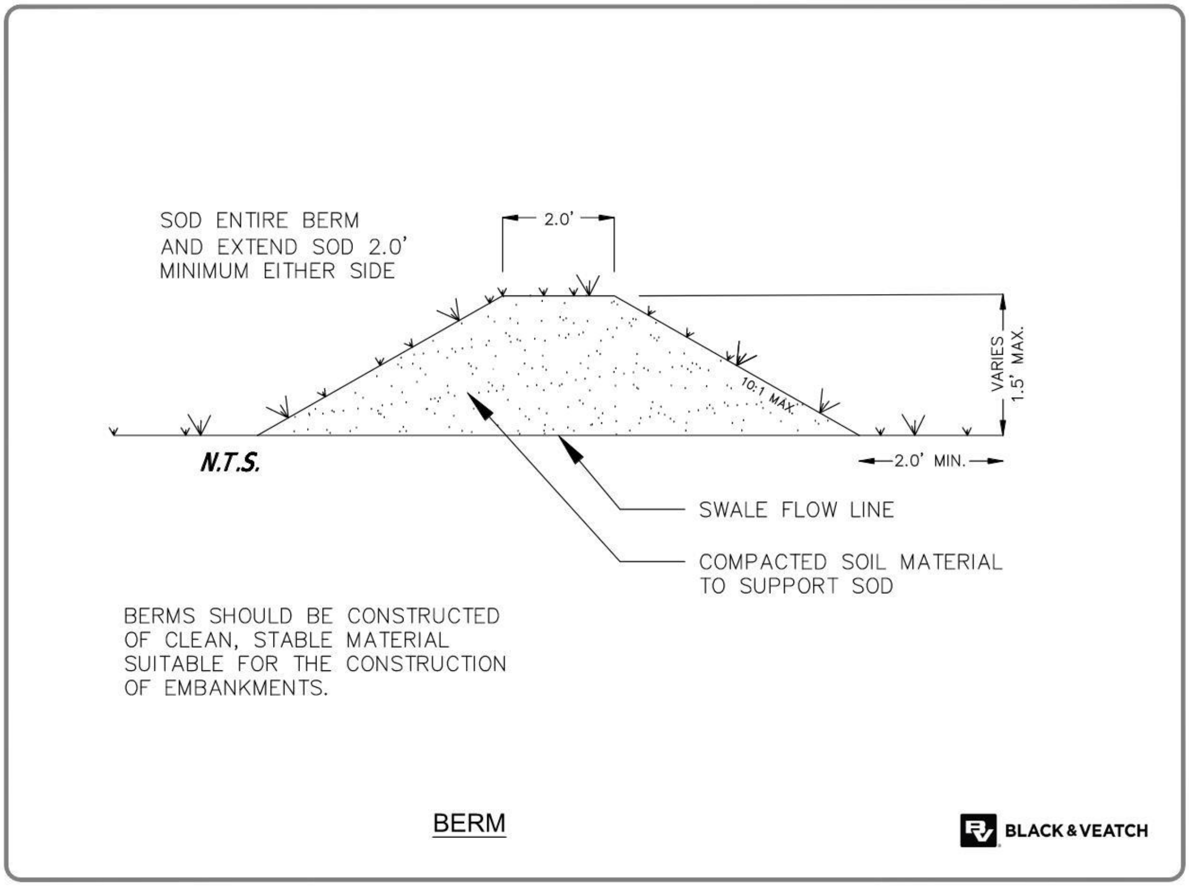


Figure 5-8 Standard Detail Depicting a Typical Stormwater Berm Design.

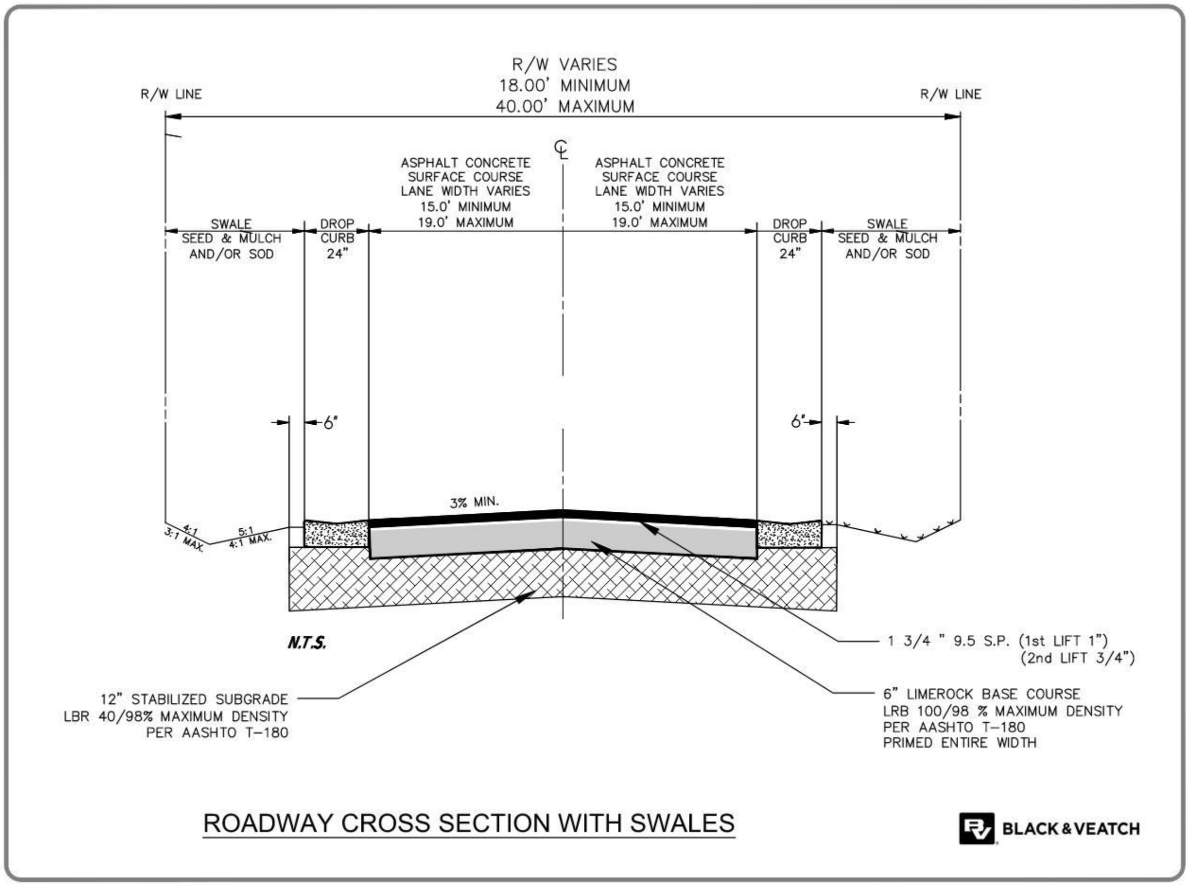


Figure 5-9 Standard Detail Depicting a Typical Roadway Cross Section with Swales

5.6 Stormwater Pump Station

A stormwater pump station would be considered if utility conflicts or sea-level rise and future-proofing to ensure stormwater could be successfully removed from the neighborhood roadways and residences; however, this is the costliest option that would also be the most intrusive stormwater mitigation method. Most other stormwater mitigation methods will blend in with the natural surroundings, while the stormwater pump station will require planning and foliage to blend in with the background. Depending on where a pump station is placed, neighboring homes would be affected by the noise of the pumps as they kick on. The pump station would be a highly effective method of moving nuisance stormwater. It may be the best option in future years as sea levels rise and draining the Fullerwood neighborhood becomes a more difficult task. As possible, the site location for the pump station would be near the intersection of Atlantic Avenue and Cross Street near the current lift station. These parcels are situated away from residences; this location may be an ideal place to construct a stormwater pump station.

6.0 Proposed Stormwater Mitigation Alternatives

Each of the alternatives developed as part of the Study includes several fundamental elements to facilitate the removal of nuisance flooding in the Fullerwood neighborhood:

- Three outfalls have been added to the Fullerwood neighborhood on Oak St, Seminole Dr, and Atlantic Ave. These outfalls are important to the design as they serve low-lying areas that currently do not have a positive drainage feature.
- Each outfall will have a backflow preventer installed.
- Road improvements include milling and overlay to slightly regrade the road or a full re-design to include gutters and an improved base course. The full suite of drainage improvements at the road level would be developed during a detailed design phase of the project.
- Pipe sizes would be a minimum of 12 inches in equivalent diameter. The elliptical pipe could be an alternative and recommended bid alternative during detailed design.
- Pipes would be reinforced concrete pipe (RCP) and maintained 12” of cover. This assumption was made due to a low volume of heavy equipment traffic.
- Roads would either be milled and overlayed or replaced to facilitate removing “Bird Bath” and promote flow to the city's drainage features.

6.1 Alternative 1

Alternative 1 considers an update and expansion of the existing conveyance system, including the implementation of the baseline requirements for the Fullerwood neighborhood. This alternative proposes installing three (3) 18” outfalls, milling and overlay for Oak Street, Althea Street, the northwest arm of Seminole Drive, and the southwestern half of Atlantic Avenue, as well as the installation of stormwater inlets and conveyance pipe. The first outfall is located at the terminus of Atlantic Avenue, the second behind 19 and 21 Oak Street, and the third just past 25 Seminole drive at the terminus of the roadway. To improve stormwater movement to the proposed outfalls, inlets and an 18” RCP conveyance system would be installed to facilitate discharge to the outfall at the end of Atlantic Avenue, the middle of Oak Street, and the end of Seminole Drive. These inlets would help support the draining of land-locked properties on Seminole Drive and support the additional flow Oak Street has received from localized development. This alternative relies heavily on conveyance pipe and provides little storage improvement. **Figure 6-1** and **Figure 6-2** provide references to the reduction of flooding that this alternative provides. The Exhibit for Alternative 1 can be found in **Appendix C**. A Class V cost estimate has been prepared for Alternative 1, shown below in **Table 6-1**, for the cost estimate survey and geotechnical exploration were not included.

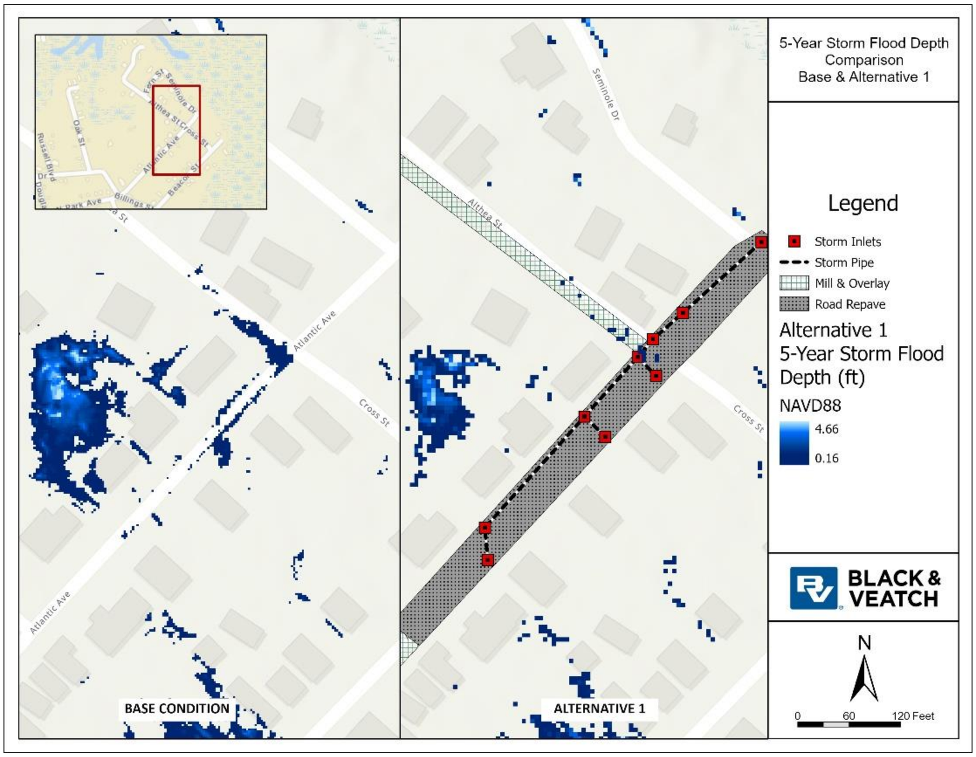


Figure 6-1 Alternative 1 - Atlantic Ave. & Althea St. Intersection 5-Year Flood Depth Comparison

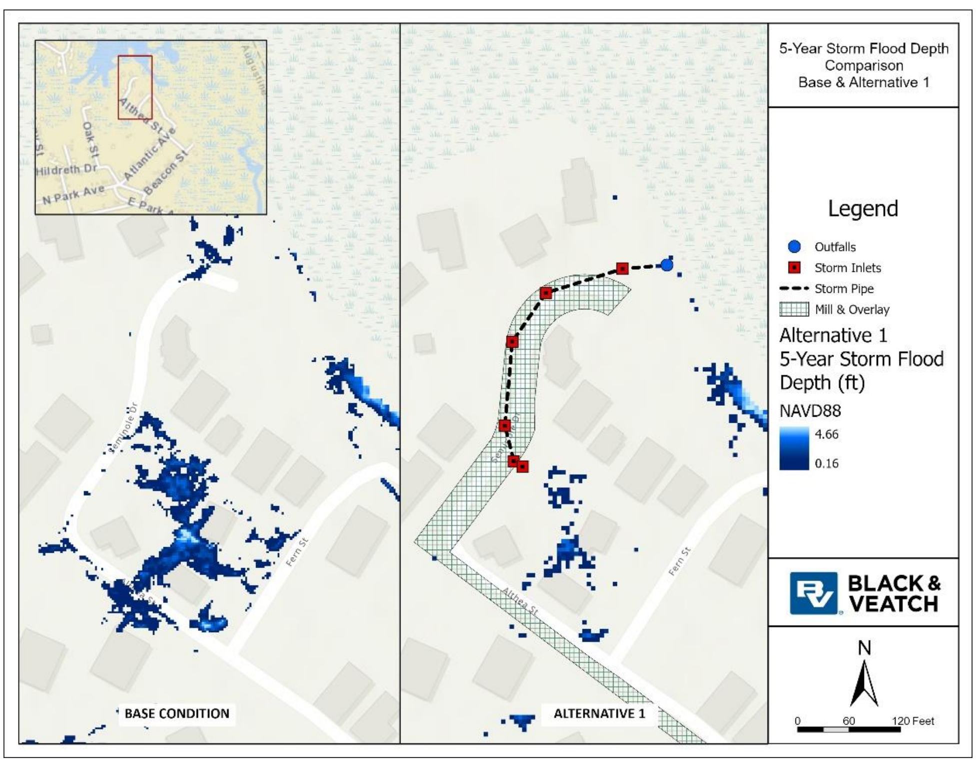


Figure 6-2 Alternative 1 - Seminole Dr. & Althea St. Intersection 5 YR Flood Depth Comparison

Table 6-1 Alternative 1 Class V Cost Estimate

ITEM	DESCRIPTION	UNITS	QUANTITY	UNIT COST	TOTAL
A	**STORMWATER SYSTEM IMPROVEMENTS**				
1.0	**Alternative One**				
	Outfalls	3.00	EA	$20,000.00	$60,000.00
	Type C Inlets	17.00	EA	$6,000.00	$102,000.00
	18" RCP Pipe	1,252.00	LF	$160.00	$200,320.00
	Mill & Overlay	900.00	CY	$200.00	$180,000.00
	Utilities Relocation	1.00	LS	$100,000.00	$100,000.00
	Road Repave	1,150.00	CY	$300.00	$345,000.00
	Subtotal				$987,320.00
			Restoration	20%	$197,464.00
			MOT	10%	$98,732.00
			Design	13%	$128,351.60
	Total				$1,411,867.60

6.2 Alternative 2

Alternative 2 includes the implementation of one storage feature on a City owned parcel off of Seminole Drive and a second off of Atlantic Avenue on parcels that the City could acquire. Between both stormwater retention ponds, the total amount of storage provided is approximately 0.12 ac-ft. Alternative 2 proposes Oak Street, Atlantic Avenue, and Beacon Street would be repaved and gutters would be installed while the northwest arm of Seminole Drive and northwest half of Althea Street would be candidates for mill and overlay. This design provides a longer-term and more resilient road design to facilitate drainage with less conveyance pipe. Gutters provide a defined feature along the road that helps mitigate the creation of localized flooding areas. **Figure 6-3** and **Figure 6-4** provide references to the reduction of flooding that this alternative provides. The Exhibit for Alternative 2 can be found in **Appendix C**. A Class V cost estimate has been prepared for Alternative 2, shown below in **Table 6-2**, for the cost estimate survey and geotechnical exploration were not included.

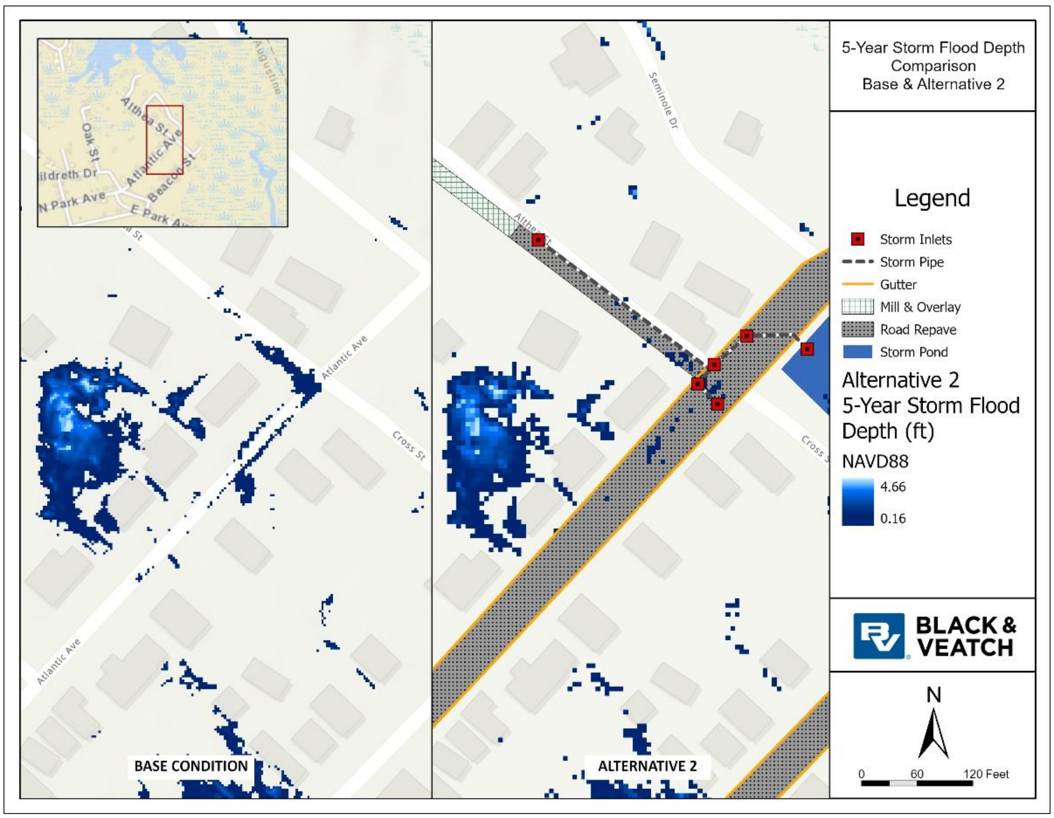


Figure 6-3 **Alternative 2 - Atlantic Ave. & Althea St. Intersection 5-Year Flood Depth Comparison**

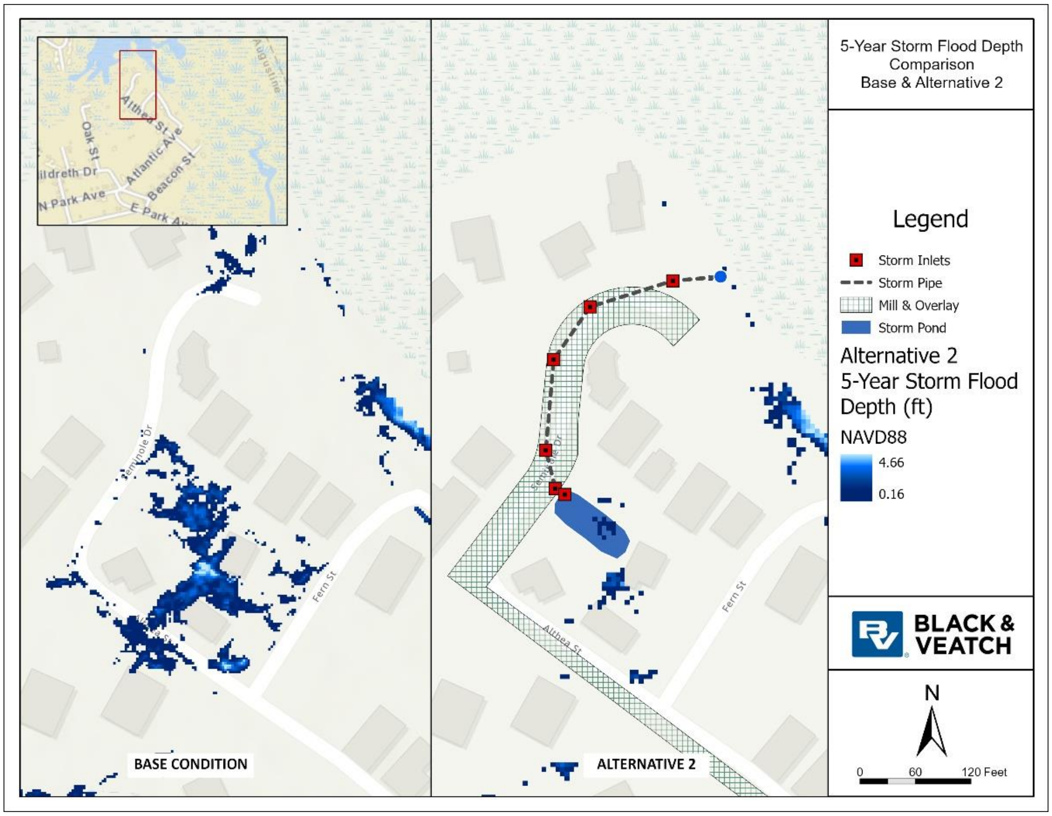


Figure 6-4 Alternative 2 - Seminole Dr. & Althea St. Intersection 5 YR Flood Depth Comparison

Table 6-2 Alternative 2 Class V Cost Estimate

ITEM	DESCRIPTION	UNITS	QUANTITY	UNIT COST	TOTAL
A	**STORMWATER SYSTEM IMPROVEMENTS**				
2.0	**Alternative Two**				
	Outfalls	3.00	EA	$20,000.00	$60,000.00
	Type C Inlets	17.00	EA	$6,000.00	$102,000.00
	18" RCP Pipe	1,249.00	LF	$160.00	$199,840.00
	Mill & Overlay	325.00	CY	$200.00	$65,000.00
	Utilities Relocation	1.00	LS	$85,000.00	$85,000.00
	Road Repave	5,500.00	CY	$300.00	$1,650,000.00
	Gutter	5,295.00	LF	$40.00	$211,800.00
	Stormwater Pond	0.42	AC	$75,000.00	$31,500.00
	Subtotal				$2,405,140.00
			Restoration	20%	$481,028.00
			MOT	10%	$240,514.00
			Design	13%	$312,668.20
	Total				$3,439,350.20

6.3 Alternative 3

Alternative 3 proposes the installation one storage feature at the property that the City currently owns off of Seminole Drive that will provide 0.03 ac-ft of storage. Like Alternative 1, Alternative 3 includes mostly mill and overlay and minimal road reconstruction only where required. The major difference this alternative provides is the inclusion of swales to support draining the rear of properties on Atlantic Avenue and Seminole Drive. The swales would be designed to be between 10 feet and 12 feet wide and have side slopes of 6:1 as not to impact the residents' daily activities. However, this alternative provides challenges since these swales would require easements to be acquired by the City and earthwork to be performed on private property to facilitate drainage patterns. **Table 1-2** lists the parcels that would be affected by the installation of these swales. **Figure 6-5** and **Figure 6-6** provide references to the reduction of flooding that this alternative provides, and the Exhibit for Alternative 3 can be found in **Appendix C**. A Class V cost estimate has been prepared for Alternative 3, shown below in **Table 6-3**, for the cost estimate survey and geotechnical exploration were not included.

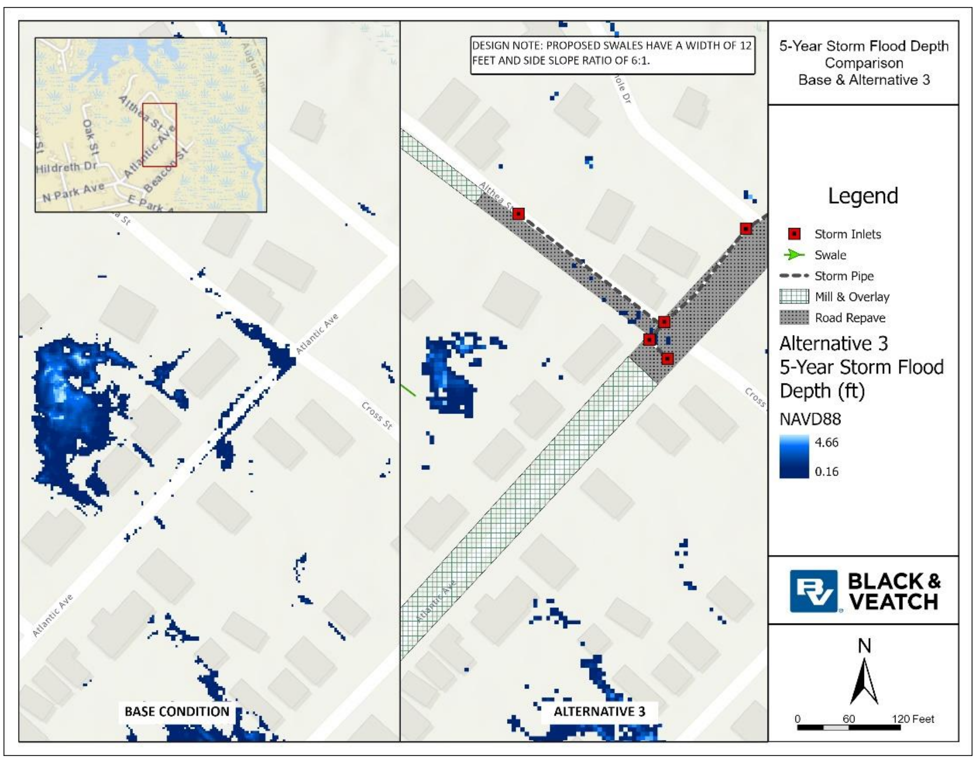


Figure 6-5 Alternative 3 - Atlantic Ave. & Althea St. Intersection 5-Year Flood Depth Comparison

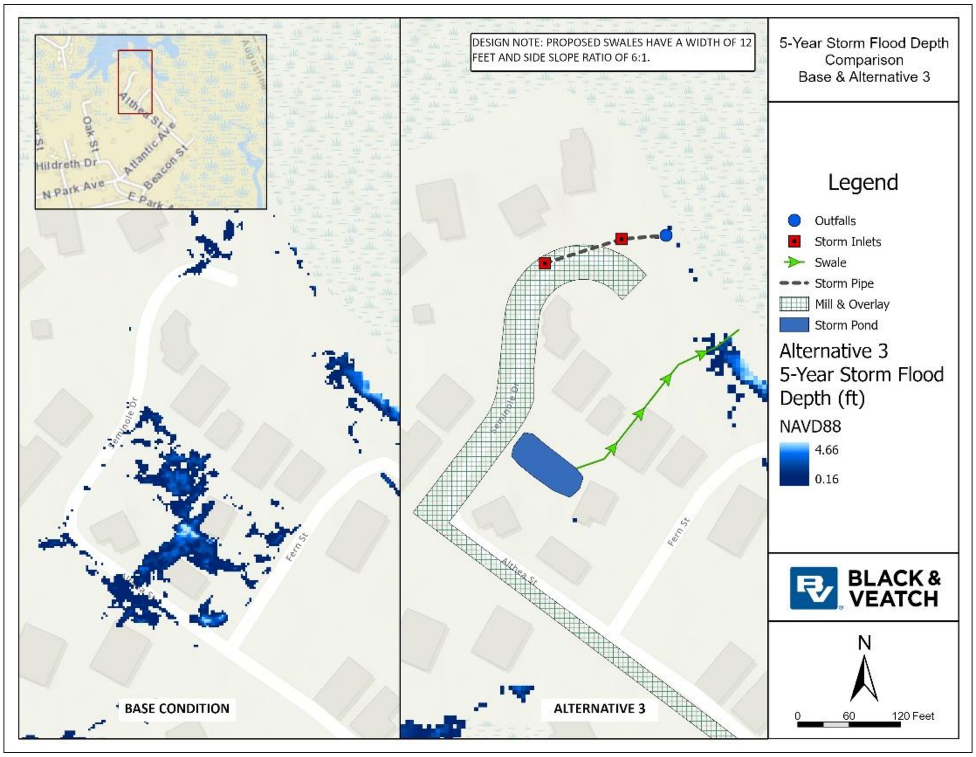


Figure 6-6 Alternative 3 - Seminole Dr. & Althea St. Intersection 5 YR Flood Depth Comparison

Table 6-3 Alternative 3 Class V Cost Estimate

ITEM	DESCRIPTION	UNITS	QUANTITY	UNIT COST	TOTAL
A	**STORMWATER SYSTEM IMPROVEMENTS**				
3.0	**Alternative Three**				
	Outfalls	3.00	EA	$20,000.00	$60,000.00
	Inlets	12.00	EA	$6,000.00	$72,000.00
	18" RCP Pipe	1,052.00	LF	$160.00	$168,320.00
	Utilities Relocation	1.00	LS	$50,000.00	$50,000.00
	Mill & Overlay	1,000.00	CY	$200.00	$200,000.00
	Road Repave	1,075.00	CY	$300.00	$322,500.00
	Swale	592.00	LF	$500.00	$296,000.00
	Total				$1,168,820.00
			Restoration	20%	$233,764.00
			MOT	10%	$116,882.00
			Design	13%	$151,946.60
	Total				$1,671,412.60

6.4 Alternative 4

Alternative 4 represents a potential future phase with increased rainfall conditions; however, any previous alternatives could be upgraded to reflect future rainfall conditions. This alternative proposes replacing and redesigning Oak Street, Seminole Drive, Althea Street, and Atlantic Avenue to include gutters which will significantly enhance the City's drainage and localized flooding issues. Alternative 4 also includes minor regrading of the City owned parcel off of Seminole Drive and the eventual inclusion of a pocket park for the resident's use. This alternative also includes a conveyance pipe from the City's Seminole Drive parcel to Atlantic Avenue and a general interconnection of the conveyance system to a stormwater pump station. The pump station represents a shift from the more passive mitigation strategies proposed in the other alternatives, requiring a system with a max pump rate of 10 cubic feet per second. The pump station would be situated near the city's existing lift station at the intersection of Althea Street and Atlantic Avenue. **Figure 6-7** and **Figure 6-8** provide references to the reduction of flooding that this alternative provides. The Exhibit for Alternative 4 can be found in **Appendix C** and a Class V cost estimate has been prepared for Alternative 4, shown below in **Table 6-4**. Geotechnical exploration and survey were not included in the cost estimate.

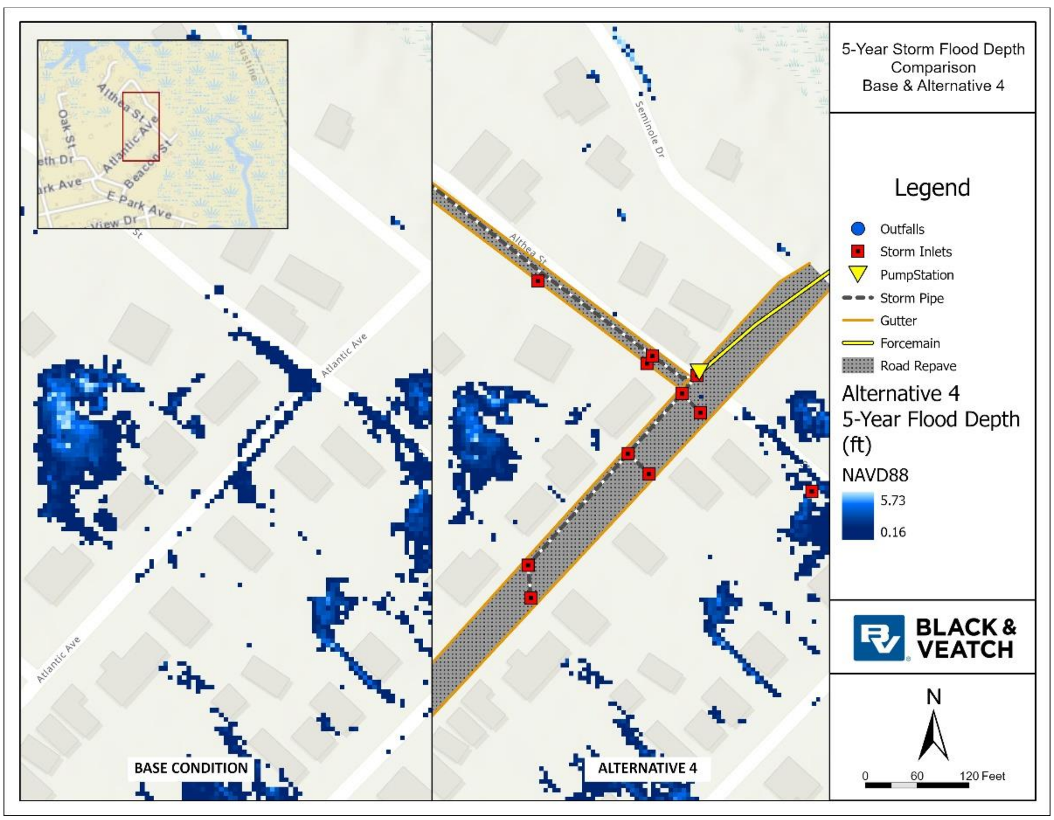


Figure 6-7 Alternative 4 - Atlantic Ave. & Althea St. Intersection 5-Year Flood Depth Comparison

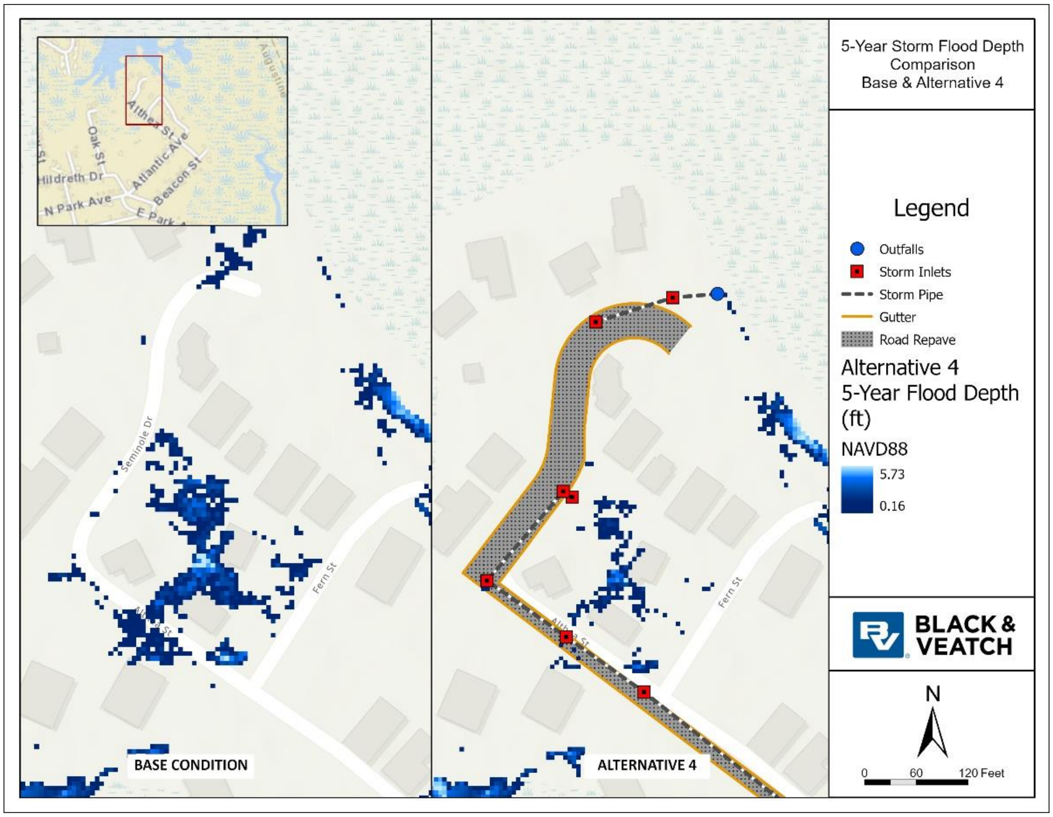


Figure 6-8 Alternative 4 - Seminole Dr. & Althea St. Intersection 5 YR Flood Depth Comparison

Table 6-4 Alternative 4 Class V Cost Estimate

ITEM	DESCRIPTION	UNITS	QUANTITY	UNIT COST	TOTAL
A	**STORMWATER SYSTEM IMPROVEMENTS**				
4.0	**Alternative Four**				
	Outfalls	3.00	EA	$20,000.00	$60,000.00
	Inlets	22.00	EA	$6,000.00	$132,000.00
	18" RCP Pipe	1,633.00	LF	$160.00	$261,280.00
	Utilities Relocation	1.00	LS	$250,000.00	$250,000.00
	Road Repave	5,000.00	CY	$300.00	$1,500,000.00
	Gutter	6,187.00	LF	$40.00	$247,480.00
	Pump	1.00	EA	$1,500,000.00	$1,500,000.00
	Forcemain	295.00	LF	$260.00	$76,700.00
	Total				$4,027,460.00
			Restoration	20%	$805,492.00
			MOT	10%	$402,746.00
			Design	13%	$523,569.80
	Total				$1,731,807.80

6.5 Alternatives Ranking

To determine the effectiveness of each alternative, FEMA's depth-damage equation was used to calculate the cost of flood damage for those homes across the Fullerwood neighborhood that experienced flooding. This calculation was performed for each parcel using the assessed home value available from St. Johns County Property Appraiser and totaled for the entire neighborhood. Any flooding that occurred on the parcel was used across the whole parcel to account for antecedent conditions, temporary field obstructions, and physical obstructions. This assumption provides a conservative approach to flood assessment to ensure that a worst-case scenario is utilized for each storm event. This was done for each design storm (5-year, 25-year, and 100-year) across all conditions, including the base and future conditions, Alternative 1, Alternative 2, Alternative 3, & Future Alternative 4. As seen in **Table 6-5** below, Alternative 3 offers the greatest reduction in depth-damage costs during a 5-year design storm. It should be noted that Alternative 3 will require easements and property owner coordination; however, it would be a robust and direct solution to the flooding within the Fullerwood Area. A summary of the model results compared to their flood depths for each alternative discussed can be found in **Appendix D** for reference. To further determine the effectiveness of each alternative, the approximate amount the City would save by implementing each alternative was divided by the cost to implement that alternative to calculate a benefit-cost ratio. As seen in **Table 6-6**, the benefit-cost is the highest for Alternative 3.

Table 6-5 Depth-Damage Costs for Each Design Storm Across All Conditions

		Condition	Depth-Damage Result	Base Depth-Damage Result Minus Alternative Depth-Damage Result
Design Storm	5-Year	**Base**	$8,560,846.52	$0.00
		Alternative 1	$7,250,750.07	$1,310,096.45
		Alternative 2	$7,266,536.70	$1,294,309.82
		Alternative 3	$6,534,725.02	$2,026,121.50
	25-Year	**Base**	$9,463,904.69	$0.00
		Alternative 1	$8,916,351.06	$547,553.63
		Alternative 2	$9,090,617.77	$373,286.92
		Alternative 3	$8,819,195.19	$644,709.50
	100-Year	**Base**	$10,223,972.64	$0.00
		Alternative 1	$10,071,299.81	$152,672.83
		Alternative 2	$10,076,580.85	$147,391.79
		Alternative 3	$9,751,139.63	$472,833.01
Future Rainfall	5-Year	**Base**	$9,126,950.87	$0.00
		Alternative 4	$8,330,217.97	$796,732.90
	25-Year	**Base**	$10,476,305.52	$0.00
		Alternative 4	$10,300,329.97	$175,975.55
	100-Year	**Base**	$11,339,724.31	$0.00
		Alternative 4	$10,853,925.73	$485,798.58

Table 6-6 Benefit-Cost Ratio by Proposed Stormwater Mitigation Alternative

Alternative	Alternative Implementation Cost	Savings Incurred by Implementing Alternative	Benefit-Cost Ratio
Alternative 1	$1,411,867.60	$1,310,096.45	0.93
Alternative 2	$3,439,350.20	$1,294,309.82	0.38
Alternative 3	$1,671,412.60	$2,026,121.50	1.21
Alternative 4	$1,731,807.80	$796,732.90	0.46

*Values in this table reflect the 5-year design storm.

6.6 Zoning & Ordinance Considerations

As redevelopment occurs, the city should consider resolving local drainage challenges by implementing best practices and design standards for residents' use. These guidelines would help to facilitate when redevelopment occurs and support the continued push for resilience. Some key details that other Cities have prepared have been provided in **Appendix F** for reference. In addition to these, possible improvements other items to consider are:

- The Community Rating System (CRS) benefits from adopting the code under section 420 Open Space Preservation. The City has progressed much under this section, but continued enhancement will support maintaining the current score. This approach can also support Section 370 Flood Insurance Promotion, Section 430 Higher Regulatory Standards, and Section 450 Stormwater Management.
    - Examples for these are provided under **Appendix E**
- Best management practices for seawalls, site development, swales, and parcel drainage can be provided.
    - Examples for these are provided under **Appendix E**

Additional details and recommendations for Zoning & Ordinance considerations can be developed under a separate work order. These recommendations and an asset management approach could elevate the city as a resilient leader and help it leverage the capital projects it has been implementing.

7.0 Future Steps

7.1 Survey Recommendations

For detailed design services, a topographic survey could be completed to provide valuable information about the project site that can be used to inform the design of the roads and drainage system. It confirms the location and dimensions of key features such as right-of-way widths, subsurface utilities, and mailboxes, and identifies any potential obstacles or constraints that may need to be taken into account in the design. Additionally, the survey can provide accurate information about the residents' finish flood elevation, which is critical for ensuring that the roads and drainage system are designed to handle potential flooding events.

7.2 30% Detailed Design

Given the competitive nature of grants, the further detailed a project is, the easier grant funding could be awarded to the project. Completing a 30% design could also confirm the water quality requirements and complete a pre-application with the SJRWMD meeting to continue the project's progression. During 30%, green infrastructure features could be implemented within the alternatives to support water quality requirements such as bioswales, rain gardens, tree boxes, or other features.

7.3 Coastal Evaluation

This study did not include a coastal evaluation. However, given the increased frequency and severity of Nor'easter storms in recent years, it is recommended that a living shoreline assessment be conducted near for the Fullerwood Neighborhood. These storms can cause significant erosion and damage to shorelines, putting nearby homes and infrastructure at risk. A living shoreline assessment can help identify areas that are particularly vulnerable to storm damage and develop a plan to mitigate these risks.

The shoreline assessment should include a thorough analysis of the shoreline's condition, including an evaluation of any existing erosion control structures and the potential for further erosion and flooding during a Nor'easter storm. Based on this analysis, recommendations can be developed for the design and implementation of a living shoreline that can help protect the shoreline from damage during future storms. This may involve the use of natural materials and vegetation to stabilize the shoreline, as well as the installation of structures such as breakwaters or revetments to provide additional protection. By implementing these recommendations, the shoreline and residents' homes can be better protected against the damaging effects of Nor'easter storms, ensuring the safety of nearby homes and infrastructure.

7.4 Geotechnical Exploration

To continue the design, geotechnical information will need to be collected to determine the extent of the road to be replaced and the suitable material for the road design.

7.5 Evaluation of Utilities Condition

Given the nature of this project, the right-of-way utilities will likely be impacted in portions of the neighborhood. During detailed design, a comprehensive evaluation of existing area utilities would provide a greater understanding of implementing the chosen alternative and determine if any existing utilities need to be repaired or replaced to support a dig-once philosophy.

7.6 Permitting Consideration

This area's future stormwater infrastructure improvements are defined as a stormwater retrofit in the Florida Department of Environmental Protection (FDEP) Environmental Resource Permit (ERP) Handbook. Therefore, an individual permit that satisfies water quality pre-treatment requirements will be required. It should be noted that In March 2024, Florida ratified a new stormwater rule, which requires the following: All stormwater treatment systems shall, at a minimum, provide a level of treatment sufficient to accomplish the greater of the following nutrient load reduction criteria:

1. An 80 percent reduction of the average annual loading of total phosphorus (TP) and total nitrogen (TN) from the proposed project; or

2. a reduction such that the average annual loading of nutrients post-development condition does not exceed the predevelopment condition nutrient loading.

Predevelopment and post-development hydrology calculations must be performed to determine which criteria apply to the project. The rule also outlines conditions that must be met if the outfall is to discharge into an impaired waterbody, and the FDEP identifies the Fullerwood neighborhood as part of an impaired waterbody area, the Tolomato River. The Stormwater Rule states the following requirements for impaired waterbodies:

Stormwater treatment systems located within a HUC 12 sub-watershed that contains impaired water and located upstream of that impaired water shall provide a level of treatment sufficient to accomplish the following:

1. An 80 percent reduction of average annual loading of TP and TN from the proposed project; and
2. a reduction such that the post-development condition average annual loading of nutrients does not exceed the predevelopment condition nutrient loading; and
3. The average annual loading of those pollutants in post-development conditions that do not meet water quality standards is less than that of the predevelopment condition.

However, the neighborhood is near the bottom of this impaired waterbody area, and the rule requires upstream treatment systems. It is recommended that the City work with the FDEP and SJRWMD in a pre-application meeting to determine impaired waterbody status and whether upstream credit can be leveraged.

8.0 Funding Options

The work proposed to mitigate flooding in the Fullerwood neighborhood will have multiple benefits, including flooding reduction, stormwater management, water quality improvements, and creating a community recreation area. While most project funding will likely come from grants and loans supporting flood reduction and stormwater management, the City should think about the project holistically to secure the maximum funding.

- **FEMA Grants.** There are numerous ways to fund stormwater and flood mitigation projects. FEMA offers two grants, Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA), that closely align with the improvements proposed in the Fullerwood neighborhood.
    - **BRIC.** This Grant focuses on hardening community lifelines (roads, shelter, water supply, etc.) with an emphasis on green infrastructure,
    - **FMA**. This grant provides funding for properties that are covered through NFIP insurance. Both of these grants are competitive and would benefit the City by grouping Fullerwood with another neighborhood as a package for either of these programs.

- **Resilient Florida Grant Program.** FDEP also offers grant money through its Resilient Florida Grant Program, which funds projects reducing a community's risk of flooding and rising sea levels. However, this grant requires the applicant to have a comprehensive vulnerability assessment already performed. The City is currently developing its Vulnerability Assessment, and including Fullerwood as an observed focus area would support its prioritization for funding.
- **Municipal Service Benefit Unit**. Given the community's interest in reducing flooding in the neighborhood, Municipal Service Benefit Units could be another funding source for the project. To fund the work, each property that receives value from the project would be given a special assessment based on how greatly it benefits them.
- **State Revolving Fund**. The Clean Water State Revolving Fund (CWSRF) Program provides low-interest loans to local governments to plan, design, and build or upgrade wastewater, stormwater, and nonpoint source pollution prevention projects.
- **FDEP.** The Water Quality Improvement Grant Program (formerly the Wastewater Grant Program) provides funding to Florida's governmental entities (cities, counties, municipalities, etc.) to address wastewater (including septic to sewer), stormwater and agricultural sources of nutrients in waterbodies that are not attaining nutrient or nutrient-related standards, have an established total maximum daily load or are located within a basin management action plan area, a reasonable assurance plan area, an accepted alternative restoration plan area, or a rural area of opportunity under s. 288.0656.