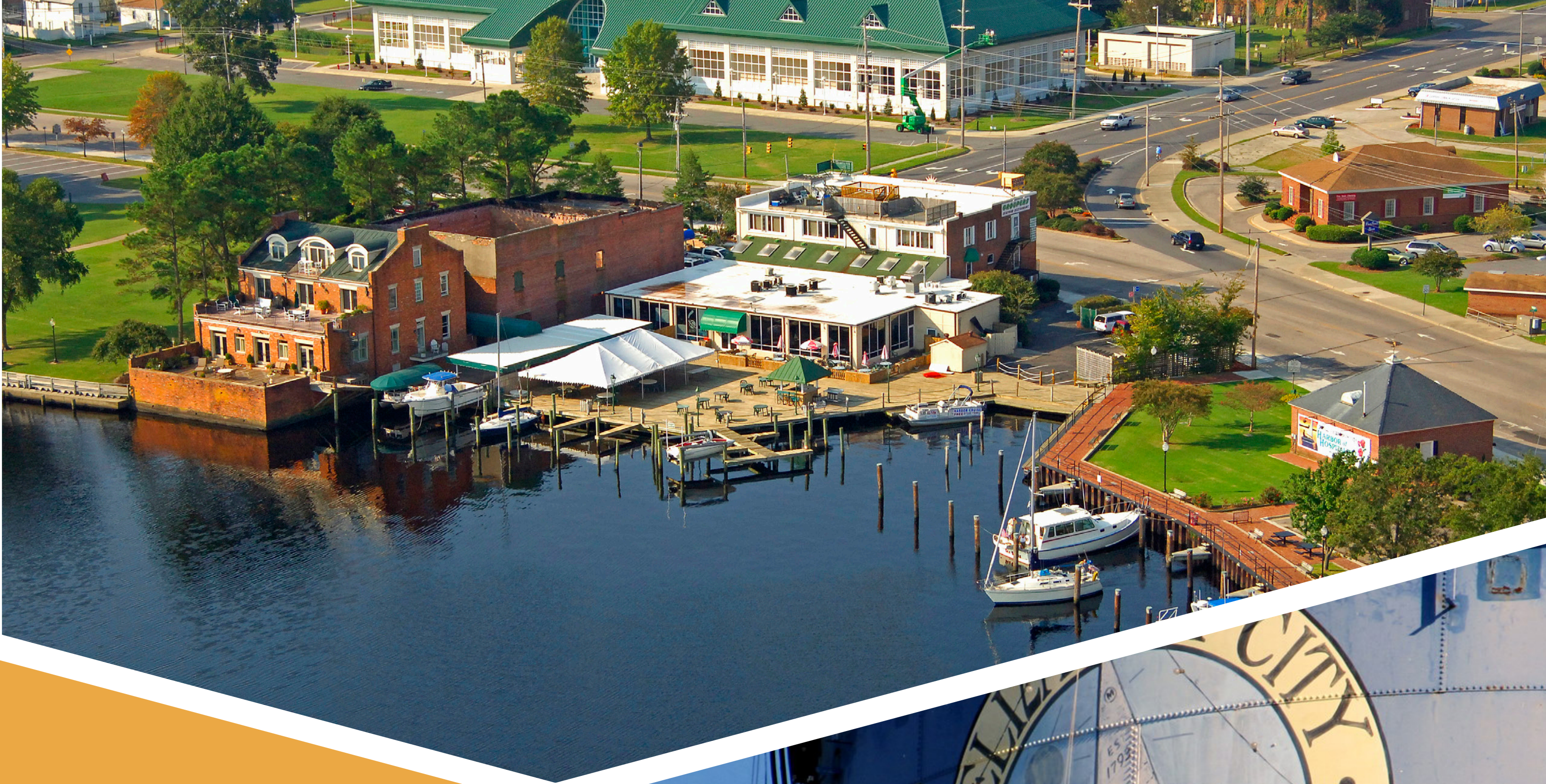

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CITY OF ELIZABETH CITY

CHARLES CREEK FLOOD MITIGATION PLAN

FINAL

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FINAL

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City of Elizabeth City

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Executive Summary

The Charles Creek area of Elizabeth City is prone to flooding due to local rainfall, coastal storms, and wind tide events. The City of Elizabeth City received a grant through North Carolina Division of Coastal Management's Planning and Management Grants Program to create a plan to mitigate flooding and increase flooding resiliency. Moffatt & Nichol (M&N) was tasked with gathering public input and developing solutions to improve flood resilience in the Charles Creek area.

In preparing this Charles Creek Flood Mitigation Plan, M&N completed an existing conditions assessment and watershed evaluation. Hydrologic/hydraulic modeling and analysis using XPSWMM was conducted to develop and support proposed flood mitigation alternatives. Work on these tasks was completed in conjunction with M&N's City of Elizabeth City's Waterfront Master Planning effort. Throughout the design and planning processes, meaningful public involvement in the development of flood mitigation alternatives was sought using an online public participation survey as well as through multiple open public meetings and preliminary plan presentations.

Potential flood mitigation options to improve resilience around Charles Creek include protective berms and road raises, a flood gate and pump system, buyouts, elevation or relocation of structures, and the implementation of green infrastructure. XPSWMM was selected to model the following conditions to determine the potential effects of flood mitigation projects using engineered solutions: 1) Existing Conditions, 2) Protective Berms, 3) Flood Gate and Pump System, and 4) Green Infrastructure. Non-engineering solutions, such as buyouts and the elevation or relocation of flood-prone buildings, were also evaluated. In addition to developing flood mitigation alternatives, post-flood recovery strategies to further improve resilience in Elizabeth City were created.

Each of these investigated solutions provides increased flood protection against local rainfall and/or wind tide surges. For these alternatives, funding approaches were explored in the form of loan and federal grant programs. Revisions to policies and ordinances related to stormwater management and floodplain development are to be considered as additional measures to meet flood resilience goals in Elizabeth City.

Based on the modeling efforts and the cost analysis, the elevation or relocation of flood-prone structures, or the use of protective berms are recommended flood mitigation alternatives for further study. From a cost-benefit standpoint, the elevation of flood-prone structures is the most cost effective (benefit-cost ratio (B/C) of 8.0) followed by relocation (B/C = 4.3). However, the use of protective berms does offer added neighborhood connectivity and recreational benefits and has a B/C of 2.9. The revision of existing ordinances to promote the use of green infrastructure as well as the enforcement of specific freeboard requirements for new and existing development would further improve flood resilience in Elizabeth City.

1 PROJECT BACKGROUND

Many areas within the lower portion of the Charles Creek watershed are just a few feet above sea level, making the area prone to flooding due to local rainfall, coastal storms, and wind tide events. The City of Elizabeth City received a grant through North Carolina Division of Coastal Management's Planning and Management Grants Program to create a plan to mitigate flooding and improve flood resilience. Moffatt & Nichol (M&N) was tasked with gathering public input and developing solutions to improve resilience in the Charles Creek area. In the past, the City has dedicated resources to reduce flooding in the upper portion of the Charles Creek watershed. This study focuses on the development of flood mitigation alternatives to decrease flooding in the lower portion of the watershed while integrating upstream improvements.

Figure 1-1. Flooding near Charles Creek (City of Elizabeth City, 2017)

Elizabeth City is comprised primarily of medium density development with intermittent forested and surrounding agricultural areas. Much of the area surrounding Charles Creek contains low-lying residential neighborhoods and swampy forested spaces. These existing land uses were to be considered in the development of feasible flood mitigation alternatives.

In preparing this Charles Creek Flood Mitigation Plan, Moffatt & Nichol (M&N) was to perform an existing conditions assessment and watershed evaluation. Hydrologic/hydraulic modeling and analyses using XPSWMM were to be conducted to develop and support proposed flood mitigation alternatives. Work on these tasks was to be completed in coordination with M&N's City of Elizabeth City's Waterfront Master Planning effort.

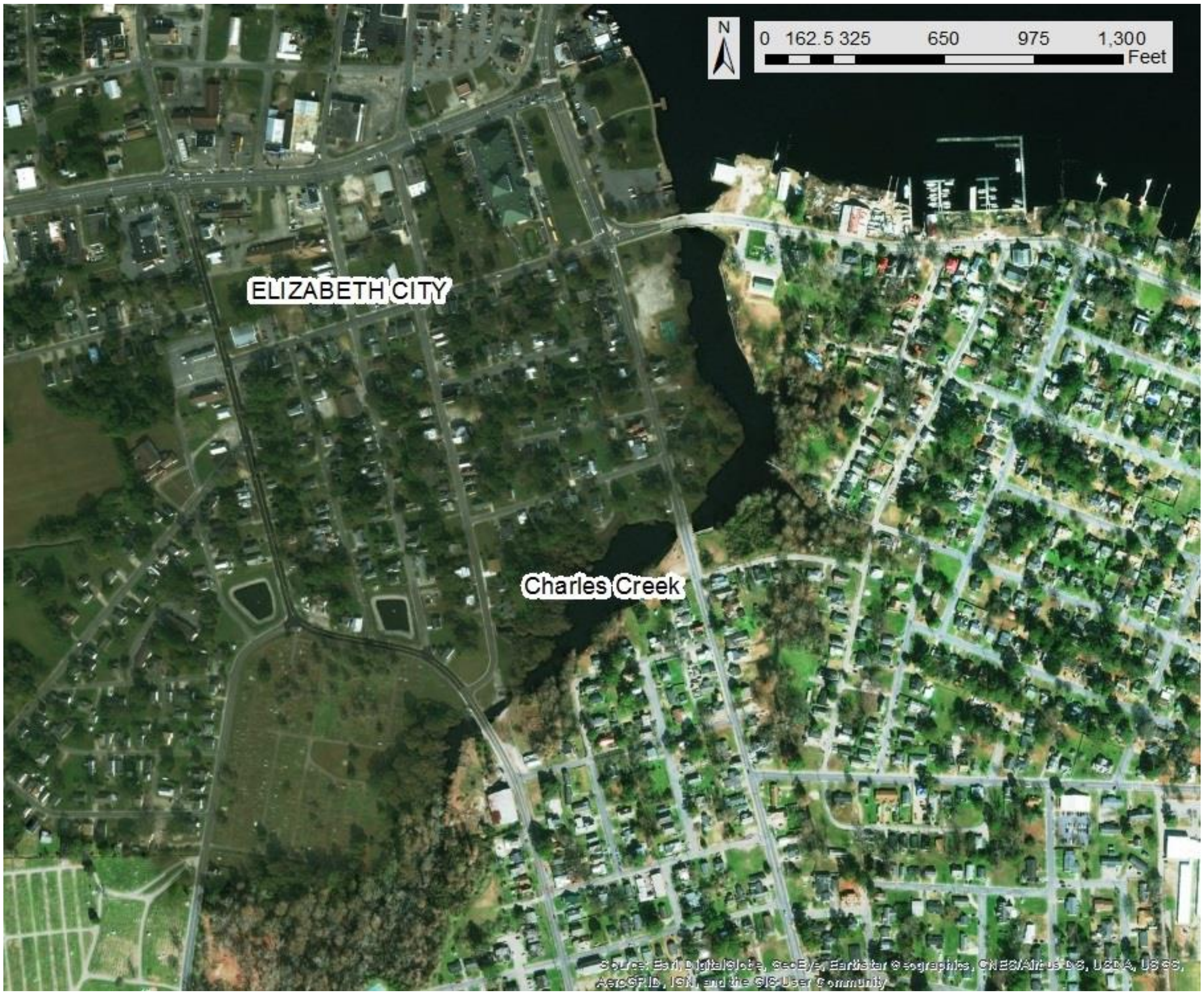

Figure 1-2. Charles Creek study area

2 AVAILABLE DATA COLLECTION

2.1 TIDES/WATER LEVELS

The North Carolina IFlows Program owns and maintains a gage in the Pasquotank River at Elizabeth City Mariners Wharf Park. The location of the gage in proximity to Charles Creek is shown in Figure 2-1. The gage was installed in April 2013 and records rainfall and water level measurements every five minutes. The Pasquotank River is subject to wind tides, meaning that Charles Creek and the Elizabeth City waterfront experience fluctuations in water levels due to wind conditions. Figure 2-2 provides a record of river stage at the Mariners Wharf Park gage from 2013 to 2017. The gage was not functional from September 2, 2016 until October 5, 2016, so data from this time period is absent from the complete stage record. This absent data may include water levels that occurred during the early stages of Hurricane Matthew.

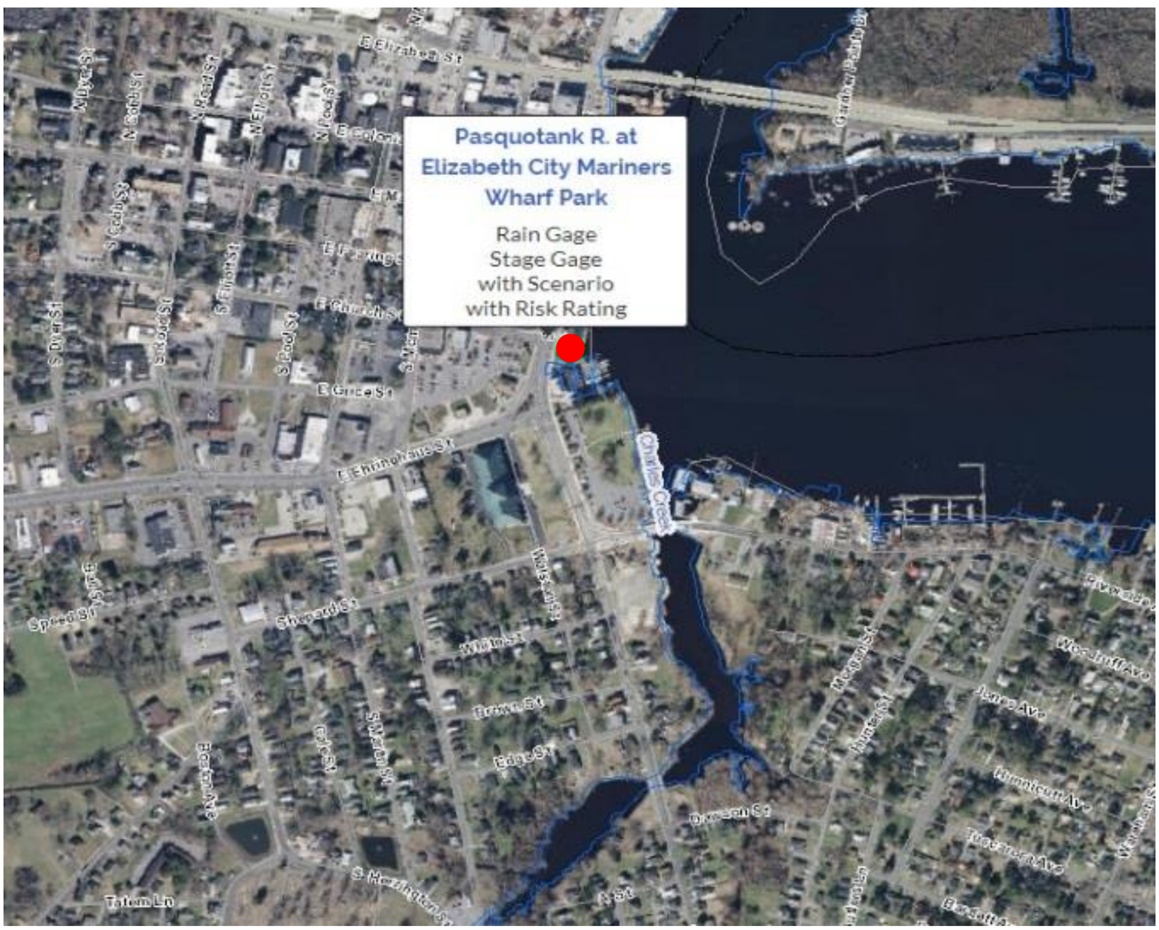

Figure 2-1. Gage at Elizabeth City Mariners Wharf Park in the Pasquotank River (North Carolina Floodplain Mapping Program, 2017)

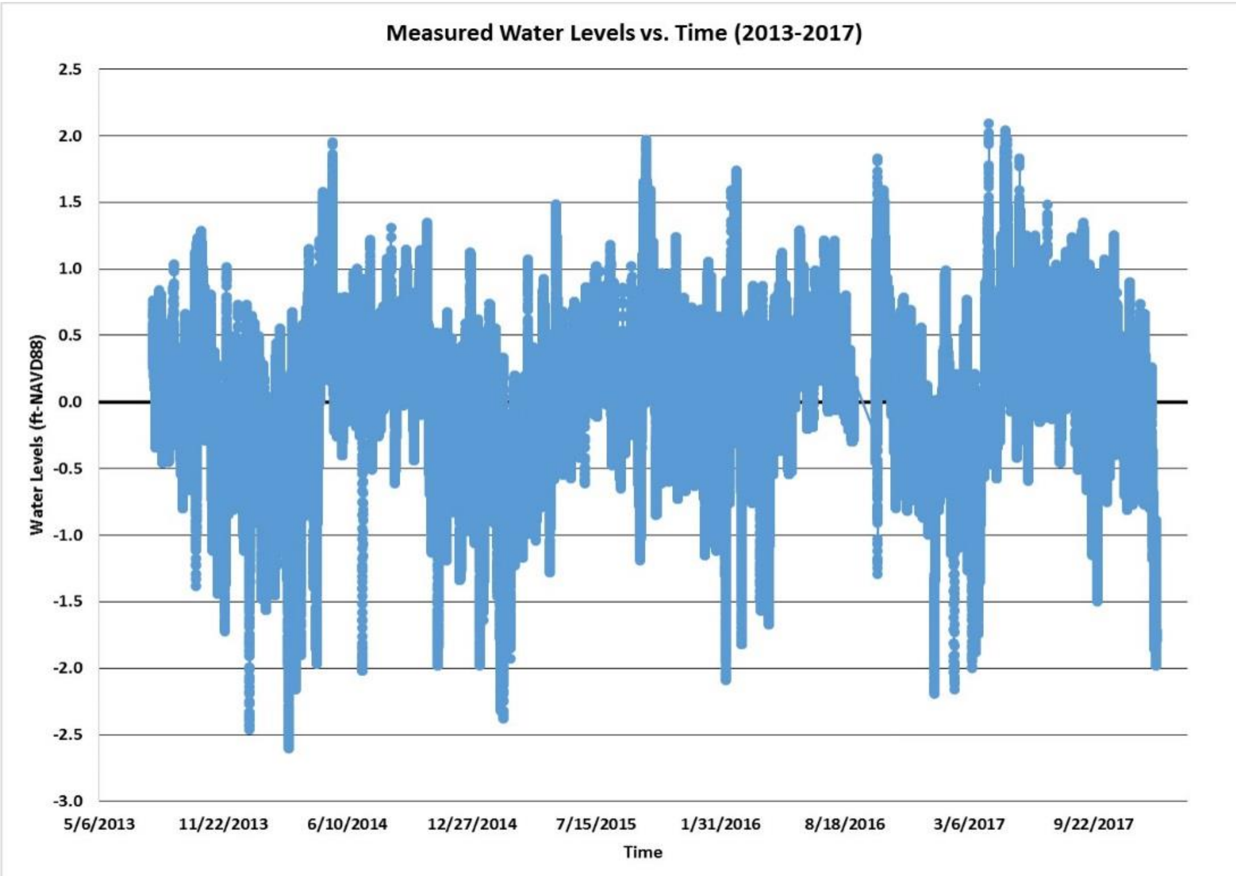

Figure 2-2. 2013-2017 water level record for gage at Elizabeth City Mariners Wharf Park (North Carolina Floodplain Mapping Program, 2017)

2.2 PRECIPITATION

Point precipitation frequency estimates were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 for Elizabeth City. The 24-hour precipitation depths for given return periods are provided in Table 2-1. These rainfall depths were applied to an SCS Type III hyetograph to create representative rainfall distributions for each storm event.

Table 2-1. 24-hour rainfall depths for given storm events in Elizabeth City

Return Period (yr)	Rainfall Depth (in)
2	3.73
10	5.73
25	7.08
50	8.24
100	9.51

As mentioned in Section 2.1, the gage at Elizabeth City Mariners Wharf Park also records rainfall measurements every five minutes. Rainfall data was compiled to create a complete record at the gage from 2013 to 2017, which can be seen in Appendix A. The magnitude and frequency of rainfall events recorded by the gage align with those provided by NOAA Atlas 14 data.

2.3 Stormwater Infrastructure

The City of Elizabeth City maintains a GIS dataset for surveyed infrastructure within the City, including stormwater pipes, inlet structures, junction boxes, and manholes. Data provided for these components includes location, pipe size and material, invert elevation, and spill crest elevation. Additional pipe data for the culverts located under Southern Avenue was provided by the North Carolina Department of Transportation (NCDOT). In areas where survey data was not available, values were estimated from adjacent existing infrastructure values (where available) as well as LiDAR data. Figure 2-3 shows the presence of stormwater infrastructure within Elizabeth City.

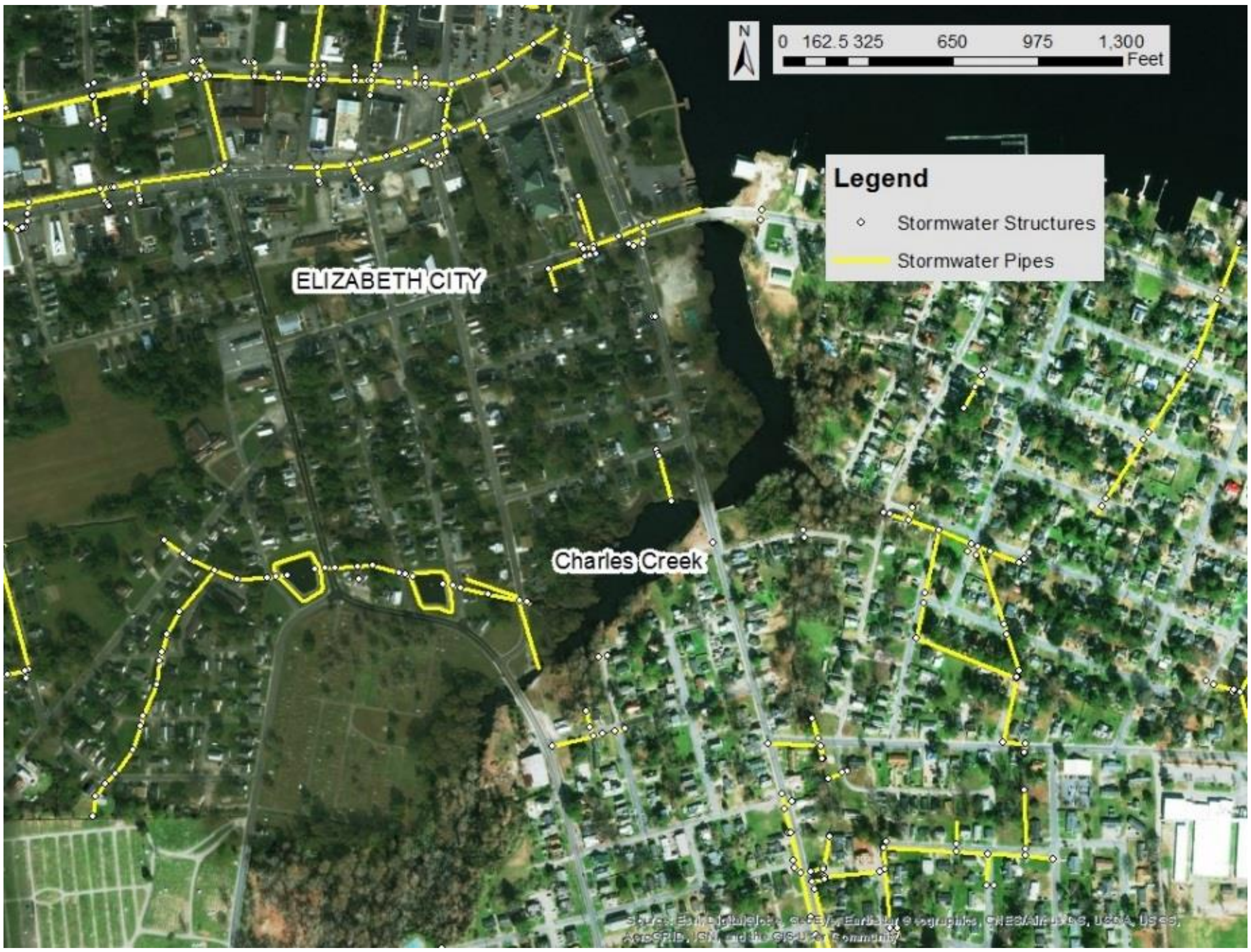

Figure 2-3. Stormwater infrastructure surrounding Charles Creek

2.4 FEMA MODELS

The North Carolina Floodplain Mapping Program (NCFMP) developed a HEC-RAS model of Charles Creek from its confluence with the Pasquotank River to approximately 0.4 miles upstream of Halstead Boulevard. The model provides channel cross sections, bridge and culvert data, and river flow information for various storm events. Modeled flood risk maps for the study area are accessible online through North Carolina's Flood Risk Information System (FRIS). See Figure 2-4 for the flood risk zone map for Charles Creek at Elizabeth City.

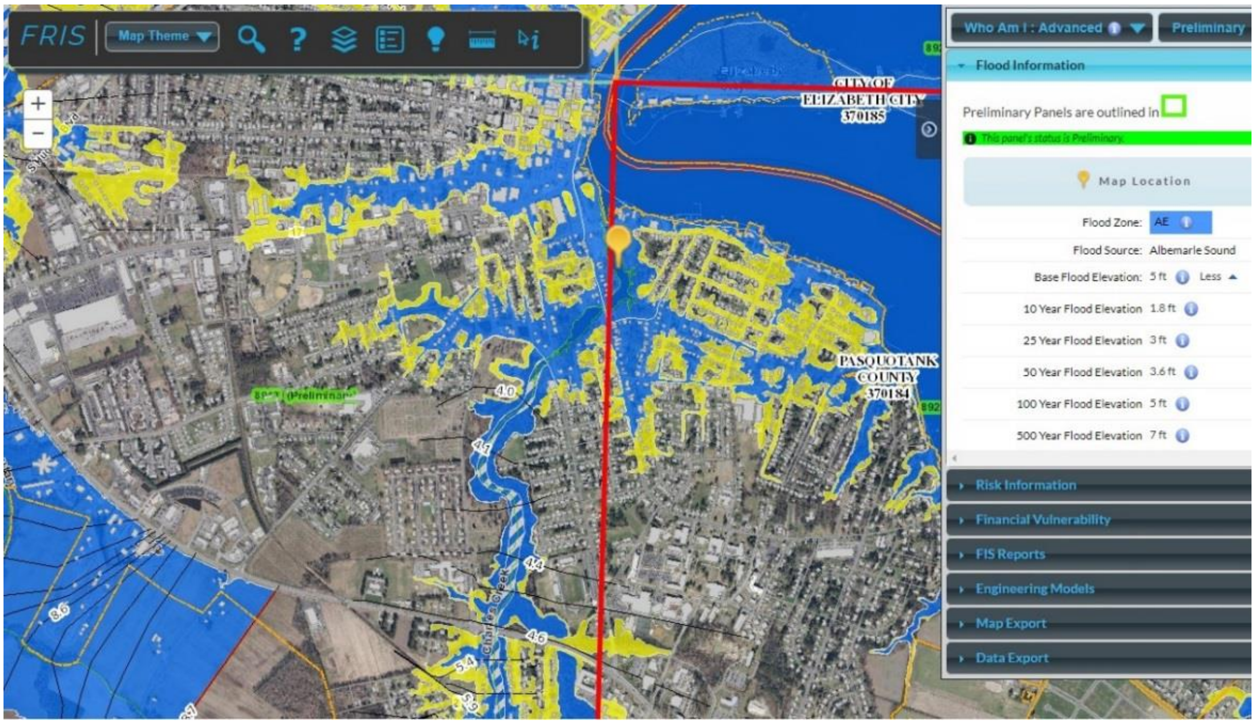

Figure 2-4. FRIS flood risk zone map for Charles Creek and Elizabeth City (North Carolina Floodplain Mapping Program, 2017)

FRIS's online mapping program provides computed flood elevations for the 10, 25, 50, 100, and 500-year flood events. These values represent the elevation to which floodwater is expected to rise during each respective storm event. Base flood elevations for events as large as the 100-year storm are provided in Table 2-2.

Table 2-2. Computed flood elevations for given flood events

Return Period (yr)	Flood Elevation (ft.-NAVD)
10	1.8
25	3.0
50	3.6
100	5.0

The North Carolina Flooding Inundation Mapping and Alert Network (FIMAN), also maintained by NCFMP, provides an online flood scenario tool to simulate flood severity caused by certain water elevations in the Pasquotank River. Flood extents, as well as an estimate of building damages incurred as a result of flooding, are shown for water elevations ranging from 0.5 to 12 ft.-NAVD based on data from the gage at Elizabeth City Mariners Wharf Park. Figure 2-5 and Figure 2-6 show sample flood scenario maps for surge elevations of 3 ft. and 5 ft.-NAVD, respectively.

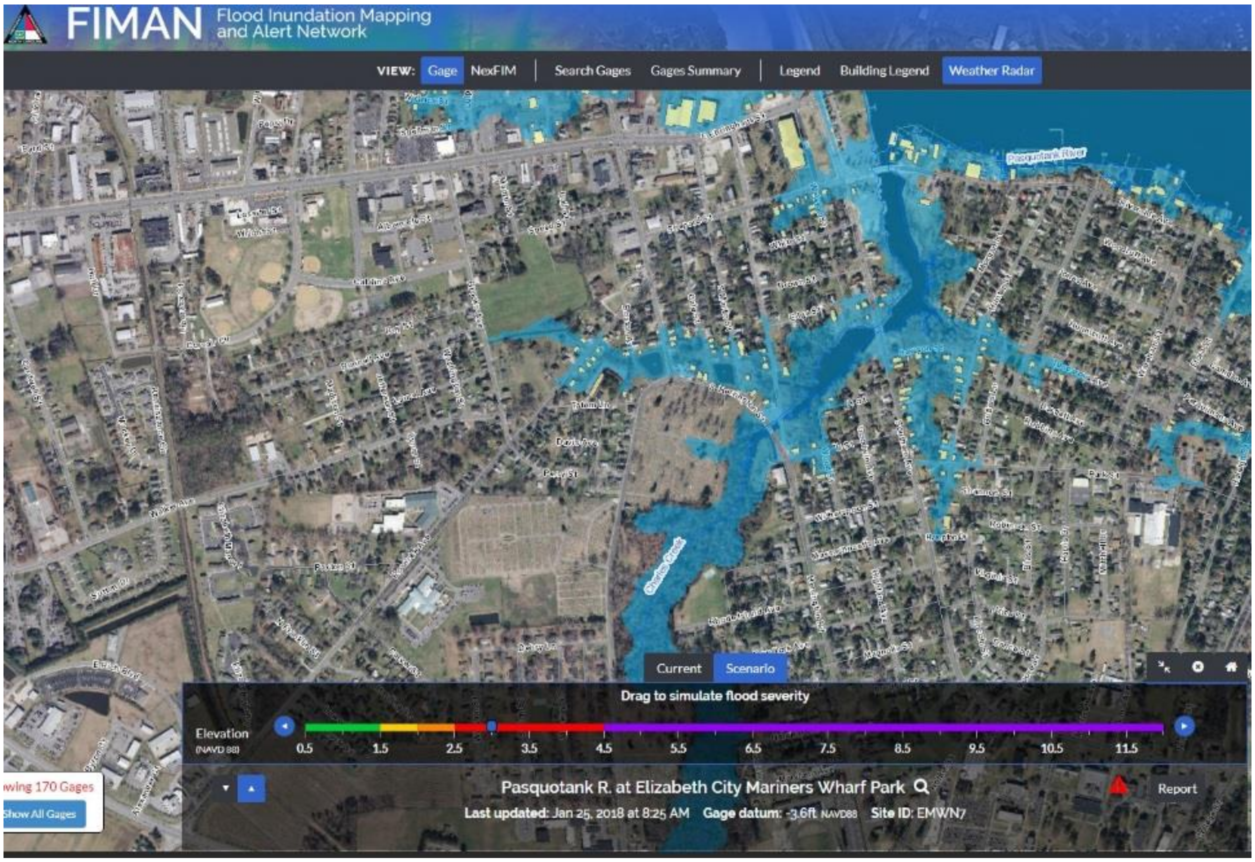

Figure 2-5. FIMAN flood scenario, 3 ft.-NAVD water elevation (North Carolina Floodplain Mapping Program, 2017)

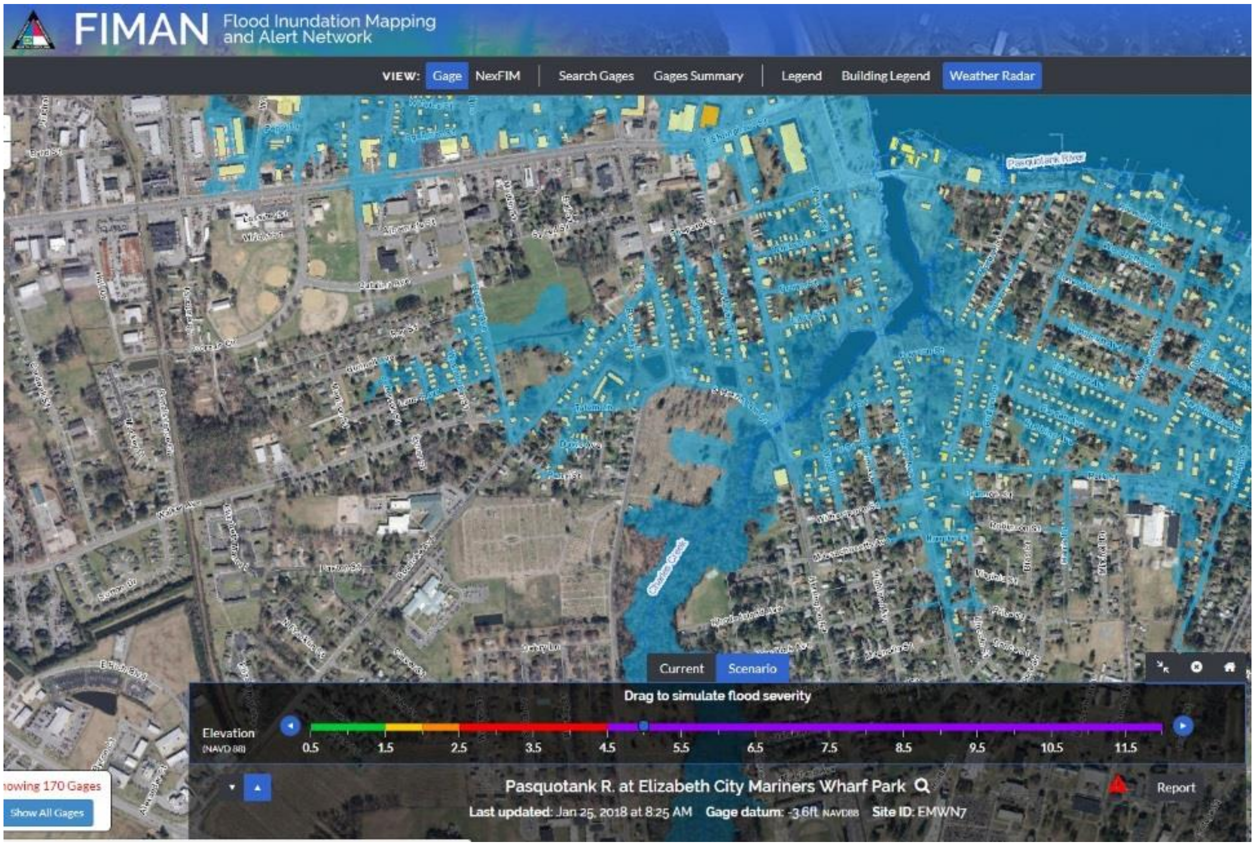

Figure 2-6. FIMAN flood scenario, 5 ft.-NAVD water elevation (North Carolina Floodplain Mapping Program, 2017)

2.5 Previous Studies and Reports

As part of previous initiatives, Elizabeth City has expended resources to study flooding and make improvements in the upper portion of the Charles Creek watershed. In 1989, the City conducted a flood mitigation study that examined options for constructed floodwalls and dikes along the Pasquotank River waterfront. This study proposed a floodwall/dike system at a plan elevation of either 6 or 8 ft.-NAVD to mitigate flooding from the River. The following flood mitigation plan focuses on potential alternatives for further study to improve resilience and provide flood protection around Charles Creek in the lower portion of the watershed.

3 EXISTING WATERSHED CONDITIONS

3.1 TOPOGRAPHY

NCFMP maintains a Quality Level 2 (QL2) LiDAR dataset for the eastern portion of the state. The QL2 LiDAR was downloaded from the NCFMP Spatial Data Download website (North Carolina Floodplain Mapping Program, 2017). The LiDAR has been processed to screen buildings, roads, tree cover and water points to separate levels, so they are easily excluded from ground points. The ground, road, and water shots were used to develop the surrounding topography. Buildings were excluded from the final terrain set and instead represented in the model as inactive areas. Bathymetry for Charles Creek was created using channel cross sections from the HEC-RAS model of the creek maintained by NCFMP. Figure 3-1 shows the LiDAR topographic surface for the Charles Creek area.

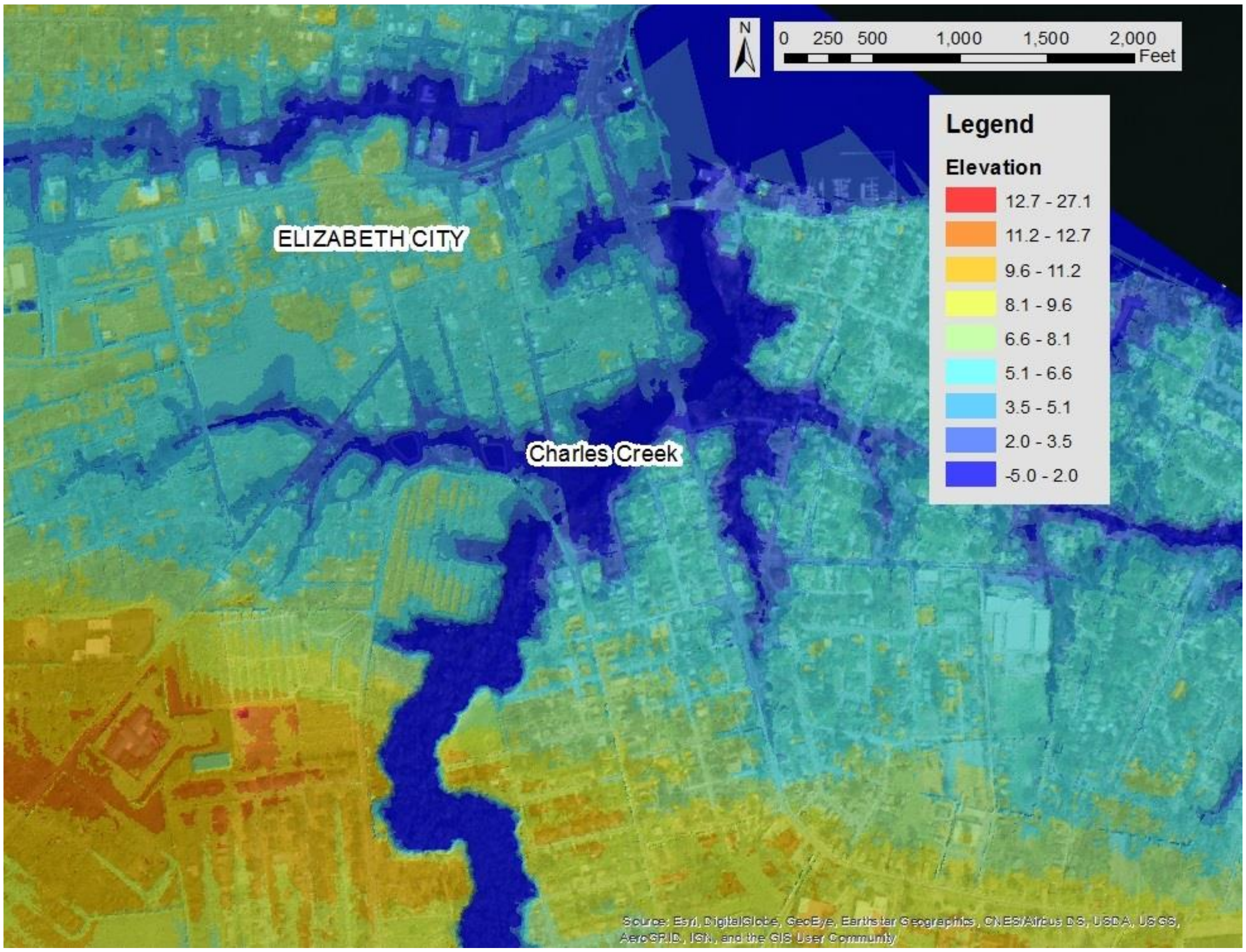

Figure 3-1. Charles Creek area topography

3.2 LAND USE

The watershed area contributing to the Charles Creek at its confluence with the Pasquotank River is approximately 3.6 square miles (Federal Emergency Management Agency, 2009). According to USGS StreamStats' watershed delineation tool, the contributing watershed area is roughly 6 square miles (Figure 3-2). Differences in these two areas can likely be contributed to the fact that StreamStats computes watershed areas based on topography alone and does not incorporate the presence of stormwater infrastructure into its calculations. Pipe networks are present within portions of the watershed that divert runoff flows away from Charles Creek, thereby decreasing the watershed area that actually drains to this water body.

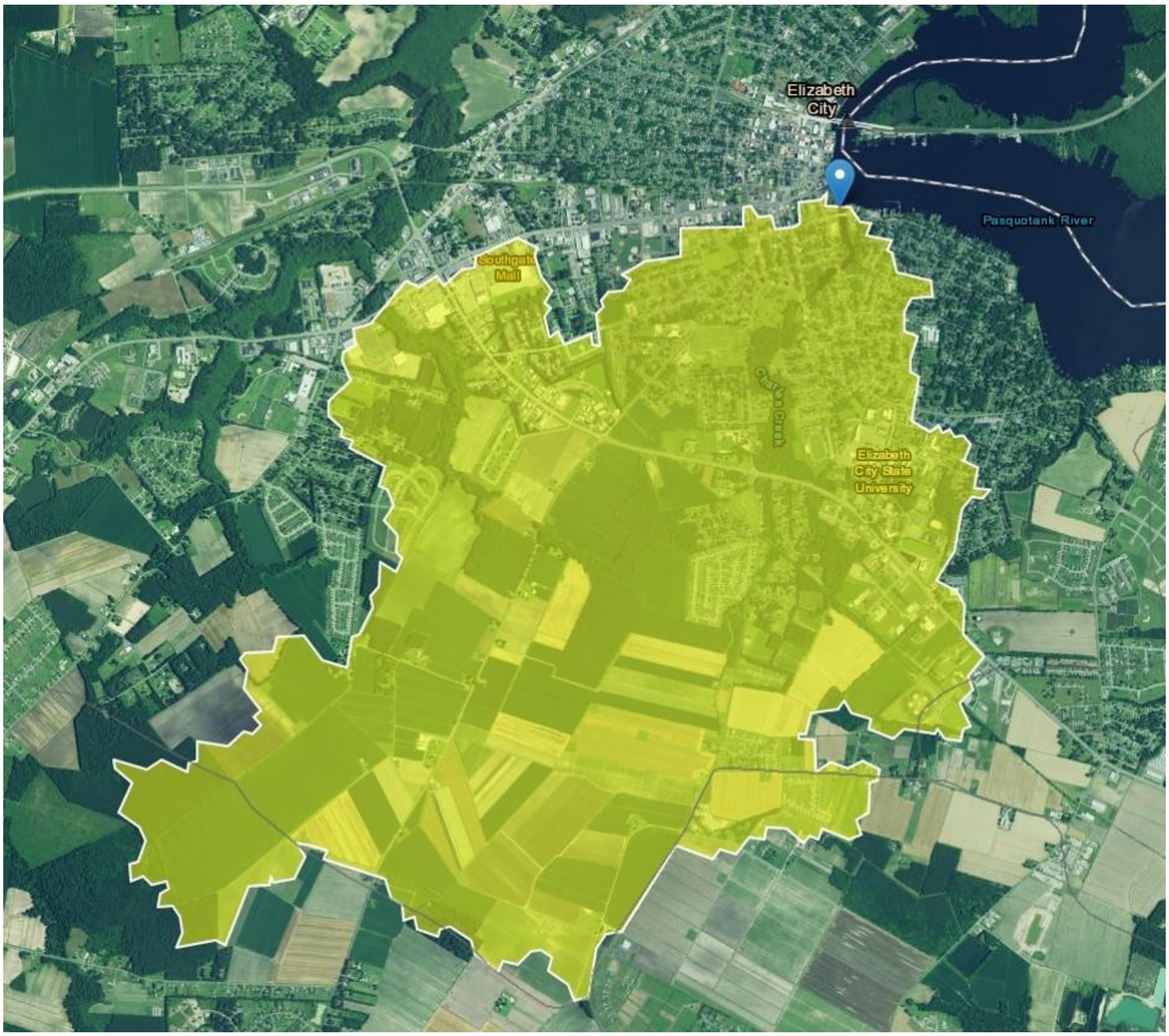

Figure 3-2. USGS StreamStats watershed delineation – Charles Creek at its confluence with the Pasquotank River (USGS, 2018)

The land use in the Charles Creek watershed is primarily residential development with intermittent agricultural fields and forested areas. For modeling purposes, land use was broken down into six different categories: river, agricultural/cemetery, forest, medium density development, pond, and roads (Figure 3-3). Unhatched areas in Figure 3-3 are designated as medium density development. Buildings were represented in the model as inactive areas (further discussed in Section 4.1).

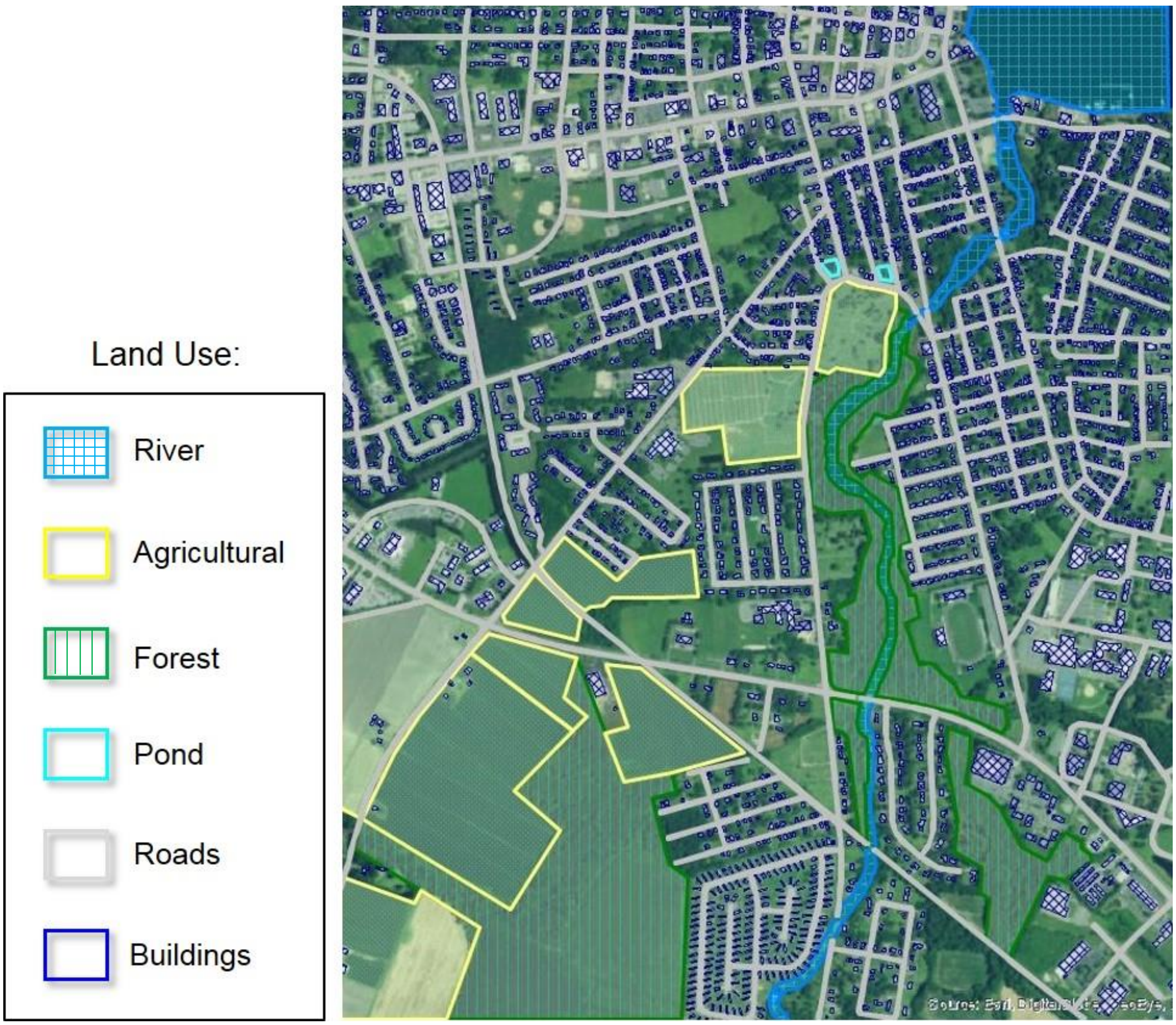

Figure 3-3. Charles Creek area land use

Manning's N-values for overland surface flow were taken from the HEC-RAS River Analysis System Hydraulic Reference Manual (US Army Corps of Engineers, 2016). For each of the six land uses described above, a Manning's N-value was assigned (Table 3-1).

Table 3-1. Overland Manning's N-Values

Land Use	Manning's N
River	0.04
Agricultural/Cemetery	0.04
Forest	0.10
Medium Density Development	0.025
Pond	0.01
Roads	0.014

3.3 SOILS

Soils belonging to three of the four hydrologic soil groups are found within the study area, creating a diversity of soil conditions throughout Elizabeth City. The most predominant soil groups present are Groups A and B. Group A and B soils have a low to moderate runoff potential and moderate to high infiltration rates. Figure 3-4 shows the soil group distribution in the study area.

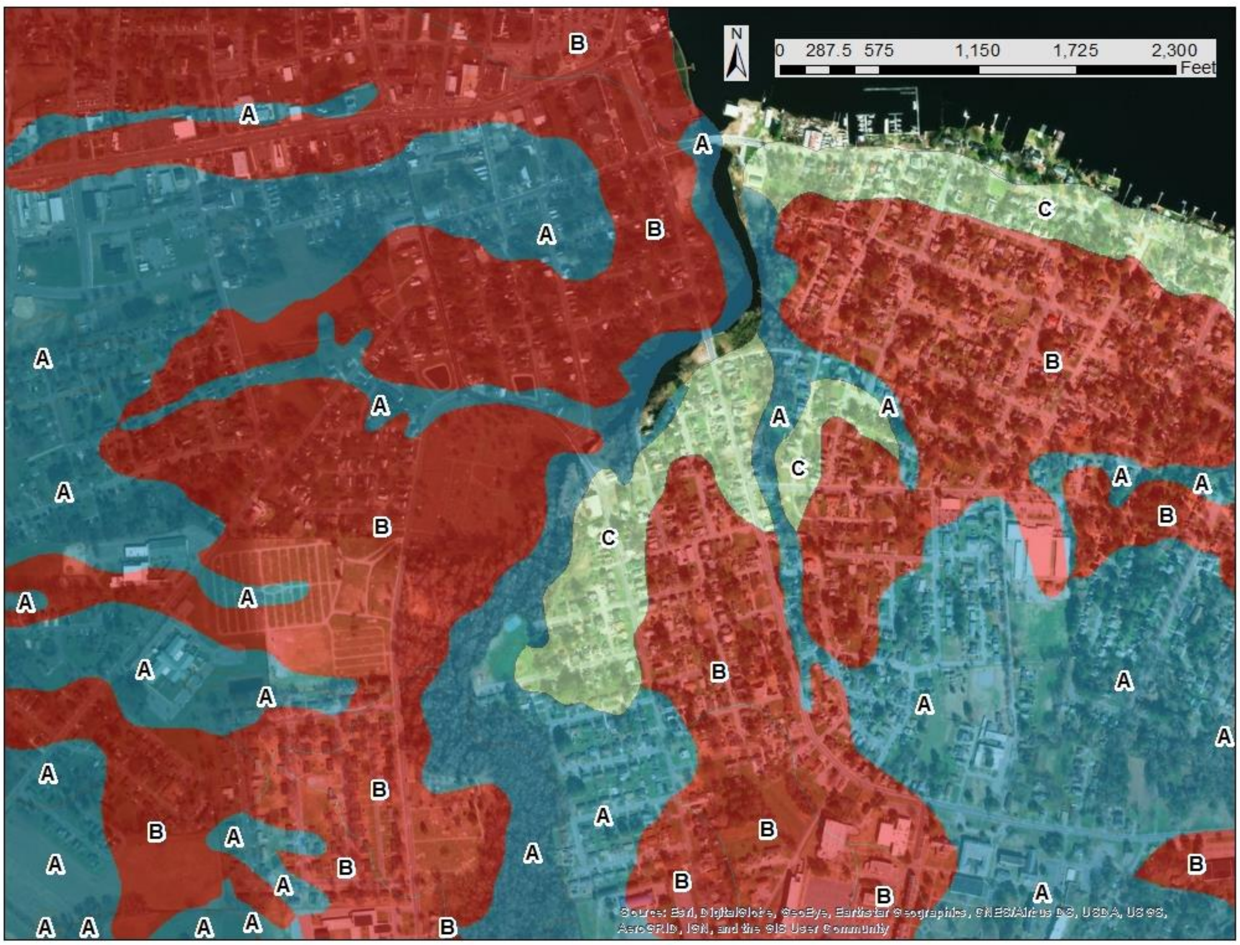

Figure 3-4. Charles Creek area soil hydrologic groups

3.4 Drainage Patterns

The drainage network within the Charles Creek study area is comprised of stormwater pipe networks, drainage ditches, and open channels. Figure 3-5 displays the locations of ditches/open channels and pipes in the study area. Not all channels shown in Figure 3-5 were modeled—only channels that were of considerable size and imperative to ensuring accurate surface flow and pipe connectivity were represented. The overall drainage patterns are toward Charles Creek and the Pasquotank River.

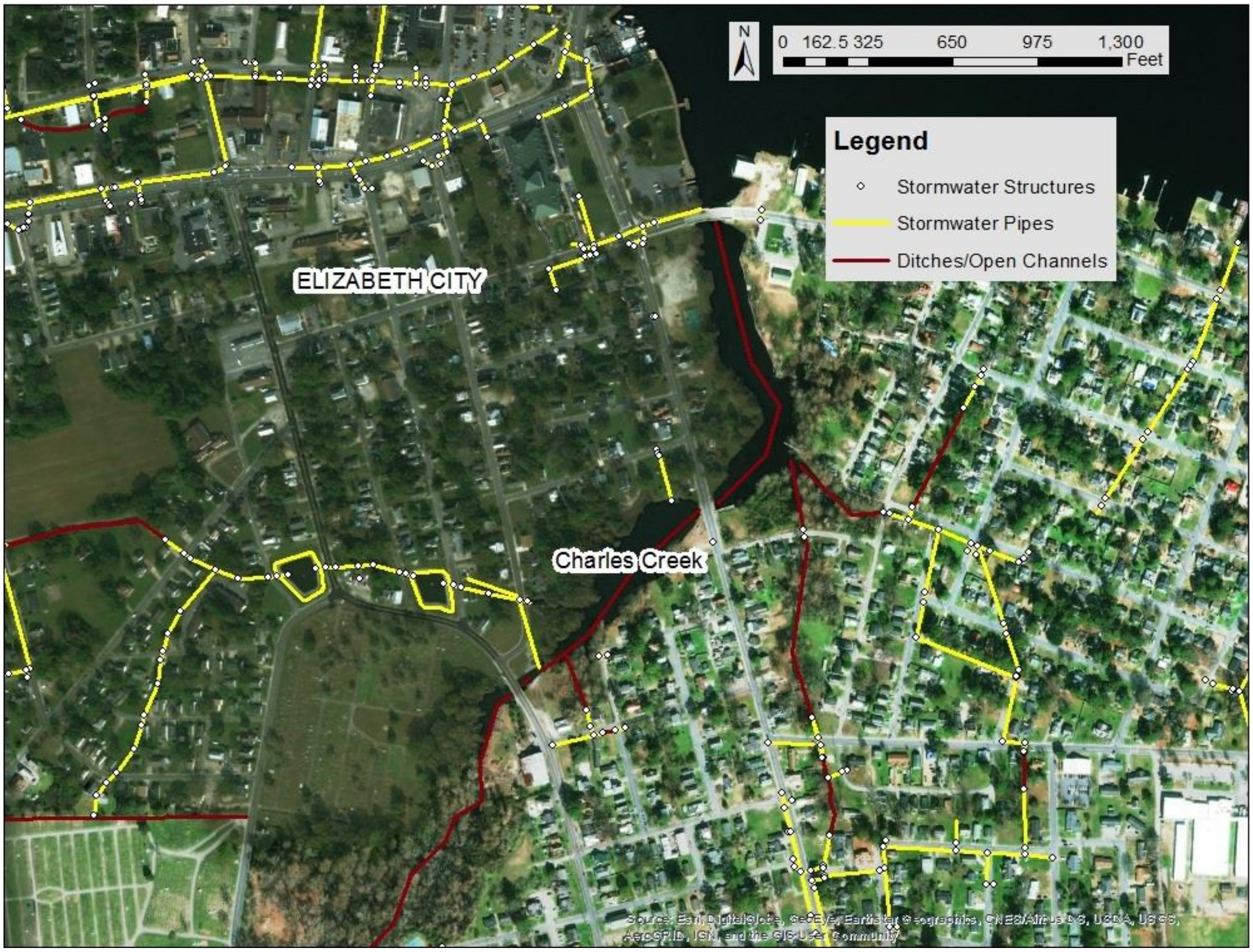

Figure 3-5. Charles Creek area drainage system

The conduit Manning's N-values were derived from *Open Channel Hydraulics* (Chow, 1959). Table 3-2 provides the values assigned to each pipe material.

Table 3-2. Conduit Manning's N-values

Pipe Material	Manning's N
Corrugated Metal	0.022
Concrete	0.013
HDPE	0.012
PVC	0.010
Terra Cotta	0.012

4 XPSWMM Modeling of Existing Conditions

4.1 Model Setup

XPSWMM uses a combination of one-dimensional (1D) storm network calculations linked to a two-dimensional (2D) surface to simulate depth-averaged flood flows. 2D surface flow is based on the TUFLOW (**T**wo-dimensional **U**nsteady **FLOW**) computational engine which solves the full 2D, depth averaged, momentum and continuity equation for free-surface flow (XP Solutions, 2016). The existing conditions XPSWMM model was developed to represent conditions in the Charles Creek area to date.

A 1D storm network was developed using a combination of nodes and links. Nodes represent inlets, pipe ends, and channel confluences. Inverts were taken from available survey or LiDAR data. Links represent pipes, culverts, and natural channels. Survey data was used to identify pipe sizes, material, Manning's roughness, and length. If survey was unavailable, these values were estimated from aerial photography and LiDAR data.

2D grid cell extents were created for the entire study area to model overland flow. A grid comprised of 20-foot grid cells was drawn around the Charles Creek study area to ensure accurate flow patterns and flood depths.

Topographical data as described in Section 3.1 was used to create a Triangular Irregular Network (TIN) surface in XPSWMM. In certain areas where the TIN data did not capture the geometry and/or elevation of drainage channels, fill areas and breaklines were used.

Inactive areas were added to the model to define areas were 2D flow cannot occur. Using Built Environment data from the NCFMP Spatial Data Download website (North Carolina Floodplain Mapping Program, 2017), inactive areas were placed at building footprints to force the 2D overland flow around buildings.

Land use data was incorporated into the model as a 2D global data parameter. Manning's N-values were assigned to each respective land use category as discussed in Section 3.2.

The 1D network is linked to the 2D surface through a series of 1D / 2D boundaries which allow for flow both to and from the 1D network across the 2D surface. Inlet nodes were linked directly to the 2D surface using the "Link to 2D surface" option under the node attributes.

This model was created to represent the flooding that occurs as a result of both local rainfall and elevated water levels in the Pasquotank River. Rainfall was entered as a global data parameter for a variety of return period events with a 24-hour duration. The 2, 10, 25, 50, and 100-year return period rainfall depths were set up within the existing conditions model. Rainfall hydrographs were applied to delineated sub catchments, each of which was assigned a curve number and time of concentration based on topography, land use, and soil parameters. Water level data was entered as a flow boundary in the Pasquotank River to allow the model to portray wind tide surges occurring during storm events. Storm surges were modeled as steady state water level boundary conditions and are further discussed in Section 4.2.

4.2 WATER LEVEL BOUNDARY CONDITIONS

As discussed in Sections 2.1 and 2.4, the Pasquotank River and Charles Creek experience variations in water level due to wind tide events. In order to determine appropriate water elevations to model, an exceedance analysis was conducted using the Pasquotank River stage record. From this analysis, a set of water levels was chosen to represent a variety of wind tide conditions. The water levels studied using the existing conditions model are shown in Table 4-1. Detailed figures pertaining to the exceedance analysis are provided in Appendix A. Most wind tide events cause a rise and fall in water level over the course of 2 to 3 days (Figure 4-1). A 24-hour rainfall event could occur as the tide was rising, at its peak, or falling. As a result, the water level boundary was conservatively modeled over the 24-hour simulation period as a steady state condition at the peak tide level.

Table 4-1. Modeled water level boundary conditions

Tide Elevation (ft.-NAVD)	
0.25	
0.5	
0.75	
1.0	
1.5	
1.8	10-yr Flood Elevation
3.0	25-yr Flood Elevation
3.6	50-yr Flood Elevation
5.0	100-yr Flood Elevation

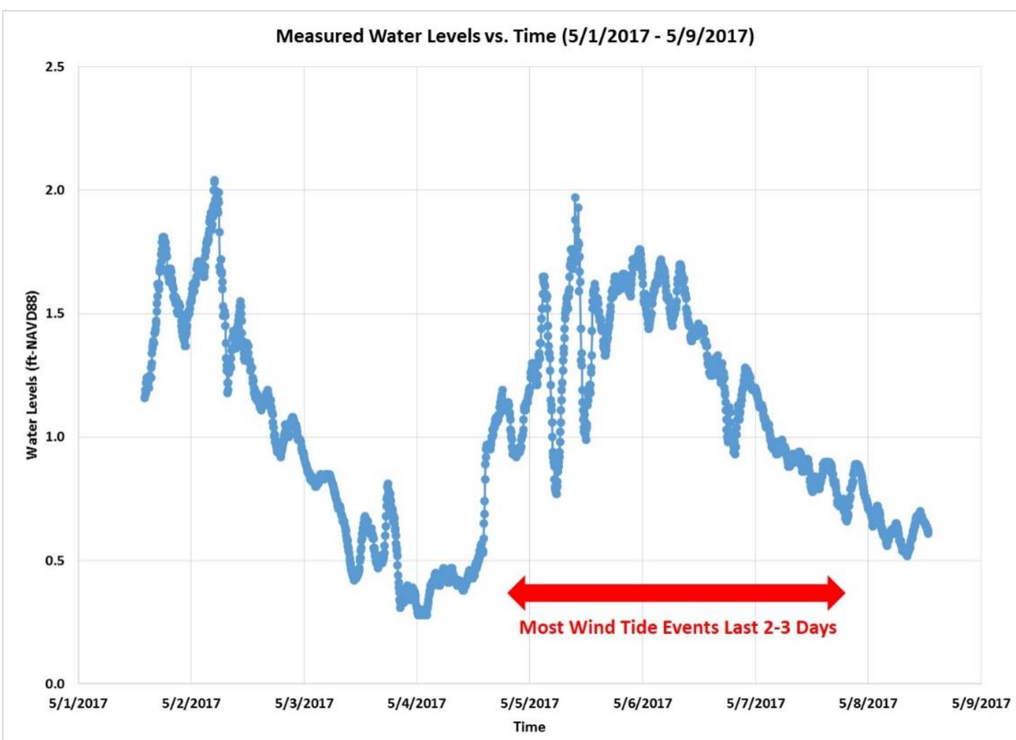

Figure 4-1. Water level variation during an example wind tide event in Elizabeth City

It can be noted that over the life of the Pasquotank River gage (approximately 5 years), the 10-year flood elevation of 1.8 ft.-NAVD, shown as a red line, was exceeded six times (a few occurred during a short duration of time) (Figure 4-2 and Table 4-2). This is an indication that given FEMA based flood elevations can expect to be reached more often than suggested by their respective return periods.

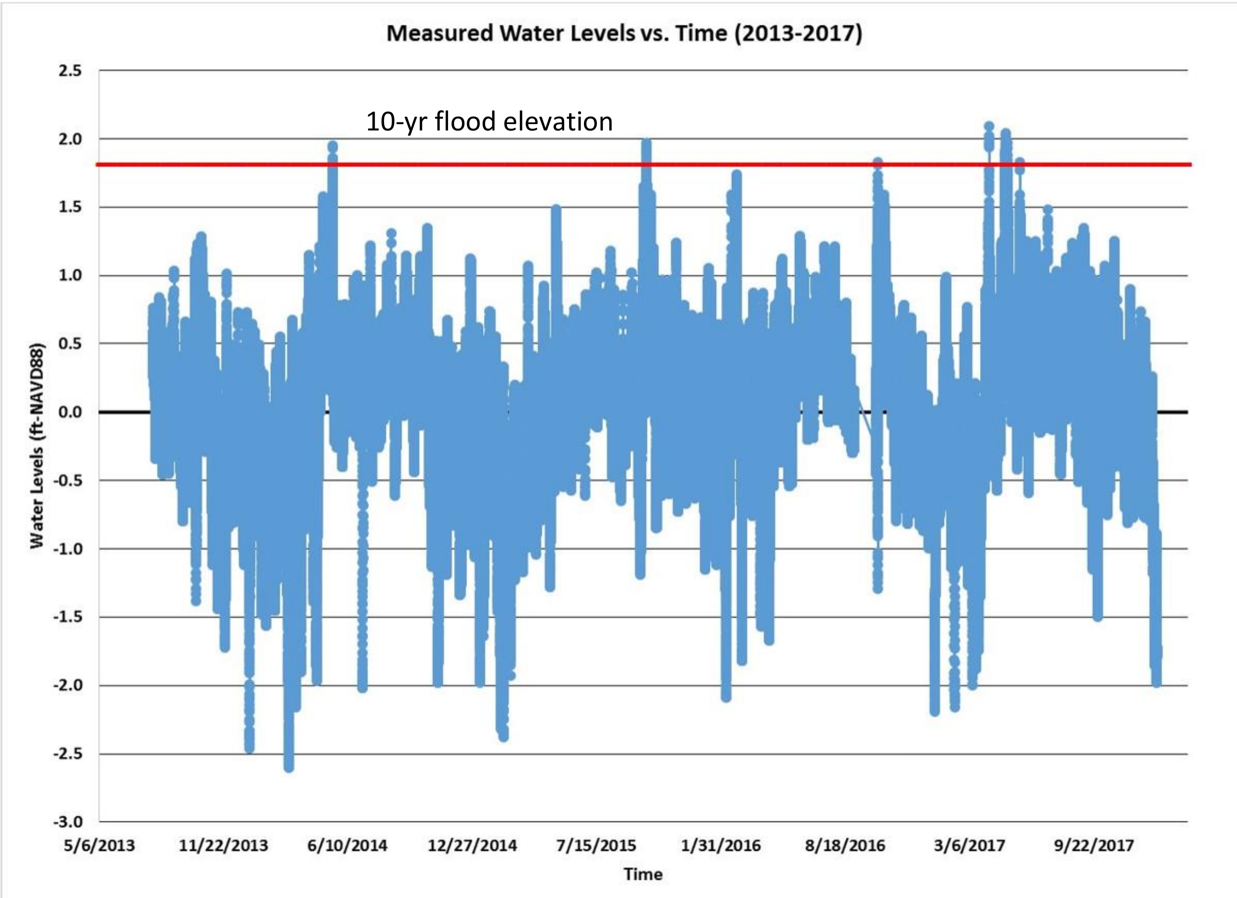

Figure 4-2. 10-yr flood elevation exceeded six times between 2013 and 2017

Table 4-2. Computed flood elevations for given flood events and occurrences in last 5 years (2013-2017)

Return Period (yr)	Flood Elevation (ft.-NAVD)	# of occurrences in last 5 years (2013-2017)
10	1.8	6
25	3.0	0
50	3.6	0
100	5.0	0

4.3 RAINFALL/TIDE COMBINATIONS

In order to study the combined flooding effects of local rainfall and elevated water levels in the Pasquotank River, several tide conditions were modeled in conjunction with each rainfall event. The use of smaller tide elevations (e.g. 0.5 ft.-NAVD) simulates flood behavior when a certain rainfall depth occurs while the Pasquotank River is relatively low. Conversely, higher tide elevations (e.g. 3 ft.-NAVD) model the flooding that may occur around Charles Creek when storms or wind tides cause the Pasquotank River stage to be relatively high.

Particular attention was paid to the combination of each rainfall event and its coincident storm surge elevation (e.g. 25-year rainfall depth and 25-year surge elevation). This setup simulates both components of a given return period event, combining corresponding rainfall depths and water levels.

4.4 CALIBRATION AND MODEL SENSITIVITY

Calibration and verification of the existing conditions model was conducted using a variety of tools and FEMA models. River flows and water surface elevations generated in XPSWMM were compared to the results of NCFMP's HEC-RAS model. The two models showed similar changes in water surface elevation throughout Charles Creek for similar events. Flooding extents produced using selected water level boundary conditions in XPSWMM were compared to flooding extents generated by FIMAN's flood scenario simulation tool at the same tide level. Comparable results were observed for the 10, 25, 50, and 100-year flood events, taking into consideration that the XPSWMM model simulates both surge levels and local rainfall while FIMAN only models storm surge elevations.

4.5 EXISTING CONDITIONS MODEL RESULTS

The existing conditions model shows flooding along Charles Creek and the Pasquotank River waterfront. Larger rainfall events produce larger flood extents in residential neighborhoods along the creek. Models run with higher water level boundaries create more flooding near the waterfront and cause higher maximum water elevations in Charles Creek. Flooding maps for a variety of storm events and surge conditions are shown in Figure 4-3 through Figure 4-8. Table 4-3 provides the total number of properties affected during the 10, 25, and 50-year storm events. A complete list and maps of affected properties and their values (combined land and structure) are provided in Appendix B.

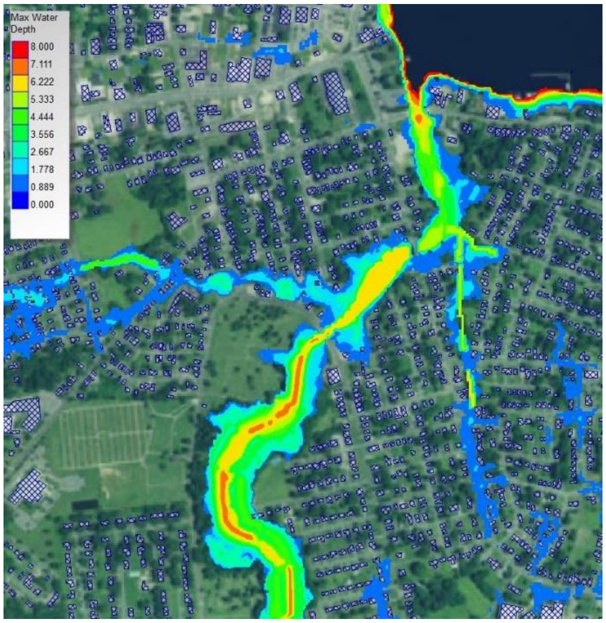

Figure 4-3. Maximum flood depth results for existing conditions – 10-yr rainfall, 1 ft.-NAVD tide level (exceeded more than 20 times in 5 years (2013-2017))

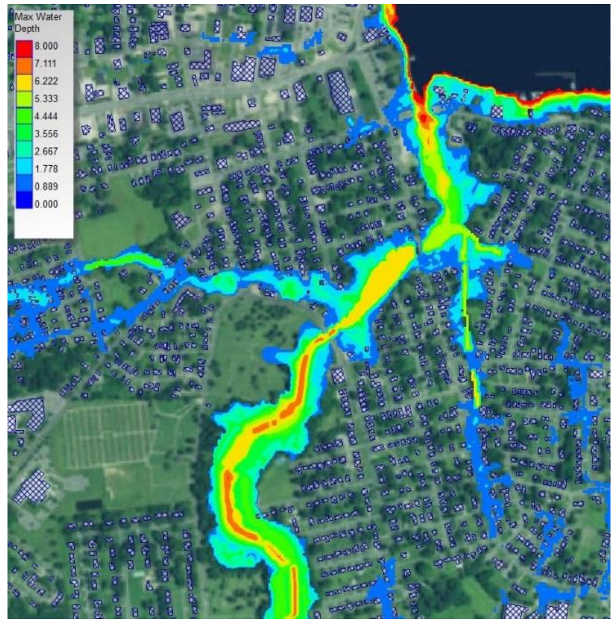

Figure 4-4. Maximum flood depth results for existing conditions – 10-yr rainfall, 1.8 ft.-NAVD tide level (10-yr surge – exceeded 6 times in 5 years (2013-2017))

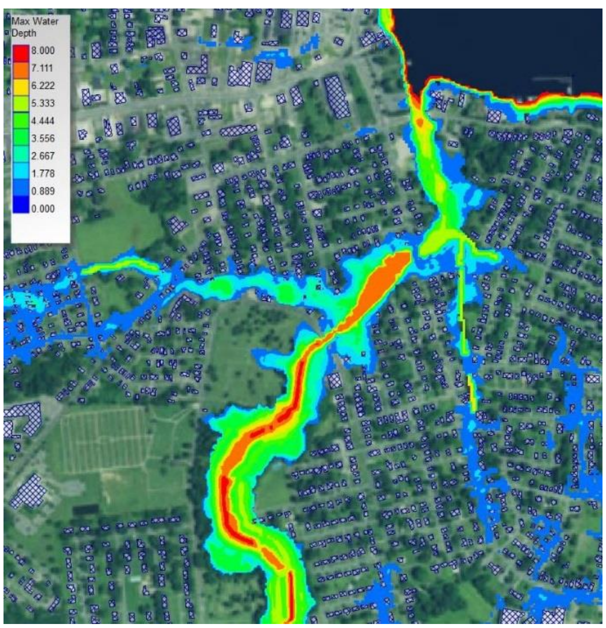

Figure 4-5. Maximum flood depth results for existing conditions – 25-yr rainfall, 1 ft.-NAVD tide level

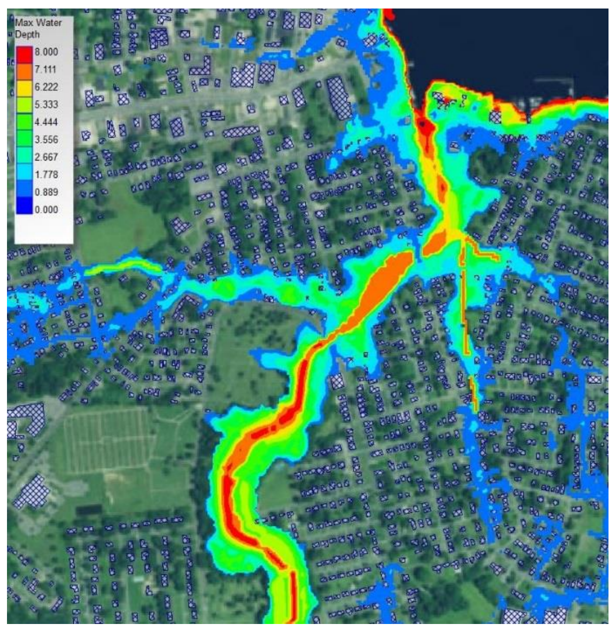

Figure 4-6. Maximum flood depth results for existing conditions – 25-yr rainfall, 3.0 ft.-NAVD tide level (25-yr surge)

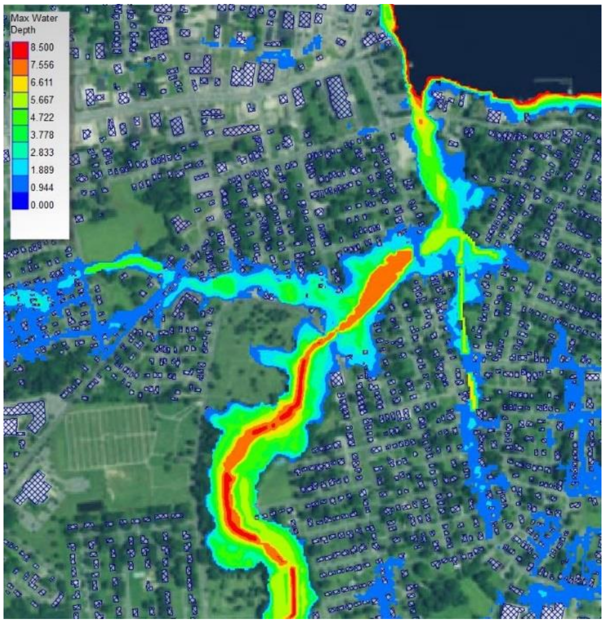

Figure 4-7. Maximum flood depth results for existing conditions – 50-yr rainfall, 1 ft.-NAVD tide level

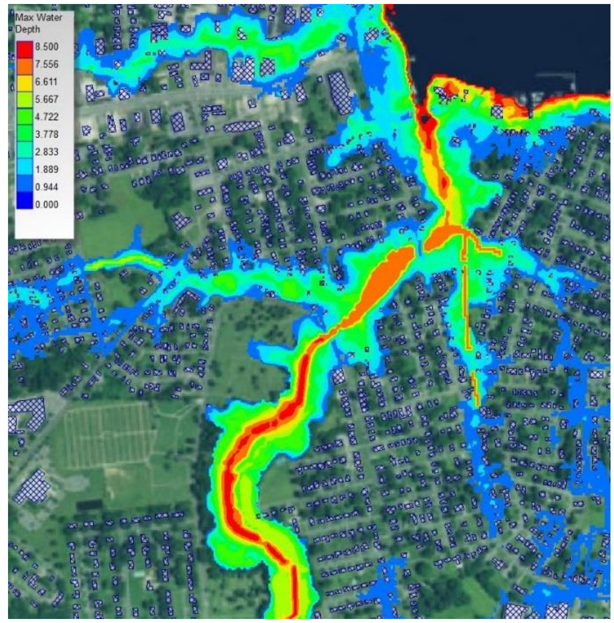

Figure 4-8. Maximum flood depth results for existing conditions – 50-yr rainfall, 3.6 ft.-NAVD tide level (50-yr surge)

Table 4-3. Affected properties during various storm events

Storm Event	Number of Affected Properties	Total Property Value
10-yr rainfall, 10-yr tide level	55	$3,670,200
25-yr rainfall, 25-yr tide level	104	$6,361,100
50-yr rainfall, 50-yr tide level	140	$8,524,000

5 FLOOD MITIGATION OPTIONS TO IMPROVE RESILIENCE

5.1 INVESTIGATED ALTERNATIVES

Flooding in Charles Creek can occur as a result of large rainfall events, elevated water levels in the Pasquotank River due to wind tides, or a combination of both occurring simultaneously. Design alternatives were developed based on technical and environmental feasibility in order to best improve the level of flood protection in the Charles Creek area. Constructed improvements would decrease the extent and magnitude of inundation, thus increasing resilience in areas prone to flooding. Buyouts and elevation or relocation of flood-prone structures were also considered as viable options to investigate. Meaningful community involvement in the development of flood mitigation alternatives was sought using an online public participation survey as well as through multiple open public meetings and preliminary plan presentations held in Elizabeth City. Additional information pertaining to public involvement and engagement is provided in Appendix C.

5.2 MULTIFUNCTION PROTECTIVE BERMS

5.2.1 Model Setup

One flood mitigation option consists of protective berms along the Charles Creek shoreline to mitigate river flooding. In this scenario, berms would be constructed where needed to retain water within the river channel and prevent flooding into neighboring residential areas (Figure 5-1). Berms would be two to four feet high (above the adjacent ground surface) and vegetated to maintain natural aesthetics in the Charles Creek area while increasing community resilience (example berm photos provided in Figure 5-2). Pipes and backflow preventers would be installed where necessary for interior drainage and to prevent ponding behind berms. In areas where berms are needed to cross over roadways, raising of roadways and bridges up to the elevation of the berms should be implemented to maintain the desired level of protection and ensure no low spots are present through which flood waters could enter. Road raises are especially vital along Southern Avenue and S Road Street. Protective berms could be used in combination with a greenway or walkway along Charles Creek to improve and promote connectivity between Mid-Atlantic Christian University, Elizabeth City State University, as well as the neighborhoods in-between. Recreational benefits for this option should also be considered.

Figure 5-1. Multifunction protective berm layout

Figure 5-2. Example vegetated protective berms

5.2.2 Model Results and Level of Protection Achieved

The construction of protective berms, along with suggested road raises, reduced flooding in neighborhoods surrounding Charles Creek. The berms are an effective means of flood protection for storms as large as the 25-year rainfall event with a moderate wind tide surge (1 ft.-NAVD) or a wind tide event alone up to an elevation of 3 ft.-NAVD. Providing protection above the 25-year flood with berming is difficult due to the localized roadway and topographic elevations. During the 25-year event, flood waters remain contained within the channel, although flooding from surrounding stormwater infrastructure and drainage ditches still occurs. Increased flood depths as a result of installing berms can be seen near Dawson Street. This flooding can be mitigated by increasing the size of the pipe that runs under Dawson Street, allowing adequate drainage from surrounding ditches into Charles Creek. The berms and road raises provide some protection during the 50-year event, but maximum flood elevations are high enough to overtop certain areas of the berms. See Figure 5-3 through Figure 5-6 for flooding maps. Representative results plots are shown for the existing and alternative cases where the alternatives provide the most protection. A complete list and map of properties affected during the 25-year storm, those for which damages are mitigated by implementing protective berms, is provided in Appendix B.

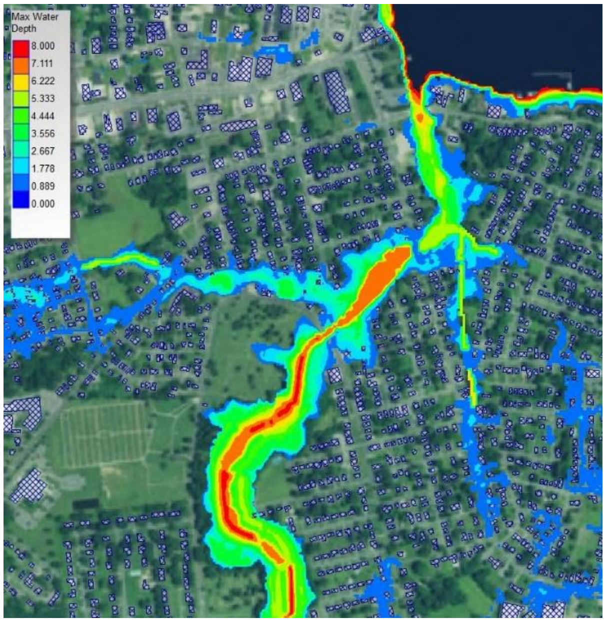

Figure 5-3. Maximum flood depth results for existing conditions – 25-yr rainfall, 1 ft.-NAVD tide level

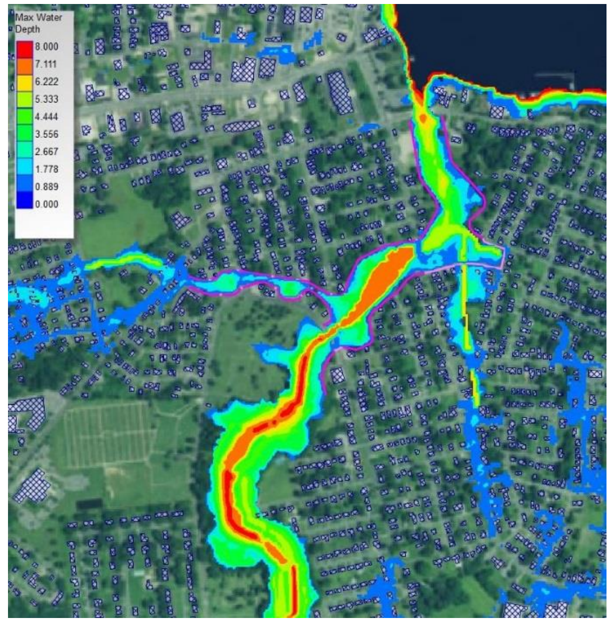

Figure 5-4. Maximum flood depth results for protective berms – 25-yr rainfall, 1 ft.-NAVD tide level

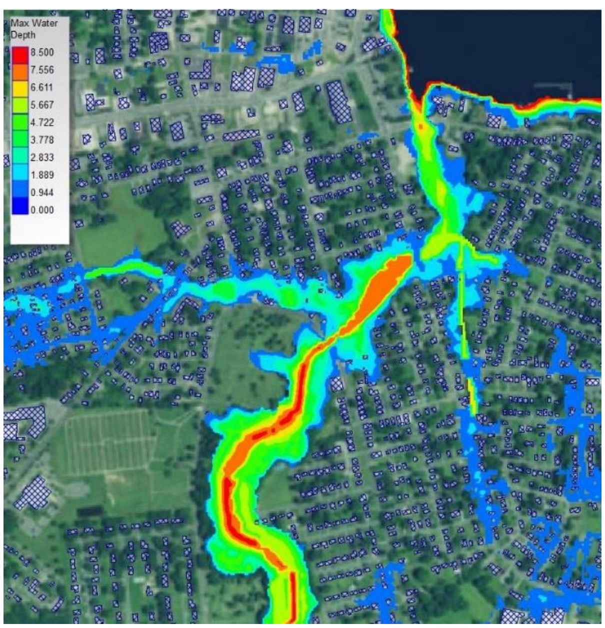

Figure 5-5. Maximum flood depth results for existing conditions – 50-yr rainfall, 1 ft.-NAVD tide level

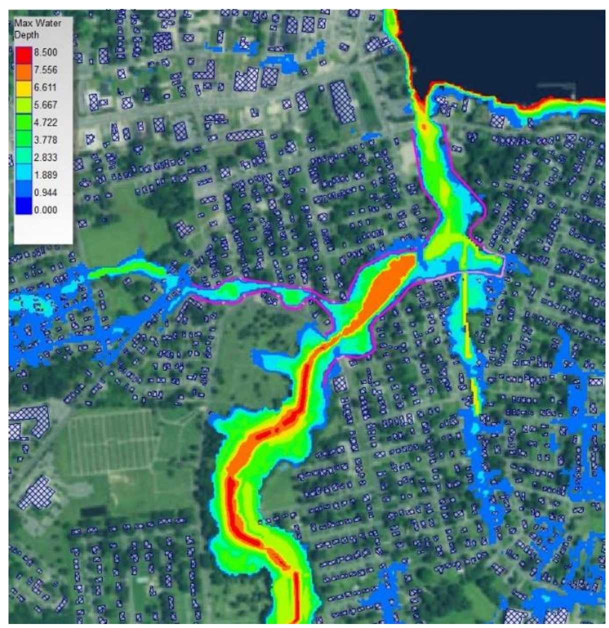

Figure 5-6. Maximum flood depth results for protective berms – 50-yr rainfall, 1 ft.-NAVD tide level

5.3 Flood Gate and Pump System

5.3.1 Model Setup

To provide flood protection during elevated wind tide conditions in the Pasquotank River, a flood gate and pump system could be implemented near Charles Creek's confluence with the river. The flood gate, installed immediately downstream of the Riverside/Shepard Street bridge, would prevent water from flowing upstream as a result of storm surges. Pumps installed upstream of the gate would redirect Charles Creek flows around the gate and allow discharge into the Pasquotank River. In order to handle large storm flows, selected pumps would be 24 to 36 inches in size and operate at up to 50,000 gallons per minute. Figure 5-7 shows the proposed flood gate location.

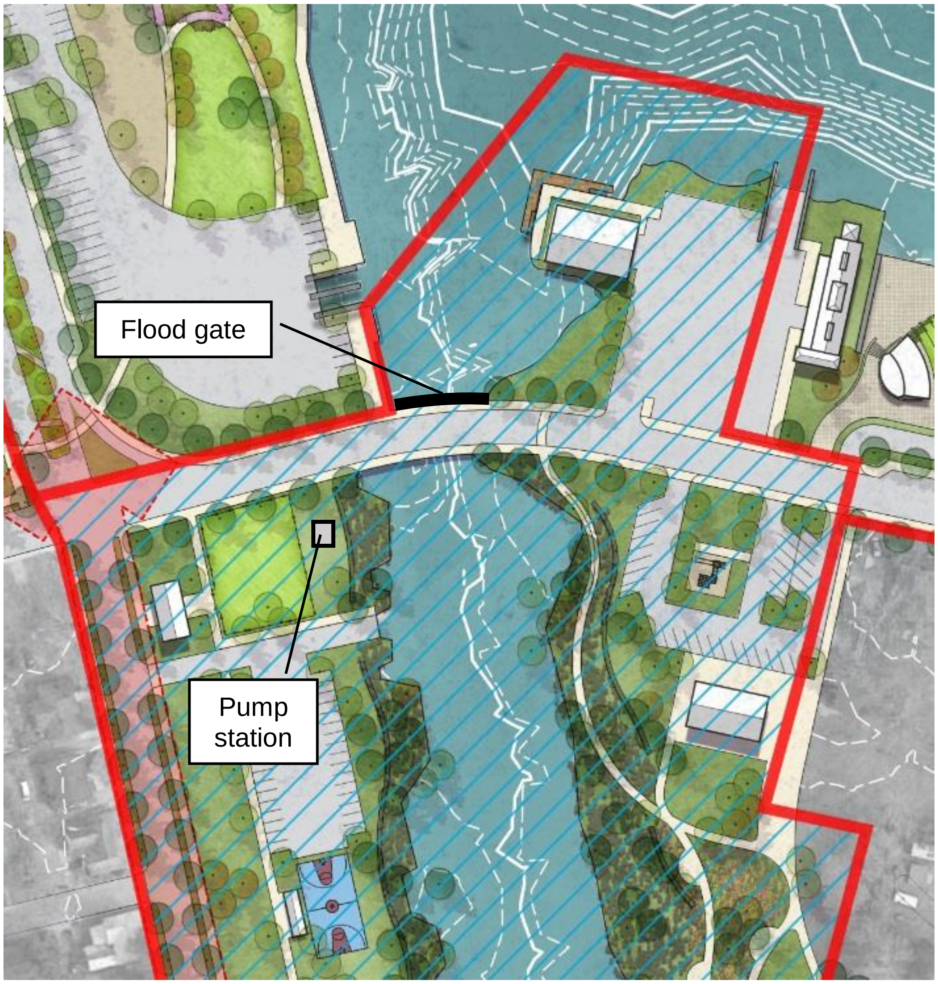

Figure 5-7. Flood gate and pump system layout

5.3.2 Model Results and Level of Protection Achieved

The implementation of a flood gate and pump system significantly reduced the extent and magnitude of flooding in the Charles Creek area for storms as large as the 50-year rainfall event with the corresponding 50-year surge of 3.6 ft.-NAVD. The flood gate blocked storm surges from moving upstream while the pumps maintained low water levels in the channel, allowing runoff volumes to drain effectively. Refer to

Figure 5-8 through Figure 5-11 for flooding maps. A complete list and map of properties affected during the 50-year storm, those for which damages are mitigated by implementing a flood gate and pump system, is provided in Appendix B.

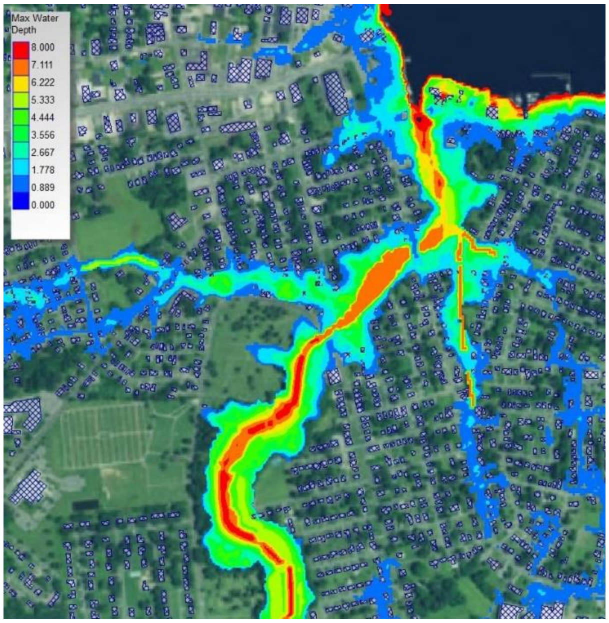

Figure 5-8. Maximum flood depth results for existing conditions – 25-yr rainfall, 3 ft.-NAVD tide level (25-yr surge)

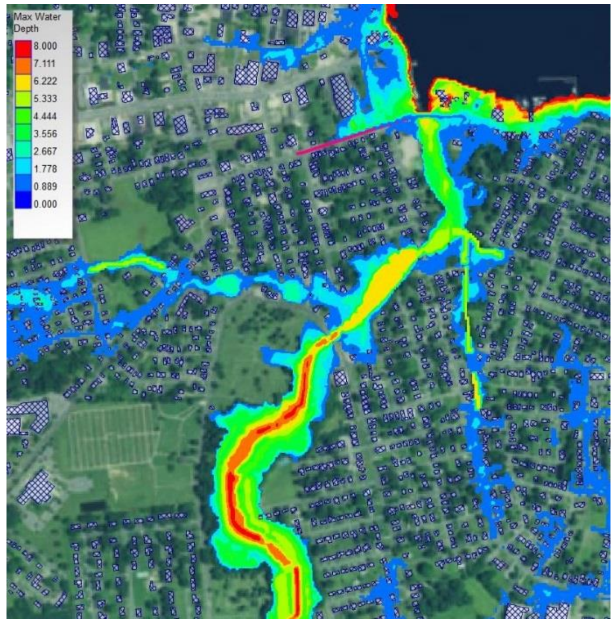

Figure 5-9. Maximum flood depth results for flood gate and pump system – 25-yr rainfall, 3 ft.-NAVD tide level (25-yr surge)

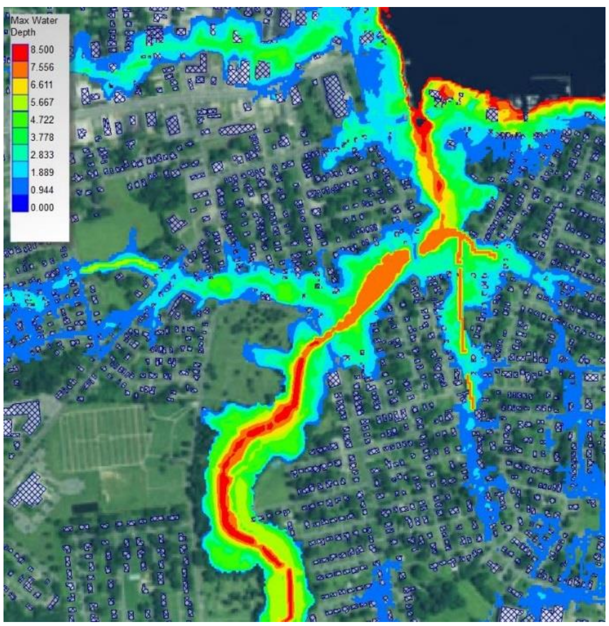

Figure 5-10. Maximum flood depth results for existing conditions – 50-yr rainfall, 3.6 ft.-NAVD tide level (50-yr surge)

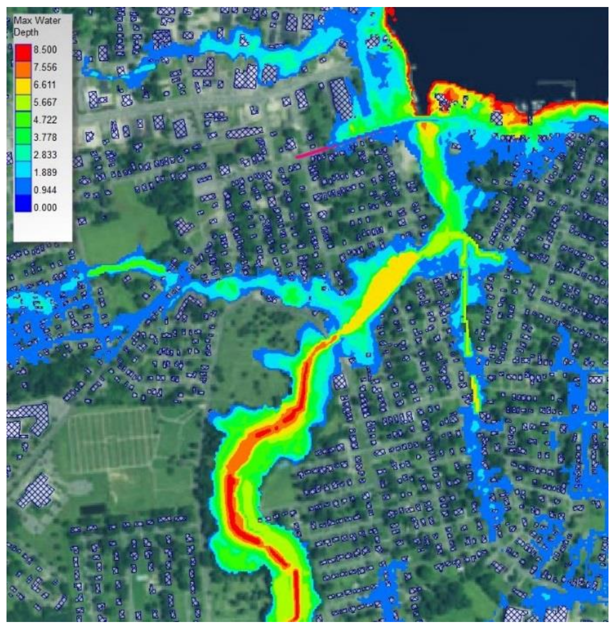

Figure 5-11. Maximum flood depth results for flood gate and pump system – 50-yr rainfall, 3.6 ft.-NAVD tide level (50-yr surge)

5.4 Green Infrastructure

5.4.1 Model Setup and Results

Green infrastructure serves as a potential add-on to the above flood mitigation options in order to improve the behavior of Elizabeth City's existing stormwater system. The installation of green infrastructure would decrease the percentage of land that is impervious, thereby reducing peak flows that run off to stormwater infrastructure. XPSWMM model results show that peak runoff flows during more severe rainfall storm events may be reduced by 5 to 10 percent by implementing green infrastructure on a widespread scale designed to intercept the first 1.5 inches of rainfall. Soil conditions in the study area (Section 3.3) are preferential for green infrastructure given that Group A and B soils with low runoff potential and high infiltration rates are present around Charles Creek. One reason that the green infrastructure was assumed to be designed to only intercept the first 1.5 inches of rainfall (versus 1.5 inches of runoff) is that some lower-lying areas within Charles Creek would likely have constraints concerning the seasonal high water table. Figure 5-12 shows example green infrastructure concepts, which can also be applied elsewhere throughout Elizabeth City and the Charles Creek watershed to improve storm drainage.

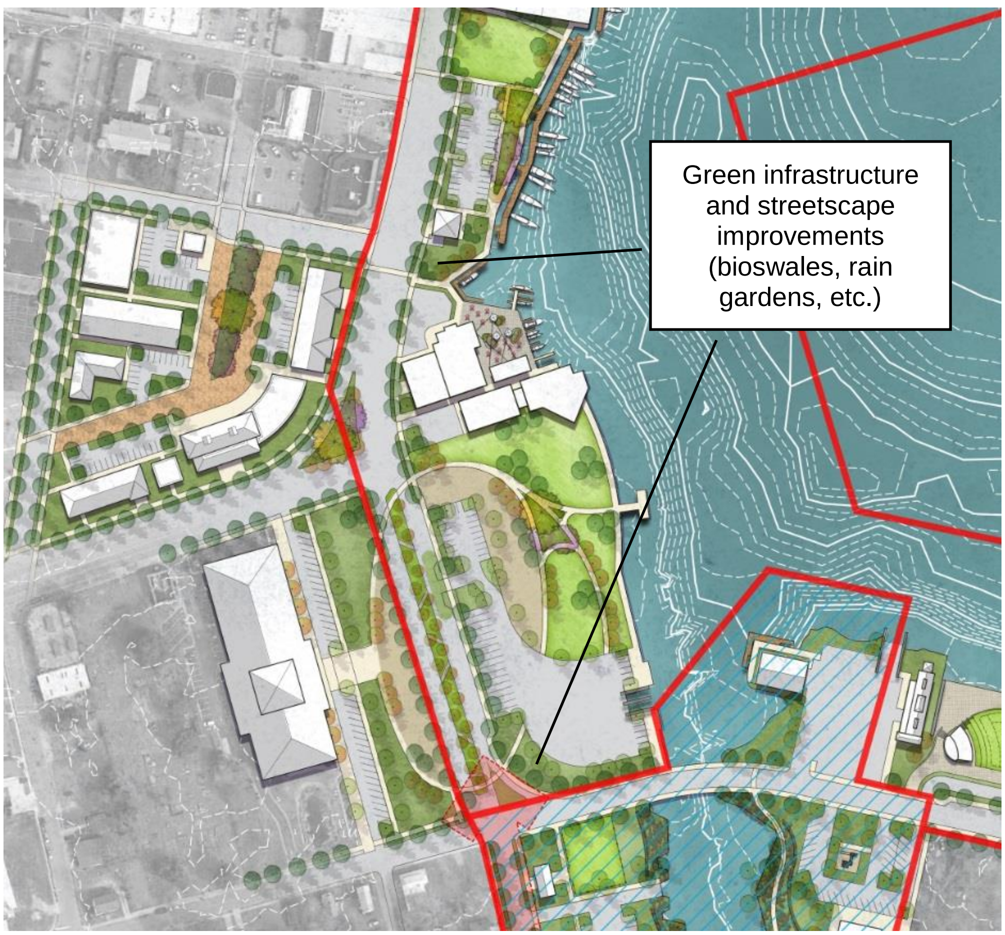

Figure 5-12. Example green infrastructure concepts

5.5 Non-Infrastructure Alternatives

In addition to investigating gray and green infrastructure flood mitigation alternatives, the option to elevate, relocate, or buyout affected structures was explored. Post-flood recovery strategies to further improve resilience were also developed and can be found in Appendix D.

5.5.1 Elevate Structures

The option to elevate affected homes and other structures was considered for each storm event. Each structure would be elevated approximately 3 feet in order to provide a substantial increase in flood protection. Concrete blocks would be used to raise the building foundation. A concept level cost to elevate each structure is $15,000. The number of buildings elevated to mitigate flooding during each storm event is provided in Table 4-3.

5.5.2 Relocate Structures

The option to relocate affected structures was evaluated based on costs to purchase affected properties and move their respective structures. Flooded buildings would be relocated approximately one mile, with a moving cost of about $20,000 per structure (number of structures provided in Table 4-3). Also included in a complete cost estimate is the land purchase cost of affected properties, provided for each storm event in Appendix B.

5.5.3 Buyout and Demolition

The buyout and demolition of affected structures was considered as an additional flood mitigation alternative. The cost to demolish structures includes the total property buyout cost (both land and structure), demolition cost (assumed to be approximately $10,000 per building), as well as the annual lost tax value of razed properties. The number of structures to be demolished for flood mitigation during each storm event is provided in Table 4-3 and the affected properties and values are listed in Appendix B.

5.6 Stormwater and Floodplain Ordinance Revisions

The City's Stormwater Ordinance was adopted in November 2001, establishing base criteria for implementing stormwater management within the City. The Floods Ordinance was adopted in 2004 and established policies and procedures for floodplain development. A brief overview of each ordinance and recommended modifications to mitigate flood losses and promote resilience are noted below.

5.6.1 Stormwater Ordinance

The purpose of the Stormwater Management Ordinance is to protect, maintain, and enhance the public health and safety by establishing minimum requirements for stormwater management, including flood control and water quality improvements. The language of the stormwater ordinance favors larger detention facilities for managing stormwater over green infrastructure. It further discourages green infrastructure by specifically stating that plans could be rejected if numerous small measures are incorporated rather than fewer larger ones (Section G, Number 4).

It is recommended that the stormwater ordinance be modified to allow/promote the use of green infrastructure for both water quantity and quality control for new development, redevelopment, and retrofit opportunities. This may be accomplished by updating the ordinance to reflect the changes to the State's stormwater rules as well as NCDEQ's new design guidance and minimum criteria, both implemented in 2017. Specific green infrastructure practices should be listed in the ordinance to reinforce the desirability of implementing these stormwater management practices such as: bioretention cells, rain gardens, permeable pavement, sand filters, and treatment bioswales. Additionally, it is recommended that the design criteria for storm events be simplified for consistency in development sizes. For instance, regardless of the type and/or size of the new development, specific design requirements for stormwater management and water quality improvement should be implemented.

5.6.2 Floods: Chapter 154 Code of Ordinances

The purpose of the Flood Ordinance is to promote public health and safety and to minimize public and private losses due to flood conditions. The ordinance does not currently require freeboard for new construction, meaning that the lowest level of a new structure must be some additional specified feet above FEMA's mapped base flood elevation. The ordinance does have a requirement for a minimum 2-foot increase from adjacent highest grade for new structures in areas where there are no FEMA mapped base flood elevations.

Based upon modeling efforts, it is recommended that the City implement a minimum 1.5-foot freeboard requirement for all new development to provide resiliency and protection during tidal surges. The City may also want to consider developing criteria to impose the freeboard requirement on existing structures where multiple loss events have occurred.

There is precedence in the City's coastal area for implementing such changes. For example, in 2014 the City of Norfolk implemented a 2-foot freeboard requirement above their FEMA mapped base flood elevations to provide resilience and to account for future sea level rises. The City of Norfolk also addressed existing development by incorporating freeboard requirements if certain cumulative damage conditions had been met (i.e., alteration of structural integrity, two flood events each causing 25 percent of the market value or more of damage to the structure).

5.6.3 Additional Resources for Ordinance Revisions

Additional resources to evaluate the City's development, stormwater, and flood management ordinances are available through the US Environmental Protection Agency (EPA) and the Center for Watershed Protection (CWP). The US EPA has developed a water quality scorecard resource that assists local governments in incorporating green infrastructure practices at the municipal, neighborhood, and site levels. The water quality scorecard is accessible from their website: http://www.epa.gov/smartgrowth/water_scorecard.htm. The EPA also has developed a matrix of recommended smart growth policy changes for climate adaptation and resilience. The matrix addresses flooding and extreme weather, sea level rise, overall strategies, etc. The guidance and matrix may also be downloaded at the EPA's smart growth website.

The CWP provides a Better Site Design Code and Ordinances Worksheet to assist in incorporating low impact development practices and green infrastructure for water quality and quantity control. These resources were updated in December 2017 and are available for download from the CWP website: www.cwp.org.

5.7 Permitting Considerations for Flood Mitigation Options

As part of the assessment of the potential flood mitigation options from the City, a meeting was conducted to inform appropriate regulatory agencies about the project and gather input on the proposed solutions. Agencies and departments, in addition to M&N representatives, in attendance are listed below. A complete list of meeting attendees and a summary of the meeting minutes is included in Appendix F.

- US Army Corps of Engineers (USACE)
- NC Division of Coastal Management (NCDCM and NCDCM-Fisheries)
- NC Division of Water Resources (NCDWR)
- Albemarle-Pamlico National Estuary Partnership - CHPP
- City of Elizabeth City – Public Works
- US Fish and Wildlife Service (USFWS)
- NCDEQ Raleigh
- NC Wildlife Resources Commission (NCWRC)
- NC Division of Waste Management (NCDWM)
- NC Division of Energy, Mineral, and Land Resources (NCDEMLR)
- City of Elizabeth City – Planning

Based on discussion with the agencies, the main concerns and feedback are as follows:

- *Wetlands* – If the protective berm option is selected for further study, a wetland delineation should be completed along the path of the berms in order to define and quantify potentially impacted wetland areas. All of the agencies agreed that the berms should ideally be located in areas where flood protection can still be provided while avoiding/minimizing wetland impacts. When impacts occur, mitigative measures will likely have to be taken to address these effects.
- *Public Trust Waters* – Berms located within the 30-foot buffer zone of Public Trust Waters should be studied to ensure that they do not cause increased runoff to these waters or cause funneling or redirection of waters to other areas increasing their flood levels.
- *Fisheries* – Significant concerns were raised by all agencies with the flood gate and pumps alternative. Most concerns centered around the system's potential detrimental effects on the spawning and migratory behaviors of anadromous fish populations (Blueback Herring and the Alewife) in Charles Creek, which is a designated anadromous fish spawning area with moratoria set from Feb 15 through Jun 15 (stated by NCDCM-Fisheries). The concern with a gate structure is that there will be pressure to operate and close the gates even during this moratoria due to nor'easters which are prevalent during that time. NCWRC and NCDCM-Fisheries have fish population and monitoring data, so these agencies should be consulted about providing the data if the flood gate and pumps alternative is studied further. NCDWR and NCWRC stated that a significant operations and maintenance plan would have to be developed for the gate closures and pump operations so that potential effects could be accurately quantified and that significant limits on times the system could be operated may be part of permit conditions.
- *Elevate/Relocate Structures* – These two flood mitigation options would likely have the lowest permitting considerations. Residents who prefer not to relocate may potentially be open to elevation of their homes. Additionally, relocation allows for the potential for wetland restoration and expansion in flood-prone areas near Charles Creek that no longer contain structures.

5.8 OPINIONS OF PROBABLE COSTS FOR FLOOD MITIGATION ALTERNATIVES

Concept level opinions of probable costs were developed for each of the investigated flood mitigation alternatives. A summary of the cost estimates for each alternative (based on similar projects and unit prices from local NCDOT bid tabs) can be found in Table 5-1. Initial project costs for each alternative were calculated to mitigate flooding during the 10, 25, and 50-year storm events. It should be noted that the costs for the protective berms and flood gate and pump system are listed as the same value for each storm event. However, the protective berms are designed to mitigate damages for storms up to the 25-year event and would not provide full flood protection during the 50-year storm event.

Table 5-1. Opinions of probable costs for flood mitigation alternatives

Alternative	Probable Cost – 10-yr Storm	Probable Cost – 25-yr Storm	Probable Cost – 50-yr Storm
Protective Berms	$2,200,000	$2,200,000	N/A
Flood Gate and Pump	$7,000,000	$7,000,000	$7,000,000
Elevate Structures	$900,000	$1,600,000	$2,100,000
Relocate Structures	$2,700,000	$3,500,000	$4,000,000
Buyout	$4,300,000	$7,500,000	$10,000,000

5.9 ESTIMATED FLOOD REDUCTION BENEFITS FOR FLOOD MITIGATION ALTERNATIVES

A complete cost-benefit analysis was conducted for each flood mitigation alternative. To determine the flood reduction benefits, property damages incurred at different base flood elevations were estimated using FIMAN's online flood scenario tool. Based on water level data discussed in Section 4.2, computed FEMA base flood elevations are reached more often than suggested by their given return period (i.e. the 10-year flood elevation has been reached six times in the last five years). Given this observation, each storm's respective water level was increased to provide a more conservative estimate of flood damages. Water levels were interpolated and extrapolated for storm events that did not have a computed base flood elevation. Adjusted water levels and corresponding damages obtained from FIMAN are provided in Table 5-2.

Table 5-2. FIMAN water levels and estimated damages for various storm events

Storm Event	FIMAN Water Level (ft.-NAVD)	Estimated Damages
1-yr	1.5	$219,000
2-yr	2.0	$414,000
10-yr	3.0	$1,100,000
25-yr	3.5	$2,000,000
50-yr	4.5	$6,000,000
100-yr	5.5	$14,000,000

In order to calculate expected annual damages, the damages incurred during each storm event were weighted based on their recurrence interval. From the estimated damages and project costs, a benefit-cost ratio was calculated for each flood mitigation alternative based on FEMA procedures. A design life of 50 years and an interest rate of 3% was assumed. Table 5-3 shows each alternative, the return period for which it provides protection, respective project costs and benefits, and its benefit-cost ratio.

Annual maintenance costs were included in the total project cost calculation where necessary (e.g. protective berms and flood gate and pump system). The annual lost tax value was included in the total building demolition cost calculations.

Table 5-3. Cost-benefit analysis for flood mitigation alternatives

Flood Mitigation Alternative	Return Period	Initial Project Cost	Present Worth Total Project Cost (Includes Flood Damages)	Net Benefits with Project (Reduced Flood Damages)	B/C
Protective Berms	25-yr	$2,200,000	$5,000,000	$14,700,000	2.9
Flood Gate and Pumps	50-yr	$7,000,000	$16,000,000	$17,000,000	1.1
Elevate Structures	50-yr	$2,100,000	$2,100,000	$17,000,000	8.0
Relocate Structures	50-yr	$4,000,000	$4,000,000	$17,000,000	4.3
Buyout	50-yr	$10,000,000	$13,100,000	$17,000,000	1.3

Based on the cost-benefit analysis, the preferred flood mitigation alternatives are elevating or relocating affected structures and the construction of multifunction protective berms. The elevation of flood-prone structures is the most cost-effective option (benefit-cost ratio (B/C) of 8.0) followed by relocation (B/C = 4.3). Although the protective berms are less cost-effective, they do provide additional neighborhood connectivity and recreational benefits and have a B/C ratio of 2.9.

While a majority of structures affected during flood events are residential homes, certain buildings along the Pasquotank River waterfront that may be of public value experience flooding. These buildings include Riverside Boatworks and properties owned by College of the Albemarle. Some affected properties are located within the Shepard Street-South Road Street and Riverside Historic Districts (National Park Service, 2018).

6 FUNDING APPROACHES

There are several federal grant programs as well as loan programs available to be pursued by the City for flood mitigation, resiliency, and green infrastructure for stormwater management. These funding opportunities are detailed below.

6.1 FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) PROGRAMS

FEMA administers three programs to fund flood mitigation planning, projects that reduce disaster losses, and projects that protect life and property from future disasters. FEMA distributes funds to each state for management. In 2014, FEMA approved North Carolina's Enhanced Hazard Mitigation Plan, making North Carolina eligible for additional funds. Local governments are considered sub-applicants and must submit applications for FEMA-appropriated funds to the North Carolina Division of Emergency Management. The three programs are described below.

6.1.1 Hazard Mitigation Grant Program (HMGP)

The HMGP provides grants in response to a Presidential disaster declaration. Projects must provide a long-term response to flood mitigation and disaster prevention such as elevating a home to reduce future flood risk as opposed to buying sand bags and pumps to combat a single flood event. Projects must produce a cost savings greater than the cost to implement the proposed project.

Types of projects that the City could consider in reducing risks associated with flooding and future disasters include acquisition and structure demolition/relocation, floodplain and stream restoration, stormwater management, and green infrastructure. Elizabeth City has several HMGP applications in progress due to the Hurricane Matthew disaster declaration.

6.1.2 Pre-Disaster Mitigation (PDM) Program

The PDM program is intended to assist States, Tribes, local communities, etc. in implementing a sustainable pre-disaster natural hazard mitigation program such that overall risk to life and structures from future disasters is reduced and reliance upon federal funding is also reduced. Types of projects eligible for PDM grants include property acquisition for open space conversion; elevating, relocating, or retrofitting structures; and hydrologic, hydraulic, and engineering studies for flood mitigation.

6.1.3 Flood Mitigation Assistance (FMA) Program

The FMA program funds plans and projects that reduce and/or eliminate the risk of structural flooding for properties insured under the National Flood Insurance Program (NFIP). Projects the City could consider for FMA program grants include structure acquisition, demolition, and relocation for insured properties. Properties must remain open space in perpetuity. Other minor structural flood mitigation measures are also eligible under the FMA program.

6.2 US Department of Housing and Urban Development (HUD) Community Development Block Grant Disaster Recovery (CDBG-DR) Program

HUD provides grants to assist in recovery from federally-declared disasters, especially in low-income areas. CDBG-DR funds may cover a much broader range of activities (unlike FEMA) and can help communities with limited resources begin recovery. Under the CDBG-DR program, Elizabeth City was awarded a grant to replace and relocate sanitary sewer systems that failed during Hurricane Matthew.

6.3 Clean Water Management Trust Fund (CWMTF) Grants

The CWMTF grants funds for the purposes of improving water quality, sustaining ecological diversity, protecting historic sites, restoring habitat, and reducing stormwater pollution. The CWMTF makes a portion of their annual grants available for innovative stormwater projects. Innovative stormwater grants may be used to improve stormwater management, reduce pollutants entering the State's waterways, improve water quality, and to research alternative solutions to water quality problems within the State. Types of projects Elizabeth City may consider for application of an innovative stormwater CWMTF grant include, but are not limited to, projects that:

- Reduce runoff volumes and rates;
- Promote infiltration and groundwater recharge;
- Sustainably maintain or improve hydrologic characteristics after land development;

- Remove pollutants of concern;
- Change attitudes, values, or behaviors; and
- Support or assist in restoration of natural systems.

The 2019 grant cycle will begin in late 2018 with training on the application process. Applicants must have access to the Grant Management System (GMS) in order to submit their applications, which are typically due at the beginning of February. Application review and site visits are conducted in the spring and grants are usually awarded in September. Projects and approaches that document and/or improve understanding of cost-benefit relationships of stormwater management systems may be considered more competitive proposals.

6.4 NC Department of Environmental Quality (NCDEQ) Water Resources Development Grant Program

This program provides 50 percent cost-share grants and technical assistance to local governments for water management (flood control, shoreline stabilization, etc.), stream restoration, water-based recreation (greenways, land acquisition, etc.) and engineering/feasibility studies. There are two grant cycles per fiscal year: June 30th and December 31st. Projects funded by the NCDEQ Water Resources Development Grant program in the past encompass replacement of failing drainage infrastructure, construction of stormwater control measures to reduce flooding and provide water quality treatment, and stream bank stabilization.

6.5 National Oceanic and Atmospheric Administration Coastal Resilience Grants Program

The NOAA Coastal Resilience Grants Program intends to build resiliency through projects that conserve and restore ecosystem processes and functions and that reduce the vulnerability of coastal communities and infrastructure from the impacts of changing oceanic conditions, extreme weather events, and climate hazards. A pre-proposal is required to be submitted by March 7th for the 2018 grant cycle. Selected applicants will be contacted to submit a full proposal based on the strength of the pre-proposal within 40 days of contact by NOAA. Grants must be funded at a 2:1 ratio. Therefore, if the City requested $100,000 in grant funds, they would need $50,000 in matching funds. The grant cycle is annual based on appropriations by Congress and typically opens in January, with awards finalized in the early Fall.

6.6 Environmental Protection Agency (EPA) Urban Waters Small Grant Program

The EPA Urban Waters Small Grant Program is open to many different entities including local governments on a two-year cycle. The last grants awarded were in October of 2016. The EPA does not have a current request for proposals online at this time; however, the City may visit the Urban Waters webpage to sign up for updates and additional tools/information in the Urban Waters learning Network. To be eligible for a grant (with individual awards up to $60,000), projects should address local water quality issues related to urban runoff, provide additional community benefits, engage underserved communities, and foster partnership. The City should consider following this grant source for future work in developing green infrastructure to improve stormwater runoff and quality. Potential partners include nearby colleges/universities, the public school system, waterfront businesses, and the Albemarle Commission.

6.7 EPA Section 205(j) Grant Program

The EPA provides funding to States for water quality planning. North Carolina typically receives approximately $100,000 annually which is administered through NCDEQ. These grants are specifically earmarked for regional Council of Governments (COGs) like the Albemarle Commission. While the COGs must be the specific grantee, they most often partner with local governments or private entities to achieve environmental goals. Recent projects funded through the 205(j) grant program included projects that improved both stormwater flood control and water quality. In 2016, the Eastern Carolina Council received a 205(j) grant partnering with the Town of Newport to map the Town's stormwater infrastructure and to conduct outreach events for its citizens on how to properly maintain stormwater infrastructure. Other types of projects funded include development of plans to restore natural runoff volumes for the Town of Beaufort and stormwater assessments and BMP recommendations for school campuses in the Tar-Pamlico and Neuse River basins.

The City may want to consider pursuing 205(j) grant funding for natural restoration and stormwater runoff reduction planning through partnerships with the Albemarle Commission and the nearby colleges and universities.

6.8 National Fish and Wildlife Foundation (NFWF) Five Star and Urban Waters Restoration Grant Program

The NFWF Five Star and Urban Waters Restoration Grant Program operates on an annual cycle and is open to any non-federal entity. Grants require a 1:1 match; however, the matching funds may be through in-kind donated or volunteer services. The funding priorities for the program include on-the-ground wetland, riparian, in-stream, and/or coastal habitat restoration, education and community outreach and participation, particularly with K-12 schools, measurable benefits, and engagement with a diverse group of community partners. The funding cycle typically begins in November with complete proposals due at the end of January. Grants are awarded in July. The City could begin investigating the potential for green infrastructure projects within the City and/or at City schools and riparian restoration along Charles Creek for the 2019 grant cycle.

6.9 Clean Water State Revolving Fund (CWSRF)

The CWSRF was established to replace the earlier Construction Grants program by amendments to the Clean Water Act in 1987. With those amendments Congress provided funds for states to establish revolving loan programs for funding of wastewater treatment facilities and projects associated with estuary and nonpoint source programs (including stormwater best management practices and stream restoration). The program makes low interest loans (½ of market rates) available with a limited amount of principle forgiveness loans and some 0% interest loans for green projects. The CWSRF is operated by the NCDEQ Division of Water Infrastructure and has two funding cycles annually in April and September. Jennifer Haynie may be contacted for additional information at 919.707.9173 or at Jennifer.haynie@ncdenr.gov.

7 PRELIMINARY PLAN RECOMMENDATIONS

Moffatt & Nichol was selected to study and provide alternatives to reduce flooding and increase resilience in the Charles Creek area of Elizabeth City. The elevation or relocation of buildings and use of protective berms are recommended flood mitigation options for further study to increase flood resilience within the City. Berms, along with the necessary road raises, provide protection against river flooding for storms as large as the 25-year event. They also can be installed in conjunction with a greenway along Charles Creek to improve connectivity between Mid-Atlantic Christian University and Elizabeth City State University. The conceptual level initial cost of constructing berms with appropriate interior drainage infrastructure is approximately $2.2 million, with a benefit-cost ratio of 2.9. Elevating affected buildings would cost about $2.1 million to mitigate damages during the 50-year storm and has a benefit-cost ratio of 8.0. While the elevation of flood-prone structures provides the highest benefit-cost ratio followed by relocating structures (B/C = 4.3), the berm option does provide additional ancillary neighborhood connectivity and recreational benefits. It should also be noted that, if preferred, a combination of the investigated alternatives may be used instead of a singular flood mitigation alternative. A preliminary discussion with permitting agencies determined that the flood gate/pump option would not be preferred and that use of berms would also require further study to determine the level of wetland mitigation that may be needed for construction. The installation of green infrastructure, as well as the revision of existing stormwater and floodplain ordinances, serve as additional measures to improve resilience in Elizabeth City. Ordinances should be revised to encourage the use of green infrastructure and implement new freeboard requirements to provide additional safety and resilience. The flood gate and pump system has the lowest benefit-cost ratio (B/C = 1.1) and also has the most permitting concerns, and therefore is not recommended for further study.

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XP Solutions. (2016). *XP2D For Integrated 1D/2D Modeling - User's Manual.*

Appendix A. Tide Exceedance Analysis and Rainfall Record

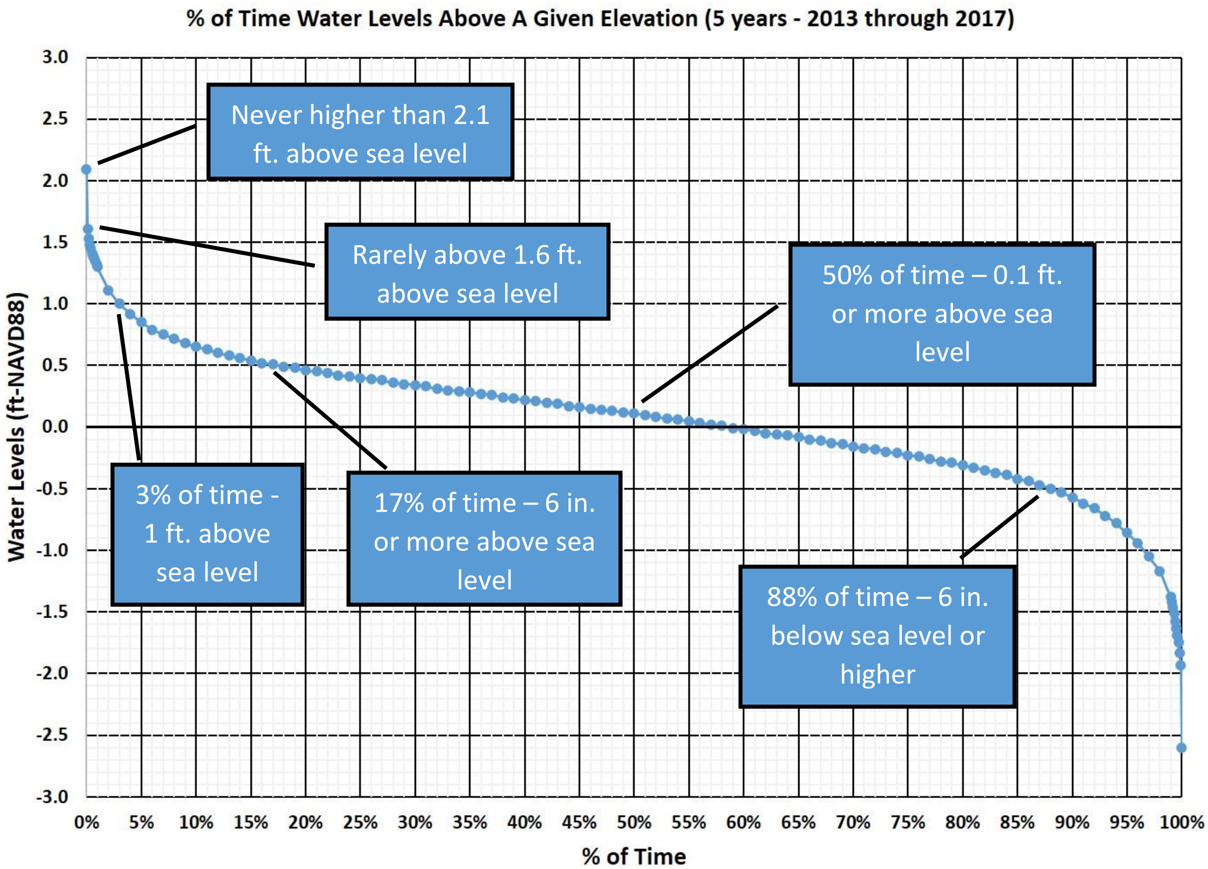

Figure A-1. Percent exceedance of water level at Mariners Wharf Park Pasquotank River gage

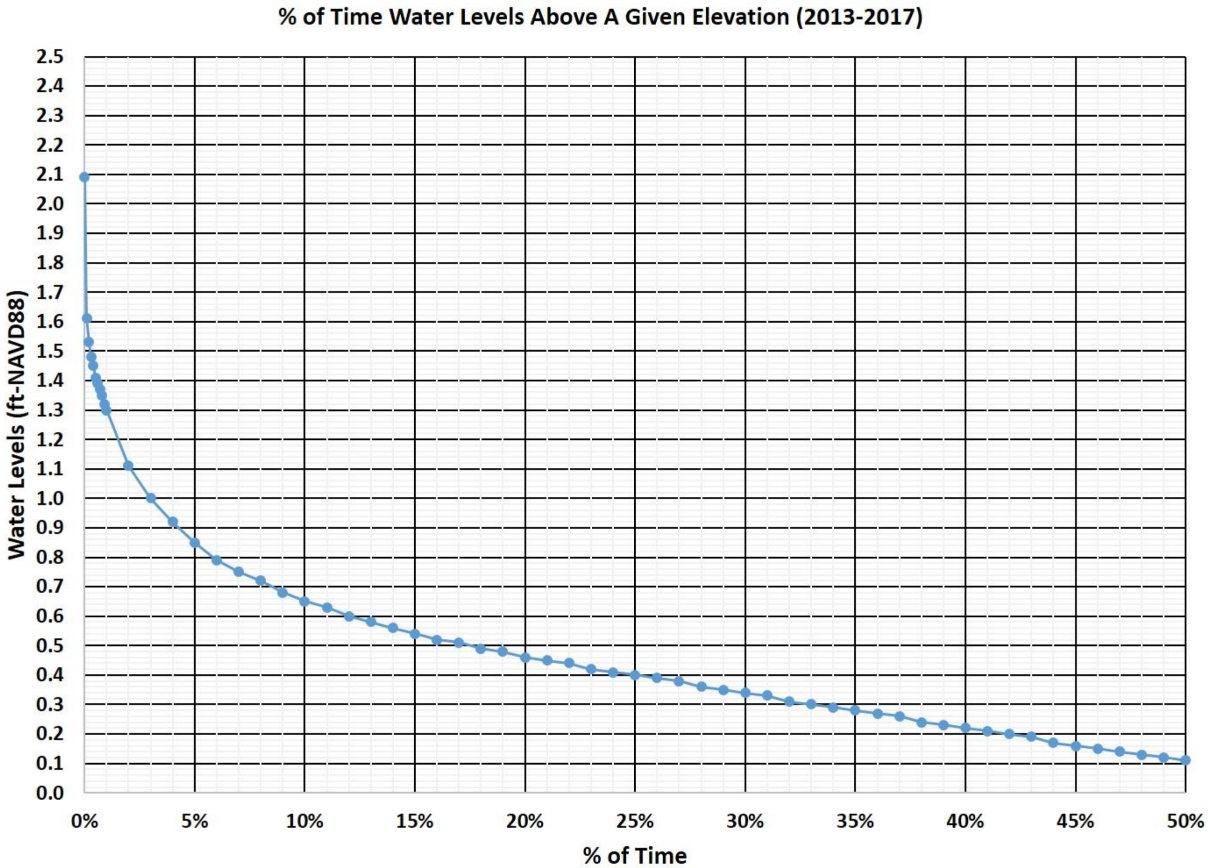

Figure A-2. Percent exceedance of water level above 0 ft.-NAVD at Mariners Wharf Park Pasquotank River gage

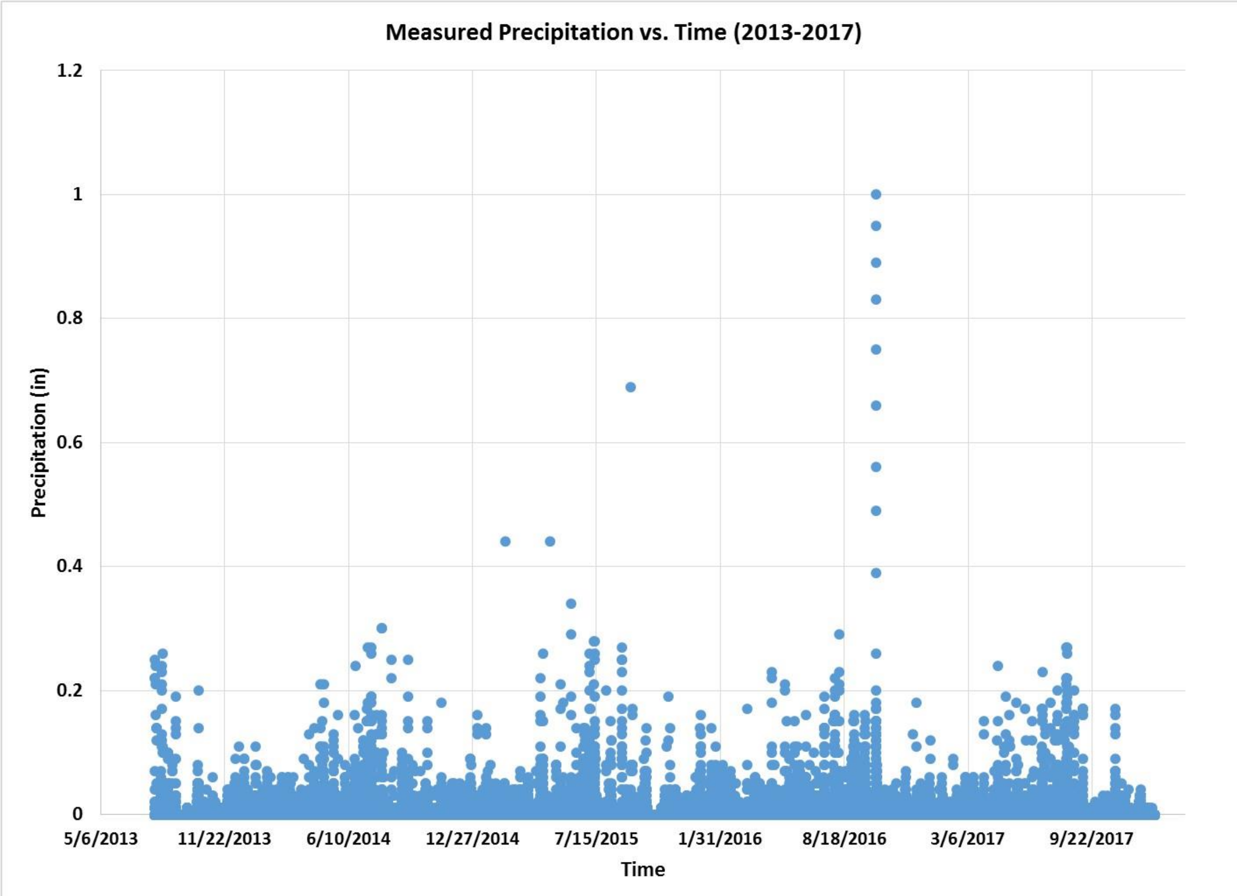

Figure A-3. Precipitation record at Pasquotank River gage (2013-2017)

Appendix B. Affected Properties During Storm Events

Note: Affected properties are based on coarse modeling and should not be used for regulatory purposes. Parcels were only included which contained structures based on available built environment data and the tables provided below.

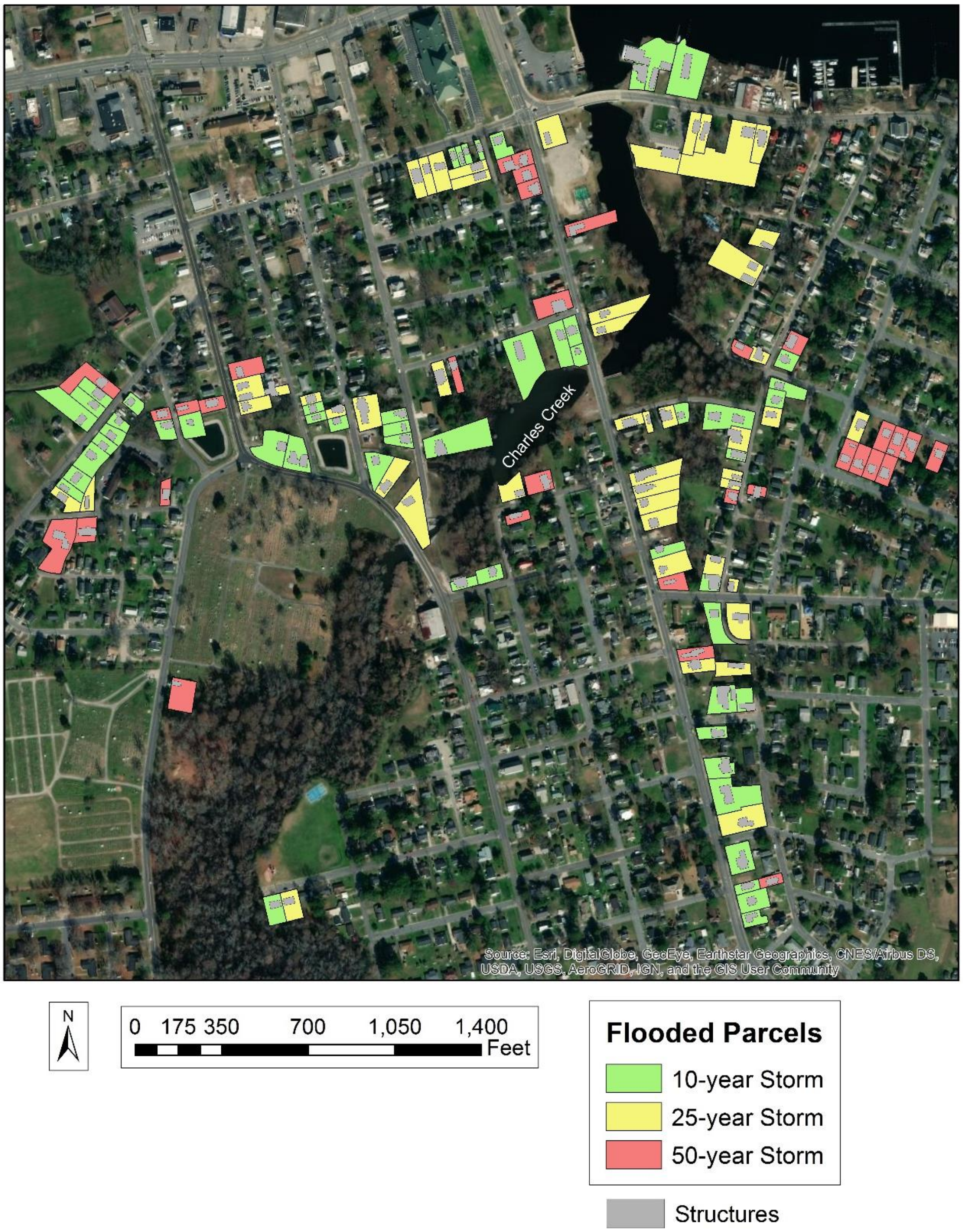

Figure B-1. Flooded structures and parcels

10-yr Storm – Flooded Structures

Parcel	Land Value	Structure Value	Total Value
1	3,900	7,600	11,500
2	3,600	0	3,600
3	3,800	5,400	9,200
4	3,500	18,400	21,900
5	10,600	29,300	39,900
6	12,200	17,900	30,100
7	9,600	40,000	49,600
8	29,100	34,200	63,300
9	10,800	0	10,800
10	18,700	29,000	47,700
11	7,400	29,700	37,100
12	7,800	29,700	37,500
13	7,200	51,900	59,100
14	6,000	32,200	38,200
15	6,900	43,500	50,400
16	9,200	36,200	45,400
17	14,900	0	14,900
18	34,300	8,900	43,200
19	20,300	68,000	88,300
20	4,600	35,900	40,500
21	5,600	30,600	36,200
22	5,600	57,900	63,500
23	20,200	16,100	36,300
24	10,400	49,700	60,100
25	8,600	18,300	26,900
26	9,800	22,300	32,100
27	29,100	148,600	177,700
28	24,000	5,600	29,600
29	11,900	40,000	51,900
30	37,600	90,700	128,300
31	21,500	19,800	41,300
32	4,100	12,600	16,700
33	10,700	35,600	46,300
34	14,700	44,600	59,300
35	79,900	0	79,900
36	187,600	2,000	189,600
37	474,400	8,500	482,900
38	37,200	101,600	138,800

Parcel	Land Value	Structure Value	Total Value
39	16,100	88,800	104,900
40	11,300	49,100	60,400
41	20,100	199,200	219,300
42	34,700	0	34,700
43	19,000	127,700	146,700
44	12,500	91,500	104,000
45	10,900	24,900	35,800
46	8,000	23,900	31,900
47	46,000	0	46,000
48	24,500	148,600	173,100
49	6,200	33,900	40,100
50	10,100	0	10,100
51	13,500	20,900	34,400
52	11,800	0	11,800
53	9,900	41,300	51,200
54	7,800	0	7,800
55	16,100	36,000	52,100
Total	**1,520,700**	**2,149,500**	**3,670,200**

25-yr Storm – Flooded Structures

Parcel	Land Value	Structure Value	Total Value
1	12,100	50,000	62,100
2	10,300	32,600	42,900
3	21,400	42,700	64,100
4	3,900	7,600	11,500
5	3,600	0	3,600
6	10,900	25,300	36,200
7	10,900	31,900	42,800
8	3,800	5,400	9,200
9	3,500	18,400	21,900
10	10,600	29,300	39,900
11	44,200	49,400	93,600
12	23,800	0	23,800
13	9,300	35,200	44,500
14	12,200	17,900	30,100
15	7,900	22,800	30,700
16	9,600	40,000	49,600
17	29,100	34,200	63,300
18	10,800	0	10,800
19	18,700	29,000	47,700
20	7,400	29,700	37,100
21	7,800	29,700	37,500
22	7,200	51,900	59,100
23	6,000	32,200	38,200
24	6,900	43,500	50,400
25	9,200	36,200	45,400
26	14,900	0	14,900
27	16,700	29,300	46,000
28	11,600	29,300	40,900
29	34,300	8,900	43,200
30	1,900	0	1,900
31	20,300	68,000	88,300
32	5,600	31,100	36,700
33	4,600	35,900	40,500
34	4,200	13,800	18,000
35	5,600	30,600	36,200
36	5,600	57,900	63,500
37	20,200	16,100	36,300
38	15,000	61,200	76,200

Parcel	Land Value	Structure Value	Total Value
39	9,600	24,600	34,200
40	10,400	49,700	60,100
41	8,600	18,300	26,900
42	9,800	22,300	32,100
43	45,400	0	45,400
44	29,100	148,600	177,700
45	15,600	59,500	75,100
46	24,000	5,600	29,600
47	11,900	40,000	51,900
48	13,200	27,400	40,600
49	9,400	45,300	54,700
50	37,600	90,700	128,300
51	21,500	19,800	41,300
52	4,100	12,600	16,700
53	10,700	35,600	46,300
54	17,300	14,900	32,200
55	23,900	0	23,900
56	14,700	44,600	59,300
57	14,700	43,600	58,300
58	34,200	0	34,200
59	12,400	43,400	55,800
60	11,900	33,400	45,300
61	102,100	50,100	152,200
62	12,700	105,700	118,400
63	79,900	0	79,900
64	187,600	2,000	189,600
65	474,400	8,500	482,900
66	12,500	62,500	75,000
67	37,200	101,600	138,800
68	16,100	88,800	104,900
69	11,300	49,100	60,400
70	20,100	199,200	219,300
71	12,800	500	13,300
72	34,700	0	34,700
73	19,000	127,700	146,700
74	15,300	85,400	100,700
75	12,500	91,500	104,000
76	21,200	77,200	98,400
77	18,700	38,300	57,000

Parcel	Land Value	Structure Value	Total Value
78	16,800	63,500	80,300
79	17,600	70,100	87,700
80	4,600	23,400	28,000
81	19,300	33,400	57,200
82	10,900	24,900	35,800
83	16,700	48,600	65,300
84	9,100	87,400	96,500
85	8,000	23,900	31,900
86	46,000	0	46,000
87	10,000	10,700	20,700
88	5,800	27,400	33,200
89	24,500	148,600	173,100
90	3,800	0	3,800
91	6,200	66,400	72,600
92	6,200	33,900	40,100
93	12,800	102,800	115,600
94	11,100	27,400	38,500
95	10,100	0	10,100
96	13,500	20,900	34,400
97	17,700	62,100	79,800
98	30,300	59,100	89,400
99	6,700	57,600	64,300
100	13,600	35,600	49,200
101	11,800	0	11,800
102	9,900	41,300	51,200
103	7,800	0	7,800
104	16,100	36,000	52,100
Total	**2,306,600**	**4,054,500**	**6,361,100**

50-yr Storm – Flooded Structures

Parcel	Land Value	Structure Value	Total Value
1	12,100	50,000	62,100
2	10,300	32,600	42,900
3	21,400	42,700	64,100
4	3,900	7,600	11,500
5	3,600	0	3,600
6	10,900	25,300	36,200
7	10,900	31,900	42,800
8	3,800	5,400	9,200
9	3,500	18,400	21,900
10	8,800	10,600	19,400
11	10,600	29,300	39,900
12	9,400	23,900	33,300
13	7,900	34,700	42,600
14	7,200	54,100	61,300
15	44,200	49,400	93,600
16	19,000	42,600	61,600
17	23,800	0	23,800
18	33,200	67,900	101,100
19	9,300	35,200	44,500
20	13,300	82,100	95,400
21	12,200	17,900	30,100
22	7,900	22,800	30,700
23	9,600	40,000	49,600
24	29,100	34,200	63,300
25	10,800	0	10,800
26	18,700	29,000	47,700
27	7,400	29,700	37,100
28	7,800	29,700	37,500
29	7,200	51,900	59,100
30	25,200	47,300	72,500
31	6,000	32,200	38,200
32	6,900	43,500	50,400
33	11,900	12,200	24,100
34	7,000	17,600	24,600
35	6,000	56,800	62,800
36	9,200	36,200	45,400
37	8,000	18,900	26,900
38	14,900	0	14,900

Parcel	Land Value	Structure Value	Total Value
39	8,200	63,800	72,000
40	16,700	29,300	46,000
41	11,600	29,300	40,900
42	15,500	34,900	50,400
43	34,300	8,900	43,200
44	1,900	0	1,900
45	20,300	68,000	88,300
46	5,600	31,100	36,700
47	4,600	35,900	40,500
48	4,200	13,800	18,000
49	5,600	30,600	36,200
50	5,600	57,900	63,500
51	20,200	16,100	36,300
52	15,000	61,200	76,200
53	8,000	24,700	32,700
54	9,600	24,600	34,200
55	10,400	49,700	60,100
56	8,600	18,300	26,900
57	9,800	22,300	32,100
58	45,400	0	45,400
59	29,100	148,600	177,700
60	15,600	59,500	75,100
61	8,700	10,600	19,300
62	24,000	5,600	29,600
63	11,900	40,000	51,900
64	13,200	27,400	40,600
65	7,800	14,000	21,800
66	15,000	70,300	85,300
67	9,400	45,300	54,700
68	37,600	90,700	128,300
69	21,500	19,800	41,300
70	18,700	111,200	129,900
71	4,100	12,600	16,700
72	10,700	35,600	46,300
73	17,300	14,900	32,200
74	23,900	0	23,900
75	31,200	130,600	161,800
76	14,700	44,600	59,300
77	14,700	43,600	58,300

Parcel	Land Value	Structure Value	Total Value
78	24,900	41,400	66,300
79	34,200	0	34,200
80	12,400	43,400	55,800
81	11,900	33,400	45,300
82	102,100	50,100	152,200
83	12,700	105,700	118,400
84	79,900	0	79,900
85	187,600	2,000	189,600
86	474,400	8,500	482,900
87	12,500	62,500	75,000
88	12,800	51,600	64,400
89	37,200	101,600	138,800
90	16,100	88,800	104,900
91	11,300	49,100	60,400
92	20,100	199,200	219,300
93	12,800	500	13,300
94	34,700	0	34,700
95	19,000	127,700	146,700
96	15,300	85,400	100,700
97	12,500	91,500	104,000
98	21,200	77,200	98,400
99	18,700	38,300	57,000
100	16,800	63,500	80,300
101	17,600	70,100	87,700
102	4,600	23,400	28,000
103	19,300	33,400	57,200
104	9,200	42,700	51,900
105	10,900	24,900	35,800
106	16,700	48,600	65,300
107	9,100	87,400	96,500
108	8,000	23,900	31,900
109	46,000	0	46,000
110	10,000	10,700	20,700
111	5,900	0	5,900
112	5,800	27,400	33,200
113	24,500	148,600	173,100
114	3,800	0	3,800
115	6,200	66,400	72,600
116	6,200	33,900	40,100

Parcel	Land Value	Structure Value	Total Value
117	12,800	102,800	115,600
118	6,200	65,200	71,400
119	11,100	27,400	38,500
120	10,100	0	10,100
121	13,500	20,900	34,400
122	19,700	48,700	68,400
123	19,700	53,700	73,400
124	19,600	48,700	68,300
125	17,700	62,100	79,800
126	8,300	9,300	17,600
127	30,300	59,100	89,400
128	6,700	57,600	64,300
129	13,600	35,600	49,200
130	11,700	0	11,700
131	11,800	0	11,800
132	19,600	61,900	81,500
133	19,600	36,300	55,900
134	19,600	82,200	101,800
135	19,600	96,700	116,300
136	19,700	38,300	58,000
137	9,900	41,300	51,200
138	7,800	0	7,800
139	16,100	36,000	52,100
140	7,800	43,500	51,300
Total	**2,820,500**	**5,703,500**	**8,524,000**

Appendix C. Public Involvement and Engagement

An important component of any flood mitigation planning process is public participation. Individual citizen and community-based input provides the planning team with a greater understanding of local concerns and increases the likelihood of successfully implementing mitigation activities by developing community "buy-in" from those directly affected by the decisions of public officials. As citizens become more involved in decisions that affect their safety, they are more likely to gain a greater appreciation of the hazards present in their community and take the steps necessary to reduce their impact. Public awareness is a key component of any community's overall mitigation strategy aimed at making a home, neighborhood, school, business, or entire planning area safer from the potential effects of the flood hazard.

Meaningful public involvement in the development of the Charles Creek Flood Mitigation Plan was sought using multiple methods including open public meetings, an online public participation survey that doubled as a project information portal, and by making draft copies of plan materials and preliminary findings available at the open public meetings for public input. Public meetings were held at three pre-determined points during the planning process: (1) near the beginning of the planning process; and (2) once an approximately 60% draft of the plan had been developed in order to gauge public perception of the preliminary draft; and (3) near the end of the planning process. These public meetings were held at a central location to the planning area to ensure that interested citizens had reasonable access to the opportunity to participate in-person in the planning process. The online public participation survey was promoted via social media outlets, email, and at project meetings and the second public open house.

Public Open Houses

Three public open house meetings were held to solicit public input. The dates of these three events are provided below.

Public Open House #1: October 18th, 2017
Public Open House #2: January 17th and 18th, 2018
Public Open House #3: March 5th and 6th, 2018
[*Note: Moffatt & Nichol did not host or participate in Public Open House #3, however, M&N did provide meeting materials for the City Planning Department to use in carrying out this meeting.*]

During the day, the public open houses provided opportunities for citizens to view preliminary plan exhibits and provided feedback on proposed design concepts to M&N team members in attendance. While the exhibits were available for viewing, other members of the M&N team attended meetings with various City groups and committees to present plan materials. Formal presentations of the plan concepts were given during the evenings of open house days, providing an additional opportunity for members of the community to view project work to date as well as ask questions and provide input. Those who attended the public open houses and concurrent small-group meetings were directed to the online public participation survey to provide additional project feedback if desired.

ONLINE PUBLIC PARTICIPATION SURVEY

The online public participation survey was formally titled the Elizabeth City Waterfront Vision Plan Survey and was made available on January 17th, 2018 and remained available until February 9th, 2018. During this time, over 3,000 website views and 368 unique survey responses were received. The survey itself is closed but is still available online for reference at www.harborofhospitality.com. Feedback from the survey was used to guide and refine draft planning concepts.

The survey provided respondents with preliminary design concepts and plan exhibits on which to base their responses. The following is a high-level summary of the responses obtained through the survey related to flood mitigation and resiliency:

- When asked on a scale of 1 to 5 how well the alternatives create greener spaces and landscaping while also promoting resiliency, 17% said 5 (i.e., "very well"), 38% said 4, 24% said 3, 8% said 2, 4% said 1 (i.e., not very well), and 12% said they were not sure (Figure C-1).

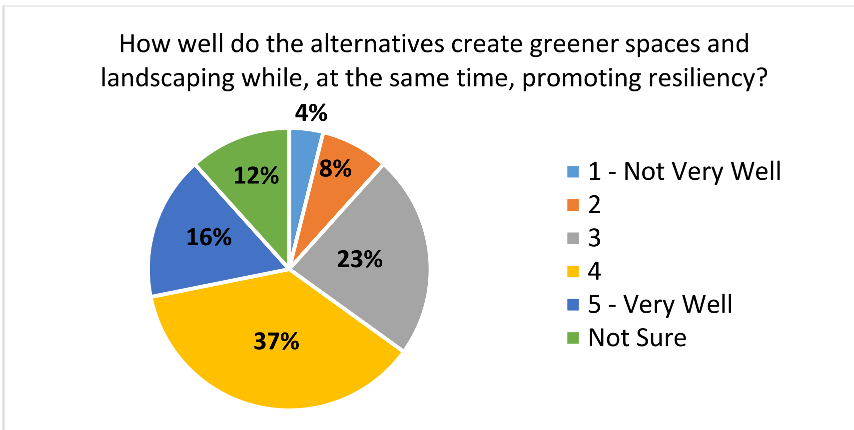

Figure C-1. Online survey question results

- When asked whether or not the respondents felt the proposed concepts would bring greater economic vitality to Elizabeth City, a key indicator of resilience, 79% said yes, 5% said no, and 17% said they were not sure (Figure C-2).

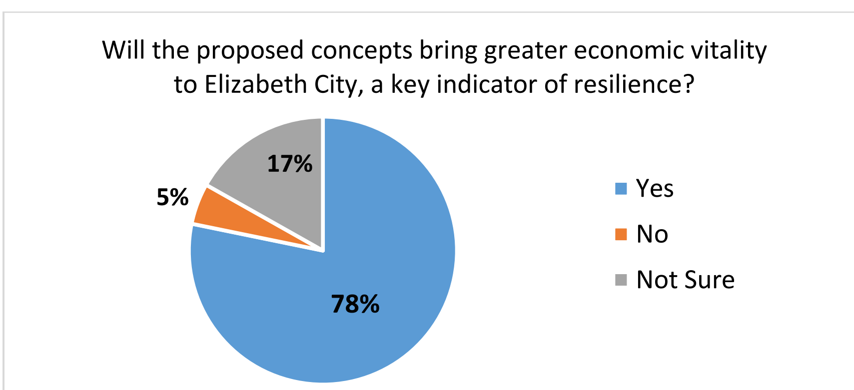

Figure C-2. Online survey question results

Appendix D. Post-Flood Recovery Strategies to Improve Resilience

Utilize Section 406 Public Assistance Program Funding for Recovery-Based Mitigation

The Section 406 public assistance program is managed by the State of North Carolina utilizing funding provided for in the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) via FEMA's Public Assistance (PA) program. Section 406 funding provides discretionary authority to fund mitigation measures in conjunction with the repair of eligible disaster-damaged facilities in declared counties following a presidentially-declared flood event. Section 406 funding must be applied to portions of the facility that were damaged by the flood event and the mitigation measure must be intended to directly reduce the potential for future, similar damages to the same facility. Additional information pertaining to both pre- and post-disaster mitigation funding opportunities to be pursued by the City can be found in Section 6.

Educate Property Owners about Flood Mitigation in the Post-Disaster Environment

The post-disaster environment can be a valuable time for public education and outreach regarding mitigation activities in which property owners can engage in to manage future flood risk. Immediately following a disaster, the mindset of most impacted individuals is to repair or replace damaged assets as quickly as possible in order to return to normal conditions. With proper education, property owners can be made aware of post-flood recovery options that help alleviate future, similar damages through post-event mitigation.

Education and outreach efforts can be widely varied, but may include: facilitating technical assistance programs that address measures that citizens can take; facilitating community workshops on potential funding sources for mitigation measures; encouraging the City and homeowners to install backflow valves on stormwater infrastructure to prevent reverse-flow flood damage; encouraging residents in flood-prone areas to elevate, relocate, or retrofit homes; educating the public about securing debris, propane tanks, yard items, and stored objects that may otherwise be swept away, damaged, or pose a hazard to surrounding residents; asking residents to help keep storm drains clear of debris during storms; and encouraging local business owners to have a continuity of operations plan in place. Community-based outreach efforts should be carried out by the City to the greatest extent practicable, particularly following flood events, as a meaningful way to alleviate future flood risk and maximize public involvement in the flood mitigation planning process.

Actively Seek to Establish New Open Space Options

By default, floodplain properties acquired through FEMA grant programs must be maintained as open space according to the requirements of the funding program. However, in the post-flood environment, other opportunities to establish open space within the Charles Creek area may become apparent through other grants, donations, etc. This may include lands that can be used for greenways, walking and biking trails, cultural and historic awareness, natural resource protection, and other options that minimize future flood risks. The post-disaster environment typically heightens awareness of flooding issues and may also be an opportune time to seek funding for the purchase of lands to be used as open space. The active pursuit of grant opportunities to maintain the presence of open space around Charles Creek is an important post-flood mitigation strategy to be carried out by the City.

Pursue Projects Identified in the Pasquotank County Resilient Redevelopment Plan

The Pasquotank County Resilient Redevelopment Plan was created by the North Carolina Division of Emergency Management following Hurricane Matthew to develop strategic recovery actions and determine any unmet funding needs required to implement these actions. These plans also provide the basis for the state's Recovery Action Plan required by the U.S. Department of Housing and Urban Development (HUD) to spend funds allocated through the Community Development Block Grant – Disaster Relief (CDBG-DR) program. The Pasquotank County plan identifies 22 specific recovery projects that are divided into four pillars: infrastructure (11 projects), housing (5 projects), economic development (4 projects), and environment (2 projects). Projects are prioritized based on a number of factors, including but not limited to technical feasibility, economic benefits, and effectiveness of risk reduction. Several of the identified projects specifically target areas within Elizabeth City. For some of these actions, implementation has already begun. As of May 2017, Pasquotank County and the City of Elizabeth City had multiple FEMA Hazard Mitigation Grant Program (HMGP) applications underway to aid in completing these projects. Any applications and projects that are not funded by the HMGP will attempt to be matched to an appropriate funding stream. Those that are not matched should be incorporated into the County's Hazard Mitigation Plan for consideration for future funding sources to meet project needs. It is vital that the City and County implement as many identified actions as is feasible to improve resilience. Additional information on available funding sources is provided in Section 6. The complete Pasquotank County Resilient Redevelopment Plan can be found online: https://files.nc.gov/rebuildnc/documents/matthew/rebuildnc_pasquotank_plan_combined.pdf.

Appendix E. CHARLES CREEK FLOODING PHOTOS

Flooding photos taken along Charles Creek following a rain event. Photos courtesy of City of Elizabeth City.






SIGN UP SHEET
INTERAGENCY/SCOPING MEETING

Scoping Meeting - Flood Management study for Charles Creek in Elizabeth City

Purpose of this meeting is to discuss a proposed project and provide environmental permitting and regulatory information which will improve communications and the permitting processes.

April 10, 2018 at 10 am
Call In Number 919-850-2823

Name	Agency	Phone	Email
Kathy Matthews	USFWS	919-856-4520 ext. 27	Kathryn_matthews@fws.gov
Johnny Martin	Moffatt + Nichol	919-781-4626	jmartin@moffattnichol.com
Chris Pullinger	NC DWR	252.948.3922	chris.pullinger@ncdenr.gov
Carl Dunn	NC DEMLR	252 948 3959	carl.dunn@ncdenr.gov
Maria Dunn	NCWRC	252 948 3916	maria.dunn@ncwildlife.org
Josh Pelletier	USACE	910-251-4605	josh.c.pelletier@usace.army.mil
Shane Staples	NCDCM-Fisheries	252-948-3950	shane.staples@ncdenr.gov
Jimmy Johnson	APNEP - CHPP	252-948-3952	jimmy.johnson@apnep.org
Lynn Mathis	NC DCM	252-264-3901	lynn.mathis@ncdenr.gov
Amanda Boone	Elizabeth City		aboone@cityofec.com
Ian McMillan	DEQ - Raleigh	919-715-4631	ian.mcmillan@ncdenr.gov
Ellen Lorscheider	DEQ DWM - Raleigh		ellen.lorscheider@ncdenr.gov
Allison Bryan	Moffatt + Nichol		abryan@moffattnichol.com
Kaitlen Alcock			Kalcock@cityofec.com
Matt Schelly			mschelly@cityofec.com

NCDEQ WASHINGTON REGIONAL OFFICE
943 WASHINGTON SQUARE MALL WASHINGTON, NC 27889 252-946-6481, FAX 252-975-3716

1 of 2

Summary of Permit Agency Scoping Meeting for Charles Creek Flood Mitigation Plan
April 10, 2018 – 10 AM – Washington Regional Office

<u>Attendees – (see sign in sheet)</u>

The meeting began with a brief presentation of the project, initial findings, and recommendations. The preliminary recommendations at this stage for further study and consideration are the elevation/relocation of structures or the construction of flood protection berms that would serve a dual purpose of providing connectivity to the waterfront as greenways.

The meeting then focused on getting permit agency feedback on the alternatives with special consideration of the berm and gate/pump alternatives, as those would likely be the only alternatives that would require permits.

Based on discussion with the agencies, the main concerns and feedback were as follows:

<u>Berm Alternative</u>

- *Wetlands* – The US Army Corps of Engineers (USACE) stated that if the protective berm option were selected for further study, a wetland delineation would have to be completed along the path of the berms in order to define and quantify potentially affected wetland areas. All agencies agreed and stated that berms should ideally be located in areas of higher ground where flood protection can still be provided while minimizing wetland impacts. The NC Wildlife Resources Commission (NCWRC) stated that even if vertical sheetpiling is used, consideration will still have to be given to areas landward of the sheetpiling that are currently wetlands. If waters can no longer reach those areas, they will be impacted. The NC Division of Water Resources (NCDWR) concurred and stated that those existing landward wetland areas would be considered a loss of use. The USACE stated that wetland mitigation would likely be required for any affected wetlands, but that they could not state at this time whether on-site mitigation would be allowed. That would not be determined until the wetland delineation was completed at a later design stage.
- *Public Trust Waters* – NC Division of Coastal Management (NCDCM) stated that berms located within the 30-foot buffer zone of Public Trust Waters should be studied further to ensure that they do not cause increased runoff to these waters, or cause funneling or redirection of waters to other areas and thereby increasing their flood levels. NCWRC and the US Fish and Wildlife Service (USFWS) concurred.

<u>Flood Gate/Pump Alternative</u>

- *Fisheries* – Significant concerns were raised by all agencies with the flood gate and pumps alternative. Most concerns centered about the system's potential detrimental effects on the spawning and migratory behaviors of anadromous fish populations (Blueback Herring and the Alewife) in Charles Creek, which is a designated anadromous fish spawning area with moratoria set from Feb 15 thru Jun 15 (stated by NCDCM-Fisheries). The concern with a gate structure is that there will be pressure to operate and close the gates even during this moratoria due to nor'easters which are prevalent during that time. NCWRC and NCDCM-Fisheries have fish population and monitoring data, so these agencies should be consulted about providing the data if the gate/pump alternative is studied further. NCDWR and NCWRC stated that a significant operations and maintenance plan would have to be developed for the gate closures and pump operations so that potential effects could be accurately quantified and that significant limits on times the system could be operated may be part of permit conditions.

- *Wetlands* – The US Army Corps of Engineers (USACE) stated that depending on how often the gate would be operated, there may be effects on wetlands with this option as well.

Elevate/Relocate Structures Alternatives

All agencies agreed that these flood mitigation options would be preferred from a permitting perspective, but understand that some property owners may not be amenable to them. USFWS asked that combinations of these options be explored and that hopefully those not open to relocation would at least be open to elevation of their homes. USFWS also stated that relocation would allow for potential expansion of existing wetlands and offer an opportunity for wetland restoration. NCWRC and NCDCM stated that opportunities for collaboration between Elizabeth City State University and the Coastal Studies Institute should be explored for additional wetland planting and enhancement along Charles Creek. It was stated that all of these options (and combinations) would be considered and that implementation of any alternatives would be subject to available project funding.

Overall Summary

All agencies reiterated that elevation and/or relocation of structures would be preferred. They agreed with the recommendations concerning the allowance of the use of green infrastructure within City stormwater ordinances and that allowing for additional freeboard to current FEMA flood levels would increase flood resilience in the Charles Creek watershed. The utilization of berms may also be allowed from a permitting perspective but the potential wetland effects, mitigation requirements, and a confirmation of no redirection of floodwaters would all have to be studied further. The flood gate/pump alternative by far had the most concerns from all the agencies, and they all agreed that the permitting path for approval of that option was not certain, and that many roadblocks could present a fatal flaw to that alternative.

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