Vulnerability Study for the City of St. Augustine Beach

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Prepared by

Crawford Murphy, & Tilly, Inc.

CMT

CONTACT INFORMATION

Gary Sneddon

Manager | Florida Region

gsneddon@cmtengr.com | 904.448.5300

Contents

Table of Figures

Executive Summary

Sea levels have risen measurably over the past century, estimated at 8 to 10 inches. The question is how this rate of sea level rise will change in the future and how will it affect the City of St. Augustine Beach?

To help answer these questions, the city embarked on a study to evaluate the vulnerability of the city with respect to nuisance flooding and storm induced flooding from sea level rise in the near future timeframe. This report details the methodology utilized to develop the approach to vulnerability from sea level rise, identifying six (6) geographic areas and associated infrastructure vulnerable to adverse sea level rise and identifying vulnerability of critical essential City and County government facilities and infrastructure.

The results of this effort are a series of maps that may mimic future versions of the FEMA Flood Insurance Rate Maps utilized for planning and building requirements today. The analysis reveals several infrastructure actions taken over the last 30 to 40 years that have built a level of protection for much of the city against short-term sea-level rise, while warning that there may be significant future impacts from sea level rise in the not-so-distant future.

This report forms the basis for the next step in planning for the impacts of sea level rise through development of a near-term Resiliency Capital Improvement Plan estimated roughly at $3.63 million and a longer-term Resiliency and Protection Adaptation plan. The adaptation plan will consider policies, planning measures, future projects, etc. to help adapt to and mitigate for impacts to vulnerable areas of the City.

This project was made possible by a Resiliency Planning Grant provided by the Florida Department of Environmental Protection's Resilient Coastlines

Background

1.1. Sea Level Rise

On average globally, the sea level has risen by about 8 inches since scientific record keeping began in 1880. This rate has increased in recent decades to a little more than an inch per decade. Global average sea level has risen by about 7–8 inches (about 16–21 cm) since 1900, with about 3 of those inches occurring since 1993. In addition to the global average sea level rise, local sea level rise – sometimes called "relative sea level rise" – happens at different rates in different places. Local sea level rise is affected by the global sea level rise, but also by local land motions, and the effects of tides, currents, and winds.

Figure 1-1 shows an increase in global average sea level in inches since 1880. Note that the blue line, tide gauge data, becomes steeper in recent decades. This indicates an increasing rate of change. The surrounding light blue-shaded area shows upper and lower 95% confidence intervals and the orange line shows sea level as measured by satellites for comparison (1993-2016). (U.S. Global Change Research Program, 2017)

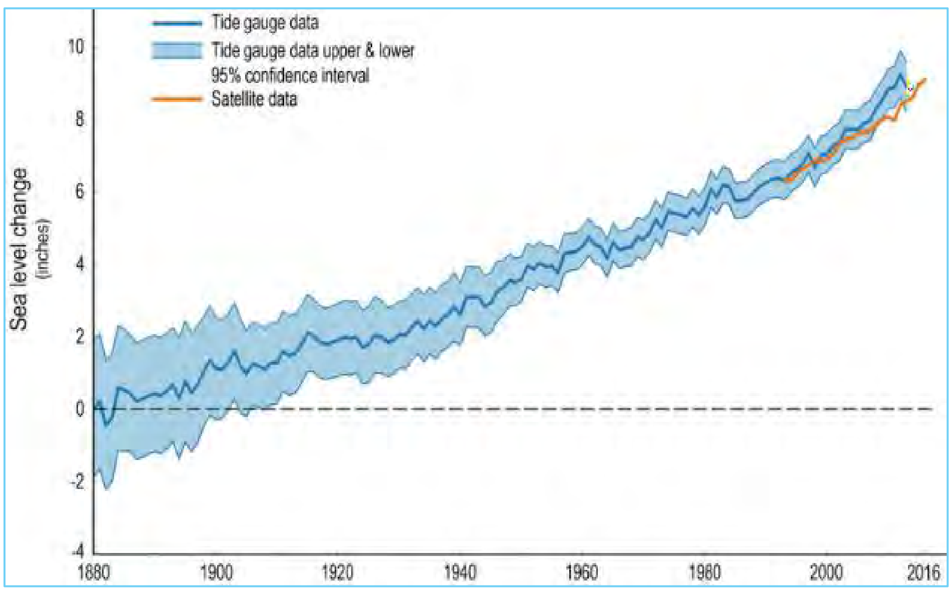

Figure 1-1. Global Average Sea Level Change (US Global Change Research Program)

The closest National Oceanic and Atmospheric Association (NOAA) primary tidal gauge to St. Augustine Beach is located at the Mayport Bar Pilot's Dock (NOAA tide gauge No. 8720218) near the ferry slip. Figure 1-2 depicts the relative change is sea level at the Mayport Bar Pilot's Dock over the 90-year history of this station. The current local rate of sea level change is approximately one inch every decade. (https://tidesandcurrents.noaa.gov/sltrends/)

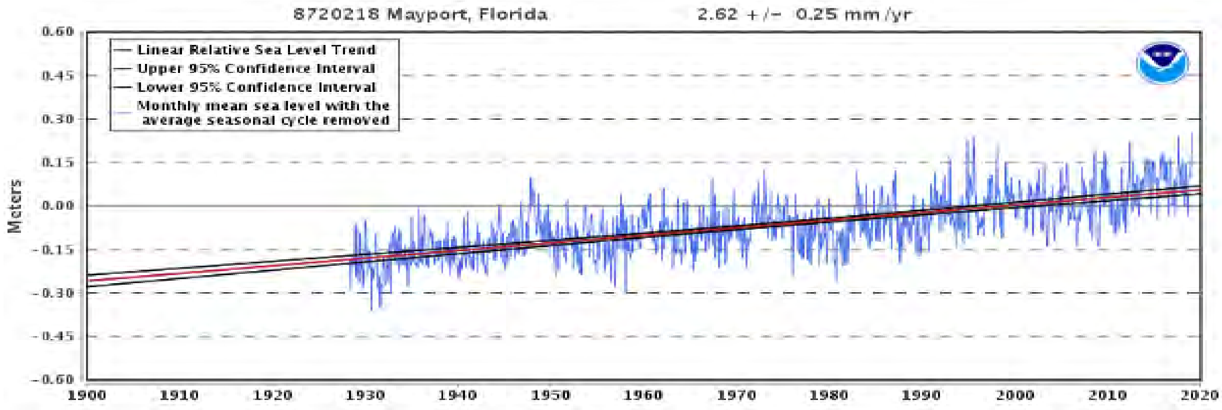

Figure 1-2. Relative Sea Level Rise - Mayport Bar Pilot's Dock (NOAA)

Although there is uncertainty relating to the change in rate of sea level rise, there is no uncertainty that sea level is rising in our area. As sea levels rise, incidents of nuisance flooding will increase and flooding due to severe weather events will affect larger areas of the city. To aid in both planning and assessing the City's potential vulnerability under future scenarios with higher sea levels, the city conducted a rigorous technical analysis to determine just what those effects may be and how they will impact residents and critical infrastructure.

1.2. Projections for Sea Level Rise

A comparison review regarding the several studies that have been published projecting local sea level rise estimates at the Mayport Bar Pilot's Dock NOAA tide gauge No. 8720218 which is the closest gauge to the City of St. Augustine Beach. The results of the various projections of sea level rise are presented graphically in Figure 1-3 and reflect the variation in projections from agency to agency.

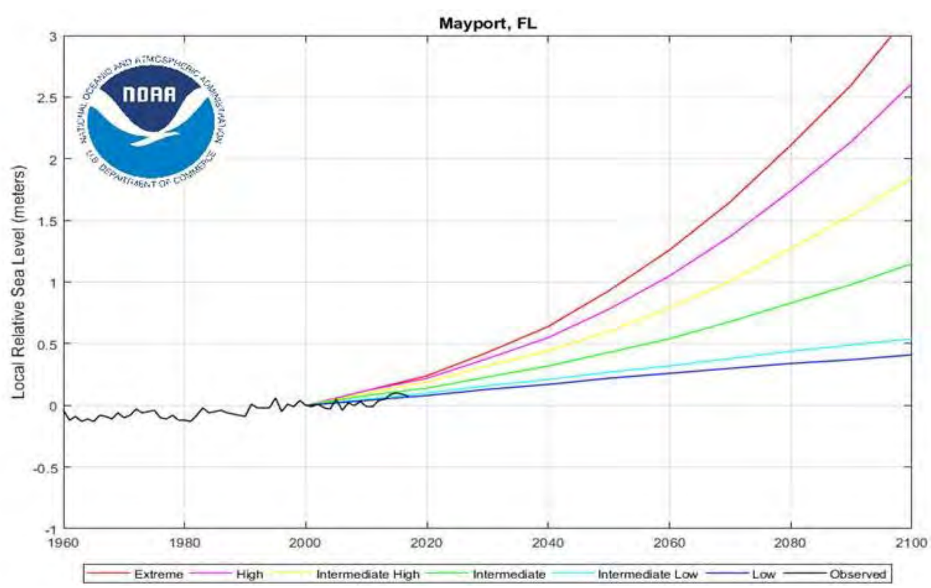

Figure 1-3. Comparison of Projected Sea Level Rise Data Sets

Only two sea level rise numerical increases are used within this study for the vulnerability assessment. Due to the level of uncertainty in the innumerable and varying projections of sea level rise put forth by a litany of agencies and scientific groups, no date projection has been added to this study. Considering most infrastructure and many buildings only have a life span within approximately 50 years, coupled with the level of uncertainty beyond approximately 50 years, suggests this time frame as a reasonable study time limit.

1.3. City History

The City of St. Augustine Beach occupies the northern portion or section of Anastasia Island, a barrier island located on the coast of the Atlantic Ocean southeast of St. Augustine. The Island runs north–south in a slightly southeastern direction to the Matanzas Inlet. The island is separated from the mainland by the Matanzas River. Part of the northern tip of the island (the Lighthouse Park area) is within St. Augustine city limits, while just south of the Lighthouse area begins the corporate limits of St. Augustine Beach. The City of St. Augustine Beach contains a land area of approx. 2.5 square miles. Lying approximately five miles southeast of the City of St. Augustine, St. Augustine Beach's boundaries are the Atlantic Ocean, the west right-of-way of SR 3-A1A, the north right-of-way of Pope Road, and Sandpiper Village subdivision to the south. SR3-A1A was built north to south from the A1A intersection with SR312 to the return connection with old A1A now called Beach Boulevard on the south end of St. Augustine Beach in the mid 1990's. SR3 A1A effectively rerouted US A1A from the beach area of St. Augustine Beach west along the dune ridge east of the Matanzas River.

The area of the current incorporated City was initially platted as 2 or 3 large subdivisions around the early part of the 20th century. A pier, boardwalk and hotel opened at St. Augustine Beach to attract tourists in 1940. The beach area tied to the pier and beach hotel grew little until in 1959 the area was incorporated into a City. The City grew rather quickly over the following 30 years as a result of property developers/builders and doubled again in developed property in the following 30 years. The 1960 census identified the City population as 396. By 1980, the population had risen to 1,289, and to 3,657 in 1990. The US Census Bureau estimates the 2020 count to be between 6,852 and 7,026.

Due to private development with little governmental oversight, the City's property development in the first 30 years (1960-1990) experienced some level of substandard supportive infrastructure dedicated to the City. However this has been in some instances corrected and in others at least mitigated in the last 30 years of development (1990-2020). Some of the remaining substandard infrastructure shows in the Vulnerability Assessment.

1.4. Stormwater Drainage/Flood Prevention

The original drainage system developed within the area now called St. Augustine Beach consisted of drainage swales and ditches paralleling primarily dirt roads. As development continued over time, the ditches were widened and the roads paved.

In the early 1990s, with the FDOT relocation of the Federal Highway A1A to the alignment of SR-3 and conversion and widening of old A1A to the county owned Beach Boulevard, extensive drainage improvements were needed to accommodate the two roadways. The first City of St. Augustine Beach stormwater Master Plan was developed in 1995, consisting of approximately 720 acres of the city and incorporating the FDOT and St. Johns County SR-3 and Beach Boulevard respectively into a 15-acre city wide master stormwater retention area for a first of its kind for Northeast Florida city wide stormwater treatment system. The 15-acre master stormwater retention area was permitted only for stormwater treatment and did not provide for stormwater attenuation or upstream flood control.

This city-wide stormwater Master Plan was updated in 2004, expanding the receiving drainage area to approximately 1,017 acres of the city and pre-permitting through the SJRWMD a list of infrastructure improvement projects for the city. (i.e., storm sewers, paved streets, government buildings, parks, etc.).

Following hurricanes Matthew and Irma and the resulting damage to the 15-acre master stormwater retention/ treatment area and washout of the overflow weir, the outfall control of the master stormwater retention area was redesigned for stormwater flood control, as a part of the FEMA Hazard Mitigation Grant Program. The new design currently under construction provides internal city flood protection from a FEMA designated 100-year reoccurrence flood elevation of 7.0 (NAVD88).

Existing Conditions

2.1. City Topographic Features

The city's topographic features are similar to all coastal Florida cities. The general topography was formed during the period when much of Florida was submerged as part of the Atlantic Ocean/Gulf of Mexico. A receding water level caused by the Ice Age created an undulating coastal dune pattern of repeating high dune, low valley area to high dune to again a low valley area. The pattern extends basically north to south parallel with the ocean. This pattern of topography creates low flood prone areas between higher elevation ancient dunes or ridges in most coastal cities and is common to St. Augustine Beach.

Figure 2-1 shows the elevation of the city based on the 2013 LiDAR topography. The repetitive dune pattern is evident along Beach Boulevard and most of the adjacent commercial business along Beach Boulevard, as all are located on one of the ridges while the area of 2nd Avenue and Mickler Road are in the low valley areas between the ridges. The area of State Route 3 (SR-3) is primarily located along one of the high ridges, while the Marsh Creek and Sea Grove subdivision are in a lower area adjacent to the Matanzas River.

This pattern of ridges and valleys controls the natural drainage pattern of the city. Elevations in the valleys range from approximately three (3) feet above sea level to six (6) feet, while the ridges can range between seven (7) feet to approximately fifteen (15) feet. Past development tended to be built above elevation five (5) feet and more recent building codes suggest a minimum elevation of eight (8) feet.

Figure 2-4. Topographic Contour Data

2.2. Master Stormwater System

Rainfall induced flooding was analyzed using the Interconnected Pond Routing (ICPR) model developed with the City's 2004 Stormwater Master Plan for 1,017 acres of drainage basins within the city. This was a necessary step given the flat topography of the city and impacts of tide height on the performance of any coastal Florida drainage system.

The City ICPR Stormwater Model includes a diurnal outfall tailwater(tidal) condition with a mean annual high-water elevation of 3.4 NAVD29 (2.4 NGVD88). The City-wide analysis has been performed using the above referenced storms with the documented diurnal tailwater condition variation.

The modeling tailwater/tidal conditions are established as the "Mean Annual High" tide for the Matanzas River set in the original model in 1995.

Table 1. Current Tailwater/Tidal Conditions

	Mean Annual High Tide (NAVD29)	(NGVD88)
Current	3.4	2.4

The primary outfall for the St Augustine Beach master stormwater system is into a canal that conveys stormwater into the Matanzas River.

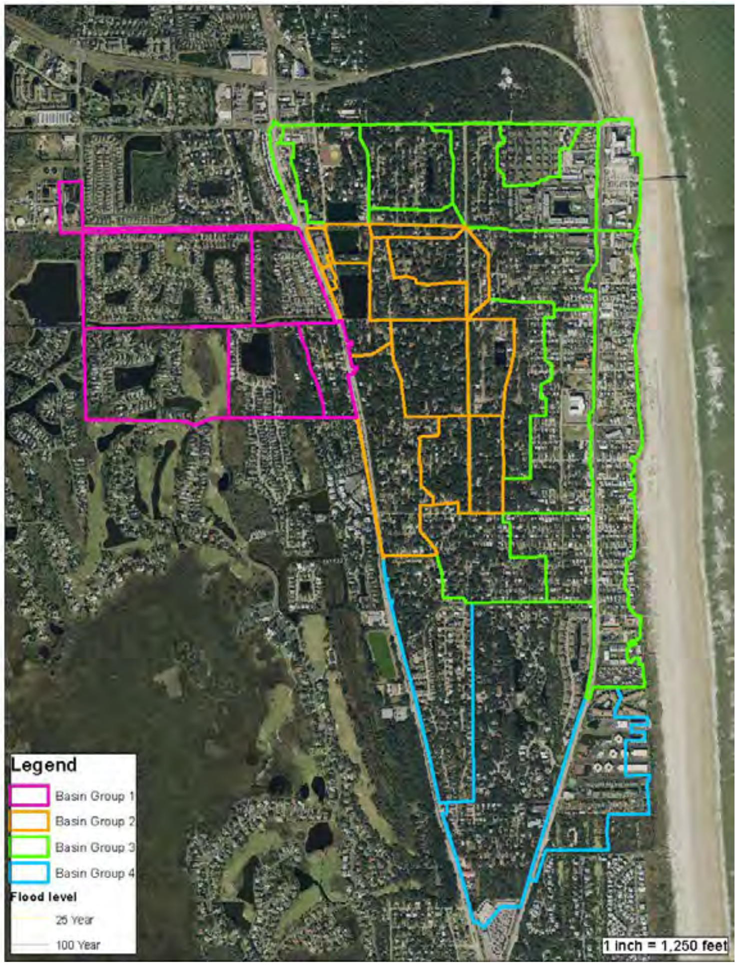

Figure 2-5. Stormwater Model Drainage Basins

Evaluation/Assessment Process

3.1. Infrastructure Data Search

The key to finding and assessing weakness in the protection of the City from sea level rise is to first have a strong understanding of the area's natural geography and the availability and condition of the supporting area infrastructure. The accumulation of such data, either found as existing or investigated and measured, determines the ultimate success of the assessment of vulnerability. The successful receipt and download of the St. Johns County 2013 LiDAR data topographic contours and finding drawings from eighty (80) past Engineering projects documenting details about existing infrastructure dating back over 25 years, established an early assessment efficiency for the project.

Details of what was portrayed by the LiDAR needed to be field verified for accuracy. Determining if the Engineering drawings evaluated above portrayed what was ultimately built in the field required a level of follow up field reconnaissance.

3.2. General Methodology

For this vulnerability assessment, 2013 LiDAR was downloaded from St. Johns County through the City of St. Augustine Beach to be integrated into GIS map layers. Although St. Johns County was in the process of updating the LiDAR from 2013 to 2020, the data was not yet proofed by the County at the time of the Vulnerability Assessment's initial Tasks and was thus not available for use under this study.

Infrastructure such as drainage ditches, road crossing pipes, piped stormwater systems, roads, and stormwater ponds were identified from past engineering design drawings of individual projects and each infrastructure system was field verified. This process coupled with the topographic indicators highlighted and isolated the areas vulnerable to rising sea level.

3.3. GIS Query and LiDAR Topographic Data

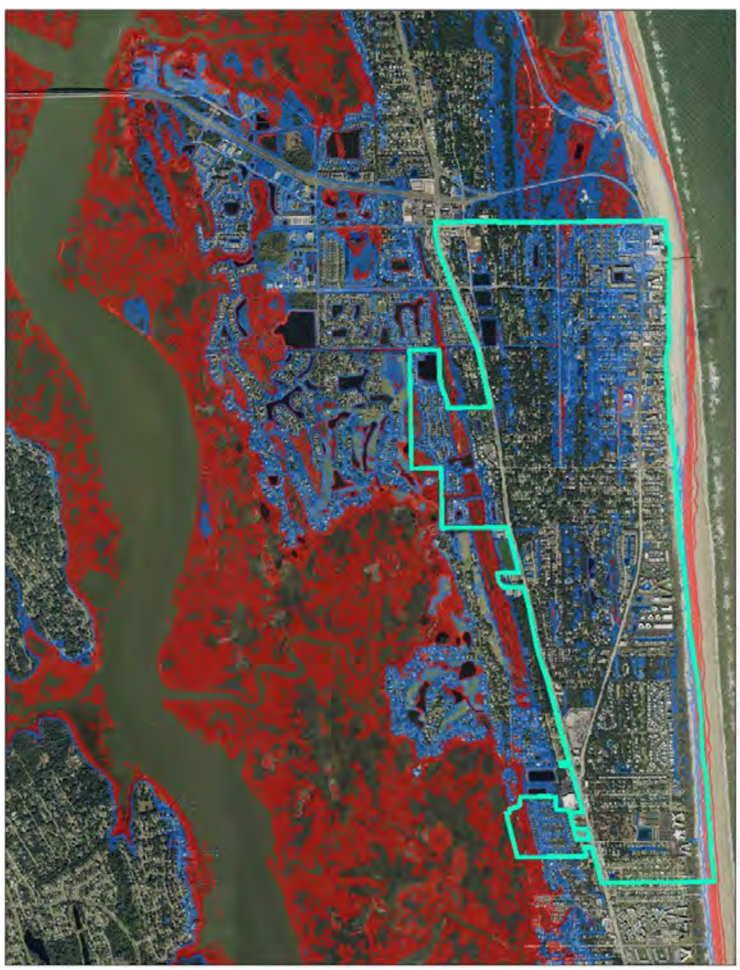

Figure 3-6. Areas vulnerable to storm events due to elevation (red elev 5/ blue 8)

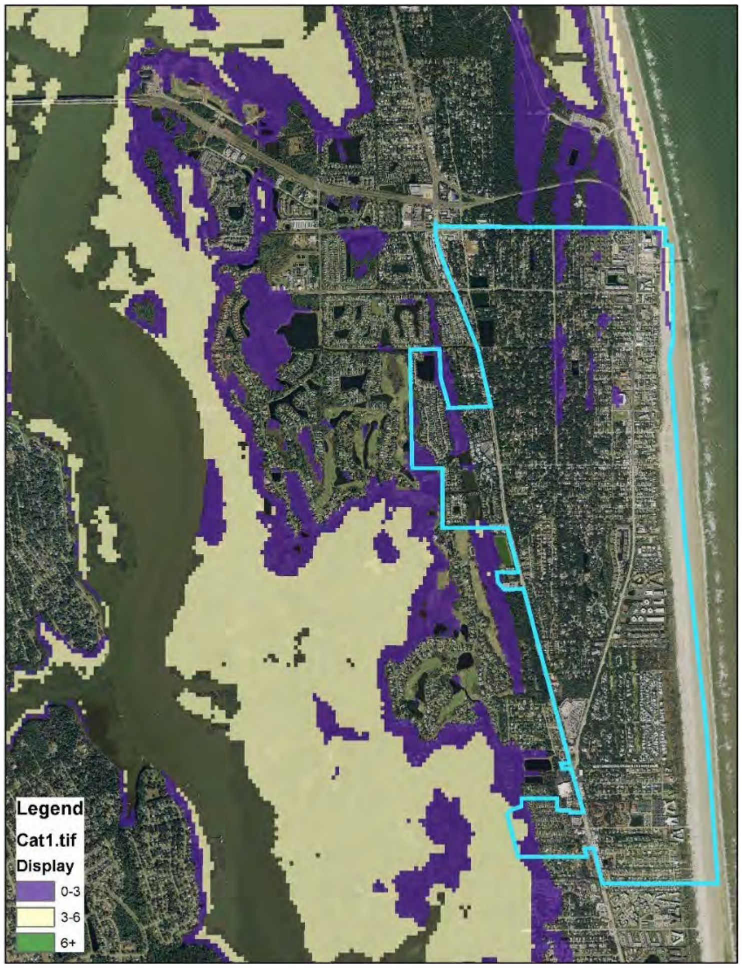

Figure 3-7. Areas vulnerable to Category 1 Hurricane storm surge

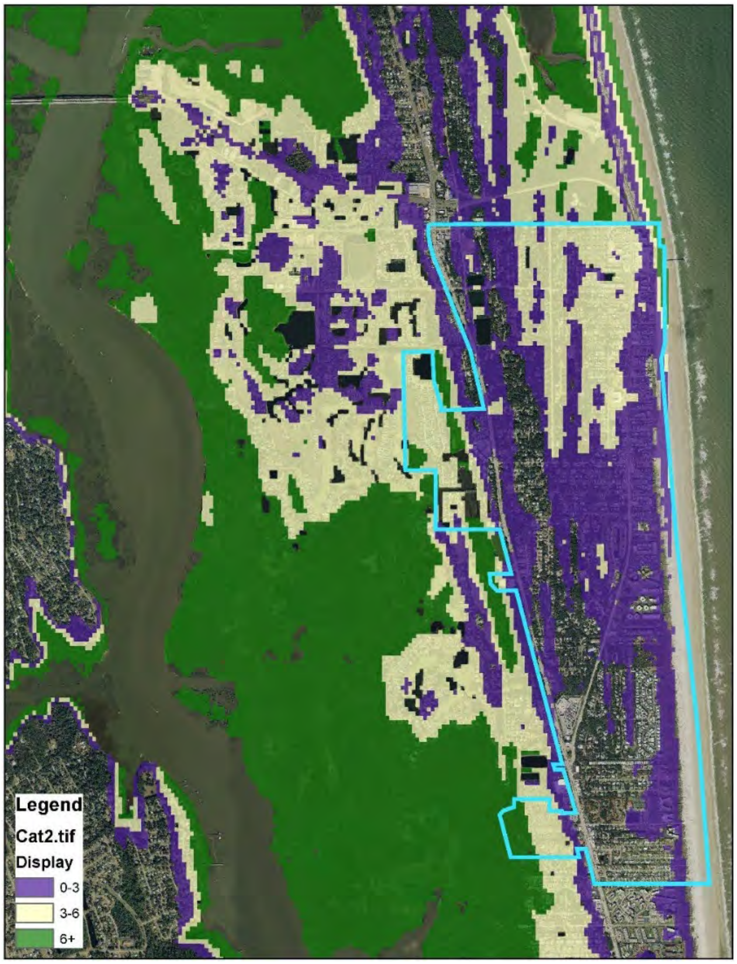

Figure 3-8. Areas vulnerable to Category 2 Hurricane storm surge

3.4. Master Stormwater Model Update

3.4.1. Stormwater Inundation Modeling

To determine how rainfall-induced flooding may be impacted by sea level rise within the City, the hydrologic and hydraulic parameters in the original 1990s Interconnected Pond Routing (ICPR) Version 3 model, that was updated during the City's 2004 Stormwater Master Plan, was updated further in this assessment to a ICPR Version 4 model adjusted to reflect identified increased boundary conditions and model node conditions impacted from rising sea levels.

The ground water table is also expected to rise with rising sea levels because of consistently higher tides. This increase in ground water will be more marked in areas directly adjacent to the coastline and would be reduced further inland. However, in the case of the City's pump-controlled stormwater system, the effective use of the pumps can effectively control the normal level of groundwater within the City master stormwater system to pre sea level rise conditions. Accordingly, the basin criteria in the stormwater model considering a controlled groundwater level retained the same relative soil storage capacity for the expected future sea level elevations.

The City's master stormwater model output data was provided for the 25 year/24-hour rainfall and 100-year/24-hour rainfall events with a base outfall tailwater(tidal) elevation of 3.4 NAVD29 (2.4 NGVD88). The primary outfall for the St Augustine Beach master stormwater system is a canal that conveys stormwater into the Matanzas River. The analysis was performed using the above referenced storms with current tailwater condition and two additional tailwater conditions.

Peak stage results from the future drainage conditions models were used to map the predicted rainfall-induced flood risk in the City for the one- and two-foot sea level rises for a series of 24-hour rain events, including the 25-year and 100-year return period rainfall events

The modeling tailwater/tidal conditions are established as the "Mean Annual High" tide for the Matanzas River set in the original model in 1995.

Table 2. Tailwater/Tidal Model Conditions

	Mean Annual High Tide (NAVD29)	(NGVD88)
Current	3.4	2.4
w/1 ft. rise	4.4	3.4
w. 2 ft. rise	5.4	4.4

The updated model reflects a total of 6 model runs, reflecting the two storm events of 25-year and 100-year for each of the three sea level elevations. The results were then mapped using the digital elevation model (DEM) generated from the 2013 St. Johns County Light Detection and Ranging (LiDAR) data. Note that this does not account for grading changes that have occurred since the LiDAR was collected.

3.4.2. No Combined Inundation

The future storm surge flood risk maps were not combined with the rainfall induced inundation maps for the 100-year return period storm for the two sea level rise increases due to the protective flood nature of the City's master stormwater system. Where there was overlap between the flood risk mapping, the higher inundation estimate from the two mapping efforts was selected unless the area was protected within the City's master stormwater system with its protective pump system. These maps independently provide for a spatial estimate of future flood risk that will serve as the basis for the vulnerability assessment.

Note that rainfall induced flood risk and coastal surge flood risk are usually evaluated relatively independently because the two forms of flood risk are neither fully dependent nor fully independent. Therefore, traditional statistical approaches are not applicable and the standard procedure to deal with this is to evaluate the two independently using common sea level rise scenarios and then take the pump-controlled flood elevation or the higher of the none pump protected combined identified risk at each location.

3.4.3. Projected Rainfall Induced Flooding

Figure 3-4 and Figure 3-5 illustrates the projected rainfall induced flooding from a 25-year and 100-year storm in St Augustine Beach for the periods of the one- and two-foot sea level rises. These maps reflects where stormwater infrastructure is inhibited. These maps, due to the uniqueness of the stormwater pump system of the City, must be viewed independently of the areas indicated as below an elevation to flood in the 100 Year flood. The pump system designed to protect against a 100-year flood elevation protects those areas indicated to flood but located within the master stormwater system of the City.

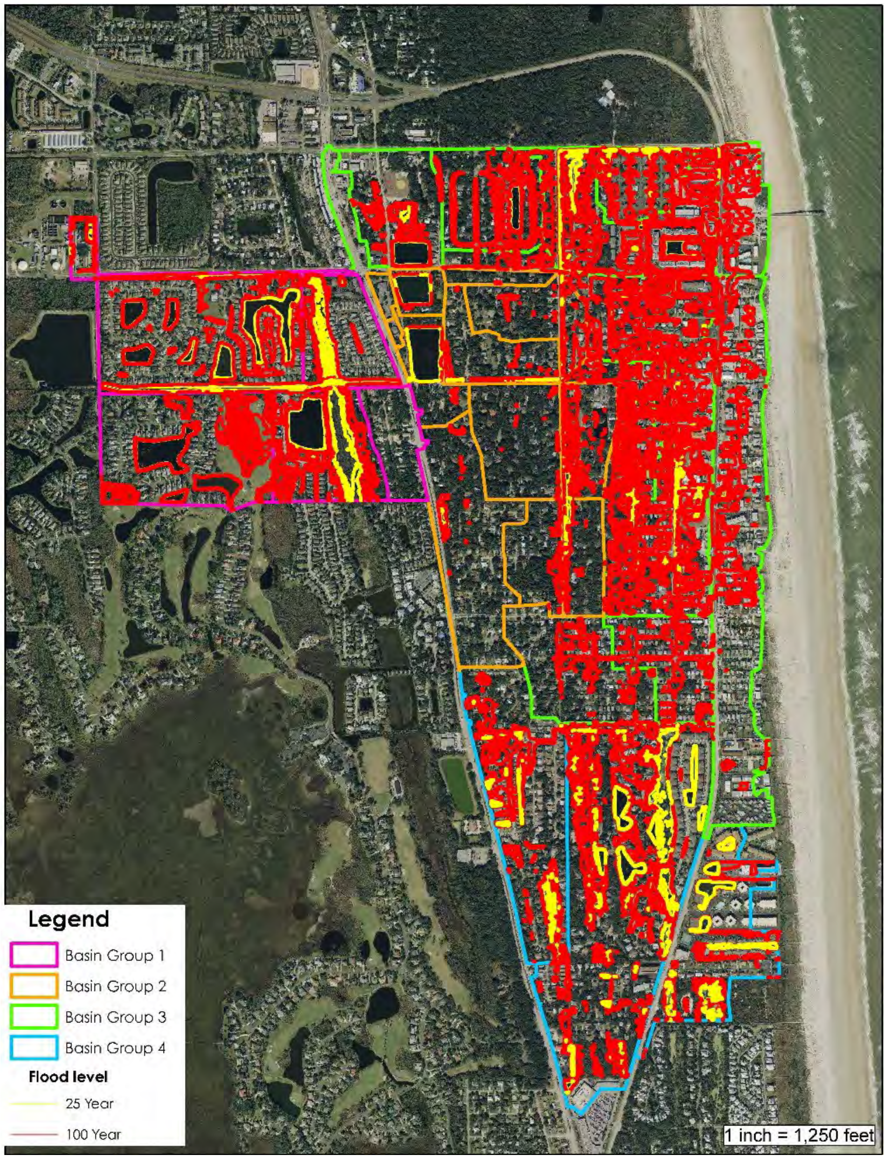

Figure 3-9. Areas vulnerable to 25- and 100-year Storm Events at Current Sea Level

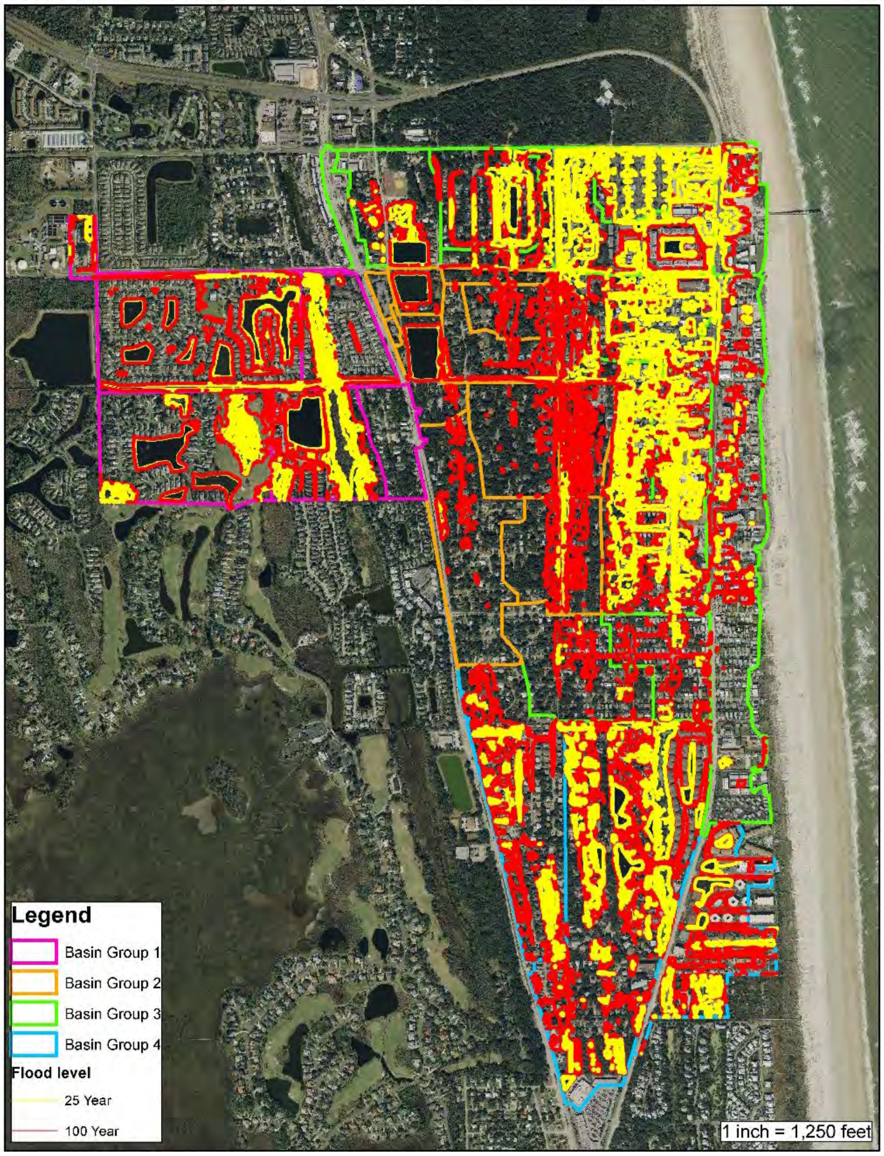

Figure 3-10. Areas vulnerable to 25- and 100-year storm events with Sea Level Rise

Assessment Findings

4.1. Existing Protective Infrastructure

In assessing how vulnerable a community is to external flood influences, it is essential to evaluate the natural geography and topography of the area in and around the community. The next step is to consider any opportunity to reinforce these geographic features with supportive manmade structures. The most common features enhanced for stormwater and flood control are hills and ridges. Over the years, state government has used the higher elevation ridges of the old dune system and by contrast avoided the low wetland areas in its construction of roadways. This design approach to roadways has proved beneficial to the City of St. Augustine Beach. The majority of the City of St. Augustine Beach is effectively surrounded in a triangle of three primary roadways, all constructed along higher ridges or artificially filled and raised to higher elevations in crossing low flood prone areas, effectively creating a protective flood protection levee system around the core City. The three roadways of Beach Boulevard, along the eastern dune line, SR 312 on the north side of the city, was placed on a filled and raised section through the coastal wetlands of Anastasia State Park and SR 3 A1A on the west side of the city along the ancient dune ridge just east of the Matanzas River.

The city also has the manmade benefit of a somewhat unique master stormwater conveyance system effectively protected from external flooding by the triangle of elevated roadways, while being capable of removing internal stormwater from within the city by use of large stormwater pumps. The upgrade of this system as part of the City's FEMA HMGP grant is currently under construction. The combination of the triangular elevated roadway network effectively surrounding the majority of the city and the internal City stormwater pumping system protects the city from flooding to a higher level than most coastal cities. This protective system has a few vulnerable penetrations or threats from flooding, having been identified and quantified within this assessment. This report further addresses these vulnerable penetrations as being capable of mitigation against flooding.

4.2. VULNERABLE AREAS

Six primary watershed areas with outfalls or unprotected storm surge were identified in and around the City of St. Augustine Beach that represent an inundation vulnerability to the city as a result of sea level rise. These six vulnerable Storm Surge or Outfalls have been identified as

1. SR 312 Area,
2. West Pope Road Area,
3. Sea Grove Area west of SR 3,
4. Ocean Trace Subdivision west of SR 3
5. Oleander Street Wetland
6. Pope Road / Ocean Pier Park on the Atlantic Ocean Beach.

Each of the six areas are described in more detail as follows.

4.2.1. SR 312 Area Vulnerable Outfalls

The SR 312 area (Figure 4-1) on the North end of St. Augustine Beach runs from the bridge crossing the Matanzas River to the end of SR 312 at Anastasia Island and Beach Boulevard in St. Augustine Beach.

The SR 312 Area has five identified drainage systems deemed to be vulnerable to flooding into the city as the result of sea level rise. All five drainage systems are located within St. Johns County and are characterized by drainage culvert crossings under SR 312 and continuing into St. Augustine Beach as a series of ditches, canals, and pipes. Each culvert crossing location under SR 312 has been referenced either east or west of the intersection of SR 3 and SR 312 on the northern limits of St. Augustine Beach. The five vulnerable areas are located along ¾ miles of SR 312. Two of the crossings are located west of the SR 3 and SR 312 Intersection, while the remaining three are located east of the SR 3 and SR 312 intersection.

Figure 4-11. Vulnerable area - SR 312

The five sub vulnerable areas have been defined, located, and described below.

1. Crossing at Station 75 feet west - Consisting of one pipe 24 inch in diameter under SR 312 flowing south to north normally into a canal to the north and eventually to the Matanzas River.
2. Crossing at Station 175 feet west - Consisting of one 60-inch diameter pipe under SR 312 flowing from a southern 34x53 inch elliptical pipe south to north through the 60 inches to the Islander Drive Pond and further north through a 72-inch pipe in a series of ponds discharging to the Matanzas River. The connected system continues south through a 42-inch x 66-inch pipe and a 42-inch pipe to Pope Road. At Pope Road, a combination of a 24-inch culvert parallel with Pope Road, 36-inch pipe also parallel with Pope Road and a 30-inch pipe crossing Pope Road combine into the 42inch pipe flowing into a pond system to the north.
3. Crossing at Station 1800 feet east – Consisting of Two parallel 48-inch diameter pipes at approximate elevation (-) 0.09. The two pipes flow south to north into Anastasia State Park.
4. Crossing at Station 2900 feet east - Consisting of Two parallel 36-inch diameter pipes at approximate elevation 0.04. The two pipes flow south to north into Anastasia State Park into the low area between SR 312 and Pope Road and ultimately to a 24-inch diameter pipe crossing under Pope Road at Lee Drive.
5. Crossing at Station 3900 feet east - Consisting of a single 36-inch diameter pipe at approximate elevation (-) 0.09. The pipe flows south to north into Anastasia State Park into the low area between SR 312 and Pope Road and ultimately to a 24-inch diameter pipe crossing under Pope Road at Schooner Court.

4.2.2. West Pope Road Area Vulnerable Outfall

The West Pope Road Area (Figure 4-2) is on the Northwest corner of St. Augustine Beach and south of the Matanzas River bridge crossing of SR 312. The outfall is located at the intersection of Mizell Road and the west end of Pope Road.

The West Pope Road Area has one identified drainage system deemed to be vulnerable to flooding into the city as the result of sea level rise. The vulnerable culvert is located within St. Johns County and extends from SR 3 to the culvert crossing along Pope Road.

Crossing at Station 2000 feet west of SR 3-The contributing drainage area consists of 1100 feet of the southern right of way of west Pope Road, 1400 feet of west 16th Street and 1300 feet of southern Mizell Road. All the area outfalls across Mizell Road at West Pope Road in a 24-inch culvert at an invert of 2.5 to a ditch tributary to the Matanzas River.

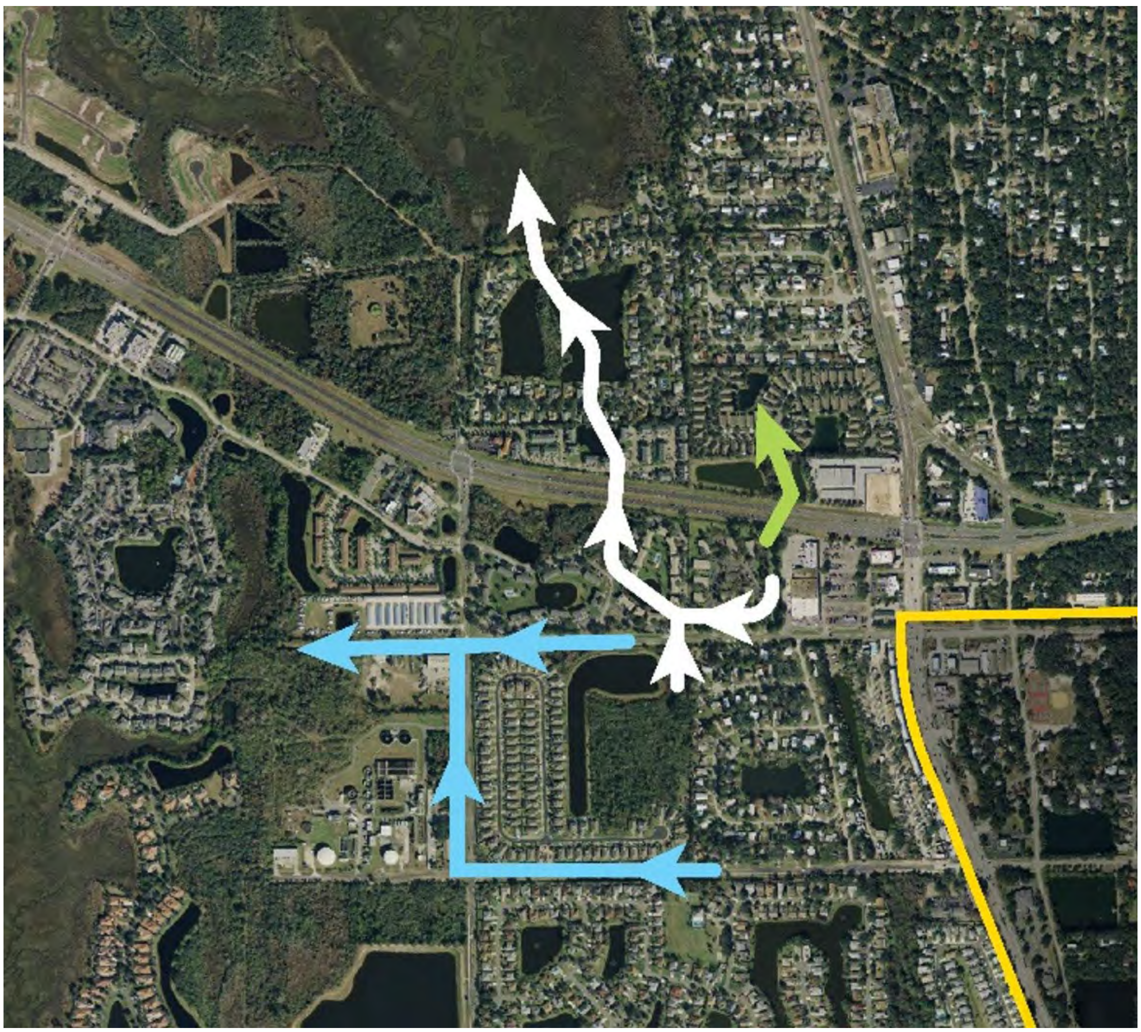

Figure 4-12. Vulnerable Area - West Pope Rd

4.2.3. Sea Grove Area Vulnerable Outfall

The Sea Grove area (Figure 4-3) lies west of the protective elevated SR 3 and adjacent to Marsh Creek and is directly connected to the marsh area and tributaries of the Matanzas River. Although the subdivision properties adjacent to the marsh are elevated to a 100-year flood elevation, the connected north/ south strand of marsh internal to Sea Grove and utilized for stormwater retention and detention is interconnected by canals, 48-inch pipes, overflow weirs all vulnerable to backflow from the tributary of the Matanzas River inundating access across the causeway. The interconnected north south strand of marsh is also separated from the northern Oleander Street wetland vulnerable area by a narrow low crossing extended from Florida Avenue that would be inundated from the Sea Grove marsh strand allowing backflow from the south to the north through the Oleander Street wetland into the City of St. Augustine Beach.

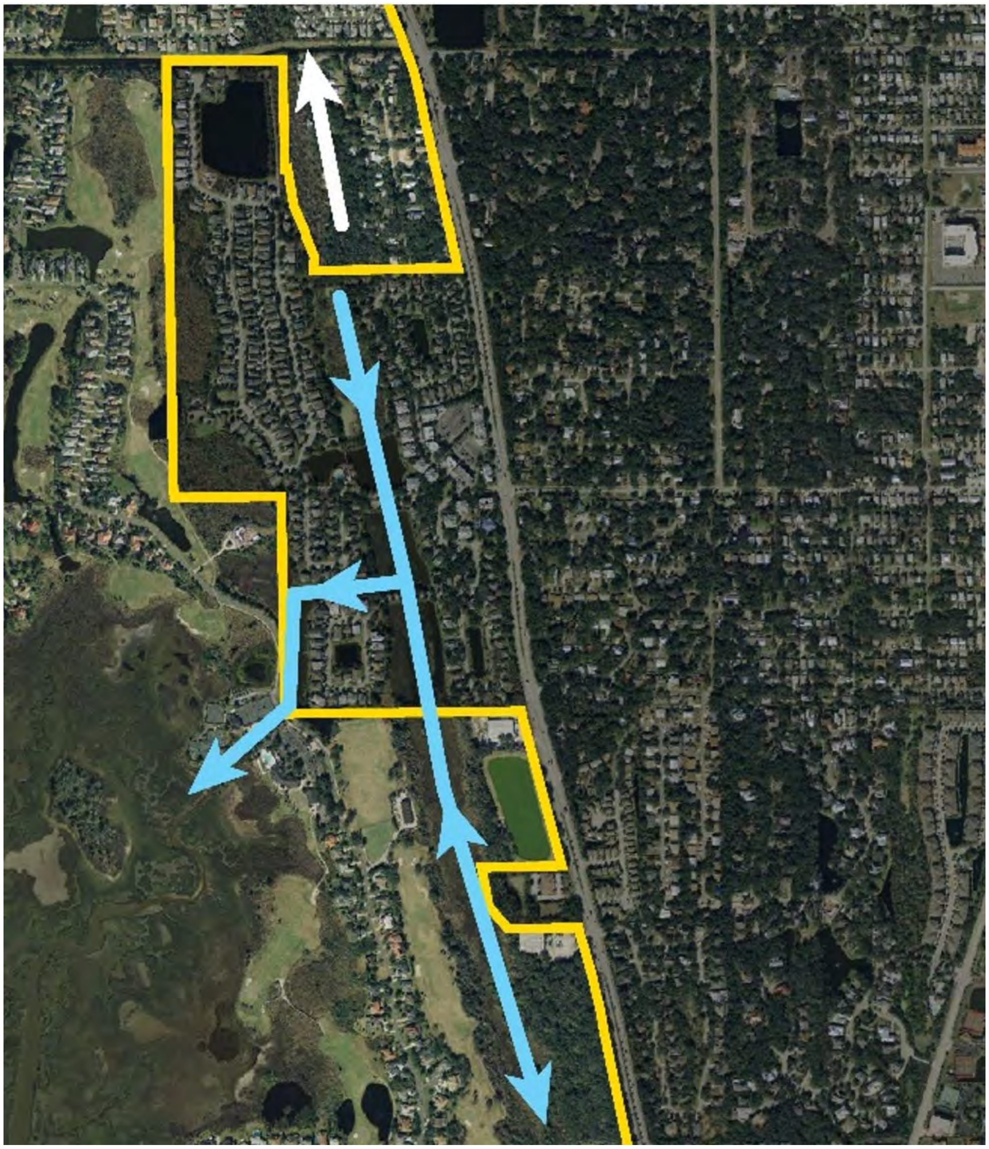

Figure 4-13. Vulnerable Area - Sea Grove

4.2.4. Ocean Trace S/D Vulnerable Outfall

The Ocean Trace area (Figure 4-4) lies west of the protective elevated SR 3 and adjacent to the marsh area of the Matanzas River. The subdivision properties adjacent to the marsh are elevated well above the 100-year flood elevation, however the 24-inch outfall storm sewer from South Ocean Trail Road is not protected from flood elevations in the marsh backflowing into and inundating South Ocean Trail Road.

Figure 4-14. Vulnerable Area - Ocean Trace

4.2.5. Oleander Street Wetland Vulnerable Area

The Oleander Street wetland is connected to the City's master stormwater system at the 11th Street canal by a 24-inch HDPE pipe, the wetland is a part of a south to north marsh strand connected at Sea Grove to a tributary of the Matanzas River.

In the event of backflowing floodwater from the Matanzas River breaching the low crossing at the end of Florida Ave, the Oleander St Wetland connection to the master stormwater system creates a vulnerable connection to the city master stormwater system.

4.2.6. Pope Road / Ocean Pier Park Surge Vulnerable

The Ocean dune/ seawall combination from the Pope Road Overlook Parking area south along the beach past St. Johns County Pier Park to the beginning of the rising dunes near 14th Street is vulnerable to storm surge into the city during a Category One Hurricane.

4.3. Impact on the City Master Stormwater System

Each of the vulnerable areas was evaluated relative to the City's operational Master Stormwater Management System. Each of the five areas, minus the Pope Road/Ocean Pier area, which is vulnerable by storm surge, were identified as stormwater basins outflowing away from the City of St. Augustine Beach not flowing into the city stormwater master system, thus having no direct impact on the City's master stormwater system under the more common rain events even in consideration of sea level rise.

However, under extreme flood conditions such as a 100-year events, all five areas may reverse flow due to an elevated sea level/Matanzas River tidal condition into the City. Only the SR 312 Vulnerable connected pipe systems, the West Pope Road Vulnerable outfall and Sea Grove breach into the Oleander St Wetland Vulnerable area have the potential to backflow into the city master stormwater system raising flood levels within the city.

Considering these vulnerable systems are not internal to the City's master stormwater system, they cannot be effectively incorporated Into the City's master ICPR stormwater computer modeling.

Resiliency & Protection

5.1. Critical Facilities

The impact of sea level rise with respect to the vulnerability of critical facilities and infrastructure within the City is important with respect to planning. Critical facilities and infrastructure within the city limits were identified in the assessment as follows:

- City Hall at SR 3 was built on higher ground adjacent to the elevated SR 3 and is not flood prone from the initial considerations of sea level rise.
- City Police Station at SR 3 was built on higher ground adjacent to City Hall and the elevated SR 3 and is not flood prone from the initial considerations of sea level rise.
- Public Works Complex at Mizell Road and Pope Road was built within the County on slightly elevated ground adjacent to the Pope Road Vulnerable Outfall. Access to the complex may be subject to flooding from the initial considerations of sea level rise.
- Fire Station at Beach Boulevard and Pier Park was built on slightly elevated ground but adjacent to the storm surge prone County Pier Park area. Access to the station may be compromised due to storm surge inundation of Beach Boulevard resulting from increased sea level rise.
- The County operated Sewage Pump Stations serving the city are located throughout the city. St. Johns County Utility Department only recognized two such stations that might be vulnerable to the site flooding.
- The two city-operated remote Stormwater Pump Stations are located west of the ocean dune line and protected by the elevated dunes from the evaluated Category one storm surge.

Although the assessment showed no direct flooding impacts to the most critical facilities from the projected sea level, secondary and access impacts to several the facilities can be expected.

County Facilities and infrastructure providing service to the city and others and located outside of the city limits are noted here but not assessed. These facilities should be evaluated in a vulnerability assessment program performed by the County.

- Anastasia Wastewater Treatment Facility at Mizell Road and 16th Street was built on slightly elevated ground. Mizell Road access to the complex may be subject to flooding from the initial considerations of sea level rise.
- Anastasia Drinking Water Treatment Facility at Mizell Road and 16th Street was built on slightly elevated ground adjacent to the Wastewater treatment facility. Mizell Road access to the complex may be subject to flooding from the initial considerations of sea level rise.

5.2. Infrastructure Constraints

Although the City has protective systems in place against broad flooding within the City, both in a protective roadway levee system and an internal City stormwater pumping system, the City does have some remaining internal stormwater conveyance constraints dating from the 1960s through 1990s. A number of the City existing ditch and piped systems, such as Mickler Road ditch, 11th Street ditch east of SR 3 and the 16th Street and Beach Boulevard stormwater collection and conveyance system are still limited in capacity and result in elevated stormwater stages during heavy rainfall in the upper reaches of the City storm sewer conveyance system. Many of these are older conveyance systems constructed without the benefit of calculated design stormwater runoff volumes and may need further evaluation under an update to the stormwater master plan to identify potential improvements to improve their stormwater conveyance hydraulics. Other more isolated areas of the city, such as individual subdivisions or local roadways, most certainly have stormwater conveyance restraints. These areas don't tend to flood to the extent of raising attention of the local residents or the city administration, but none the less represent a level of service below the accepted norms and should be identified and prioritized in a more focused update of the stormwater master plan.

5.3. Long Term Infrastructure Measures

Proposed Mitigation/Resiliency method by vulnerability area

5.3.1. SR 312 Area

- Five drainage systems all located in St. Johns County
- Crossing at Station 75 West – 24-inch pipe intercept pipe at the southern ROW of SR 312.
- Crossing at Station 175 West – 34x53 inch pipe intercept the pipe at the southern side of the SR 312 ROW.
- Crossing at Station 1800-, 2900-, and 3900-feet East – The area tributary to these three crossings is a natural low and can store a substantial amount of floodwater. Intercept of the area should occur at the SR312 three crossings and at the 24-inch pipe crossings of Pope Road at Lee Drive and Schooner Court, both on the south side of Pope Road. The method of intercept and control at Pope Road will consist of structural blocking and rerouting the Schooner Court area drainage from its crossing at Pope Road westward to the Lee Drive area, a structural blocking of the Lee Drive crossing of Pope Road and redirecting both Schooner Court and Lee Drive to the existing City master stormwater drainage connection at the Mickler Blvd and Pope Road. Considering SR312 is

approximately3 feet higher in elevation than Pope Road the method of intercept will also include structural intercepts at each of the SR312 crossings.

5.3.2. West Pope Road Outfall

- Crossing at Station 2000 West of SR 3 – 24-inch pipe under Mizell Road. Intercept the pipe at west side of Mizell Road.

5.3.3. Sea Grove Area Outfall

- The Sea Grove area -the marsh utilized for stormwater retention and detention is interconnected by a 48-inch pipe under the causeway- Intercept the 48-inch pipe at the cause way crossing.

5.3.4. Ocean Trace S/D Outfall

- The Ocean Trace area-The 24-inch outfall storm sewer under South Ocean Trail Road is not protected from flood prone marsh. Intercept the 24-inch pipe at east side of South Ocean Trail Road.

5.3.5. Oleander Street Wetland Vulnerable Area

- The Oleander Street wetland is connected at the 11th Street canal by a 24-inch HDPE pipe-Intercept the pipe at the south side of the 11th St. Canal.

5.3.6. Pope Road / Ocean Pier Park Surge Vulnerable

- The Ocean seawall from the Pope Road Overlook south fronting Pier Park - Storm surge for Category One Hurricane exceeds existing wall- Raise protective wall landward of the existing wall 7 feet.

5.4. Cost Considerations

5.4.1. Vulnerable Area Mitigation Scenarios

In consideration of the need for initial budgeting of mitigation and resiliency measures for City flood protection against the identified vulnerable access points of flood water backflow into the city, we developed an infrastructure scenario for modifying the seawall area along Pier Park against storm surge. This scenario anticipates an additional sea wall constructed to approximately elevation 12 as a backup to the current seawall.

Additionally, we developed an infrastructure scenario for modifying the vulnerable storm sewer piped systems. The following four graphics depict the situation anticipated, a normal operation of the vulnerable storm sewer and the flooding and backflow situation of the vulnerable storm sewer. The only differing proposed flood protection system associated with the drainage pipe vulnerable areas occurs with the three eastern most SR312 crossing combined with the two Pope Road pipe crossings. The three SR312 crossings can be structurally blocked from sea level rise backflow into the City without the pumping system while the two Pope Road crossings can also be structurally blocked from the flood prone area between Pope Road and SR312 . The rainfall induced drainage to the two Pope Road crossings can rerouted from Schooner

Court and Lee Drive to the City master stormwater system at Mickler Boulevard, thereby routing this rainfall induced stormwater to the City master stormwater system.

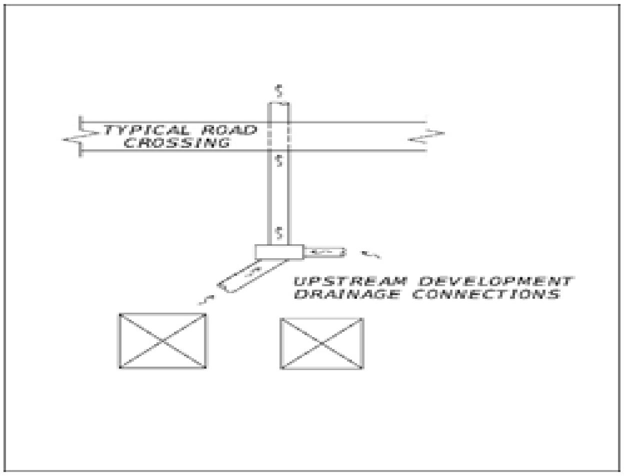

Figure 5-16. Normal Operational Discharge

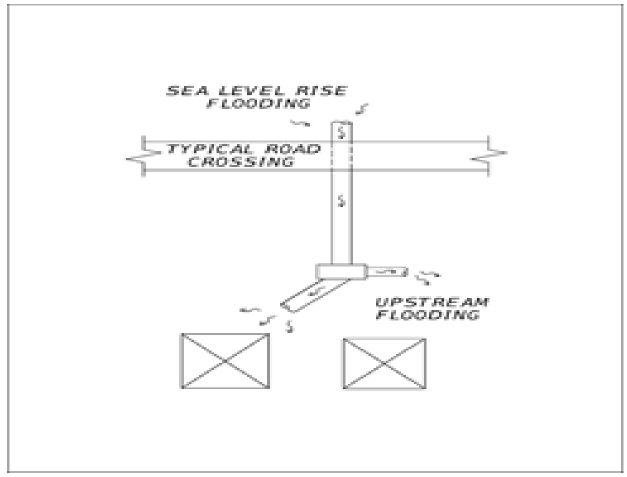

Figure 5-17. Sea Level Induced Flood Backflow

The infrastructure considered at each vulnerable pipe system, anticipates the pipe system will penetrate a raised roadway or similar filled and raised area and this location can be modified and reinforced to provide a level of protection against flood backflow into the city, while providing a method of removing any rain induced accumulation of stormwater from the upstream City to the flooded downstream area. Figure 5-3 and Figure 5-4 depict the scenario of modifying and reinforcing the crossing with the detailed description of the components below.

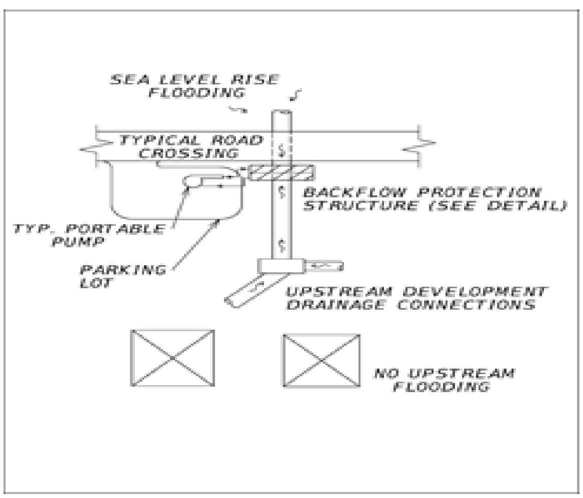

Figure 5-15. Sea Level Flood Backflow w/ Backflow Protection System

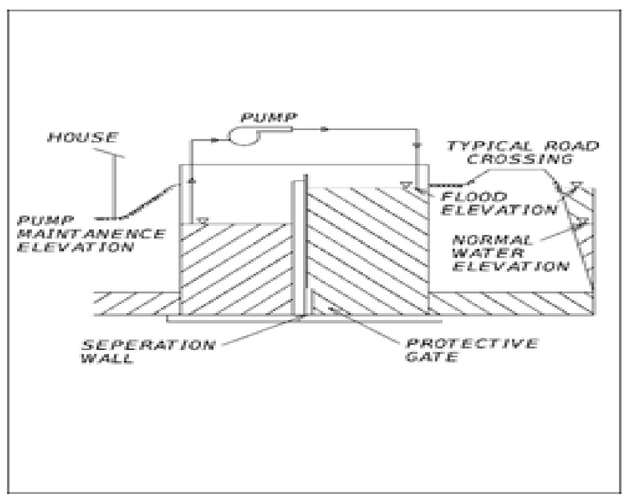

Figure 5-18. Backflow Protection System

The design concept includes the following.

1. A concrete storm sewer structure placed over the vulnerable storm sewer outfall pipe sized to accommodate an estimated flow for the associated vulnerable pipe size, typically starting at approximately 12 ft by 12 ft, with a dividing wall separating the upstream flow chamber from

downstream backflow chamber with a (or multiple gates and/or structures for the larger pipe systems) mounted flood gate in the wall.

2. The staging levels in both chambers to be mounted, and all operational portions to be controlled from an electrical control panel.
3. A pre-installed pressure pipe system with above ground quick disconnects on the upstream chamber for a pump suction and on the downstream backflow chamber as the pump discharge.
4. A concrete pad for installation and tie down of a portable diesel pump and a concrete enclosure for placement of a portable fuel tank.
5. Site work for a driveway access and set up of the portable pump system the pumps to be a minimum of 5000gpm with multiple pump set-ups for the few areas needing as much as 25,000gpm

5.5. Cost Estimating

The basis for construction cost estimates is an order of magnitude for rough budgeting purposes considering the lack of individual site details, governmental jurisdiction issues or detailed evaluation of various other mitigation options for addressing the vulnerable areas. The estimates are based upon current and near-term bidding conditions and should be considered within a range of accuracy of 30%.

Number	Vulnerable Area	Estimated Const Cost
1	SR 312 – 75 Feet West	$275,000
2	SR 312 – 175 Feet West	$530,000
3	SR 312 & Pope Road at Lee Drive	$275,000
4	SR 312 & Pope Road at Schooner Court	$275,000
5	West Pope Road (at Mizell Road)	$275,000
6	Sea Grove Area	$410,000
7	Ocean Trace	$275,000
8	Oleander St. Wetland	$275,000
9	Ocean Pier Park /Pope Road Overlook Sea wall	$650,000
TOTAL ESTIMATED 2022 CONSTRUCTION COST		$3,240,000
ESTIMATED SURVEY & ENGINEERING COST		$390,000
TOTAL CIP PROJECT COST		$3,630,000

Recommendation

6.1. Conclusion

The information contained in this report is intended to be used for planning purposes to begin to identify and address municipal infrastructure at risk. Understanding that a one-foot rise could occur in the next 20 to 30 years, adaptation strategies should be developed for locations identified as vulnerable in the first scenario. In addition to the vulnerability of infrastructure identified to lie at or below projected sea levels up to a two-foot scenario; the municipality may also be at risk due to secondary threats such as flooding events and ponding, storm drainage, erosion, bridge clearance, etc. Sea level may continue to rise beyond two feet. The City municipal authorities should begin the development of policies to address these risks and institutionalize the consideration of climate issues for adaptation strategies.

Thanks to a couple of forward-thinking infrastructure programs, the City of St Augustine Beach has time to plan mitigation and resiliency actions to combat the eventual sea level rise and its impacts. The infrastructure programs of construction of primarily FDOT elevated roadways forming a triangle around the heavier urbanized areas of the city and the upgrade of the master stormwater system of the city to elevations to protect against the recognized hundred-year flood has given time to plan.

6.2. Vulnerability Mitigation Capital Improvement Plan

As a result of the City's decision to assess its vulnerability to near-term sea level rise, several drainage areas have been identified as vulnerable to sea level induced flood backflow into the city, as well as the identification of an area of the coastal seawall vulnerable to moderate Category one Hurricane storm surge.

As the next step in the process of addressing the vulnerability, an adaptation plan is recommended and one of the first strategies in the plan is development of "protection strategies" involving the budgeting of capital to address hardening the drainage system against the sea level rise flood possibility.

To this end we have developed an order of magnitude project cost estimate for each vulnerable access point and as an overall capital Improvement.

The Order of Magnitude cost estimate is $3.63 million and has been provided in a format to allow individual vulnerable areas to be budgeted and implemented for mitigation.

6.3. Adaptation Planning

The next forward planning step is for the City to begin an adaptation planning process. The adaptation planning process would engage stakeholders to evaluate the sea level rise predictions and consider what actions, if any, should be taken.

The Florida Department of Economic Development (DEO) has resources available to assist local governments in this process and multiple communities have already completed their adaptation plans, while the State legislature is taking steps to start funding mitigation plans. The DEO describes the following five strategies for adaptation planning:

1. **Protection** - Protection strategies involve "hard" and "soft" structurally defensive measures to mitigate the impacts of current and future flooding, such as seawalls or beach renourishment, in order to maintain existing development.
2. **Accommodation** - Accommodation strategies do not act as a barrier to inundation but rather alter the design, construction, and use of structures to handle periodic flooding. Examples include elevating structures and stormwater retrofits that improve drainage or use natural areas to soak up or store water and runoff (i.e., green infrastructure).
3. **Strategic Relocation** - Strategic relocation involves the possible relocation of existing development to safer areas through voluntary or incentivized measures in populated, hazard prone areas that reduce the intensity of development and/or gradually increase setbacks over time. Such options usually involve the transition of vulnerable land from private to public ownership, but may also include other strategies such as transfer of development rights, purchase of development rights, and rolling easements.

4. **Avoidance** - Avoidance involves anticipatory actions taken to direct new development away from vulnerable lands to safer areas. Examples include land conservation, conservation easements, transfer of development rights, and increased coastal setbacks.
5. **Procedural** - Procedural strategies aim to generate vulnerability and adaptation information, increase awareness of vulnerabilities and adaptation options, or incorporate such information into plans or policies. Examples include vulnerability assessments, community outreach and education activities, new comprehensive plan language addressing sea level rise, and real estate disclosures.

6.4. Revisit the Vulnerability Conditions with Time

The conditions surrounding the Vulnerability Assessment have been identified, evaluated and calculated based upon what we know today and supported by governmental agency information, also based upon today's knowledge. The projections of what will occur over the next 20 to 50 years will be found in the future to only have been partially accurate. This has been a key reason for limiting the assessment to only a 50 year look into the future, knowing that the accuracy of any prediction of the future diminishes with time and periodic adjustments in our predictions and projections will be inevitable.

The Vulnerability Assessment should remain a flexible document subject to periodic update and refinement.