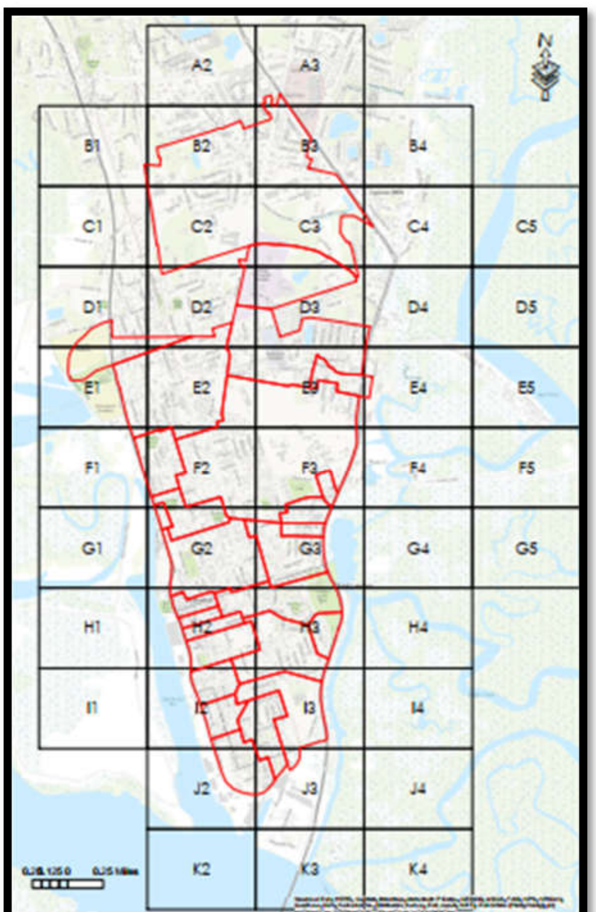
INITIAL STORMWATER MASTER PLAN



GEORGIA REGISTERED No. PE034189 PROFESSIONAL 3-17-2020 ENGINEER BURKE B MURPH III

PREPARED FOR:

CITY OF BRUNSWICK

PREPARED BY:

GWES, LLC

PROJECT NO. 092.01.3.19

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I EXECUTIVE SUMMARY

The Initial Stormwater Master Plan presents an evaluation of existing stormwater issues, deficiencies, and recommendations for improving stormwater drainage in Brunswick, GA (City). The City is divided into 26 drainage basins containing 31 different outfalls. Refer to Appendix A for the City Watershed Drainage Map.

An evaluation of existing stormwater inventory, previous stormwater work, and system deficiencies was performed in due diligence to determine the appropriate course of action to properly assess and summarize known stormwater issues throughout the City. Based upon this evaluation, 15 recommended Capital Improvement Projects (CIPs) are identified based upon existing stormwater drainage system deficiencies. Each CIP is discussed and given a priority score for such improvements based on five stormwater related parameters and engineering judgment. These improvements are ranked in order of importance based on quantitative analysis and engineering judgment. Refer to Sections VIII for recommendations for improvements with preliminary opinions of probable cost, respectively. Refer to Appendix B for a Conceptual CIP Location Map. A summary of CIPs according to ranked prioritization is provided in Table 1.

Table 1: CIP - Recommended Improvements Prioritization

CIP	Engineering Judgment Prioritization Parameters				Final Recommended Improvement Ranking
	Project Description	Priority Point Ranking	Preliminary Budgetary Cost	Opinion of CIP Improvement Impact	
A	Albany Street (near F and G St)	13	$790,000	High	1
E	Intersection of Macon & Talmadge Ave	15	$600,000	High	2
N	Riverside Neighborhood	14	$690,000	High	3
C	Wildwood Ditch (near Boxwood St & Myrtle Ave)	12	$1,400,000	High	4
H	Highway 17 Tide Control	12	$1,605,000	High	5
K	Lanier Boulevard at Glynn Middle School	11	$2,245,000	High	6
D	Altama Avenue and Second Street*	8	$180,000	Low	7
F	Talmadge Avenue Ditches*	8	$325,000	Low	8
B	Parkwood Drive (West End)	10	$400,000	Moderate	9
I	P Street Basin	13	$6,170,000	Moderate	10
G	Ports Authority - Tide Control	12	$1,515,000	Moderate	11
L	Habersham Park	10	$670,000	Moderate	12
O	GIS Inventory Collection	1	$750,000	Moderate	13
M	Urbana Neighborhood at Atlanta Avenue	13	$535,000	Low	14
J	Magnolia Park Outfall to Fairgrounds	2	$925,000	Low	15

Recommended CIP preliminary opinion of probable cost overall total is approximately $18,400,000.

II DISCLAIMER

This document entitled ***Initial Stormwater Master Plan*** was prepared by **GWES, LLC** (GWES) for the use of the **City**. Information provided in this document was based on GWES' professional judgment of existing stormwater drainage conditions taken from information supplied by the City and previous studies performed within identified sub-basins. This document is considered an initial master plan with an evaluation of hydrologic and hydraulic conditions related to specific stormwater drainage infrastructure based upon available information. It is the intent of this document to provide the City with a defined path to address stormwater issues and to budget for such improvements.

Any reliance on this document by any third party is prohibited. Any use which a third party makes of this document is the responsibility of such third party to verify all information provided by GWES. GWES shall not be responsible for financial damages suffered as a result of use of this document to justify results and decisions for future drainage projects.

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III PURPOSE AND SCOPE

The City implemented a stormwater utility in August 2018, with the first planned major project of the utility being the preparation of an initial stormwater master plan. The City's intent for the initial plan is to identify potential projects to help plan for funding opportunities such as SPLOST collections CIPs and to help obtain other funding sources such as federal and state grant opportunities. The initial plan will benefit the City's understanding on how to direct utility and other funding to the highest priority maintenance and improvement areas.

The City has identified stormwater problems of varying magnitude and does desire to develop a plan to prioritize, fund, and complete remediation and improvement projects. The purpose of this report is to identify and to evaluate stormwater drainage issues in the City and to develop an initial plan detailing recommended improvement projects.

The scope of this effort includes the tasks listed below:

Task 1 – Existing Conditions Analysis

GWES delineated the City's primary drainage basins, conducted a field assessment of existing drainage features and components. In addition, GWES conducted hydrologic and hydraulic analysis of existing drainage conditions and deficiencies.

Task 2 – Stormwater Master Plan Development

Based on that analysis, GWES identified potential CIPs, provided conceptual modeling and analysis of improvement alternatives, and provided opinions of probable costs of design and construction of identified projects. GWES also developed a maintenance plan for cleaning and upkeep of ditches, pipes, and storm structures. Finally, GWES identified short-term stormwater improvements that may be accomplished by City resources as "in-house" projects.

IV EXISTING STORMWATER SYSTEM INVENTORY

Evaluation of existing stormwater infrastructure inventory included an in-depth review of available information in the City's Geographic Information System (GIS), available county-wide information in Arc-GIS, stormwater drainage infrastructure criteria gathered from previous development and improvements projects, and additional GIS information provided by Goodwyn, Mills, and Cawood, Inc. (GMC), who are in the process of updating the City's GIS.

GIS Stormwater Inventory

Per approval by the City to coordinate with Glynn County for Arc-GIS shape files associated with stormwater inventory, the following information was supplied and/or gathered for evaluation:

- *Streams / Rivers:* The streams and rivers datasets cover the entire county. It appeared to have all named and most un-named streams in the City's drainage areas.

- *Stormwater Outfalls:* GWES has identified 31 outfalls located throughout the City based on available information by location and the name.

- *Stormwater Structures:* The GIS data contains 3,659 stormwater structure locations. There are numerous attribute fields associated with this data set that are empty and/or listed as unverified. The data set is incomplete.

- *Pipes / Conveyance:* The GIS data contains 3,145 segments of stormwater conveyance infrastructure throughout the City. Similar to the above, there are numerous attribute fields associated with this data set that are empty and/or listed as unverified. Additionally, GWES has verified that there are many stormwater piping, ditches, flumes, and other methods of conveyance of stormwater that are not identified within the data set.

- *Stormwater Detention:* The GIS data identified 20 private and/or public detention areas throughout the City.

- *Watersheds / Drainage Basins:* The City's drainage basins are not defined in the GIS data; however, GWES has identified 26 drainage basins within its limits, as shown in Table 2 below. There are multiple outfalls located in five (5) of the identified drainage basins.

Table 2: City Drainage Sub-Basin	
Sub-Basin	**Surface Area (Acre)**
Albermarle Street/ Ocean Avenue Outfall	126
Cook Street Outfall	14
Dartmouth Street Outfall	39
E Gloucester Street Outfall	102
E Monck Street/ Holly Avenue Outfall	125
E Prince Street Outfall	134
Fourth Street Outfall	171
H Street Outfall	185
Howe Street Outfall	67
I Street Outfall	34
Lanier Boulevard Outfall	32
M Street Outfall	64
Magnolia Park Outfall	751
Mansfield Street Outfall	25
N Street Outfall	601
Newcastle Street Outfall	80
Norwich Street Outfall	78
P Street Outfall	74
Palmetto Outfall	93
Parkwood Drive Outfall	39
T Street Outfall	296
Talmadge Avenue Outfall	18
W Gloucester Street Outfall	23
W Monck Street Outfall	15
W Prince Street Outfall	47
Wildwood Drive Outfall	253

V EXISTING STORMWATER ISSUES

A detailed evaluation of stormwater issues is constrained due to the lack of storm drainage infrastructure information including, but not limited to, verified pipe/culvert/inlet/structure locations, sizes, and invert elevations, drainage easements, and detention pond design criteria and intent.

Field Reconnaissance Evaluation

As part of the field reconnaissance performed on October 14th and 15th, 2019, GWES visited the following known locations of problematic storm drainage issues (in no particular order):

- Albany Street (near F and G Street)
- Parkwood Drive (West End)
- Wildwood Ditch (near Boxwood Street and Myrtle Avenue)
- Altama Avenue and Second Street
- Intersection of Macon and Talmadge Avenue
- Talmadge Avenue Ditches
- Urbana Neighborhood at Atlanta Avenue
- Riverside Neighborhood

Field reconnaissance has been documented in Appendix C (Field Reconnaissance Photographs) and Appendix D (Field Reconnaissance Stormwater Inventory). The City's work order history for stormwater related issues has been included in Appendix E (Work Order History).

Albany Street (near F and G Street)

- Severe flooding observed on both sides of Albany Street during field visit.
- Stormwater inlets were not accepting flow on east side of Albany Street.
- Stormwater was flowing in a westerly direction over the median in the middle of Albany Street.
- Flooding was occurring at intersection of Albany Street and F Street.
- Albany Street between F and G Street appears to be a low area.
- Runoff from this area eventually flows to H Street Outfall.
- The area has been the subject of stormwater complaints in the past.
- Existing infrastructure is in need of maintenance and/or replacement.
- Additional infrastructure may also be necessary to address deficiencies.

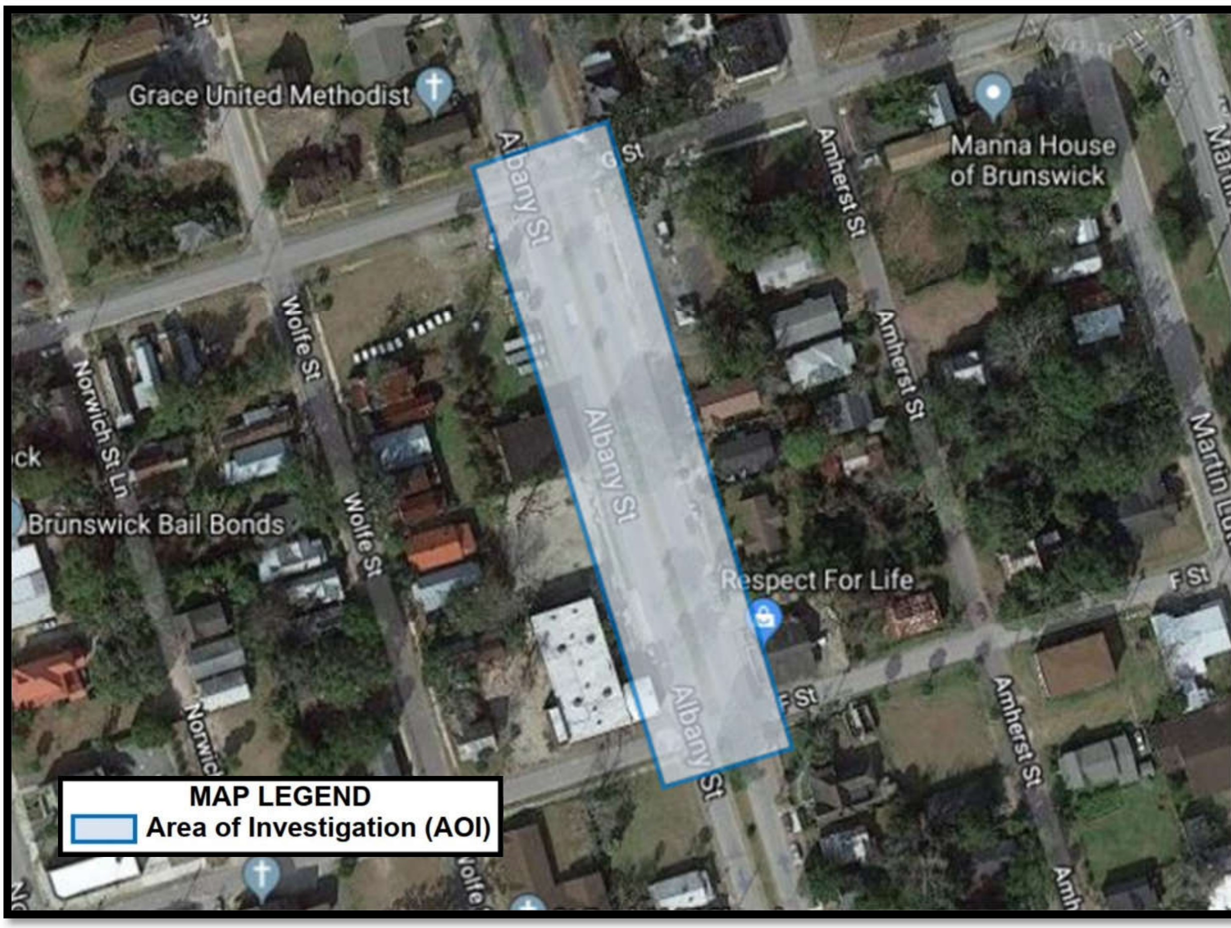

Figure 1: Albany Street (near F and G Street) AOI

Parkwood Drive (West End)

- During initial field visit, the inlets were in poor condition and had not been cleaned out, containing standing water, silt and debris.
- Could not locate yard inlet connected to pipe flowing north along N Cleburne Street on the east side.
- During another field visit following a rain event, the inlet at the corner of Parkwood Drive and N Cleburne Street was not accepting flow, water was backed up in the gutter along Parkwood Drive.
- Additionally, there was standing water in the parking lots of Coastal Medical Equipment & Uniforms and Jackie's Seafood Market.
- Runoff from this area eventually flows to T Street Outfall.
- The area has been the subject of stormwater complaints in the past.
- Existing infrastructure is in need of maintenance and/or replacement.
- Additional infrastructure may also be necessary to address deficiencies.

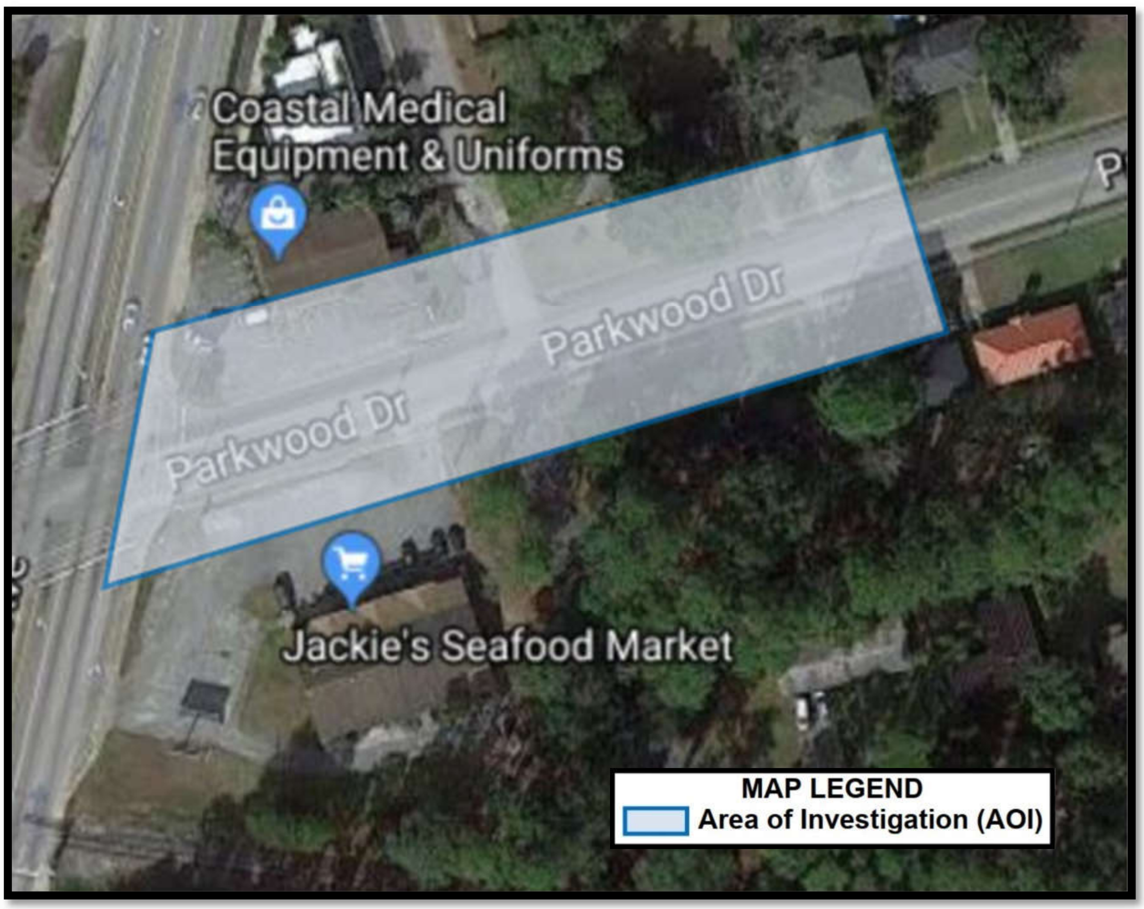

Figure 2: Parkwood Drive (West End) AOI

Wildwood Ditch (near Boxwood Street and Myrtle Avenue)

- Flooding tends to occur near church as water backs up during a rain event (affected by tides) into backyards resulting in erosion.
- Settling has occurred downstream in front of Budget Motel.
- City replaced culvert running under Wisteria Avenue in 2018, sized according to upstream pipe capacity.
- During initial field visit, the 48" pipe system that flows adjacent to church and then makes a 90 degree turn into the ditch system flowing along Myrtle Street was ¾ full at high tide.
- Upstream Wisteria Avenue 30" pipes were ½ full, Willow Avenue 36" pipe was ½ full.
- Private retention pond located off Lakeside Drive contains 18" overflow pipe that flows into Wildwood ditch system at corner of Lakeside Drive and Wildwood Drive.
- Runoff from this area eventually flows to Wildwood Drive Outfall.
- The area has been the subject of stormwater complaints in the past.
- Existing ditch system may require maintenance and/or shore stabilization.
- Existing stormwater infrastructure near church (48" pipe and 90 degree junction box) and tidewater may be causing bottlenecking or tailwater issue resulting in flooding.

Figure 3: Wildwood Ditches (near Boxwood Street and Myrtle Avenue) AOI

Altama Avenue and Second Street

- During initial field visit, the corner of Altama Avenue and 2nd Street appears to be a low spot.
- Curb and gutter is in place; however, it does not appear to flow to any existing structure.
- During another field visit following a rain event, there was some standing water in the gutter.
- Additionally, there were some flooding issues heading south along Altama Avenue in front of abandoned building, existing stormwater infrastructure does not appear to be accepting flow.
- Area does not appear to flow toward a specific outfall.
- The area has been the subject of stormwater complaints in the past.
- Area may require additional stormwater infrastructure in order to connect to existing system and reduce flooding issues.

Figure 4: Altama Avenue and Second Street AOI

Intersection of Macon and Talmadge Avenue

- During initial field visit, inlets were in poor condition, full of water, silt, and debris.
- Inlets appear to be affected by tides as they were full of water during site visit prior to rain.
- During another field visit during a rain event, there was flooding at corner of Macon and Talmadge Avenue around inlet and along eastern side of Macon Avenue heading south.
- Runoff from this area eventually flows to unnamed outfall on eastern side of Highway 17 into marsh.
- The area has been the subject of stormwater complaints in the past, see Appendix E for work order history.
- Existing stormwater infrastructure is in need of maintenance and/or replacement.
- Area may require additional stormwater infrastructure, tidal control and/or an increase in capacity in order to reduce flooding issues.

Figure 5: Intersection of Macon and Talmadge Avenue AOI

Talmadge Avenue Ditches

- Talmadge Avenue does not currently have stormwater infrastructure heading west past Macon Avenue with the ability to convey water toward an outfall.
- During initial field visit, there were signs of flooding along Talmadge Avenue.
- Construction of ditches and/or installation of curb and gutter may alleviate flooding issues.

Figure 6: Talmadge Avenue Ditches AOI

Urbana Neighborhood at Atlanta Avenue

- During initial field visit during a rain event, there was flooding at multiple intersections and along the sides of Atlanta Avenue in the gutter.
- At the intersections of Tillman Avenue, Goodyear Avenue and Niles Avenue with Atlanta Avenue, the inlets are in poor condition and need to be cleaned out.
    - Curb and gutter is in need of maintenance, it is currently causing drainage issues at all intersections.
    - Multiple curb inlets contain filter fabric under the grate, causing drainage issues.
- At the intersection of Wilson Avenue and Atlanta Avenue, inlet has been paved over, causing flooding issues at that corner.
    - Other inlets are in poor condition, need to be cleaned out, full of water, silt and debris.
    - Curb and gutter is in need of maintenance, it is currently causing drainage issues.
- Pavement is 3-4 inches thick above gutter, making it difficult to perform gutter maintenance.
- Debris in gutter is causing additional drainage issues.
- Runoff from this area eventually flows to Atlanta Avenue Outfall.
- The area has been the subject of stormwater complaints in the past.
- Area may require additional stormwater infrastructure, tidal control, and/or an increase in capacity in order to reduce flooding issues.

Figure 7: Urbana Neighborhood at Atlanta Avenue AOI

Riverside Neighborhood

- During initial field visit, there were multiple signs of flooding throughout the neighborhood including erosion, roadway damage, blocked driveway culverts, and damaged lawns.
- All inlets were at least ¾ full due to tides at time of inspection, no apparent tidal control on outfalls.
- Through conversations with multiple residents, some areas experience flooding due to tides while others are susceptible to flooding during rain events.
- During another field visit following a rain event, the areas susceptible to flooding were apparent.
- Low areas with little to no infrastructure (or inadequate) appear to have the most frequent flooding issues, including Wassaw Island Circle, Julenton Island Drive, along Riverside Drive, and at the entrance to the neighborhood.
- The area has been the subject of stormwater complaints in the past.
- On-going projects in area include:
    - 1st house near entrance – replace drive culvert and install inlet to marsh
    - Talahi Island Lane – connect to existing system w/ pipe replacements
- Area may require additional stormwater infrastructure, tidal control and/or an increase in capacity in order to reduce flooding issues.

Figure 8: Riverside Neighborhood AOI

Previous Stormwater Work Evaluation

An investigation of previous stormwater consulting work performed for the City was evaluated for a more in-depth understanding of stormwater history. The previous stormwater consulting work addressed both broad and specific stormwater issues throughout the City as follows: P Street Basin, Magnolia Park Outfall to Fairgrounds, Lanier Blvd at Middle School, and Habersham Park. Field reconnaissance has been documented in Appendix C (Field Reconnaissance Photographs) and Appendix D (Field Reconnaissance Stormwater Inventory). Each identified area is discussed below:

<u>P Street Basin</u>

In Stantec Consulting Services, Inc's (Stantec) 2011 "N" & "P" St. Combined Hydrology Study, the "N" and "P" Street stormwater history was described as follows:

"Due to inadequate and deteriorating storm drainage infrastructure in the "N" St. & "P" St. basins, the City of Brunswick obtained the services of Stantec to evaluate and design a storm drainage system that would improve stormwater runoff in flood prone areas within the limits of the basin. The original design plan called the "N" St. Drainage and Sanitary Sewer Improvements was divided into four phases of work. The first two phases of work specific to the "N" St. basin were completed in February 2009.

Phase I was designed as a 24" PVC pipe stormwater bypass, which relieves the "N" St. basin Phase II improvements from surcharge. The bypass routes stormwater from Tillman Ave to the Lanier Plaza storm drainage system to the south and east to Terry Creek.

Phase II was designed to adequately handle stormwater runoff and replace deteriorating storm drainage infrastructure within the "N" St. basin. Phase II construction divided the "N" St. basin into the "N" St. and "P" St. basins based on the natural topographic ridge line located along "O" St. The area south of "O" St. was designed to be in the "N" St. basin and the area north to be in the "P" St. basin. Phase II construction is summarized as twin 48" reinforced concrete pipes (RCP) running west to east in the middle of "N" St. collecting stormwater runoff from Georgia DOT approved structures at intersections and on side streets, and a single 48" RCP running in the middle of "M" St. and Tillman Ave. The outfall for Phase II construction is a triple 48" RCP headwall located in the Hercules west drainage ditch.

During the construction of Phase I, representatives from Stantec, City of Brunswick, and EMC Engineering Services coordinated in an effort to allow positive drainage through the Hercules' drainage ditch at the "N" St. Outfall. At the request of EMC and with the approval of the City, the headwall was raised to an elevation specified by EMC. As a result, the slope on the 48" pipes entering the headwall was decreased as needed to meet the requested elevation of 2.90', which decreased the carrying capacity of the City's new system.

Phase III improvements were designed to adequately convey stormwater runoff from Phase IV improvements within the "P" St. basin and route it across Hercules' property to the outfall located in the Hercules east drainage ditch. Phase III construction is summarized as a 54" RCP storm sewer running east through the north part of Hercules property to a concrete headwall. Phase III design was coordinated with Hercules' representatives during the planning of the storm piping alignment. Phase III improvements were scheduled to be complete before Phase IV improvements commenced. Phase IV improvements are summarized as a series of varying pipe sizes on side streets within the "P" St. basin routing stormwater to a main trunk line on "R" St., which is connected to the Phase III improvements. Recent reports from the City of Brunswick indicate that Phases III and IV improvements cannot be completed as designed due to inability to secure easements from Hercules" (now Pinova).

Field Reconnaissance

- During recent field visit following a rain event on October 15th, roadway surfaces were in poor condition. It was clear that there were flooding issues at multiple intersections, and stormwater infrastructure was in need of maintenance and/or repair.
- The area has been the subject of stormwater complaints in the past.

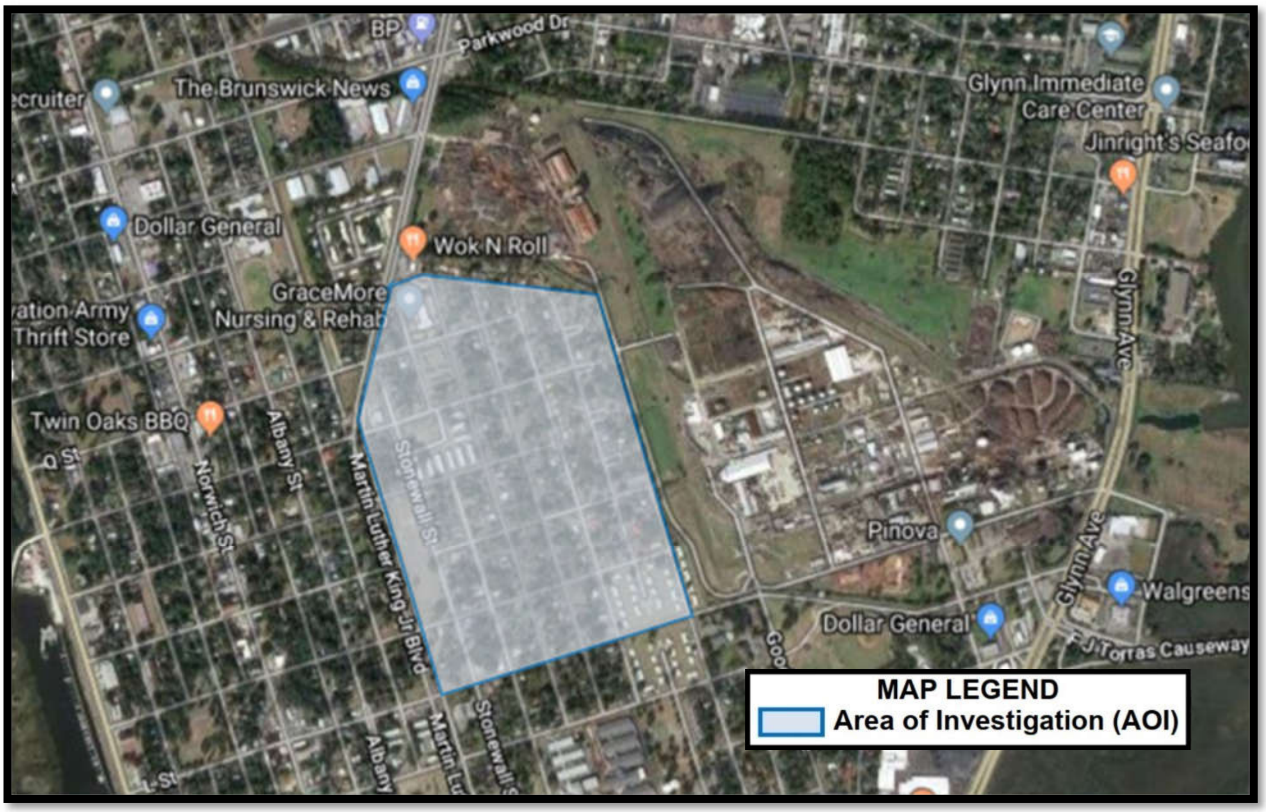

Figure 9: P Street Basin AOI

Magnolia Park Outfall to Fairgrounds

The Magnolia Park neighborhood has a history with flooding problems associated with its large watershed, its series of drainage ditches, and its existing storm drainage infrastructure. The City and Stantec worked together to address flooding problems and potential storm drainage improvements within and surrounding the neighborhood.

The first effort to improve storm drainage within the neighborhood was the *Magnolia Park Storm Drainage Improvements* project dated February 2000. This project addressed improvements to the neighborhood's perimeter drainage ditch and new infrastructure under Tara Lane and Woodland Way. These improvements were constructed in 2000. However, some improvements were designed, but not considered as a part of the contract. These improvements have not been completed to date.

The next effort was the *Watershed Drainage Study for College and Magnolia Park* dated June 2006 prepared by Stantec, which analyzed the capacities of existing storm drainage infrastructure in and surrounding Magnolia Park. Based on recommendations in the study, the first phase of improvements (Improvement MP-A) was constructed and completed in December 2011. Other recommendations in the study called for improvements (Improvement MP-B) to the perimeter drainage ditch that were not a part of the original February 2000 contract.

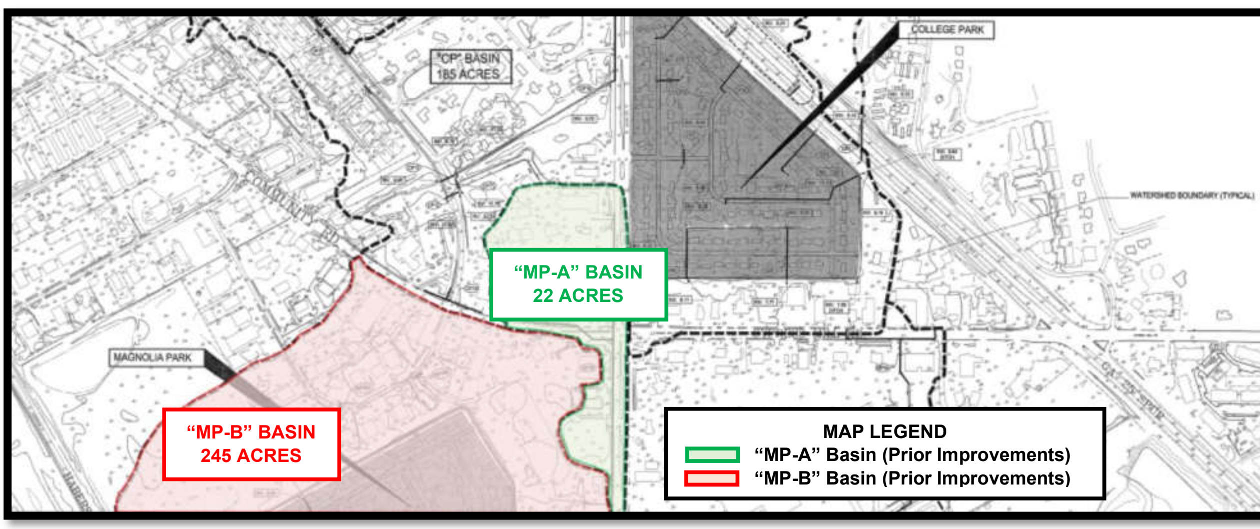

Figure 10: MP-A and MP-B Basin Map

The *Magnolia Park Storm Drainage Improvements Phase II* design, dated August 2012, included Improvement MP-B, dealt with improvements to the perimeter drainage ditch and storm drainage infrastructure. The project was completed in March 2014 and consisted of the installation of approximately 700 linear feet (LF) of storm drainage piping, storm drainage yard inlets, grading of upstream and downstream channel, and approximately 25,000 ft^2 of grout filled erosion control mattress.

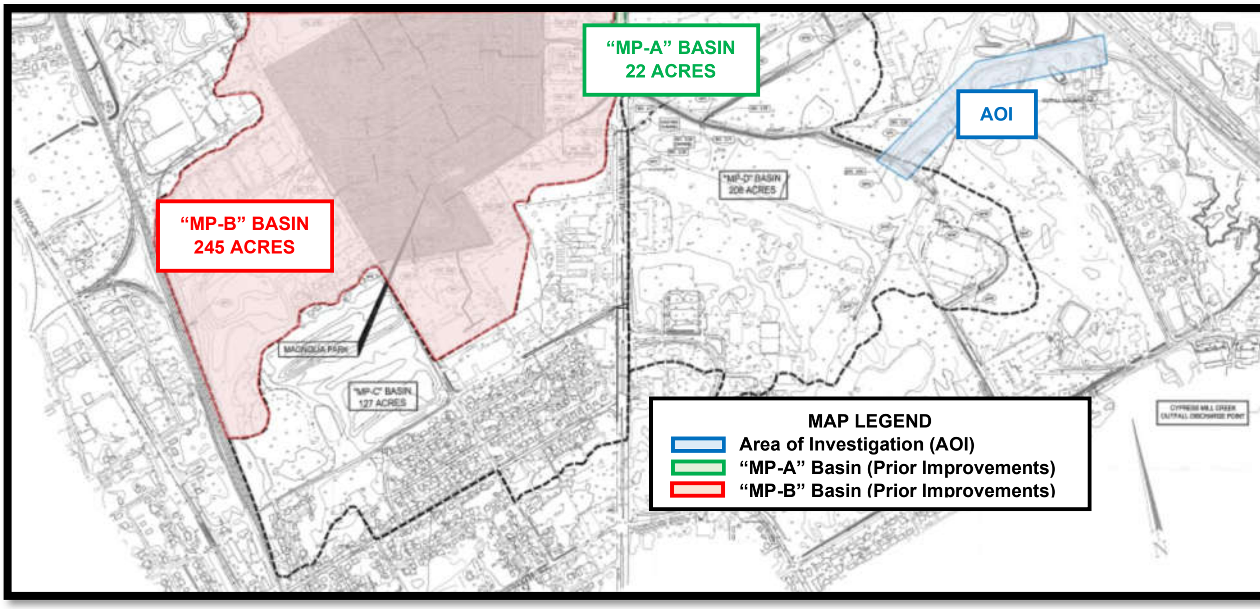

Figure 11: MP-A and MP-B Basin Map w/ AOI

In January 2018, the City released an RFP for *Magnolia Park Storm Drainage, Water Utility and Roadway Improvements* that stated the roadways within the neighborhood are in various states of disrepair and in need of resurfacing. Many of the storm drainage roadway crossings are constructed of corrugated metal pipe. Similarly, the water lines in the neighborhood are outdated and in need of replacement. The scope of this project is to include storm drainage inlet and crossing replacement, water line replacement, and roadway reconstruction. The project is currently under construction with an estimated completion in 2020.

While many of the most recent projects have been designed to address flooding issues within the Magnolia Park neighborhood, the downstream impacts of these improvements should also be addressed. Currently, all flow from the Magnolia Park basin flow under Altama Avenue and along Emory Dawson (Community Action Drive) to three (3) existing 60" RCPs. Additionally, stormwater from the Glynn County Football Stadium area flows through a 48" RCP under Community Action Drive and converge with the Magnolia Park flow into the ditch system heading east to Cypress Mill Creek.

Field Reconnaissance

- During a recent field visit, the four (4) pipes running under Community Action Drive were 1/2 full at high tide with no recent rain.
    - Th outlet side of pipes are partially filled with sediment.
    - The inlet side remains clean.
    - A tailwater exists.
- The system does not flow into the large pond near Golden Isles Parkway (appears to be freshwater).
- The Magnolia Park Outfall is located at the end of Dolphin Street, downstream of where two ditch systems converge and Dolphin Street drains into Cypress Mill Creek through a 24" RCP.
- The area has been the subject of stormwater complaints in the past.
- To reduce potential flooding issues, capacity of infrastructure may need to be increased and/or tidal control structures may be necessary.

Figure 12: Magnolia Park Outfall to Fairgrounds AOI

Habersham Park

The *Habersham Park Hydrology Study,* completed in 2010 by Stantec, evaluated drainage patterns in the Habersham Park neighborhood. The report was commissioned as a result of several complaints from residents within Habersham Park regarding inadequate drainage of stormwater runoff. In order to assess potential problems within the neighborhood, storm culverts were inventoried and evaluated for capacity and compared to the estimated stormwater runoff for periodic storm events. Recommendations for improvements within the Habersham Park area were presented; however, the concepts for improving drainage were not intended to be the final design criteria for improvements.

Information used in the report was gathered from multiple sources including topographic information compiled from previous surveys for the Dixville Sanitary Sewer project, MLK Blvd Extension, and the Glynn Middle School (GMS) design drawings. The surveys were reviewed and combined with a field investigation to verify the general drainage patterns and flow routes for runoff within the studied areas.

Three (3) distinct drainage basins were determined to have a direct impact on Habersham Park's drainage. The first basin is a 48-acre residential neighborhood west of Habersham Park (Contributing Basin A). The second basin is the 12-acre Habersham Park neighborhood. The third basin is the Glynn Middle School (GMS) property consisting of 20 acres.

Field Reconnaissance

- During a recent field visit during a rain event, ditches were overgrown with vegetation, and stormwater infrastructure was in need of maintenance and/or repair.
- To reduce potential flooding issues, capacity of infrastructure may need to be increased, tidal control structures may be necessary, and/or divert flow to another outfall if feasible.

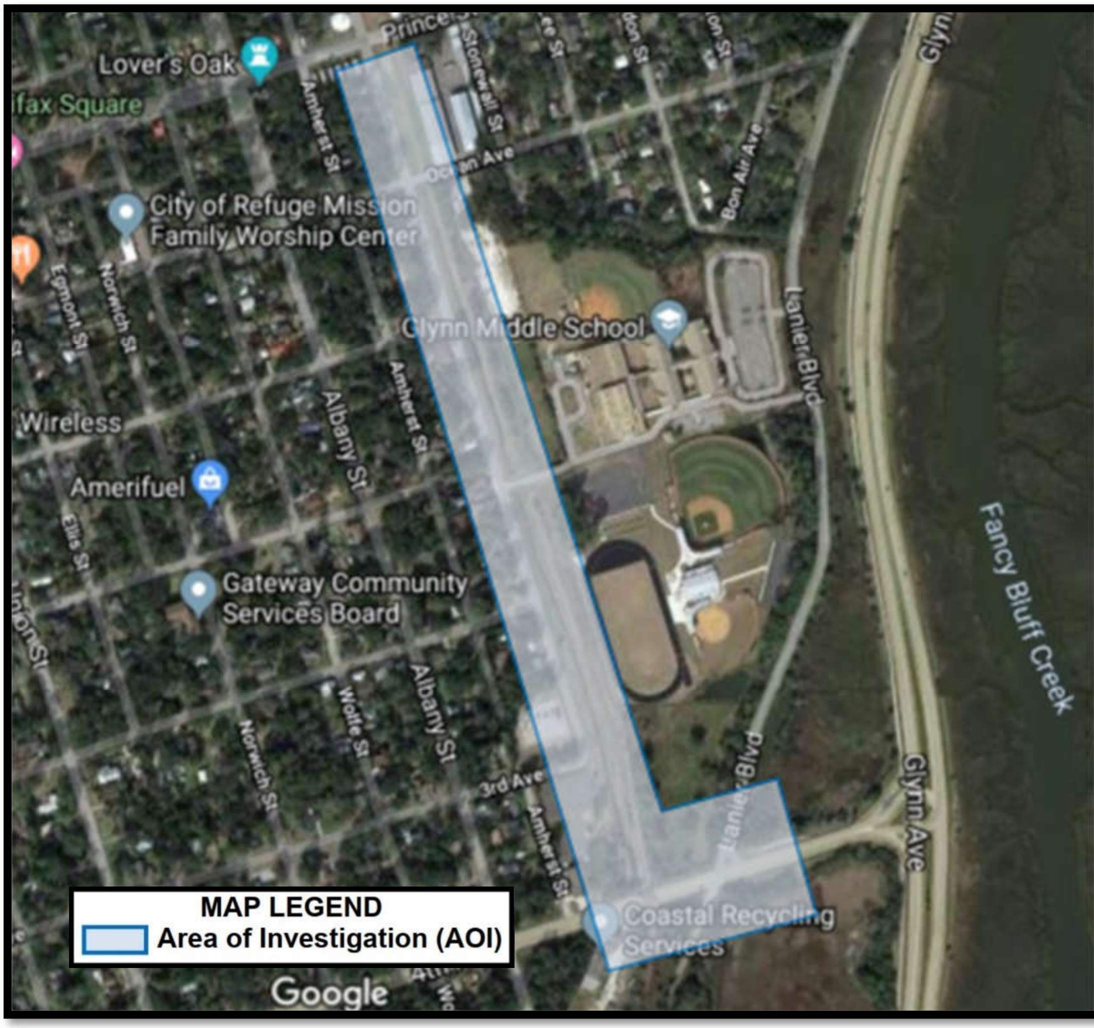

Figure 13: Habersham Park AOI

Lanier Boulevard at Glynn Middle School (GMS)

Hydrologic and hydraulic analysis for this area was covered in the *Habersham Park Hydrology Study* in 2010, prepared by Stantec.

In 2019, road improvements were made along Lanier Boulevard near GMS. During construction, it was determined that multiple pipes running under Lanier Boulevard needed to be replaced based on their deteriorated condition. According to the City, the pipes were replaced with the same size pipes at the same inverts and no additional hydrologic analysis was completed to determine if the existing pipes were adequately sized.

Field Reconnaissance

- During a recent field visit during a rain event, parts of Lanier Boulevard were under construction, ditches were near capacity, stormwater pipes under Lanier Boulevard were surcharged, and tidewater was flowing into outfall/Lanier system.
- The area has been the subject of stormwater complaints in the past.
- To reduce potential flooding issues, capacity of infrastructure may need to be increased, tidal control structures may be necessary, and/or divert flow to another outfall if feasible.

Figure 14: Lanier Boulevard at GMS AOI

In summary, existing stormwater issues are more significant in low-lying areas and in areas where the existing stormwater drainage system is affected by tides. Inadequate capacity of existing stormwater drainage infrastructure, incomplete maintenance, and erosion are commonalities in all drainage basins regarding flooding issues. Area and elevation limitations within public road rights-of-way may prove to be challenging in regard to improving ditch and/or pipe capacity. Construction permitting may also prove to be challenging due to work within tidally influenced drainage systems.

Outfall Evaluation

As shown in the FEMA Flood Zone Map located in Appendix J, the City is susceptible to flooding in multiple areas. In Table 3 below, each outfall identified by the City has been listed along with available GIS information and/or field verified data. Additional information has been included in Appendix B based on field reconnaissance and in Appendix F based on available GIS information. In some cases, the outfall was inaccessible during site visit and/or missing GIS information.

Table 3: Outfall Data

Sub-Basin	Structure Info	# of Pipes	Pipe Size	Pipe Material	Tide Control
Albermarle Street / Ocean Avenue Outfall	Concrete Headwall	1	30"	RCP	None
Atlanta Avenue Outfall	Concrete Headwall	1	36"	RCP	None
Cook Street Outfall	Concrete Headwall	1	36"	RCP	Tidal Gate
Dartmouth Street Outfall	Clay Open Pipe	1	18"	Clay	None
E Gloucester Street Outfall	Concrete Headwall	1	48"	RCP	None
E Monck Street / Holly Avenue Outfall	Concrete Headwall	1	48"	RCP	None
E Prince Street Outfall	Concrete Headwall	1	7'x9'	BOX CULVERT	None
Fourth Street Outfall	HDPE Open Pipe	1	60"	HDPE	None
H Street Outfall	Missing GIS	UNK	UNK	RCP	None
Howe Street Outfall	Concrete Open Pipe	1	60"	RCP	None
I Street Outfall	Concrete Flared End Section	1	36"	RCP	None
Lanier Boulevard Outfall	Concrete Headwall	1	30"	RCP	None
Lanier Plaza Outfall	Concrete Open Pipe	1	24"	RCP	None
Lanier Boulevard S. of Middle School Outfall	Concrete Open Pipe	1	30"	RCP	None
M Street Outfall	Concrete Flared End Section	1	42"	RCP	None
Magnolia Park Outfall	Concrete Open Pipe	1	24"	RCP	None
Mansfield Street Outfall	Missing GIS	1	54"	RCP	Tidal Valve
N Street Outfall	Missing GIS	UNK	UNK	UNK	None
Newcastle Street Outfall (South)	Concrete Headwall	2	36"	RCP	Tide Gates
Newcastle Street Outfall (West)	Concrete Flared End Section	1	24"	RCP	None
Norwich Street Outfall	Ditch	N/A	N/A	N/A	None
P Street Outfall	Missing GIS	1	18"	RCP	None
Palmetto Outfall	Ditch	N/A	N/A	N/A	None
Parkwood Drive Outfall	Concrete Headwall	2	36"	RCP	Twin Tide Gates
T Street Outfall	Ditch	N/A	N/A	N/A	None
Talmadge Avenue Outfall	Concrete Flared End Section	1	18"	RCP	None
Talmadge and Macon Avenue Outfall	Concrete Open Pipe	1	18"	RCP	None
W Gloucester Street Outfall	Missing GIS	UNK	UNK	HDPE	None
W Monck Street Outfall	CMP Open Pipe	1	48"	CMP	None
W Prince Street Outfall	Clay Open Pipe	1	24"	Clay	None
Wildwood Drive Outfall	Concrete Headwall	1	48"	RCP	None

Ports Authority – Tide Control

Field Reconnaissance of 13 Outfalls

- During on-site field reconnaissance performed by others, it appears the majority of outfalls did not contain tide control, multiple outfalls were completely submerged based on the tide elevation, and/or the location was not accessible
- To reduce inland flooding issues, tide control may need to be installed either at the outfall or upstream location depending upon permitting issues and cost

Figure 15: Ports Authority – Tide Control AOI

Highway 17 Tide Control

Field Reconnaissance of 18 Outfalls

- During a recent field visit, the majority of outfalls do not contain tide control, multiple outfalls were completely submerged based on the tide elevation, and multiple outfalls were surrounded by marsh debris and trash, see Appendix C for photos and Appendix D for field visit notes at each outfall
- To reduce inland flooding issues, tide control may need to be installed either at the outfall or upstream location depending upon permitting issues and cost

Figure 16: Highway 17 Tide Control AOI

VI EXISTING STORMWATER SYSTEM DEFICIENCIES

Based upon the evaluation of existing stormwater inventory and known stormwater issues, it is apparent that deficiencies are causing serious flooding problems throughout the City. Deficiencies identified are broken down per category as follows:

1. GIS Stormwater Inventory

The City maintains its GIS database and is in the process of updating it. Upon evaluation, the following deficiencies per attribute are noted as follows:

- *Streams / Rivers:* This data appears to be blue lines taken from available USGS information for Glynn County. It does provide a good indication of waters of the state (streams / rivers) that exist in drainage basins within the City; however, more waters of the state may exist that are not shown in the available data. This data is considered minimally deficient.

- *Stormwater Outfalls:* The GIS attributes that define the 31 stormwater outfalls are limited with missing attributes that include the outfall type, size, condition, elevation, material, photograph, maintenance record, etc. It is unclear if more or fewer outfalls are present within the City. This data is considered moderately deficient.

- *Stormwater Structures*: Stormwater inlets may refer to catch basins, curb inlets, yard inlets, drop inlets, roadway driveway culvert headwalls, similar inlets, and outfalls. The GIS attributes that define the 3,659 stormwater structures are limited with missing attributes that include type, size, condition, elevation, material, photograph, maintenance record, flood complaints, year of construction, or other related attributes. It is unclear how many more inlets may exist within the City limits that are not identified. This data is considered moderately deficient.

- *Stormwater Detention*: The GIS attributes that define the 20 stormwater detention facilities are limited with missing attributes that include inlet size, outlet size, type, condition, elevations, material, storage capacity, photographs, maintenance records, or year of construction, or other related attributes. This data is considered moderately deficient.

- *Pipes / Conveyance*: Identification and associated attributes for much of this data is incomplete and/or unverified. Typical attributes would include pipe location, size, material, directional flow, slope, depth, elevations, condition, adequacy, maintenance records, year of construction, and other related attributes. This data is considered moderately deficient.

- *Watersheds / Drainage Basins*: The City's drainage basins are not defined in the GIS data. This data is considered extremely deficient.

2. Stormwater Drainage Infrastructure Inadequacy

From evaluation of site reconnaissance information and previous stormwater related consulting work, it is apparent most drainage issues within the City are related to infrastructure inadequacy regarding capacity, tidal influence, and/or maintenance.

Stormwater drainage infrastructure represents inlets, pipes, flumes, curb and gutter, swales, detention ponds, bridges, ditches, outfalls, etc. throughout the City. Inadequacy may refer to lack of, undersized, un-maintained, and/or damaged infrastructure.

According to the City's *Ordinance 984 - Section 22A-38* – "all conveyances including pipes and open channels except those associated with detention facilities shall be designed for the 25-year frequency storm. Inlets for conveyances shall be designed for an equal frequency storm. Similarly, Georgia Department of Transportation (GDOT) standards for infrastructure capacity typically require design criteria at the 25-year storm frequency event for culverts, drainage ditches, and other stormwater drainage infrastructure."

Stormwater drainage infrastructure on City property and within City rights-of-way and drainage easements are the responsibility of the City to operate and maintain. As land use changes with residential, commercial, and industrial development over time, aging infrastructure that was once adequate may no longer be in regard to capacity. This may truly be the result of increased stormwater runoff from development constructed prior to City stormwater management regulations and subsequent enforcement as discussed in *Chapter 22A of the City's municipal code.*

Based upon our evaluation of information provided from site reconnaissance, available GIS information, and previous stormwater work, it is our opinion that extreme deficiencies with stormwater drainage infrastructure capacity are present in the City. It is unclear to the exact location and degree of all infrastructure capacity inadequacy based upon our evaluation of available information. However, of the areas of investigation that have been identified above, GWES has either performed and/or evaluated preliminary hydrologic and hydraulic analysis of those existing drainage conditions and deficiencies in the following section. As CIPs are identified, planned, and designed, additional hydrologic and hydraulic criteria along with topographic survey will be required to determine and/or verify infrastructure inadequacies specific to a project area.

VII HYDROLOGIC AND HYDRAULIC ANALYSIS

For each of the areas of investigation that have not been previously analyzed, a preliminary hydrologic and hydraulic model was prepared using Civil3D Hydraflow Hydrograph Software to estimate the runoff volumes and peak flows used to determine potential inadequacies within the system as well as to identify conceptual improvements.

Rainfall Estimation

Rainfall intensities for each area of investigation were derived from NOAA Atlas 14, Volume 9, Version 2 for Brunswick, GA, UGA (Latitude 31.1497°, -81.4956°).

The following table provides the rainfall depths that were used in the analysis:

Table 4: City Drainage Sub-Basin	
Design Storm	**Rainfall Depth**
1-Year 24-Hour	3.36"
2-Year 24-Hour	4.08"
5-Year 24-Hour	5.04"
10-Year 24-Hour	5.76"
25-Year 24-Hour	6.72"
50-Year 24-Hour	7.68"
100-Year 24-Hour	8.16"

Peak Flow

Based on the constraints shown in the figure below, the Rational Method was used to determine peak runoff rate for each sub-basin delineated in the area of investigation, except for one sub-basin near Wildwood Drive. The SCS Method was utilized to estimate peak flows in that sub-basin due to the existing stormwater management facility. These methods were selected based upon a verification of their accuracy in duplicating local hydrologic estimates for a range of design storms and the analysis of these parameters is fundamental to the design of storm drainage systems.

Method	Size Limitations[1]	Comments
Rational	0 – 25 acres	Method can be used for estimating peak flows and the design of small site or subdivision storm sewer systems. Not to be used for storage design.
SCS[2]	0 – 2000 acres*	Method can be used for estimating peak flows and hydrographs for all design applications.
USGS	25 acres to 25 mi^2	Method can be used for estimating peak flows for all design applications.
USGS	128 acres to 25 mi^2	Method can be used for estimating hydrographs for all design applications.
Water Quality	Limits set for each Structural Control	Method used for calculating the Water Quality Volume (WQ_v)

[1]Size limitation refers to the drainage basin for the stormwater management facility (e.g., culvert, inlet).
[2]There are many readily available programs (such as HEC-1) that utilize this methodology
* 2,000-acre upper size limit applies to single basin simplified peak flow only.

Figure 17: Peak Flow Method Constraints

Contributing Drainage Areas and Sub-basins

The contributing watersheds for each area of investigation were delineated based on available GIS information and 1-foot contours provided by the City. Each area was split into contributing sub-basins when modeling to estimate the existing runoff volumes and peak flows.

Model Results for Existing Flow

Based on the parameters listed above, the maximum runoff rate for each sub-basin was calculated for a 25-year storm. The existing stormwater infrastructure was then analyzed to determine the current capacity of the system versus the estimated capacity required to sufficiently handle a 25-year storm. Those results have been included in a table for each area of investigation along with a summary identifying potential causes for drainage issues in the area. The model results for existing flow are included in **Appendix F**.

Albany Street (near F and G Street)

Model Results for Existing Flow

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	Rational	-------	0.000	7.846	-------	9.509	10.71	12.45	13.82	15.18	Albany Street (near F and G Street)

Additional Information

Hydraflow Hydrographs Model Summary											
Drainage Sub-Basin	Pipe Size/Ditch 1	Pipe Capacity (cfs)	Pipe Size/Ditch 2	Pipe Capacity (cfs)	Highest Elev. (ft)	Lowest Elev. (ft)	Slope	Sub-Basin Area (Ac.)	Tc (min)	Max Runoff Rate 25 Year (cfs)	Min Pipe Size Needed
H Street Outfall	12" CMP	1.21			10	8	0.36%	4.77	21.00	12.45	24" RCP

Results Summary

Based upon the evaluation of available GIS information provided by the City and collected during field reconnaissance, preliminary hydrologic and hydraulic analysis of this area of investigation has identified the following issues:

- Existing infrastructure is undersized to handle 25-year storm
  - Existing 12" CMP, Clay, and HDPE Pipes are inadequate
- Existing topography in area has resulted in flooding issues (low-lying area)
- Existing infrastructure is in need of maintenance
- Lack of infrastructure in area has resulted in additional flooding issues
- Missing GIS information

Parkwood Drive (West End)

Model Results for Existing Flow

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	Rational	-------	0.000	5.081	-------	6.145	6.914	8.035	8.911	9.783	Parkwood Ave - A
2	Rational	-------	0.000	7.442	-------	9.081	10.26	11.96	13.30	14.62	Parkwood Ave - B

Additional Information

Hydraflow Hydrographs Model Summary											
Drainage Sub-Basin	Pipe Size/Ditch 1	Pipe Capacity (cfs)	Pipe Size/Ditch 2	Pipe Capacity (cfs)	Highest Elev. (ft)	Lowest Elev. (ft)	Slope	Sub-Basin Area (Ac.)	Tc (min)	Max Runoff Rate 25 Year (cfs)	Min Pipe Size Needed
A	12" RCP	2.23			15	13	0.39%	3.01	20.00	8.04	24" RCP
B	12" RCP	2.02	15" CMP	2.07	14.5	13	0.28%	4.98	25.00	11.96	24" RCP

Results Summary

- Existing infrastructure is undersized to handle 25-year storm
    - Existing 12” RCP’s and 15” CMP’s are inadequate
- Existing infrastructure is in need of maintenance
- Lack of infrastructure in area has resulted in additional flooding issues
- Missing GIS information

Wildwood Ditch (near Boxwood Street and Myrtle Avenue)

Model Results for Existing Flow

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	SCS Runoff	-------	26.01	41.09	-------	72.12	103.93	156.65	205.02	257.15	Pond Sub-Basin
2	Rational	-------	0.000	22.87	-------	27.49	30.84	35.75	39.58	43.40	Hospital to Ditch
3	Rational	-------	0.000	14.20	-------	17.41	19.70	23.02	25.61	28.19	South of Wildwood Drive
4	Rational	-------	0.000	22.16	-------	26.63	29.88	34.63	38.35	42.05	South of Wildwood Ditch
5	Rational	-------	0.000	9.718	-------	11.90	13.45	15.71	17.47	19.23	North of Wildwood Ditch
6	Reservoir	1	0.769	1.251	-------	2.342	3.416	5.751	8.831	11.24	Wildwood Pond
7	Combine	2, 3, 6	0.769	31.49	-------	38.06	42.80	49.72	55.14	60.52	Wildwood and Lakeside Intersection
8	Combine	4, 5, 7	0.769	59.77	-------	72.18	81.15	94.24	104.48	114.67	Wildwood Ditch Flow

Additional Information

Hydraflow Hydrographs Model Summary											
Drainage Sub-Basin	Pipe Size/Ditch 1	Pipe Capacity (cfs)	Pipe Size/Ditch 2	Pipe Capacity (cfs)	Highest Elev. (ft)	Lowest Elev. (ft)	Slope	Sub-Basin Area (Ac.)	Tc (min)	Max Runoff Rate 25 Year (cfs)	Min Pipe Size Needed
Hospital to Ditch					14	11	0.60%	12.48	22.60	35.75	36" RCP
South of Wildwood	12"RCP	2.77			11	9	0.21%	10.15	17.00	23.02	30" RCP
Pond Sub-Basin					13	10	0.44%	36.04	28.00	5.75	18" RCP
South of Wildwood Ditch	15"RCP	4.29	18"RCP	6.98	10	8	0.41%	12.09	17.00	34.63	36" RCP
North of Wildwood Ditch	18"RCP	5.77	15"RCP	3.55	11	8.5	0.30%	11.33	27.00	15.71	24" RCP

Existing Wildwood Pond Assumptions

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	SCS Runoff	-------	26.01	41.09	-------	72.12	103.93	156.65	205.02	257.15	Pond Sub-Basin
2	Rational	-------	0.000	22.87	-------	27.49	30.84	35.75	39.58	43.40	Hospital to Ditch
3	Rational	-------	0.000	14.20	-------	17.41	19.70	23.02	25.61	28.19	South of Wildwood Drive
4	Rational	-------	0.000	22.16	-------	26.63	29.88	34.63	38.35	42.05	South of Wildwood Ditch
5	Rational	-------	0.000	9.718	-------	11.90	13.45	15.71	17.47	19.23	North of Wildwood Ditch
6	Reservoir	1	0.769	1.251	-------	2.342	3.416	5.751	8.831	11.24	Wildwood Pond
7	Combine	2, 3, 6	0.769	31.49	-------	38.06	42.80	49.72	55.14	60.52	Wildwood and Lakeside Intersection
8	Combine	4, 5, 7	0.769	59.77	-------	72.18	81.15	94.24	104.48	114.67	Wildwood Ditch Flow

Additional Capacity Analysis of Existing Infrastructure

Existing Drainage Infrastructure	Pipe Size/Ditch 1	Pipe Capacity (cfs)	Slope	Max Runoff Rate 25 Year (cfs)	Min Pipe Size Needed
Lakeside Driv e	36"RCP	**36.61**	0.30%	**49.72**	42" RCP
Willow	36" RCP	**36.61**	0.30%	**49.72**	42" RCP
Wisteria	2 - 30" RCP	**45.04**	0.30%	**94.24**	54" RCP
48" @ Church	48" RCP	**78.85**	0.30%	**94.24**	54" RCP
Ditch Capacity	12'x8'x4' Deep	**18.63 to 49.68**	0.30%	**94.24**	54" RCP

Results Summary

- Existing infrastructure is undersized to handle 25-year storm
  - Existing culverts at Lakeside Drive, Willow Ave, and Wisteria Ave are inadequate
  - Existing 48" RCP near church at eastern end of Wildwood ditch system is inadequate
  - Existing ditch at eastern end is inadequate
- Existing system design is resulting in bottlenecking
- System capacity is affected by tides; however, system is not equipped with tide control
- Existing infrastructure is in need of maintenance
- Missing GIS information

Altama Avenue and Second Street

Model Results for Existing Flow

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	Rational	-------	0.000	2.609	-------	3.113	3.481	4.022	4.446	4.867	Altama and 2nd Street Model

Additional Information

Hydraflow Hydrographs Model Summary											
Drainage Sub-Basin	Pipe Size/Ditch 1	Pipe Capacity (cfs)	Pipe Size/Ditch 2	Pipe Capacity (cfs)	Highest Elev. (ft)	Lowest Elev. (ft)	Slope	Sub-Basin Area (Ac.)	Tc (min)	Max Runoff Rate 25 Year (cfs)	Min Pipe Size Needed
I Street Outfall					17	15	0.75%	1.30	14.00	4.02	15" RCP

Results Summary

- Lack of infrastructure in area has resulted in flooding issues
- Existing topography in area has resulted in flooding issues (low-lying area)
- Missing GIS information

Intersection of Macon and Talmadge Avenue

Model Results for Existing Flow

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	Rational	-------	0.000	6.500	-------	7.846	8.820	10.24	11.35	12.46	Talmadge and Macon Int. Model

Additional Information

Hydraflow Hydrographs Model Summary											
Drainage Sub-Basin	Pipe Size/Ditch 1	Pipe Capacity (cfs)	Pipe Size/Ditch 2	Pipe Capacity (cfs)	Highest Elev. (ft)	Lowest Elev. (ft)	Slope	Sub-Basin Area (Ac.)	Tc (min)	Max Runoff Rate 25 Year (cfs)	Min Pipe Size Needed
Talmadge Avenue Outfall	12" RCP	2.62			8	5	0.54%	3.75	19.00	10.24	24" RCP

Results Summary

- Existing infrastructure is undersized to handle 25-year storm
  - Existing 12" RCP's are inadequate
- Existing topography in area has resulted in flooding issues (low-lying area)
- System capacity is affected by tides; however, system is not equipped with tide control
- Lack of infrastructure in area has resulted in additional flooding issues
- Existing infrastructure is in need of maintenance
- Missing GIS information

Talmadge Avenue Ditches

Model Results for Existing Flow

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	Rational	-------	0.000	2.236	-------	2.687	3.015	3.494	3.870	4.243	Talmadge Ditches A Model
2	Rational	-------	0.000	4.227	-------	5.068	5.681	6.578	7.280	7.979	Talmadge Ditches B Model
3	Rational	-------	0.000	2.822	-------	3.392	3.806	4.411	4.885	5.356	Talmadge Ditches C Model
4	Rational	-------	0.000	1.649	-------	1.982	2.224	2.578	2.855	3.130	Talmadge Ditches C Model

Additional Information

Hydraflow Hydrographs Model Summary											
Drainage Sub-Basin	Pipe Size/Ditch 1	Pipe Capacity (cfs)	Pipe Size/Ditch 2	Pipe Capacity (cfs)	Highest Elev. (ft)	Lowest Elev. (ft)	Slope	Sub-Basin Area (Ac.)	Tc (min)	Max Runoff Rate 25 Year (cfs)	Min Pipe Size Needed
A (Northwest)					12	8	0.77%	1.22	17.00	3.49	15" RCP
B (Southwest)					12	8	0.73%	2.24	16.00	6.58	15" RCP
C (Southeast)					8	5.5	0.59%	1.54	17.00	4.41	15" RCP
D (Northeast)					8	5.5	0.62%	0.90	17.00	2.58	12" RCP

Results Summary

- Lack of infrastructure in area has resulted in flooding issues
- Existing topography in area has resulted in flooding issues (low-lying area)

Urbana Neighborhood at Atlanta Avenue

Model Results for Existing Flow

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	Rational	-------	0.000	5.621	-------	6.798	7.649	8.889	9.859	10.82	Urbana @ Atlanta Avenue A Model
2	Rational	-------	0.000	8.474	-------	10.57	12.06	14.19	15.85	17.50	Urbana @ Atlanta Avenue B Model
3	Rational	-------	0.000	12.35	-------	15.16	17.16	20.07	22.33	24.59	Urbana @ Atlanta Avenue C Model
4	Rational	-------	0.000	3.128	-------	3.798	4.280	4.982	5.530	6.076	Urbana @ Atlanta Avenue D Model
5	Rational	-------	0.000	1.266	-------	1.531	1.723	2.002	2.220	2.438	Urbana @ Atlanta Avenue E Model
6	Combine	1, 2,	0.000	9.473	-------	11.61	13.13	15.34	17.06	18.78	A+B Resultant
7	Combine	3, 6	0.000	21.03	-------	25.87	29.32	34.31	38.20	42.07	A+B+C Resultant
8	Combine	4, 7	0.000	23.16	-------	28.46	32.24	37.70	41.97	46.21	A+B+C+D Resultant
9	Combine	5, 8	0.000	23.85	-------	29.30	33.18	38.80	43.19	47.55	A+B+C+D+E Resultant

Additional Information

Hydraflow Hydrographs Model Summary											
Drainage Sub-Basin	Pipe Size/Ditch 1	Pipe Capacity (cfs)	Pipe Size/Ditch 2	Pipe Capacity (cfs)	Highest Elev. (ft)	Lowest Elev. (ft)	Slope	Sub-Basin Area (Ac.)	Tc (min)	Max Runoff Rate 25 Year (cfs)	Min Pipe Size Needed
A (West to East)	48" RCP	74.8			12	10	0.27%	3.33	20.00	8.89	24" RCP
B	12" RCP	1.34	15" RCP	2.88	11	9.5	0.14%	8.05	44.00	14.19	30" RCP
C	12" Clay	1.89	15" Clay	3.43	12	9	0.28%	9.01	29.00	20.07	30" RCP
D	12" RCP	1.99			10	8.75	0.31%	1.95	22.00	4.98	18" RCP
E	12" RCP	2.02			9	8	0.32%	0.75	20.00	2.02	12" RCP

Results Summary

- Some existing infrastructure is undersized to handle 25-year storm
  - Existing 12" and 15" pipes at the intersections of Niles Ave, Goodyear Ave, and Wilson Ave with Atlanta Ave are inadequate
- Existing 48" RCP running down the middle of Atlanta Avenue appears to be adequate based upon the results of the model
- Existing topography in area has resulted in flooding issues (low-lying area)
- Lack of infrastructure in area has resulted in additional flooding issues
- Existing infrastructure is in need of maintenance
- Height of pavement in relation to existing gutter line may have contributed to maintenance issues with the curb and gutter
- Missing GIS information

Riverside Neighborhood

Model Results for Existing Flow @ Wassaw Island

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	Rational	-------	0.000	2.447	-------	2.960	3.331	3.871	4.293	4.713	Riverside (Wassaw Island) Model
2	Rational	-------	0.000	0.853	-------	1.005	1.118	1.285	1.416	1.547	Riverside (Entrance) Model

Additional Information

Hydraflow Hydrographs Model Summary											
Drainage Sub-Basin	Pipe Size/Ditch 1	Pipe Capacity (cfs)	Pipe Size/Ditch 2	Pipe Capacity (cfs)	Highest Elev. (ft)	Lowest Elev. (ft)	Slope	Sub-Basin Area (Ac.)	Tc (min)	Max Runoff Rate 25 Year (cfs)	Min Pipe Size Needed
Wassaw Island	N/A		N/A		6	5	0.34%	1.45	20.00	3.87	18"RCP
Entrance	N/A		N/A		6	5	0.93%	0.37	10.00	1.29	12"RCP

Results Summary

- Existing infrastructure is undersized to handle 25-year storm without tide control
- Existing topography in area has resulted in flooding issues (low-lying area)
- Residential lots that have been built up to minimize flooding on the property have resulted in flooding issues on neighboring properties and in the right-of-way
- System capacity is affected by tides; however, system is not equipped with tide control
- Lack of infrastructure in area has resulted in additional flooding issues
- Existing infrastructure is in need of maintenance
- Missing GIS information

P Street Basin

Previously Completed Hydrologic and Hydraulic Analysis

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	SCS Runoff	-------	83.81	114.20	-------	165.85	197.06	242.24	273.50	315.08	P St Sub-Basin
2	SCS Runoff	-------	35.10	48.05	-------	70.24	83.73	103.30	116.88	134.97	Upper N St Sub-Basin
3	SCS Runoff	-------	47.64	64.91	-------	94.27	112.01	137.69	155.46	179.10	K St Sub-Basin
4	SCS Runoff	-------	65.03	88.36	-------	127.87	151.67	186.00	209.70	241.20	Lower N St Sub-Basin
5	Combine	1, 2, 3, 4	156.41	213.63	-------	311.46	370.73	456.53	515.95	595.19	System Outfall

Results Summary

Based upon the evaluation of previously completed hydrologic and hydraulic of this area of investigation and collected during field reconnaissance, the following issues were identified:

As presented in the *"N" & "P" St. Combined Hydrology* Study completed by Stantec in September 2011, "an analysis of the hydrology and the hydraulics of the existing infrastructure indicates the receiving pipe on Hercules property is undersized. The infrastructure along "N" St has sufficient capacity to carry runoff generated within the watershed, however, the receiving pipe at Hercules/Pinova will act as a bottleneck and surcharge the "N" St collection system for the 5-year, 24-hour storm and above. Two general options are offered for alleviating this bottleneck; either install additional piping/ditch capacity at Hercules or re-route a portion of the flow such that it has a free-flowing outfall.

The "P" St sub-basin appears to contain sufficient infrastructure to transport runoff; however, improper routing and aging infrastructure have likely reduced its runoff capacity. Basic improvements along Bartow and Cleburne streets would connect existing "P" St infrastructure along N St and improve the overall "P" St system capacity. Furthermore, it is recommended that an investigation be performed regarding the structural integrity and degree of sediment build-up within the existing infrastructure in the "P" St sub-basin. The results of this investigation may suggest the need to improve aging infrastructure in order to maximize runoff capacity within this sub-basin."

Magnolia Park Outfall to Fairgrounds

Previously Completed Hydrologic and Hydraulic Analysis

CITY OF BRUNSWICK, GEORGIA
COLLEGE PARK/ MAGNOLIA PARK DRAINAGE STUDY

EXISTING DRAINAGE STRUCTURES

WATERSHED BASIN: MP – MAGNOLIA PARK

STRUCTURE IDENTIFIER	LOCATION OF DRAINAGE STRUCTURE	STRUCTURE DESCRIPTION	CROSS SECTIONAL FLOW AREA (S.F.)	THEORETICAL EXISTING STRUCTURE CAPACITY (1) (cfs)	WATERSHED DRAINAGE AREA (ACRES)	ESTIMATED EXISTING CONDITON DISCHARGES FOR STORM EVENTS, cfs (2)						STATUS (3) STRUCTURE ADEQUATE FOR 25 YEAR STORM		COMMENTS
						2 YEAR	5 YEAR	10 YEAR	25 YEAR	50 YEAR	100 YEAR	YES	NO	
MP2	B.O.E. ACCESS ROAD	TRIPLE 60" RCP	58.9	510 (o)	602	170	257	349	463	546	648	X		

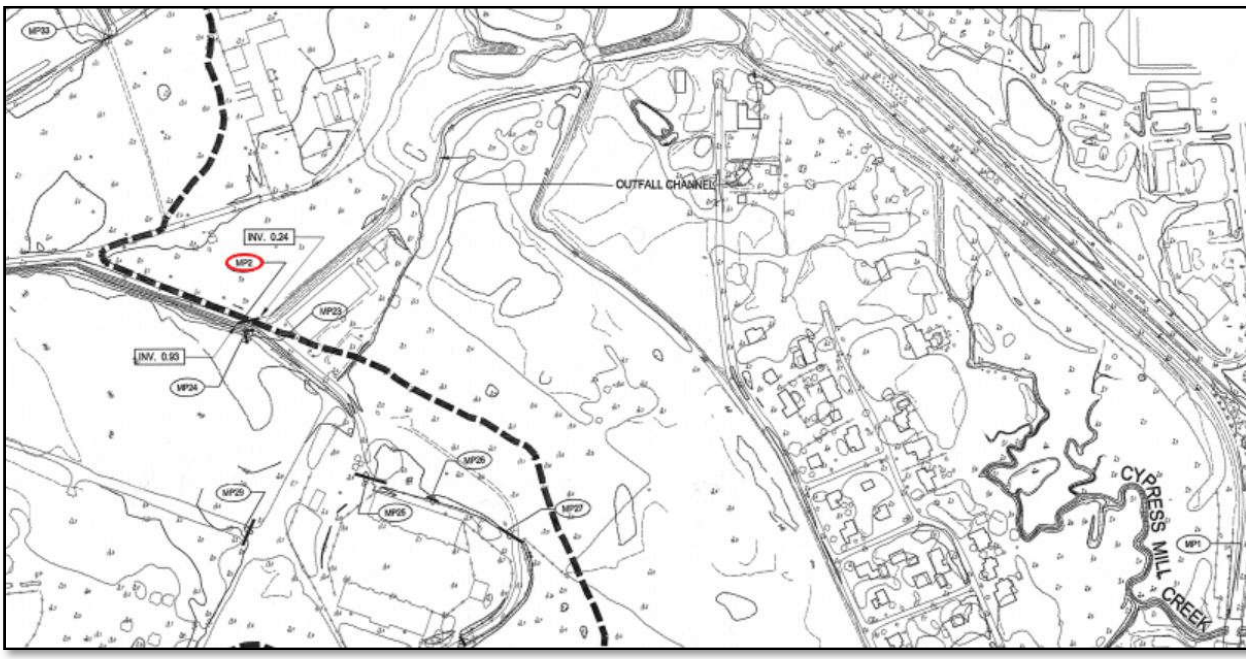

Figure 18: MP2 Structure Location

Additional Tailwater Calculation Inputs:

Headwater (Upstream Water Surface Elevation): 3.43 (1/2 full)
Culvert Inlet Invert Elevation: 0.93
Culvert Diameter: 60.00 inches
Length of Culvert: 60.00 linear feet
Culvert Outlet Invert Elevation: 0.24
Tailwater (Downstream) Elevation: 2.74 (1/2 full)

Capacity for 1 x 60" RCP (1/2 full) = 43.0 cfs
Capacity for 3 x 60" RCP (1/2 full) = **129.0 cfs**

Results Summary

Based upon the evaluation of previously completed hydrologic and hydraulic of this area of investigation and collected during field reconnaissance, the following issues were identified:

- Existing infrastructure is undersized to handle 25-year storm without tide control
- System capacity is affected by tides; however, system is not equipped with tide control
- Missing GIS information

As mentioned earlier, many of the most recent projects have been designed to address flooding issues within the Magnolia Park neighborhood; however, the downstream impacts of these improvements have not been addressed. Currently, all flows from the Magnolia Park basin flow under Altama Avenue and along Community Action Drive to three (3) existing 60" RCPs. According to the *College Park/Magnolia Park Drainage Study*, the theoretical existing structure capacity of the three (3) 60" RCPs is 510 cfs, which would be adequate to handle the 25-year storm (463 cfs). While that may be accurate, the calculations do not appear to take into account the tailwater condition created by the tidally influenced Cypress Mill Creek. Assuming the pipe is half full (as it was during field visit), the theoretical capacity of the three (3) 60" RCPs drops to 129.0 cfs when a tailwater is introduced to the equation based upon the inputs listed above. At 129.0 cfs, the RCPs would no longer be able to handle the 25-year storm and may result in potential flooding issues upstream.

Habersham Park and Lanier Boulevard at GMS

Previously Completed Hydrologic and Hydraulic Analysis

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	SCS Runoff	-------	69.02	86.22	-------	115.23	138.54	161.85	196.74	225.71	Contributing Basin A
2	SCS Runoff	-------	20.08	25.06	-------	33.46	40.21	46.95	57.04	65.42	Habersham Park Basin
3	Combine	1, 2	87.75	109.46	-------	146.26	175.84	205.41	249.68	286.42	Channel A

Summary of Drainage Patterns from Drainage Basins to the Marsh

- Runoff from all three drainage basins is routed through Channel "A" which lies between GMS and Habersham Park. (Q_{25}=220 cfs)
- A 36" pipe under Lanier Blvd. passes runoff from Channel "A" to the marsh between Lanier Blvd. and Highway 17. ($Q_{36\text{" Pipe}}$ = 47 cfs)

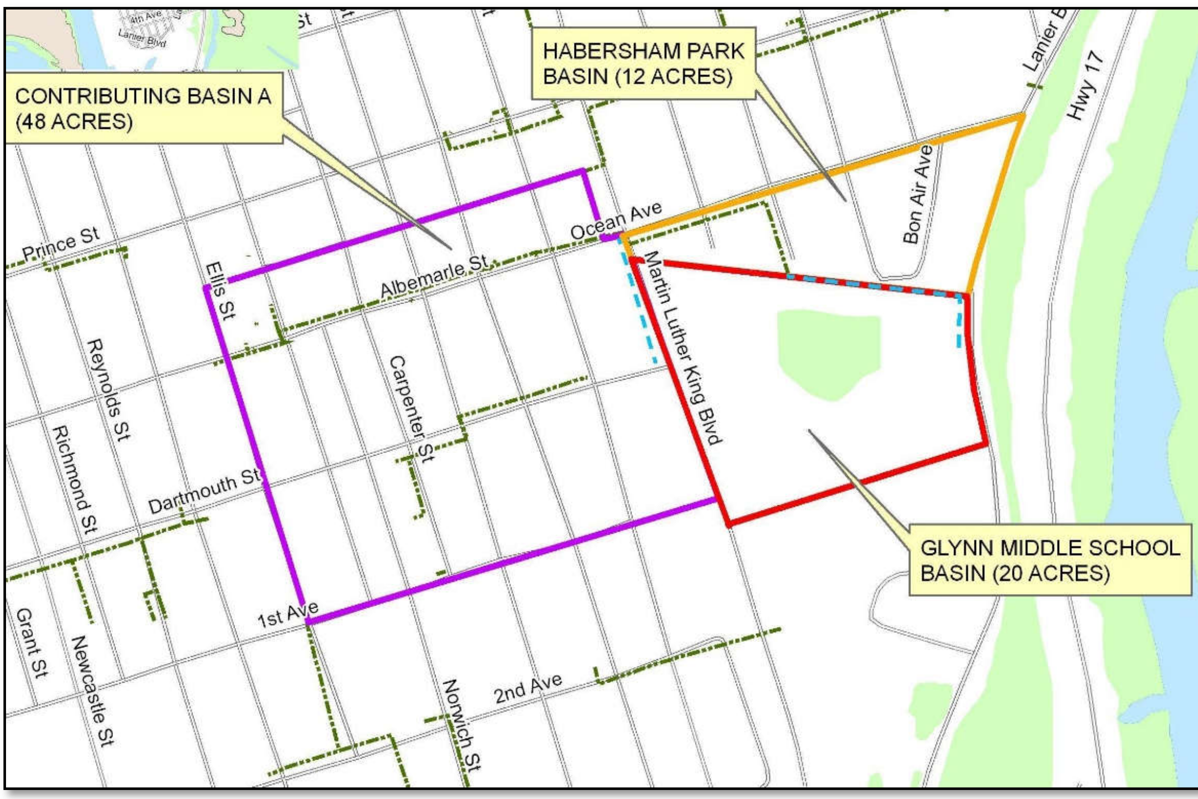

Figure 19: Drainage Basin Summary Map

Results Summary

Based upon the evaluation of previously completed hydrologic and hydraulic of this area of investigation and collected during field reconnaissance, the following issues were identified:

Potential Causes of Flooding in Habersham Park

- The piping intended to collect and pass runoff from Habersham Park is not adequately sized to pass the combined flow from Contributing Basin "A" and Habersham Park.
- The grate inlets within Habersham Park provide a source of relief for the undersized piping system, allowing runoff to surcharge out of these inlets.
- Furthermore, the grate inlets are not capable of providing drainage relief within the neighborhood.

Sizing and Condition of Channel Lying Between GMS and Habersham Park (Channel "A")

- Channel "A" is overgrown with vegetation (see photo right). Improved maintenance would increase the ability of Channel "A" to pass flow.
- Habersham Park is lower than GMS property. Any spillage out of Channel "A" will spill into Habersham park rather than GMS property.

Lanier Blvd Crossing

- Flow is intended to pass from Channel "A" through a 36" pipe under Lanier Blvd. (Q_{25} = 220 cfs, $Q_{36\text{" pipe}}$ = 47 cfs)
- Culvert is not adequately sized to pass flow from all three drainage basins causing backup into Channel "A" and overtopping of Lanier Blvd.

VIII IDENTIFIED CAPITAL IMPROVEMENT PROJECTS

Based upon coordination with City staff, site reconnaissance, evaluation of previously performed stormwater work, and existing stormwater drainage infrastructure deficiencies, a list of 15 potential CIPs with associated preliminary costs are evaluated for the City's use in establishing future Stormwater Improvement and Operation and Maintenance (O&M) Budgets.

Preliminary costs include approximate engineering and construction fees, but do not include land and easement acquisition or associated legal fees. These costs are subject to change based upon market conditions and the extent of work required determined during the planning and engineering phase of each CIP. Detailed opinion of probable costs of proposed improvements have been included in Appendix K. These CIPs may not include all stormwater related issues throughout the City and are not described in any particular order. Identified CIPs were discussed with City prior to detailed evaluation. Prioritization of potential CIPs are further discussed in detailed in the next section.

A. Albany Street (near F and G Street)

Localized flooding issues along Albany Street between F and G Streets have been documented by the City during periods of heavy rainfall. These flooding issues may be attributed to undersized infrastructure, a lack of infrastructure, and a need for maintenance. Recommended improvements may include, but are not limited to, installation and/or replacement of piping and structures to adequately handle stormwater flow within its specific watershed. Removal and replacement of existing curb and gutter and pavement may also be necessary to properly convey stormwater to recommended infrastructure improvements. Based on preliminary hydrologic and hydraulic analysis of this area of investigation, 24-inch diameter pipes are recommended to handle the 25-year storm.

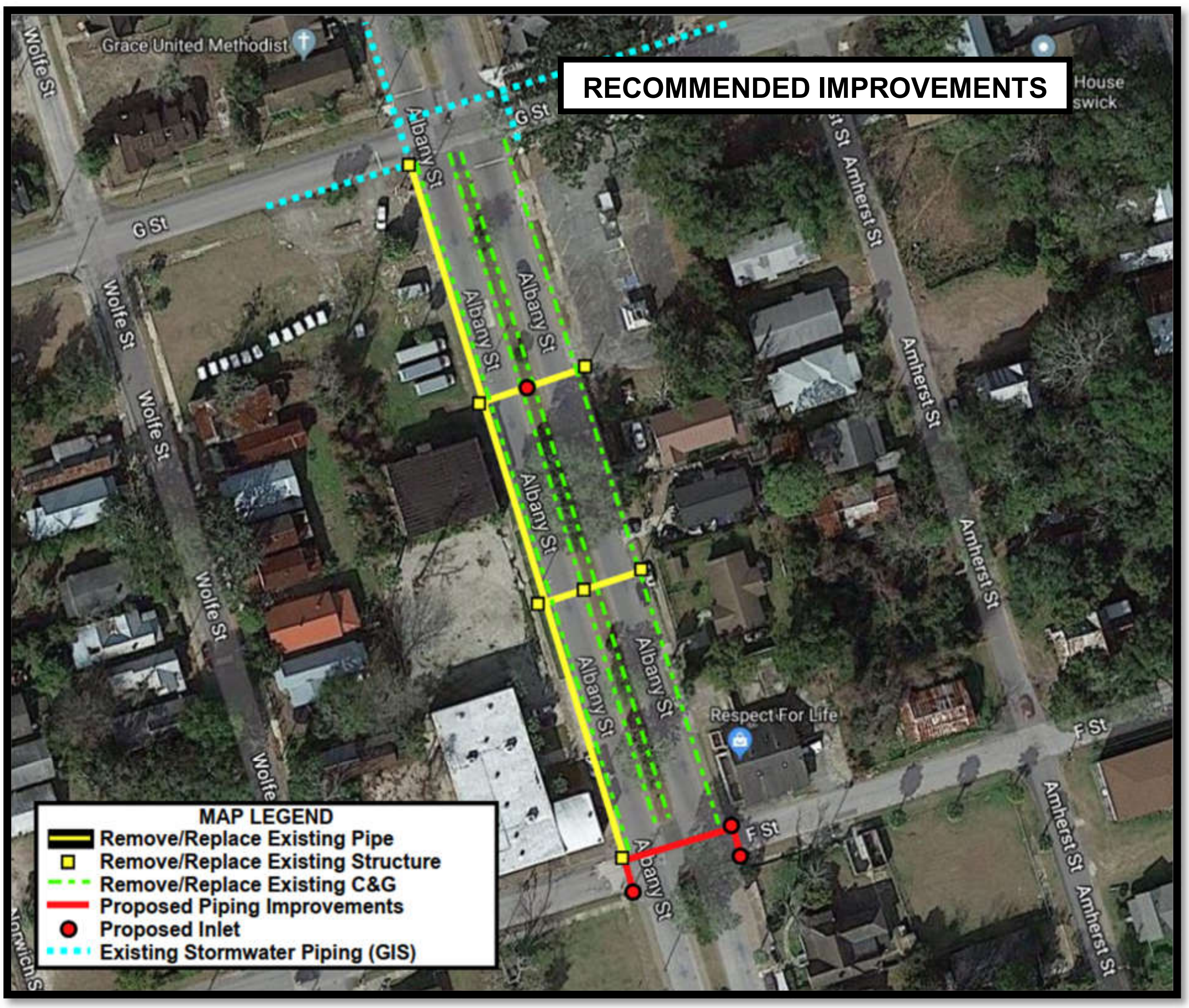

Figure 20: Albany Street (near F and G Street) Recommended Improvements

Preliminary Budgeting Cost

Mobilization/Demobilization		$50,000
Traffic and Pedestrian Control		$10,000
Erosion and Sedimentation Control		$20,000
Grading Complete		$50,000
Storm Drainage Infrastructure		$393,500
Miscellaneous Utility Relocation Allowance		$50,000
	Sub-Total	$573,500
	Contingency (25%)	$143,375
	Engineering (10%)	$71,688
	Total	**$788,563**

B. Parkwood Drive (West End)

Localized flooding issues along the west end of Parkwood Drive have been documented by the City during periods of heavy rainfall. These flooding issues may be attributed to undersized infrastructure, a lack of infrastructure, and a need for maintenance. Recommended improvements may include, but are not limited to, installation and/or replacement of piping and structures to adequately handle stormwater flow within its specific watershed. Removal and replacement of existing curb and gutter and pavement may also be necessary in the R/W adjacent to the Coastal Medical Equipment and Uniforms parking lot in order to properly convey stormwater to recommended infrastructure improvements. Based on preliminary hydrologic and hydraulic analysis of this area of investigation, 24-inch diameter pipes are recommended to handle the 25-year storm.

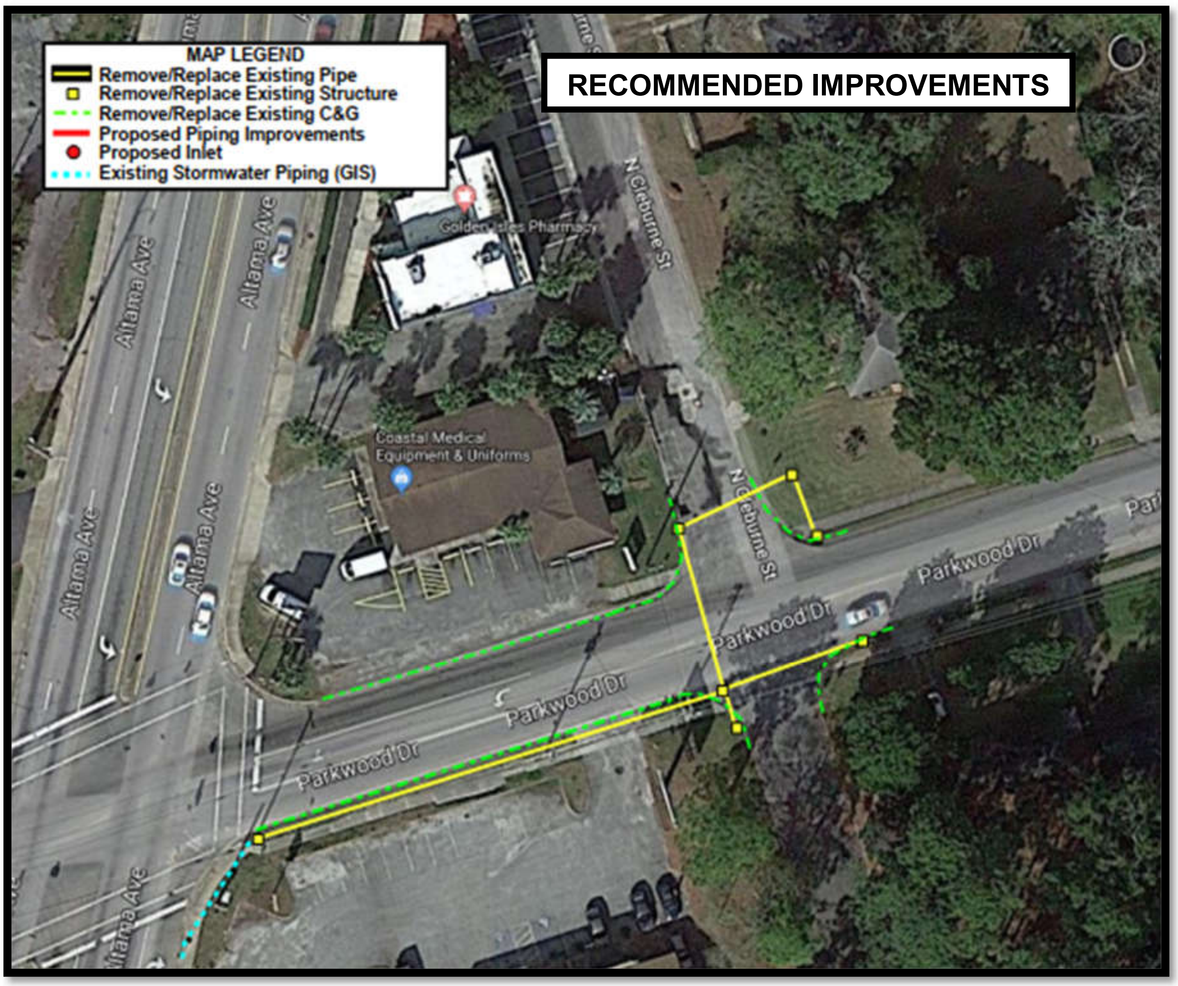

Figure 21: Parkwood Drive (West End) Recommended Improvements

Preliminary Budgeting Cost

Mobilization/Demobilization		$35,000
Traffic and Pedestrian Control		$5,000
Erosion and Sedimentation Control		$15,000
Grading Complete		$40,000
Storm Drainage Infrastructure		$169,475
Miscellaneous Utility Relocation Allowance		$25,000
	Sub-Total	$289,475
	Contingency (25%)	$72,369
	Engineering (10%)	$36,184
	Total	**$398,028**

C. Wildwood Ditch (Near Boxwood Street and Myrtle Avenue)

Known flooding issues exist along the Wildwood Drive ditch system near Boxwood Street and Myrtle Avenue. Additional flooding issues have recently been reported in the areas around the Goodyear Neighborhood Pond. These flooding issues may be attributed to undersized infrastructure, a lack of tide control, an inadequate ditch system, a lack of storage capacity, and a need for maintenance. Based on preliminary hydrologic and hydraulic analysis of this area of investigation, the existing culverts at Lakeside Drive, Willow Avenue, and Wisteria Avenue are inadequate and may need to be replaced. Recommended improvements may include, but are not limited to, installation and/or replacement of piping and structures, installation of tide control, providing ditch improvements, and performing pond improvements to adequately handle stormwater flow within its specific watershed. Recommended ditch improvements between Willow and Wisteria Avenue include the installation of 4" grout filled erosion control mattress to prevent additional erosion and reduce maintenance issues. Based on preliminary hydrologic and hydraulic analysis of this area of investigation, 42-inch diameter pipes have been recommended from Lakeside Drive to Willow Avenue and 54-inch diameter pipes have been recommend from Wisteria Avenue to an existing ditch running along Myrtle Avenue in order to handle the 25-year storm. Specific pond improvements will need to be determined through additional investigation, survey, and system modeling.

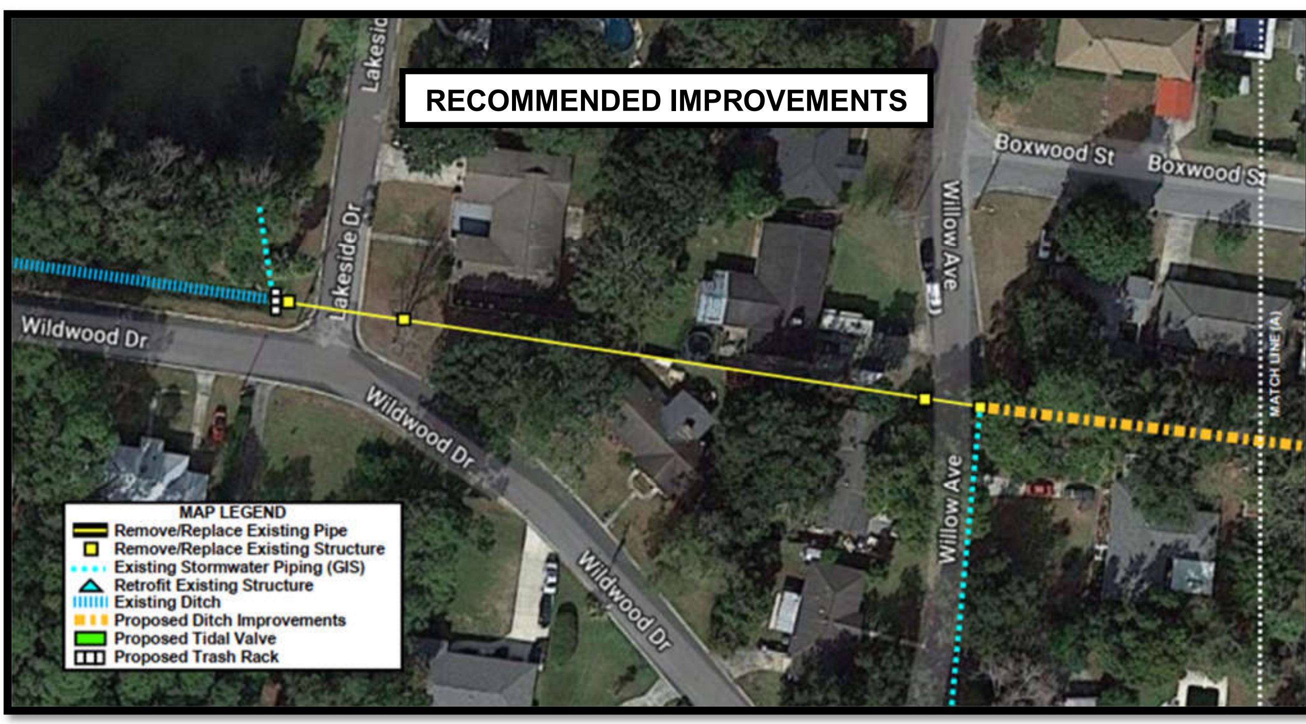

Figure 22: Wildwood Ditch (near Lakeside Dr and Willow Ave) Recommended Improvements

Figure 22: Wildwood Ditch (near Wisteria Ave and Boxwood St) Recommended Improvements

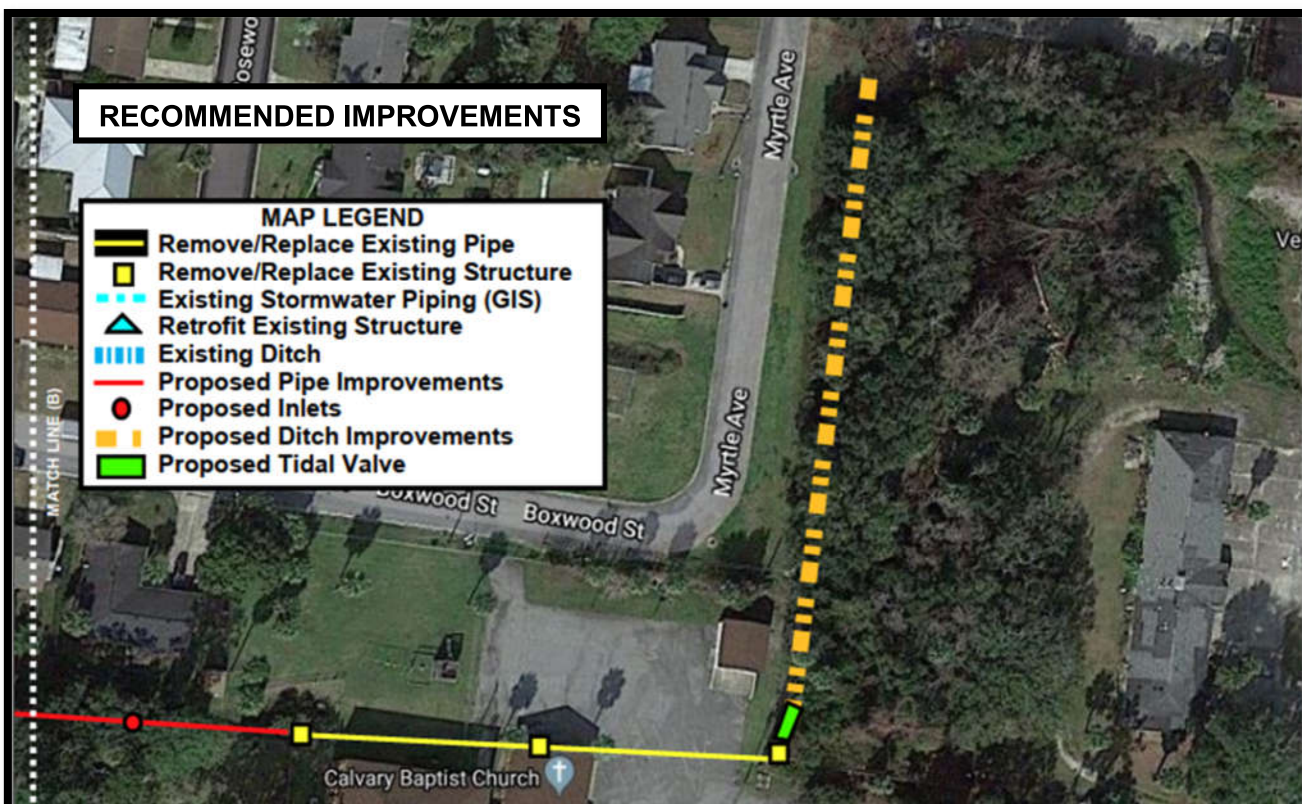

Figure 23: Wildwood Ditch (near Boxwood St and Myrtle Ave) Recommended Improvements

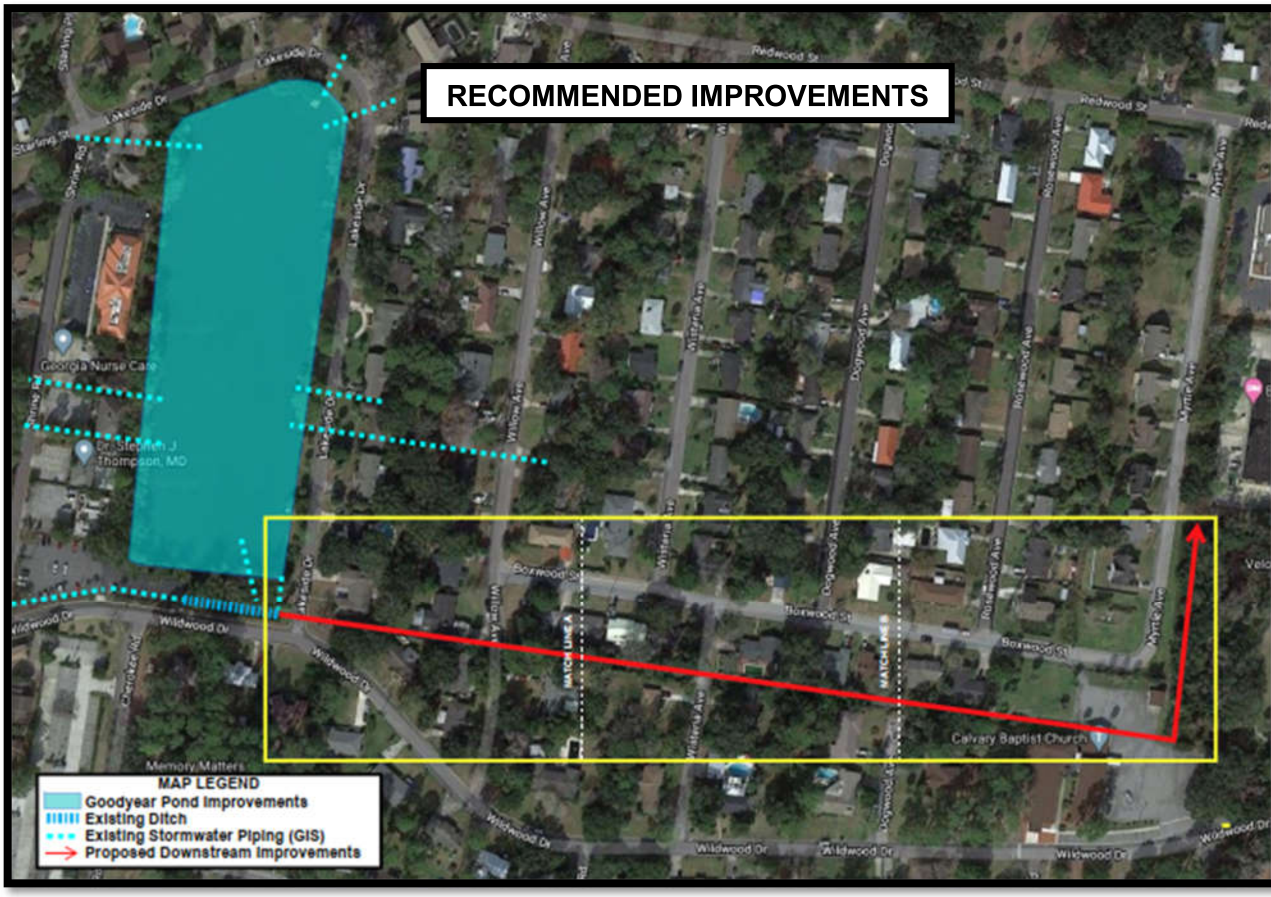

Figure 24: Goodyear Pond Recommended Improvements

Preliminary Budgeting Cost

Mobilization/Demobilization	$100,000
Traffic and Pedestrian Control	$15,000
Erosion and Sedimentation Control	$20,000
Grading Complete	$50,000
Storm Drainage Infrastructure	$546,175
Goodyear Neighborhood Pond Improvements	$250,000
Miscellaneous Utility Relocation Allowance	$35,000
Sub-Total	$1,016,175
Contingency (25%)	$254,044
Engineering (10%)	$127,022
Total	**$1,397,241**

D. Altama Avenue and Second Street

Localized flooding issues at the intersection of Second Street and Altama Avenue have been documented by the City during periods of heavy rainfall. These flooding issues may be attributed to a lack of infrastructure. Recommended improvements may include, but are not limited to, installation of piping and structures to adequately convey stormwater flow to an existing stormwater system. Based on preliminary hydrologic and hydraulic analysis of this area of investigation, 15-inch diameter pipes are recommended to handle the 25-year storm.

Figure 24: Altama Avenue and Second Street Recommended Improvements

Preliminary Budgeting Cost

Mobilization/Demobilization		$35,000
Traffic and Pedestrian Control		$5,000
Erosion and Sedimentation Control		$5,000
Grading Complete		$10,000
Storm Drainage Infrastructure		$52.450
Miscellaneous Utility Relocation Allowance		$25,000
	Sub-Total	$132,450
	Contingency (25%)	$33,113
	Engineering (10%)	$16,556
	Total	**$182,119**

E. Intersection of Macon and Talmadge Avenue

Known flooding issues exist at the intersection of Macon Avenue and Talmadge Avenue during periods of heavy rainfall. These flooding issues may be attributed to inadequately sized infrastructure, a lack of infrastructure tide control, and a need for maintenance. Recommended improvements may include, but are not limited to, installation and/or replacement of piping and structures, installation of curb and gutter along Macon Avenue, and installation of tide control to adequately handle stormwater flow within its specific watershed. Based on preliminary hydrologic and hydraulic analysis of this area of investigation, 24-inch diameter pipes are recommended to handle the 25-year storm.

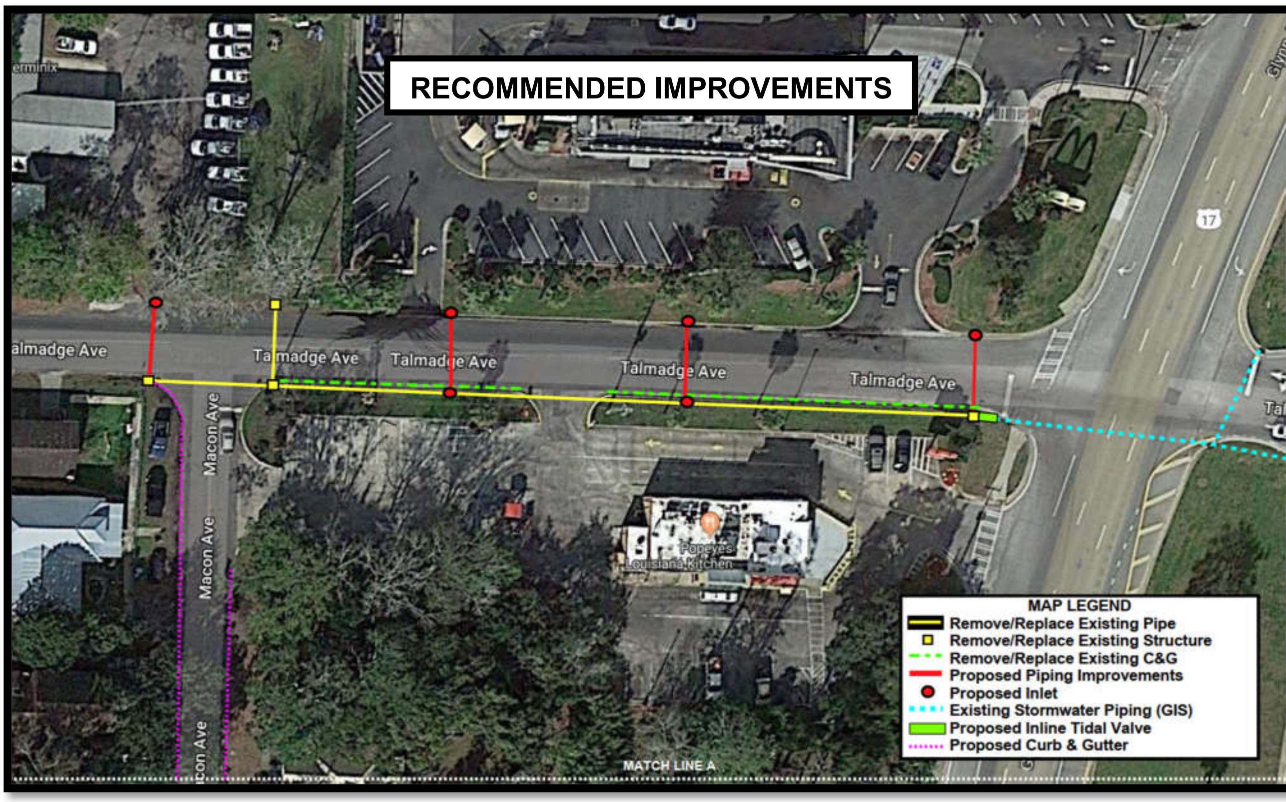

Figure 25: Intersection of Macon and Talmadge Avenue Recommended Improvements

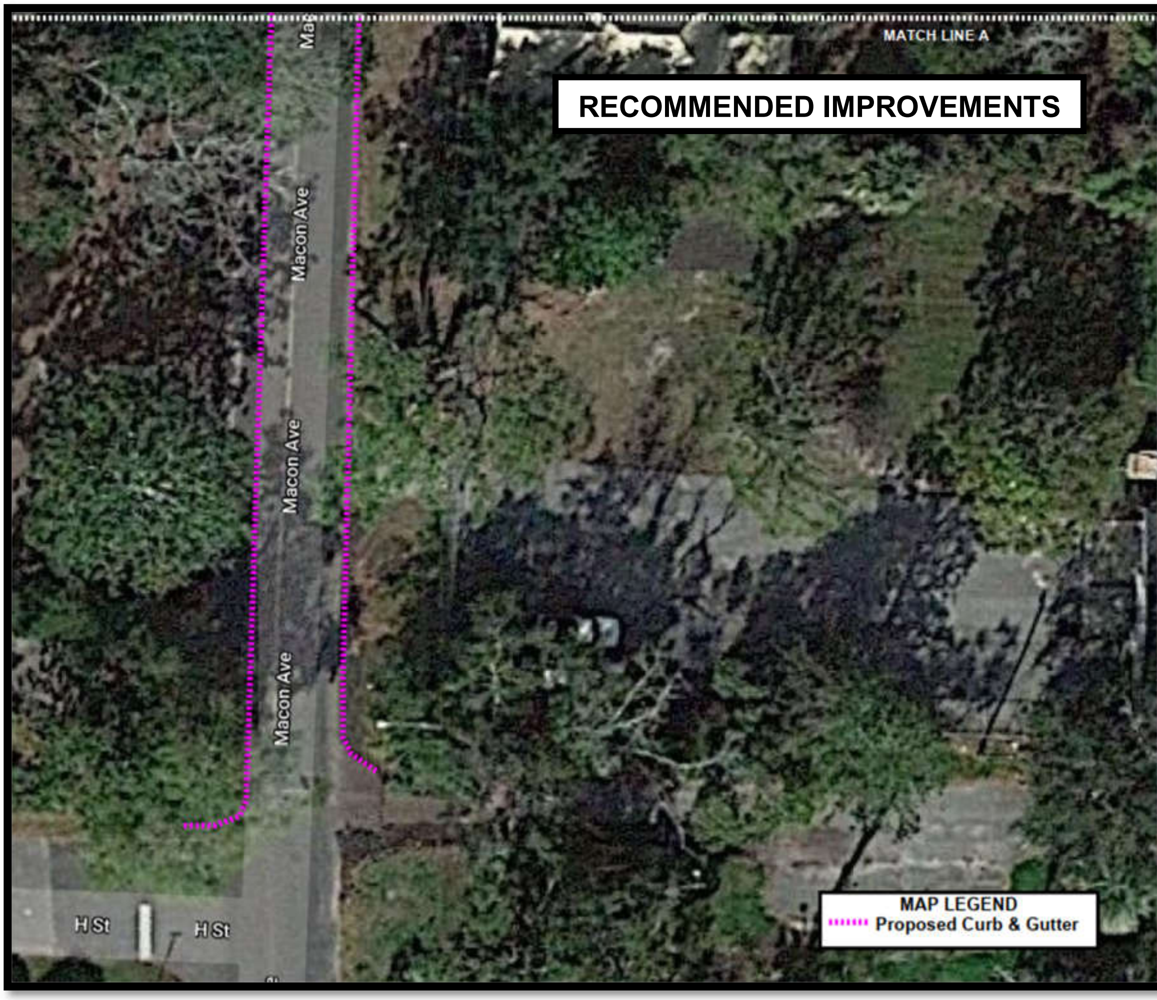

Figure 26: Macon Avenue Recommended Improvements

Preliminary Budgeting Cost

Mobilization/Demobilization	$50,000
Traffic and Pedestrian Control	$5,000
Erosion and Sedimentation Control	$15,000
Grading Complete	$40,000
Storm Drainage Infrastructure	$277,025
Miscellaneous Utility Relocation Allowance	$50,000
Sub-Total	$437,025
Contingency (25%)	$109,256
Engineering (10%)	$54,628
Total	**$600,909**

F. Talmadge Avenue Ditches

Known flooding issues exist along Talmadge Avenue during periods of heavy rainfall. These flooding issues may be attributed to a lack of stormwater infrastructure. Recommended improvements may include, but are not limited to, construction of a ditch system along both sides of the road to adequately convey stormwater flow to an existing stormwater system. Based on preliminary hydrologic and hydraulic analysis of this area of investigation, 18-inch diameter road culverts have been recommended to handle the 25-year storm.

Figure 27: Talmadge Avenue Ditches Recommended Improvements

Preliminary Budgeting Cost

Mobilization/Demobilization	$35,000
Traffic and Pedestrian Control	$10,000
Erosion and Sedimentation Control	$15,000
Grading Complete	$100,000
Storm Drainage Infrastructure	$51,075
Miscellaneous Utility Relocation Allowance	$25,000
Sub-Total	$236,075
Contingency (25%)	$59,019
Engineering (10%)	$29,509
Total	**$324,603**

G. Ports Authority – Tide Control

Existing stormwater issues are more significant in low-lying areas and in areas where the existing stormwater drainage system is affected by tides. Recommended improvements may include, but are not limited to, installation of tide control to adequately handle stormwater flow within each sub-basin. While it would be beneficial to install tide control on every outfall throughout the City, it may not be feasible due to construction permitting, outfall location, and/or overall cost benefit. Based upon available GIS information and/or field verified data, preliminary budget costs are provided for each outfall in the table below. Budget estimates include the Tideflex Inline Check Valve (additional info provided in Appendix J) + Freight, as well as, the installed probable cost (typically ranging from 2 to 3.5 times the valve cost). Due to potential permitting issues and cost, tide control may need to be installed either at the outfall or an upstream location. Additional analysis and design services may be necessary to determine whether the existing outfall or upstream location is adequate to handle the 25-year storm within each sub-basin. In some applications, it may be necessary to utilize alternative tide control technologies based upon the outfall location and design limitations.

<u>Preliminary Budgeting Cost</u>

Ports Authority – Tide Control Budget Costs						
Sub-Basin	**# of Pipes**	**Pipe Size (in)**	**Pipe Material**	**Tide Control**	**Preliminary Budget (Valve + Freight)**	**Preliminary Budget (Installed)**
Dartmouth Street Outfall	1	18*	Clay	None	$ 3,828.00	$ 11,484.00
H Street Outfall*	UNK	UNK	RCP	UNK	$ 50,000.00	$ 150,000.00
Howe Street Outfall	1	60*	RCP	None	$ 55,302.00	$ 165,906.00
M Street Outfall	1	42*	RCP	None	$ 17,076.00	$ 51,228.00
Mansfield Street Outfall	1	54*	RCP	Tidal Valve	$ 50,000.00	$ 150,000.00
Newcastle Street Outfall (West)	1	24*	RCP	None	$ 5,550.00	$ 16,650.00
P Street Outfall	1	18*	RCP	None	$ 3,828.00	$ 11,484.00
Palmetto Outfall*	N/A	N/A	N/A	None	$ 50,000.00	$ 150,000.00
T Street Outfall (Ditch)*	N/A	N/A	N/A	None	$ 50,000.00	$ 150,000.00
W Gloucester Street Outfall*	UNK	UNK	HDPE	None	$ 50,000.00	$ 150,000.00
W Monck Street Outfall	1	48*	CMP	None	$ 26,496.00	$ 79,488.00
W Prince Street Outfall	1	24*	Clay	None	$ 5,550.00	$ 16,650.00
* Assumptions are made for size and associated cost.					*Sub-Total*	$ 1,102,890.00
					Contingency (25%)	$ 275,722.50
					Engineering (10%)	$ 137,861.25
					Total	$ 1,516,473.75

H. Highway 17 - Tide Control

See Section G (Ports Authority – Tide Control) for recommended improvements analysis

Preliminary Budgeting Cost

Highway 17 – Tide Control Budget Costs								
Sub-Basin	**# of Pipes**	**Pipe Size (in)**	**Pipe Material**	**Tide Control**	**Preliminary Budget (Valve + Freight)**		**Preliminary Budget (Installed)**	
Albermarle St / Ocean Ave Outfall	1	30	RCP	None	$	9,816.00	$	29,448.00
Atlanta Avenue Outfall	1	36	RCP	None	$	11,454.00	$	34,362.00
Cook Street Outfall	1	36	RCP	Tidal Gate	-		-	
E Gloucester Street Outfall	1	48	RCP	None	$	26,496.00	$	79,488.00
E Monck Street/ Holly Ave Outfall	1	48	RCP	None	$	26,496.00	$	79,488.00
E Prince Street Outfall	1	7x9	BOX CULVERT	None	-		$	250,000.00
Fourth Street Outfall	1	60	HDPE	None	$	55,302.00	$	165,906.00
I Street Outfall	1	36	RCP	None	$	11,454.00	$	34,362.00
Lanier Boulevard Outfall	1	30	RCP	None	$	9,816.00	$	29,448.00
Lanier Plaza Outfall	1	24	RCP	None	$	5,550.00	$	16,650.00
Lanier Blvd S. of Middle School Outfall	1	30	RCP	None	$	9,816.00	$	29,448.00
Magnolia Park Outfall	1	24	RCP	None	$	5,550.00	$	16,650.00
N Street Outfall*	UNK	UNK	UNK	None	$	50,000.00	$	150,000.00
Newcastle Street Outfall (South)	2	36	RCP	Tide Gates	-		-	
Norwich Street Outfall (Ditch)*	N/A	N/A	N/A	None	$	50,000.00	$	150,000.00
Parkwood Drive Outfall	2	36	RCP	Twin Tide Gates	-		-	
Talmadge Avenue Outfall	1	18	RCP	None	$	3,828.00	$	11,484.00
Talmadge Ave & Macon Ave Outfall	1	18	RCP	None	$	3,828.00	$	11,484.00
Wildwood Drive Outfall	1	48	RCP	None	$	26,496.00	$	79,488.00
					Sub-Total		$	1,167,706.00
					Contingency (25%)		$	291,926.50
					Engineering (10%)		$	145,963.25
					Total		$	1,605,595.75

* Assumptions are made for size and associated cost.

I. P Street Basin

The existing storm sewer system was installed in the "N" Street and "P" Street basins in the late 1960's and early 1970's. Over the last fifty years, this system has become inadequate, deteriorated, and maintenance prone. Due to the scope of improvements required to address those issues, the *"N" St. Storm Drainage Improvements* project was divided into four (4) phases of work. The first two (2) phases of work were completed in February 2009.

Phase I was constructed as a 24" PVC bypass from Davis Road to the Lanier Plaza storm drainage system to the south. Phase II was constructed to handle stormwater runoff and replace stormwater infrastructure within the "N" Street basin that had deteriorated from Pinova property to MLK Jr. Blvd. Phase II construction divided the "N" Street basin into the "N" Street and "P" Street Basins.

Phases III and IV were designed but were not constructed due to inability to secure easements from Pinova. Phase III construction consists of 54" RCP storm sewer running east through the north part of the property to a concrete headwall. Phase III construction was designed to handle stormwater runoff from Phase IV construction within the "P" Street Basin and route it through the Pinova property to the existing outfall. Phase IV construction is summarized as a system of varying pipe sizes on multiple streets within the "P" Street Basin routing stormwater runoff to a main trunk line that will be connected to the 54" RCP storm sewer constructed in Phase III.

Since the property is now owned by Pinova, it is recommended that the City revisit easement discussions with them to determine the feasibility of completing Phases III and IV of the *"N" Street Storm Drainage Improvements.* If easements can be secured, it is recommended that the previously completed plans be updated to meet current permitting and erosion and sedimentation control requirements. Additional design changes may also be necessary based on recently completed improvements within each sub-basin and/or the inability to acquire necessary easements for the existing design.

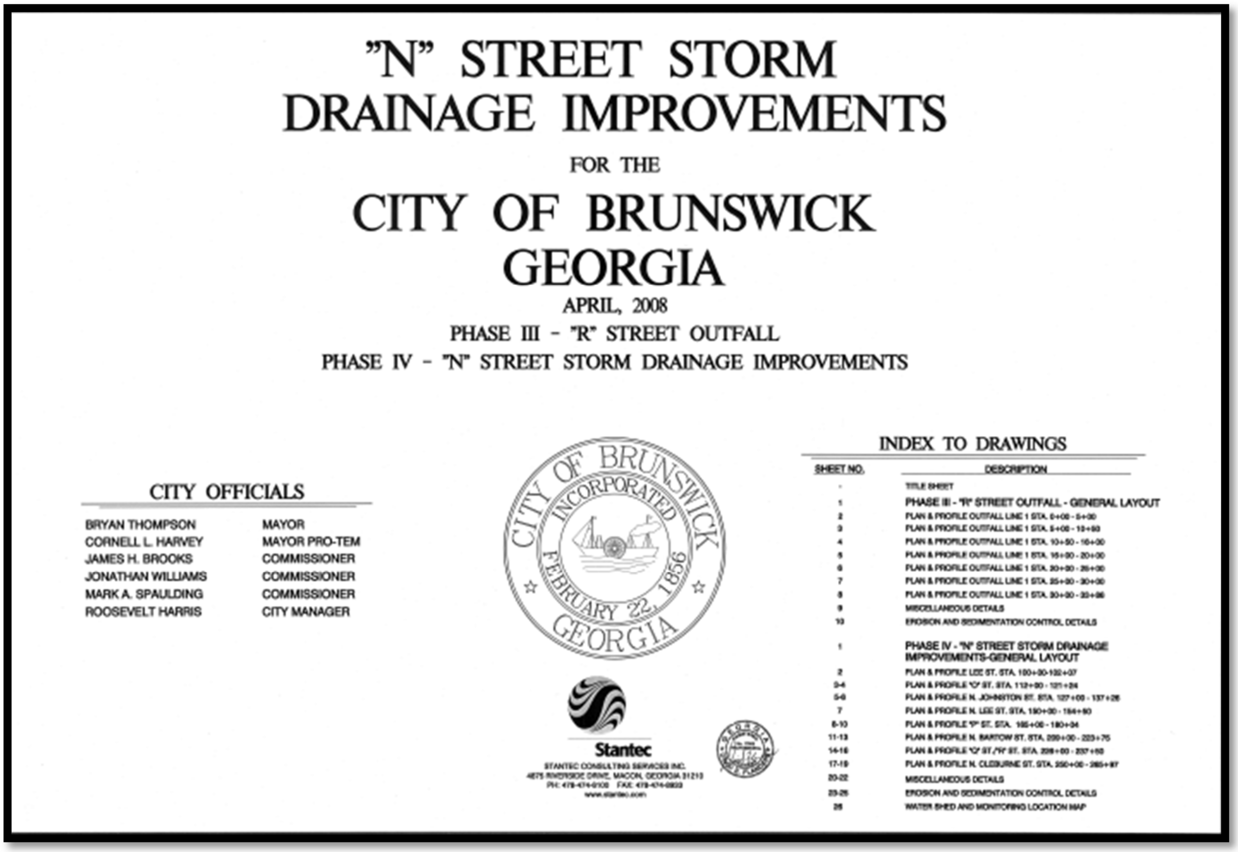

Figure 28: "N" Street Storm Drainage Improvements Phase III & IV Plans

<u>Preliminary Budgeting Cost</u>

Mobilization/Demobilization		$250,000
Traffic and Pedestrian Control		$100,000
Erosion and Sedimentation Control		$80,000
Grading Complete		$200,000
Storm Drainage Infrastructure		$3,755,510
Miscellaneous Utility Relocation Allowance		$100,000
	Sub-Total	$4,485,510
	Contingency (25%)	$1,121,378
	Engineering (10%)	$560,689
	Total	**$6,167,576**

J. Magnolia Park Outfall to Fairgrounds

Recent projects within the Magnolia Park neighborhood have been designed to address known flooding issues; however, down-gradient infrastructure improvements have not been addressed. Flow from the Magnolia Park basin conveyed under Altama Avenue and along Emory Dawson Parkway (Community Action Drive) to three (3) existing 60" RCPs. Based on evaluating previously completed hydrologic and hydraulic analysis, the existing infrastructure is undersized to handle the 25-year storm without tide control. Recommended improvements may include, but are not limited to, installation of tide control and trash racks on all three (3) existing 60" RCPs as well as the adjacent 48" RCP to adequately handle stormwater flow and reduce tailwater conditions that negatively impact the Magnolia Park Basin. Inline check valves are the recommended form of tide control in this application.

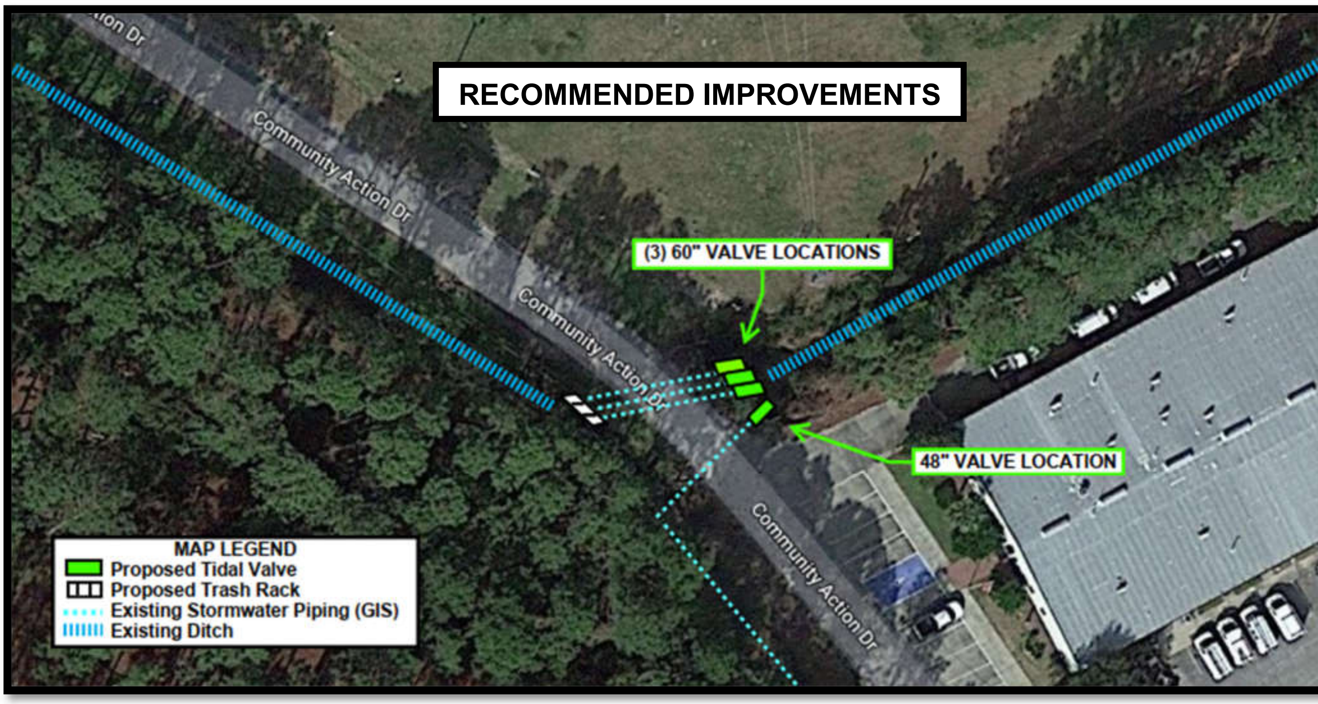

Figure 29: Magnolia Park Outfall to Fairgrounds Recommended Improvements

Preliminary Budgeting Cost

Mobilization/Demobilization		$50,000
Traffic and Pedestrian Control		$1,500
Erosion and Sedimentation Control		$5,000
Grading Complete		$5,000
Storm Drainage Infrastructure		$599,706
Miscellaneous Utility Relocation Allowance		$10,000
	Sub-Total	$671,206
	Contingency (25%)	$167,802
	Engineering (10%	$83,901
	Total	**$922,908**

K. Lanier Boulevard at GMS

Known flooding issues exist along Lanier Boulevard near GMS during periods of heavy rainfall and high tides. These flooding issues may be attributed to low roadway elevation, undersized infrastructure, a lack of infrastructure, a lack of tide control, and a need for maintenance. Recommended improvements may include, but are not limited to, installation and/or replacement of piping and structures, raising the elevation of Lanier Bvd by approximately three (3) feet, and enhancing existing drainage swales to adequately handle stormwater flow within its specific watershed. Tide control was not recommended due to the area's relative location to the marsh, the potential construction permitting issues, and the current elevation of the roadway. Based on an evaluation of previous hydrologic and hydraulic analysis of this area of investigation, the following stormwater pipe sizes have been recommended along Lanier Boulevard to handle the 25-year storm:

- Replacing 36" pipe under Lanier Blvd passing runoff from Channel "A" to the marsh between Lanier Blvd. and Highway 17 with two (2) 54" pipes ($Q_{54\text{" Pipe}}$ = 140 cfs each)
- Replacing four (4) GMS entrance culverts with 36" pipes (currently 15-18")
- Replacing 18" pipe under Lanier Blvd in front of GMS with a 54" pipe
- Replacing two (2) 36" pipes under Lanier Blvd passing runoff from GMS to the marsh, east of the existing stormwater pond with two (2) 54" pipes ($Q_{54\text{" Pipe}}$ = 140 cfs each)
- Adding an additional 36" pipe to the four (4) existing 36" pipes under Lanier Boulevard to the north of 4th Avenue, increasing Q_{25} to 235 cfs

Figure 30: Lanier Boulevard at GMS Recommended Improvements

Figure 31: Lanier Boulevard at GMS Recommended Improvements

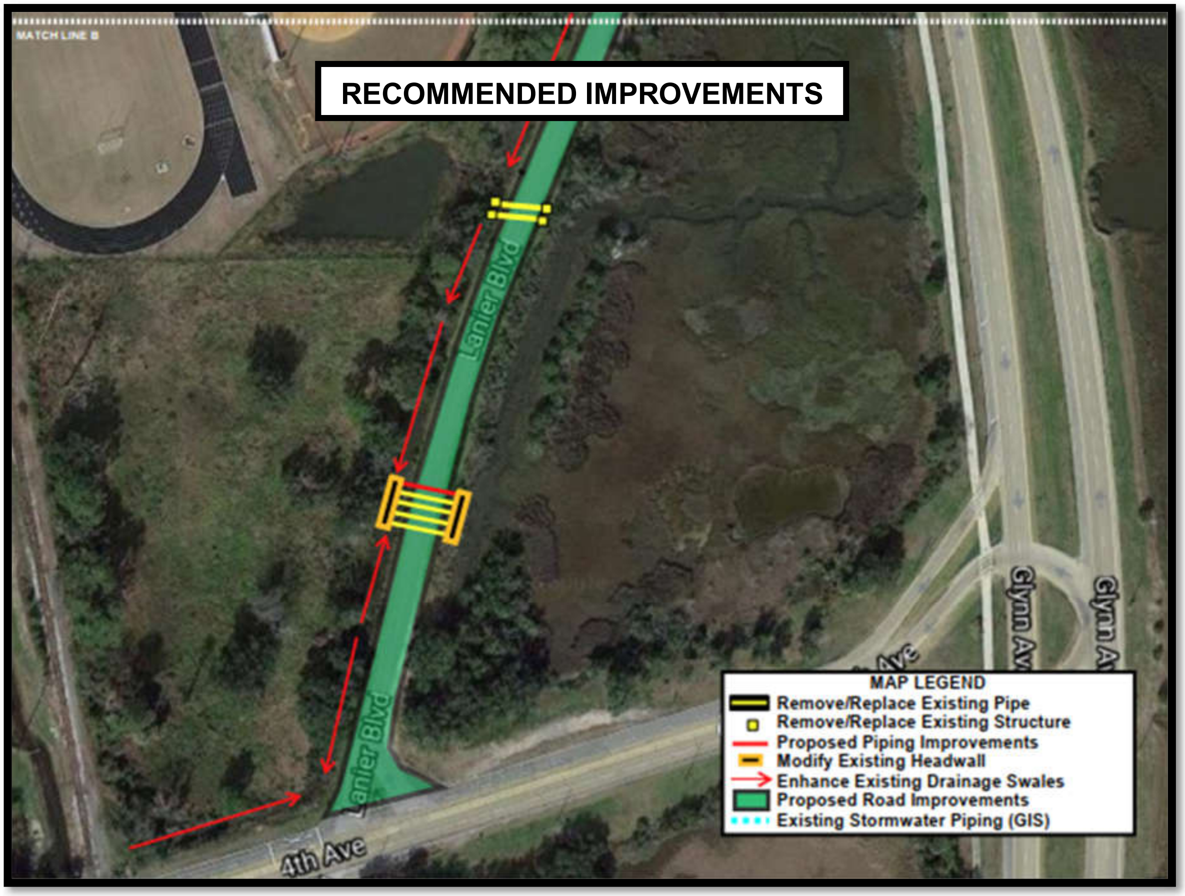

Figure 32: Lanier Boulevard at GMS Recommended Improvements

<u>Preliminary Budgeting Cost</u>

Mobilization/Demobilization		$200,000
Traffic and Pedestrian Control		$100,000
Erosion and Sedimentation Control		$50,000
Grading Complete		$400,000
Storm Drainage Infrastructure		$807,125
Miscellaneous Utility Relocation Allowance		$75,000
	Sub-Total	$1,632,125
	Contingency (25%)	$408,031
	Engineering (10%)	$204,016
	Total	**$2,244,172**

L. Habersham Park

Known flooding issues exist along Lanier Boulevard near GMS and in the Habersham Park areas during periods of heavy rainfall. These flooding issues may be attributed to undersized infrastructure, a lack of infrastructure, a lack of tide control, and a need for maintenance. In order to alleviate capacity issues along Lanier Boulevard and the existing storm drainage system within Habersham Park, it is recommended to route runoff from Contributing Basin "A" (identified in hydrologic and hydraulic analysis of area) towards drainage infrastructure to the south along MLK Jr. Blvd and under Lanier Blvd. This not only improves conditions within Habersham Park, but also provides a benefit to a greater part of the southwest Brunswick Peninsula. Recommended improvements may include, but are not limited to, installation and/or replacement of piping and structures and enhancing existing drainage swales to adequately handle stormwater flow within its specific watershed. Based on an evaluation of previous hydrologic and hydraulic analysis of this area of investigation, the following pipe sizes have been recommended to handle the 25-year storm:

- Replacing 36" CMP under abandoned railroad track with three (3) 54" pipes ($Q_{42\text{" Pipe}}$ = 70 cfs each)
- Installing three (3) 54" pipes ($Q_{42\text{" Pipe}}$ = 70 cfs each) under 4th Avenue, connecting Contributing Basin "A" with 15+ acres of new stormwater detention

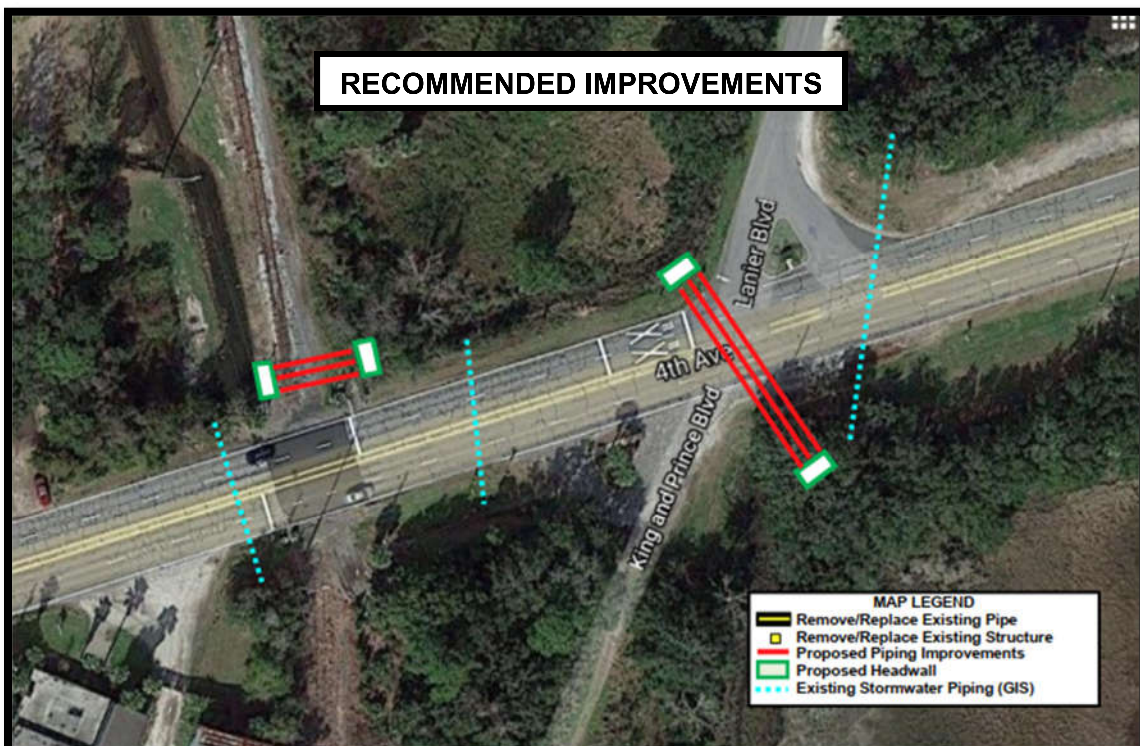

Figure 33: Habersham Park Recommended Improvements

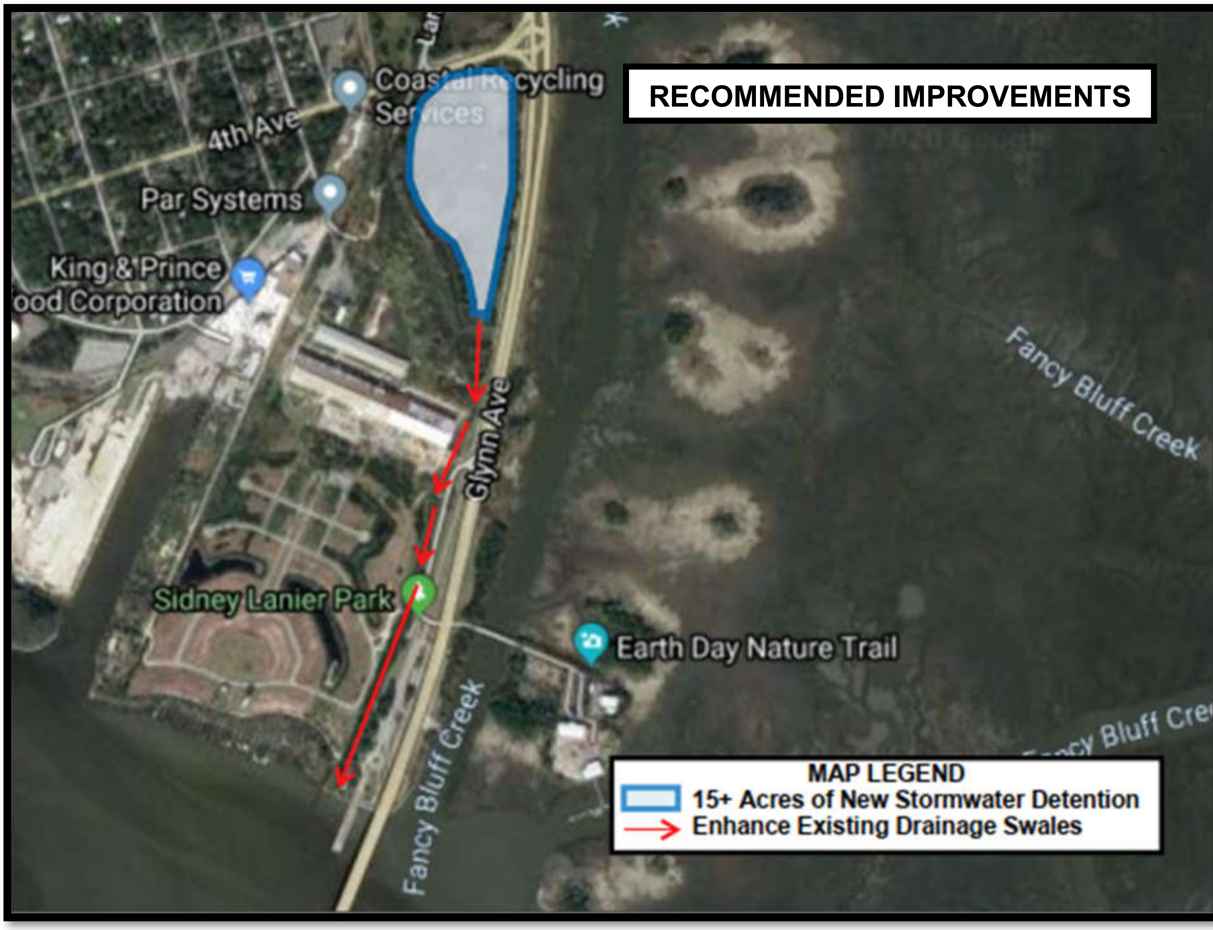

Figure 34: Habersham Park Recommended Improvements

<u>Preliminary Budgeting Cost</u>

Mobilization/Demobilization		$50,000
Traffic and Pedestrian Control		$25,000
Erosion and Sedimentation Control		$25,000
Grading Complete		$50,000
Storm Drainage Infrastructure		$312,750
Miscellaneous Utility Relocation Allowance		$25,000
		$25,000
	Sub-Total	$487,750
	Contingency (25%)	$121,938
	Engineering (10%)	$60,969
	Total	**$670,656**

M. Urbana Neighborhood at Atlanta Avenue

Known flooding issues exist along Atlanta Avenue at multiple intersections, during periods of heavy rainfall. These flooding issues may be attributed to undersized infrastructure, a lack of infrastructure, and a need for maintenance. Recommended improvements may include, but are not limited to, installation and/or replacement of piping and structures, and improved maintenance to adequately handle stormwater flow within its specific watershed. Additionally, it is recommended that Atlanta Avenue eventually be milled down and repaved to match the gutter line elevation in order to reduce maintenance issues and improve positive drainage. Based on preliminary hydrologic and hydraulic analysis of this area of investigation, the following pipe sizes have been recommended for each intersection with Atlanta Avenue to handle the 25-year storm:

- Tillman Avenue Intersection – 30"
- Niles Avenue Intersection – 30"
- Goodyear Avenue Intersection – 30"
- Wilson Avenue Intersection – 18"

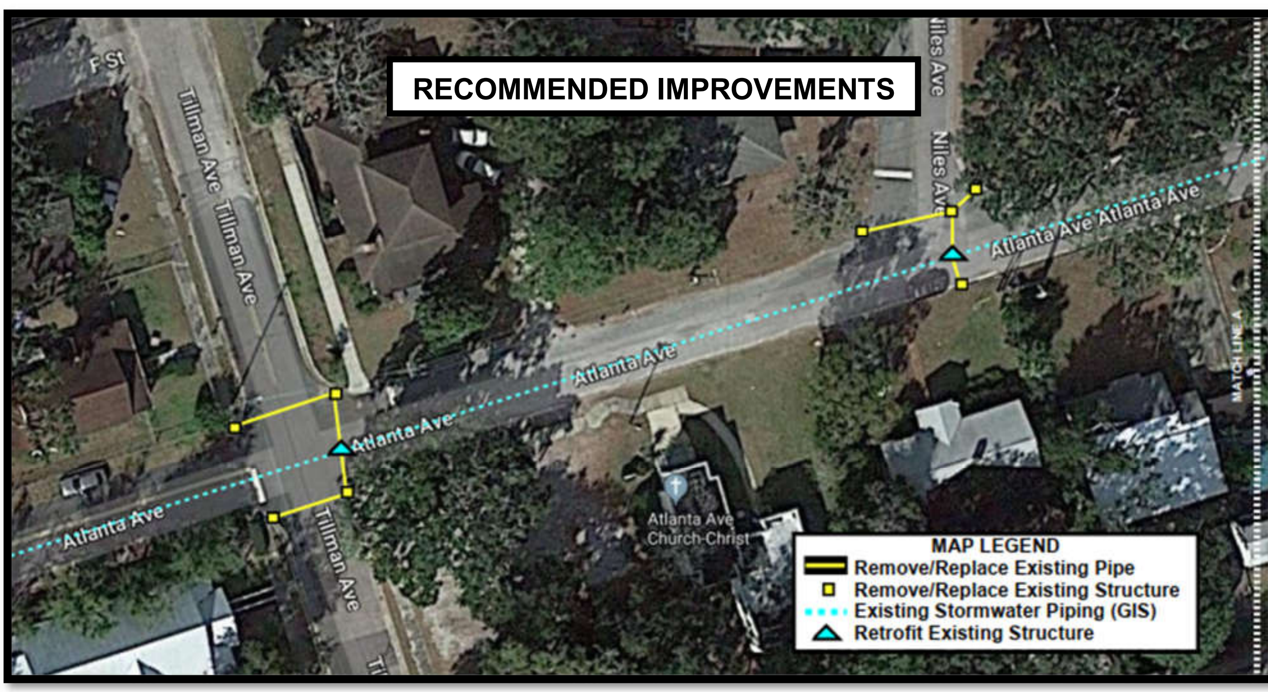

Figure 35: Atlanta Avenue Recommended Improvements

Figure 36: Atlanta Avenue Recommended Improvements

<u>Preliminary Budgeting Cost</u>

Mobilization/Demobilization		$50,000
Traffic and Pedestrian Control		$15,000
Erosion and Sedimentation Control		$15,000
Grading Complete		$20,000
Storm Drainage Improvements		$190,600
Miscellaneous Utility Relocation Allowance		$100,000
	Sub-Total	$390,600
	Contingency (25%)	$97,650
	Engineering (10%)	$48,825
	Total	**$537,075**

N. Riverside Neighborhood

Known flooding issues exist within the Riverside Neighborhood during periods of heavy rainfall and/or high tides. These flooding issues may be attributed to undersized infrastructure, a lack of infrastructure, a lack of tide control, its' low-lying elevation, and its relative location to the surrounding marsh. Recommended improvements may include, but are not limited to, installation and/or replacement of piping and structures and installation of tide control to adequately handle stormwater flow within its specific watershed. Based on preliminary hydrologic and hydraulic analysis of this area of investigation, 18-inch diameter pipes have been recommended for the Wassau Island Circle improvements to handle the 25-year storm. Additionally, TideFlex TF-1 Check Valves (Appendix J) have been recommended for the nine (9) outfalls identified below. Due to its' low-lying elevation, the lack of area available for storage capacity, and the relatively high cost for minimal drainage improvements, the Riverside Neighborhood will continue to be susceptible to flooding in certain areas unless significant improvements are made not only by the City, but by homeowners as well.

Figure 37: Riverside Neighborhood Recommended Outfall Improvements

Figure 38: Riverside Neighborhood Recommended Improvements

<u>Preliminary Budgeting Estimate</u>

Mobilization/Demobilization		$50,000
Traffic and Pedestrian Control		$10,000
Erosion and Sedimentation Control		$60,000
Grading Complete		$75,000
Installation		$255,400
Miscellaneous Utility Relocation Allowance		$50,000
	Sub-Total	$500,400
	Contingency (25%)	$125,100
	Engineering (10%)	$62,550
	Total	**$688,050**

O. GIS Inventory Collection

Multiple attributes within the City's GIS database are considered deficient. The City maintains its GIS database and GMC is in the process of updating it for the City's MS4 Permit. While some GIS attribute deficiencies may be addressed during the update, it is recommended to overhaul the existing database by mapping all system attributes at survey grade accuracy. Going forward, the GIS could serve as an asset management and analysis tool for the City to track a wide range of stormwater drainage system information including maintenance, repairs, complaints, CIPs, and verified details about all system components. For this system to function effectively, regular management and maintenance will be required. Recommended maintenance would include annual system updates and monthly database maintenance. Annual updates are necessary to ensure the database is accurate, and all aspects/attributes of the system are up to date.

Overhauling the existing database with survey grade accuracy may include the following:

- Field collection of stormwater infrastructure data using sub-meter survey grade technology
- Data conversion from paper, CAD, aerial photography, and other records
- Update existing GIS database with collected data for the following identified attributes:
    - **Streams / Rivers / Ditches** – top of bank and invert elevation
    - **Stormwater Outfalls** - outfall type, size, condition, invert elevation, material, photograph, maintenance record, etc.
    - **Stormwater Structures** - type, size, condition, top and invert elevations, material, photograph, maintenance record, flood complaints, year of construction, or other related attributes.
    - **Stormwater Detention** - inlet size, outlet size, type, condition, elevations, material, storage capacity, photographs, maintenance records, or year of construction, or other related attributes.
    - **Pipes / Conveyance** - pipe location, size, material, directional flow, slope, depth, invert elevation, condition, adequacy, maintenance records, year of construction, and other related attributes.
    - **Watersheds / Drainage Basins**

Preliminary Budgeting Estimate

Field Collection of Stormwater Infrastructure Data (Survey Grade)	$400,000
Data Conversion	$75,000
Update Existing GIS Database	$125,000
Sub-Total	$600,000
Contingency (25%)	$150,000
Engineering (10%)	$75,000
Total	**$750,000**

IX CAPITAL EQUIPMENT AND STAFFING NEEDS

As identified in multiple areas of investigation throughout this report, the need for maintenance is a recurring issue for an inadequate, deteriorated, and failed stormwater drainage system that is over 50 years old in some areas. The City has identified a long list of projects, this report has identified and added to that list, and with each major storm event new issues arise. While each of these identified CIPs must be addressed, it is also necessary for the City to implement a maintenance program that will allow them to be proactive with repairs and reduce the number of additional projects that may be added to the list in the future.

In order to respond quickly to identified problems, it is necessary for the City to be equipped with the necessary equipment and trained operators to do so. The ability to address small jobs in-house creates efficiency, avoiding contract and scheduling delays as well as mobilization costs. Additionally, the in-house capability to perform more frequent inspection and maintenance activities may reduce potential contracted services to perform similar activities at an increased cost. Currently, the City uses the following list of equipment to perform maintenance activities and complete small jobs in-house:

- Excavator
- Mini excavator
- Front-end loader (2)
- Track loader
- Dump truck
- Flatbed dump truck
- Street sweeper (2)
- Vacuum truck
- Camera trailer
- Pickup trucks (2)

While this list of equipment can perform maintenance activities and some in-house small projects, additional equipment is needed to address the growing number of stormwater issues around the City due to the aging infrastructure. Proper maintenance of stormwater inlets, pipe conveyances, and outlet structures is crucial in thwarting flood related risks during storm events. Cleaning streets, bike lanes, sidewalks, gutters, and other paved areas is important preventative maintenance to allow the City's stormwater system to function properly. Finally, the ability to complete more small projects in-house will allow the City to be proactive with repairs and reduce the number of emergency projects. The following list of capital equipment is recommended and/or identified by the City as needed to address these issues:

(1) An additional combination vacuum truck and catch basin cleaner is recommended to provide adequate maintenance.
(2) An additional sweet sweeper is recommended to increase the City's ability to perform needed maintenance activities.
(3) An additional excavator and mini excavator are recommended to improve the City's ability to complete more small projects in-house.
(4) The City has identified a need for a front-end loader, a new Closed-Circuit Television (CCTV) vehicle, a new truck with a trailer, and a new dump truck to improve maintenance activities and the ability to complete in-house projects.

(5) Additional supporting tools such as an air compressor, plugs, bypass pumping, sump pumps, etc. may also be necessary depending upon project scopes and City needs.

While the City will continuously need to replace aging equipment and employ trained operators to perform on-going maintenance activities, the additional equipment listed above will allow the City to better address maintenance issues that are prevalent in each of the CIPs mentioned above. Purchasing used models may reduce cost by up to 50%. Prioritizing equipment purchases and staffing additions is recommended as funds are available.

<u>Preliminary Budgeting Estimate</u>

Equipment Description	Range
Combination Vacuum Truck and Catch Basin Cleaner	$250,000 - $400,000
Street Sweeper	$200,000 - $300,000
Medium Sized Excavator (15 to 20 tons)	$100,000 - $200,000
Mini Excavator	$30,000 - $50,000
Front End Loader	$100,000 - $200,000
CCTV Vehicle/Trailer	$200,000 - $300,000
F450 Truck (or equal)	$50,000 - $75,000
Trailer (20 ft Gooseneck, Tandem Axle)	$15,000 - $30,000
Dump Truck	$100,000 - $150,000
Additional Supporting Equipment	$250,000
Sub-Total	$1,295,000 - $1,955,000
Total	$1,295,000 - $1,955,000

In addition to the recommended/needed list of equipment, staffing to operate and maintain this equipment is also a necessity. Based on the on-going need for maintenance of the City's aging stormwater drainage system and the potential ability of performing small in-house projects with additional equipment, a synchronized increase in staffing is recommended as new equipment purchases are made.

X PRIORITIZATION

Prioritization provides the City a method for implementing the stormwater drainage improvements in a responsible and justifiable manner. It is important to identify the elements that have the greatest impact for improved stormwater drainage. Prioritization for recommended improvements is based on justifiable and quantifiable evidence of the existing stormwater conveyance infrastructure. Evidence of known flooding issues provided by the City is reviewed and engineering judgments applied in determining the final improvement rankings.

Prioritization of recommended improvements is based on a point value scale for five (5) parameters relating to the existing stormwater conveyance infrastructure. Priority points provide a quantifiable ranking system, which is used to make a value-based judgment on sub-basins having the greatest stormwater related needs. If the existing infrastructure within an identified CIP qualifies for a parameter category, the CIP receives the total point value for that stormwater related parameter. Each CIP receives a priority point total.

The point value scale and parameters are defined as follows:

Parameter	Priority Point Value
Current Flooding Issue (Street, Yard, Building)	5
Undersized Piped Sewer/Culvert Infrastructure	4
Lack of Infrastructure	3
Tide Control Issue/Non-Existent	2
Maintenance Issue	1

Refer to Table 5 for a summary of priority point totals for recommended improvements.

Table 5: CIP - Recommended Improvements Prioritization						
CIP	Prioritization Parameters					Priority Points Total
	Localized Flooding (Yards, Building, Street)	Undersized Infrastructure	Lack of Infrastructure	Tide Control Issue	Maintenance Issue	
A	5	4	3	0	1	13
B	5	4	0	0	1	10
C	5	4	0	2	1	12
D	5	0	3	0	0	8
E	5	4	3	2	1	15
F	5	0	3	0	0	8
G	5	4	0	2	1	12
H	5	4	0	2	1	12
I	5	4	3	0	1	13
J	0	0	0	2	0	2
K	5	4	0	2	0	11
L	5	0	3	2	0	10
M	5	4	3	0	1	13
N	5	4	3	2	0	14
O	0	0	0	0	1	1

Prioritization of recommended improvements must also consider engineering judgment, which is not completely based on a quantitative point system. For the purpose of this master plan, engineering judgment not only considers priority points per CIP, but also the size of CIP, the preliminary opinion of probable cost, and the impacts of recommended improvements per CIP. These parameters give insight to the positive impacts made to each CIP regarding stormwater drainage improvements.

CIPs that require immediate improvements regarding flooding issues are given the highest priority; therefore, improvements in these CIPs have the greatest impact for the City. CIPs that require improvements, but are not considered immediate, are given a lower level of priority; therefore, improvements have moderate impacts in the City. By contrast, CIPs addressing localized flooding issues in a small area are given low priority.

Taking into consideration all the priority point totals and engineering judgment parameters, recommended improvements are logically and justifiably ranked. Refer to Table 1 for the final ranking for recommended improvements within the City using engineering judgment in conjunction with results in Table 6. Recommended improvements are ranked 1 through 15 in order of importance (1 – greatest impact and 15 – least impact).

Table 6: CIP - Recommended Improvements Prioritization

CIP	Engineering Judgment Prioritization Parameters				Final Recommended Improvement Ranking
	Project Description	**Priority Points**	**Preliminary Budgetary Cost**	**Opinion of CIP Improvement Impact**	
A	Albany Street (near F and G St)	13	$790,000	High	1
B	Parkwood Drive (West End)	10	$400,000	Moderate	9
C	Wildwood Ditch (near Boxwood St & Myrtle Ave)	12	$1,400,000	High	4
D	Altama Avenue and Second Street*	8	$180,000	Low	7
E	Intersection of Macon & Talmadge Ave	15	$600,000	High	2
F	Talmadge Avenue Ditches*	8	$325,000	Low	8
G	Ports Authority - Tide Control	12	$1,515,000	Moderate	11
H	Highway 17 Tide Control	12	$1,605,000	High	5
I	P Street Basin	13	$6,170,000	Moderate	10
J	Magnolia Park Outfall to Fairgrounds	2	$925,000	Low	15
K	Lanier Boulevard at GMS	11	$2,245,000	High	6
L	Habersham Park	10	$670,000	Moderate	12
M	Urbana Neighborhood at Atlanta Avenue	13	$535,000	Low	14
N	Riverside Neighborhood	14	$690,000	High	3
O	GIS Inventory Collection	1	$750,000	Moderate	13

*Potential in-house projects to be completed by City resources

XI "IN-HOUSE" STORMWATER IMPROVEMENT PROJECTS (SHORT TERM)

As mentioned in Section IX, the ability to complete short-term stormwater improvements as "in-house" projects creates efficiency, avoids contract and scheduling delays as well as mobilization costs, and will allow the City to be proactive with repairs and reduce the number of emergency project. Based on the City's capabilities, two (2) CIP's have been identified that may be accomplished by City crews as "in-house" projects. These CIP's include:

CIP F - Talmadge Avenue Ditches ~ $325,000

Recommended improvements may include, but are not limited to, construction of a ditch system along both sides of the road to adequately convey stormwater flow to an existing stormwater system.

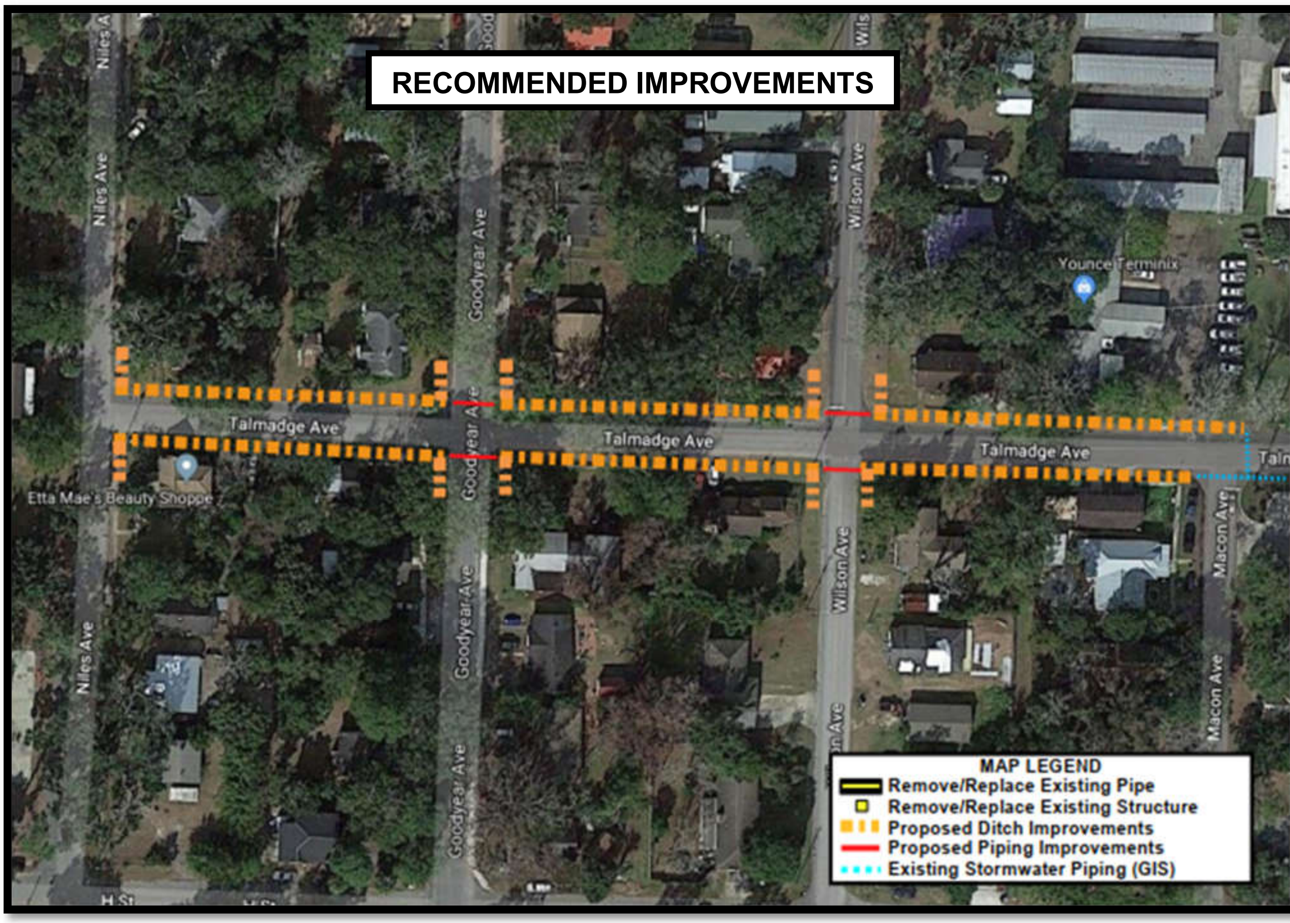

Figure 39: Talmadge Avenue Ditches Potential "In-House" Project

CIP D - Altama Avenue and Second Street ~ $180,000

Recommended improvements may include, but are not limited to, installation of piping and structures to adequately convey stormwater flow to an existing stormwater system.

Figure 40: Altama Avenue and Second Street Potential "In-House" Project

Additional "In-House" Projects

While only two (2) complete "in-house" projects have been identified, the City also has the capability to complete some improvements identified in each of the CIP's that may reduce existing flooding issues in certain areas and decrease the possibility of emergency projects. These improvements may include additional maintenance, installation of tide control in flood prone areas, and/or installation of erosion control measures. As capital equipment and staffing needs are addressed, the capability of City crews to complete additional "in-house" projects and perform proactive maintenance should increase.

Program Objectives

- Maintain pipes, street drains, roadside ditches, in stream culverts, detention ponds, outfalls, and habitat enhancements.
- Reduce or eliminate pollutant discharges that can affect health, safety, environment, water quality, and aquatic resources.
- Meet the Illicit Discharge Detection and Elimination requirements of the City's Phase II National Pollutant Discharge Elimination System (NPDES) Permit.

Maintenance

This maintenance plan shall be used as a guide to assist staff with proper inspection, cleaning and upkeep of ditches, pipes, storm structures, and outfalls. Inspection and maintenance of stormwater drainage infrastructure is critical to the functionality of the City's system. Proper maintenance may reduce the likelihood of potential flooding issues in low lying areas. Routine inspection and maintenance records including photographs are recommended to be included in the City's GIS database for easy access and secured placement of information. Inspection and maintenance costs may include personnel, equipment, machinery, etc.

The City's O&M field crews maintain, repair, and upgrade public stormwater infrastructure, with the aim of maximizing stormwater conveyance, preventing flooding, reducing pollutant loadings, and minimizing the need for new construction projects. The City maintains 3,659 stormwater structure locations, 3,145 segments of stormwater conveyance infrastructure, 20 private and/or public detention areas, and 31 outfalls within its limits. They are currently inspected based upon the Municipal Separate Storm Sewer System (MS4) Zone they are located in. The MS4 Zones have been identified in Appendix L. All MS4 structure inspections shall be based upon deterioration of structure, clogging/ deposits, excessive silt/ vegetation, pollutants, and dry or wet weather flow.

Street and Drainage Structure Inspection and Maintenance Procedures

The 3,659 stormwater structure locations and 3,145 segments of stormwater conveyance infrastructure located in the City will be inspected every five (5) years based upon the defined MS4 Zone. This list will be updated annually to reflect new construction. Flooding complaints in the area shall be prioritized and addressed in a timely manner. An inspection and maintenance checklist has been provided on the following page for use by the City's inspection and maintenance field crews. The inspection checklist will be used and kept on file along with documentation of corrective action for any problems noted during the inspection.

Items to be inspected (included on checklist):

- Catch basin/drop inlet
- Storm manhole
- Storm sewer piping
- Ditches/channels
- Roadside/Cross Culverts
- Sediment Basins

Street and Drainage Structure Inspection and Maintenance Checklist

Street and Drainage Inspection and Maintenance Checklist Guide

Inspection Area: ____ **MS4 Zone:** ________________

Inspection Date: _______________ **Last Inspection Date:** _______________ **Inspected By:** _______________

Component/Item Inspected	Problems Observed	Maintenance/ Repair Necessary	Maintenance Task	Action
Circle One	**Circle One**	**Circle One**	**Identify Any/All Tasks**	**Completed**
Catch Basin/Drop Inlet	Deterioration of Structure		1 - Repair	
Storm Manhole	Clogged Inlet		2 - Clean Out	Yes / No
Storm Sewer Piping	Deposits in Structure	Yes	3 - Replace	
Ditches/Channels	Clogged Pipe		4 - Mow Vegetation	**Scheduled**
Roadside/Cross Culverts	Excessive Vegetation		5 - Schedule Ditch Cleaning	
Sediment Basins	Debris		6 - Regrade Ditch	Yes / No
Other______________________	Excessive Siltation		7 - Review Size and Replace	
	Deteriorated Pipe	No	8 - Line Pipe	**Date**
	Excessive Sediment Deposits		9 - Install Rip Rap	
	Pollutants		10 - Other________________	
	Other_____________________			

Additional Notes:

Street and Drainage Inspection and Maintenance Checklist

Date of Inspection: ____________________ **Inspection Area:** _________________________ **Inspected By:** ______________________

Reason for Inspection: ____

Current Weather: ______________________ **Rain (inches): in last 24 hrs:** ___________________ **in last week:** __________________

Facility Type	Location		Problems Observed	Maintenance Task		Maintenance Follow-up	
(CB/DI, Piping, Etc.)	GIS#/GPS	Description	Identify	Code	Description	Date Completed	Initials

Detention Pond Inspection and Maintenance Procedures

The public detention areas located in Brunswick will be inspected every five (5) years based upon the defined MS4 Zone. This list will be updated annually to reflect new construction. Flooding complaints in the area shall be prioritized and addressed in a timely manner. An inspection and maintenance checklist has been provided on the following page for use by the City's inspection and maintenance field crews. The inspection checklist will be used and kept on file along with documentation of corrective action for any problems noted during the inspection.

Items to be inspected (included on checklist):

- Stormwater Pond
- Pond Banks
- Inlet Pipe
- Outlet Pipe
- Outlet Control Structure
- Dam/Berm
- Emergency Spillway
- Upstream Conveyance
- Downstream Conveyance
- Access Area

Detention Pond Inspection and Maintenance Checklist

Detention Pond Inspection and Maintenance Checklist Guide

Inspection Area: ____ **MS4 Zone:** __________________

Inspection Date: ________________ **Last Inspection Date:** _______________ **Inspected By:** ________________

Component/Item Inspected	Problems Observed		Maintenance Task	Action
Circle All That Apply	**Circle All That Apply**		**Circle All That Apply**	**Completed**
Stormwater Pond	Deterioration of Structure	Excessive Siltation	1 - Repair	Yes / No
Pond Banks	Clogged Inlet	Storage Capacity	2 - Clean Out	
Inlet Pipe	Deposits in Structure	Obstructions	3 - Replace	
Outlet Pipe	Clogged Pipe	Structure Cracks/Holes	4 - Mow Vegetation	
Outlet Control Structure	Excessive Vegetation	Water Quality	5 - Schedule Ditch Cleaning	**Scheduled**
Dam/Berm	Sediment Accumulation	Erosion/Sloughing	6 - Regrade Ditch	
Emergency Spillway	Water Flow Issues	Mosquito Presence	7 - Review Size and Replace	Yes / No
Upstream Conveyance	Trash/Debris	Other____________________	8 - Line Pipe	
Downstream Conveyance			9 - Install Rip Rap	
Access Area	**Maintenance/Repair Necessary**		10 – Mosquito Control	**Date**
Other____________________	**Circle One**		11 – Further Evaluation Needed	
	Yes	No	12 – Other ___________________	

Additional Notes:

Detention Pond Inspection and Maintenance Checklist

Date of Inspection: ____________________ **Inspection Area:** _________________________ **Inspected By:** ______________________

Reason for Inspection: ____

Current Weather: ______________________ **Rain (inches): in last 24 hrs:** ___________________ **in last week:** __________________

Facility Type	Location		Problems Observed	Maintenance Task		Maintenance Follow-up	
(Pond, OCS, Etc.)	Structure ID	Description	Identify	Code	Description	Date Completed	Initials

Outfall Maintenance Inspection and Maintenance Procedures

The 31 outfalls located in Brunswick will be inspected every five (5) years based upon the defined MS4 Zone. This list will be updated annually to reflect new construction. Flooding complaints in the area shall be prioritized and addressed in a timely manner. An inspection and maintenance checklist has been provided on the following page for use by the City's inspection and maintenance field crews. The inspection checklist will be used and kept on file along with documentation of corrective action for any problems noted during the inspection.

Items to be inspected (included on checklist):

- Outfall Area
- Outlet Pipe
- Headwall
- Flared End Section
- Tide Control Structure
- Trash Rack
- Upstream Conveyance

Outfall Inspection and Maintenance Checklist Guide

Inspection Area: ______________________________ **MS4 Zone:** ______________

Inspection Date: ______________ **Last Inspection Date:** ______________ **Inspected By:** ______________

Component/Item Inspected	Problems Observed		Maintenance Task	Action
Circle All That Apply	Circle All That Apply		Circle All That Apply	Completed
Outfall Area	Deterioration of Structure	Excessive Siltation	1 - Repair	Yes / No
Outlet Pipe	Clogged Inlet	Deteriorated Pipe	2 - Clean Out	
Headwall	Deposits in Structure	Obstructions	3 - Replace	
Flared End Section	Clogged Pipe	Structure Cracks/Holes	4 - Mow Vegetation	
Tide Control Structure	Excessive Vegetation	Water Quality	5 - Schedule Outfall Cleaning	Scheduled
Trash Rack	Sediment Accumulation	Erosion	6 - Regrade Ditch	
Upstream Conveyance	Water Flow Issues	Tide Control Failure	7 - Review Size and Replace	Yes / No
Other________________	Trash/Debris	Other________________	8 - Install Rip Rap	
			9 - Further Evaluation Needed	
	Maintenance/Repair Necessary		10 – Other ________________	Date
	Circle One			
	Yes	No		

Additional Notes:

Outfall Inspection and Maintenance Checklist

Date of Inspection: ____________________ **Inspection Area:** _________________________ **Inspected By:** ______________________

Reason for Inspection: ____

Current Weather: ______________________ **Rain (inches): in last 24 hrs:** ___________________ **in last week:** __________________

Facility Type	Location		Problems Observed	Maintenance Task		Maintenance Follow-up	
(Outfall, Pipe, Etc.)	Structure ID	Description	Identify	Code	Description	Date Completed	Initials

MS4 Inspection and Maintenance Procedures

As identified in Chapter 7 of the City's Storm Water Management Plan (SWMP), the City must develop, implement, and enforce a program to detect and to eliminate illicit discharges as a part of their MS4. The control measures identified in Chapter 7 are intended to provide the City with a method of effectively addressing and detecting illegal discharges that contribute significantly to pollution. As part of the stormwater drainage maintenance plan, BMP #3a of the SWMP has been included for reference and shall be integrated into the maintenance plan schedule.

Best Management Practice (BMP) #3a: Field Inspections

Description *of BMP: All 27 outfalls will be visually inspected biannually at low tide to check for dry weather flows. Public works staff will look for dry weather flow and visually apparent pollution as they clear ditches and respond to flooding. Also, the City has purchased sewer video and truck equipment. The equipment and staff will be utilized on an as-needed basis by the public works department to inspect storm sewers for emergency response or enigmatic scenarios.*

Measurable *Goal(s): Visually inspect 100% of the 27 outfalls every two years. Visually inspect approximately 1 mile of ditches annually. Video of storm drains will take place on an as-needed basis. The number of outfalls inspected, the number of miles of ditches inspected, and number of miles of storm sewers videoed each year will be included in the annual report.*

Documentation *to be submitted with each annual report: The documentation will include a list of the outfalls which were inspected during the reporting year along with photos taken of each outfall. List of items to be documented include: verification of information concerning outfalls; digital photographs of the outfall pipe or manhole showing the structure and its immediate surroundings; any visual indications of an illicit discharge. In the event that any new outfall not noted on current or past outfall inventories is discovered, a dry-weather screening noting dry weather flow, pipe size and material, direction of pipe from manhole, depth of pipe invert relative to manhole rim, and date and time of inspection will be performed. All new outfalls will be immediately reported, in writing, to the Public Works Director.*

Person *(position) responsible for overall management and implementation of the BMP: Public Works Director*

Rationale *for choosing BMP and setting measurable goal(s): The number of outfalls within the City limits lend themselves to visual inspections. Storm drains are tidally influenced and checking for dry weather flow is difficult because the pipes are filled twice per day by the tides. Any pollutants are highly diluted by tides and the high salinity of estuarine water renders many simple analytical tests invalid. Almost all of the storm drains are very old and are equally susceptible to having illicit connections. The City suspects illicit connections which can be positively identified by the video camera if necessary.*

How *will you determine whether this BMP is effective in reducing pollution to stormwater in accordance with Part 5.1.4 of the Permit: A reduction in the amount of illicit discharges flowing into the stormwater sewer system will indicate that the visual inspections followed by an enforcement action are effective. Video inspections will positively identify the sources of illicit discharges and allow the City to determine the source of the discharge and eliminate it.*

References: *Stormwater Complaint SOP (MCM4), Stormwater Complaint Report Form (MCM4), Illicit Discharge Detection and Elimination SOP, Field Screening SOP*

In addition to Chapter 7 of the SWMP, Chapter 10 addresses pollution prevention and good housekeeping for municipal operations. It requires the City to develop and implement an operation and maintenance program that includes a training component and has the ultimate goal of preventing or reducing pollutant runoff from municipal operations (GA EPD Guidance Document, February 2012). As mentioned for BMP #3a, these MS4 requirements have been included for reference and shall be integrated into the maintenance plan schedule. The following table identifies nine (9) good housekeeping practices for the City that will contribute greatly towards helping minimize stormwater contamination.

Table 7: Good Housekeeping Practices

BMP	BMP Description
BMP #1 – MS4 Control Structure Inventory and Map	Develop and update an inventory and map of the MS4 structures within the permitted area.
BMP #2 – Inspection of MS4 Control Structures	Inspections of MS4 control structures will be conducted such that 100% of the structures are inspected in a 5- year period.
BMP #3 – Maintain MS4 Constructed Controls	Conduct maintenance on MS4 control structures, as needed.
BMP #4 - Street Sweeping	Sweep 25 miles per day of city streets.
BMP #5 - Training Program for City Employees	100% of affected employees trained every two years.
BMP #6 - Municipal Waste Disposal	The amount disposed from municipal outdoor activities will be tracked and reported to the EPD in the annual report.
BMP #7 – New Flood Management Project Assessments for Water Quality Impacts	Water quality improvements will be considered during the design of drainage improvements.
BMP #8 – Existing Flood Management Project Assessments for Water Quality Impacts	The City will conduct an assessment of existing publicly-owned flood management projects for potential retrofitting to address water quality impacts.
BMP #9 – Municipal Facility Inventory and Maintenance	The City will develop an inventory of municipal facilities with the potential to cause pollution (including fleet or maintenance shops, wastewater treatment facilities, drinking water treatment facilities, parks, etc). 100% of these facilities, as well as, storage/stockpile areas will be inspected within the 5-year permit term.

Please refer to Chapter 10 of the City's SWMP for additional information on the BMP requirements for pollution prevention and good housekeeping practices.

Initial Inspection and Maintenance Schedule

The initial maintenance schedule provided in this maintenance plan shall be used as a guide to assist staff with proper inspection, cleaning and upkeep of ditches, pipes, storm structures, and outfalls in conjunction with MS4 inspection and maintenance requirements. This schedule shall be updated as MS4 requirements are updated, CIP's are completed, and/or the City's capabilities change. The schedule below is broken down by stormwater structure/facility type, MS4 zone location, and recommended inspection and maintenance schedule. The College Park and Magnolia Park Neighborhoods inspection and maintenance schedule have also been included due to the number of issues identified in those areas. As improvements are made, the schedule may be updated accordingly to adequately maintain stormwater infrastructure.

Table 8: Initial Inspection/Maintenance Plan

Structure/Facility Type	MS4 Zone	Schedule	Year/Season
Street Drainage Structure Inspection/Maintenance	1	Every 5 Years	2020
	2		2021
	3		2022
	4		2023
	5		2024
Detention Pond Inspection/Maintenance	1	Every 5 Years	2020
	2		2021
	3		2022
	4		2023
	5		2024
Non-MS4 Outfall Inspection/Maintenance	1	Every 5 Years	2020
	2		2021
	3		2022
	4		2023
	5		2024
MS4 Control Structures* Inspection/Maintenance	1	Every 5 Years	2020
	2		2021
	3		2022
	4		2023
	5		2024
MS4 Outfall** Inspection/Maintenance	1	Bi-Annually	2020
	2		2020
	3		2021
	4		2021
	5		2021
College Park Area	4	Semi-Annually	Spring
			Fall
Magnolia Park Area	4	Semi-Annually	Summer
			Winter

*MS4 Control Structure Inspection/Maintenance may also include stormwater infrastructure identified in Master Plan

**MS4 Outfall Inspection/Maintenance may also include outfalls identified in Master Plan

XIII CONCLUSIONS AND RECOMMENDATIONS

In summary, the City is in serious need to address stormwater drainage deficiencies as identified in the CIPs. Deficiencies include, but are not limited to, lack of stormwater drainage infrastructure GIS information, stormwater drainage infrastructure, proper maintenance, and equipment as well as inadequate stormwater drainage infrastructure capacity.

Stormwater drainage infrastructure may include, but is not limited to, drainage swales and ditches, tide control, catch basin curb inlets, drop and yard inlets, driveway and roadway culverts, stormwater detention facilities, and associated piping. The total preliminary opinion of probable construction cost for all 15 CIPs is $18,400,000.

Funding these projects over a reasonable time frame may be a challenge in regard to the current stormwater budget of the City's General Fund and available SPLOST funds designated for stormwater improvements. It is recommended that the City investigate other funding mechanisms to assist with the overall costs of future stormwater improvements.