Vernon River Watershed Management Plan

Savannah, Georgia
2022

Developed through a multi-organization collaboration including City of Savannah, Chatham County, Cuddybum Hydrology, Ogeechee Riverkeeper, Savannah State University, UGA-Skidaway Institute of Oceanography, Institute for Water and Health at Georgia Southern University, and other local partners.

Table of Contents

Executive Summary

This Watershed Management Plan (WMP) attempts to identify, assess, and respond to the persistent bacterial and pathogen issues on the Vernon River and its tributaries. It updates the 2013 Vernon River WMP based on growing scientific knowledge, a reassessment of best management practices, updated water quality standards, and renewed efforts to recover and restore this long-suffering watershed.

The 2023 Vernon River WMP seeks to address the existing issues through three phases of efforts. First, the WMP will attempt to establish a clear, data-driven understanding of the causes and sources of the watershed's impairment through increased monitoring, synthesizing existing data, and analyzing the most significant contributors. Second, relying on those analyses, the WMP methodically determines which mitigation strategies are most urgently needed and will be the most effective in reducing bacterial impairment. Finally, based on the available technical and financial opportunities, the WMP identifies specific management measures, education campaigns, long-term metrics for assessing success in pollution load reduction, and timelines for implementation. Through successful implementation of these efforts, the collaborators are hopeful that water quality throughout the Vernon River watershed will improve, and the aquatic ecosystem will begin its recovery.

This effort has been the result of years-long collaborations between local governments, educational institutions, advocacy organizations, watershed residents, and other stakeholders. Special thanks to the City of Savannah, Town of Vernonburg, Chatham County, Georgia Southern University, Savannah State University, UGA Skidaway Institute of Oceanography, and Ogeechee Riverkeeper.

Introduction

Purpose of the Watershed Management Plan

Water quality concerns including pathogen impairment have existed at the local and state level for the Vernon River Watershed in Savannah, Ga, for at least two decades. Over that time, various efforts have been implemented to investigate and improve water quality in this watershed. These efforts include a Watershed Management Plan (WMP) developed in 2013. While this and other efforts by various stakeholders have been employed and some improvements observed, water quality metrics have not seen sufficient improvement overall. Recent developments in methodology, available data, and stakeholder investment have created an opportunity to enhance the engagement and corrective actions steps beyond what has been previously possible. This renewed engagement includes the development a revised WMP to more thoroughly address USEPA's *Nine Elements of Watershed Planning*. USEPA's "Handbook for Developing Watershed Plans to Restore and Protect Our Waters" and GAEPD's "Watershed Planning Guidance" were used as resources in the planning process. According to USEPA and GAEPD guidelines, Watershed Management Plans are intended as platforms for evaluating and tracking water quality protection and restoration. These plans are designed to accommodate continual updates and revisions as new conditions and information warrant. In addition, field verification of watershed characteristics and listing data should be built into the preparation of the plans. The overall goal of the plans is to define a set of actions that will help achieve water quality standards set by the State of Georgia. This management plan for the Vernon River Watershed provides 1) identification of causes and sources of impairments; 2) an estimate of the expected load reductions; 3) assessment of the various management measures needed and the critical areas where they need to be implemented; 4) an estimate of the amount of technical and financial assistance needed to implement the plan and the sources of this assistance; 5) a plan for an education and information component; 6) a schedule for implementation; 7) interim measurable milestones for NPS management measures; 8) criteria for evaluating progress toward load reductions; and 9) a long-term monitoring strategy to correlate the previous two items.

Watershed Planning Committee Meetings

Meeting 1 Participants– May 19, 2022

- Will Monroe, Watershed Resident (Town of Vernonburg)
- Ivey Monroe, Watershed Resident (Town of Vernonburg)
- Mike Baggett, Watershed Resident (Savannah)
- Sara Malphrus, Watershed Resident (Savannah)
- Angela Willis, Savannah K-12 Science Teacher
- Michael Dayoub, Ogeechee Riverkeeper/ Watershed Resident (Savannah)
- Shawn Rosenquist, Cuddybum Hydrology
- Asli Aslan, Georgia Southern University
- Carol Pride, Savannah State University/Watershed Resident (Savannah)
- Jessica Brown, UGA Marine Extension and Georgia Sea Grant
- Joe Richardson, Town of Vernonburg
- Laura Walker, City of Savannah
- Sue Ebanks, Savannah State University
- Jennifer Lindsay, Watershed Resident (Savannah)
- Luke Roberson, Institute for Water and Health at Georgia Southern University

- Damon Mullis, Ogeechee Riverkeeper
- Meaghan Gerard, Ogeechee Riverkeeper
- Kris Howard, Ogeechee Riverkeeper
- Carly Nielsen, Ogeechee Riverkeeper

Meeting 2 Participants– November 10, 2022

- Carol Pride, Savannah State University/Watershed Resident (Savannah)
- Luke Roberson, Institute for Water and Health at Georgia Southern University
- Chris Rustin, Chatham County Health Department
- Lauren Baker-Newton, Chatham County Health Department
- Laura Walker, City of Savannah
- Jennifer Lindsay, Watershed Resident (Savannah)
- Michael Dayoub, Ogeechee Riverkeeper/ Watershed Resident (Savannah)
- Jackie Jackson, Chatham County Resilience Program Administrator
- Jen Hilburn, One Hundred Miles
- Ellie McKenzie, Watershed Resident (Town of Vernonburg)
- Angela Willis, Savannah K-12 Science Teacher
- Shawn Rosenquist, Cuddybum Hydrology

Meeting 3 Participants– April 20, 2023

- Jennifer Lindsay, Watershed Resident (Savannah)
- Be Kirsch, Ogeechee Riverkeeper
- Carol Pride, Savannah State University/Watershed Resident (Savannah)
- Clay Mobley, Ogeechee Riverkeeper
- Asli Aslan, Georgia Southern University
- Shawn Risenquist, City of Savannah
- Jen Hilburn, One Hundred Miles
- Sue Ebanks, Savannah State University
- Michael Dayoub, Ogeechee Riverkeeper/ Watershed Resident (Savannah)

Terms and Abbreviations

- BMP – Best Management Practice
- BST – Bacterial Source Tracking
- CFU – Colony Forming Unit
- CSAH – Chatham Savannah Authority for the Homeless
- DO – Dissolved Oxygen
- DOC – Dissolved Organic Carbon
- EC – E. Coli
- ENT – Enterococcus
- FC – Fecal Coliform
- FIB – Fecal Indicator Bacteria
- FOG – Fat, Oil, and Grease
- I&I – Inflow and Infiltration
- LA – Load Allocation
- MS4 – Municipal Separate Stormwater System
- NPS – Non-Point Source
- SSO – Sanitary Sewer Overflow
- STV – Statistical Threshold Value
- TMDL – Total Maximum Daily Load, "A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant. A TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant." (epa.gov)
- WLA – Waste Load Allocation, Point Sources
- WLAsw – Waste Load Allocation, Stormwater
- WMP – Watershed Management Plan
- WPCP – Wastewater Pollution Control Plant

Background Information

Vernon Watershed Description

Relevant HUC 8 and HUC 12 Delineations

The relevant HUC8 is the "Ogeechee Coastal" watershed (Figure 1). It essentially represents all the drainage area along the Georgia coast between the Savannah, Ogeechee, and Altamaha rivers that drains to the ocean or near-ocean estuarine waters near the mouth of these three rivers. It contains portions of Chatham, Bryan, Liberty, Long, and McIntosh counties. Land use in this watershed varies greatly from very urban in most of the Chatham County portion to very rural portions of Bryan, Liberty, and McIntosh counties. Many water bodies in this watershed are highly influence by coastal hydrology including tides and periodic tropical storms.

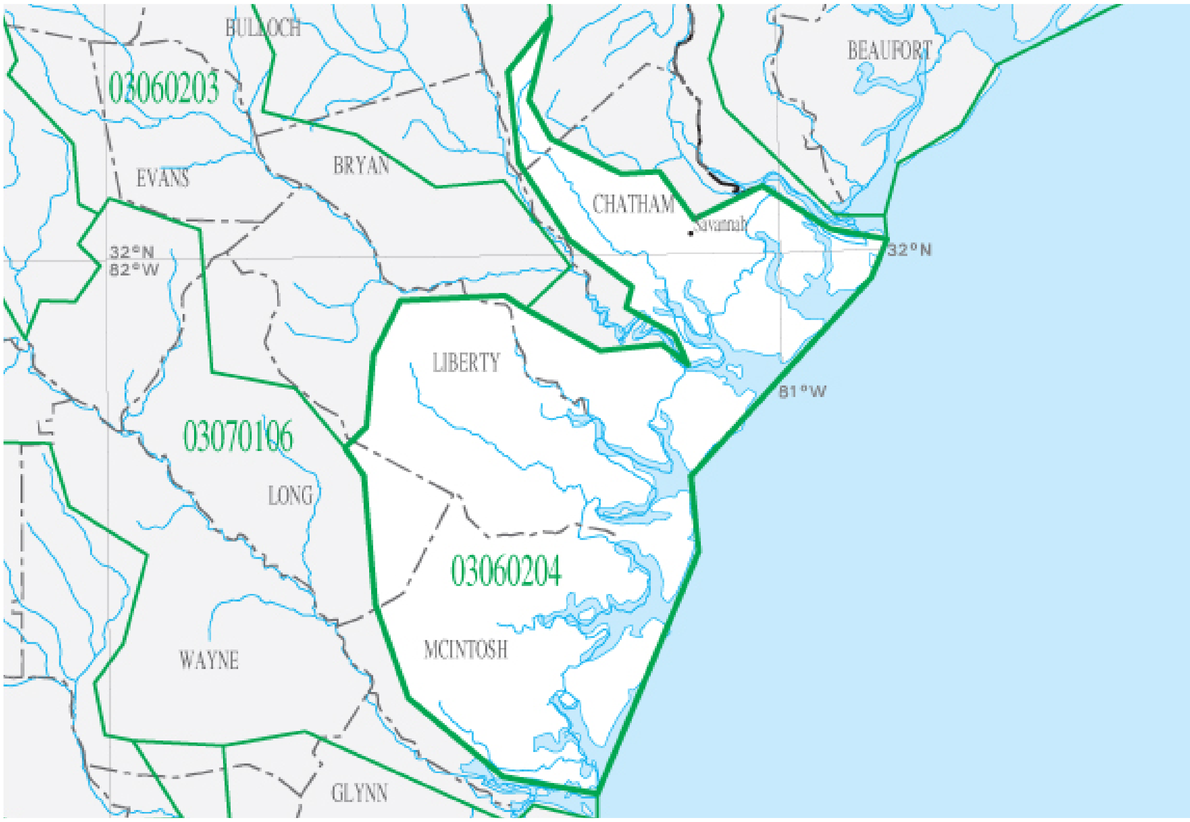


Figure 1. HUC8 containing the target watershed (03060204 – Ogeechee Coastal)

The target watershed, as delineated, includes portions of two HUC12 delineations (Figure 2). The northern HUC12 (pink) is not entirely included in our delineation of the target watershed. Fine scale delineation including stormwater infrastructure reveals that part of this HUC12 likely drains elsewhere. The southern HUC12 (yellow) is also not entirely included because a portion is below the impaired reach. This lower portion does not historically demonstrate measured values consistent with impairment based on historic data. The delineation shown (pink lines) represents a delineation done using high resolution LIDAR DEM data with the delineation tool available in the PCSWMM hydrodynamic modeling software. The delineation was then refined by manually adjusting the delineation to account for stormwater infrastructure. A calibrated hydrodynamic model has been created as a part of this WMP process for the target watershed.

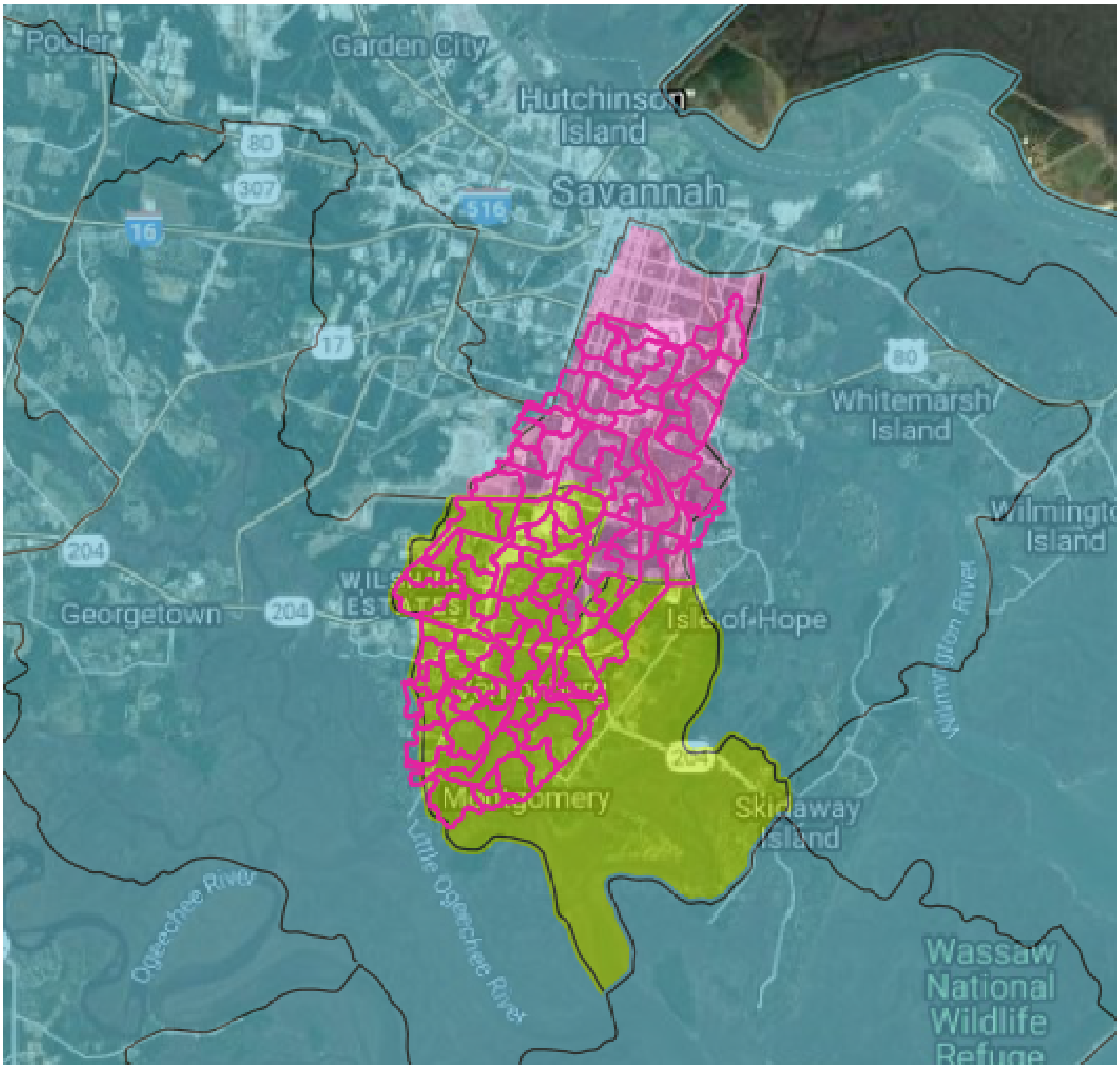


Figure 2. The target watershed includes portions of two HUC12s, to the north 030602040302 (8816 acres) and to the south 030602040303(17,908 acres). The unincluded portion of the northern HUC12 is not included because it was too coarsely delineated, and the unincluded portion of the southern HUC12 is downstream of our target watershed.

Critical Watershed Statistics

- Study area: 15,832 acres
- Average annual discharge volume of 2.65 billion cubic feet of freshwater
- Elevation ranges from below mean sea level to approximately 40 feet with most of the elevation between 0 and 25 feet, average of 13.6 feet (NAVD88)
- Entirely located within Chatham County, GA
- Predominant soil types within the watershed include Chipley Fine Sand and related (16.8%), Ellabell Loamy Sand (8.5%), Lakeland Sand (5.6%), Leon Find Sand (4.7%), Ocilla Complex and related (7%), Ogeechee Loamy Fine Sand and related

(8.1%), Tidal Marsh (16.6%), Open Water (10.6%), Urban Land (12.3%) and other (9.8%) Detailed soil descriptions available in appendix E.

- Lower Coastal physiographic region, sedimentary rock formations are dominant.

Tributary Descriptions

The Vernon River proper and Hayner's Creek upstream of it consist of approximately 34,000 ft of meandering Tidal Creek with large cross-sectional area and extensive salt marsh platform. Channel widths range from 100 ft at the north of this section to 1000 ft near the south. Floodplain width, inclusive of the salt marsh platform, ranges from 1000 ft at the north of this section to 5000 ft at the south. Tidal range is between 5 and 10 feet with about 90% of this range extending to the upstream extents of this section of the water body. This water body connects to the Little Ogeechee River downstream after approximately 23,000 additional feet of tidal creek. The Little Ogeechee River connects in another 10,000 ft to Ossabaw Sound. Upstream, the Vernon River receives freshwater inputs from 3 major and several minor tributaries.
The largest and most upstream contributor is the Casey Canal system draining 6,440 acres. It contains 25,800 ft of highly channelized and managed canal including a tide gate and two pump stations. Channel width in the canal is about 50 ft at the base and close to 100 ft at the top of the channel. A large portion of the Casey Canal system is supplied via buried stormwater conveyance including at least 16 major outfalls to the canal. However, open channel contributions also exist. Approximately 15,000 feet of open channel/canal, known as Habersham Canal, joins Casey about 1/3 of the distance upstream from its confluence downstream with the tidal creek. Most of Habersham is about 20 ft wide at the base and about 40ft wide at the top of the channel.

The Harmon Canal system also feeds the lower estuary system while draining and area of 2,360 acres. It is divided into a northern (Chippawa Canal) and western (Harmon Canal) branch after about 2,900 ft of channel with each branch having an additional 9,000-10,000 ft of channel. This system is not tide gated and is tidal for the entire portion below the Harmon/Chippawa confluence and for approximately 1000 feet up both branches. The area above this tidal portion is considered part of the MS4 system. The end of the MS4 is approximately at Edgewater Road on Harmon and Montgomery Cross Road on Chippewa. Channel shape varies but the top of the channel in most of the more downstream areas is about 50 ft wide.

The Wilshire Canal system also feeds the estuary portion with a contributing area of 1,870 acres. It consists of a dominant northern branch (Wilshire Canal) with 15,000 ft of channel and smaller southern branch (Holland Canal) with 6,000 ft of channel and about 25% of the drainage area of the northern branch. The northern branch is tide gated while the southern branch is not tide gated but does have a weir in place near the estuary that limits tidal flow. The location of the tidal gate and weir, both below White Bluff Road, are approximately the end of the MS4 system. The channels in the northern branch are around 75 ft wide at the top of the channel while the channels in the southern branch are around 40 ft in width at the top of the channel.
There are at least 3 notable smaller tributaries that enter the Vernon River estuary from the west further downstream from the ones already listed and even more minor contributors on both sides of the estuary. The largest, Coffee Bluff Canal, enters the tidal creek from the west below Vernonburg and drains 800 acres with 3,900 ft of perennial channel. It is not tide gated. These tributaries are considered part of the MS4 down to the location where salt marsh begins.

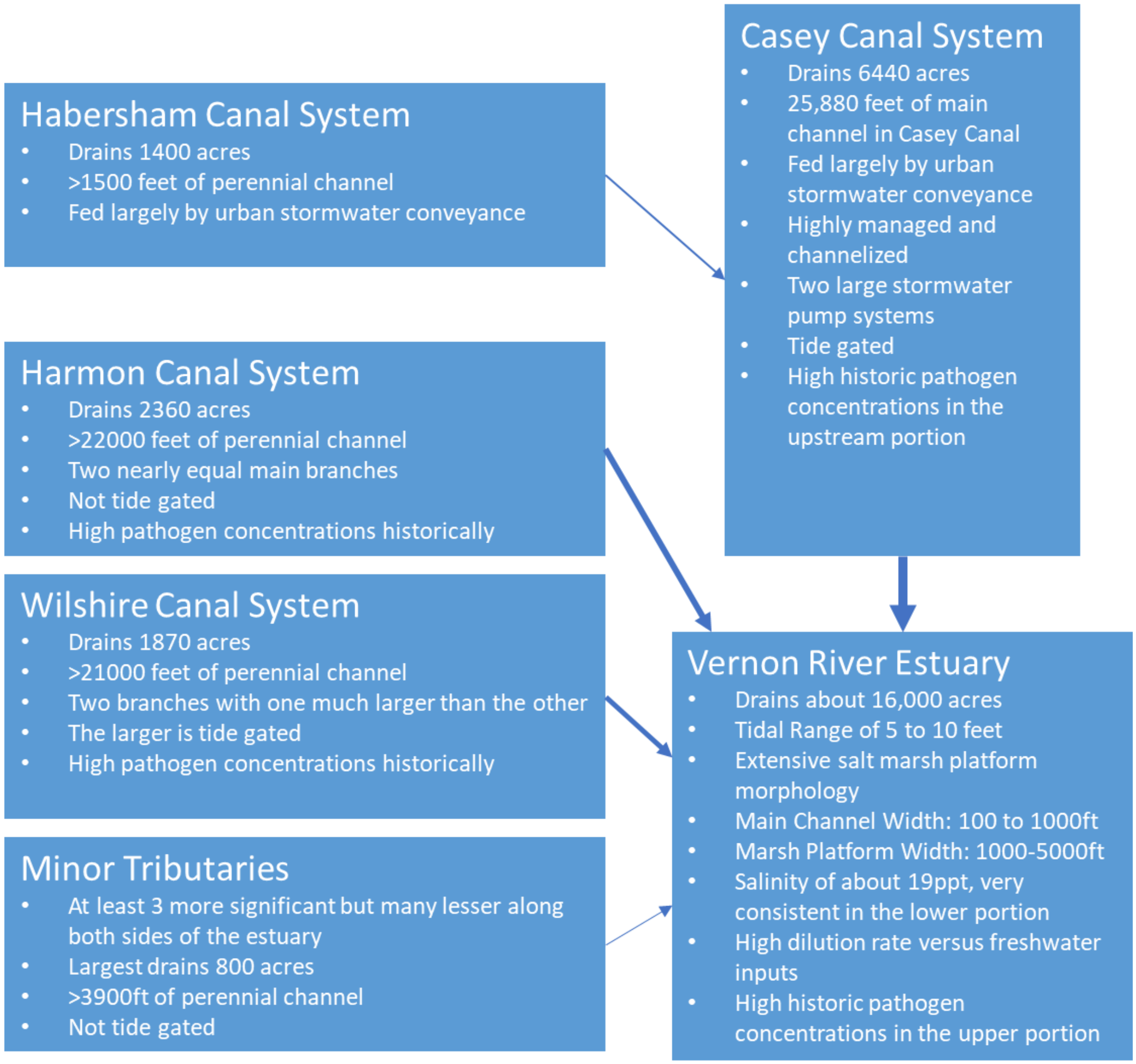


Figure 3. Vernon River Tributary Schematic and Brief Description.

Relevant Municipalities

There are three relevant municipalities for the target watershed, City of Savannah, Town of Vernonburg, and unincorporated Chatham County (Figure 4). The overwhelming majority of the watershed is the City of Savannah. The Town of Vernonburg is adjacent to the estuary portion of the Vernon River on the west. The contributing area from unincorporated Chatham County is on the east side of the estuary portion including the Vernon River and Hayner's Creek. A small amount of this county portion on the east of the estuary may also drain to the lower portions of Casey Canal.

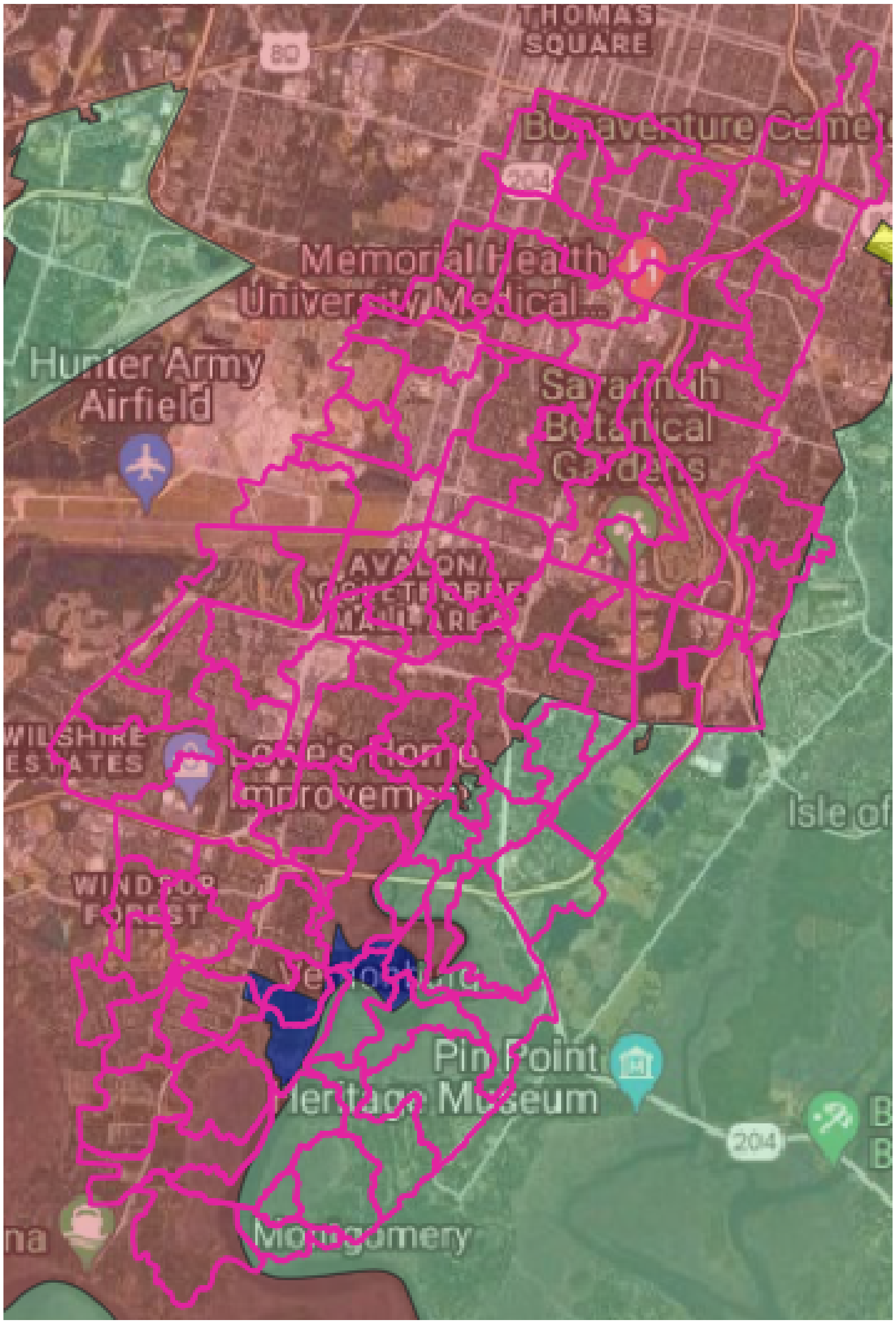


Figure 4. Relevant Municipalities for the Vernon River Watershed include City of Savannah (red/brown), Town of Vernonburg (blue) and Unincorporated Chatham County (green).

Ogeechee Watershed Description

The Vernon River only connects to the Ogeechee River at Ossabaw Sound after connecting the Little Ogeechee River and therefore has little connection or relevance to the mainstem of this watershed (Figure 5). Extensive descriptions of the Ogeechee Watershed can be found elsewhere (https://water.usgs.gov/lookup/getwatershed?03060202; https://garivers.org/ogeechee-river/) and will not be detailed here.

Figure 5. Ogeechee River Watershed including the relevant HUC8 for the target watershed.

Impairment History

Relevant Pathogen Standards

Fecal Coliform, hereafter referred to in this document as FC, has historically been the relevant indicator bacteria and measurement end point for impairment in the target watershed (Figure 6). This has now changed. New guidance suggests that the standard has migrated to E. coli (for freshwater fishing designated use) and Enterococcus (for "estuarine" fishing designated use), hereafter referred to in this document as EC and ENT (Figure 7). Units for these measurements are MPN/100ml throughout the document unless otherwise noted. The location and hydraulic modifications in the target watershed cause the impaired reach to straddle both criteria. When GAEPD has been consulted as to how to determine if a particular sampling location should be considered estuarine, the answer that we have received is that a salinity of 0.5 ppt is the threshold, below which E. coli is to be used and above which ENT is to be used. This criterion places some historic sampling sites and some new monitoring sites on each side. Some monitoring sites may fall under different criteria depending on when they are sampled (high tide, low tide, rain event, storm surge, etc.) For many historical sampling sites, both FC and ENT were analyzed for many of the same samples. For many of the new sampling sites both EC and ENT have been analyzed for many of the same samples. All available data will be presented.

The water use classification for the listed stream segments in the Ogeechee River Basin is Fishing. The criterion violated is listed as fecal coliform. The potential cause(s) listed include urban runoff, nonpoint sources, and municipal facilities. The use classification water quality standards for fecal coliform bacteria, as stated in the *State of Georgia's Rules and Regulations for Water Quality Control*, Chapter 391-3-6-.03(6)(c)(iii) (GA EPD, 2002), are:

Bacteria: For the months of May through October, when water contact recreation activities are expected to occur, fecal coliform not to exceed a geometric mean of 200 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours. Should water quality and sanitary studies show fecal coliform levels from non-human sources exceed 200/100 ml (geometric mean) occasionally, then the allowable geometric mean fecal coliform shall not exceed 300 per 100 ml in lakes and reservoirs and 500 per 100 ml in free flowing freshwater streams. For the months of November through April, fecal coliform not to exceed a geometric mean of 1,000 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours and not to exceed a maximum of 4,000 per 100 ml for any sample. The State does not encourage swimming in surface waters since a number of factors, which are beyond the control of any State regulatory agency, contribute to elevated levels of fecal coliform. For waters designated as approved shellfish harvesting waters by the appropriate State agencies, the requirements will be consistent with those established by the State and Federal agencies responsible for the National Shellfish Sanitation Program. The requirements are found in the National Shellfish Sanitation Program Manual of Operation, Revised 1988, Interstate Shellfish Sanitation Conference, U. S. Department of Health and Human Services (PHS/FDA), and the Center for Food Safety and Applied Nutrition. Streams designated as generally supporting shellfish are listed in Paragraph 391-3-6-.03(14).

Figure 6. Excerpt from the 2005 TMDL describing the relevant pathogen standards at that time.

Designated Use	counts/100 mL		
	Recreation	Drinking Water*/ Fishing	Drinking Water*/ Fishing
	Year Round	May-October	November-April
Fecal Coliform			
30-day Geomean	200	200*	1000*
Single Sample Maximum			4000*
E. coli			
30-day Geomean	126	126*	265*
STV	410	410*	861*
Entercococci			
30-day Geomean	35	35	74
STV	130	130	273

* Criteria that apply to waterbodies designated as drinking water.

Figure 7. Proposed Pathogen Criteria in 2018 GAEPD guidance document.

GAEPD 2002 303d List

Portions of the target watershed appear on the 303d list at least as far back as 2002 (Figure 8). Impairment status extended from roughly the Truman Parkway bridge at the Vernon River to most upstream portions of the Casey Canal. This assessment was based on samples taken at the Montgomery Cross Bridge, just below the lower pump station and tide gate on the Casey Canal. Impairments included dissolved oxygen, pathogens (FC), and fish consumption guidelines (elevated level of Dieldrin). This WMP will not address DO or fish consumption guidelines.

BASIN/STREAM (Data Source)	LOCATION	WATER USE CLASSIFICATION	CRITERION VIOLATED	POTENTIAL CAUSE(S)	ACTIONS TO ALLEVIATE	MILES	305(b)	303(d)	Priority
Hayners Creek (known upstream as Casey Canal) (1)	Casey Canal (Montgomery Crossroad) to Vernon River (Chatham Co.)	Fishing	DO,FC,FCG	UR	Urban runoff is being addressed in the EPD Stormwater Management Strategy. An areawide stormwater permit was reissued to Chatham County in 4/14/00. Fish Consumption Guidelines due to levels of Dieldrin in the fish tissue of striped mullet and is a partial support. Dieldrin is a pesticide that has been restricted from use in the U.S.	2	X	X	2
Casey Canal (1)	Head of Canal to DeRenne Ave., Savannah (Chatham Co.)	Fishing	DO,FC	UR	Urban runoff is being addressed in the EPD Stormwater Management Strategy. An areawide stormwater permit was reissued to the City of Savannah in 4/14/00.	3	X	X	2
Casey Canal (1)	DeRenne Ave. to Montgomery Crossroad, Savannah (Chatham Co.)	Fishing	DO,FC,FCG	UR	Urban runoff is being addressed in the EPD Stormwater Management Strategy. An areawide stormwater permit was reissued to the City of Savannah in 4/14/00. Fish Consumption Guidelines due to levels of Dieldrin in the fish tissue of striped mullet and is a partial support. Dieldrin is a pesticide that has been restricted from use in the U.S.	3	X	X	2

Figure 8. 2002 GAEPD 303d list including portions of Hayner's Creek and Casey Canal from Truman Parkway to the top of Casey Canal.

GAEPD 2020 303d List

Eighteen years later, the assessment of the watershed is largely unchanged, although the upper portion of Casey and the Hayner's Creek portion are no longer listed for fish consumption guidelines (Figure 9). In the meantime, a TMDL was completed in 2005 and revised in 2007.

Casey Canal	Head of Canal to DeRenne Ave., Savannah	Ogeechee	Not Supporting	DO, FC	3	4a	TMDLs completed DO 2005 (revised 2007), FC 2005.
GAR030602040308	Chatham	Fishing	1,10,50,51	UR	Miles		
Casey Canal	DeRenne Ave. to Montgomery Crossroad, Savannah	Ogeechee	Not Supporting	DO, FC, Fish Tissue (Dieldrin)	3	4a	TMDLs completed DO 2005 (revised 2007), FC 2005, Fish Tissue (Dieldrin) 2005.
GAR030602040309	Chatham	Fishing	10,50,51,59	UR	Miles		
Hayners Creek (known upstream as Casey Canal)	Casey Canal (Montgomery Crossroad) to Vernon River	Ogeechee	Not Supporting	DO, FC	2	4a	TMDLs completed DO 2005 (revised 2007), FC 2005, Fish Tissue (Dieldrin) 2005.
GAR030602040310	Chatham	Fishing	1,10,50,51	UR	Miles		

Figure 9. 2020 GAEPD 303d list including portions of Hayner's Creek and Casey Canal from Truman Parkway to the top of Casey Canal

2005 TMDL Findings

Of note in the figure below, the LA for this watershed is approximately 27% of the TMDL, with the WLAsw contributing 63%, 10% MOS (Figure 10). This indicates that to meet state standards, either the natural and non-MS4 nonpoint contributions would have to be much lower than in most watersheds, or the MS4 contributions will have to be reduced well below permitted levels.

Stream Segment	Current Load (counts/ 30 days)	TMDL Components					Percent Reduction
		WLA (counts/ 30 days)[1]	WLAsw (counts/ 30 days)	LA (counts/ 30 days)	MOS (counts/ 30 days)	TMDL (counts/ 30 days)	
Big Creek	7.71E+12			3.04E+12	3.38E+11	3.38E+12	56
Buckhead Creek	1.35E+13	4.09E+10		5.41E+12	6.06E+11	6.06E+12	55
Canoochee River	7.22E+13	3.37E+10		2.98E+13	3.32E+12	3.32E+13	54
Casey Canal - Head of Canal to DeRenne Ave, Savannah	5.81E+15		1.59E+14	6.82E+13	2.52E+13	2.52E+14	96
Casey Canal - DeRenne Ave to Montgomery Crossroad, Savannah	5.81E+15		1.59E+14	6.82E+13	2.52E+13	2.52E+14	96
Cedar Creek	1.18E+10			1.32E+09	1.47E+08	1.47E+09	88
Fifteenmile Creek	1.54E+14			3.21E+13	3.57E+12	3.57E+13	77
Hayners Creek (known upstream as Casey Canal)	5.81E+15		1.59E+14	6.82E+13	2.52E+13	2.52E+14	96

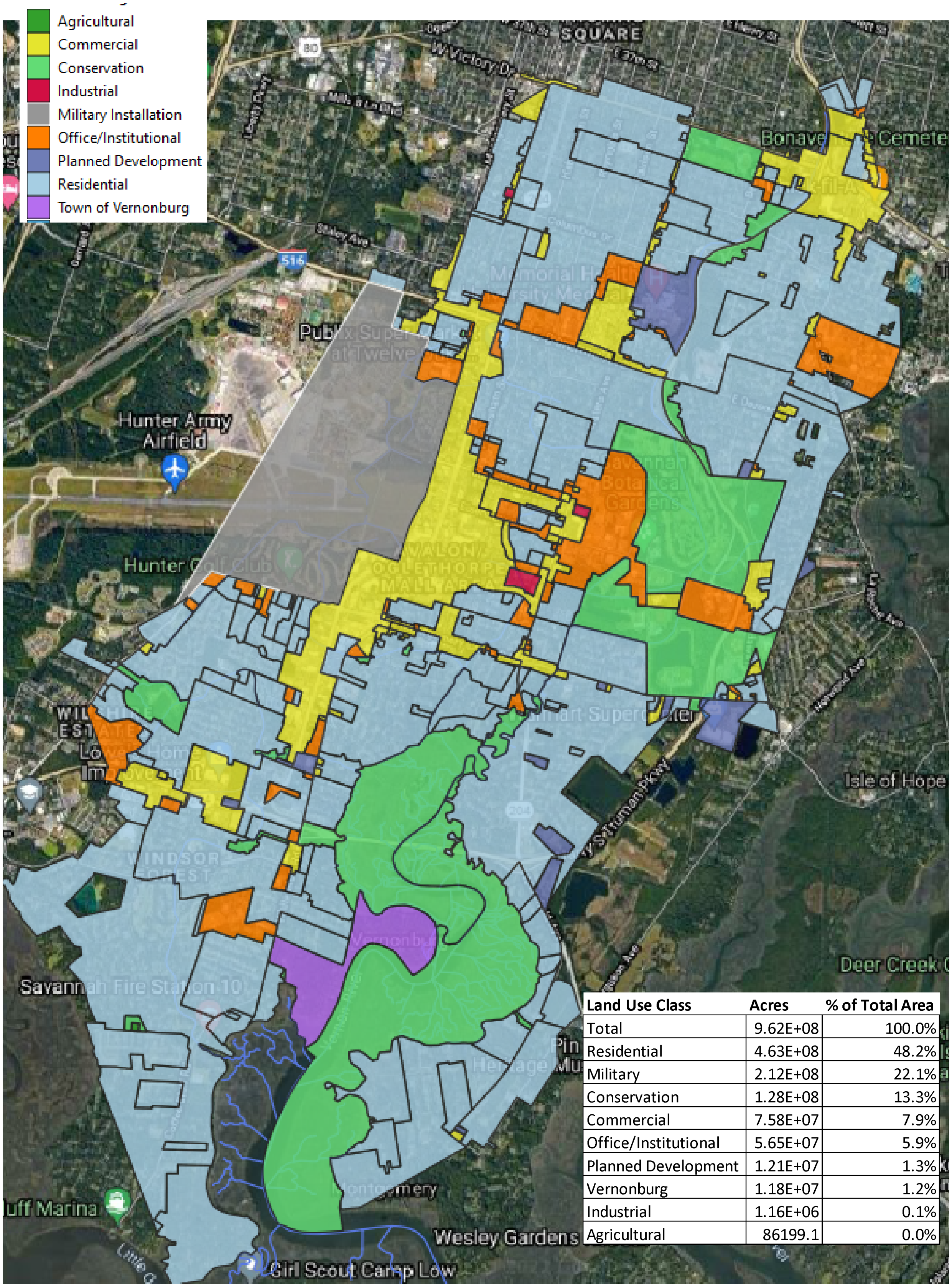
Figure 10. 2005 TMDL Components including the three relevant portions of the Vernon River watershed.

Land Use Characteristics

Both the 2005 TMDL-based and 2022 GIS-based land indicate that the relevant watershed is dominated by residential areas, and to a lesser extent conservation and dense commercial land use (Figures 11 and 12).

Stream/Segment	Landuse Categories - Acres (Percent)													
	Open Water	Residential	High Intensity Commercial, Industrial, Transportation	Bare Rock, Sand, Clay	Quarries, Strip Mines, Gravel Pits	Transitional	Forest	Row Crops	Pasture, Hay	Other Grasses (Urban, recreational; e.g. parks, lawns)	Woody Wetlands	Emergent Herbaceous Wetlands	Total	Landuse Source
Big Creek	252 (0.4)	20 (0.0)	21 (0.0)	43 (0.1)	3 (0.0)	2,307 (3.6)	28,720 (45.0)	23,867 (37.4)	1,710 (2.7)	3 (0.0)	6,801 (10.7)	17 (0.0)	63,763	NLCD
Buckhead Creek	725 (0.4)	636 (0.3)	376 (0.2)	80 (0.0)	- (0.0)	8,147 (4.4)	60,605 (33.0)	77,190 (42.0)	8,003 (4.4)	106 (0.1)	27,785 (15.1)	174 (0.1)	183,827	NLCD
Canoochee River	1,228 (0.9)	874 (0.6)	542 (0.4)	82 (0.1)	346 (0.3)	14,572 (10.6)	69,887 (50.7)	36,879 (26.7)	3,659 (2.7)	137 (0.1)	9,722 (7.0)	46 (0.0)	137,974	NLCD
Casey Canal Head of Canal to DeRenne Ave, Savannah	5 (0.1)	2,760 (61.2)	783 (17.3)	10 (0.2)	- (0.0)	238 (5.3)	382 (8.5)	96 (2.1)	24 (0.5)	54 (1.2)	161 (3.6)	1 (0.0)	4,513	NLCD
Casey Canal DeRenne Ave to Montgomery Crossroad, Savannah	125 (1.3)	4,433 (46.1)	1,607 (16.7)	27 (0.3)	- (0.0)	576 (6.0)	1,358 (14.1)	456 (4.7)	43 (0.4)	422 (4.4)	555 (5.8)	18 (0.2)	9,618	NLCD
Cedar Creek	482 (1.2)	278 (0.7)	97 (0.2)	32 (0.1)	- (0.0)	2,267 (5.7)	14,471 (36.4)	16,166 (40.6)	2,806 (7.0)	28 (0.1)	3,168 (8.0)	14 (0.0)	39,808	NLCD
Fifteenmile Creek	1,162 (1.2)	394 (0.4)	377 (0.4)	45 (0.0)	1 (0.0)	5,981 (6.2)	37,621 (39.1)	38,626 (40.1)	4,240 (4.4)	87 (0.1)	7,727 (8.0)	9 (0.0)	96,270	NLCD
Hayners Creek (known upstream as Casey Canal)	144 (1.4)	4,630 (45.9)	1,631 (16.2)	27 (0.3)	- (0.0)	593 (5.9)	1,490 (14.8)	458 (4.5)	43 (0.4)	429 (4.3)	559 (5.5)	87 (0.9)	10,092	NLCD

Figure 11. Land use description from the 2005 TMDL including the relevant reaches.



Land Use Class	Acres	% of Total Area
Total	9.62E+08	100.0%
Residential	4.63E+08	48.2%
Military	2.12E+08	22.1%
Conservation	1.28E+08	13.3%
Commercial	7.58E+07	7.9%
Office/Institutional	5.65E+07	5.9%
Planned Development	1.21E+07	1.3%
Vernonburg	1.18E+07	1.2%
Industrial	1.16E+06	0.1%
Agricultural	86199.1	0.0%

Figure 12. A more detailed 2022 land use assessment from SAGIS data

Hydrology

A hydrodynamic model of the watershed has been developed to provide a baseline of understanding for the movement of water within the target watershed. It includes the following components (Figure 13):

- 117 subcatchments (average size of 135 acres),
- Approximately 190,000 ft of conduit, including natural channels, canals, and stormwater pipes of various materials and sizes. Natural channels have been modeled with irregular profiles based on lidar elevation data.
- Two virtual pump stations to represent the pump stations at Montgomery Cross and Derenne Avenue.
- Three rainfall regions supported with data from real-time weather stations.
- Depth calibration data enhanced by conductivity from three long-term, real-time monitoring stations in critical areas and additional deployed depth sensors in additional areas. The long-term station areas include Casey Canal (to calibrate the model to pump performance), Vernon River at Vernonburg (to determine the tidal range and timing at the model outfall, and Harmon Canal (to calibrate the attenuation of tidal behavior into the upper watershed). Additional sites for model refinement include temporary depth stations on Chippewa Canal and Wilshire Canal.

This model has proven useful in providing context for the study of pathogen sources and transport in the target watershed. For instance, the model indicates in agreement with prior research that, "The rapid recovery of the Vernon River system to pre-rainfall conditions following a storm event suggests that throughput of stormwater is rapid." and "stormwater entering the Vernon River is rapidly exchanged with and diluted by the larger water volume of the little Ogeechee River and Green Island Sound outside the boundaries of the Vernon River" (Savidge and Blanton, 2010). In other words, the channels in the system rise and fall quickly in response to rainfall, the storm pulse is delivered quickly to the estuary, and it is highly diluted in that estuary. As such, samples taken in the estuary are not directly indicative of upstream conditions. For example, for a sample taken in the Vernon River near Vernonburg during an outgoing tide, only about 3% of that sample originated as runoff in the upstream watershed while approximately 97% of that sample came from incoming saltwater in the previous incoming tide with its unique, averaged, and lower, bacterial concentrations. This ratio decreases as you move up in the watershed, but the acting principle is still relevant at some level for many sampling sites. Pathogen values taken at these sites must be adjusted up for this dilution as a mixing problem to be indicative of the contribution of upstream runoff. This is one reason why understanding hydrology is so important to the study of pathogen impairment in tidal watersheds. Another product of the model is an estimate of the average annual flow from each portion of the watershed and the relative contribution of each section to the annual freshwater discharge of the entire watershed. This has been summarized with values at the historic sampling sites (Figure 14).

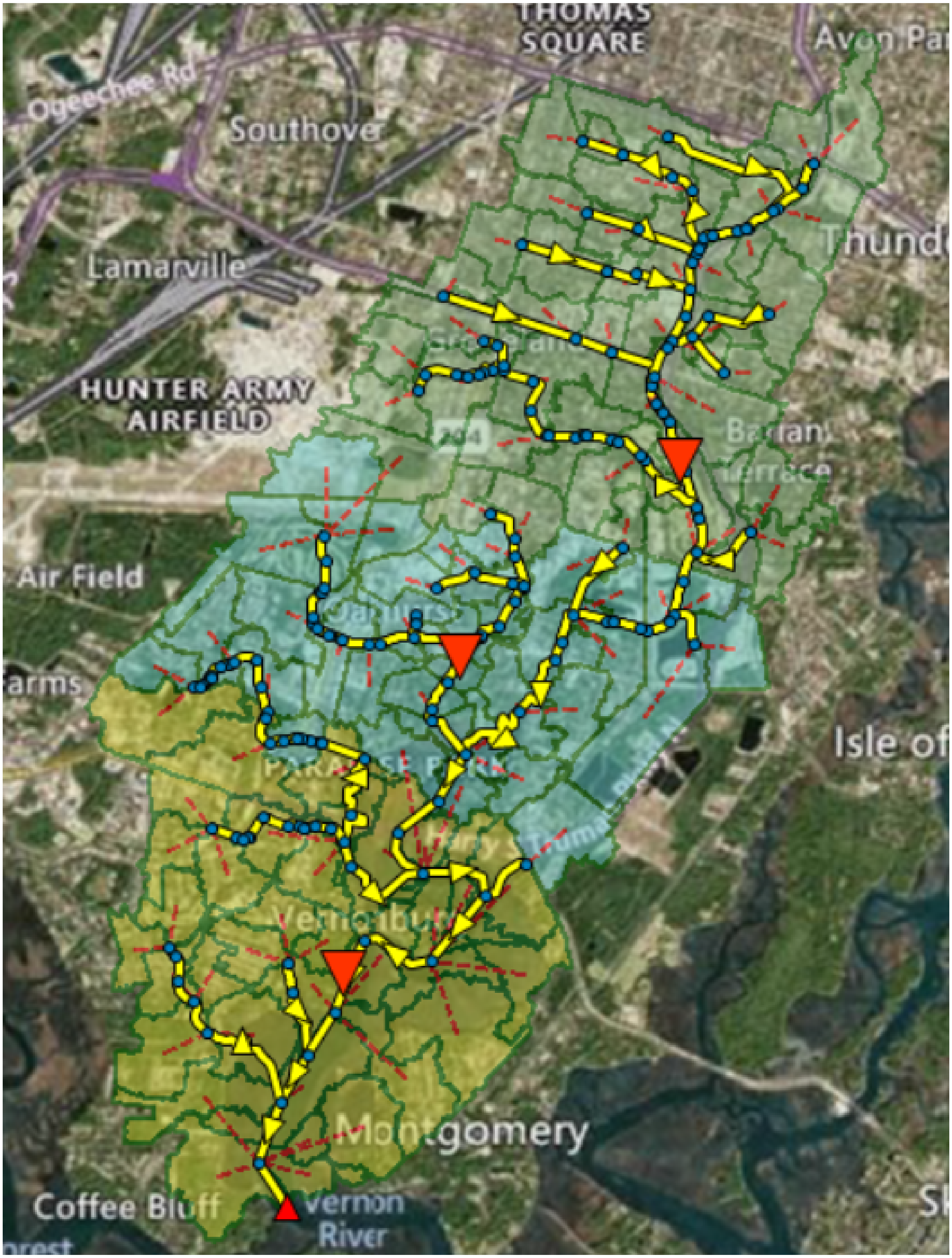


Figure 13. Hydrodynamic model including three rainfall regions and three real-time weather and stream gauging stations. Colors indicate the three rainfall data regions.

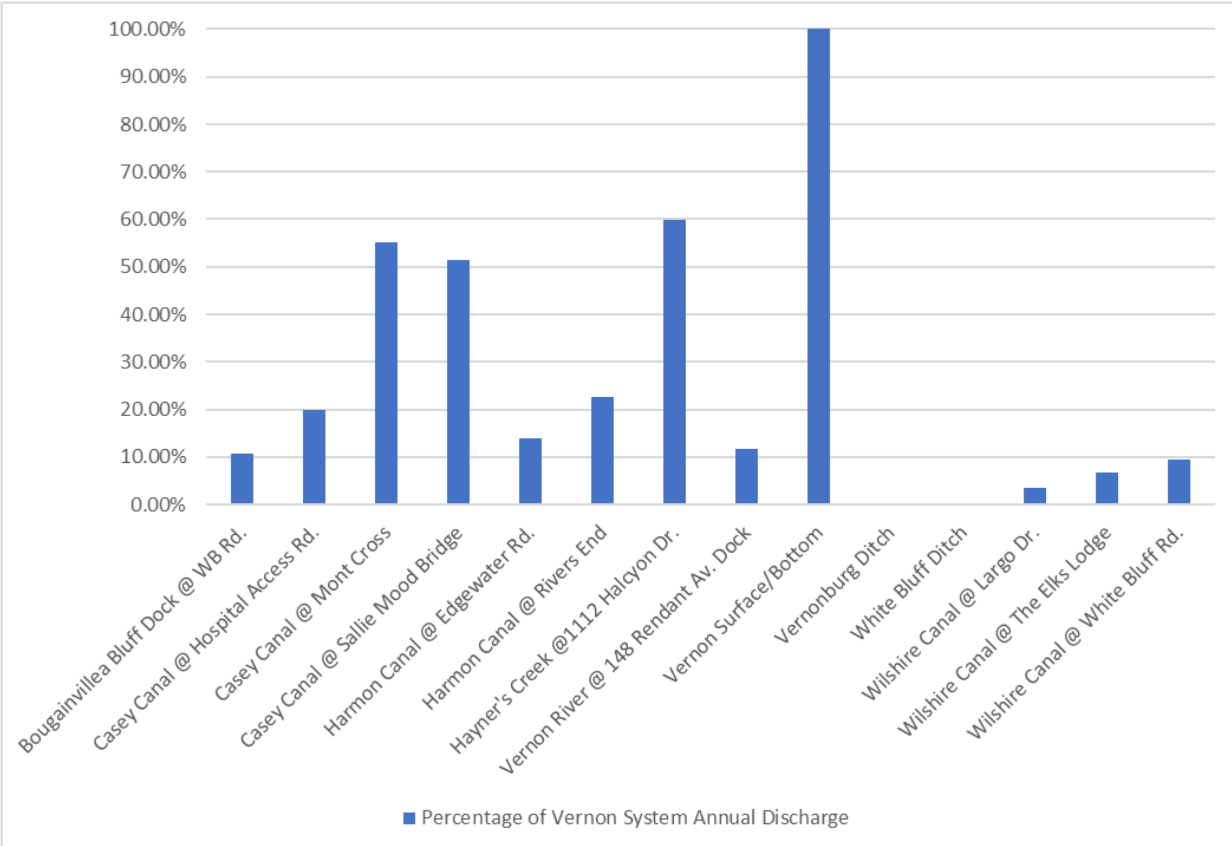


Figure 14. Percentage of the Vernon River system's annual discharge at each historic sampling site

Element 1: Identification of Causes and Sources of Impairments

E1.A - Potential Contributing Sources/Factors

The following potential sources of FIB are all relevant to the target watershed in such a way that they could potentially be significant contributors. The order presented here does not indicate in any way which of these sources is thought to be a more significant contributor and the inclusion of any one source in this list does not imply that it has been verified as a significant source.

E1.A.i - Degraded Stream Health

Bacteria, including indicator bacteria, have known predators in an aquatic system as a part of the overall ecological food web. If this food web is disrupted by pollutants, it can decrease predation and result in an increase of "pollution tolerant" species, of which indicator bacteria could well be.

E1.A.ii - Municipal Sewer

The majority of the developed watershed is serviced by municipal sewer including many areas identified as higher contribution areas. There are approximately 1.7 million feet of gravity sewer line and another 177,000 feet of force main in this target watershed. This does not account for the many private laterals which are all also potential points of contamination, particularly as they

age. Private laterals also are not usually subject to the same level of maintenance and inspection as municipal sewer mains. Without better data to estimate probability of failure, structure age has been used to estimate areas of higher probability failure in sewer laterals. The prior BST study identified human origin for the majority of the bacteria in the overall watershed (52%) based on the percentages at the most downstream Vernon River sites, which are inclusive of runoff from the entire watershed. This could be septic or sewer in origin. The wildlife designation was the next most common in that study at the Vernon sites, at 44%. Regarding the BST study, it is important to note that given the very high concentrations of pathogen indicators seen in these water bodies, there would likely still be impairment were either the "wildlife" or the "human" contributions considered entirely separately. Sewer lines in Savannah, like most cities, include conveyance components with a wide variety of material and ages. Efforts are underway in Savannah to maintain and modernize conveyance infrastructure, but many instances of older pipes or materials more prone to failure are still present and many of them have not been rehabilitated. Pipes under this condition are distributed throughout the target watershed. They are most concerning in areas of low elevation. The locations of these low elevation, age/material concern pipes are somewhat correlated with areas of highest concern. Sewage spills in the watershed are a matter of public record and are shown on a map below. An estimate has been made of the total bacterial load of these known spills with reasonable assumptions made for the concentration of pathogens in the sewage and the volume of sewage spilled. This can then be compared to the total estimated bacterial load from the system based on historical data. This rough estimate indicates that the known spills could account for between 1% and 30% of the total bacterial load in any given year. The wide confidence range is due to 1) the wide range in potential values for bacterial load in wastewater, 2) uncertainty in the actual spill volume, and 3) differing spill volumes in particular years. Sanitary Sewer Overflows (SSOs) can occur for a variety of reasons, including usage exceeding design parameters, clogged sewer lines, damaged sewer lines, Inflow and Infiltration (I&I), or some combination of these. Reductions in I&I can help reduce pressure on lines that are at or near capacity. Available GIS data indicates that there are several gravity sewer manholes in the watershed with top elevations of less than 10 feet. Some of them are located in priority areas of known contamination.

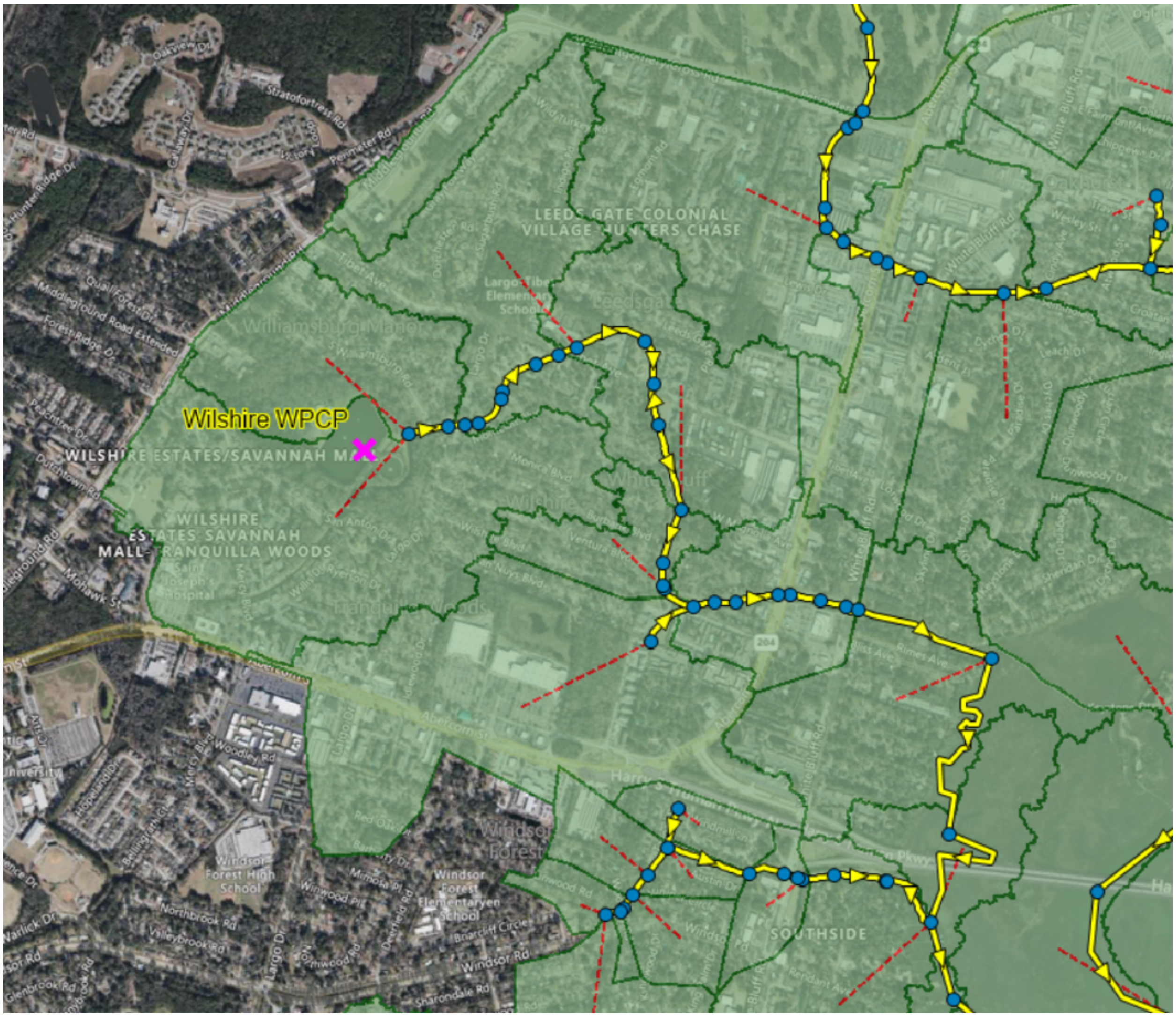


Figure 15. Wilshire WPCP

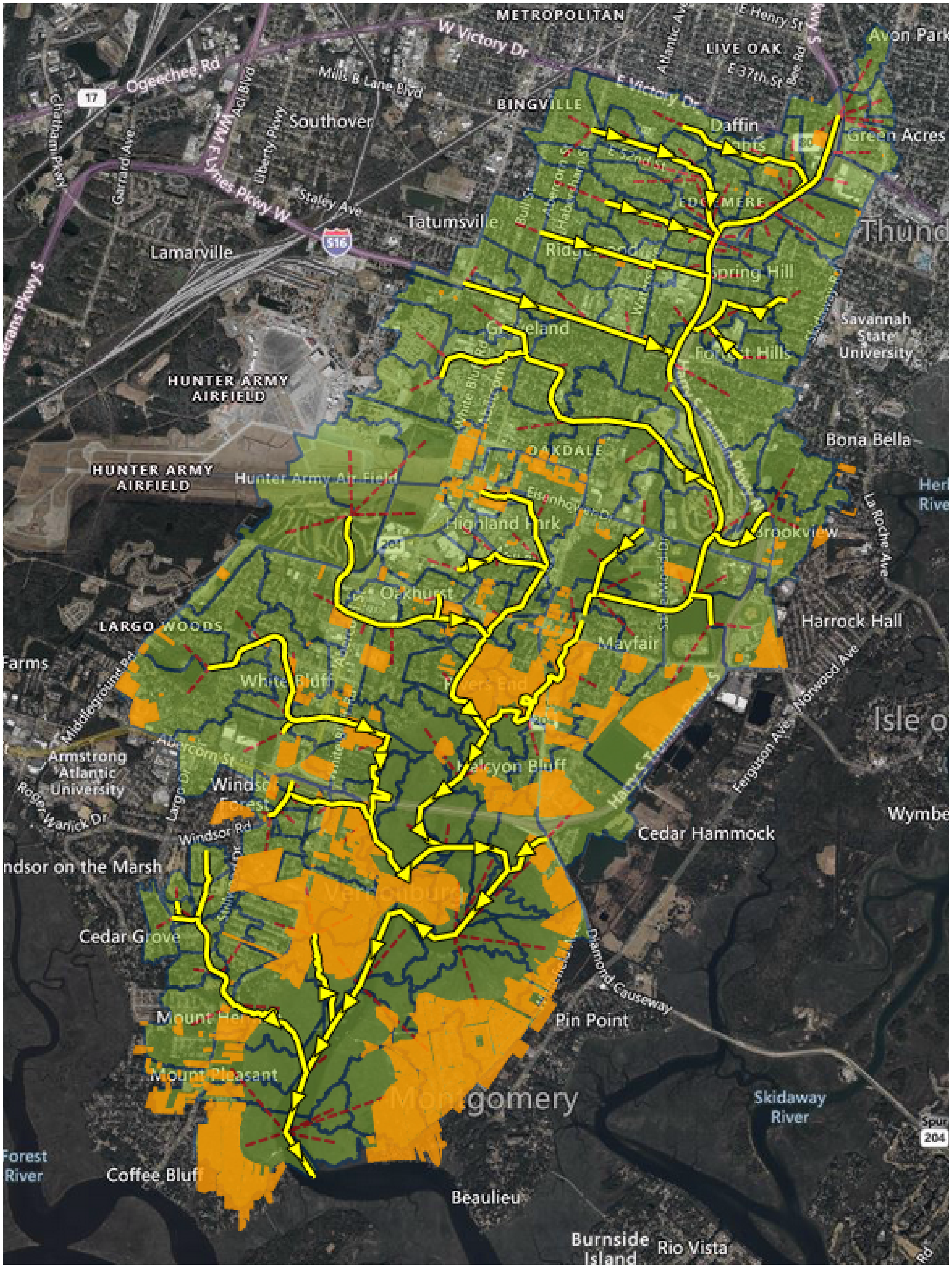


Figure 16. Public versus Private Sewage in the target watershed (Municipal Sewer-Green, Private Septic-Orange)

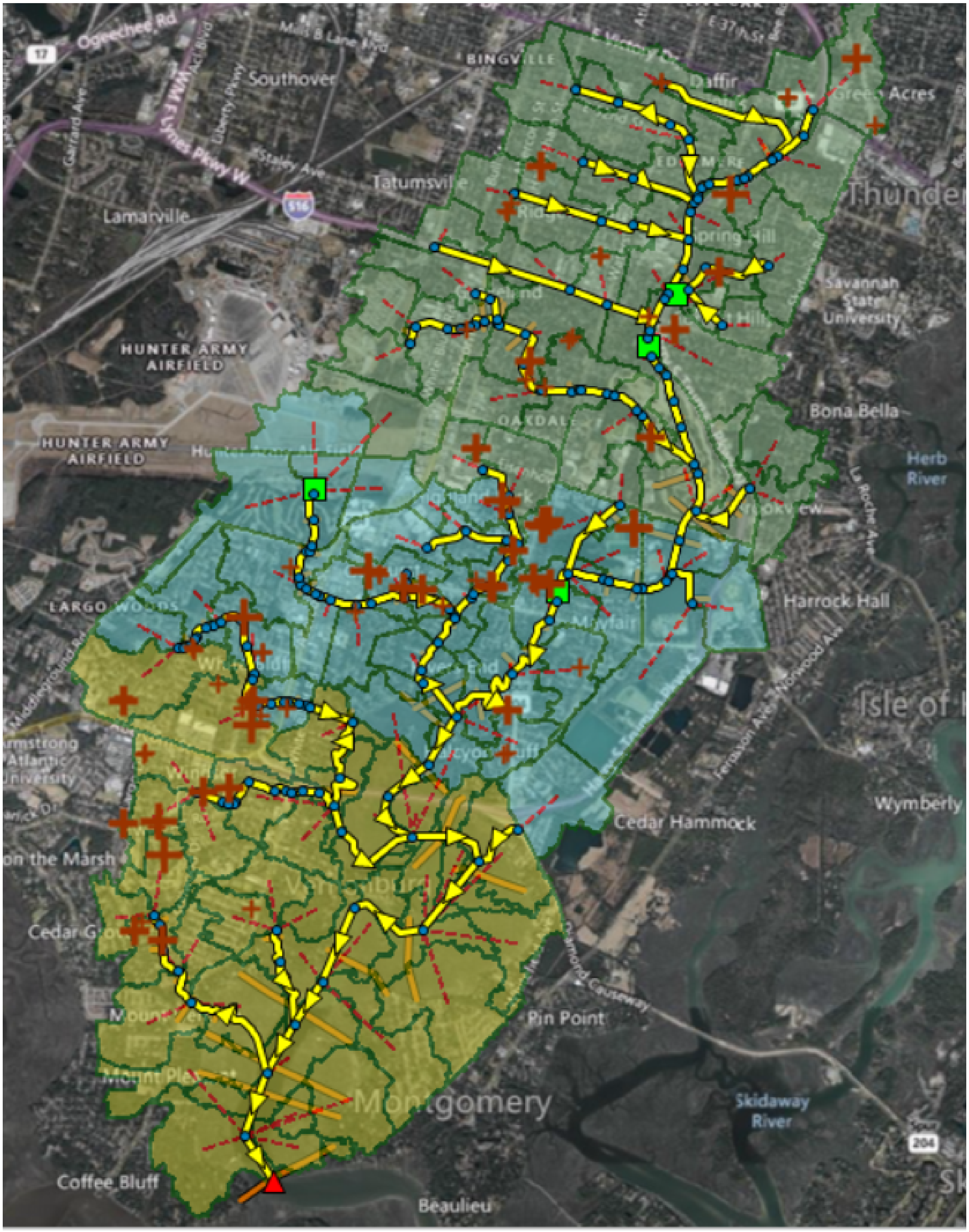


Figure 17. Documented sewage spills in the target watershed from 2005-2021. The cross icons are size graded to indicate the estimated size of the spill.

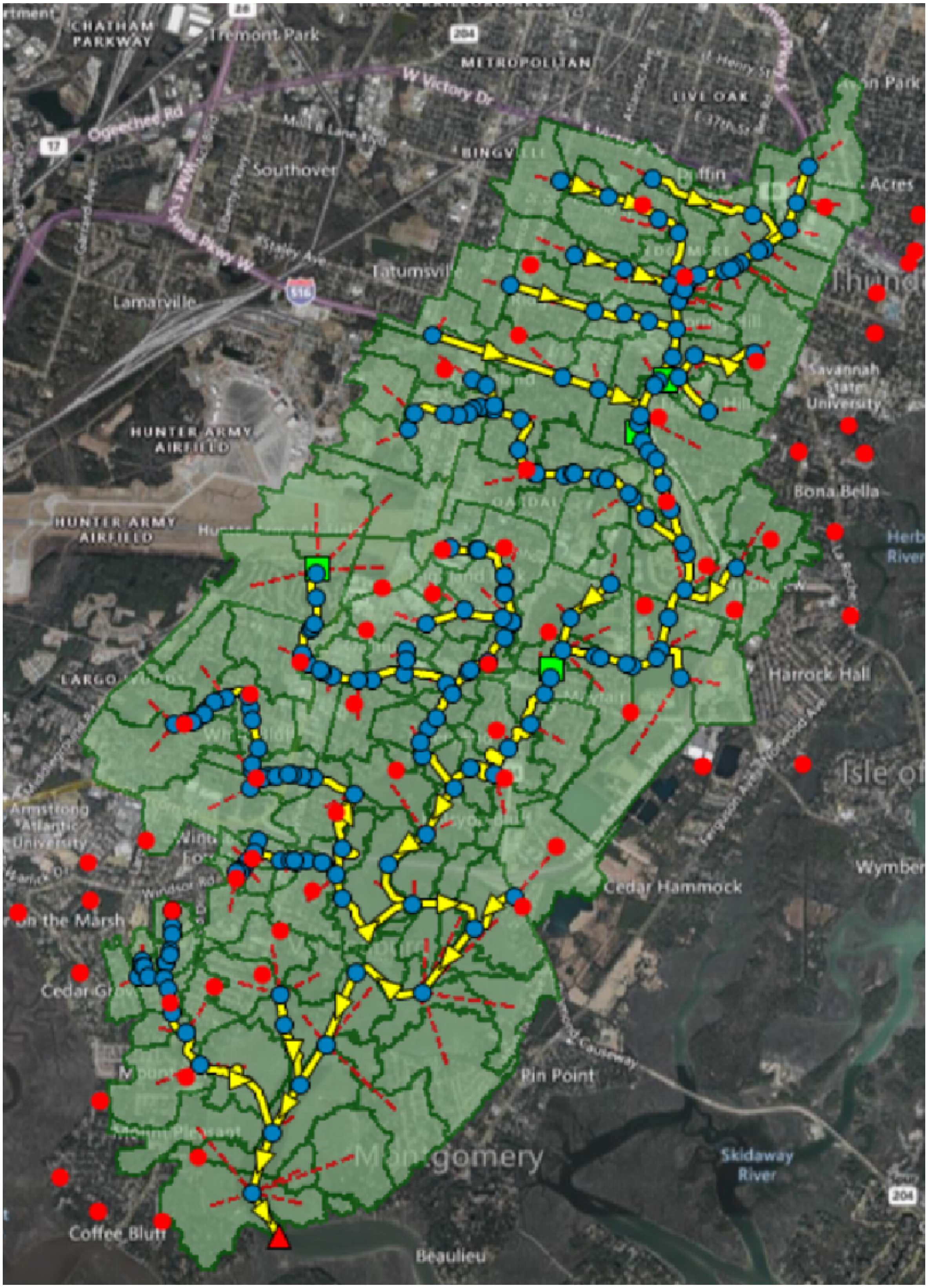


Figure 18. Locations of sewage lift stations, a higher risk part of the sewage system.

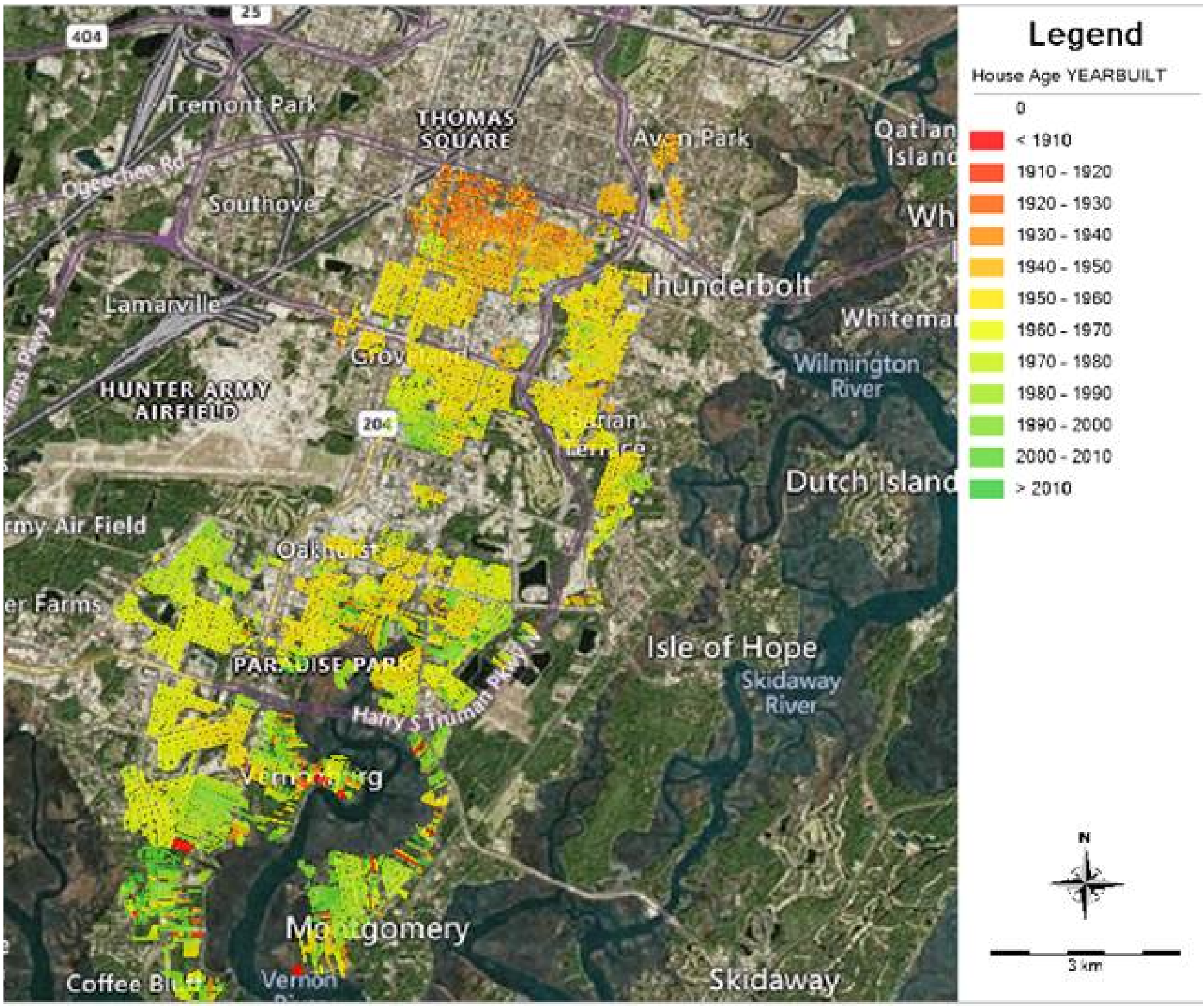


Figure 19. Building age in various parts of the watershed, indicating elevated risk of private sewer lateral failure for older buildings.

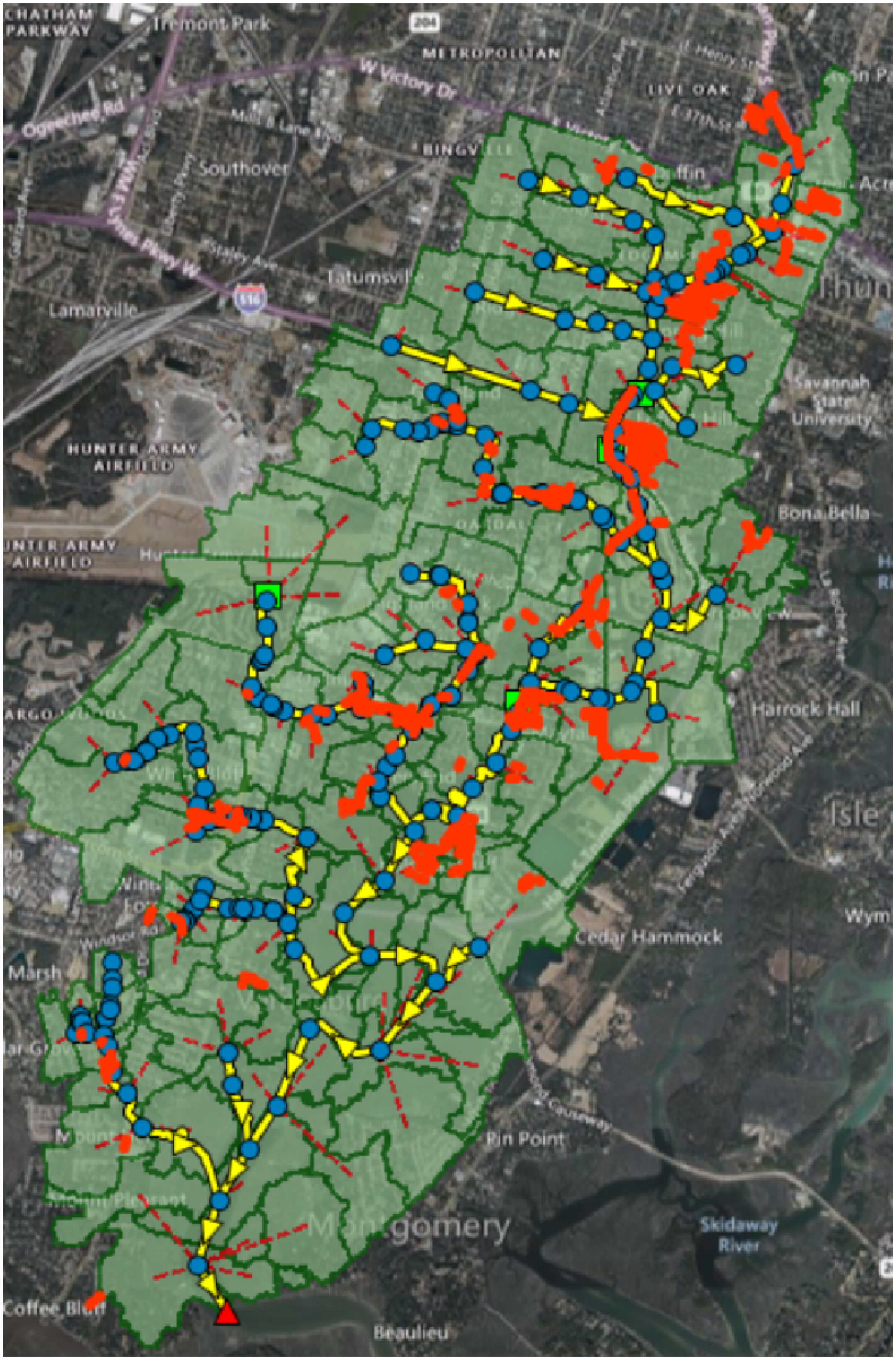


Figure 20. Locations of sewer lines at low elevation (<11ft) made from material of higher failure risk (Mostly “Truss” and Concrete).

E1.A.iii - Private Wastewater Treatment/Septic Systems

The existing private sewer systems areas are mostly located around the estuary portion of the Vernon River and Hayner's Creek as well as tidally affected portions of several tributaries. However, there are other areas around the city that retain significant numbers of septic systems, including the upstream portion of Chippewa Canal and portions of Wilshire Canal. The places septic system dominate that are also confirmed as high contribution sites in historic data are in the lower portions of Harmon Canal, middle and lower portions of Wilshire Canal, upper portion of Chippewa Canal and the upper portions of Hayner's Creek. They cannot be eliminated as major contributors for Harmon Canal, Hayner's Creek, Chippewa Canal, and Wilshire Canal at this time. In 2002, there were approximately 14,183 septic systems in Chatham County (2005 TMDL) and the BST study indicated approximately 2,500 systems in the target watershed, with 80% in the unincorporated Chatham County portion. A 2022 GIS search of the confirmed septic properties in the target watershed in this study revealed approximately 1,900 confirmed and suspected active systems with a median build year of 1985 and 25% built prior to 1976 (Figure 21). USDA soil survey results indicate that the entirety of the watershed is classified as "very limited" for septic absorption fields.

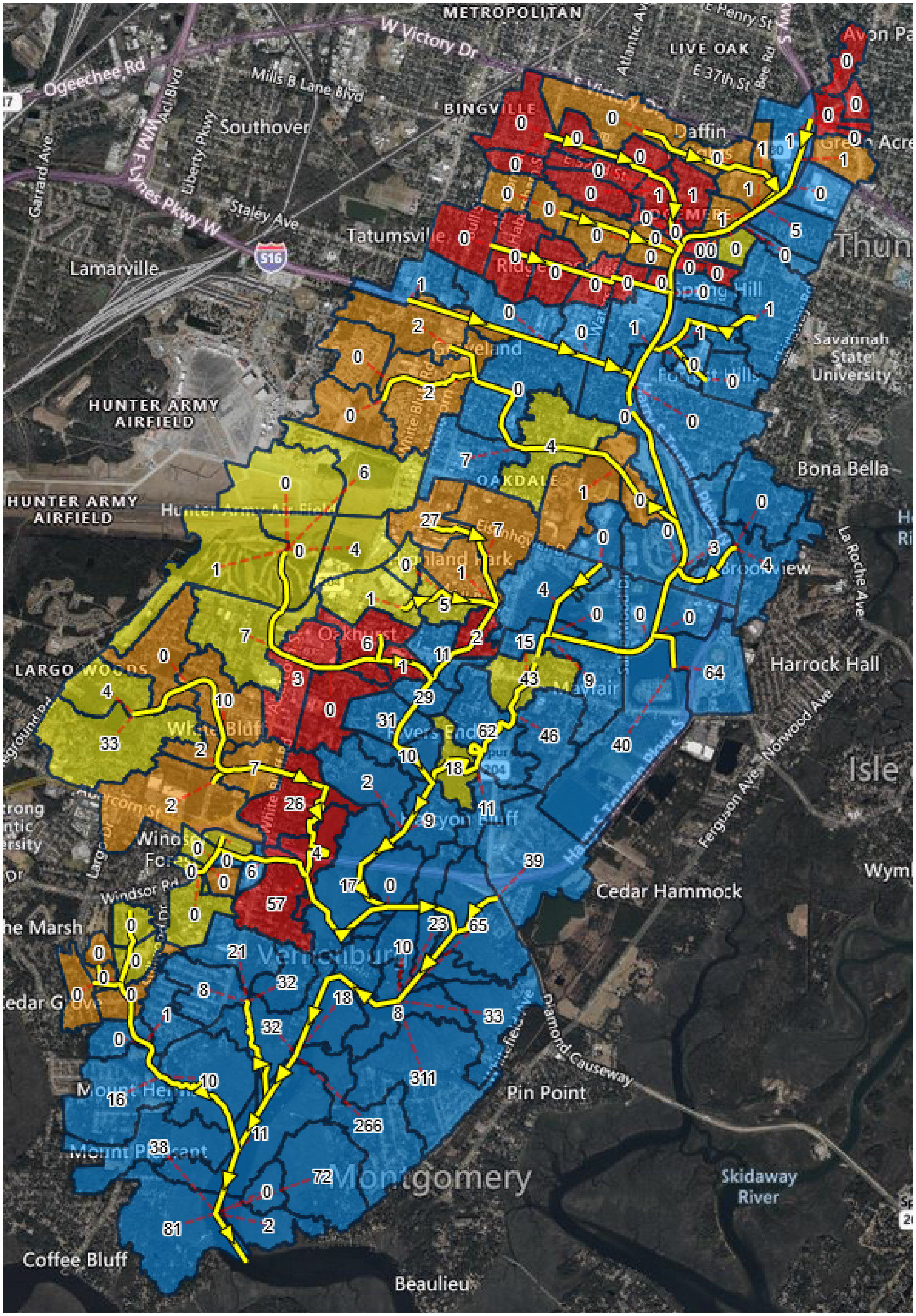


Figure 21. Prevalence of Septic Systems in each subcatchment. The labels indicate the number of active septic systems in each subcatchment and the colors of the subcatchments indicate the level

of bacterial loading, to be discussed in a later section (Warmer colors indicate higher FIB loading per acre).

E1.A.iv - Pathogen Indicator Bacteria Colonized in Sediment

Prior research has indicated the survival of indicator bacteria in sediments. It is possible that bacteria associated with sediments may be settling and growing in certain areas in the watershed, then being resuspended during high flows. Testing in this watershed indicated that underlying sediments may contain FIB at much higher concentrations than the overlying water column. In a proof of concept experiment, sediment was added in a 1:1 volumetric ratio to the overlying water, mixed, and the supernatant removed for analysis. This was compared to an identical sample with no sediment. In most cases the samples containing sediment were either similar in concentration or up to about 5 times higher than the overlying water column (Figure 22). However, a sample including sediment from Casey Canal contained 300 times the E. coli count as the overlying water column, indicating a much higher potential for a colonization, growth, and resuspension during high flows as a significant bacterial source. One sediment sample, at Wilshire Canal and White Bluff Road, was lower in the sediment than the water by about 3x. While no statistically significant findings can be taken from this experiment, it provides indication that sediment could be a significant source of bacteria in Casey and Habersham Canal and that these areas may be experiencing increased survival or growth of FIB. Temperature, salinity, and sediment size/type are well known contributors to survivability of various fecal indicator bacteria (FIB) in natural waters. However, Surbeck et al. (2010) indicated that threshold phosphorus and DOC concentrations can also have a strong effect on the survival or growth of FIB in sediments. They proposed threshold values of 0.07 mg/L phosphorus and 7 mg/L DOC above which FIB counts either maintain indefinitely or grow exponentially. In this sediment resuspension scenario, stream gradient may be relevant to understanding, give the potential for settling and resuspension (Figure 23).

Tributary	Site	Sample Date	Days Since Rain	FIB	1:1 Sediment/Water Mixture Supernatant (CFU/100ml)	Overlying Water (CFU/100ml)	Ratio
Casey	Site 1W	07/06/2022	5	EC	86640	300	288.8
Wilshire	White Bluff Road	07/06/2022	5	EC	860	2160	0.398148
Habersham	Agonic Road	07/06/2022	5	EC	1100	310	3.548387
Harmon	Site 5	07/06/2022	5	EC	7490	7710	0.971466
Harmon	Site 2	07/06/2022	5	EC	30760	6090	5.050903
Casey	Site 1W	08/08/2022	1	EC	198630	77010	2.579275
Wilshire	White Bluff Road	08/08/2022	1	EC	860	980	0.877551
Habersham	Agonic Road	08/08/2022	1	EC	20980	200	104.9
Harmon	Site 5	08/08/2022	1	EC	200	1340	0.149254
Harmon	Site 2	08/08/2022	1	EC	4100	6910	0.593343

Figure 22. Data from a sediment FIB concentration experiment in the Vernon watershed.

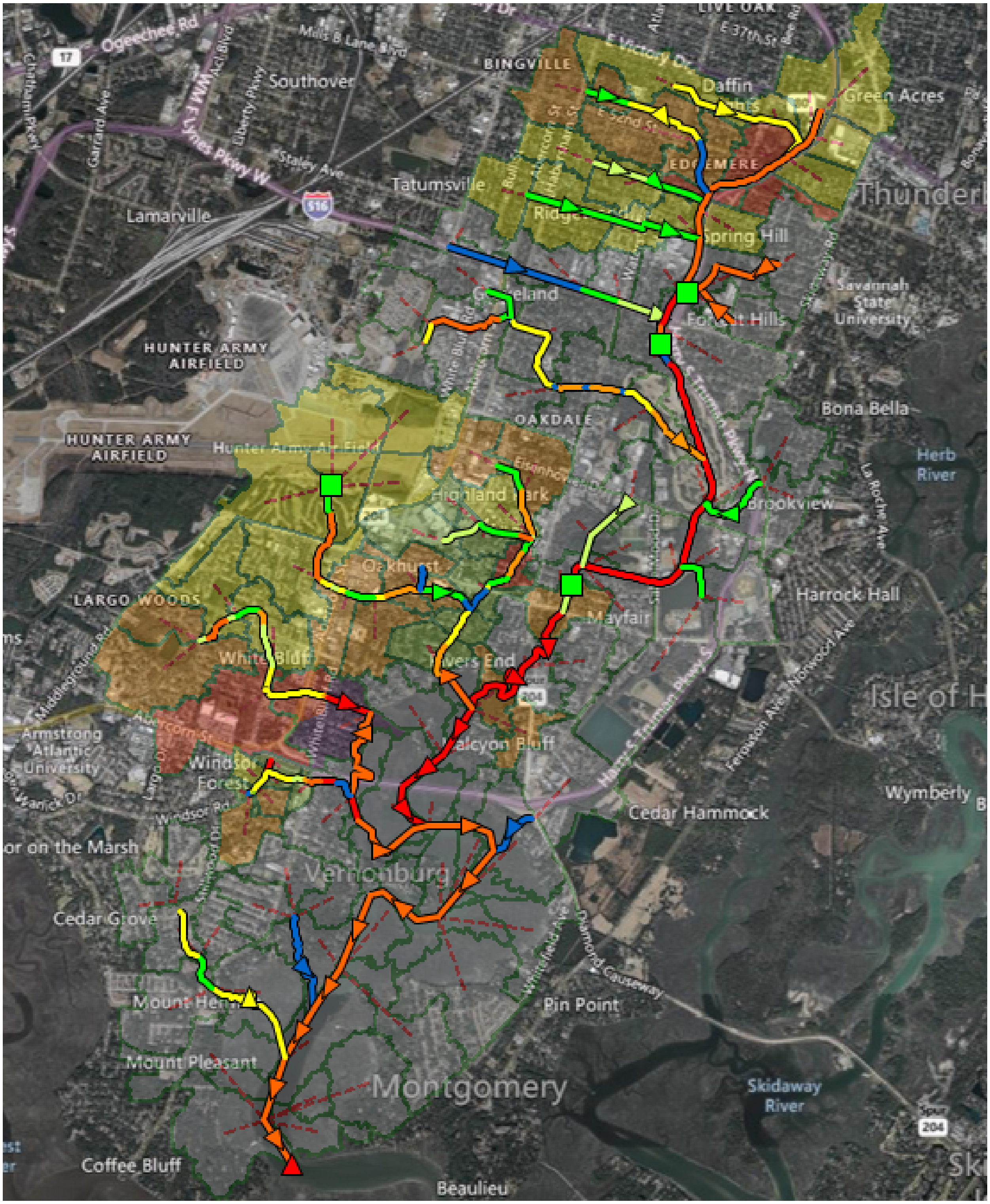


Figure 23. Gradient distribution of stormwater infrastructure. Warmer colors are lower stream gradients with greater potential for sediment accumulation.

E1.A.v - Landfill Leachate/Runoff

There are no active landfill sites in this watershed, but according to the 2005 TMDL there are several older inactive landfill sites in Chatham County. One of them is the Thomas Avenue Landfill, which is located in the target watershed. According to a 1998 Environmental Impact Statement on the construction of the Harry Truman Parkway, the site was in operation as an "inert waste landfill" and there are records of additional unauthorized dumping activities in the vicinity (https://play.google.com/store/books/details?id=2LI1AQAAMAAJ&rdid=book-2LI1AQAAMAAJ&rdot=1). Unsubstantiated online sources indicate that there were several FEMA reports of unauthorized burning on the site between 2004 and 2010 (homemetry.com). In a 2017 *Savannah Now* article, the Thomas Avenue site is described as an "organic waste landfill." This site is subject to continuing air and groundwater monitoring, but this monitoring does not include pathogens. According to a 2021 monitoring report accessed through GEOS, the site was capped around 2002, and is experiencing dissolved methane impacts that result in impacted groundwater chemistry (geos.epd.georgia.gov).

E1.A.vi - WPCP

In addition to the sewer network and potential leaks and spills from that network, there is one operational WPCP in the watershed. According to permit GA0020443, the Wilshire WCPC, located at 11015 Largo Drive, is currently permitted to discharge a monthly average of 4.5MGD to the Savannah River Basin. While, according to this permit, the facility is not discharging to the affected watershed, its physical presence in the watershed still presents a risk of contamination of the waterway due to potential leaking infrastructure or system overflow.

E1.A.vii - Wildlife

While wildlife does have a natural contribution to pathogen concentrations in natural spaces and unimpaired water bodies, some factors can cause wildlife to have an elevated impact. The BST study that was conducted in this watershed identified wildlife as a dominant source of bacteria. It was identified as contributing at least half of the bacteria in the Wilshire, Harmon, and Hayner's portions of the watershed and was still a significant contributor in the Casey and Vernon portions. However, a couple of factors should be noted regarding this finding. First, it should be noted that the BST study indicated poor discrimination for sewer sources, with 29% being incorrectly described as wildlife. This could have exaggerated the wildlife findings in this study to some degree. Also, since many of the BST study sites are highly tidal, there is a large, even dominant, signal from downstream sources toward Ossabaw sound, where wildlife is known to exist. Furthermore, even if a large percentage of the bacteria present are from wildlife origin, the concentrations present place the water body far above a normal background condition, indicating that some factors may be contributing to the increased delivery and survivability of bacteria in this water body that may be a result of human impacts. Approximately 35% of this watershed is either military installation (low development density) or conservation zoning, indicating the presence of urban refugia for wildlife. Most of the conservation zoning is near water bodies. Wildlife may also be using water infrastructure as refugia in the urban environment. Racoons are known to use storm infrastructure as dens (Kern, 1991) and have been shown to contribute to stormwater pathogen loading (Ram et al., 2007). However, racoon markers were included in the prior BST study and indicated limited impact. Other potential sources of "wildlife" contribution include urban agriculture animals such as chickens, which could have showed up as bird in the

BST study, and other feral animals, such as cats. All together these factors could result in a higher-than-normal concentration of "wildlife" defecating near water bodies that could increase the "natural background" concentration of pathogens to some degree.

E1.A.viii - Pets/Urban Livestock

Pet waste is a typical target for pathogen reduction in impaired streams. A question often raised is why open defecation by dogs is an issue while other canine species such as coyotes and wolves defecate in the wild without problem. Density is the most relevant difference. According to Shelter Animals Count, Chatham County, GA had over 4,400 intakes of dogs and cats during 2021, most of which were owner relinquished animals. This is not counting all the wanted/kept pets in Chatham County or the feral animals, including many cats, that are not picked up by animal control. 2021 reports from both WJCL and WSAV News note that shelters are over capacity with stray and relinquished animals. This could be compared to a relative few wild canine species that could be expected to inhabit an area the size of Chatham County, resulting in an unbalanced condition of natural waste management. Regarding areas of highest potential concentration, there are two dog parks in the target watershed, Herty Pines Dog Park on Bee Road and Windsor Forest Dog Park on Linwood Road. There are also several dog day care facilities or veterinary clinics offering boarding (Southside Hospital for Animals, Abercorn Street; Banfield Pet Hospital, Victory Drive; Crossroads Animal Hospital, Montgomery Cross; VCA Greater Savannah Animal Hospital, Derenne Ave; Von Trapp Animal Lodge, Waters Ave; Barkie Bow Wows, Montgomery Cross Rd; The Hipster Hound, Abercorn St; Animal House at Live Oak, Thomas Ave; and Carols' Pampered Pets, Commercial Dr). There is also a pet rescue center, Coastal Pet Rescue, on Thomas Ave and the Humane Society for Greater Savannah on Sallie Mood Dr. The BST study indicated that pets were a relatively minor contributor to the overall pathogen load observed in the watershed. In addition to traditional pets, urban agriculture is a growing trend in Savannah. The city updated its ordinance related to urban animals in 2015 and now permits, with some limitations, chickens, pigs, cows, sheep, goats, and various other small mammals. The most common form of livestock farming in the target watershed is probably small-scale chicken farming. The Savannah Backyard Chickens social media group, created in 2009, now boasts over 6,000 members. It is likely that any contribution from domestic chickens could have been categorized as bird (wildlife) in the prior BST study. Other urban livestock such as goats could likewise have been categorized as other animal (wildlife) but could also have been categorized as human or pet.

E1.A.ix - Unhoused Communities/Open Defecation

According to Chatham Savannah Authority for the Homeless (CSAH), there were 1,009 unhoused individuals identified in a 2018 survey with an additional 800 unhoused students identified through the public school system. However, estimates from other sources are much higher. An article from WSAV News places the number closer to 4,000 including those who experience unhoused periods. CSAH has also identified 39 known unregulated encampments of unhoused individuals, 7 of which are in the Vernon watershed (Figure 24). These encampments do not have improved water or sanitation services, and significant open defecation is likely to occur from humans and pets. The encampments are mostly located on city owned land, which is disproportionately low lying, prone to flooding, and adjacent to waterways (Figure 25). In an article from Connect Savannah, camps are reported to be clustered around both ends of Truman Parkway among other known locations.

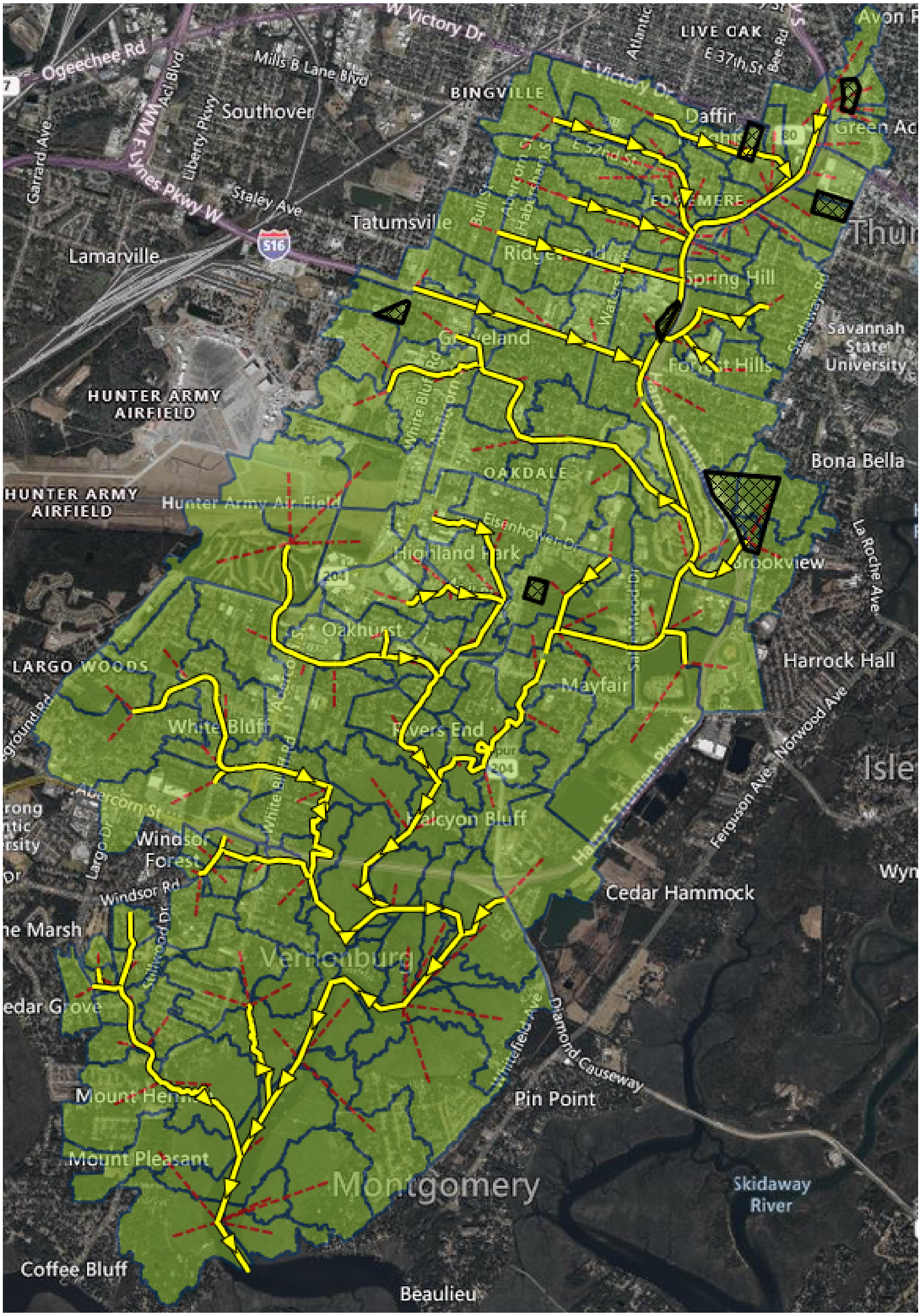


Figure 24. Areas provided by CSAH containing known encampments of unhoused individuals.

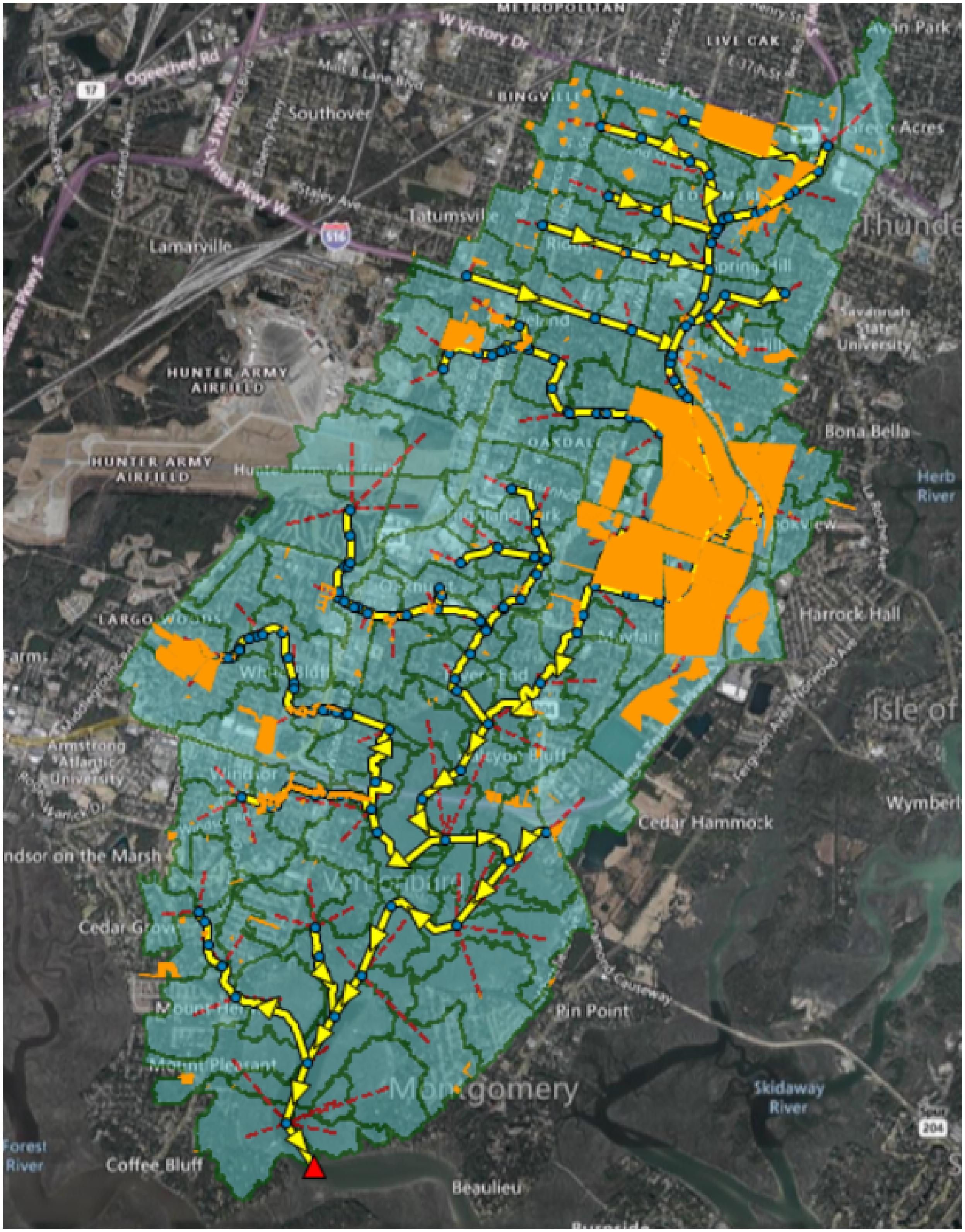


Figure 25. Parcels owned by the city or county in the target watershed representing sites with higher probability of containing encampments of unhoused individuals.

E1.B - Watershed Impact Schematic

In keeping with the WMP guidance documents, a watershed impact schematic has been developed (Figure 26).

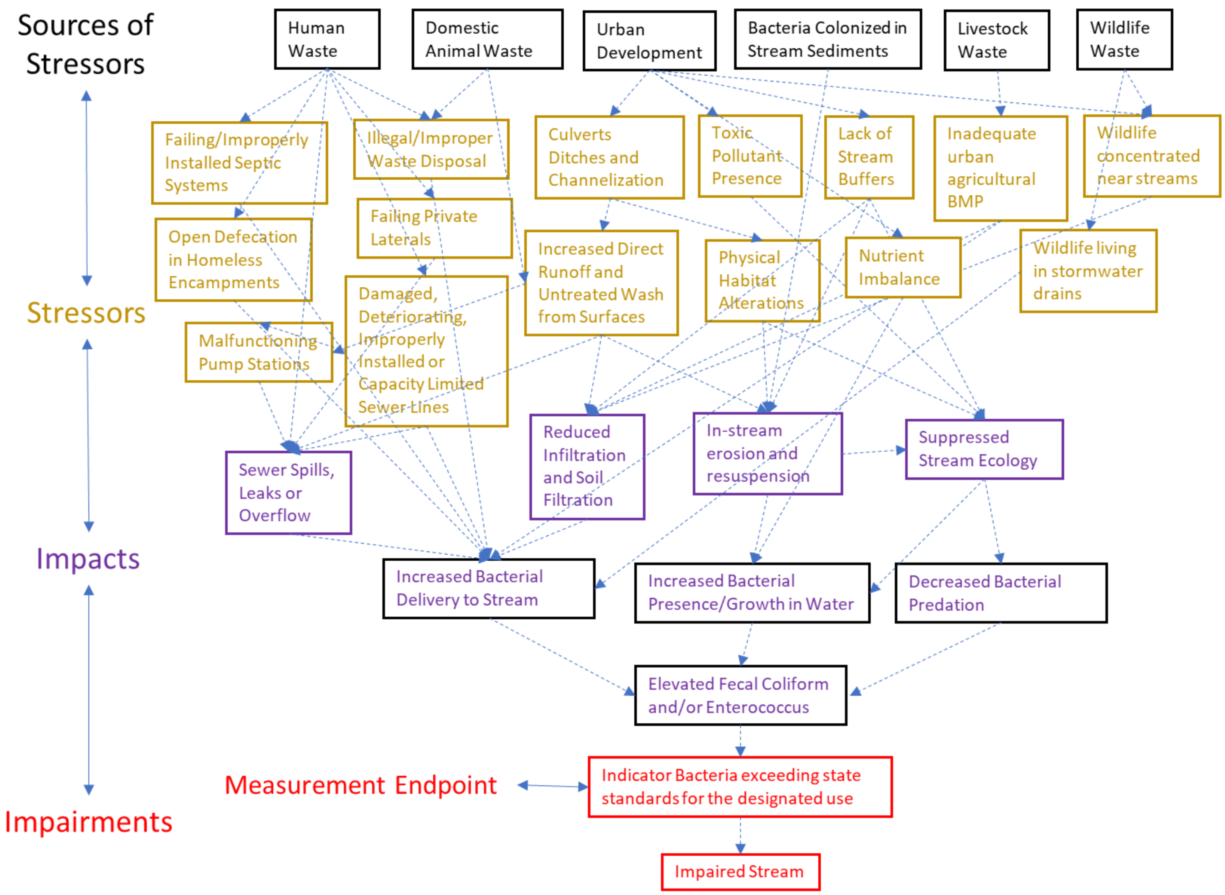


Figure 26. Watershed Impact Schematic

E1.C – High Single Sample Distribution

The figures below indicate the location and magnitude of the highest concentration samples observed in the historic and recent data (Figure 27-29). All samples are shown and enumerated by the histogram data, but they are size graded in the corresponding bins with the larger icons indicating larger concentrations.

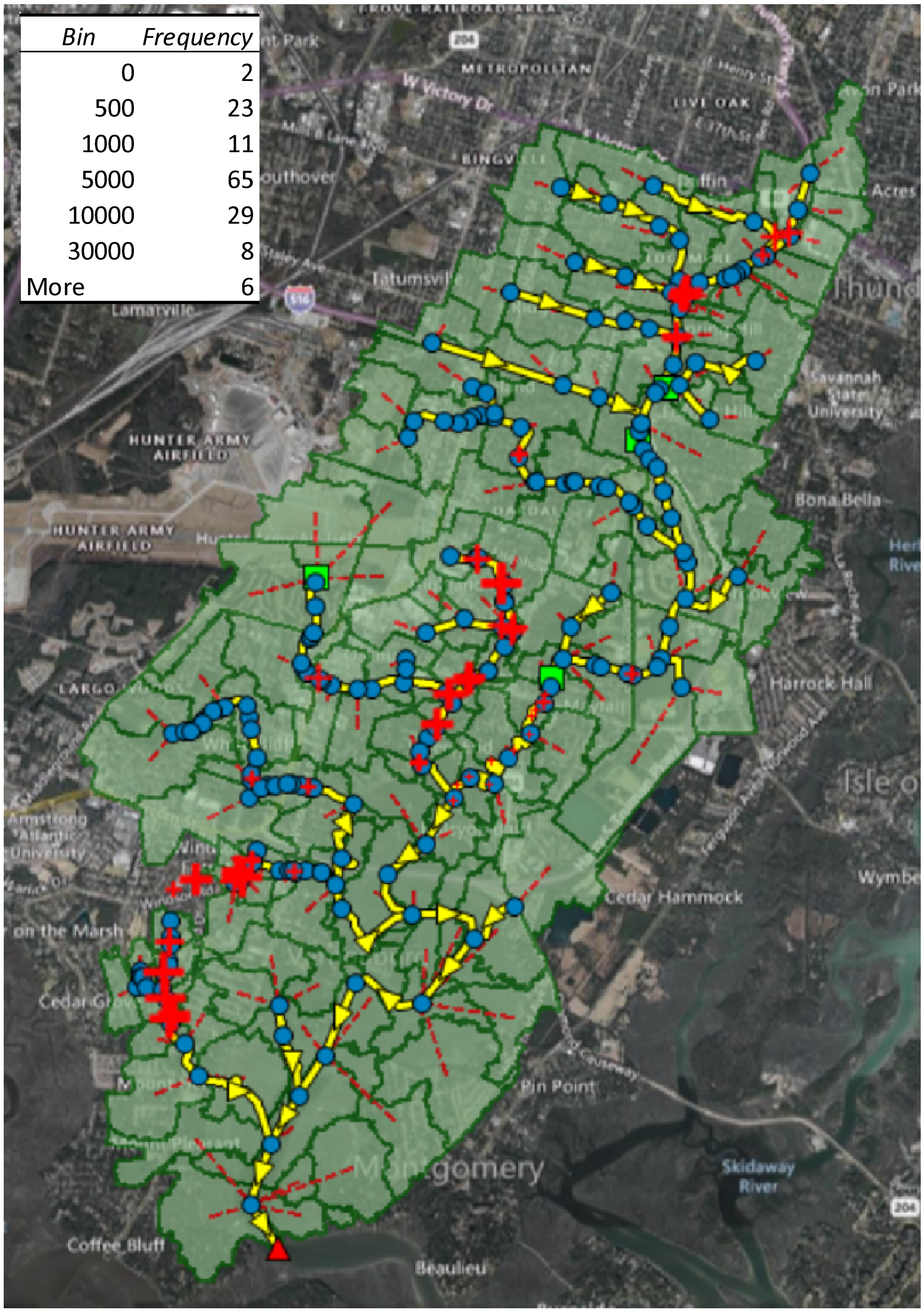
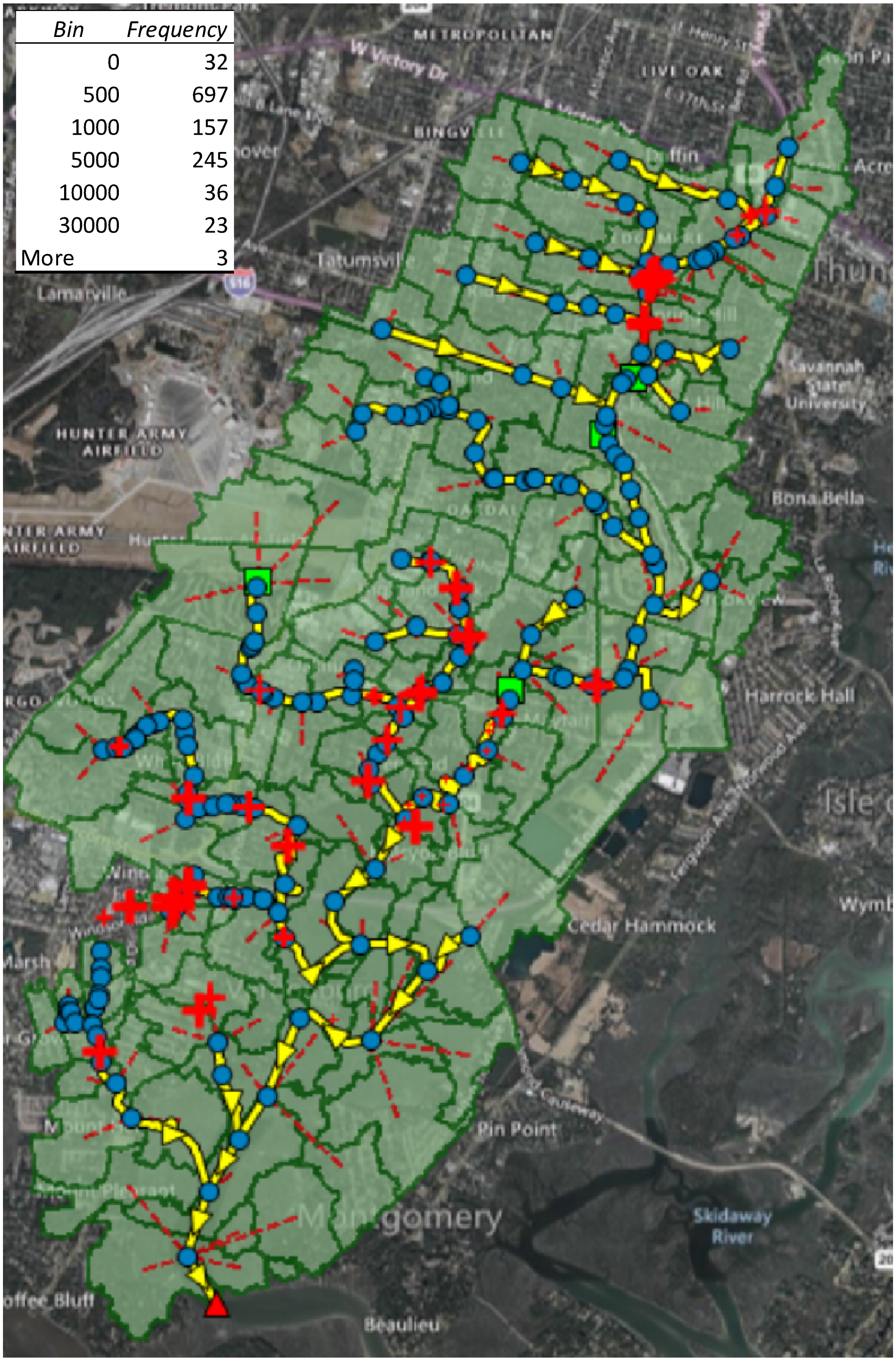
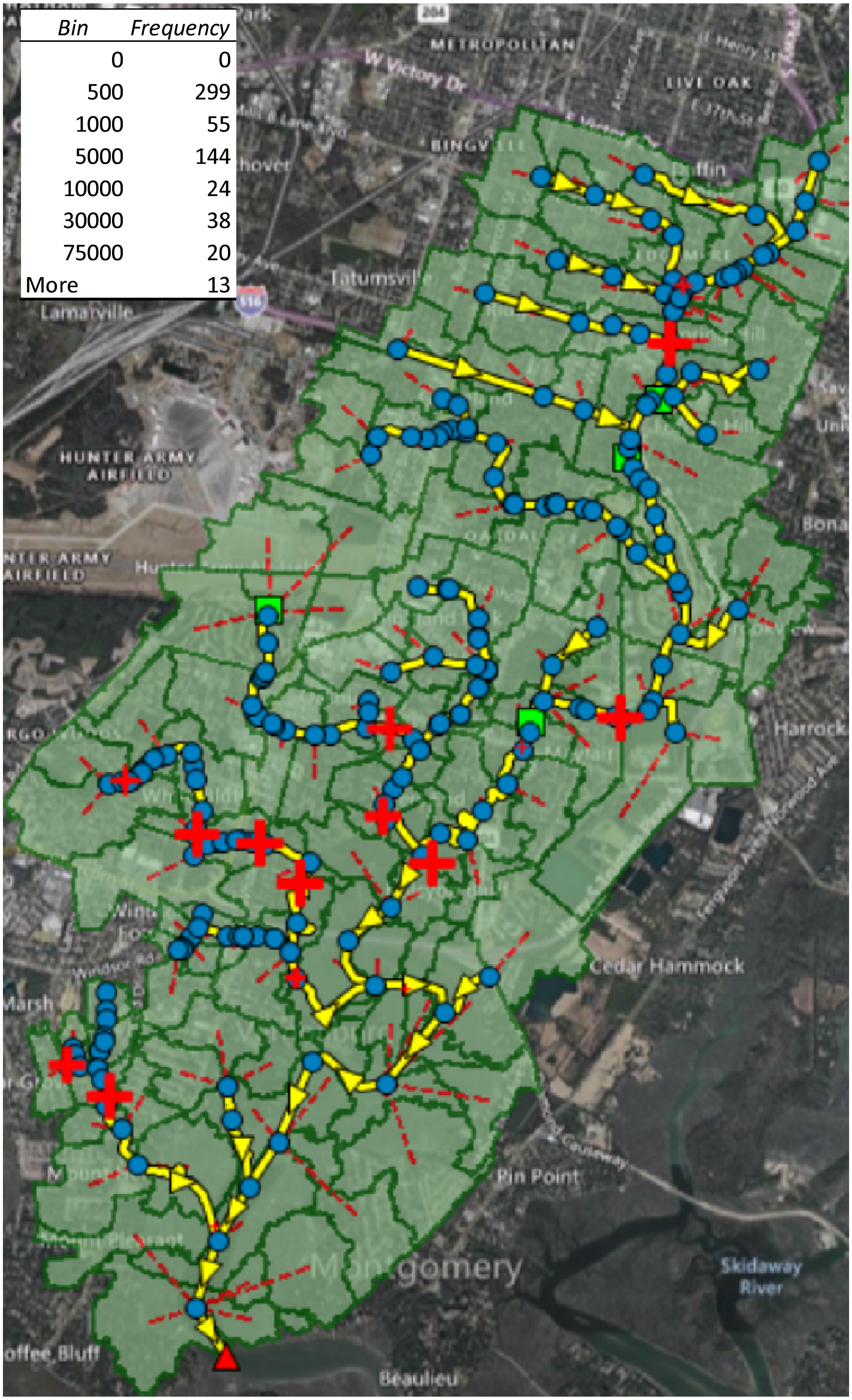


Figure 27. High Single Sample Results – EC



Bin	Frequency
0	32
500	697
1000	157
5000	245
10000	36
30000	23
More	3

Figure 28. High Single Sample Results – ENT



Bin	Frequency
0	0
500	299
1000	55
5000	144
10000	24
30000	38
75000	20
More	13

Figure 29. High Single Sample Results – FC

E1.D – Source Complexity

One of the difficulties in high confidence determinations of sources in this watershed are the source complexities present, even over relatively small areas. Nowhere is this more apparent than in Wilshire Canal (Figure 30).

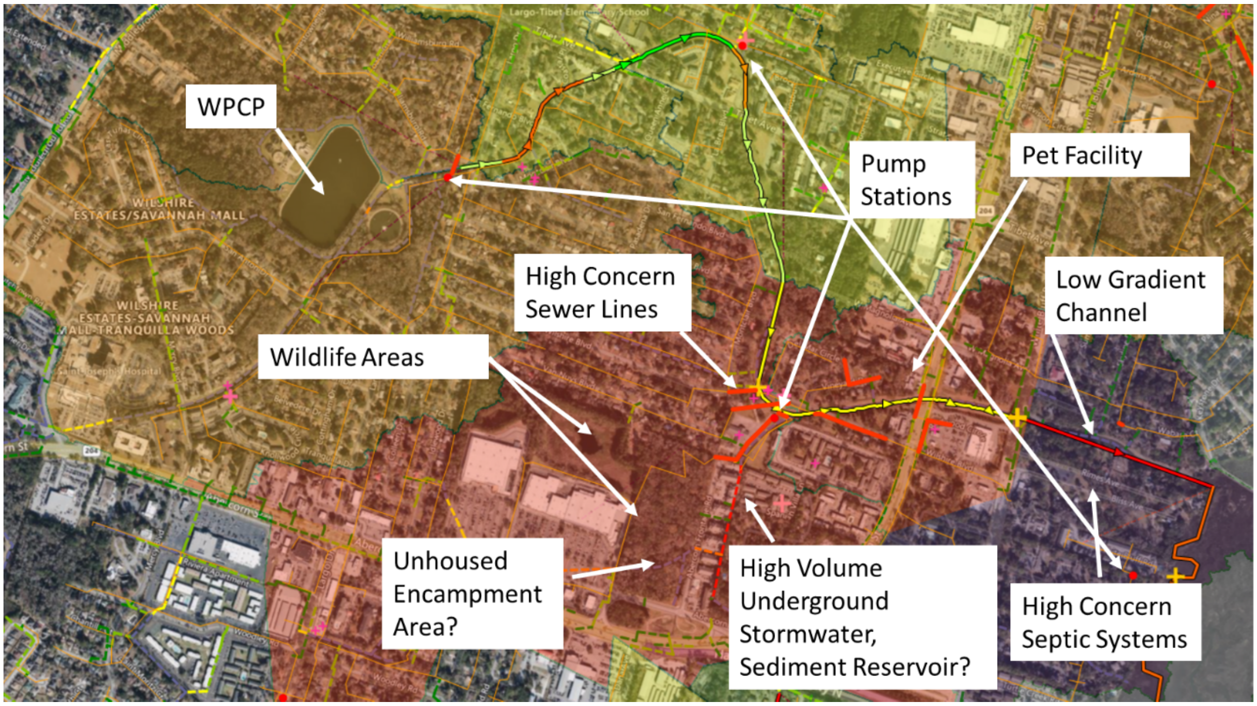


Figure 30. Complexity of potential sources demonstrated by Wilshire Canal System.

E1.E – Pathogen Rainfall Response

To more fully understand the nature of pathogen contamination and likely sources, a statistical study was done on available data to investigate the relationship between rainfall and pathogen concentrations in the watershed. There are three possible scenarios: 1) positive correlation, where rainfall is associated with increased concentrations, 2) no correlation, where rainfall does affect concentrations, and 3) negative correlation, where rainfall is associated with decreased concentrations. Typically, the first scenario is assumed for most NPS pollutants, (1)where runoff is picking up and carrying ground deposited or sediment attached pollutants, (2)where runoff interacts with failing septic systems to push contamination to water bodies over land or through subsurface flow, (3)where leaks into ditches or other temporary locations are flushed downstream, or (4)where I&I or nuisance flooding cause SSOs or other interconnection between sewer and storm infrastructure. The third scenario may occur in a situation where there are significant septic or sewer leaks that are occurring constantly as a baseline condition, and where there is insufficient runoff to drive processes to counteract that effect and rainfall actually serves to dilute the constant baseline flow of pollution. The second scenario could occur where there is a balance between the first and third scenario eliminating any clear correlation. In this case a Wilcoxon Rank Sum Test was used to compare the median concentration between rainfall affected (0-3 days antecedent rainfall) and rainfall unaffected (4+ days antecedent rainfall). All available data were used including approximately 10 years of data from historic monitoring sites and available data from new monitoring sites, though new dry weather testing was limited. Each

FIB type was tested separately. Sample size for each site/indicator/weather combination varied from just 2 samples to as many as 94. The overwhelming result was positive correlation, with some nuance. FC was positively correlated with rainfall for all sites with available data. EC was not correlated for any sites, but data was extremely limited with most sites having just 2 or 3 samples for each weather condition. Coffee Canal had a few more samples and may be a special case as a known sewer spill occurred when data was taken. ENT was positively correlated with rainfall for all sites and had more than 2 or 3 samples for each weather condition except for the Vernon River at Vernonburg and Vernonburg Ditch in Vernonburg, which were both almost significant. Another consideration, other than significance of correlation, is how much higher the concentrations are due to rainfall, or how much the rainfall factors affect concentration. Higher impact would indicate a dominance of the rainfall driven factors discussed. All the means for wet and dry weather are available in the tables of Appendix D along with significance, but of note, there are significant differences in the ratio of dry to wet concentrations between sites. For ENT, most sites have a wet/dry ratio for mean concentration between 2.5 and 5, but there are two outliers. Wilshire @ Elks Lodge is particularly insensitive to rainfall with a ratio of just 1. Wilshire @ Largo, which is upstream of Elks Lodge, only had 2 dry weather samples for FC and ENT, but it there was no significant difference for either indicator. The dry weather mean for ENT at Largo is higher than its wet weather mean. On the other end of the spectrum Harmon Canal @ Rivers End is particularly sensitive to rainfall with a ratio of 8.5. For FC, most ratios are between 2.5 and 8.5, with two exceptions, both in Casey Canal. Casey @ Hospital and Casey @ Sallie Mood are both particularly sensitive to rainfall with ratios of 21 and 44, respectively. Some potential inferences from this information include the following:

- Wilshire upstream of Elks Lodge may be driven more than other areas by a dry weather source, such as a failing sewer line, septic system, or WCPC leak that does not require rainfall for failure.
- Harmon/Chippewa Canal may have sources that are more driven by rainfall, but it may experience this behavior due to minimum dilution of the sample during wet weather when tidal impact may be less at that site.
- Casey Canal may also have sources that are more driven by rainfall, but it may experience this behavior due to the existence of pumping stations moving water only during rainfall and/or the disturbance of sediments in the canal during pumping and high flows which have been shown to have much higher concentrations than the overlying water. The extremely high ratio at Sallie Mood is probably consistent with the interpretation that most of the pathogen contamination in Casey is entering above the DeRenne pump station.

E1.F – Conductivity Walks and Historic Conductivity Data

Taking high spatial density conductivity data during baseflow conditions can indicate the presence of a conductivity source (such as a wastewater discharge) or a dilution effect where one tributary has a clearly lower conductivity than another. The higher conductivity tributary could be indicative of a distributed wastewater leakage. Conductivity is generally set by local soils and geology but can be influenced by discharges including wastewater (higher conductivity), irrigation water (generally lower conductivity), or other pollutants (impacts depends on the pollutant). In addition to conductivity walks, some historic conductivity exists for historic sampling sites that contain valuable information.

E1.F.i - Chippewa Canal Conductivity Data

A 2022 stream walk from Montgomery Cross Road to Madison Avenue (about 4,300 feet total) revealed that the western branch connecting at Mall Blvd has a strong discrete diluting influence indicating a much lower conductivity signature than the norther branch and a higher than expected conductivity in the northern branch (Figure 31). There was a rapid increase in conductivity observed moving downstream (over about 500 feet) from Madison Avenue to a confluence with a small tributary, then a stable high conductivity until the confluence with the larger tributary at Mall Blvd (over about 1,200 feet). This higher conductivity could be consistent with a wastewater or septic system source.

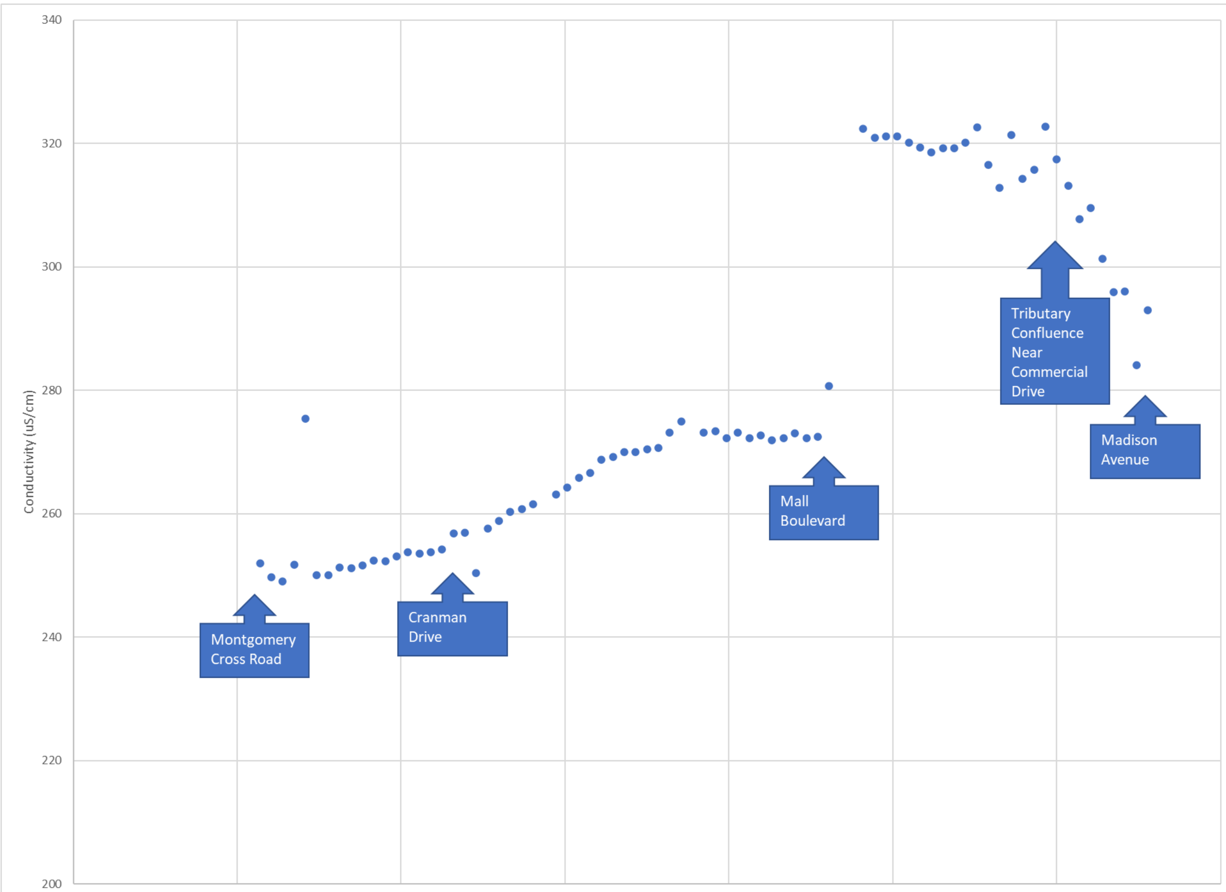


Figure 31. Conductivity Walk Data on Chippewa Canal indicating one area with likely wastewater or septic discharge during dry weather.

E1.F.ii - Wilshire Canal (Historic Data)

There is a noteworthy increase in conductivity data from the Largo Drive historic sampling site (mean value of 201 uS/cm) to the Elks Lodge historic sampling site (310 uS/cm). The Elks Lodge site had significant variability including measurements under 100 uS/cm and over 500 uS/cm while the Largo Drive Site was much more stable. This may indicate a source of wastewater or septic discharge between these sites.

E1.G – Litter Data

During the same period that FIB data was being collected in the watershed, litter traps were installed and litter collection was quantified on several occasions. This was done both to bring attention to the importance of litter as a pollutant on its own and to investigate a possible link between the quantity of litter and the magnitude of FIB concentrations. The immediately preceding rainfall was highest for the June sample and lowest for the April sample. Total litter collected did seem to correlate to rainfall. The Chippewa site had over twice as many pounds of litter removed, but slightly fewer overall items. The difference in mass was explained by the June sampling. Both of these sites turned out to have similar FIB concentrations. The site on Harmon Canal had higher average flows, about 5 times the average annual flow. By this measure the contributing area for the Chippewa site had higher litter contributions per unit of flow or per acre of contributing watershed. There was no obvious conclusion for the relationship between litter and FIB, other than the possible indication that sites high in litter may also be high in FIB, but as both sites were similar in regard to both, there are no conclusions to be drawn from this data.

	Chippewa	Harmon	Total
	28 March 2022	28 March 2022	28 March 2022
Pounds	34.2	44.2	78.4
Items	504	437	941
	20 April 2022	20 April 2022	20 April 2022
Pounds	26.6	17.1	43.7
Items	200	544	744
	9 June 2022	13 June 2022	June 2022
Pounds	112.7	7.6	120.3
Items	553	438	991
	All Dates	All Dates	All Dates
Pounds	173.5	68.9	242.4
Items	1257	1419	2676

Figure 32. Litter data for two sampling sites included in this study, Chippewa Canal at Madison Avenue and Harmon Canal at Edgewater Road. All dates are in 2022.

Element 2: An Estimate of the Expected Load Reductions from Management Measures

E2.A – Pathogen Data

E2.A.i - Historical Indicator Bacteria Data

A collection of 14 sampling sites were monitored by the City of Savannah, Town of Vernonburg, and Ogeechee Riverkeeper from 2012 to 2020. There was a large amount of variability in the data, but based on average mass contribution per acre determined through the hydrodynamic model, some areas indicated consistently higher pathogen loading (Figures 33-39). This same study included a statistical correlation study of concentrations to potential explanatory factors including rainfall volume, antecedent rainfall, tide, and temperature. The statistical study found that at many sites pathogen loading indicated significant positive correlation with a combination of rainfall volume, recent antecedent rainfall, low tide conditions, and higher temperatures.

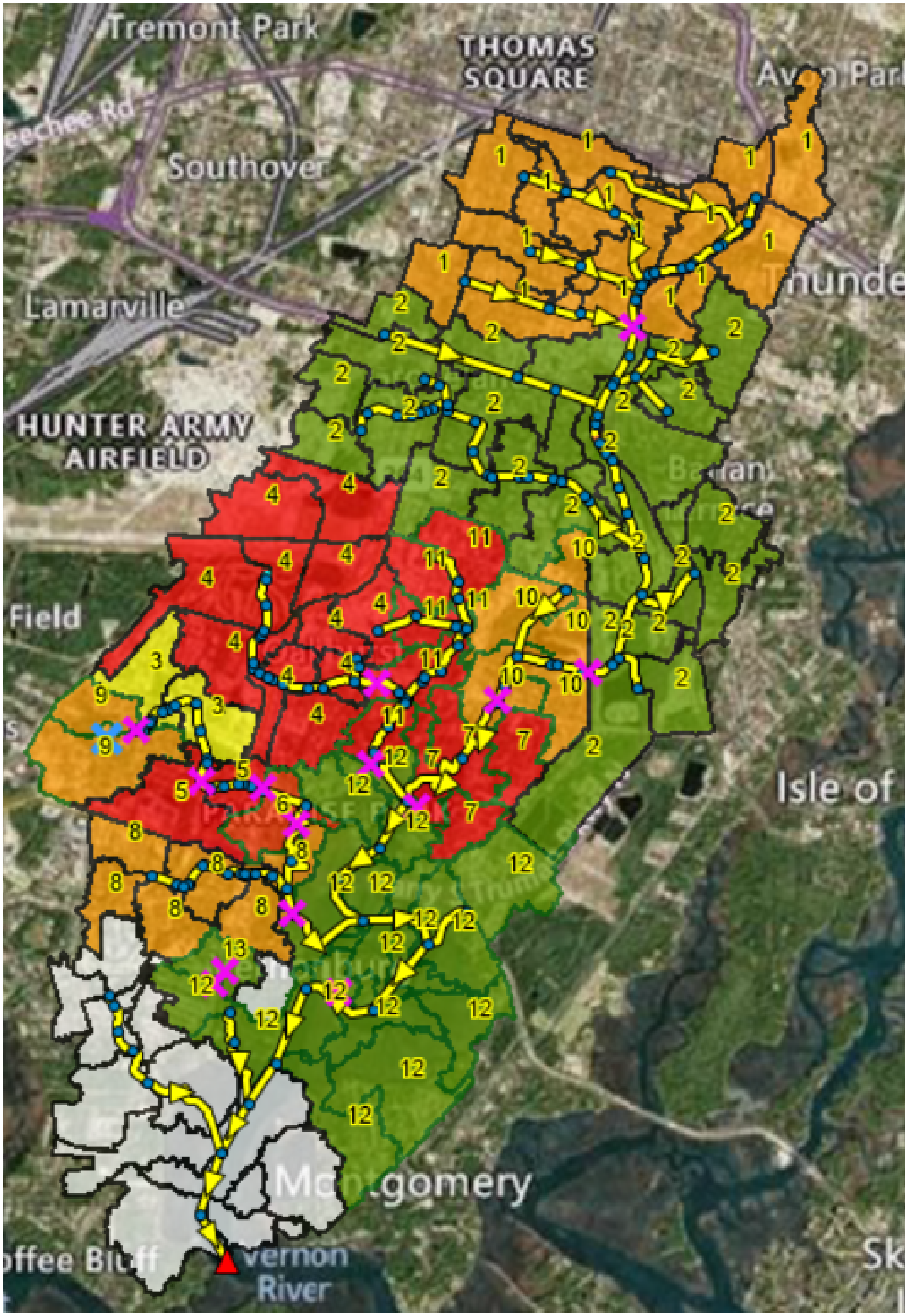


Figure 33. Highest Contributing Areas based on historic sampling (in order from least to most total bacterial load contribution: green, yellow, orange, red). Numeric labels indicate common monitoring sites.

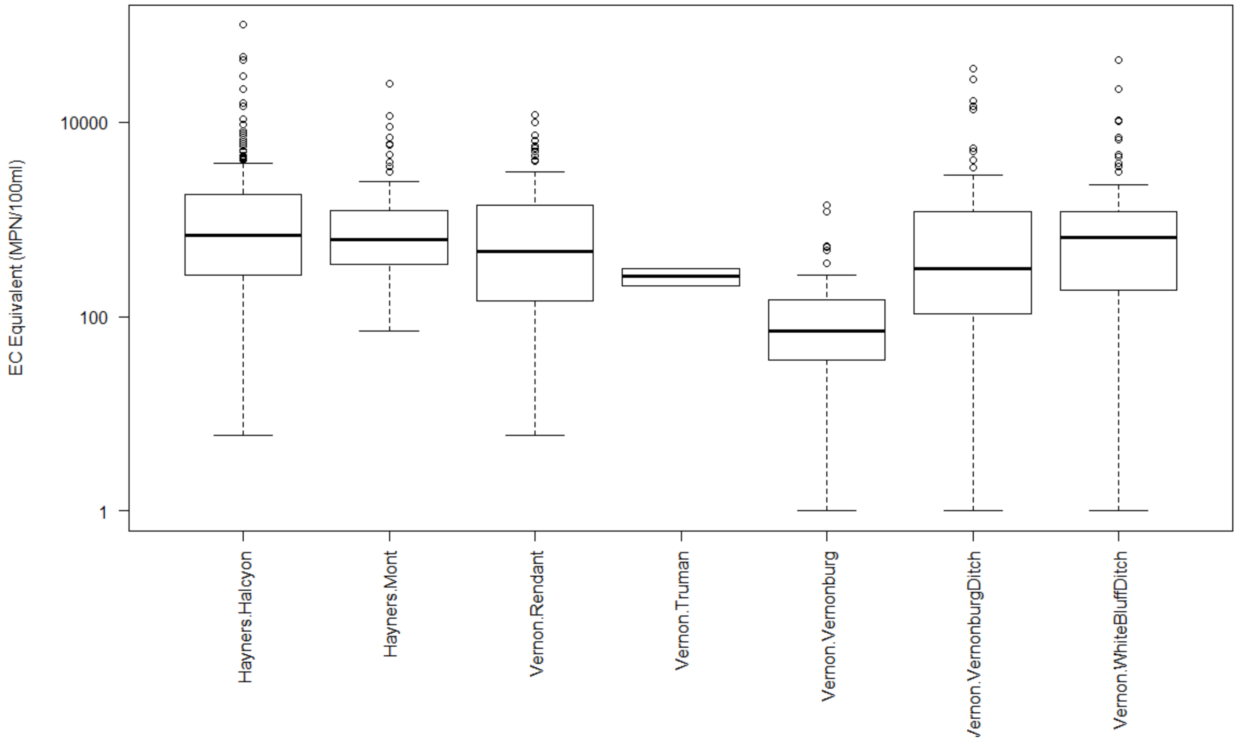


Figure 34. Boxplot of all bacterial counts for all data for each site from the indicated database. (Vernon River/Hayner's Creek)

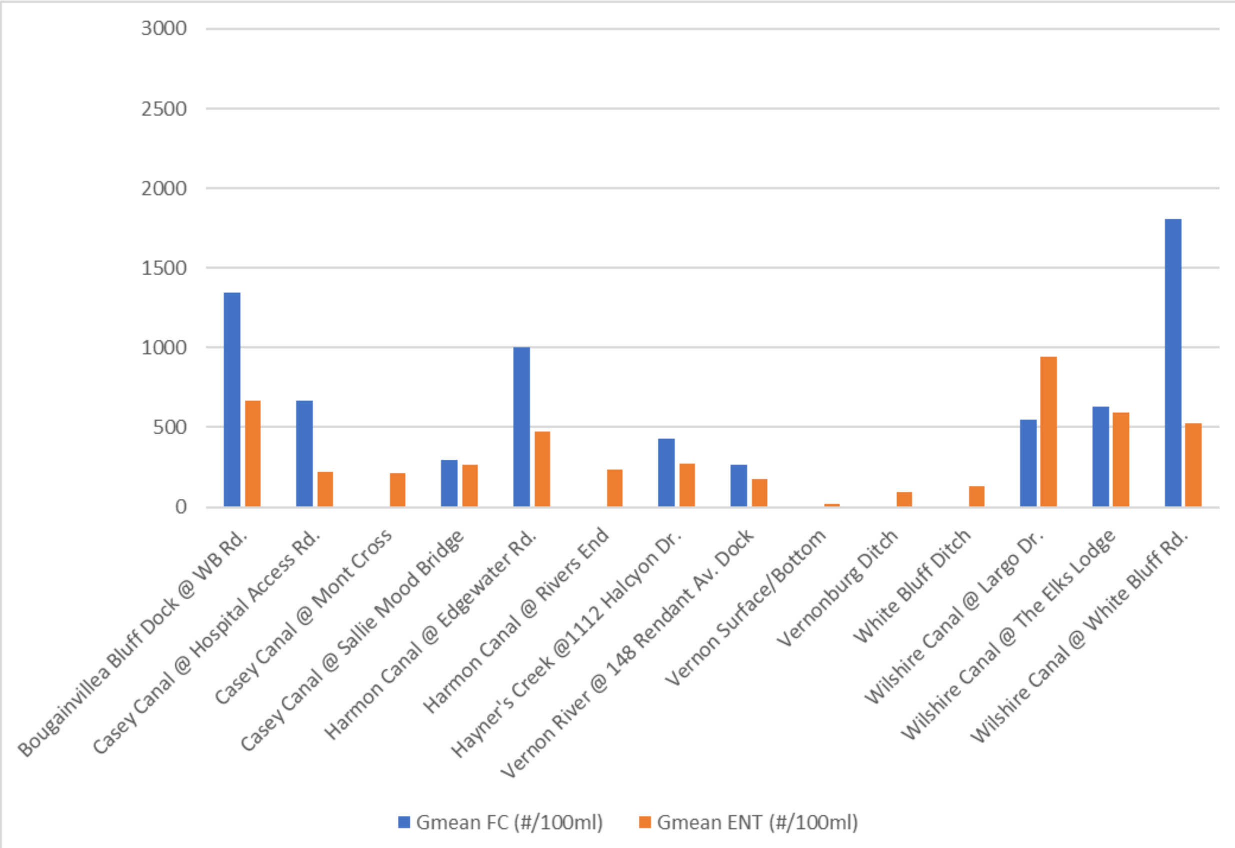


Figure 35. Geomeans of bacterial counts for all data for each site from the historic database. These values have not been adjusted for tidal dilution.

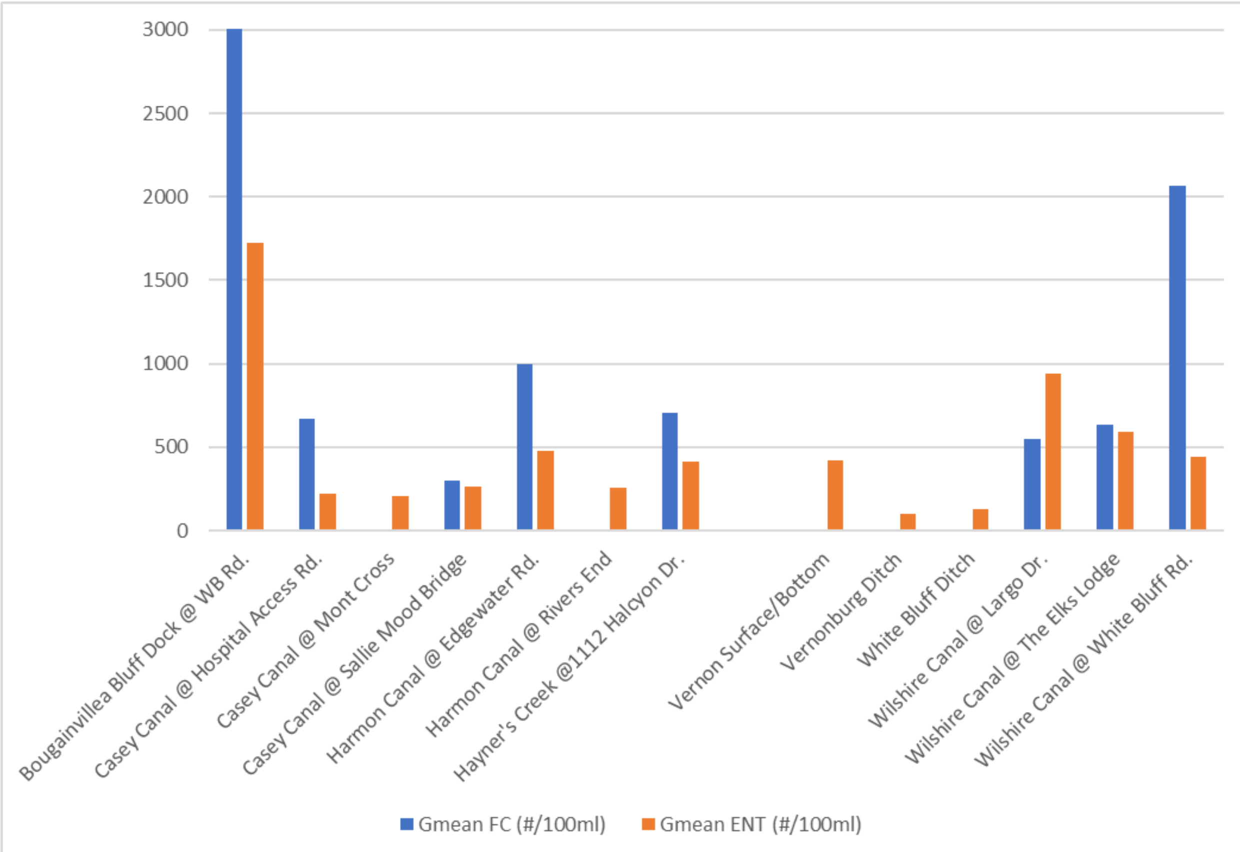


Figure 36. Geomeans of bacterial counts for all data for each site from the indicated database. These data are adjusted with the aid of average salinity and hydrodynamic modelling to account for tidal dilution of downstream flow. The Rendant Avenue Site is not included due to low confidence in the incoming FIB concentrations.

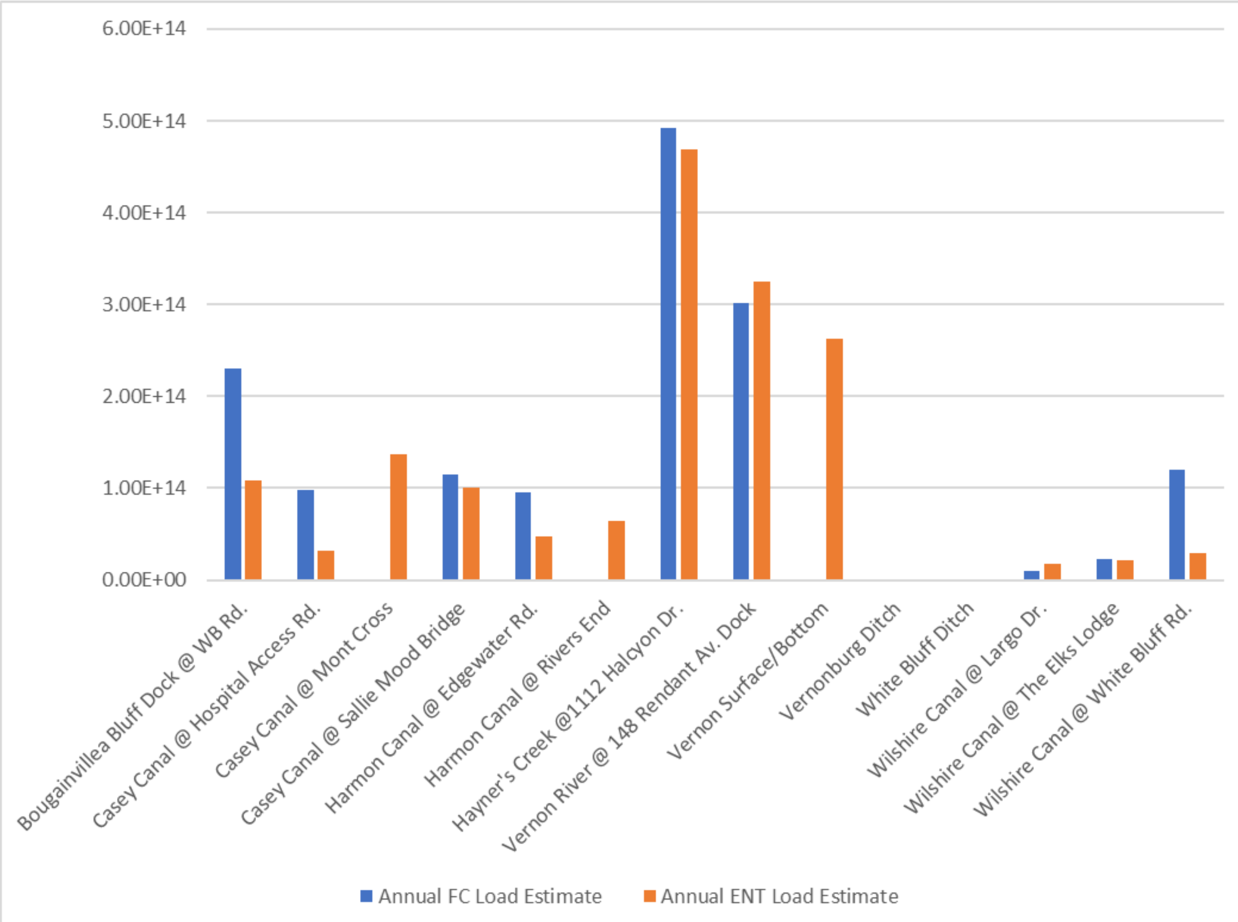


Figure 37. Total annual bacterial load estimates for each site from the indicated database. These data are estimated with the aid of average salinity to account for tidal dilution of downstream flow.

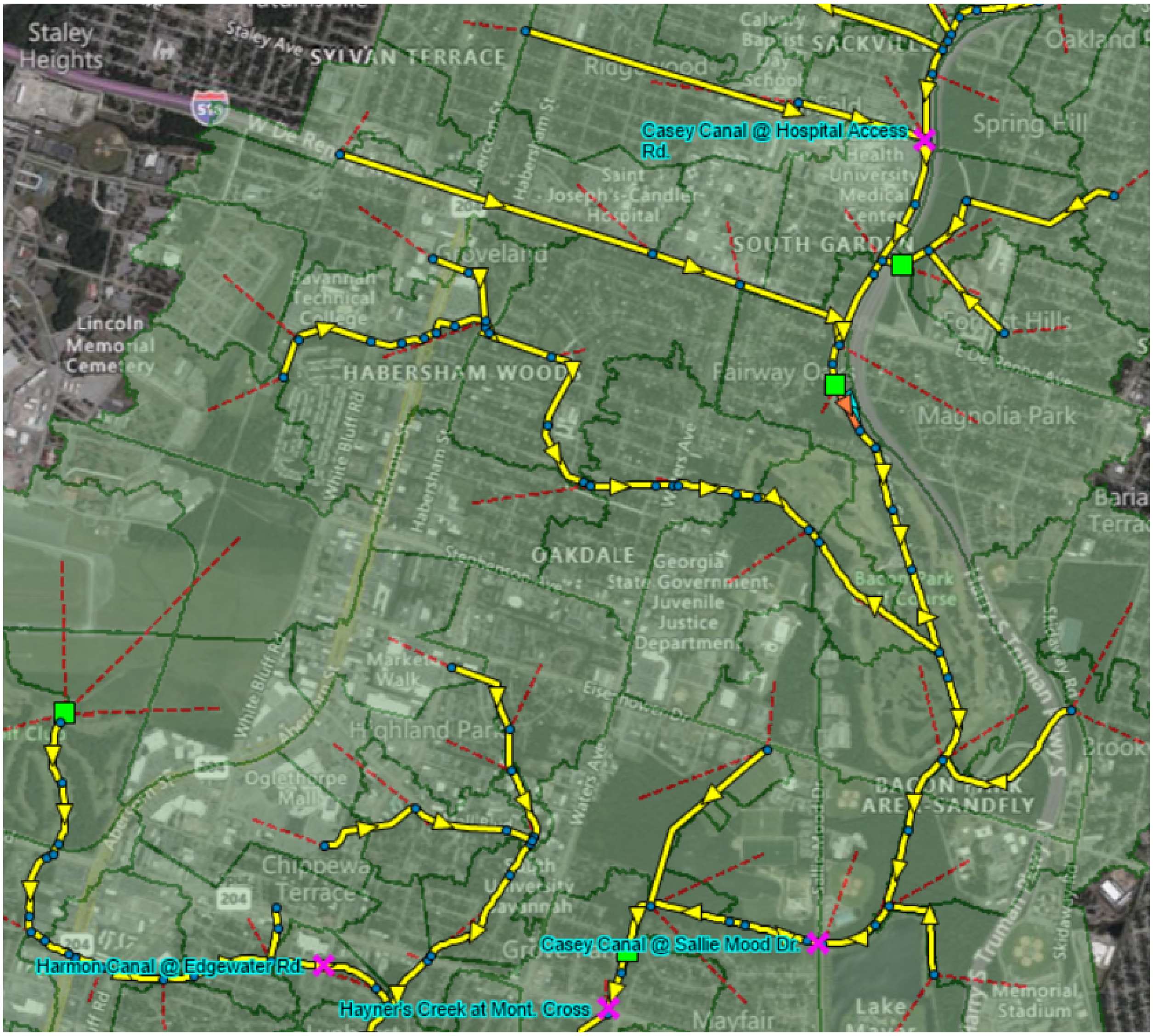


Figure 38. Historic Monitoring Sites (Upper Watershed)

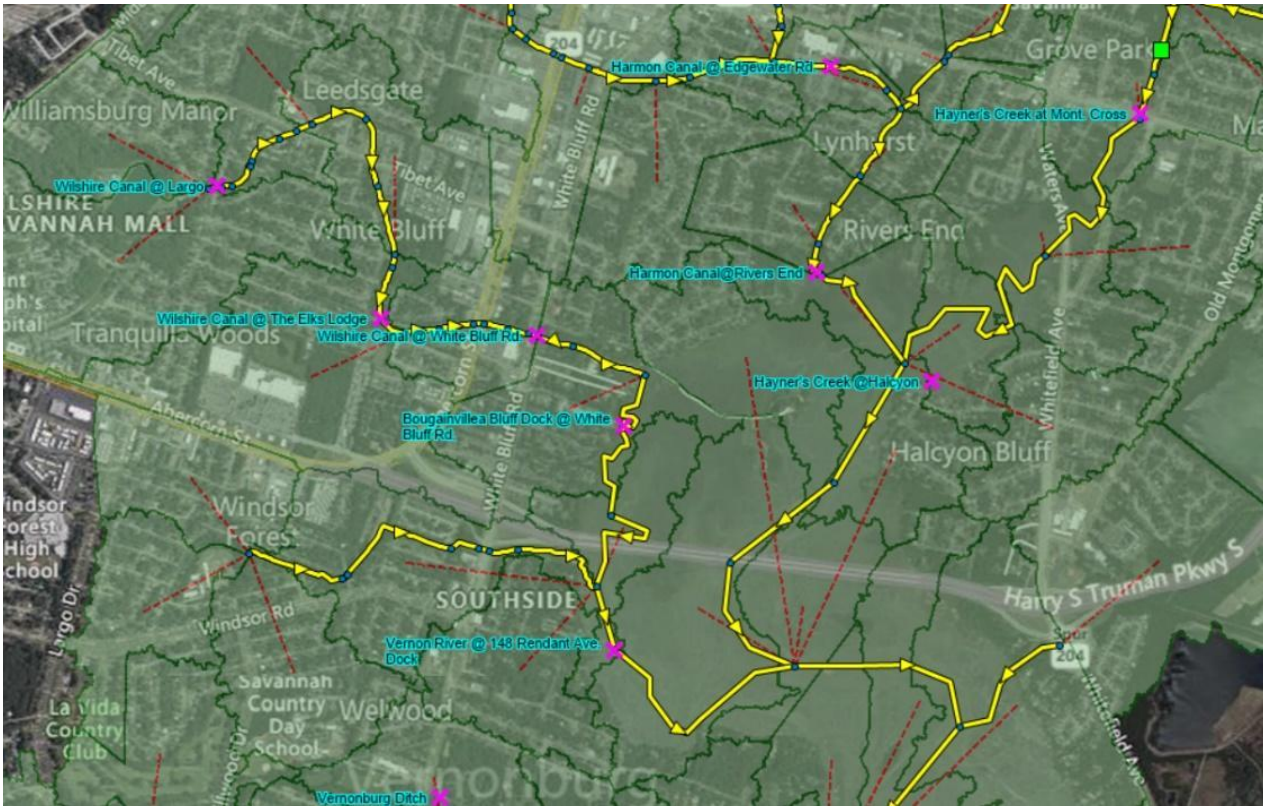


Figure 39. Historic Monitoring Sites (Lower Watershed)

E2.A.ii - Additional High-Density, Lagrangian Data

Based on the historical data, a follow up study was done in 2022 as a part of this WMP effort on the areas highlighted in the historical data, but with 1) higher spatial resolution, 2) Lagrangian sampling (according to travel time), and 3) with sampling primarily done immediately following rain events based on historic correlations. Samples are taken according to travel time to reduce temporal variability that would confuse efforts to identify hotspots. This data was then applied to volumes produced by the calibrated hydrodynamic model developed for this project (Appendix B) and included with the historic data in a comprehensive data analysis.

E2.A.iii - Data Analysis Process

First, historic and new data were compiled and stored in a shared comprehensive database, access available upon request. Data was sorted for further analysis based on analyte (FC, ENT, and EC) and also by wet and dry weather (0-3 days antecedent rainfall and greater than 3 days antecedent rainfall). Flow data was applied to this data from the model in three ways. First, 24 hours of flow data relevant to each sampling site from a hypothetical 1-inch, 6-hour storm event was applied to the mean concentrations of all wet-weather data so it could be analyzed comprehensively. Second, 24-hours of modeled baseflow was applied to all dry-weather samples for comprehensive comparison. Baseflow was estimated in the model as a fraction of infiltration and distributed evenly according to surface area and time. Third, modeled flow data from the actual storm events sampled was applied to the applicable newer data to isolate hotspots and check for continuity with comprehensive analysis. 24-hour mass loadings at each site were

estimated from the flow data and sample data. For areas experiencing tidal influence, a mixing ratio had to be developed to estimate the concentration of the downstream flow as the concentration sampled represented a mixture of downstream saline and upstream fresh water. The ratio was determined in two ways for greater accuracy, (1) from salinity measurements at each site, and (2) from model flow estimates. Downstream FIB concentrations were estimated from downstream sampling sites, allowing for a calculation of the estimated freshwater contribution from upstream that could be applied to the estimated freshwater flow. Contributing surface area for each site was also included to determine estimated loadings per acre. To compare data comprehensively, results for FC and ENT were converted to "EC equivalent" by using the ratio of the relevant state standards. For instance, the EC equivalent of a ENT sample of 100 would be 100*(126/35) = 360. Analysis tables are available in Appendix C. An estimate of the potential contribution of the loading passing each site to the downstream concentration in the estuary is also provided based on the percentage of overall freshwater discharge represented at that site. This can help assess priority based on overall impact, regardless of sample concentrations at that site.

E2.A.iv - Additional Harmon/Chippewa Canal High-Density Data

While there was a lot of variability, some patterns did emerge (Figures 40-42). First, the entire area has very high pathogen concentrations. The areas between H1 and H2 and between H3 and H5 seem to be consistently observed as source areas of additional loading. Also, in dry weather sampling (results not shown), areas around H2 and H8 have indicated high results.

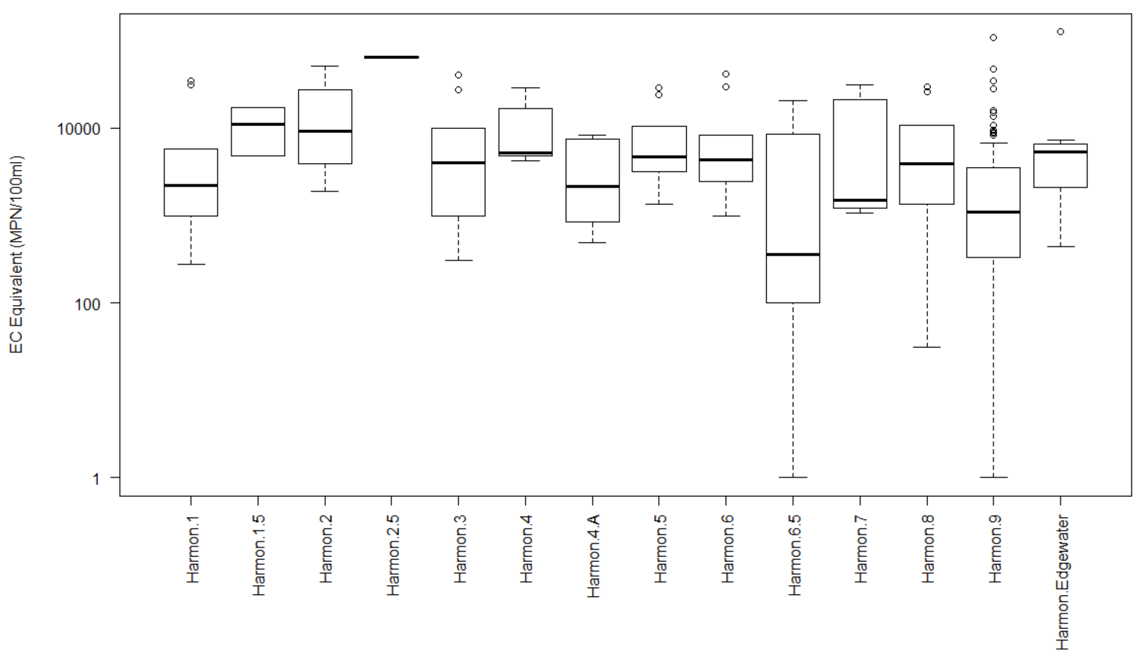


Figure 40. Boxplot of bacterial counts for all data for each site from the indicated database. (Harmon/Chippewa Canal Tributary System)

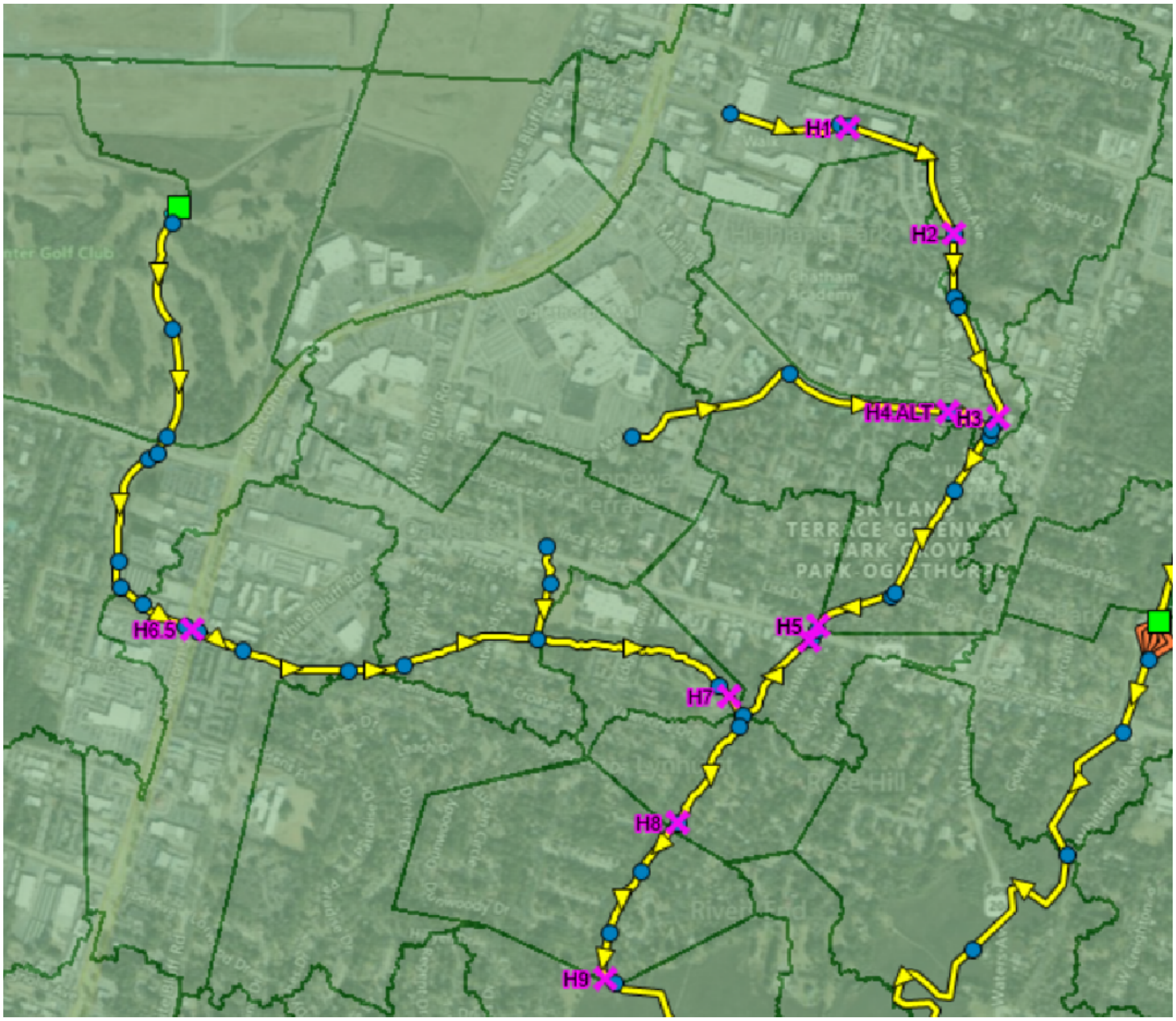


Figure 41. New Monitoring Sites (Harmon/Chippewa Canal Tributary System)

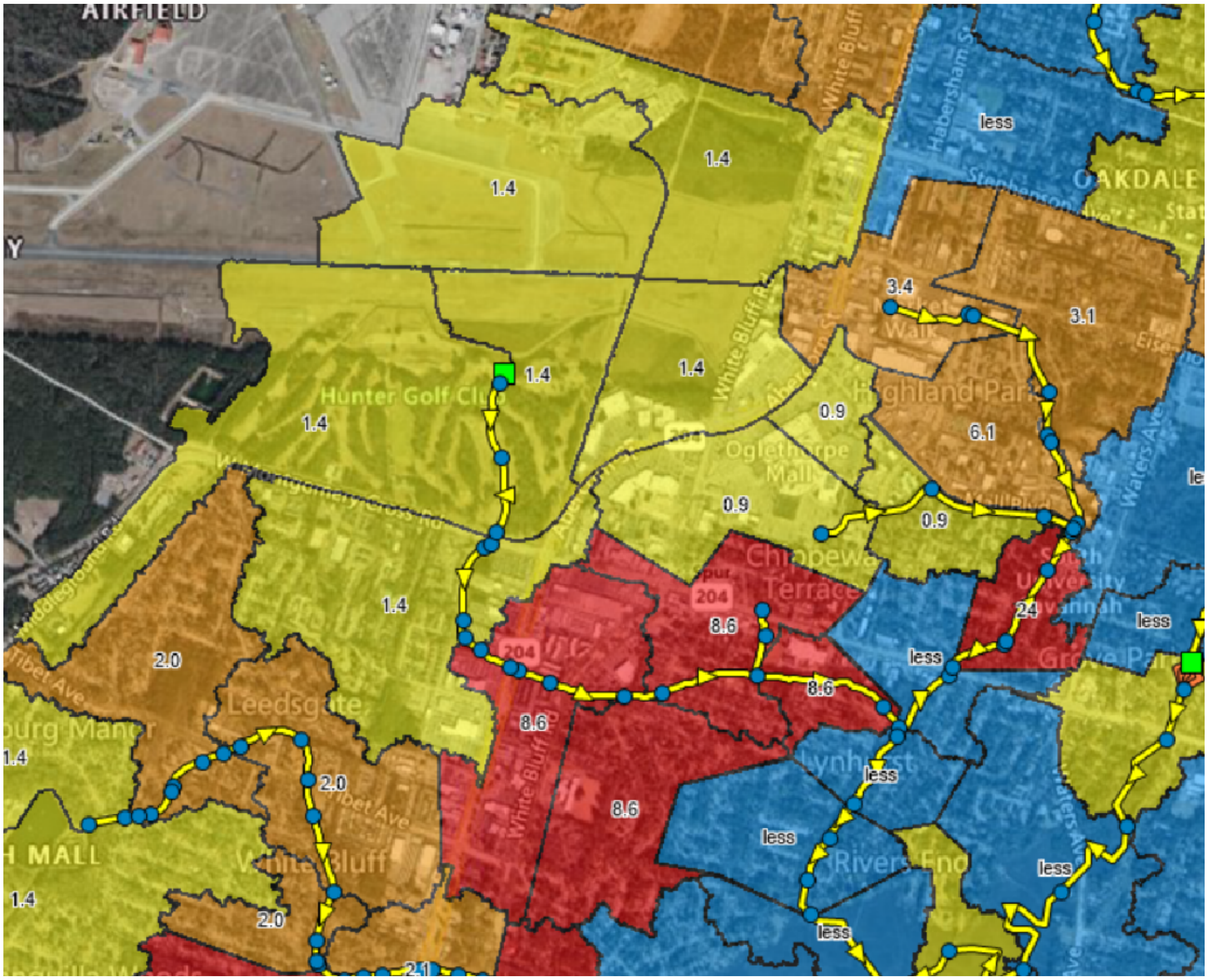


Figure 42. Wet Weather Pathogen Hotspots (Harmon/Chippewa Canal Tributary System). Labels for each sub watershed indicate 10^9 MPN/acre-day in EC equivalent. Colors indicate overall range of loading contribution with warmer colors indicating more contribution.

E2.A.v - Harmon Site 2 Hydrograph-based FIB Concentration Analysis

This site was identified as a hot spot for bacteria in the Harmon system and has 7 individual EC samples under different rainfall conditions, making it ideal for analysis of FIB data in combination with the calibrated model hydrograph (Figures 43-44). The highest concentration sample was taken 8 days after a relatively minor rainfall event. There had only been 4 inches of rainfall in the 3 prior months with no event having a peak intensity greater than 1 in/hr or total rainfall greater than 1 inch. The next highest concentration sample was taken almost 24 hours after a rainfall event that resulted in a peak flow of 45cfs. This rainfall event was about 0.33 inches of rain over 1 hour. The next three samples had approximately the same concentration. The first sample of these was taken at the first flush of an event of about the same magnitude. The second of these was taken approximately 27 hours after a 3-inch rainfall event that resulted in a peak flow of almost 800cfs. The third of these was taken 5 days after a series of rainfall events of about 1.5 inches total. The second to lowest concentration sample was taken during a minor rainfall event, and the lowest concentration sample was taken 4 days after a very minor

rainfall event and about 15 days after a 3-inch rainfall event. It may be reasonable to suspect that the source in this area is accumulated during dry weather based on this analysis.

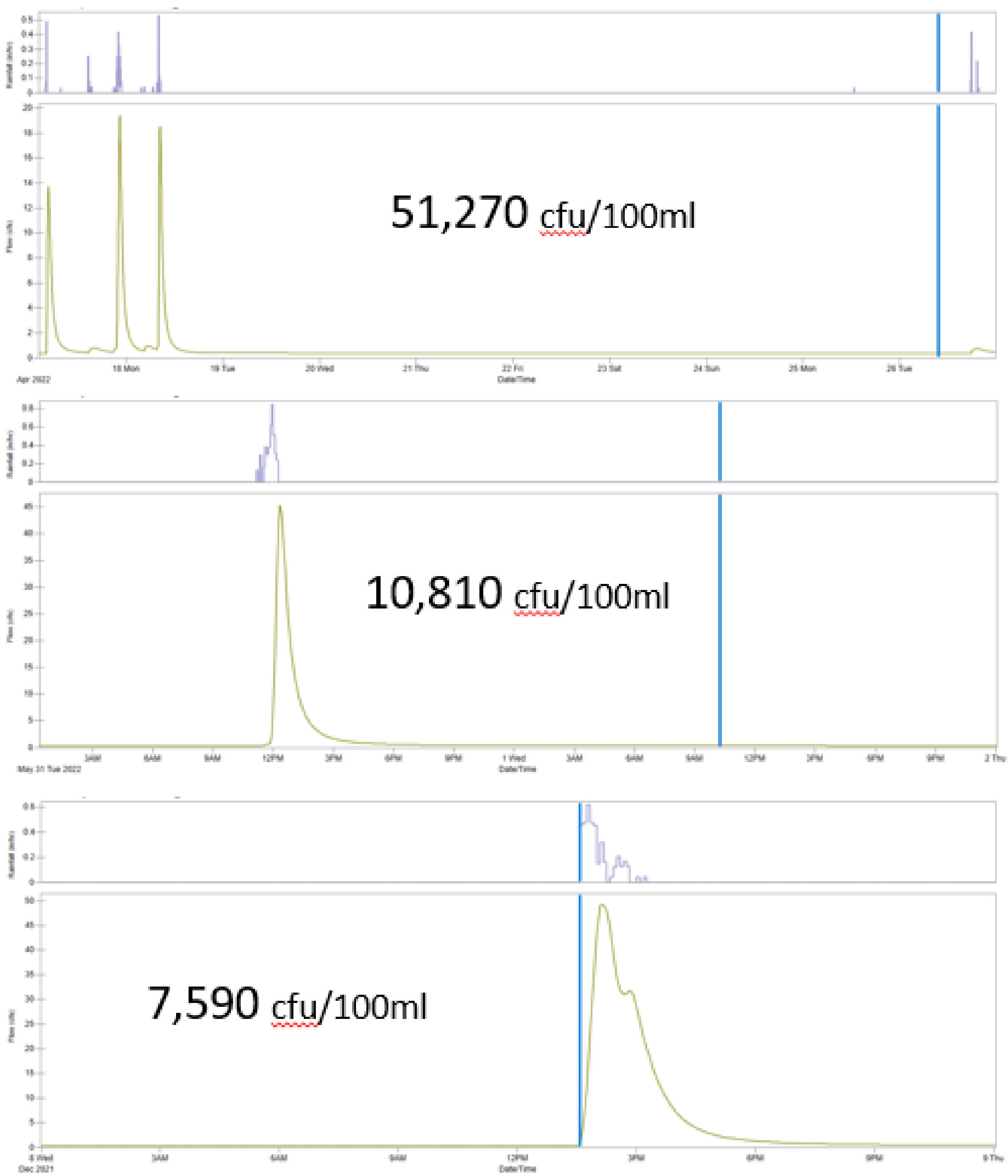


Figure 43. The position of the water sample compared to the modeled hydrograph at the sampling site.

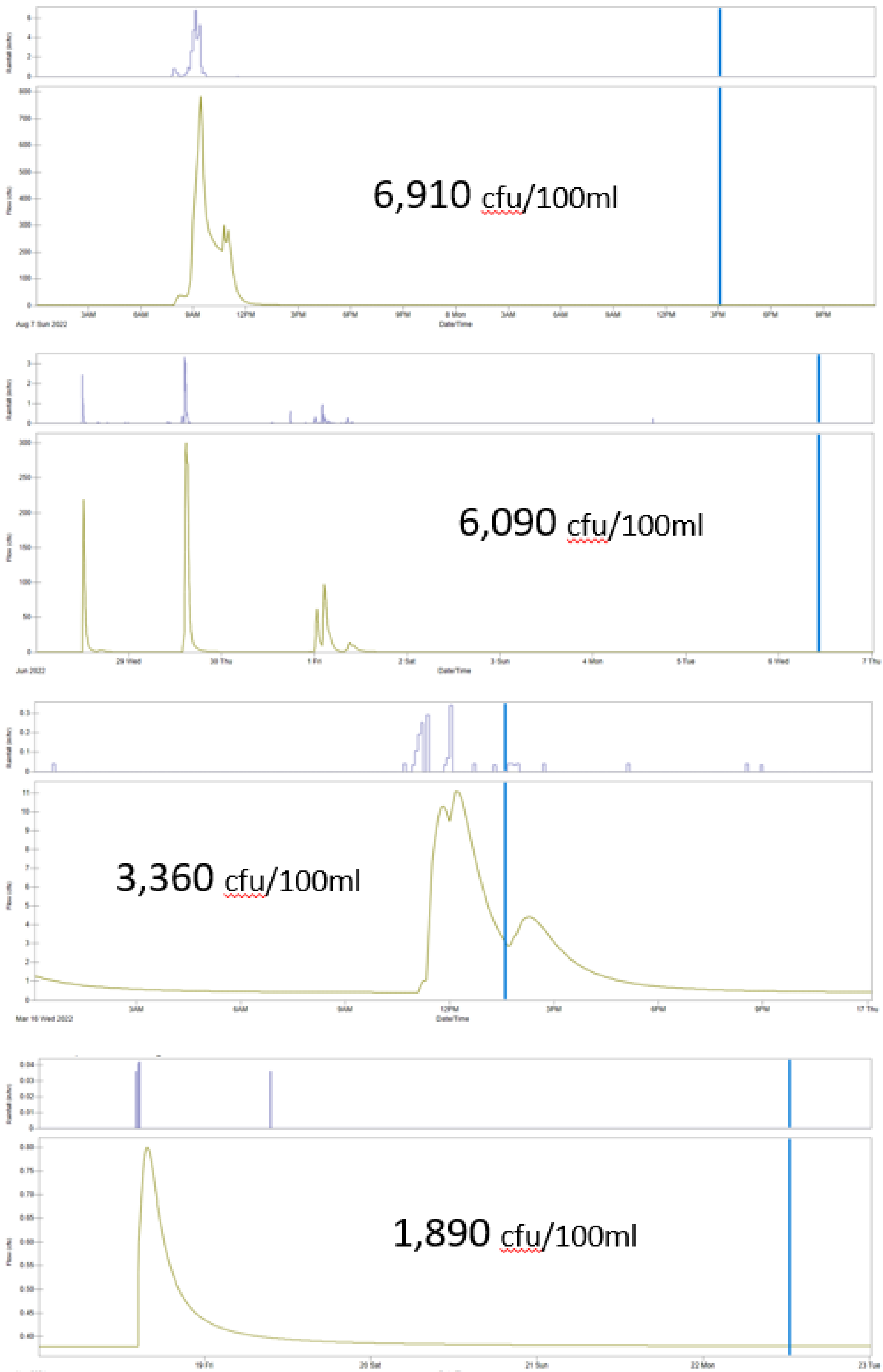
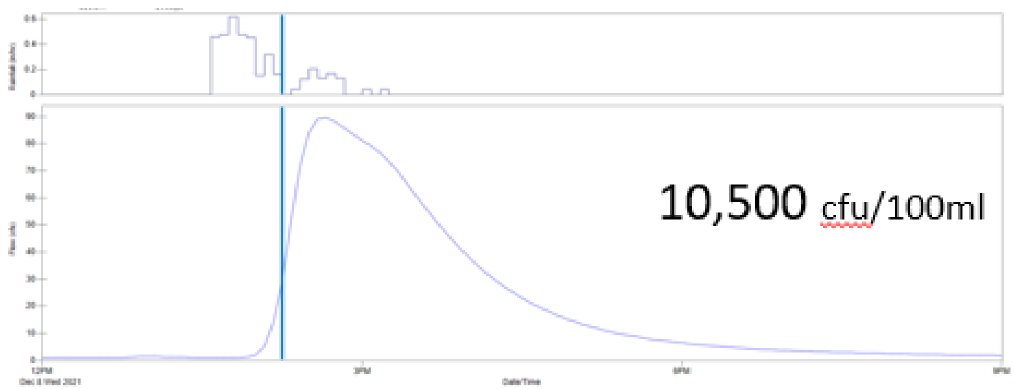
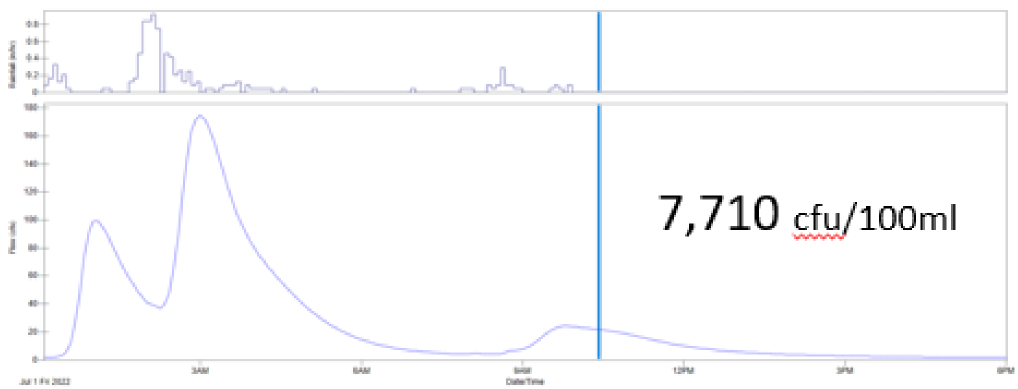


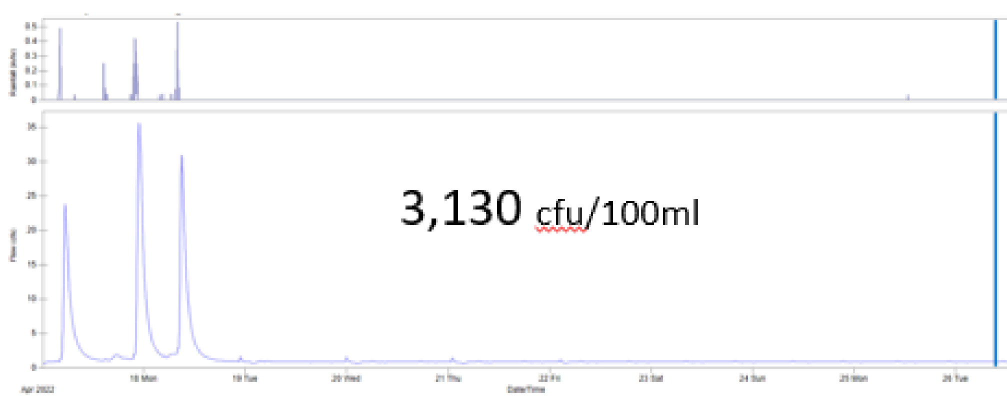
Figure 44. The position of the water sample compared to the modeled hydrograph at the sampling site.

E2.A.vi - Harmon Site 5 Hydrograph-based FIB Concentration Analysis

This site was identified as a hot spot for bacteria in the Harmon system and has 4 individual EC samples under different rainfall conditions, making it ideal for analysis of FIB data in combination with the calibrated model hydrograph (Figure 45). The highest concentration sample was taken during the first flush of an event resulting in a peak flow of 90cfs. The second highest concentration sample was taken approximately 7 hours after the peak of an event resulting in a peak flow of 100cfs. The third highest concentration sample was taken approximately 8 days after a series of small rainfall events with peak flows of about 40cfs. The lowest concentration sample was taken approximately 6 hours after the peak of an event resulting in a peak flow of 900cfs. This rainfall event was approximately 3 inches of rain in 3 hours. It may be reasonable to suspect that the source in this area is associated with rainfall, but is diluted with higher rainfall amounts, based on this analysis.


10,500 cfu/100ml


7,710 cfu/100ml


3,130 cfu/100ml

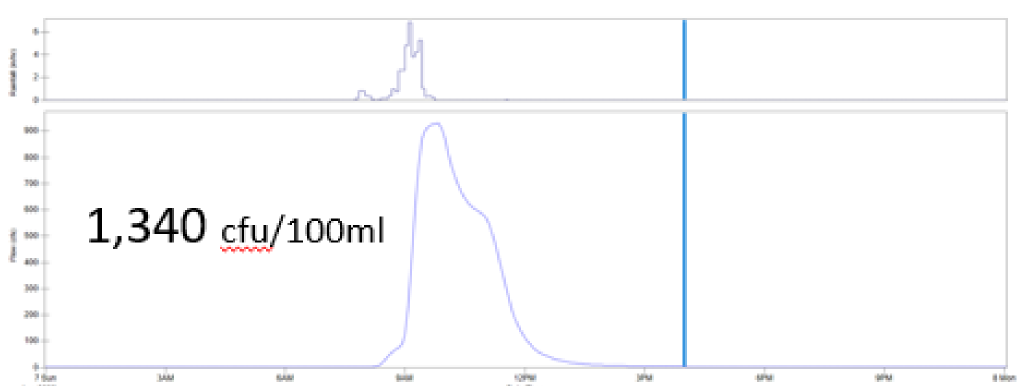

1,340 cfu/100ml

Figure 45. The position of the water sample compared to the modeled hydrograph at the sampling site.

E2.A.vii - Additional Upper Casey Canal High-Density Data

Again, lots of variability, high concentrations overall, and some patterns did emerge (Figures 46-48). All the major culverts on the west side of the canal indicate high loading, with some being especially high. These may need more detailed analysis by the city to determine sources. On the west side of the canal, there are a few smaller areas that indicate high loading.

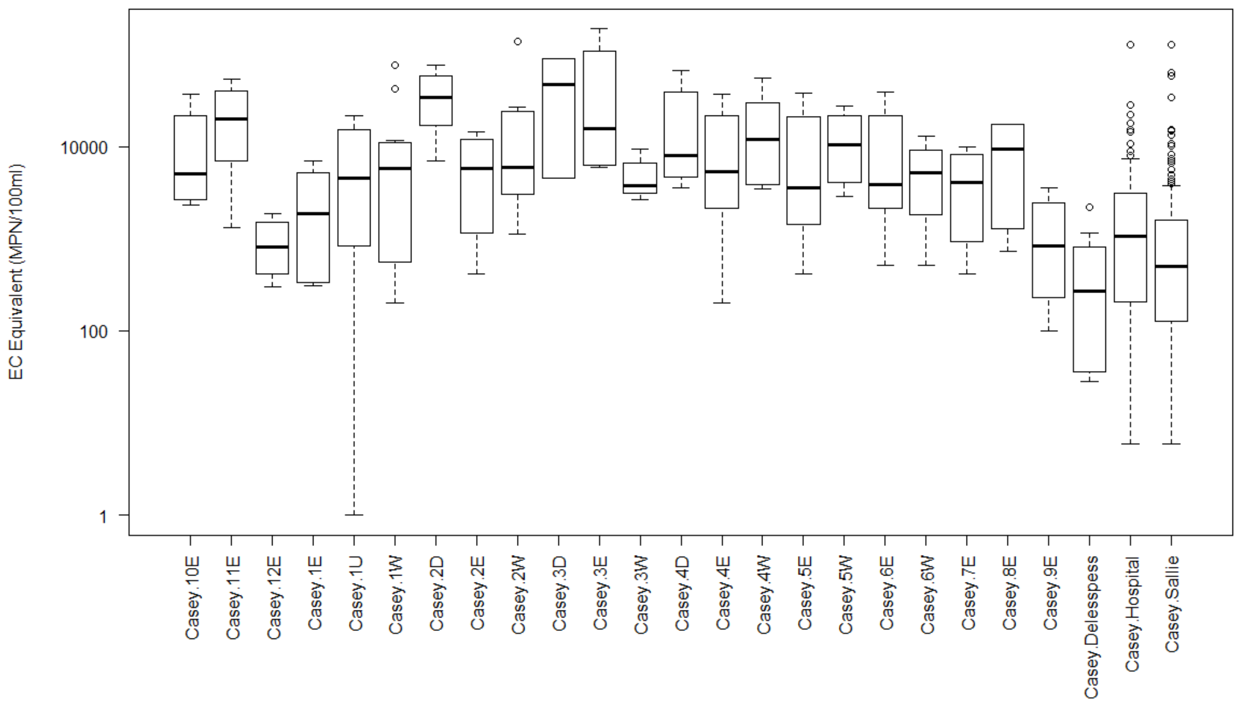


Figure 46. Boxplot of bacterial counts for all data for each site from the indicated database. (Upper Casey Canal Tributary System)

Figure 47. New Monitoring Sites (Upper Casey Canal Tributary System) Labels are omitted due to high density. There are 18 sampling sites, representing each culvert over 36” entering the canal, except for one that was missed between 4W and 5W.

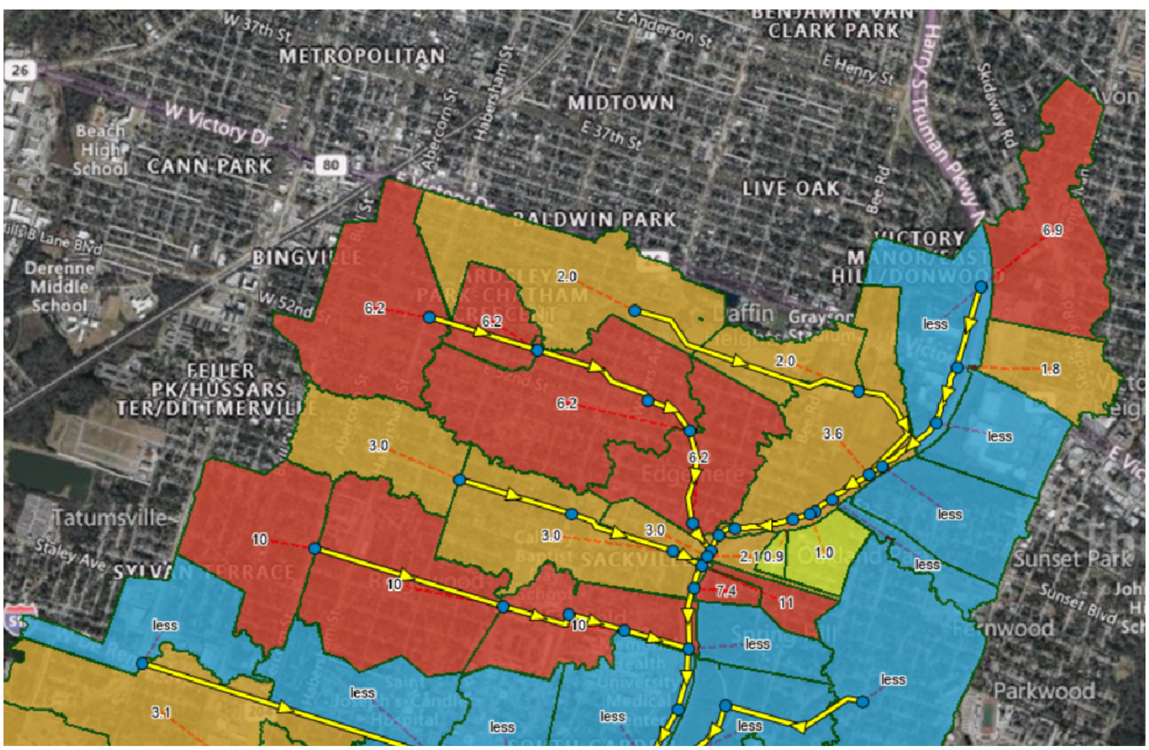
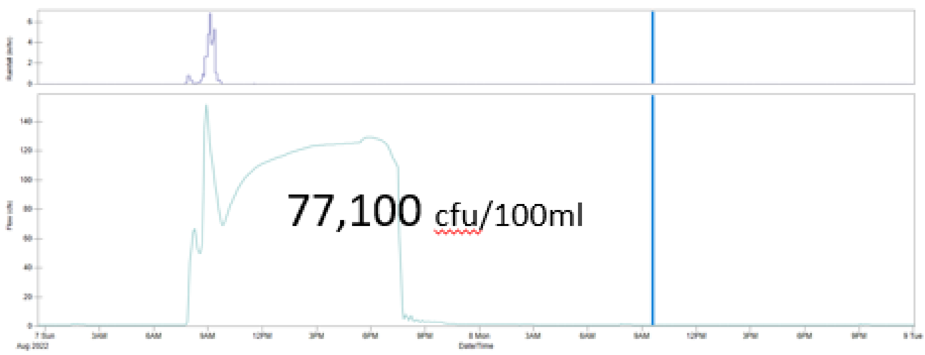
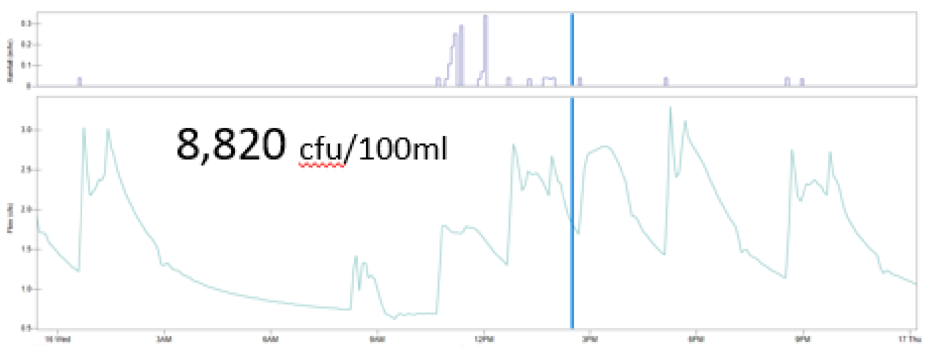


Figure 48. Wet Weather Pathogen Hotspots (Upper Casey Canal Tributary System). Labels for each sub watershed indicate 10^9 MPN/acre-day in EC equivalent.

E2.A.viii - Casey Conduit 1W Hydrograph-based FIB Concentration Analysis

This site was identified as a hot spot for bacteria in the Upper Casey system and has 6 individual EC samples under different rainfall conditions, making it ideal for analysis of FIB data in combination with the calibrated model hydrograph (Figures 49-50). The highest concentration sample was taken approximately 15 hours after a rainfall event that produced a peak flow of approximately 130cfs in the stormwater culvert. The rainfall event was approximately 3 inches of rain in 3 hours. The second and third highest samples were taken during smaller rainfall events totaling about 0.5 inches over 24 hours. The next highest sample was taken about 15 hours after an event that produced a peak flow of approximately 90cfs in the stormwater culvert. The next to lowest concentration sample was taken about 48 hours after a small storm event, and the lowest concentration sample was taken approximately 24 hours after several days of very low intensity rainfall. It may be reasonable to suspect that the source in this area is associated with rainfall, and higher rainfall amounts may result in higher concentrations.





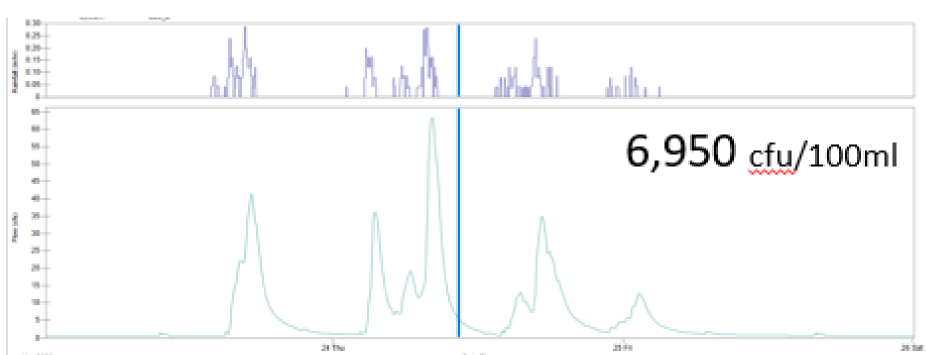
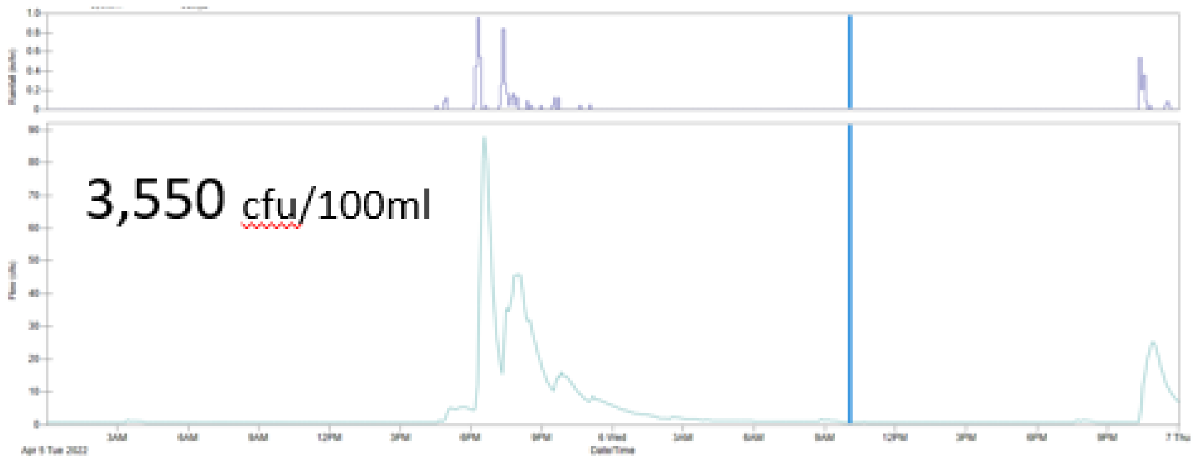
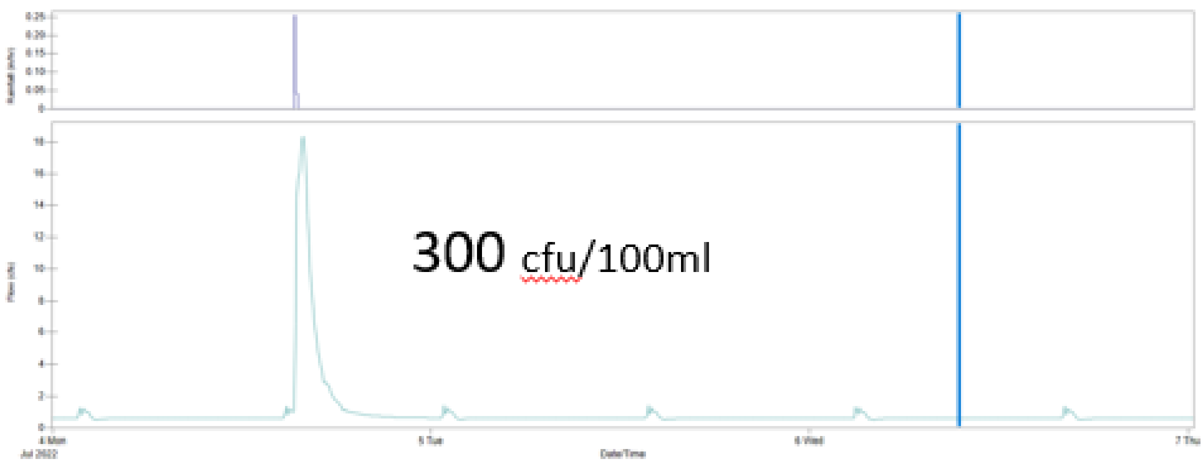


Figure 49. The position of the water sample compared to the modeled hydrograph at the sampling site.





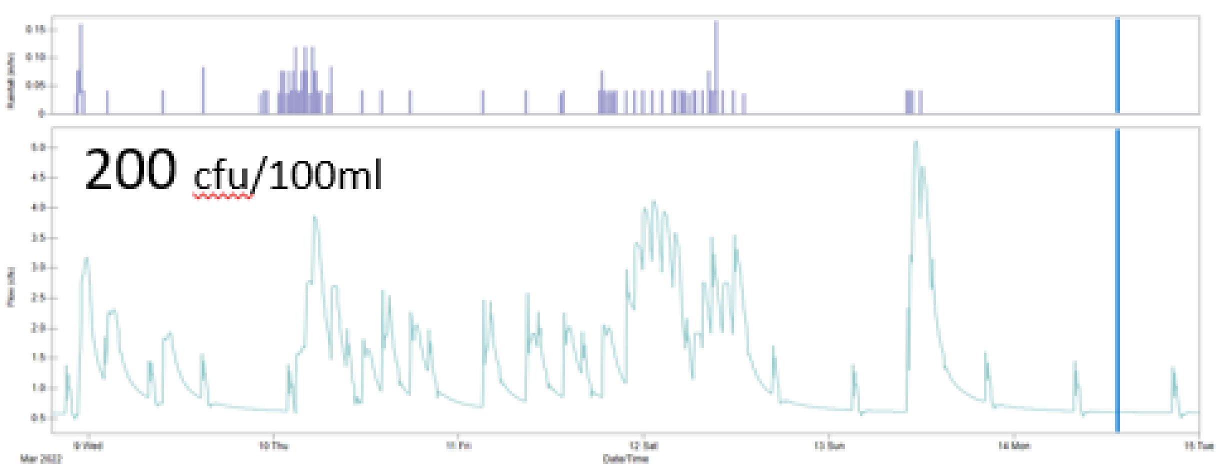


Figure 50. The position of the water sample compared to the modeled hydrograph at the sampling site.

E2.A.ix - Additional Wilshire/Holland Casey Canal High-Density Data

Again, lots of variability, especially in Wilshire, high concentrations overall, and some patterns did emerge (Figures 51-53). In Wilshire, there is an area at the downstream end of the canal that is frequently very high, but the entire canal is a large contributor on a consistent basis. In Holland, there was one ditch on the south bank, whose drainage area seemed to be a consistently high contributing area.

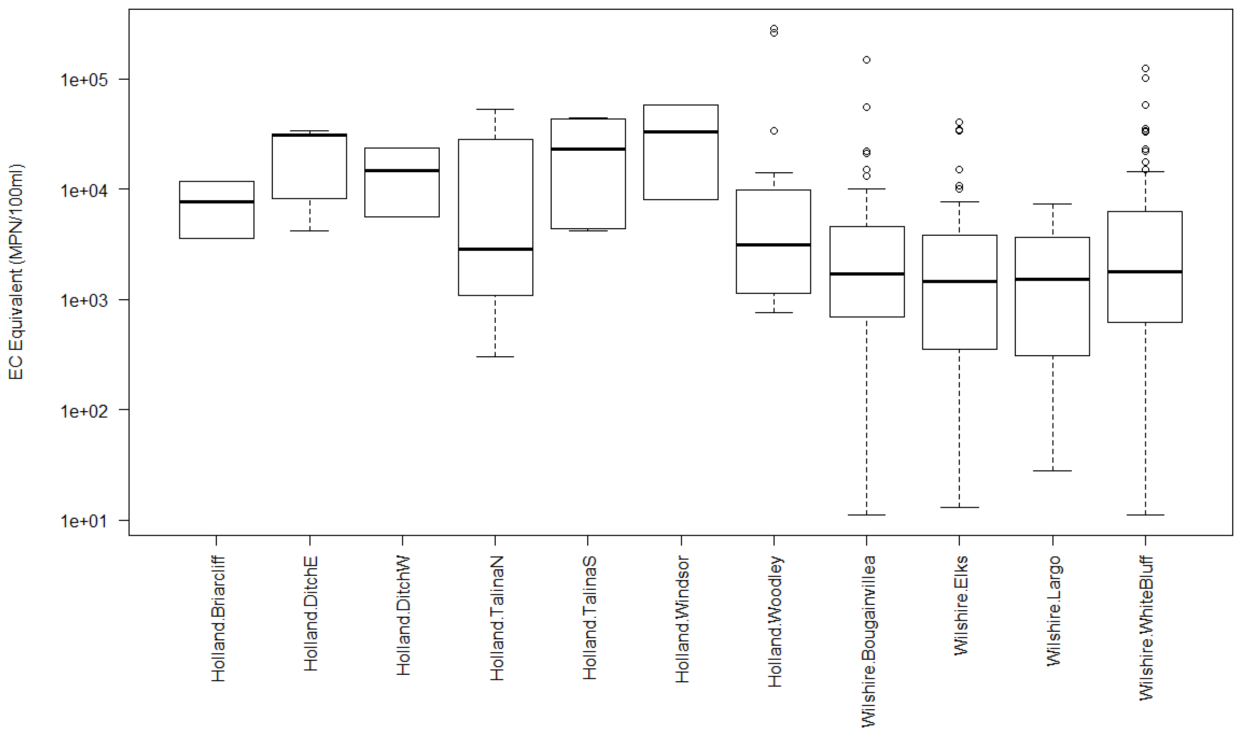


Figure 51. Boxplot of bacterial counts for all data for each site from the indicated database. (Wilshire/Holland Canal Tributary System)

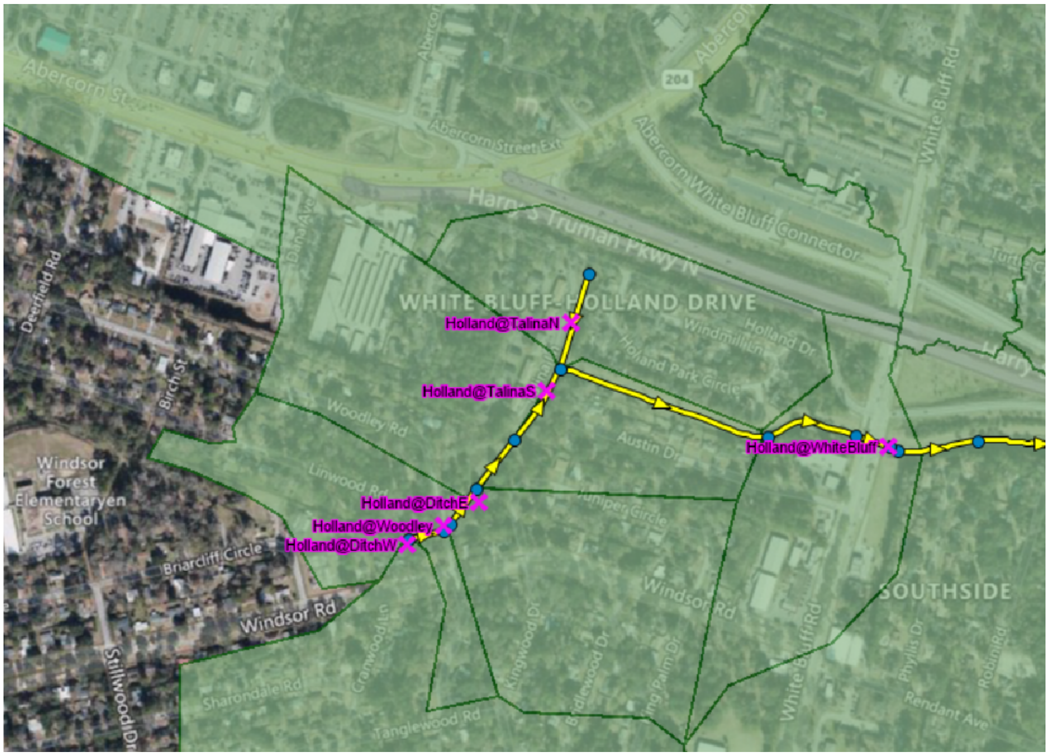


Figure 52. New Monitoring Sites (Wilshire/Holland Canal Tributary System)

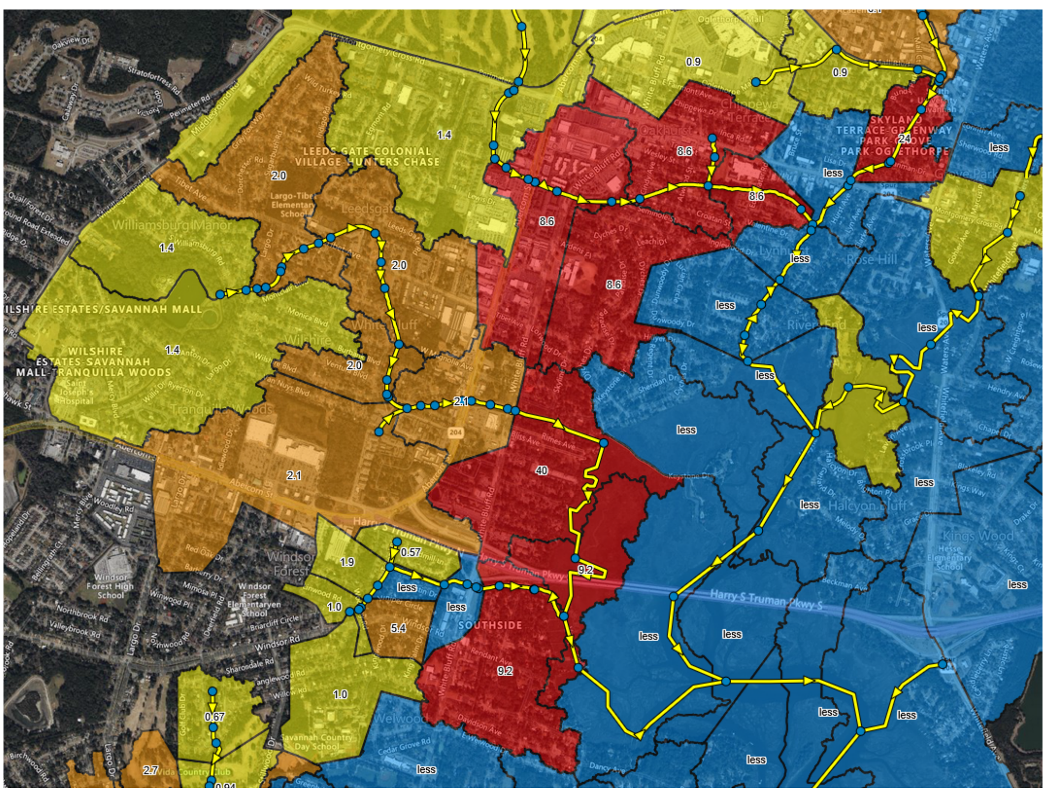


Figure 53. Wet Weather Pathogen Hotspots (Wilshire/Holland Canal Tributary System) Labels for each sub watershed indicate 10^9 MPN/acre-day in EC equivalent.

E2.A.x - Additional Habersham Canal High-Density Data

Again, lots of variability, high concentrations overall, and some patterns did emerge (Figures 54-56). The areas at the very top and the very bottom of this canal seemed to be the highest contributing areas.

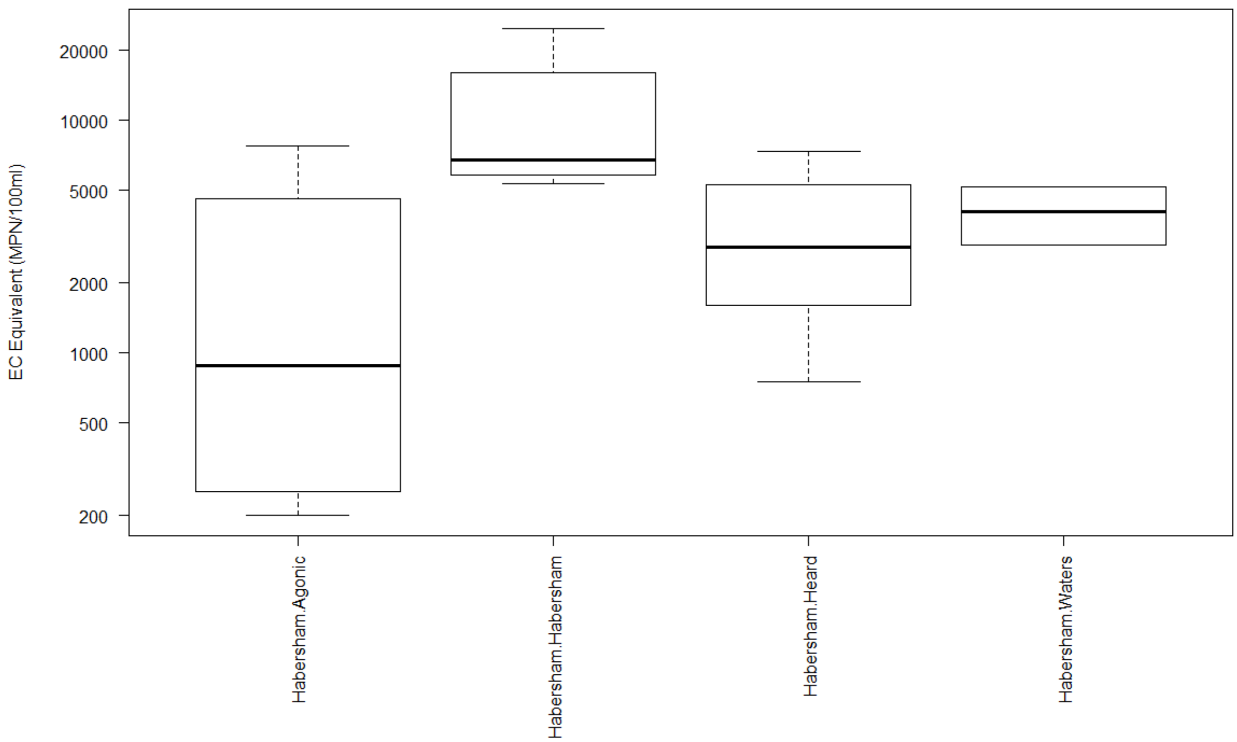


Figure 54. Boxplot of bacterial counts for all data for each site from the indicated database. (Habersham Canal Tributary System)

Figure 55. New Monitoring Sites (Habersham Canal Tributary System)

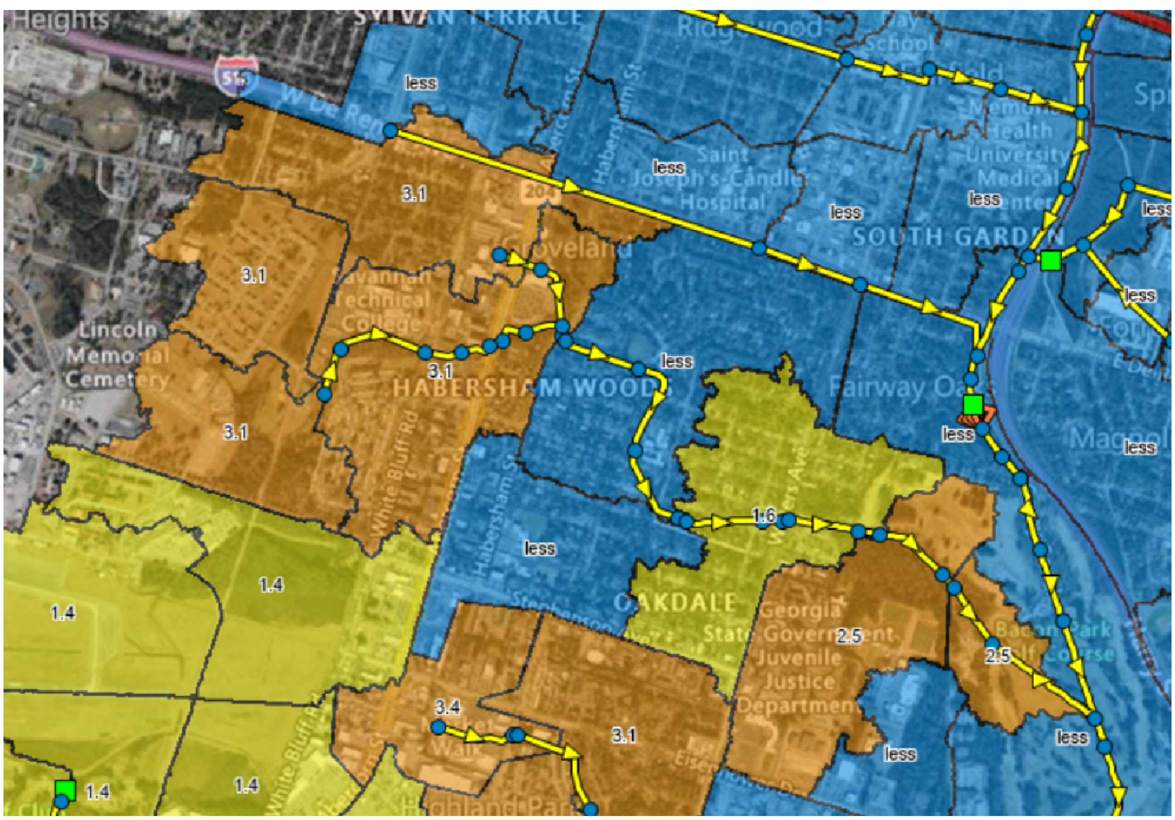


Figure 56. Wet Weather Pathogen Hotspots (Habersham Canal Tributary System) Labels for each sub watershed indicate 10^9 MPN/acre-day in EC equivalent.

E2.A.xi - Additional Coffee Canal High-Density Data

Again, lots of variability, especially in Wilshire, high concentrations overall, and some patterns did emerge (Figures 57-59). The areas at the downstream end and the tributary entering from the west seem to be the highest contributing areas.

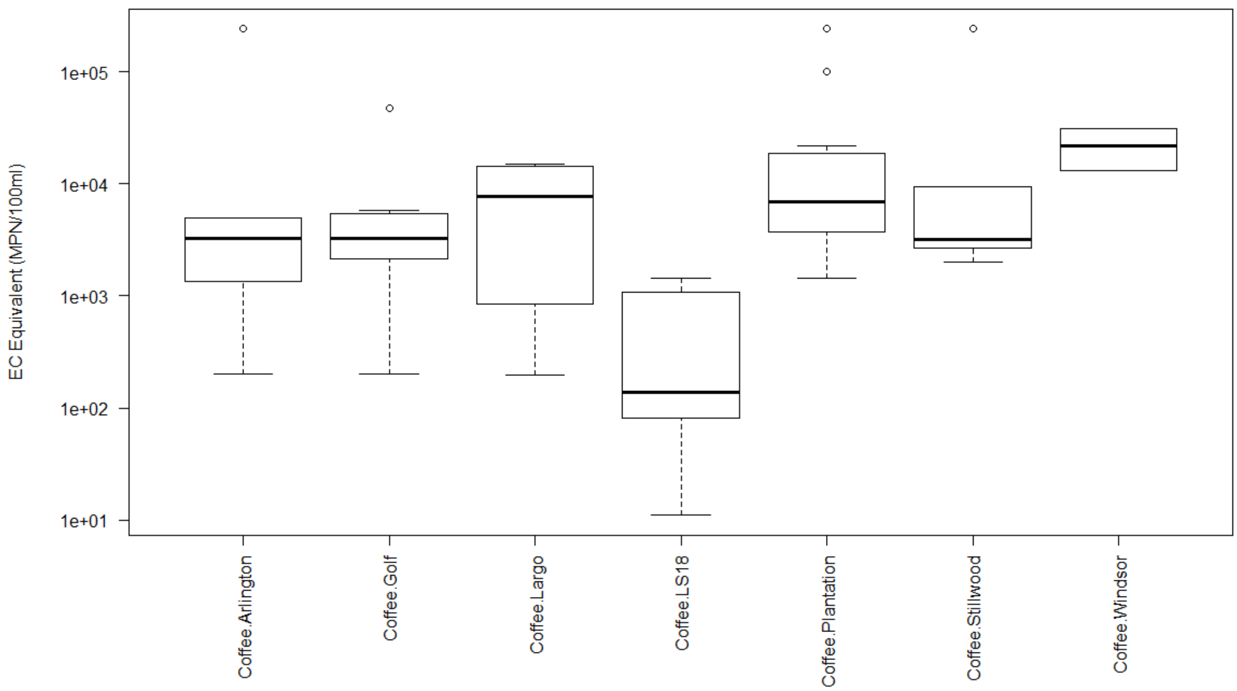


Figure 57. Boxplot of bacterial counts for all data for each site from the indicated database. (Coffee Canal Tributary System)

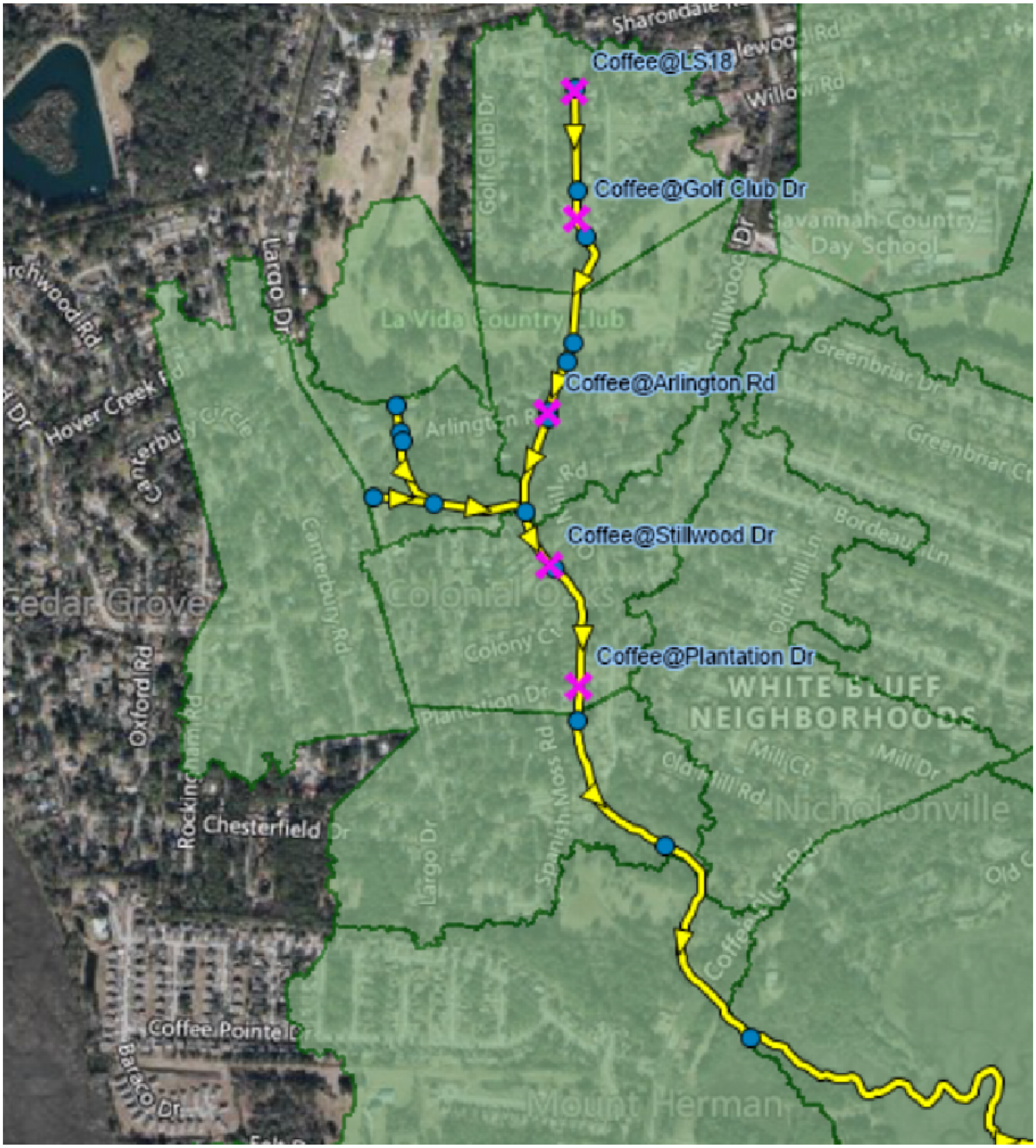


Figure 58. New Monitoring Sites (Coffee Canal Tributary System)

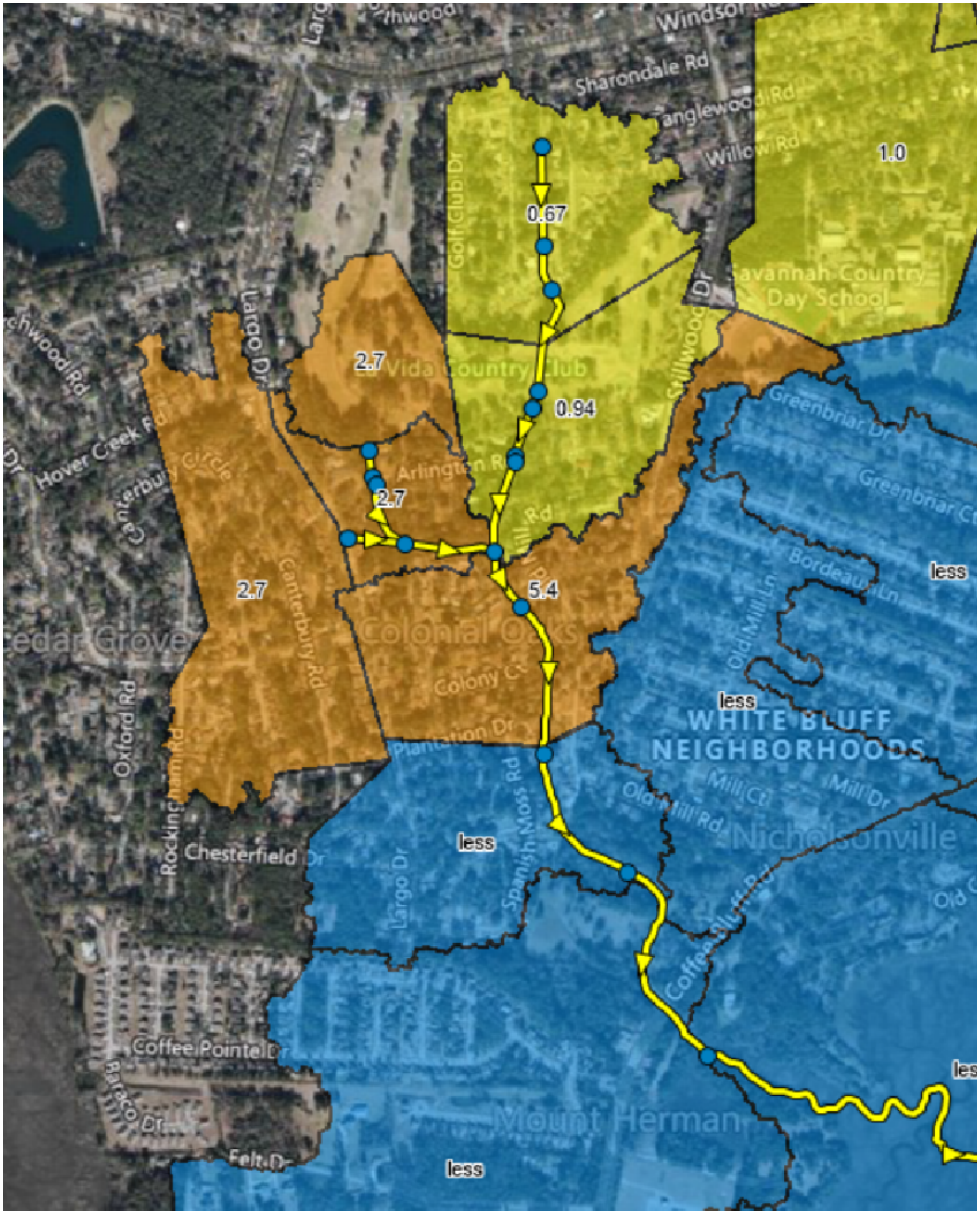


Figure 59. Wet Weather Pathogen Hotspots (Coffee Canal Tributary System) Labels for each sub watershed indicate 10^9 MPN/acre-day in EC equivalent.

E2.A.xii - Additional Hayner's Creek High-Density Data

This is a unique area to report on because of the slightly different sampling that took place there based on access. These samples were taken in one day, at low tide, by boat due to limited access. There were two high areas, one around Montgomery Cross Road, and another near Halcyon Bluff (Figures 60-61). No boxplot is available for this section due to the limited data.

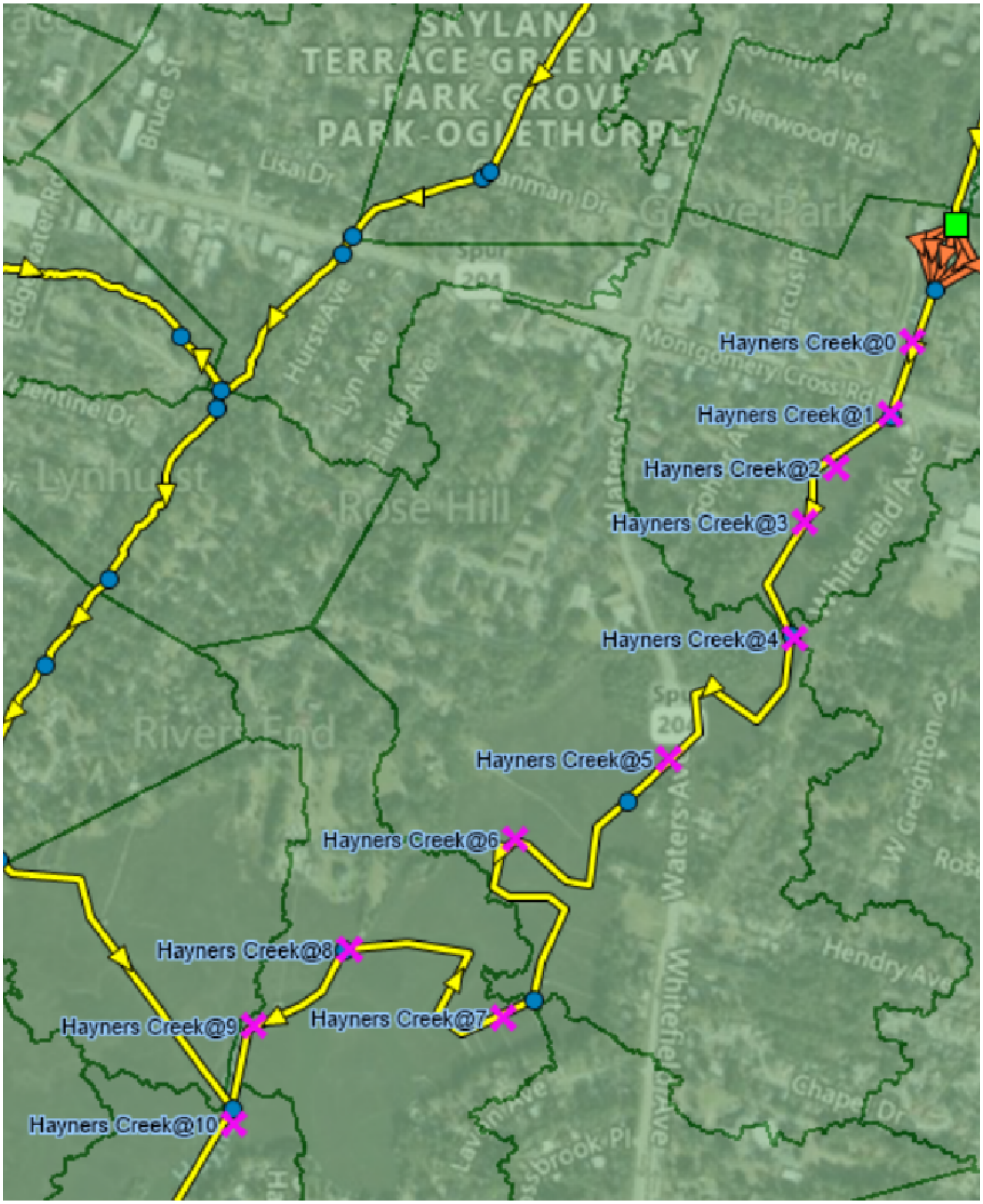


Figure 60. New Monitoring Sites (Hayner's Creek System)

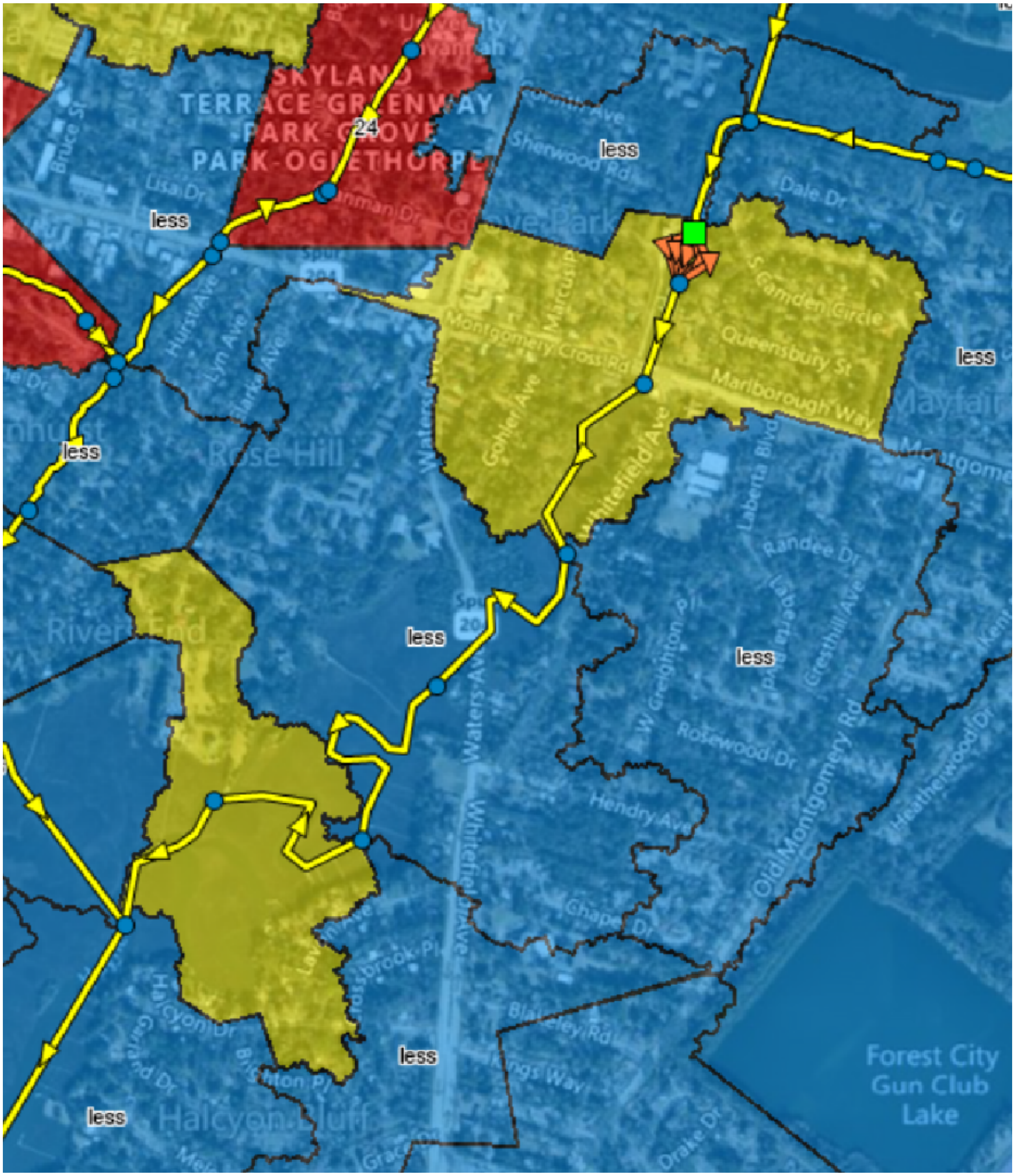


Figure 61. Wet Weather Pathogen Hotspots (Hayner's Creek System System) Only one sample set was done from these sites at low tide due to sampling access difficulty. The yellow area had concentrations approximately 2x the other sites.

E2.A.xiii - Dry Weather Data

While mass loadings are not as high as during rainfall, these number are significant because they are still relatively high, because we have a significant number of dry weather days, and because it may indicate the type of sources present in those areas, which would have to be reaching the water bodies without rainfall (Figure 62). Areas of particular concern in this view of the data include upper Casey Canal, Coffee Canal, Lower Wilshire, and Upper and Lower Chippewa. The area in Lower Wilshire and Upper Chippewa have a significant number of private septic systems, but the other areas are almost entirely municipal sewer. This analysis is not as spatially dense as the wet-weather sampling, so note that the issues could exist in relatively small portions of the highlighted areas.

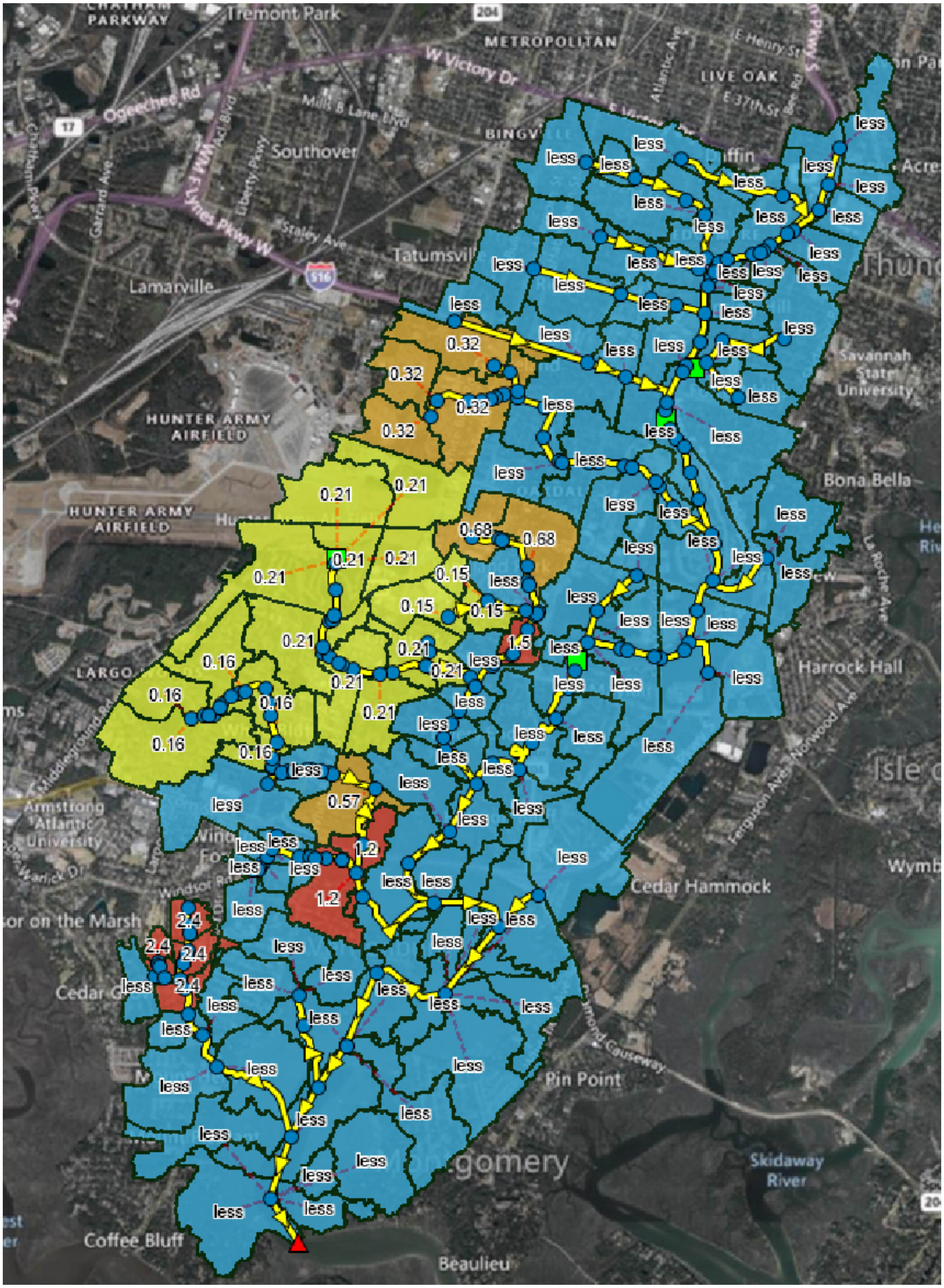


Figure 62. Dry Weather Pathogen Hotspots (Entire System) Labels for each subwatershed indicate 10^9 MPN/acre-day in EC equivalent.

E2.A.xiv - Data Summary

While the listed impairment for this watershed is Hayner's Creek and Casey Canal, most of the watershed is experiencing elevated concentrations. This includes Casey and Hayner's, but also Wilshire, Harmon, Chippewa, Coffee, and Holland Canals. All sites with more than two relevant samples other than the Vernon River at Vernonburg had a mean wet weather ENT concentration far exceeding the winter standards. This was the same for FC except for Vernon River at Vernonburg and nearby Rendant and the same for EC at all available sites, which did not include Rendant or Vernonburg. While mean is more sensitive to high values than geomean, most or all would still exceed. Dry weather results are not that different with only Hayner's Creek, Bougainvillea, and the end of Harmon Canal joining the list of exceptions that are currently meeting the winter standard for FC. Rendant fails by FC and ENT during dry weather and only the very end of Harmon meets the standard for EC. Again, a few more sites may pass based on the less sensitive geomean, but not many. Overall, it is necessary to reach Vernonburg in the mainstem Vernon River for sufficient downstream dilution to consistently bring concentrations below winter standards, and even then, they are not consistently meeting summer standards. To meet winter standards consistently at the outlets of the main tributaries, which would be a good intermediate goal for watershed management, loading would have to reduce, depending on the indicator used, by 81-92% for Casey Canal, 93-96% for Harmon Canal, and 93-98% for Wilshire Canal. Meeting summer standards in these tributaries would require reductions above 95% in all cases. The tributaries should be addressed in the order given based on the relative contribution of those tributaries at approximately 50%, 20%, and 10% respectively of the overall freshwater discharge. Other tributaries, including Holland and Coffee Canals, should also be addressed for their own local impact, but have limited impact on the currently impaired reaches. In Casey, the upper region, especially the outfalls between Delesseps Ave and Dixie Ave, should be prioritized based on higher loading per acre. In Chippewa/Harmon, upper Chippewa and the lower portions of Chippewa and Harmon should be prioritized based on higher loading per acre. In Wilshire, the middle and lower portions should be prioritized, but in this tributary, sources seem to be particularly widespread.

Element 3: Assessment of the NPS Management Measures Needed and the Critical Areas Where They Need to be Implemented

E3.A – Priority Source/Factor Concerns by Land Use

Only land uses over 5% of total area are listed and concerns are listed in decreasing order of importance for each source area (Figure 63). This section provides a top-level overview of the type of sources that are likely to be present for each land use. It helps to inform the following section.

Land Use Type (Percentage of Watershed)	Potential Sources Relevant to Land Use
Residential (48%)	• Municipal Sewer/Laterals • Private Wastewater/Septic • Pet/Urban Livestock Waste • Degraded Stream Health
Military (22%)	• Wildlife • Municipal Sewer/Laterals • Degraded Stream Health
Conservation (13%)	• Municipal Sewer • Wildlife • WPCP • Stream Health • Bacteria in Sediment • Unhoused Encampments/Open Defecation • Landfill Leachate
Commercial (8%)	• Municipal Sewer/Laterals • Private Wastewater/Septic • Degraded Stream Health • Unhoused Encampments/Open Defecation
Office/Institutional (6%)	• Municipal Sewer/Laterals • Private Wastewater/Septic • Degraded Stream Health • Unhoused Encampments/Open Defecation

Figure 63. Table Indicating Likely Pathogen Sources for each land use.

E3.B – Priority Areas by Measured Concentrations & Annual Loadings

The following areas have been prioritized based on their overall mass contribution to the downstream impaired area, their mass loading per acre, and their concentration (Figures 64-66).

E3.B.i - Red Areas

Red Priority Area	**Land Use(s)**	**Identified High Probability Sources**
Upper Casey Canal, near the canal, west bank, between Delesseps Ave and Dixie Ave	Residential, Office, and Conservation	● High priority sewer lines ● Cross Connections ● Unhoused Encampments/Open Defecation ● Failing Laterals ● Daffin Park/Dog Park
Lower end of Wilshire Canal (Below White Bluff);	Residential, Conservation	● Private Wastewater/Septic at low elevation ● High priority sewer lines ● Indication of dry weather sources
Chippewa Canal (Above Montgomery Cross Road, between Cranmon Drive and Mall Blvd);	Residential, Commercial, and Office	● Failing Laterals ● Indication of dry weather sources
Upper Casey, near the canal, east bank, outfall just below Delesseps Ave	Residential	● High priority sewer lines ● Cross Connections
Lower End of Harmon Canal (Between White Bluff and Confluence with Chippewa)	Residential, Commercial, and Office	● High priority sewer lines ● Limited Private Wastewater/Septic near stream ● Failing Laterals

Figure 64. Table indicating red priority areas and investigated/high probability sources.

E3.B.ii - Orange Areas

Orange Priority Area	Land Use(s)	Identified High Probability Sources
Upper Casey Canal, 6x6 box culvert and 5’ circular culvert entering Casey Canal at Delesseps Ave and Dixie Ave	Mostly Residential, some Conservation and small portion of Office	• Cross-connected Sewer • Failing Laterals
Upper End of Habersham Canal (Above Habersham Drive)	Residential, Office, Commercial, Military	• High priority sewer lines • Failing Laterals on Northern Portion
Lower End of Habersham Canal (Between Waters Ave and Agonic Dr.)	Golf Course, Office, Residential	• High priority sewer lines • Wildlife
Middle/Upper Wilshire Canal (Between Largo and White Bluff)	Military, Residential, Commercial, Conservation, Office	• High priority sewer lines • Unhoused Encampments/Open Defecation? • Wildlife • Failing Laterals especially just upstream of Elks Lodge • Indication of significant dry weather sources • Private Wastewater/Septic
Coffee Canal (Especially between Arlington Dr and Plantation Drive)	Residential	• High priority sewer lines • Know stormwater volume/erosion issues • Failing Laterals • Indication of dry weather sources
Chippewa Canal (Above Mall Blvd, especially along Van Buren Ave);	Residential, Commercial, and Office	• High priority sewer lines • Failing Laterals • Indication of dry weather sources • Private Wastewater/Septic
Holland Canal Ditch Entering from East just below Woodley Road	Residential	• High priority sewer lines • Failing Laterals

Figure 65. Table indicating orange priority areas and investigated/high probability sources.

E3.B.iii - Yellow Areas

Yellow Priority Area	Land Use(s)	Identified High Probability Sources
Upper End of Harmon Canal (Above White Bluff) and Tributary to Chippewa Canal	Military, Golf Course, Residential, Commercial	• Few High priority sewer lines near White Bluff • Wildlife
Hayner's Creek (Near Lavon Ave and near Montgomery Cross Road)	Residential and Conservation	• High priority sewer lines • Known septic issues • Lift Station Issue • Failing Laterals
Upper Casey Canal, 5' circular culvert entering on the west below Delesseps Ave	Residential	• Unhoused Encampments/Open Defecation? • Cross-connected Sewer? • Failing Laterals
Upper Casey Canal, two culverts including 6'x5' box and 42" circular between Delesseps Ave and 52nd Street	Residential and Conservation	• High priority sewer lines • Unhoused Encampments/Open Defecation?
Upper Casey Canal, two 6'x5' box culverts entering at Victory Drive on east bank	Residential and Commercial	• High priority sewer lines
Coffee Canal (Especially above Arlington Dr.)	Residential, Golf Course	• Know stormwater volume/erosion issues • Known Sewer Spill during sampling • Failing Laterals
Holland Canal, ditch entering from the south just above Woodley Rd and area immediately around Woodley Rd	Residential, Conservation, and Office	• High priority sewer lines • Failing Laterals • Dog Park
Upper end of Wilshire Canal (Above Largo Drive)	Residential, Conservation, Office	• WPCP spills • High priority sewer lines

Figure 66. Table indicating yellow priority areas and investigated/high probability sources.

E3.C – Description of Potential BMP

E3.C.i - Non-Structural BMP Descriptions

1. Targeted Sewer Lateral Education – This measure is intended to increase awareness of the need to inspect and maintain privately owned sewer laterals as a homeowner responsibility for public safety and ecological health. The educational campaign can be city-wide but will be more intensely marketed in priority areas that have failing laterals as a likely pathogen source.

2. Water Quality App or Text Alert – This measure is intended to increase awareness overall of the current condition of pathogen impairment in Savannah's waters and the potential public health and safety concerns as well as ecological health concerns. We intend for it to increase public acceptance of water quality investment and support for elected officials to prioritize water quality. We plan to incorporate information about various high probability sources identified through this WMP.
3. K-12 Stormwater/Sewer Field Trips – This measure is intended to sow seeds of resource conservation and protection for the next generation. We also hope to engage parents by extension in taking steps to improve and protect water quality. We plan to incorporate information about various high probability sources identified through this WMP.
4. Targeted Septic Care Education - This measure is intended to increase awareness of the need to inspect and maintain privately owned septic systems as a homeowner responsibility for public safety and ecological health. The educational campaign can be city-wide but will be more intensely marketed in priority areas that have septic systems as a likely pathogen source.
5. Municipal Septic Maintenance/Inspection/Limitation Policy Updates – The intention of this measure is to establish a septic system ordinance or policy changes for relevant municipalities that requires homeowners using a septic system to periodically inspect and maintain that system to ensure basic elements of proper functionality. We also intend to investigate the possibility of a limitation on the installation of new septic systems, especially in areas that could be susceptible to failure due to anticipated sea level rise. The town of Vernonburg already has a septic ordinance and similar ordinances can be found in Nags Head, SC, Folly Beach, SC, and James Island, SC.
6. Cost Share for Septic Maintenance and Repair – Understanding that the costs of septic inspection, maintenance, and especially repair can be significant, we anticipate that along with an ordinance. There may need to be cost share options, especially for low-income homeowners. We propose to look at various funding options.
7. Targeted Pet Waste Disposal Education – Many options exist for pet waste education, including a comprehensive guidance document from Phinizy Center (Appendix E)
8. Education on Toilet Use for Unhoused Communities – The intention of this measure is to enhance the effectiveness of the structural measure listed to provide toilets to unhoused communities. We anticipate that some educational campaign will be necessary to maximize efficacy that includes listening to the voice of the unhoused community as a stakeholder in that process.
9. Municipal Sewer Lateral Inspection/Maintenance Policy Updates – The intention of this measure is to establish a private sewer lateral ordinance or policy changes for relevant municipalities that requires homeowners with private laterals to inspect and maintain that system to ensure basic elements of proper functionality. Anticipating difficulty with public acceptance of such a requirement, we recommend that the selection of this measure be accompanied by broadly implemented education on the importance of sewer lateral inspection and maintenance along with cost-share and insurance options. This measure could be rolled into a storm water utility establishment and funded through its fee. Cities with model programs to consider include Knoxville, TN, Austin, TX, El Cajon, CA, and Santa Barbara, CA.
10. Cost Share for Sewer Lateral Maintenance and Repair- Understanding that the costs of sewer lateral inspection, maintenance, and especially repair can be significant, we

anticipate that along with an ordinance. There may need to be cost share options, especially for low-income homeowners. We propose to look at various funding options including lateral insurance programs (Insurance Program, UWM, 2010).

11. Incentives for Installing Pervious Surfaces– This is a practical step to reduce the volume of runoff that can result in I&I, nuisance flooding, and reduced filtration of pollutants in runoff. Reduced runoff means that an increased percentage of runoff can be subject to infiltration, reducing runoff-driven pathogen contamination, if opportunities for infiltration exist in that portion of the watershed. We know that the pathogen loading in the Vernon Watershed is highly correlated to rainfall, with some indication that higher rainfall totals increase loading further. Therefore, widespread runoff and infiltration practices should result in reduced pathogen delivery.
12. Wildlife Management Program (Hunting/Capture/Harassment) – As indicated previously in this document, increased wildlife density near streams may be artificially increasing the "natural background" condition. If populations can be shown to be more than natural densities, various removal strategies might be implemented to decrease the source of indicator bacteria to the water bodies.
13. Alternative Urban Livestock Waste Management Program (Covered Storage, Soil Incorporation, Septic/Sewer Disposal, Garbage Disposal) – This measure intends to provide resource options to urban agriculturalists with livestock including poultry and livestock animals currently allowed under city ordinances. This measure includes education, and we recommend using UGA ag extension or NRCS as a model or participating program for this measure.
14. Reducing NPS Pollutants for Improved Ecological Health – This measure seeks to improve overall water body health and decrease survival and growth of pathogens by reducing the input of various contaminants to the stream. This will result in a healthier environment where more bacterial predation can occur. The intention is for relevant municipalities to develop ordinances, policy updates, design manual changes, or MS4 plan modifications to limit the release of NPS pollutants by commercial services, private homeowners, or both based on scientific understanding of how certain pollutants or usages can negatively impact water quality.
15. Nutrient Source Management Education – – This measure seems to improve overall water body health and decrease survival and growth of pathogens by maintaining a nutrient balance. Excess DOC and phosphorus in particular have been shown to increase survival and growth of FIB. Furthermore, nutrient criteria may be on the horizon for MS4 systems anyway and this would allow Savannah to be ahead of the curve. The intention is to educate the public to take voluntary steps to limit behaviors that could negatively impact nutrient balance in our waterways.
16. Nutrient Source Management Policy – This measure seeks to improve overall water body health and decrease survival and growth of pathogens by maintaining a nutrient balance. Excess DOC and phosphorus in particular have been shown to increase survival and growth of FIB. Furthermore, nutrient criteria may be on the horizon for MS4 systems anyway and this would allow Savannah to be ahead of the curve. The intention is for relevant municipalities to develop ordinances, policy updates, design manual changes, or MS4 plan modifications to limit the release of excess nutrients. This includes septic and sewer leaks, but also lawn fertilization and agricultural waste management.

E3.C.ii - Structural BMP Descriptions

1. Septic to Sewer Conversion – This measure involves extending sewer lines into areas currently not serviced to allow customers currently using private septic systems to install a private lateral and go onto municipal sewer. In some limited cases a sewer line may already be present where a private septic system is in use. This measure can face difficulties because there is negative financial incentive in the current system for a private septic system customer to pay a significant cost to install a lateral based on a assessment of possible failure when they are not incurring any cost for a septic system that may or may not be failing. Further, the septic system remains installed and may retain the potential to impact the waterway during rainfall, even after it is no longer in use (Robertson and Harman, 1999), reducing the efficacy of the measure. Lastly, legal counsel has informed us that it is largely unprecedented and possibly not legally possible for the municipality to mandate such a change.
2. Septic Inspection and Maintenance – This measure involves a septic professional visiting the site and checking to ensure that the system is not clogged and not experiencing obvious surface failure around the tank or drain field. A basic evaluation by a septic service is not likely to find a subsurface problem resulting in undertreated water reaching a waterbody. Maintenance steps, if necessary, might involve cleaning a filter protecting the drain field, pumping solids from the septic tank, or recommendations to amend or replace the drain field. In some cases, recommendations are made to install mounded systems where failure is occurring.
3. Septic Repair or Replacement – This measure is related to Septic Inspection and Maintenance but is directly related to following through on recommendations for major work being done such as sealing holes in a septic tank, tank replacement, drain field replacement, installation of a mounded system, or installation of an entirely new system.
4. Pet Waste Bag Dispenser/Receptacle – This measure involves the installation of pet waste management stations at common dog walking locations to reduce the incidence of pet waste left on the ground. It can face difficulties due to vandalism, patrons not using the service, continued provision of bags, and the need to service the waste disposal compartment with a municipal employee.
5. Dog Park Runoff Structures (vegetated buffers, infiltration, and filtration structures) – This measure is an attempt to intercept and treat polluted runoff when pet waste is not picked up by owners. It assumes low compliance with regulations or education to pick up pet waste. It is typically less cost effective than prevention measures. It may be possible to implement a municipal ordinance or code requirement to stipulate that such structures must be present in dog parks and outdoor areas associated with high population areas such as dog day care facilities and veterinary clinics. Structures can clog or suffer other performance failures.
6. Portable or Low-Cost Permanent Toilets for Unhoused Communities – This measure involves the provision of portable toilets or low-cost, pit-latrine style toilets in areas where unhoused communities exist. It is often done from a public health standpoint as much as for a water quality standpoint. It can be controversial based on the perception of “enabling” or “supporting” the unhoused population with public funds or “condoning” an encampment site that may be on private property or breaking municipal ordinances. Providing toilets also does not ensure usage, which may be improved with education to some degree.

7. Relocation of Unhoused Communities / City Sanctioned Sites – This measure involves closing homeless encampments in environmentally sensitive areas either by eviction of unhoused populations or relocation to a preferred site. This can be controversial on both sides of the issue based on perception of "cruelty" based on eviction or forced relocation or perception of "condoning" a presence on a sanctioned site. Sanctioned sites can also bring up the question of municipal liability.
8. Sewer/Lateral Leak Detection Activities – This measure is meant to increase the level of confidence that laterals in an area of suspected failure are leaking and/or identify which ones are leaking. This measure cannot independently reduce concentrations, but municipalities could potentially use this information along with an ordinance to require maintenance of the observed failing laterals and reduce contamination of water bodies.
9. Visual Inspection/Televising High Failure Risk Lines – This measure is meant to increase the level of confidence that sewer lines with higher failure risk in an area of suspected failure are leaking and/or identify which ones are actually leaking. This measure cannot independently reduce concentrations, but municipalities could potentially use this information along with prioritized maintenance funding to repair leaks and reduce contamination of water bodies.
10. Inspection/Repair of Lift Stations – this measure is meant to increase the confidence that a suspected lift station is the cause of failure and take corrective actions to stop leaks or overflows to water bodies.
11. Sewer Line and/or Private Lateral Rehab/Replacement – This measure takes the additional step of repairing privately owned laterals or municipally-owned sewer lines that have been confirmed as failing with inspection. Repair of municipally owned lines would happen by the municipality and repair of privately owned lines could happen from the municipality, the owner, or a third party.
12. Sewer I&I corrective actions – This measure targets activities meant to reduce the incidence of I&I in gravity sewer lines in priority areas of the watershed. Various methods might be used to identify I&I and take steps to reduce it including identification of manholes with low rim elevations, raising or sealing manholes, planning for sufficient stormwater management and nuisance flooding abatement, and elimination of cross-connections.
13. Sewer modeling, capacity review, and enhancement projects – This measure is an attempt to use modeling, data analysis and engineering review to find areas where performance is not meeting demand of the sewer system and propose solutions.
14. Urban Stream Restoration Activities - Geomorphology and Stability – The goal of this measure is to develop an ecologically healthier stream that is more resistant to survival of FIB. This measure does this by taking stream restoration measures specifically intended to create natural morphology and greater natural sediment stability.
15. Urban Stream Restoration Activities - Habitat Restoration – The goal of this measure is to develop an ecologically healthier stream that is more resistant to survival of FIB. This measure does this by taking stream restoration measures that increase suitable habitat for organisms throughout the food web.
16. Structural Runoff Reduction BMP (Rain Barrels or Cisterns) – This is a practical step to reduce the volume of runoff that can result in I&I, nuisance flooding, and reduced filtration of pollutants in runoff. Reduced runoff means that an increased percentage of runoff can be subject to infiltration, reducing runoff-driven pathogen contamination,

provided that opportunities for infiltration exist in that portion of the watershed. We know that the pathogen loading in the Vernon Watershed is highly correlated to rainfall, with some indication that higher rainfall totals increase loading further. Therefore, widespread runoff and infiltration practices should result in reduced pathogen delivery.

17. Reducing NPS Pollutants with filtration strategies – This measure aims to improve the overall health of the water bodies, thereby making them a less hospitable environment for FIB bacteria to thrive. PAH and pesticides are of particular concern. The cost per likely benefit is probably very high, but the ancillary benefits to water quality is also very high. There are a wide range of structural filtration BMP that could be used in high impact areas to the impact of PAH and pesticides.
18. New or Enhanced Stream Buffers or Natural Levee Mimics – This measure is specifically targeted at addressing contamination from overland flow picking up surface pollutants and filtering them before entering small streams. In many areas of the watershed surface runoff may enter drop inlets as opposed to flowing directly into streams and would not be captured by this measure, although drop inlet filters may be able to assist in that capacity. This measure is also specifically targeted to pathogen sources from surface deposition, which are largely limited to pet waste, agricultural waste, surface failure of septic systems, and wildlife. If the problem is largely sewer lines, laterals, or subsurface septic drainage, this measure is unlikely to provide as much benefit.
19. Urban Water Quality BMP (including nutrients) - Upland Structures (Constructed Wetlands, Retention Ponds, Infiltration Features) – This measured intends to intercept and treat impaired water for both pathogens and nutrients. Phosphorus in particular has been shown to increase the growth of FIB in sediments and sufficient reductions are likely to reduce pathogen numbers downstream. To be effective, the structures must be located downstream of a known source, which would most likely be related to surface runoff as described above under the section on stream buffers.
20. Urban Water Quality BMP (including nutrients) - Instream or Diversion Structures (Riparian Diversion Wetlands, Wetland Restoration) – This measure targets improvement to a high concentration stream by diverting it, especially during storm flow, to a riparian treatment structure that can retain both nutrients and pathogens and reduce the loading that goes further downstream. There is at least one particular location in Casey Canal that might be suitable for this strategy. The downside is that it does nothing to prevent the pathogens from entering or impairing the upstream portion and may create a reservoir in the filtration practice if not design to promote the death of the organisms.
21. Instream Sediment Removal Structure – The goal of this measure is to decrease the loading of bacteria travelling downstream by removing suspended sediment that FIB are known to be associated with. The success of this measure would depend on the quantity of suspended sediment and the practicality of removing it in sufficient amounts.
22. Sediment Removal – This measure aims to periodically remove sediment in areas identified to have high reservoirs of FIB in sediments. Removal would reduce the changes of recontamination when sediments are mobilized and reduce the nutrient and toxicity component in sediments for greater stream health.

E3.D – BMP Selection Process

E3.D.i - Estimation of Sources as a Percent of Total Loading

The values in this table are very influential to the determination of which BMP are anticipated to have the highest impact. It is critical that they are well established. It is recommended that

additional BST testing be conducted in this watershed to verify the accuracy of these numbers, especially to verify that the percentage of human contribution is near 74% as assumed below.

Source	Source as a Percent of total Load	Notes
Wildlife	20	The BST study prior to the 2013 WMP found 22% of FIB loading attributable to wildlife in Casey Canal
Failing Sewer Laterals	13	This should be some percentage of the 50% overall municipal sewer failure, probably mostly from wet weather. Of the 60 priority watershed areas about 30% have little or no likelihood of impairment from identified high priority lines, indicating increased likelihood of lateral failure
Municipal Sewer wet weather failure SSO	30	The prior BST study in Casey found 74% Human, so municipal sewer is 74%, minus the septic 20%, minus the open defecation 4% is 50%. Dry sewer is probably about 10-15% of wet. Municipal Sewer wet vs. dry in Casey seems to be dominated by wet, other areas seem to be 5-10 times more loading when weather is wet.
Failing Septic	20	At most this should be 100% of the source for the septic service. The septic served parcels total 1,900 acres out of the watershed parcel total of approximately 11,300 acres, 17%. Loading from the septic relevant area is likely 33% of total loading at most by ENT, 20% at most by FC. 9% of parcels are septic.
Pets/Urban Livestock	5	The BST study prior to the 2013 WMP found 4% attributable to pets in Casey.
Degraded Stream Health/Indicator Bacterial Growth/Survivability*	100	Surbeck et al. (2010) found a decay potential of 10x about every 10 hours, a 90% reduction given 10 hours residence time in the system.
Bacteria in Sediment*	10	up to 290x of the concentration in the overlying water in some samples from Casey and Habersham Canals during dry weather, other tributaries were much less and probably negligible compared to other sources. A rough estimate based on the the length and width of Casey indicates that sediment distrubance could be a significant source in Casey, perhaps 1000 MPN increase for a 1" rain event if 2" of sediment is distrubed, which would be about 20-30% of the EC equivalent exiting Casey, which in turn is 50% of the water across the watershed. All other areas must be adjusted down proportionally to account for 10% sediment source, -5% from wet sewer, -2% from septic, -2% from wildlife, -1% from unhoused.
Unhoused Communities/Open Defecation	5	A study by Okullu et al. (2017) found an increase of between 11% to 51% in EC counts when the community open defecation percentage increased from 17% to 51% of the community in Africa. Our unhoused population is much lower, but possibly in more sensitive areas.
Municipal Sewer Dry Weather Leaks	7	Total sewer is probably about 50% of total. Dry sewer is probably about 10-15% of wet. Municipal Sewer wet vs. dry in Casey seems to be dominated by wet, other areas seem to be 5-10 times more loading when weather is wet.
*Not included in total to 100% because it applies to all sources seperately		

E3.D.ii - Non-structural BMP Criteria and Metrics

Best Management Practice	Measurement	Criteria for Estimating Effectiveness	Metric for Monitoring BMP
1. Targeted Sewer Lateral Education	identification of sewer laterals as significant source at least for a particular area	x	
	survey of maintenance conducted 6 months later		x
	before and after monitoring in impaired channel downstream		x
2. Water Quality App /Text Alert/Media Campaign			
	demonstrated reluctance of political action on new ordinances and funding to support actions to reduce pathogens	x	
	demonstrated lack of community priority in support of actions to reduce pathogens	x	
	identification of septic, private lateral, urban agriculture and/or pet waste as significant, widespread sources	x	
	measured changes in community attitudes toward the issue		x
	measured changes in willingness of community leadership to pass ordinances or fund supportive actions		x
3. K12 Stormwater/Sewer Field Trips			
	demonstrated reluctance of political action on new ordinances and funding to support actions to reduce pathogens	x	
	demonstrated lack of community priority in support of actions to reduce pathogens	x	
	documentation of effectivness to raise awareness and influence mindset on water quality issues		
	measured changes in community attitudes toward the issue		x
	measured changes in willingness of community leadership to pass ordinances or fund supportive actions		x
4. Targeted Septic Care Education			
	identification of septic as significant source at least for a particular area	x	
	survey of maintenance changes 6 months later		
	before and after monitoring in impaired channel downstream		x
5. Municipal Septic Maintenance/Inspection/Limitation Policy Updates			
	identification of septic as significant, widespread source	x	
	confirmation of Maintenance/Repair/Replace/Sewer Conversion		x

Best Management Practice	Measurement	Criteria for Estimating Effectiveness	Metric for Monitoring BMP
6. Cost Share for Septic Maintenance and Repair			
	identification of septic as significant, widespread sources	x	
	confirmation of Maintenance/Repair/Replace/Sewer Conversion		x
7. Targeted Pet Waste Disposal Education			
	BST study indicates significant non-human contribution to fecal bacteria loading	x	
	before and after monitoring in impaired channel downstream		x
8. Education on Toilet Use for Unhoused Communities			
	quantification of toilet usage		x
	before and after monitoring in impaired channel downstream		x
9. Municipal Sewer Lateral Inspection/Maintenance Policy Updates			
	monitoring hotspots in sewer serviced areas and clean inspection of sewer lines	x	
	quantification of lateral repairs		x
	before and after monitoring in impaired channel downstream		x
10. Cost Share for Sewer Lateral Maintenance and Repair			
	identification of sewer laterals as likely, widespread sources	x	
	confirmation of Maintenance/Repair		x
11. Incentives for Installing Pervious Surfaces			
	measurements taken during rainfall events far exceed those taken during dry periods	x	
	Identification of physical instability of stream banks and beds	x	
	positive association of sediment with fecal bacteria	x	
	quantification of conversion of impervious to pervious		x
	reduction in downstream flow during comperable rain events		x
	before and after monitoring in impaired channel downstream		x

Best Management Practice	Measurement	Criteria for Estimating Effectiveness	Metric for Monitoring BMP
12. Wildlife Management Program (Hunting/Capture/Harassment)			
	BST study indicates significant non-human contribution to fecal bacteria loading	x	
	indication of wildlife population in excess of natural densities	x	
	wildlife corridors identified along stream corridores with monitored hotspots	x	
	before and after quantification of animal populations in stream corridors		x
	before and after monitoringin impaired channel downstream		x
13. Alternative Urban Livestock Waste Management (Covered Storage, Soil Incorporation, Septic/Sewer Disposal, Garbage Disposal)			
	BST study indicates significant non-human contribution to fecal bacteria loading	x	
	survey of urban farmers to quantify change in practices		x
	before and after monitoringin impaired channel downstream		x
14. Municipal NPS Pollutant for Ecological Health			
	Identification of pollutant presence in impaired water bodies	x	
	demonstrated reluctance of political action on new ordinances and funding to support actions to reduce pathogens	x	
	reduced concentrations of pollutants		x
	improved stream health metrics		x
	before and after monitoringin impaired channel downstream		x
15. Nutrient Source Management Education	assessed magnitude of potential impact of public behaviors on nutrient inputs	x	
	measurement of elevated concentrations of nutrients, especially DOC and TP, in impaired streams	x	
	reduced concentrations of nutrients, especially DOC and TP, in impaired streams		x
	before and after monitoringin impaired channel downstream		x
16. Municipal Nutrient Source Management Policy (Nitrogen, Phosphorus)			
	demonstrated reluctance of political action on new ordinances and funding to support actions to reduce pathogens	x	
	measurement of elevated concentrations of nutrients, especially DOC and TP, in impaired streams	x	
	reduced concentrations of nutrients, especially DOC and TP, in impaired streams		x
	before and after monitoringin impaired channel downstream		x

E3.D.iii - Non-structural BMP Cost, Funding Options, and Reductions

BMP	Range of Implementation Cost	Intended Funding Source Options	Notes	Intended Target Source	Percent Reduction from Source	Source as a Percent of total Load	Percent Reduction in Stream	Notes
1. Targeted Sewer Lateral Education	$20,000-$40,000/year	Stormwater Utility, Non-profit program, 319h grant	Assuming 0.25-0.5 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	Failing Sewer Laterals	20	13	3	Potentially high impact due to low awareness of this issue, might successfully influence 25% of affected with a successful campaign to follow up, but not all of those will be completely successful.
2. Water Quality App /Text Alert/Media Campaign	$20,000-$40,000/year	Stormwater Utility, Non-profit program, 319h grant	Assuming 0.25-0.5 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	All	10	100	10	Over the long term, might impact 25% to take actions, but those will not be entirely effective.
3. K-12 Stormwater/Sewer Field Trips	$20,000-$40,000/year	Stormwater Utility, Non-profit program, 319h grant	Assuming 0.25-0.5 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	All	10	100	10	Over the long term, might impact 25% to take actions, but those will not be entirely effective.
4. Targeted Septic Care Education	$20,000-$40,000/year	Stormwater Utility, Non-profit program, 319h grant	Assuming 0.25-0.5 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	Failing Septic	20	20	4	Might successfully influence 25% of the target population with a successful campaign to follow up, not all of those will be completely successful.
5. Municipal Septic Maintenance/Inspection/Limitation Policy Updates	$20,000-$40,000/year	City Budget	Assuming 0.25-0.5 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	Failing Septic	65	20	13	High likehood of improvement for systems that are identifiable as failing, 25% may not be, some noncompliance due to various reasons including cost, but higher impact long term with limits on new systems.
6. Cost Share for Septic Maintenance and Repair	$1,400,000-$1,800,000	Private Homeowners/Businesses, Non-profit grant program, 319h Grant	20% cost share or tax rebate of repair/replace cost from structural table.	Failing Septic	75	20	15	Increased compliance due to cost alleviation.
7. Targeted Pet Waste Disposal Education	$20,000-$40,000/year	Stormwater Utility, Non-profit program, 319h grant	Assuming 0.25-0.5 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	Pets/Urban Livestock	10	5	1	Given the existing knowledge on this issue, further education campaigns may have limited success unless highly targetted.
8. Education on Toilet Use for Unhoused Communities	$20,000-$40,000/year	Stormwater Utility, Non-profit program, 319h grant	Assuming 0.25-0.5 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	Unhoused Communities/Open Defecation	10	5	1	May create some improvement, but this population is likely not as compliant with traditional educational messages.

BMP	Range of Implementation Cost	Intended Funding Source Options	Notes	Intended Target Source	Percent Reduction from Source	Source as a Percent of total Load	Percent Reduction in Stream	Notes
9. Municipal Sewer Lateral Inspection/Maintenance Policy Updates	$20,000-$200,000/year	City Budget	Costs could be in the higher end of this range if the city incures cost for inspection and informing homeowners of failures.	Failing Sewer Laterals	60	13	8	Costs are high and percevied value may be low. Compliance may be an issue, success rate for abatement where it is done should be high.
10. Cost Share for Sewer Lateral Maintenance and Repair	$3,500,000-$4,500,000 / one time	Private Homeowners/Businesses, Non-profit grant program, 319h Grant, Laterals Insurance Program, HUD Block Grant	Assuming half of the estimated repair costs to be shared.	Failing Sewer Laterals	85	13	11	Increased compliance due to cost alleviation.
11. Incentives for Installing Pervious Surfaces	$13,000,000-$26,000,000	Stormwater Utility	Assuming an installation cost with labor of $20/square foot, a incentive of 20% cost share or tax rebate, and a target replacement of 5-10% of the watershed (3.25E6 - 6.5E6 sq ft).	Comprehensively			10	Runoff reduction is likely to be limited overall, but there may be localized improvements if well targeted.
				Wildlife	5	20	1	
				Municpal Sewer wet weather failure SSO	5	30	2	
				Failing Septic	5	20	1	
				Pets/Urban Livestock	5	5	0	
				Bacteria in Sediment	5	10	1	
				Degraded Stream Health/Indicator Bacterial Growth/Survivability	5	100	5	
				Wildlife	5	20	1	If viable and continuous, may decrease wildlife by 10-20%, but needs to be targeted towards birds based on prior BST study, which is unlikely to be viable or continuous.
12. Wildlife Management Program (Hunting/Capture/Harassment)	$20,000-$40,000/year	Stormwater Utility, Non-profit program, 319h grant	Assuming 0.25-0.5 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	Wildlife	5	20	1	
13. Alternative Urban Livestock Waste Management (Covered Storage, Soil Incorporation, Septic/Sewer Disposal, Garbage Disposal)	$40,000-$80,000/year	Stormwater Utility, Non-profit program, 319h grant	Assuming 0.5-1 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	Pets/Urban Livestock	10	5	1	Given the existing knowledge on this issue, further education campaigns may have limited success unless highly targetted.
14. Municipal NPS Pollutant for Ecological Health	$20,000-$40,000/year	Stormwater Utility, Non-profit program, 319h grant	Assuming 0.25-0.5 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	Degraded Stream Health/Indicator Bacterial Growth/Survivability	20	100	20	An effective ordinance might improve stream health by 50% toward the potential bacterial decay improvement of 40%.
15. Nutrient Source Management Education	$20,000-$40,000/year	Stormwater Utility, Non-profit program, 319h grant	Assuming 0.25-0.5 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	Degraded Stream Health/Indicator Bacterial Growth/Survivability	8	100	8	An effective ordinance might improve stream health by 20% toward the potential bacterial decay improvement of 40%.
16. Municipal Nutrient Source Management Policy (Nitrogen, Phosphorus)	$20,000-$40,000/year	Stormwater Utility, Non-profit program, 319h grant	Assuming 0.25-0.5 full-time agent to implement, $40,000 salary, 2x overhead multiplier.	Degraded Stream Health/Indicator Bacterial Growth/Survivability	20	100	20	An effective ordinance might improve stream health by 50% toward the potential bacterial decay improvement of 40%.

E3.Di.iv - Structural BMP Criteria and Metrics

Best Management Practice	Measurement	Criteria for Estimating Effectiveness	Metric for Monitoring BMP
1. Septic to Sewer Conversion in Low Elevation Areas (Coastal Resiliency)			
	hot spots identified in high density sampling and modeling pointing definetively to septic	x	
	need to prioritize as long term solution for sea level rise	x	
	survey or historical data on willingness to switch to sewer or legal ability to mandate switch	x	
	before and after monitoring in impaired channel downstream		x
2. Septic Inspection and Maintenance			
	hot spots identified in high density sampling and modeling pointing definetively to septic	x	
	subsequent inspection to verify condition		x
3. Septic Repair or Replacement			
	hot spots identified in high density sampling and modeling pointing definetively to septic	x	
	published failure rate data/inspections indicating need for replacement	x	
	before and after monitoring in impaired channel downstream		x
4. Pet Waste Bag Dispenser/Receptacle			
	BST study indicates significant non-human contribution to fecal bacteria loading	x	
	quantification of bag/dispoal container useage		x
	before and after monitoring in impaired channel downstream		x
5. Dog Park Runoff Structures (vegetated buffers, infiltration and filtration structures)			
	BST study indicates significant non-human contribution to fecal bacteria loading	x	
	before and after monitoring in impaired channel downstream		x
6. Portable or Low-Cost Permanant Toilets for Unhoused Communities			
	monitored hotspots definetely identify known unhoused community locations	x	
	quantification of toilet usage		x
	before and after monitoring in impaired channel downstream		x

Best Management Practice	Measurement	Criteria for Estimating Effectiveness	Metric for Monitoring BMP
7. Relocation of Unhoused Communities / City Sanctioned Sites			
	monitored hotspots definetely identify known unhoused community locations	x	
	willingness of the community to relocate	x	
	before and after monitoring in impaired channel downstream		x
8. Sewer/Lateral Leak Detection Activities			
	high likelihood of sewer as a source in identified hotspots	x	
	BST results indicating high proportion of Human Source	x	
	positive location of leaks in monitored area		x
9. Visual Inspection/Televising High Failure Risk Lines			
	high likelihood of sewer as a source in identified hotspots near high failure risk lines	x	
	BST results indicating high proportion of Human Source	x	
	positive location of poor pipe condiitons in monitored area		x
10. Inspection/Repair of Lift Stations			
	high likelihood of sewer as a source in identified hotspots near lift stations	x	
	BST results indicating high proportion of Human Source	x	
	positive identification of lift station failures		x
	before and after monitoring in impaired channel downstream		x
11. Priority Sewer Line Rehab/Replacement			
	identification of problems during visual inspection or leak detection	x	
	before and after monitoring in impaired channel downstream		x
12. Sewer I&I corrective actions			
	observed or modeled issues with SSO related to capacity during rainfall	x	
	reduced flow in sewer pipes during comperable rain events		x
13. Sewer modeling, capacity review, and enhancement projects			
	likelihood of sewer as a probable source for hotspots	x	
	BST results indicating high proportion of Human Source	x	
	identification of problem failure points		x
14. Urban Stream Restoration Activities - Geomorphology and Stability			
	Identification of physical instability of stream banks and beds	x	
	positive association of sediment with fecal bacteria	x	
	Measured improvement in stream stability and turbidity during rain events		x

Best Management Practice	Measurement	Criteria for Estimating Effectiveness	Metric for Monitoring BMP
15. Urban Stream Restoration Activities - Habitat Restoration			
	poor stream health metrics such as macroinvertebrate assessments	x	
	improved stream health metrics		x
	before and after monitoring in impaired channel downstream		x
16. Structural Runoff Reduction BMP (Rain Barrels or Cisterns)			
	correlation between hotspots and impervious surface	x	
	positive association of sediment with fecal bacteria	x	
	reduced flow in downstream channels during comperable events		x
	before and after monitoring in impaired channel downstream		x
17. Reducing NPS Pollutants with filtration strategies			
	Identification of pollutant presence in impaired water bodies	x	
	reduced concentrations ofpollutants		x
	improved stream health metrics		x
	before and after monitoring in impaired channel downstream		x
18. New or Enhanced Stream Buffers or Natural Levee Mimics			
	BST study indicates significant non-human contribution to fecal bacteria loading	x	
	measurements taken during rainfall events far exceed those taken during dry periods	x	
	before and after monitoring in impaired channel downstream		x
19. Urban Water Quality BMP (including nutrients) - Upland Structures (Constructed Wetlands, Retention Ponds, Infiltration Features)			
	measurements taken during rainfall events far exceed those taken during dry periods	x	
20. Urban Water Quality BMP (including nutrients) - Instream or Diversion Structures (Riparian Diversion Wetlands, Wetland Restoration)	availability of proven technologies to reduce survival of pathogens in streams	x	
	availability of location to implement structure	x	
	published research on benefits of similar structures	x	
	before and after monitoring in impaired channel downstream		x
21. Instream Sediment Removal Structure (Clarifier)			
	positive association of sediment with fecal bacteria	x	
	verification of high fecal loading in removed sediment		x
	before and after monitoring in impaired channel downstream		x
22. Sediment Removal			
	positive association of sediment with fecal bacteria	x	
	verification of high fecal loading in removed sediment		x
	before and after monitoring in impaired channel downstream		x

E3.D.v - Structural BMP Cost, Funding Options, and Reductions

BMP	Range of Implementation Cost	Intended Funding Source Options	Notes	Intended Target Source	Percent Reduction from Source	Source as a Percent of total Load	Percent Reduction in Stream	Notes
1.Septic to Sewer Conversion in Low Elevation Areas (Coastal Resiliency)	10,000,000+	GEFA septic to sewer program, future state or federal program targeting climate change adaptation	A wide range of costs based on particular situation and scale of implementation. A previous estimate for one of the priority areas in this watershed was in excess of $10 million.	Failing Septic	80	20	16	Some limitation exists due to inability to mandate municipal sewer hookups and from the continued risk of contamination from abandoned systems, but this is a more permenant solution
2. Septic Inspection and Maintenance	$700,000 - $900,000 / every 5-10 years	Private Homeowners/Businesses, 319h Grant	1,400-1,800 systems assuming an average inspection/maintenance fee of $500.	Failing Septic	50	20	10	25% may be failing in a way that couldn't readily be caught by standard inspection, not all of those caught will be repaired, and the efficacy assumes public funding.
3. Septic Repair or Replacement	$7,000,000 - $9,000,000 / one time	Private Homeowners/Businesses, 319h Grant	Assuming $15,000 for a complex mounded system, $5,000 for more standard repairs, 50% of systems failing, 25% needing mounded systems.	Failing Septic	75	20	15	25% may be failing in a way that couldn't readily be caught by standard inspection, not all of those caught will be repaired, and the efficacy assumes public funding.
4. Pet Waste Bag Dispenser/Receptacle	$60,000 - $75,000 / one time	Stormwater Utility, Non-profit program, 319h grant	40-50 locations at $1,500 each.	Pets/Urban Livestock	50	5	3	Compliance is not guaranteed.
5. Dog Park Runoff Structures (vegetated buffers, infiltration and filtration structures)	not highly ranked	not highly ranked		Pets/Urban Livestock	50	5	3	Filtration of impacted water is not guaranteed and removal is less than 100%
6. Portable or Low-Cost Permanant Toilets for Unhoused Communities	$100,000-$320,000 /one time; $20,000 annual repairs	Stormwater Utility, Non-profit program, 319h grant	40 unhoused community camps, $1,500-$8,000 for a composting toilet (nps.gov), 2-4 toilets per camp.	Unhoused Communities/Open Defecation	70	5	4	Compliance is not guaranteed.
7. Relocation of Unhoused Communities / City Sanctioned Sites	not highly ranked	not highly ranked		Unhoused Communities/Open Defecation	80	5	4	Compliance with relocation is not guaranteed.
8. Sewer Leak Detection Activities	$2,500 -$3,100	Stormwater Utility, Non-profit program, 319h grant	$1,500 for instrument, 30-40 miles of primary channel to walk, 5 miles per day, 6-10 days, $20/hr.	Municipal Sewer Dry Weather Leaks/ Some wet weather failure	80	20	16	Assuming leaks will be fixed, but not all will be seen, especially without televising. This measure is likely to catch both dry weather and some wet weather sewer failures.
9. Visual Inspection/Televising High Failure Risk Lines	$100,000 - $400,000	City Sewer Budget	$2 per linear foot according to Infratechservices, at least 10-20 miles of high prority lines.	Municipal Sewer Dry Weather Leaks/ Some wet weather failure	90	20	18	Assuming leaks will be fixed, but not all will be seen, especially without televising. This measure is likely to catch both dry weather and some wet weather sewer failures.
10. Inspection/Repair of Lift Stations	$100 - $500,000/lift station	City Sewer Budget	Wide range of costs based on level of inspection and findings for possible repair up to replacement of the entire structure.	Municipal Sewer Dry Weather Leaks/ Some wet weather failure	95	20	19	assuming leaks will be fixed, but not entirely, this measure is likely to catch both dry weather and some wet weather sewer failures
11. Priority Sewer Line Rehab/Replacement	$5,000,000 - $10,000,000	City Sewer Budget	Assuming $200 per foot for trenchless lining, 25,000-50,000 feet of priority replacement based on evaluation of high risk lines.	Municipal Sewer Dry Weather Leaks/ Some wet weather failure	95	20	19	Assuming leaks will be fixed, but not entirely. This measure is likely to catch both dry weather and some wet weather sewer failures.
12. Sewer I&I corrective actions	$200,000 - $10,000,000	City Sewer Budget	Assuming a consultant charge for data analysis at this scale of $100,000-$150,000, and potential repair costs on par with sewer line replacement.	Municpal Sewer wet weather failure SSO	50	30	15	This is likely to abate SSO for a percentage of lower intensity storms.
13. Sewer modeling, capacity review, and enhancement projects	$200,000 - $10,000,000	City Sewer Budget	Assuming a consultant charge for model development and capacity review at this scale of $100,000-$150,000, and potential repair costs on par with sewer line replacement.	Municpal Sewer wet weather failure SSO	60	30	18	Similar to I&I, likely to abate SSO for a percentage of lower intensity storms, may be more effective than general I&I measures.

BMP	Range of Implementation Cost	Intended Funding Source Options	Notes	Intended Target Source	Percent Reduction from Source	Source as a Percent of total Load	Percent Reduction in Stream	Notes
14. Urban Stream Restoration Activities - Geomorphology and Stability	$10,000,000 - $50,000,000	Stormwater Utility, Non-profit program, 319h grant	$500-$1,200 per linear foot (Kenney et al, 2012); 10% of modeled channels is 19,000 feet, 20% is 38,000 feet.	Degraded Stream Health/Indicator Bacterial Growth/Survivability	10	100	10	According to Surbeck, potential is 40-90% based on residence time in our systems, the current level of impairment, and the likely attainment of improvement, but this is based on nutrients and DOC, which would only be indirectly affected by this type of stream restoration, perhaps improved by 25%
15. Urban Stream Restoration Activities - Habitat Restoration	$2,700,000 - $5,400,000	Stormwater Utility, Non-profit program, 319h grant	Based on a funded Augusta, Ga project costing $350,000 for 2,600 ft of stream ($135/linear foot) and a restoration priority in this watershed of 20,000 - 40,000 feet.	Degraded Stream Health/Indicator Bacterial Growth/Survivability	10	100	10	according to Surbeck, potential is 40-90% based on residence time in our systems, the current level of impairment, and the likely attainment of improvement, but this is based on nutrients and DOC, which would only be indirectly affected by this type of stream restoration, perhaps improved by 25%.
16. Structural Runoff Reduction BMP (Rain Barrels or Cisterns)	$40,000,000 - $50,000,000	Stormwater Utility, Non-profit program, 319h grant	20,000 - 25,000 structures, capturing 0.5" of rain from a 1500 sq. ft. Each house requires 500 gallon capture system, installation cost approximatley $2,000 per system.	Comprehensively			15	Typical rain barrel usage is not that significant compared to normal rainfall, installation of meaningful distributed storage containers, at the scale of 500 gallons or more per home, could have significant impacts on runoff, reducing the runoff volume of a 1-inch storm by 5-10% depending on the area.
				Wildlife	8	20	2	
				Municpal Sewer wet weather failure SSO	8	30	2	
				Failing Septic	8	20	2	
				Pets/Urban Livestock	8	5	0	
				Degraded Stream Health/Indicator Bacterial Growth/Survivability	8	100	8	
				Bacteria in Sediment	8	10	1	
17. Reducing NPS Pollutants with filtration strategies	$5,000,000 - $100,000,000	Stormwater Utility, Non-profit program, 319h grant	Potential costs mirror urban water quality BMP to be effective at scale.	Comprehensively			28	
				Degraded Stream Health/Indicator Bacterial Growth/Survivability	20	100	20	Potentially 50% improvement toward potential gains of 40% predicted by Surbeck.
				Bacteria in Sediment	75	10	8	
18. New or Enhanced Stream Buffers or Natural Levee Mimics	$10,000,000- $50,000,000	Stormwater Utility, Non-profit program, 319h grant	Similar to geomorphology stream restoration costs.	Comprehensively			5	
				Failing Septic	10	20	2	Potential to reduce overland flow sources due to increased soil filtration, if implemented over 20 of the watershed, might reduce by 50% of that area.
				Pets/Urban Livestock	10	5	1	
				Wildlife	10	20	2	

BMP	Range of Implementation Cost	Intended Funding Source Options	Notes	Intended Target Source	Percent Reduction from Source	Source as a Percent of total Load	Percent Reduction in Stream	Notes
19. Urban Water Quality BMP (including nutrients) - Upland Structures (Constructed Wetlands, Retention Ponds, Infiltration Features)	$5,000,000 - $100,000,000	Stormwater Utility, Non-profit program, 319h grant	$1-$20 per cubic foot, 10,000,000 cubic feet in a 1.25" storm event, treating half would be 5,000,000 cubic feet.	Comprehensively			33	
				Wildlife	22	20	4	Reductions of 75% in the water captured by the BMP, which is likely to be a small percentage of the watershed, would need to be implemented over a large scale, 30% or more.
				Municpal Sewer wet weather failure SSO	10	30	3	Reduced likelihood of capturing SSOs compared to other sources.
				Failing Septic	15	2	0	Reduced likelihood of capturing failed septic compared to other sources.
				Pets/Urban Livestock	22	5	1	
				Degraded Stream Health/Indicator Bacterial Growth/Survivability	22	100	22	
				Bacteria in Sediment	22	10	2	
20. Urban Water Quality BMP (including nutrients) - Instream or Diversion Structures (Riparian Diversion Wetlands, Wetland Restoration)	$40,000,000 - $80,00,000	Stormwater Utility, Non-profit program, 319h grant	$26,000-$55,000 per acre from USEPA (1999), 50-100 acres available, increased by 50% to account for inflation since 1999.	Comprehensively			17	
				Wildlife	20	20	4	Could treat about half of the highest concentration stormwater at 75% efficacy if implemented in the right location, possibly lower Casey Canal, which is roughly half of the watershed volume.
				Municpal Sewer wet weather failure SSO	20	30	6	
				Failing Septic	20	20	4	
				Pets/Urban Livestock	20	5	1	
				Bacteria in Sediment	20	10	2	
21. Instream Sediment Removal Structure (Clarifier)	not highly ranked	Stormwater Utility, Non-profit program, 319h grant		Comprehensively			9	Kunkel et al. 2013 indicates that most FIB attached to particles <0.004mm, which don't settle well.
				Wildlife	7	20	1	Could remove some sediment associated bacteria for sediments of settleable size, which are less likely to host pathogens, if it reduced TSS by 50% and possibly pathogens by 25% of that for 50% of the watershed.
				Municpal Sewer wet weather failure SSO	7	30	2	
				Failing Septic	7	20	1	
				Pets/Urban Livestock	7	5	0	
				Degraded Stream Health/Indicator Bacterial Growth/Survivability	3	100	3	Could improve downstream ecological health by perhaps 20% of the potential gain of 40%, but for only about 50% of the stream.
				Bacteria in Sediment	7	10	1	
22. Sediment Removal	not highly ranked	not highly ranked	Dredging Casey Canal and moving Sediment offsite, likely very expensive and very complicated.	Bacteria in Sediment	50	10	5	Unlikely to remove all impacted sediment, perhaps 70% of sediment in the areas making up 70% of the total impact.

E3.E – BMP Selection Summary

Based on a comprehensive assessment of the above tables, in consideration of estimates of 1) cost, 2) efficacy, 3) local suitability, 4) funding potential, and 5) community acceptance, the following management measures have been indicated as preferred, in the following four tiers:

Tier One – "Must Have It" Measures

- Awareness Measures
  - Water Quality App /Text Alert/Media Campaign
  - K-12 Stormwater/Sewer Field Trips
  - Nutrient Source Management Education
- Municipal Policy Updates (Should cooperatively involve all relevant municipalities)
  - Municipal Septic Maintenance/Inspection/Limitation Ordinance or Policy Updates
  - Municipal Sewer Lateral Inspection/Maintenance Ordinance or Policy Updates
  - Municipal NPS Pollutants Reduction Policy Updates
  - Municipal Nutrient Source Management Policy Updates
- Cost Share Programs
  - Cost Share for Septic Maintenance and Repair
  - Cost Share for Sewer Lateral Maintenance and Repair
- Infrastructure Management Measures
  - Sewer I&I corrective actions
  - Sewer modeling, capacity review, and enhancement projects
  - Sewer Leak Detection Activities
  - Visual Inspection/Televising High Failure Risk Lines
  - Inspection/Repair of Lift Stations
  - Priority Sewer Line Rehab/Replacement
- Structural Measures
  - Septic Repair or Replacement

Tier Two – "Should Have It" Measures

- Structural Measures
  - Structural Runoff Reduction BMP (Rain Barrels or Cisterns)
  - Reducing NPS Pollutants with filtration strategies
  - Urban Water Quality BMP (including nutrients) - Upland Structures (Constructed Wetlands, Retention Ponds, Infiltration Features)
- Coastal Resiliency Measures
  - Septic to Sewer Conversion in Low Elevation Areas

Tier Three – "Like to Have It" Measures

- Cost Incentive Programs
  - Incentives for Installing Pervious Surfaces
- Ecological Restoration Measures
  - Urban Stream Restoration Activities - Geomorphology and Stability
  - Urban Stream Restoration Activities - Habitat Restoration
  - Urban Water Quality BMP (including nutrients) - Instream or Diversion Structures (Riparian Diversion Wetlands, Wetland Restoration)

Tier Four – "Could be Nice to Have It" measures includes any listed measures not in the top three tiers

E3.F – Watershed Impact Schematic with Top Tier Interventions

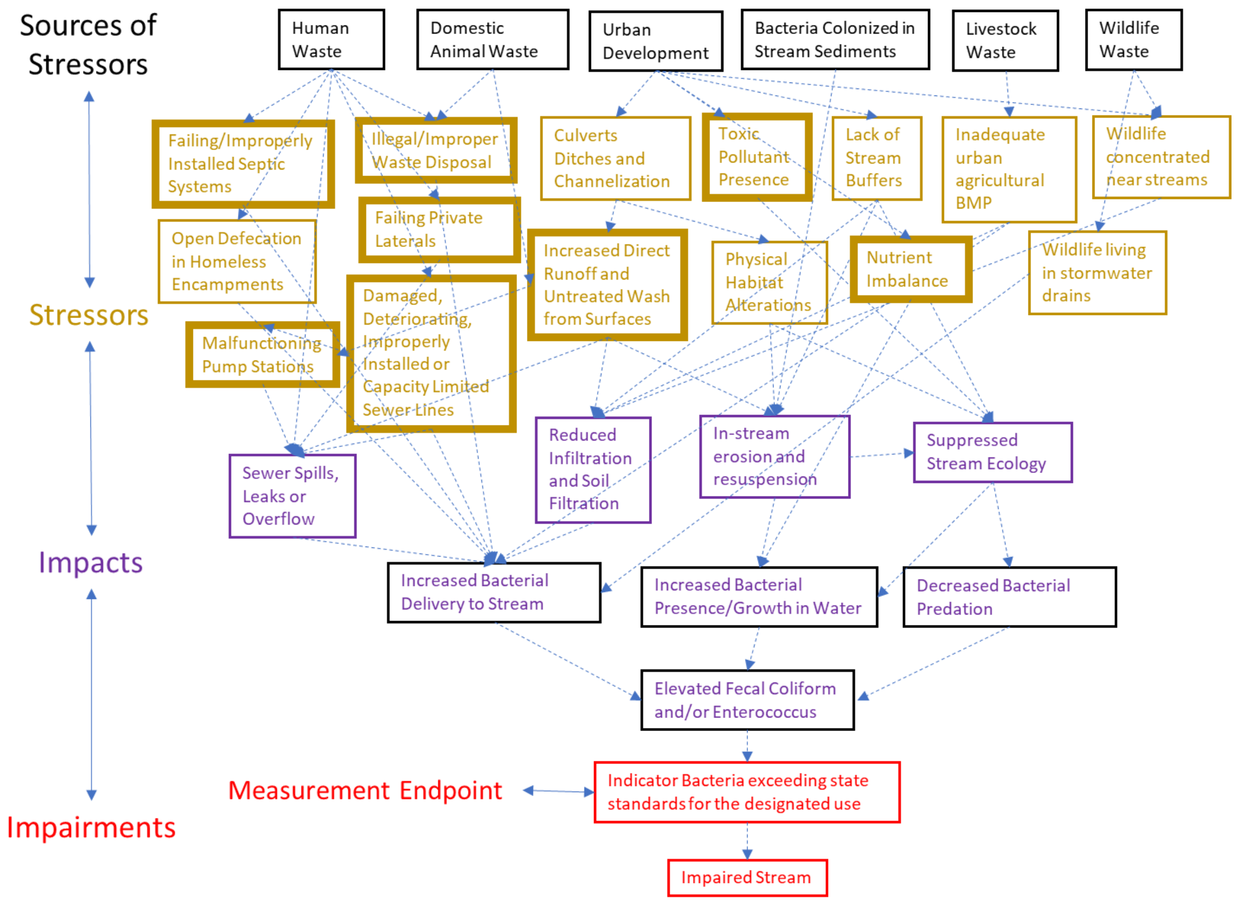


Figure 67. Watershed Impact Schematic with Top Tier Interventions Highlighted

Element 4: An Estimate of the Amount of Technical and Financial Assistance Needed to Implement the Plan and the Sources of this Assistance

E4.A – Responsible Parties

E4.A.i - Technical Committee

This group of individuals, as a subset of the larger watershed planning committee, met on a more frequent basis and held discussion of a more technical nature in the development of a monitoring plan, data analysis, and development of technical recommendations.

- Shawn Rosenquist, Cuddybum Hydrology
- Laura Walker, City of Savannah
- Marc Frischer, UGA Skidaway Institute of Oceanography
- Damon Mullis, Ogeechee Riverkeeper
- Asli Aslan, Georgia Southern University
- Sue Ebanks, Savannah State University

- Joe Richardson, Town of Vernonburg
- Luke Roberson, Georgia Southern University

This group, with some possible additions, will continue to meet on a regular basis moving forward during the implementation of the plan (quarterly basis minimum). Possible additions to this group include:

- Chris Rustin, Department of Public Health
- Jackie Jackson, Chatham County
- US Army Corp of Engineers
- Hunter Army Airfield Representative

E4.A.ii - Zoning and Development Agencies

Two zoning agencies are relevant to this watershed under the cooperative Metropolitan Planning Commission. They make recommendations to both Chatham County and the City of Savannah.

- Metropolitan Planning Commission
  - Zoning Board of Appeals
  - Historic District Board of Review
- Chatham County Commission
- City of Savannah Council

E4.B – Code and Regulation Evaluation

On a local level, the City of Savannah, Chatham County, and the Town of Vernonburg, based on their relative jurisdictions, will hold the authority to make determinations on implementation of codes, regulations, and other recommendations resulting from this plan. This includes the Savannah City Council, Chatham County Board of Commissioners, and Vernonburg Town Council. Chatham County Health Department may also have a code and regulatory role related to septic systems. All activities will also fall under the regulatory authority of GAEPD, USEPA, and US Army Corp of Engineers.

E4.C – Implementation Resources

Implementation of this plan has relevance to three distinct municipal governments and the regional water planning council. Various departments under each municipality may be able to provide critical resources for one or more measures contained within this plan.

- City of Savannah
  - Greenscapes Division - This department will be important for any work that involves public greenspaces, such as dog parks, golf courses, etc.
  - Office of Sustainability - This is the main department that our water quality work has been coordinated with. Laura Walker is in this department. They will have an active role moving forward in coordinating the implementation of the WMP with various stakeholders.
  - Development Services - This department will be important for any work requiring engineering approval for structures and flood control measures involved in any actions to improve water quality.
  - Water Resources - This department is critically important for aspects of the WMP that involve city sewer services and private laterals, educational activities, and stormwater volume management

    - Planning and Urban Design - This department will be critically important for any proposed actions that involve property acquisition or other major structural actions.
- Chatham County
    - Chatham County Resilience Program - This department may be important relative to floodplain management, sea level rise, and related capital projects.
    - Animal Services - This department may be important relative to pet, wildlife, and urban agriculture actions and activities.
    - Cooperative Extension Services - This department may be important relative to urban agriculture.
    - Engineering - This department may be important relative to county sewer infrastructure and stormwater systems.
    - Public Works - This department may also be important relative to county sewer infrastructure and stormwater systems.
- Town of Vernonburg
    - Town Council
- Coastal Georgia Water Planning Council
- Department of Public Health

E4.D – Funding

The following is a list of possible funding sources. We have connected these with BMP in the BMP Table.

- Establishment of a Stormwater Utility for Savannah – NPS pollutant sources, Runoff Reduction, Instream water quality
- 319 Grant Program – Runoff Reduction, Instream Water Quality BMP, Septic Systems, Wildlife
- Non-Profit Programs/Grants – Education Components, Wildlife, Septic Systems, Pet Waste, Urban Agriculture
- GEFA Loans – Sewer Systems
- GEFA Septic to Sewer Program – Septic to Sewer Conversions
- Regional Water Plan Seed Grant (Georgia Coastal) – Nutrients, Pesticides, and NPS Pathogens, Urban Ag Management, and Wildlife Management are relevant to the regional plan
- HUD Block Grant – Sewer Laterals
- Coastal Incentive Grant –Stormwater
- NFWF Coastal Resilience Fund – Septic
- GEMA/FEMA Resilience Grants – Sewer Infrastructure
- State Revolving Loan Fund – Septic to Sewer Conversions, Sewer Systems, Sewer Laterals
- Sewer Lateral Insurance Programs – Sewer Laterals
- City of Savannah Sewer Budget – Lift Stations and Priority Pipes
- Private Homeowners/Businesses – Septic Systems, Pet Waste, Urban Agriculture, Sewer Laterals

Element 5: A Plan for an Education and Information Component

E5.A – Public Sewer Citizenship

E5.A.i - Message

Municipal sewer systems in the City of Savannah could benefit from greater public citizenship. Three areas involving public education could improve the operational effectiveness of municipal sewer in a way that could likely prevent or limit contamination of waterways. These areas include: 1) Fat, Oil, and Grease (FOG) reduction; 2) maintenance/inspection/repair of private laterals; and 3) spill/CSO reporting. The target audience for this message is every citizen/business in Savannah being served by municipal sewer. The message, in coordination with relevant municipalities and existing programs, includes the following:

- Please do not dispose of fat, oil, and grease items down any drain connected to municipal sewer. This includes oil from frying, drippings from cooking meat, and other sources. Please note that disposal with soap or hot water does not alleviate the issue. This material should be disposed of in the garbage.
- If you are connected to municipal sewer, you most likely still have an underground sewer line that belongs to you. This line could be fully or partially resulting in problems for your home or nearby water bodies. If you are experiencing any of the following symptoms, you could be experiencing a failing lateral:
    - Slow drains
    - Gurgling drains
    - Drain backup/overflows often occurring in showers or around the base of toilets
    - Unusually wet spots in the yard especially during dry weather
- If you observe water, especially foul-smelling water, flowing out of the top of a manhole or out of the ground near a manhole, please contact the city using 311.

E5.A.ii - Method

We propose an educational video on the above topics that is accessible on either a digital or paper water/sewer bill sent to sewer customers where complete viewing results in the opportunity for a small rebate on that month's bill.

E5.A.iii - Metric

We propose to keep a record of the number of video views and the addresses they correspond to.

E5.B – Private Septic System Stewardship

E5.B.i - Message

The age of many of the septic systems in the Vernon River watershed, and the low elevation of many of them, make them more susceptible than average to failure resulting in impact to waterways. These systems can function acceptably in some cases if properly maintained. In other cases, they should be replaced or exchanged for a public sewer connection. Public education including evaluation of the effectiveness of the system and proper maintenance could reduce the likelihood of pollution to local waterways. The message, in coordination with relevant municipalities and existing programs, includes the following:

- If you do not pay for sewer service, you probably have a private septic system to treat your wastewater. You likely own this system and are responsible for its proper operation.

- If you are experiencing any of the following symptoms, you could be experiencing a failing septic system:
    - Slow drains
    - Gurgling drains
    - Drain backup/overflows often occurring in showers or around the base of toilets.
    - Unusually wet spots in the yard especially during dry weather
- Even if you are not experiencing any of these symptoms your system may be failing in a way that results in leakage to nearby waterways.
- Evaluation by a septic system professional can allow you to know if your septic system is functioning properly and if it requires maintenance.
- Septic systems rely on living organisms to function properly. There are several things that you can do to improve the overall health and functioning of your system. Learn more about care for your system from the EPA at https://www.epa.gov/septic/how-care-your-septic-system.

E5.B.ii - Method

We propose an educational video on the above topics that is accessible on either a digital or paper water/sewer bill sent to "water only" customers where complete viewing results in the opportunity for a small rebate on that month's bill. An additional discount can be obtained by verification of inspection and service from a qualified septic professional.

E5.B.iii - Metric

We propose to keep a record of the number of video views and the addresses they correspond to.

E5.C – Healthy Community Waterways

E5.C.i - Message

To reach the point of community citizenship where we can consistently support the investments and care required to prevent pollution of our waterways, we need a general buy-in from the community that such things are worthwhile, and practical to support given the priority of other concerns in their lives. They need to become more willing to engage in activities at their own homes or businesses to support water quality and send the message to elected officials that they want it to be a priority. This should be done in coordination with relevant municipalities and existing programs.

E5.C.ii - Method

Building the kind of community buy-in for the value of ecosystem services that we truly need is best accomplished from youth. This process of developing this WMP has drawn in K-12 involvement as stakeholders and with field trips. We seek to continue this kind of involvement in K-12 to instill value for ecosystem services in Savannah's next generation. Also, we seem to build a larger community including adults through information and personal experiences. Community signage has been a part of the development of the WMP and we want to continue to use signage to inform the community of the health status of their waterways. We are looking to the development of a water quality app or text alert system based on pathogen concentrations for increased awareness. We also want to reach out to our community to get them involved at various levels through the Riverkeeper and Adopt-A-Stream organizations. Examples of

involvement over a range of levels includes: 1) receiving newsletters, 2) attending monitoring and cleanup events, 3) attending fundraisers, 4) attending stakeholder meetings, 5) allowing monitoring access on their property, 6) volunteering with K-12 events, and 7) advocating for attention and funding on these issues with local elected officials.

E5.C.iii - Metric
We propose to keep a record of K-12 event participation, record of any app or text alert usage, demonstrated changes in attitudes of elected officials toward water quality initiatives,

E5.D – Campaign for the Unhoused

E5.D.i - Message
Unhoused communities are disproportionately likely to be on low lying, publicly owned land near waterways. Open defecation in these areas can cause pollution to waterways. Education of the community at large on the importance of meeting the needs for unhoused communities and education of the unhoused communities on use of improved sanitation facilities could result in improvement to impaired waterways. The message, in coordination with relevant municipalities and existing programs, includes the following:

- Provision of improved sanitation to unhoused communities is a worthwhile investment in community health and wellness.
- Consideration and understanding of the unique needs of unhoused communities are necessary to provide workable improved sanitation solutions.
- As an unhoused individual the use of improved sanitation facilities is very important to the health of our waterways.

E5.D.ii - Method
Delivery of a flier highlighting the health and ecological benefits of improved toilet use to unhoused individuals along with local food distribution programs. Presentation to the Savannah City Council and Chatham County Board of Commissioners explaining.

E5.D.iii - Metric
We proposed to keep track of the number of fliers distributed.

Element 6: A Schedule for Implementation of Management Measures

Task #	Task Description	Responsible Party	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	Beyond
	Tier One – "Must Have It" Measures													
	Awareness Measures													
1	Water Quality App /Text Alert/Media Campaign	Ogeechee Riverkeeper												
2	K-12 Stormwater/Sewer Field Trips	Ogeechee Riverkeeper												
3	Nutrient Source Management Education	Ogeechee Riverkeeper												
	Municipal Policy Updates													
4	Municipal Septic Maintenance/Inspection/Limitation Ordinance or Policy Updates	City of Savannah												
5	Municipal Sewer Lateral Inspection/Maintenance Ordinance or Policy Updates	City of Savannah												
6	Municipal NPS Pollutants Reduction Policy Updates	City of Savannah												
7	Municipal Nutrient Source Management Policy Updates	City of Savannah												
	Cost Share Programs													
14	Cost Share for Septic Maintenance and Repair	Ogeechee Riverkeeper												
15	Cost Share for Sewer Lateral Maintenance and Repair	Ogeechee Riverkeeper												
	Infrastructure Management Measures													
8	Sewer I&I corrective actions	City of Savannah												
9	Sewer modeling, capacity review, and enhancement projects	City of Savannah												
10	Sewer Leak Detection Activities	City of Savannah												
11	Visual Inspection/Televising High Failure Risk Lines	City of Savannah												
12	Inspection/Repair of Lift Stations	City of Savannah												
13	Priority Sewer Line Rehab/Replacement	City of Savannah												
	Tier Two – "Should Have It" Measures													
	Structural Measures													
16	Septic Repair or Replacement													
17	Structural Runoff Reduction BMP (Rain Barrels or Cisterns)	Ogeechee Riverkeeper												
18	Reducing NPS Pollutants with filtration strategies	City of Savannah												
19	Urban Water Quality BMP (including nutrients) - Upland Structures (Constructed Wetlands, Retention Ponds, Infiltration Features)	City of Savannah/Private Landowners												
	Tier Three – "Like to Have It" Measures													
	Cost Incentive Programs													
20	Incentives for Installing Pervious Surfaces	City of Savannah												
	Coastal Resiliency Measures													
21	Septic to Sewer Conversion in Low Elevation Areas	City of Savannah												
	Ecological Restoration Measures													
22	Urban Stream Restoration Activities - Geomorphology and Stability	City of Savannah												
23	Urban Stream Restoration Activities - Habitat Restoration	City of Savannah												
24	Urban Water Quality BMP (including nutrients) - Instream or Diversion Structures (Riparian Diversion Wetlands, Wetland Restoration)	City of Savannah												
	Tier Four – "Could be Nice to Have It" Measures													
25	Any listed measures not in the top three tiers	TBD												

Element 7: Interim Measurable Milestones for Management Measures

Task#	Task Description	Interim Milestones for Implementation	Responsible Party	Qtr1 2023	Qtr2 2023	Qtr3 2023	Qtr4 2023	Qtr1 2024	Qtr2 2024	Qtr3 2024	Qtr4 2024	Qtr1 2025	Qtr2 2025	Qtr3 2025	Qtr4 2025	Beyond
	Tier One – "Must Have It" Measures															
	Awareness Measures															
1	Water Quality App/Text Alert/Media Campaign															
		Identify Funding Source	Ogeechee Riverkeeper													
		Identify Human Resources and Develop Materials/App	Ogeechee Riverkeeper													
		Begin Campaign	Ogeechee Riverkeeper													
		Measure Participation	Ogeechee Riverkeeper													
2	K-12 Stormwater/Sewer Field Trips															
		Identify Partnering Schools	Ogeechee Riverkeeper													
		Host Events for Teachers	Ogeechee Riverkeeper													
		Support Curriculum and Participation	Ogeechee Riverkeeper													
		Measure Participation	Ogeechee Riverkeeper													
3	Nutrient Source Management Education															
		Identify Funding Source	Ogeechee Riverkeeper													
		Identify Human Resources and Develop Materials	Ogeechee Riverkeeper													
		Begin Campaign	Ogeechee Riverkeeper													
		Measure Participation	Ogeechee Riverkeeper													
	Municipal Ordinances															
4	Municipal Septic Maintenance/Inspection/Limitation Ordinance or Policy Updates															
		Verify failure in a sample of septic systems in priority areas	WMP Technical Team													
		Decide on the best course of action including Ordinance, Policy Update, Local Design Manual Changes, or MS4 Program Update														
		Make the case to city administrators and engage in campaign to encourage public support	WMP Technical Team													
		Gather scientific support for the limitations in the ordinance or policy update	WMP Technical Team													
		Draft the Ordinance or policy update	WMP Technical Team													
		Policy Change or Ordinance Passage by city administrators	City of Savannah													
5	Municipal Sewer Lateral Inspection/Maintenance Ordinance or Policy Updates															
		Verify failure in a sample of septic systems in priority areas	WMP Technical Team													
		Decide on the best course of action including Ordinance, Policy Update, Local Design Manual Changes, or MS4 Program Update														
		Make the case to city administrators and engage in campaign to encourage public support	WMP Technical Team													
		Gather scientific support for the limitations in the ordinance or policy update	WMP Technical Team													
		Draft the Ordinance or policy update	WMP Technical Team													
		Policy Change or Ordinance Passage by city administrators	City of Savannah													
6	Municipal NPS Pollutants Reduction Policy Updates															
		Decide on the best course of action including Ordinance, Policy Update, Local Design Manual Changes, or MS4 Program Update	WMP Technical Team													
		Make the case to city administrators and engage in campaign to encourage public support														
		Gather scientific support for the limitations in the ordinance or policy update	WMP Technical Team													
		Draft the Ordinance or policy update	WMP Technical Team													
		Policy Change or Ordinance Passage by city administrators	City of Savannah													
7	Municipal Nutrient Source Management Policy Updates															
		Decide on the best course of action including Ordinance, Policy Update, Local Design Manual Changes, or MS4 Program Update	WMP Technical Team													
		Make the case to city administrators and engage in campaign to encourage public support														
		Gather scientific support for the limitations in the ordinance or policy update	WMP Technical Team													
		Draft the Ordinance or policy update	WMP Technical Team													
		Policy Change or Ordinance Passage by city administrators	City of Savannah													
	Infrastructure Management Measures															
8	Sewer I&I corrective actions															
		Modeling/Monitoring to identified I&I areas	City of Savannah													
		Direct Investigation of identified areas for failure modes	City of Savannah													
		Determine corrective actions	City of Savannah													
		Implement corrective actions	City of Savannah													
9	Sewer modeling, capacity review, and enhancement projects															
		Modeling/Monitoring to identified capacity limited areas	City of Savannah													
		Determine corrective actions	City of Savannah													
		Implement corrective actions	City of Savannah													
10	Sewer Leak Detection Activities															
		Modeling/Monitoring to identified areas with significant leaks	City of Savannah													
		Determine corrective actions	City of Savannah													
		Implement corrective actions	City of Savannah													
11	Visual Inspection/Televising High Failure Risk Lines		City of Savannah													
12	Inspection/Repair of Lift Stations		City of Savannah													
13	Priority Sewer Line Rehab/Replacement		City of Savannah													

Element 8: Criteria for Evaluating Progress Toward Load Reductions

The ultimate purpose of the long-term monitoring plan is to track the progress and effectiveness of BMP implementation to move the stream out of an impaired condition. The key parameters for study will be the FIB used to measure compliance with state standards, flow, phosphorus, DOC, and bacterial source tracking DNA fingerprinting. Because of the nature of this watershed, and based on the current regulations, both EC and ENT will be used, depending on the location. ENT will be used instead of EC if the salinity of the sample exceeds 5ppt. Sampling should be conducted in accordance with the 30-d geometric mean technique at least once between May and October annually for 5-10 years. The ultimate goal is to achieve levels below state standards for EC geomeans (126/630, Summer/Winter) and for ENT geomeans (35/175, Summer/Winter) for the watershed. The hardest of these to achieve will likely be 35 cfu/100ml ENT in saline Hayner's creek during the summer. Given the current scale of the issue, and the size and complexity of the watershed, intermediate goals are necessary. The following goal schedule indicates the proposed progress toward that ultimate goal. Sections are prioritized based on their overall loading to the system, starting with Casey Canal, then Harmon/Chippewa, Wilshire, Coffee, and Holland. Upstream/freshwater areas are also prioritized over downstream/saltwater to eliminate source confusion and build success momentum.

Season	**Location**	**Relevant Geomean Standard**	**Achieve By**
Any	Coffee@Plantation Dr	350 Enterococci/1260 E. coli	2025
Any	Hayners@Mont Cross Rd	350 Enterococci/1260 E. coli	2025
Any	Harmon@Rivers End	350 Enterococci/1260 E. coli	2025
Any	Vernon@Bouganvillea	350 Enterococci	2026
Any	Vernon@Rendant	350 Enterococci	2026
Any	Hayners@Waters Ave	350 Enterococci	2026
Any	Vernon@Vernonburg	175 Enterococci	2026
Winter	Coffee@Plantation Dr	175 Enterococci/630 E. coli	2030
Winter	Hayners@Mont Cross Rd	175 Enterococci/630 E. coli	2030
Winter	Harmon@Rivers End	175 Enterococci/630 E. coli	2030
Winter	Vernon@Bouganvillea	175 Enterococci	2033
Winter	Vernon@Rendant	175 Enterococci	2033
Winter	Hayners@Waters Ave	175 Enterococci	2033
Winter	Vernon@Vernonburg	175 Enterococci	2033
Summer	Coffee@Plantation Dr	35 Enterococci/126 E. coli	2037
Summer	Hayners@Mont Cross Rd	35 Enterococci/126 E. coli	2037
Summer	Harmon@Rivers End	35 Enterococci/126 E. coli	2037
Summer	Vernon@Bouganvillea	35 Enterococci	2040
Summer	Vernon@Rendant	35 Enterococci	2040
Summer	Hayners@Waters Ave	35 Enterococci	2040
Summer	Vernon@Vernonburg	35 Enterococci	2040

Element 9: A Long-term Monitoring Strategy Connecting Elements Seven and Eight

We recommend long-term monitoring of the watershed throughout and beyond the schedule laid out in Element 8. Between 2023 and 2040, we recommend that minimum samples be taken according to the following schedule. Additional samples may be taken over higher spatial densities for diagnostic and source identification purposes. For each location, 4 samples should be collected over no more than 30 days with each sample being at least 24 hours apart. Multiple sites can be collected on the same days. This should be done twice during November-April, and twice during May-October, for each site. Therefore, each site should have 4 EPD-protocol geomeans collected per year, two summer, two winter. For each site, the FIB indicated in Table x should be used. Since the watershed has demonstrated sensitivity to rainfall, it is necessary to stipulate sampling conditions in order to avoid comparing geomeans with and without rainfall effect. Therefore, each set of 4 samples within a 30-d period should have 1 sample that is taken within 72 hours of rainfall, and 3 that are not.

Year	Locations
2023	Coffee@Plantation Dr, Hayners@Mont Cross Rd, Harmon@Rivers End
2024	Coffee@Plantation Dr, Hayners@Mont Cross Rd, Harmon@Rivers End
2025	Coffee@Plantation Dr, Hayners@Mont Cross Rd, Harmon@Rivers End
2026	Vernon@Bouganvillea; Vernon@Rendant; Hayners@Waters Ave; Vernon@Vernonburg
2027	Vernon@Bouganvillea; Vernon@Rendant; Hayners@Waters Ave; Vernon@Vernonburg
2028	Vernon@Bouganvillea; Vernon@Rendant; Hayners@Waters Ave; Vernon@Vernonburg
2029	Coffee@Plantation Dr, Hayners@Mont Cross Rd, Harmon@Rivers End
2030	Coffee@Plantation Dr, Hayners@Mont Cross Rd, Harmon@Rivers End
2031	Coffee@Plantation Dr, Hayners@Mont Cross Rd, Harmon@Rivers End
2032	Vernon@Bouganvillea; Vernon@Rendant; Hayners@Waters Ave; Vernon@Vernonburg
2033	Vernon@Bouganvillea; Vernon@Rendant; Hayners@Waters Ave; Vernon@Vernonburg
2034	Vernon@Bouganvillea; Vernon@Rendant; Hayners@Waters Ave; Vernon@Vernonburg
2035	Coffee@Plantation Dr, Hayners@Mont Cross Rd, Harmon@Rivers End
2036	Coffee@Plantation Dr, Hayners@Mont Cross Rd, Harmon@Rivers End
2037	Coffee@Plantation Dr, Hayners@Mont Cross Rd, Harmon@Rivers End
2038	Vernon@Bouganvillea; Vernon@Rendant; Hayners@Waters Ave; Vernon@Vernonburg
2039	Vernon@Bouganvillea; Vernon@Rendant; Hayners@Waters Ave; Vernon@Vernonburg
2040	Vernon@Bouganvillea; Vernon@Rendant; Hayners@Waters Ave; Vernon@Vernonburg

Beyond 2040, assuming that all goals have been met, we recommend that monitoring be done indefinitely at a handful of sites to ensure continued health of the water body. Sampling sites should include Vernon@Vernonburg; Harmon@Rivers End; Vernon@Bouganvillea; and Hayners@Mont Cross Rd. These sites should have two EPD-protocol geomeans collected per year, one summer and one winter. Each geomean should still include one rainfall affect sample and 3 that are not.

In addition to traditional grab sample monitoring, we recommend the installation of a minimum of one continuous monitoring probe utilizing tryptophan fluorescence sensor technology to monitor FIB (Ward and MacDonald, 2021).

References

GAEPD. 2010. "Water Quality in Georgia 2000-2001." Georgia Department of Natural Resources Environmental Protection Division.

GAEPD. 2020. "2020 Integrated 305(b)/303(d) List – Coastal Streams." Georgia Department of Natural Resources Environmental Protection Division.

GAEPD. 2005. "Total Maximum Daily Load Evaluation for Twenty-One Stream Segments in the Ogeechee River Basin for Fecal Coliform" Georgia Department of Natural Resources Environmental Protection Division.

Kenney, M., P. Wilcock, B. Hobbs, N. Flores, D. Martínez. 2012."Is Urban Stream Restoration Worth It?" JAWRA, Vol. 48, No. 3, https://doi.org/10.1111/j.1752-1688.2011.00635.x

Kern, W.H. 1991. "Northern Racoon" IFAS Extension, University of Florida, WEC-34, https://edis.ifas.ufl.edu.

Kunkel, E., C. Privette, C. Sawyer, J. Hayes. 2013. "Attachment of Escherichia coli to fine sediment particles within construction sediment basins." Advances in Bioscience and Biotechnology. Vol.4, No. 3A, DOI:10.4236/abb.2013.43A054

Okullo, J., W. Moturi, G. Ogendi. 2017. "Open Defaecation and Its Effects on the Bacteriological Quality of Drinking Water Sources in Isiolo County, Kenya." Environmental Health Insights. https://doi.org/10.1177/1178630217735539

Power, C., R. Feldner, B. Scanlon, M. Frischer, and J. Richardson. 2007., "Bacterial Source Tracking in the Vernon River Watershed." *Proceedings of the 2007 Georgia Water Resources Conference*, March 27–29, 2007, University of Georgia.

Ram, J., B. Thompson, C. Turner, J Nechvatal, H. Sheehan, and J. Bobrin. 2007. Identification of pets and raccoons as sources of bacterial contamination of urban storm sewers using a sequence-based bacterial source tracking method", Water Research, ISSN: 0043-1354, Vol: 41, Issue: 16, Page: 3605-3614

Robertson, W. and J. Harmon. 1999. "Phosphate Plume persistence at two decommissioned septic systems sites." Groundwater. 37(2) 228-236

Savidge, W. and J. Blanton, 2010. "Urban Runoff and Oxygen Dynamics on Salt Marsh Platforms." CIG Annual Report Submitted to Georgia Coastal Zone Management Program.

Surbeck, C., S. Jiang, and S. Grant. 2010. "Ecological Control of Fecal Indicator Bacteria in an Urban Stream." Environ. Sci. Technol, 44,631-637

USEPA. 2022. "How to Care for Your Septic System." https://www.epa.gov/septic/how-care-your-septic-system

Ward, J. and A. MacDonald. 2021. “Triptophan-lik fourescence as a high-level screening tool for detecting microbial contramination ion drinking water.” Science of the Total Environment. Vol. 750, Jan 2021.

Appendix A – TMDL Listing Data

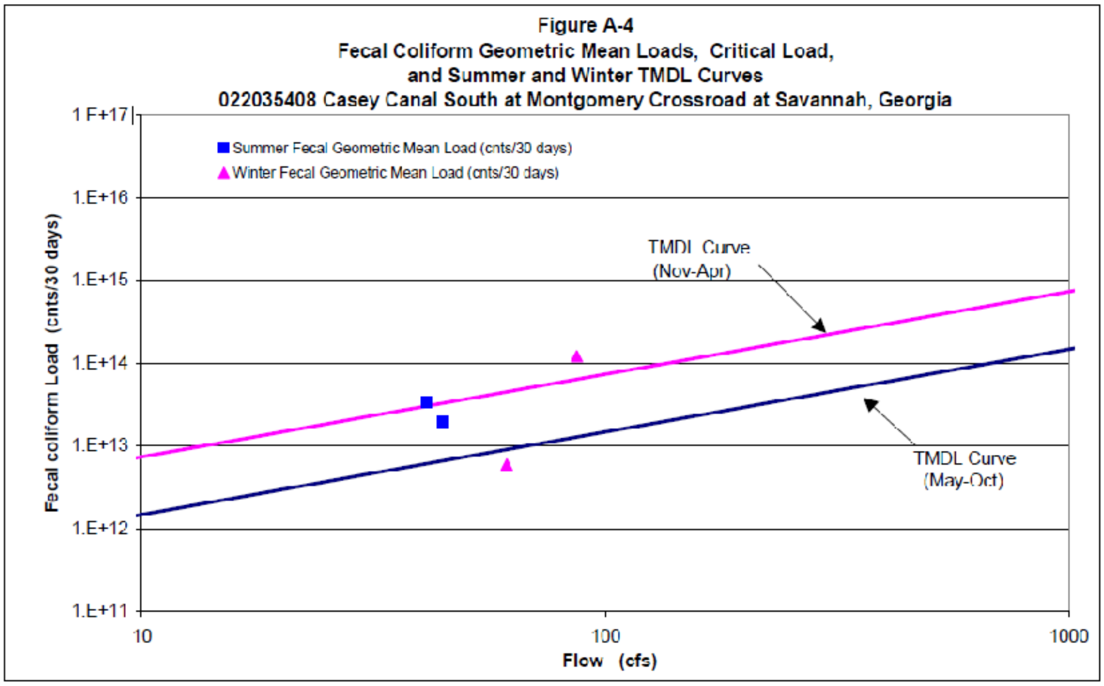


Table A-4. Data for Figure A-4

Date	Observed Fecal Coliform (counts/100 ml)	Estimated Instantaneous Flow On Sample Day (cfs)	Geometric Mean (counts/100 ml)	Mean Flow (cfs)	Geometric Mean Fecal Coliform Loading (counts/30 days)	Geometric Mean TMDL Fecal Coliform Loading (counts/30 days)
20-Feb-02	1300	111.0				
5-Mar-02	**92000**	86.0				
12-Mar-02	330	61.0				
26-Mar-02	330	89.0	1900	86.8	1.21E+14	6.37E+13
14-May-02	330	39.0				
21 May 02	3300	40.0				
4-Jun-02	80	41.0				
11 Jun 02	17000	45.0	1103	41.3	3.34E+13	6.06E+12
9-Jul-02	490	44.0				
16 Jul 02	1100	44.0				
23-Jul-02	490	44.0				
1-Aug-02	460	46.0	590	44.5	1.93E+13	6.53E+12
20-Nov-02	790	57.0				
5-Dec-02	20	53.0				
10-Dec-02	20	70.0				
17-Dec-02	940	65.0	131	61.3	5.90E+12	4.50E+13

Appendix B – Vernon River Hydrodynamic Model Development and Calibration

Model Overview

A hydrodynamic model of the watershed has been developed to provide a baseline of understanding for the movement of water within the target watershed. It includes the following components (Figure 13):

- 117 subcatchments (average size of 135 acres),
- Approximately 190,000 ft of conduit, including natural channels, canals, and stormwater pipes of various materials and sizes. Natural channels have been modeled with irregular profiles based on lidar elevation data.
- Two virtual pump stations to represent the pump stations at Montgomery Cross and Derenne Avenue.
- Three rainfall regions supported with data from real-time weather stations.
- Depth calibration data enhanced by conductivity from three long-term, real-time monitoring stations in critical areas and additional deployed depth sensors in additional areas. The long-term station areas include Casey Canal (to calibrate the model to pump performance), Vernon River at Vernonburg (to determine the tidal range and timing at the model outfall, and Harmon Canal (to calibrate the attenuation of tidal behavior into the upper watershed). Additional sites for model refinement include temporary depth stations on Chippewa Canal and Wilshire Canal.

Input Data

Input data for the model includes the following:

Data	Source	Purpose
Lidar-based DEM		Watershed Delineation/Location of Potential Problematic Source Locations, Stream Channel Location, Cross Sectional Profile Estimation
Chatham County Stormwater Infrastructure	Chatham County	Delineation Refinement, Conduit Development
City of Savannah Stormwater Infrastructure	City of Savannah	Delineation Refinement, Conduit Development
Historic Reported Sewer Spills	GAEPD	Location and Estimation of Spill Contribution to Impairment
FIB Data	City of Savannah, Town of Vernonburg, Ogeechee Riverkeeper	Determination of Pathogen Loading
Unhouse Community Encampments	CSAH	Determination of Contribution Potential
Septic System Locations	City of Savannah	Determination of Contribution Potential

City of Savannah Sewer Infrastructure	City of Savannah	Determination of Contribution Potential
Parcels Information	City of Savannah	Home Age, Septic or Sewer
Road Shapefile	City of Savannah	Development of Impervious Layer
Soils Layer	USDA	Determination of Curve Number
Monitoring Station Data (Rainfall, Depth, Velocity, Salinity)	Cuddybum	Calibration

Input/Calibration Data Summary

Rainfall

Depth Gages at Vernon River and Casey Canal had several periods of outage due to gage clogging at Casey Canal and Lightening Strike/Equipment Malfunction at Vernon River where Harmon Bluff data was substituted. Outage periods were approximately 10% of the year for both stations.

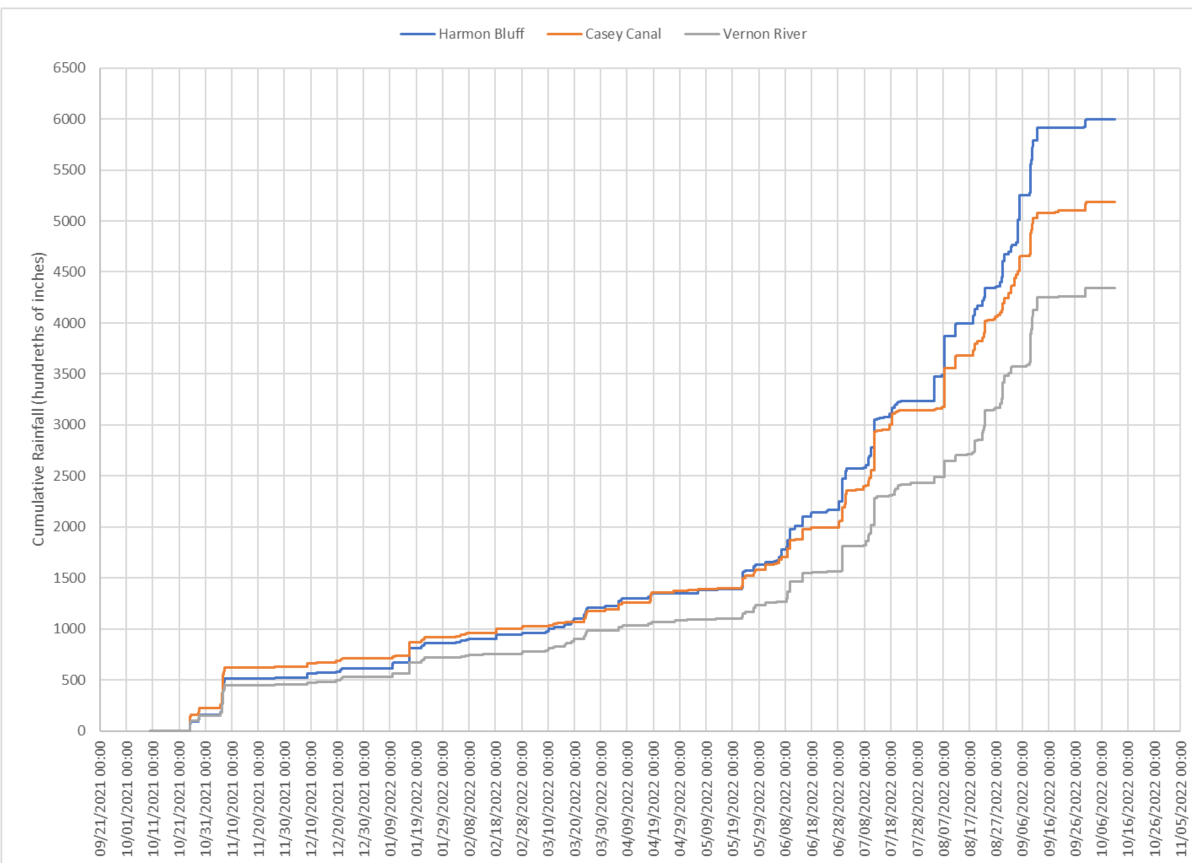


Figure A. Cumulative Rainfall at Monitoring Stations

Depth

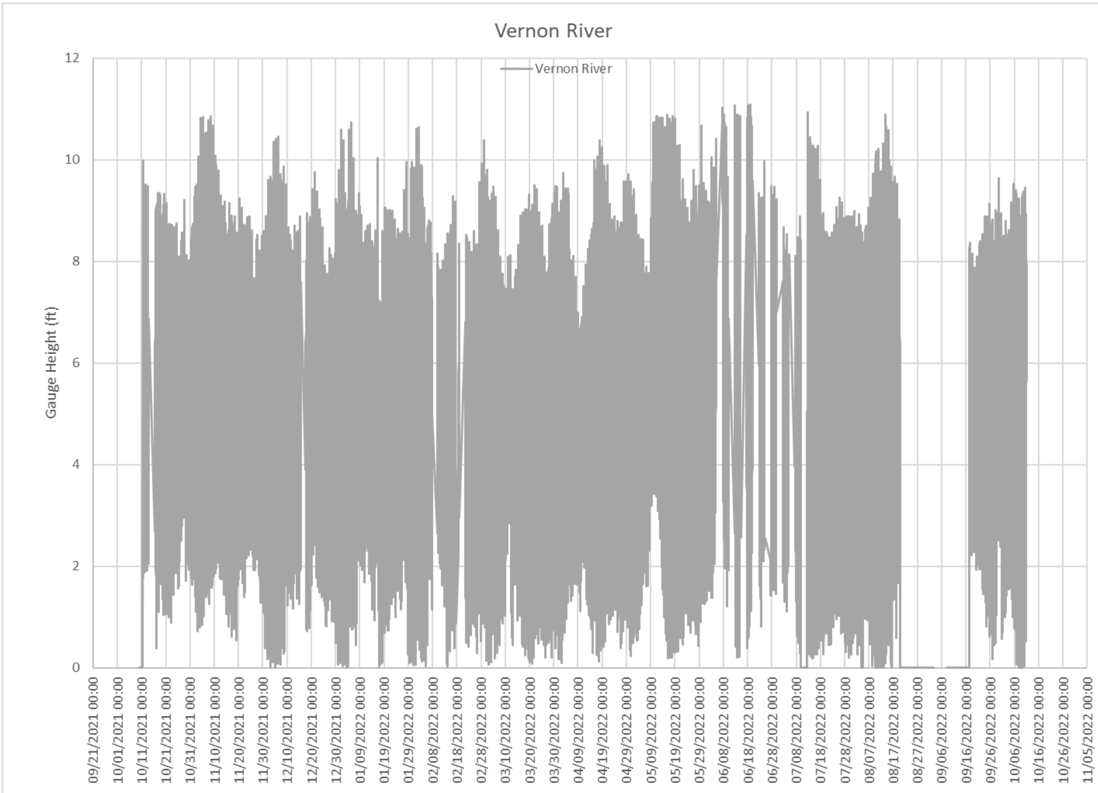


Figure B. Depth at Vernon River

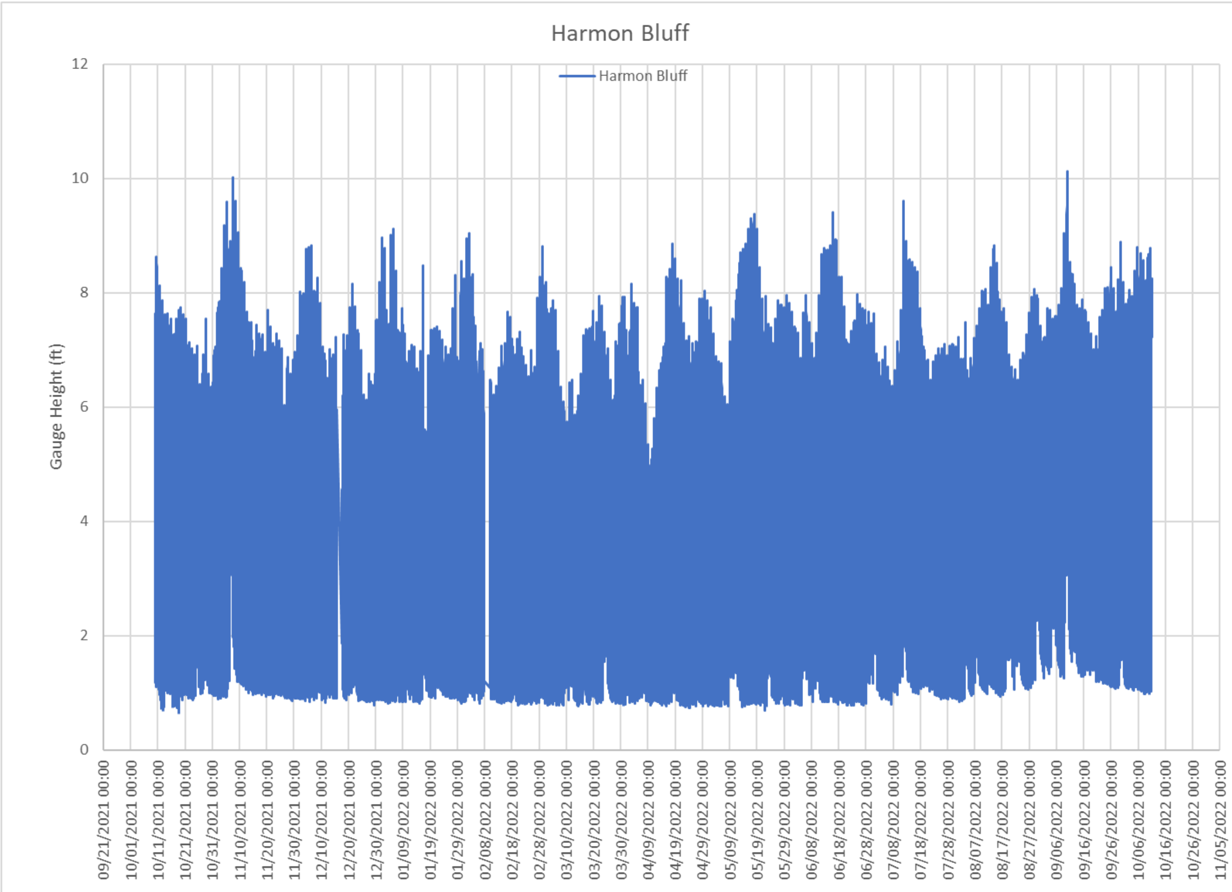


Figure C. Depth at Harmon Bluff

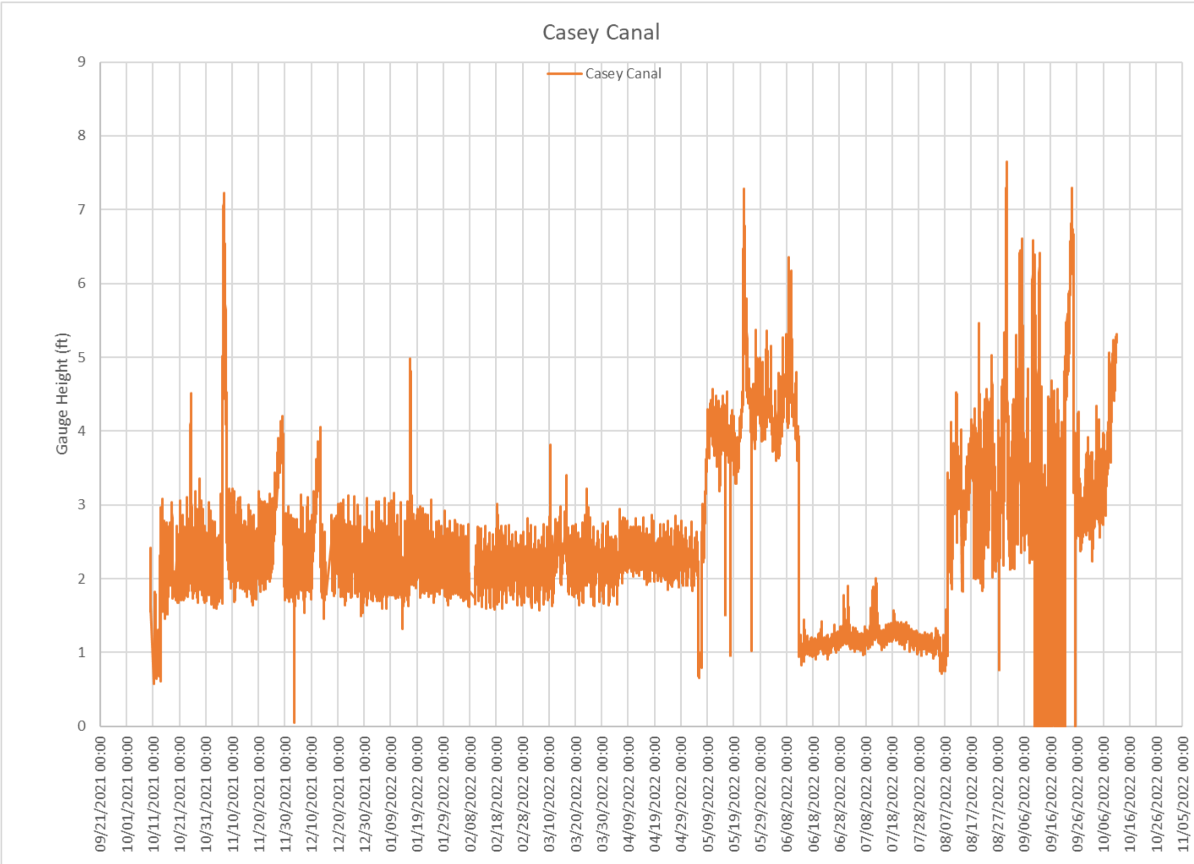


Figure D. Depth at Casey Canal

Salinity

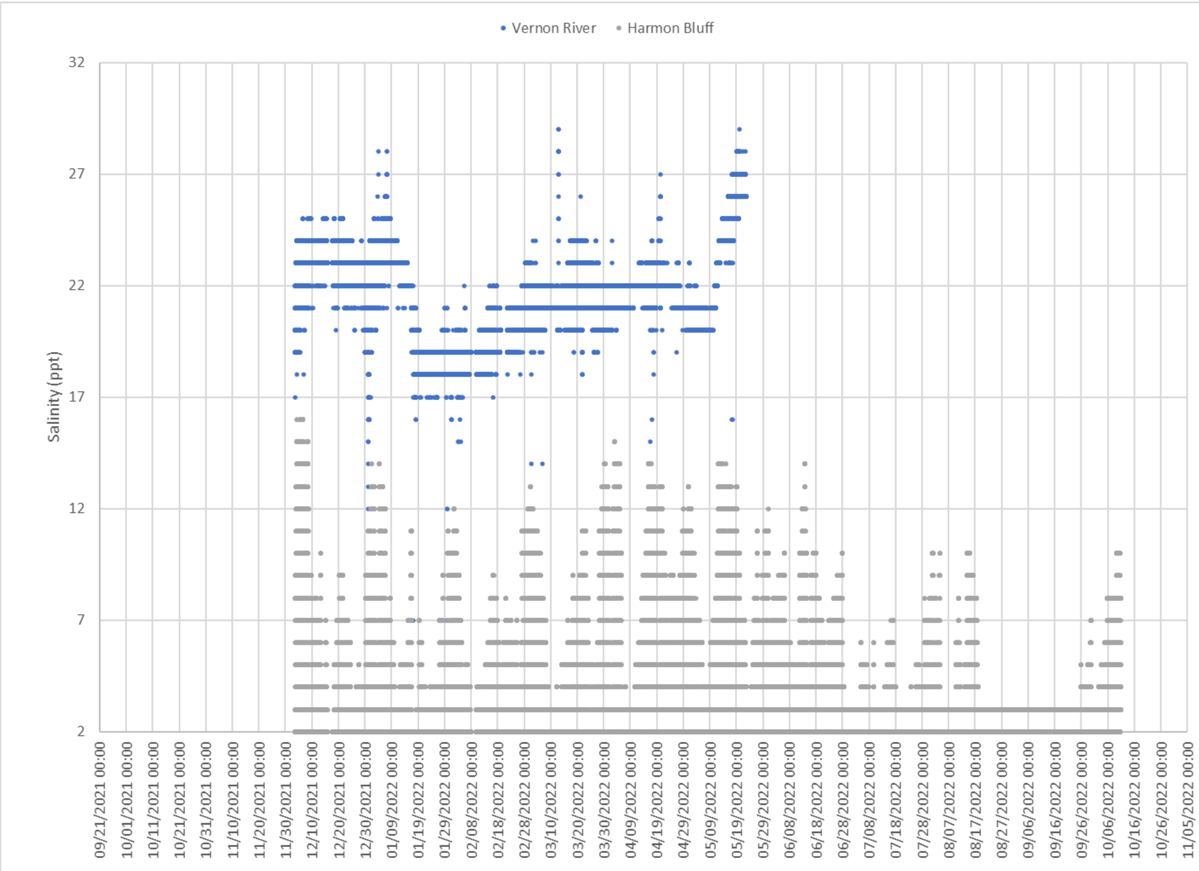


Figure E. Salinity at Two of the Monitoring Stations

Results

`Calibration Results

Vernonburg Station

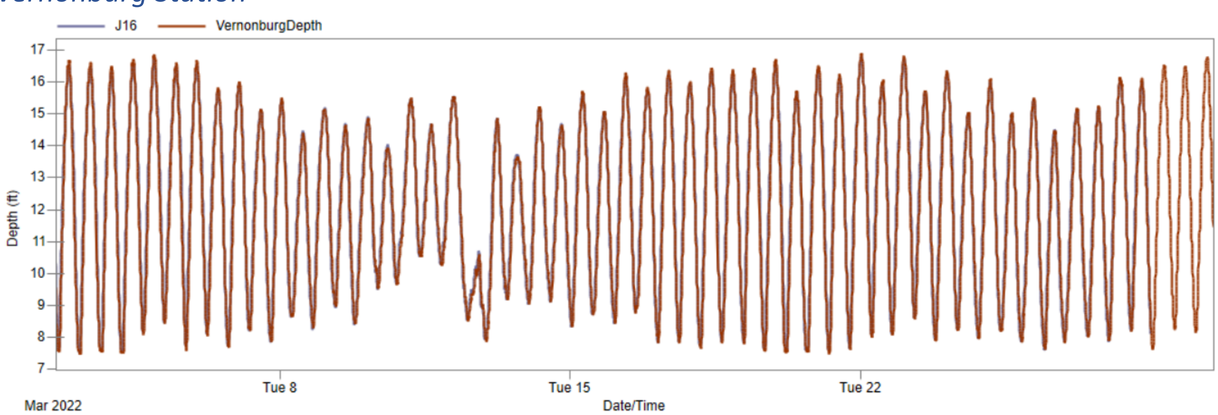


Figure F. Low Resolution Calibration at Vernonburg (Red – Measured, Grey-Modeled)

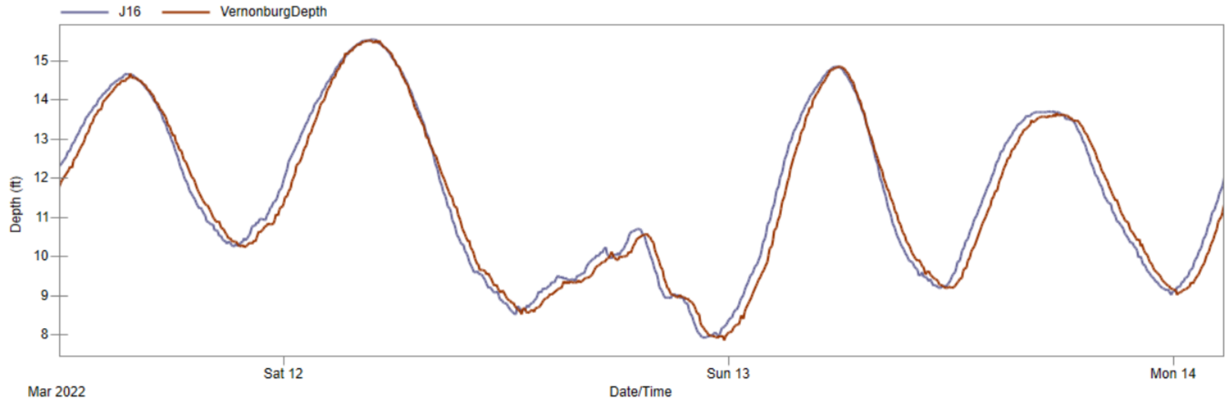


Figure G. High Resolution Calibration at Vernonburg (Red – Measured, Grey-Modeled)

Figure H. Salinity Calibration at Vernonburg to be added

Harmon Bluff Station

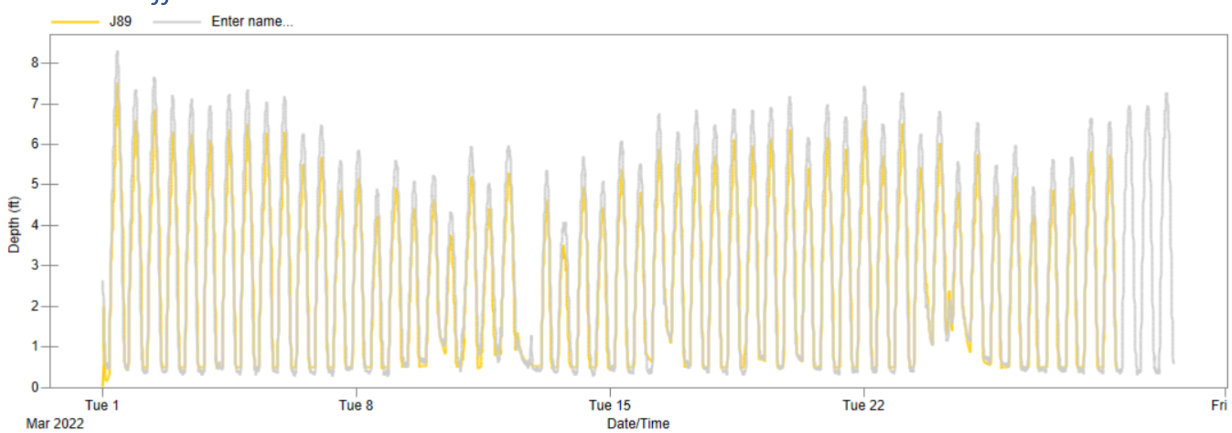


Figure I. Low Resolution Calibration at Harmon Bluff (Yellow– Measured, Grey-Modeled)

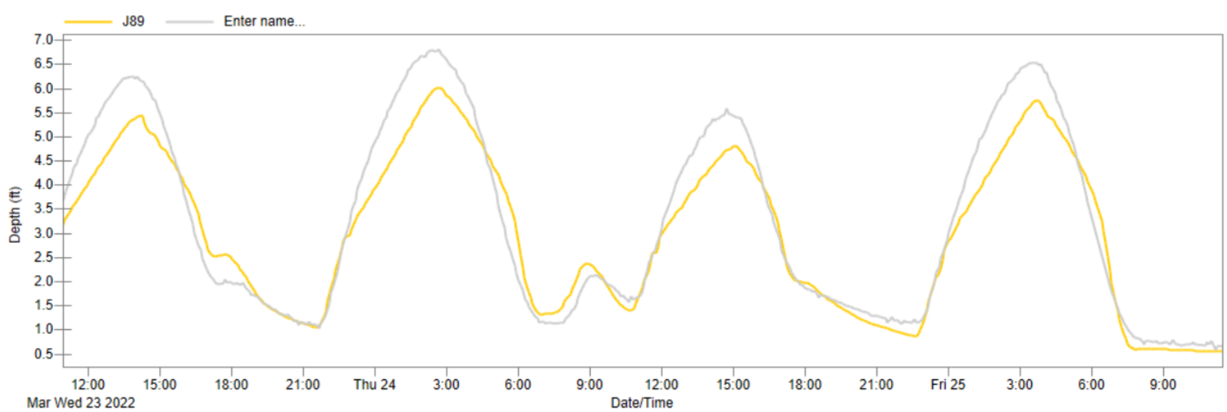


Figure J. High Resolution Calibration at Harmon Bluff (Yellow– Measured, Grey-Modeled)

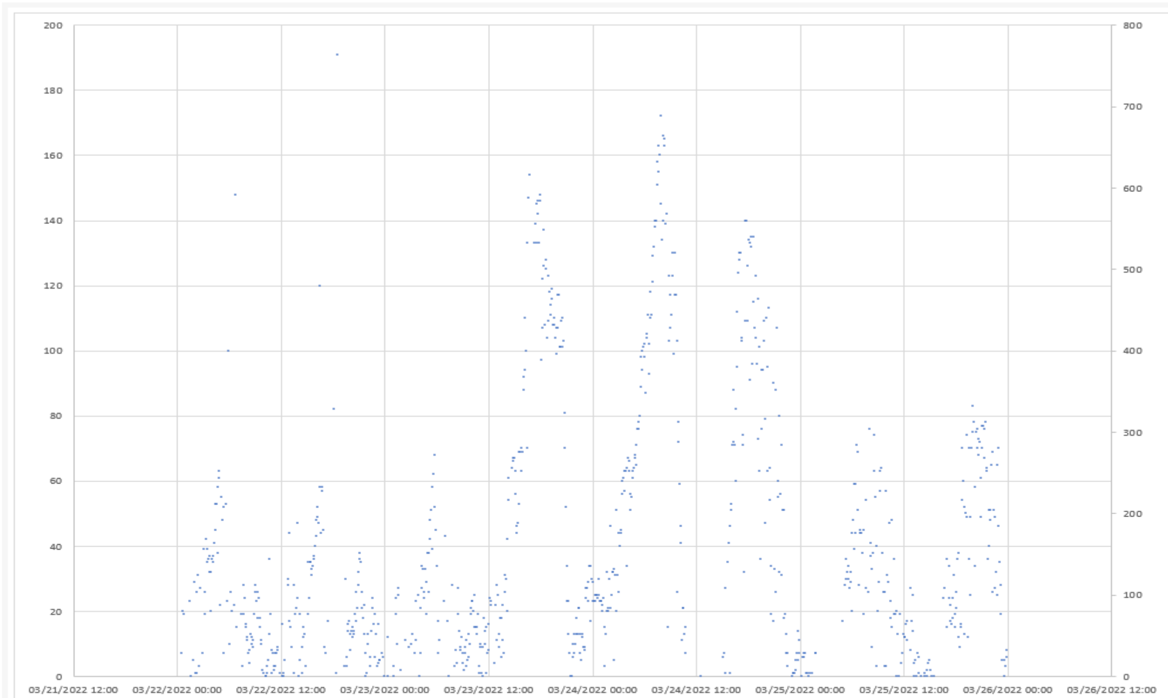


Figure K. Velocity Calibration at Harmon Bluff – Measured Velocity in hundredths of fps

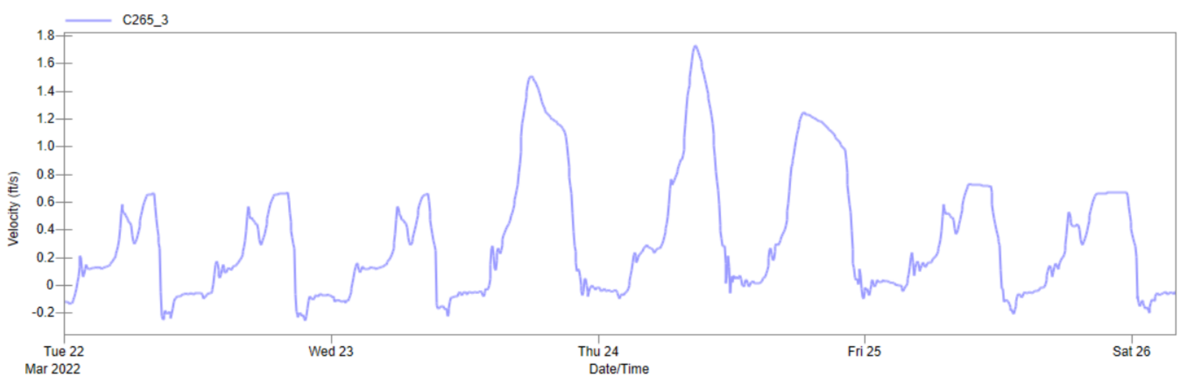


Figure L. Velocity Calibration at Harmon Bluff – Modeled Velocity in fps

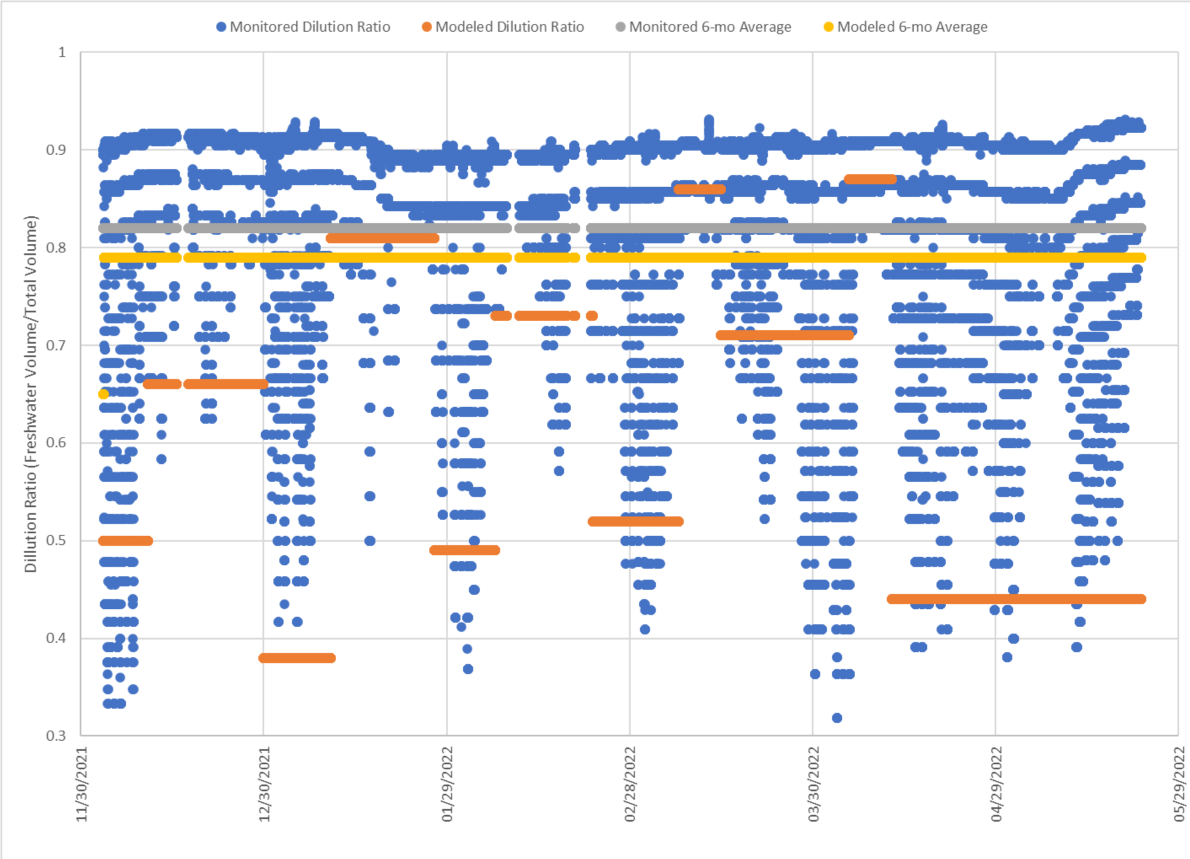


Figure M. Salinity Calibration at Harmon Bluff. Monitored dilution from salinity, modeled dilution from hydrology. Modeled values averaged over indicated intervals.

Casey Canal Station at Agonic Road

This calibration was difficult based on the ability to model baseflow accurately with the stormwater pump settings. While the timing of on and off cycles were not precise, care was taken to make sure that the magnitude and duration of individual pump cycles was accurate and that rain event pump cycles were accurate.

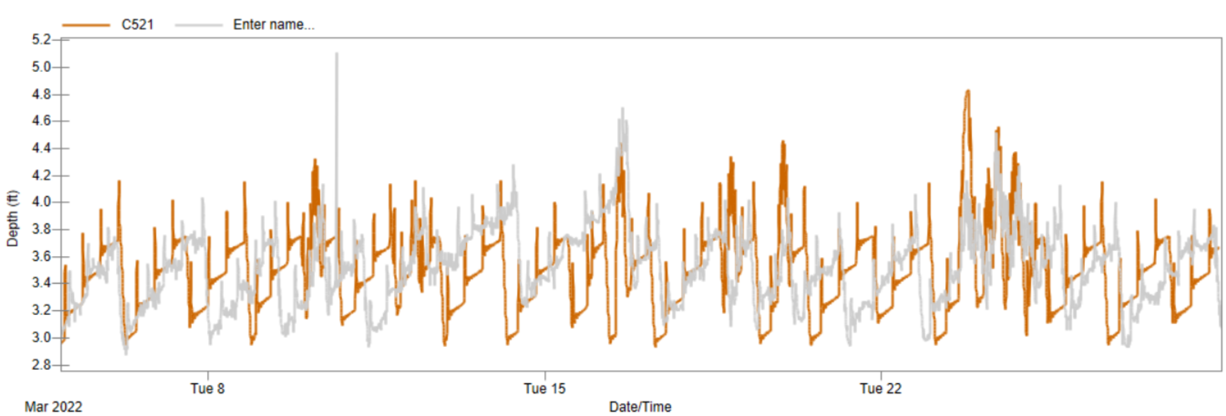


Figure N. Low Resolution Calibration at Casey Canal (Orange– Measured, Grey-Modeled)

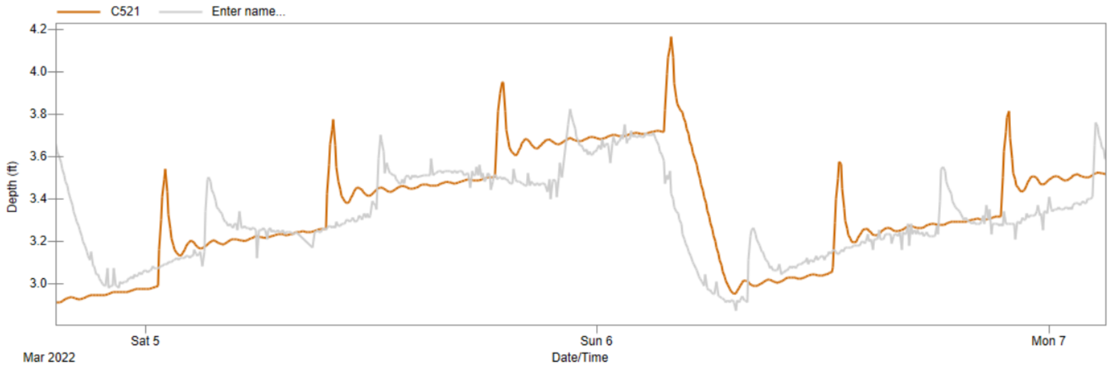


Figure O. High Resolution Calibration at Casey Canal (Orange – Measured, Grey-Modeled)

Annual Flows, Dilution, and Freshwater Flow %

This charge provides the A\annual flow totals dilution Ratios, and percent of total freshwater flow for the system. This is based on the monitoring data collected from Oct 2021 to Oct 2022. Percent of total freshwater flow indicates the percentage of the total annual freshwater flow from the system that flowed past that station.

Site	Total Volume (MG)	Freshwater Volume (MG)	Contributing Acres	Analysis Dilution Ratio***	Hydraulic Dillution Ratio/ % Freshwater	% of Total Freshwater
Casey.10E	73	73	60	1.00	1.00	0.5%
Casey.11E	208	208	132	1.00	1.00	1.4%
Casey.1E	33	33	46	1.00	1.00	0.2%
Casey.1U	503	503	370	1.00	1.00	3.5%
Casey.1W	539	539	398	1.00	1.00	3.7%
Casey.2D	1930	1930	1410	1.00	1.00	13.3%
Casey.2E	10	10	5	1.00	1.00	0.1%
Casey.2W	291	291	228	1.00	1.00	2.0%
Casey.3D	2250	2250	1659	1.00	1.00	15.5%
Casey.3E	25	25	21	1.00	1.00	0.2%
Casey.3W	24	24	20	1.00	1.00	0.2%
Casey.4D	1154	1154	2114	1.00	1.00	7.9%
Casey.4E	15	15	9	1.00	1.00	0.1%
Casey.4W	726	726	494	1.00	1.00	5.0%
Casey.5E	7	7	6	1.00	1.00	0.0%
Casey.5W	162	162	141	1.00	1.00	1.1%
Casey.6E	29	29	31	1.00	1.00	0.2%
Casey.6W	302	302	220	1.00	1.00	2.1%
Casey.7E	25	25	28	1.00	1.00	0.2%
Casey.8E	73	73	86	1.00	1.00	0.5%
Casey.9E	77	77	70	1.00	1.00	0.5%
Casey.Delesseps	2250	2250	1410	1.00	1.00	15.5%
Casey.Hospital	2850	2850	2114	1.00	1.00	19.6%
Casey.Sallie	7400	7400	5972	1.00	1.00	50.8%
Coffee.Arlington	69	69	91	1.00	1.00	0.5%
Coffee.Golf	35	35	47	1.00	1.00	0.2%
Coffee.Largo	36	36	66	1.00	1.00	0.2%
Coffee.LS18	17	17	20	1.00	1.00	0.1%
Coffee.Plantation	233	233	258	1.00	1.00	1.6%
Coffee.Stillwood	162	162	200	1.00	1.00	1.1%
Habersham.Agonic	1700	1700	1348	1.00	1.00	11.7%
Habersham.Habersham	865	865	618	1.00	1.00	5.9%
Habersham.Heard	1140	1140	847	1.00	1.00	7.8%
Habersham.Waters	1300	1300	980	1.00	1.00	8.9%
Harmon.1	185	185	104	1.00	1.00	1.3%
Harmon.2	396	396	249	1.00	1.00	2.7%
Harmon.3	560	560	344	1.00	1.00	3.8%
Harmon.4A	343	343	210	1.00	1.00	2.4%
Harmon.5	965	965	606	1.00	1.00	6.6%
Harmon.6	1062	1062	681	1.00	1.00	7.3%
Harmon.6.5	1430	1430	1115	1.00	1.00	9.8%
Harmon.7	2490	2057	1533	**	0.83	14.1%
Harmon.8	6000	3170	2260	0.65	0.53	21.8%
Harmon.9	8760	3275	2354	0.50	0.37	22.5%
Harmon.Edgewater	2125	2012	1495	0.95	0.95	13.8%
Hayners.Mont	11500	8100	6597	0.65	0.70	55.6%
Hayners.Halcyon	*	*	73	0.32	*	*
Hayners.Waters	15536	8260	6730	0.65	0.53	56.7%
Holland.DitchE	16	16	27	1.00	1.00	0.1%
Holland.DitchW	37	37	87	1.00	1.00	0.3%
Holland.TalinaN	18	18	24	1.00	1.00	0.1%
Holland.TalinaS	135	135	157	1.00	1.00	0.9%
Holland.White	172	172	193	1.00	1.00	1.2%
Holland.Woodley	83	83	104	1.00	1.00	0.6%
Vernon.Bougainvillea	4952	1550	1238	0.40	0.31	10.6%
Vernon.Rendant	39900	2000	1680	0.10	0.05	13.7%
Vernon.Truman	162800	10900	3090	0.10	0.07	74.9%
Vernon.Vernonburg	1092800	13350	4770	0.03	0.01	91.7%
Vernon.VernonburgDitch	47	47	107	1.00	1.00	0.3%
Vernon.WhiteBluffDitch	54	54	109	1.00	1.00	0.4%
Wilshire.Elks	964	964	725	1.00	1.00	6.6%
Wilshire.Largo	507	507	378	1.00	1.00	3.5%
Wilshire.WhiteBluff	2325	1350	1079	0.65	0.58	9.3%

* The model had insufficient information to estimate this value

** This value was not included in historic data to dillute

*** These values were a compromise between salinity and hydraulic data

Figure P. Model output from one year of monitored rainfall data. (Oct 2021-Oct 2022)

Appendix C – Data Analysis Tables

Wet Weather ENT

Site	One Day Volume (M	Contributing Acres	% of Freshwater Discharge	Volume (MG)/acr	Number of Samples	Highest Recorded (MPN/100ml)	Lowest Recorded (MPN/100ml)	Mean (MPN/100n	Rainfall Significance (p-value)	Dilution Ratio	Estimated Saltwater Mean (MPN/100ml)	Estimated Freshwater Mean (MPN/100ml)	Estimated Wet Weather Mas	Estimated mass/acre	Estimated EC Equivalent mass/acre	Potential ENT MPN Contribution at Vernonburg with Dilution
Casey.1U	5.77	370	0.034	0.016	2	6020	4200	5110	IDS	1		5110	1.1E+12	3.0E+09	1.1E+10	5.2
Casey.1W	6.42	398	0.038	0.016	2	11780	3230	7505	IDS	1		7505	1.8E+12	4.6E+09	1.7E+10	8.5
Casey.2D	23.2	1410	0.136	0.016	2	20980	11180	16080	IDS	1		16080	1.4E+13	1.0E+10	3.6E+10	65.4
Casey.2W	3.98	228	0.023	0.017	2	37840	6130	21985	IDS	1		21985	3.3E+12	1.5E+10	5.2E+10	15.4
Casey.4D	34.5	2114	0.202	0.016	2	18500	2850	10675	IDS	1		10675	1.4E+13	6.6E+09	2.4E+10	64.6
Casey.4W	9.4	494	0.055	0.019	2	15150	12340	13745	IDS	1		13745	4.9E+12	9.9E+09	3.6E+10	22.7
Casey.6W	3.57	220	0.021	0.016	2	2590	2460	2525	IDS	1		2525	3.4E+11	1.6E+09	5.6E+09	1.6
Casey.Delesseps	23.2	1410	0.136	0.016	2	324	228	276	NS	1		276	2.4E+11	1.7E+08	6.2E+08	1.1
Casey.Hospital	34.3	2114	0.201	0.016	29	7915	20	1339	6.E-04	1		1339	1.7E+12	8.2E+08	3.0E+09	8.1
Casey.Sallie	78	5972	0.456	0.013	63	17329	10	1016	7.E-06	1		1016	3.0E+12	5.0E+08	1.8E+09	13.9
Harmon 1	2.31	104	0.014	0.022	3	9600	620	6308	IDS	1		6308	5.5E+11	5.3E+09	1.9E+10	2.6
Harmon 2	4.41	249	0.026	0.018	3	10120	3450	7425	NS	1		7425	1.2E+12	5.0E+09	1.8E+10	5.7
Harmon 3	6.64	344	0.039	0.019	3	11120	1100	6592	IDS	1		6592	1.7E+12	4.8E+09	1.7E+10	7.7
Harmon 4A	4.2	210	0.025	0.020	2	2280	750	1515	IDS	1		1515	2.4E+11	1.1E+09	4.1E+09	1.1
Harmon 5	11.7	606	0.068	0.019	3	7915	1210	5252	IDS	1		5252	2.3E+12	3.8E+09	1.4E+10	10.8
Harmon 6	12.6	681	0.074	0.019	3	11450	1190	6979	IDS	1		6979	3.3E+12	4.9E+09	1.8E+10	15.4
Harmon 6.5	9.41	1115	0.055	0.008	2	5730	99	2915	IDS	1		2915	1.0E+12	9.3E+08	3.4E+09	4.8
Harmon 7	16	1533	0.094	0.010	3	8704	410	5771	IDS	1		5771	3.5E+12	2.3E+09	8.2E+09	16.2
Harmon 8	29.6	2260	0.173	0.013	3	8130	1090	5478	IDS	0.65	2588	7035	7.9E+12	3.5E+09	1.3E+10	36.5
Harmon 9	30.8	2354	0.180	0.013	35	30000	0	2588	4.E-04	0.5	400	4775	5.6E+12	2.4E+09	8.5E+09	25.8
Hayners.4	1.1	133	0.006	0.008	2	2022	281	1152	IDS	0.6	400	1653	6.9E+10	5.2E+08	1.9E+09	0.3
Hayners.Halcyon	0.17	73	0.001	0.002	94	12997	10	1141	3.E-07	0.32	400	2715	1.7E+10	2.4E+08	8.6E+08	0.1
Hayners.Mort	82.9	6597	0.485	0.013	32	6867	31	902	2.E-03	0.65	500	1119	3.5E+12	5.3E+08	1.9E+09	16.3
Holland DitchE	0.27	27	0.002	0.010	3	9330	6630	8273	IDS	1		8273	8.5E+10	3.1E+09	1.1E+10	0.4
Holland TalinaN	0.33	24	0.002	0.014	2	14670	1080	7875	IDS	1		7875	9.8E+10	4.1E+09	1.5E+10	0.5
Holland TalinaS	1.26	157	0.007	0.008	2	12360	11450	11905	IDS	1		11905	5.7E+11	3.6E+09	1.3E+10	2.6
Holland Woodley	0.7	104	0.004	0.007	6	79150	237	27015	IDS	1		27015	7.2E+11	6.9E+09	2.5E+10	3.3
Vernon Bougainvillea	12.4	1238	0.073	0.010	45	41060	115	2455	4.E-04	0.4	810	4922	2.3E+12	1.9E+09	6.7E+09	10.7
Vernon Rendant	18	1680	0.105	0.011	30	3318.8	31	810	2.E-03	0.15	61	5052	3.4E+12	2.1E+09	7.4E+09	16.0
Vernon Vernonburg	17.1	4770	1.000	0.036	53	389	0	61	NS (.06)	0.03	35	912	5.9E+12	1.2E+09	4.5E+09	27.4
Vernon VernonburgDitch	0.61	107	0.004	0.006	26	7701	0	1007	NS (.07)	1		1007	2.3E+10	2.2E+08	7.8E+08	0.1
Vernon WhiteBluffDitch	0.77	109	0.005	0.007	26	12033	10	1041	3.E-02	1		1041	3.0E+10	2.8E+08	1.0E+09	0.1
Wilshire Elks	6.92	725	0.040	0.010	50	9606	121	1273	3.E-02	1		1273	3.3E+11	4.6E+08	1.7E+09	1.5
Wilshire Largo	3.48	378	0.020	0.009	19	2022	197	1095	NS	1		1095	1.4E+11	3.8E+08	1.4E+09	0.7
Wilshire WhiteBluff	11.4	1079	0.067	0.011	81	9208	10	1678	3.E-07	0.65	2455	1259	5.4E+11	5.0E+08	1.8E+09	2.5

Wet Weather FC

Site	One Day Volume (M	Contributing Acres	% of Freshwater Discharge	Volume (MG)/acre	Number of Samples	Highest Recorded (MPN/100ml)	Lowest Recorded (MPN/100ml)	Mean (MPN/100m	Rainfall Significance (p-value)	Dilution Ratio	Estimated Saltwater Mean (MPN/100ml)	Estimated Freshwater Mean (MPN/100ml)	Estimated Wet Weather Mass	Estimated mass/acre	Estimated EC Equivalent mass/acre	Potential FC MPN Contribution at Vernonburg with Dilution
Casey.Delesseps	23.2	1410	0.136	0.016	2	3500	700	2100	NS	1		2100	1.8E+12	1.3E+09	8.3E+08	8.5
Casey.Hospital	34.3	2114	0.201	0.016	29	200000	130	12358	3.E-05	1		12358	1.6E+13	7.6E+09	4.8E+09	74.4
Casey.Sallie	78	5972	0.456	0.013	63	200000	9	8168	2.E-05	1		8168	2.4E+13	4.0E+09	2.5E+09	111.8
Coffee.Largo	0.55	66	0.003	0.008	3	22000	310	8237	IDS	1		8237	1.7E+11	2.6E+09	1.6E+09	0.8
Coffee.LS18	0.08	20	0.000	0.004	3	2300	220	1407	NS	1		1407	4.3E+09	2.1E+08	1.3E+08	0.0
Coffee.Plantation	2.18	258	0.013	0.008	5	160000	2400	45260	NS	1		45260	3.7E+12	1.4E+10	9.1E+09	17.3
Harmon.9	30.8	2354	0.180	0.013	2	24000	5400	14700	NS	0.5	476	28924	3.4E+13	1.4E+10	9.0E+09	156.3
Harmon.Edgewater	15.6	1495	0.091	0.010	2	200000	700	100350	NS	0.95	14700	104858	6.2E+13	4.1E+10	2.6E+10	287.0
Hayners.Halcyon	0.17	73	0.001	0.002	63	160000	9	5201	2.E-02	0.32	476	15242	9.8E+10	1.3E+09	8.5E+08	0.5
Vernon.Bougainvillea	12.4	1238	0.073	0.010	48	35000	45	6946	1.E-03	0.4	862	16072	7.6E+12	6.1E+09	3.8E+09	35.0
Vernon.Rendant	18	1680	0.105	0.011	30	4900	20	862	5.E-03	0.15	126	5036	3.4E+12	2.0E+09	1.3E+09	15.9
Vernon.Truman	153	3090	0.895	0.050	2	490	330	410	IDS	0.1	126	2966	1.7E+13	5.6E+09	3.5E+09	79.6
Wilshire.Elks	6.92	725	0.040	0.010	51	54000	20	4258	7.E-03	1		4258	1.1E+12	1.5E+09	9.7E+08	5.2
Wilshire.Largo	3.48	378	0.020	0.009	19	7900	45	1057	NS	1		1057	1.4E+11	3.7E+08	2.3E+08	0.6
Wilshire.WhiteBluff	11.4	1079	0.067	0.011	51	200000	200	27638	2.E-04	0.65	6946	38781	1.7E+13	1.6E+10	9.8E+09	77.6

Wet Weather EC

Site	One Day Volume (M	Contributing Acres	% of Freshwater Discharge	Volume (MG)/acre	Number of Samples	Highest Recorded (MPN/100ml)	Lowest Recorded (MPN/100ml)	Mean (MPN/100m	Rainfall Significance (p-value)	Dilution Ratio	Estimated Saltwater Mean (MPN/100ml)	Estimated Freshwater Mean (MPN/100ml)	Estimated Wet Weather Mass	Estimated mass/acre	Potential EC MPN Contribution at Vernonburg with Dilution
Casey.10E	1.1	60	0.006	0.018	2	2960	2310	2635	IDS	1		2635	1.1E+11	1.8E+09	0.5
Casey.11E	1.69	132	0.010	0.013	2	27230	1310	14270	IDS	1		14270	9.1E+11	6.9E+09	4.2
Casey.12E	•	•	•	•	2	520	300	410	IDS	1		410	•	•	•
Casey.1E	0.31	46	0.002	0.007	2	3370	310	1840	IDS	1		1840	2.2E+10	4.7E+08	0.1
Casey.1U	5.77	370	0.034	0.016	3	7890	840	3277	IDS	1		3277	7.2E+11	1.9E+09	3.3
Casey.1W	6.42	398	0.038	0.016	6	77010	410	16902	IDS	1		16902	4.1E+12	1.0E+10	19.0
Casey.2D	23.2	1410	0.136	0.016	2	27230	6910	17070	IDS	1		17070	1.5E+13	1.1E+10	69.5
Casey.2E	0.13	5	0.001	0.026	2	14550	410	7480	IDS	1		7480	3.7E+10	7.4E+09	0.2
Casey.2W	3.98	228	0.023	0.017	4	6270	2200	4480	IDS	1		4480	6.8E+11	3.0E+09	3.1
Casey.3E	0.38	21	0.002	0.018	2	24890	5880	15385	IDS	1		15385	2.2E+11	1.1E+10	1.0
Casey.3W	0.37	20	0.002	0.019	2	3960	3590	3775	IDS	1		3775	5.3E+10	2.6E+09	0.2
Casey.4D	34.5	2114	0.202	0.016	2	5810	3550	4680	IDS	1		4680	6.1E+12	2.9E+09	28.3
Casey.4E	0.24	9	0.001	0.027	2	4020	200	2110	IDS	1		2110	1.9E+10	2.1E+09	0.1
Casey.4W	9.4	494	0.055	0.019	4	14550	3630	8628	IDS	1		8628	3.1E+12	6.2E+09	14.2
Casey.5E	0.1	6	0.001	0.017	2	2430	410	1420	IDS	1		1420	5.4E+09	9.0E+08	0.0
Casey.5W	1.43	141	0.008	0.010	2	15800	2880	9340	IDS	1		9340	5.1E+11	3.6E+09	2.3
Casey.6E	0.39	31	0.002	0.013	2	3770	520	2145	IDS	1		2145	3.2E+10	1.0E+09	0.1
Casey.6W	3.57	220	0.021	0.016	4	5730	520	3178	IDS	1		3178	4.3E+11	2.0E+09	2.0
Casey.7E	0.34	28	0.002	0.012	2	1460	410	935	IDS	1		935	1.2E+10	4.3E+08	0.1
Casey.8E	0.76	86	0.004	0.009	2	1850	730	1290	IDS	1		1290	3.7E+10	4.3E+08	0.2
Casey.9E	1.17	70	0.007	0.017	2	1320	100	710	IDS	1		710	3.1E+10	4.5E+08	0.1
Coffee.Arlington	0.4	91	0.002	0.004	2	4990	4650	4820	NS	1		4820	7.3E+10	8.0E+08	0.3
Coffee.Golf	0.2	47	0.001	0.004	4	5760	2820	4168	NS	1		4168	3.2E+10	6.7E+08	0.1
Coffee.Plantation	2.18	258	0.013	0.008	3	14210	5040	8183	NS	1		8183	6.8E+11	2.6E+09	3.1
Coffee.Stillwood	1.55	200	0.009	0.008	2	9320	3050	6185	NS	1		6185	3.6E+11	1.8E+09	1.7
Habersham.Agonic	16.2	1348	0.095	0.012	2	7760	1450	4605	IDS	1		4605	2.8E+12	2.1E+09	13.1
Habersham.Habersham	7.95	618	0.046	0.013	3	7330	5380	6317	IDS	1		6317	1.9E+12	3.1E+09	8.8
Habersham.Heard	10.2	847	0.060	0.012	3	7380	2460	4357	IDS	1		4357	1.7E+12	2.0E+09	7.8
Habersham.Waters	12.3	980	0.072	0.013	2	5210	2920	4065	IDS	1		4065	1.9E+12	1.9E+09	8.8
Harmon.1	2.31	104	0.014	0.022	3	5730	1210	3984	NS	1		3984	3.5E+11	3.4E+09	1.6
Harmon.2	4.41	249	0.026	0.018	4	7590	3310	4655	NS	1		4655	7.8E+11	3.1E+09	3.6
Harmon.3	6.64	344	0.039	0.019	3	9850	1090	5396	NS	1		5396	1.4E+12	3.9E+09	6.3
Harmon.4A	4.2	210	0.025	0.020	2	1560	850	1205	NS	1		1205	1.9E+11	9.1E+08	0.9
Harmon.5	11.7	606	0.068	0.019	3	10500	3270	6261	NS	1		6261	2.8E+12	4.6E+09	12.9
Harmon.6	12.6	681	0.074	0.019	3	8290	2430	5404	NS	0.95		5689	2.7E+12	4.0E+09	12.6
Harmon.6.5	9.41	1115	0.055	0.008	2	8500	99	4300	NS	1		4300	1.5E+12	1.4E+09	7.1
Harmon.7	16	1533	0.094	0.010	3	20980	1090	8451	NS	1		8451	5.1E+12	3.3E+09	23.7
Harmon.8	29.6	2260	0.173	0.013	3	10760	1100	5156	NS	0.65	2038	6835	7.7E+12	3.4E+09	35.5
Harmon.9	30.8	2354	0.180	0.013	6	4569	520	2038	NS	0.5	300	3775	4.4E+12	1.9E+09	20.4
Holland.DitchE	0.27	27	0.002	0.010	3	30760	4200	14373	IDS	1		14373	1.5E+11	5.4E+09	0.7
Holland.TalinaN	0.33	24	0.002	0.014	2	1890	300	1095	IDS	1		1095	1.4E+10	5.7E+08	0.1
Holland.TalinaS	1.26	157	0.007	0.008	2	4640	4200	4420	IDS	1		4420	2.1E+11	1.3E+09	1.0
Holland.Woodley	0.7	104	0.004	0.007	8	13960	756.6	4093	IDS	1		4093	1.1E+11	1.0E+09	0.5
Wilshire.WhiteBluff	11.4	1079	0.067	0.011	3	9080	1450	4120	IDS	0.65	4376	3982	1.7E+12	1.6E+09	8.0

Dry Weather ENT

Site	Average Flow (cfs)	One Day Volume (M	Contributing Acr	% of Freshwater Discharg	MG/acre	Number of Sampl	Highest Recorded (MPN/100ml)	Lowest Recorded (MPN/100ml)	Mean (MPN/100ml)	Dilution Ratio	Estimated Saltwater Mean (MPN/100n	Estimated Freshwater Mean (MPN/100ml	Estimated Dry Weather Ma	Estimated mass/acre	Estimated EC Equivalent mass/acre	Potential ENT MPN Contribution at Vernonburg with Dilution
Harmon.2	0.38	0.2455522	249	0.006	0.001	2	12110	5040	8575	1		8575	8.0E+10	3.2E+08	1.2E+09	1.6
Vernon.Rendant	4	2.58476	1680	0.066	0.002	22	1583	20	319	0.15	25	1988	1.9E+11	1.2E+08	4.2E+08	3.9
Harmon.Edgewater	2.25	1.4539275	1495	0.037	0.001	2	1583	1464	1524	0.95	304	1588	8.7E+10	5.9E+07	2.1E+08	1.8
Wilshire.Largo	0.57	0.3683283	378	0.009	0.001	2	2022	757	1390	1		1390	1.9E+10	5.1E+07	1.8E+08	0.4
Wilshire.Elks	1.09	0.7043471	725	0.018	0.001	24	11199	109	1190	1		1190	3.2E+10	4.4E+07	1.6E+08	0.6
Vernon.Bougainvillea	1.9	1.227761	1238	0.031	0.001	26	2406	86	642	0.4	319	1126	5.2E+10	4.2E+07	1.5E+08	1.1
Wilshire.WhiteBluff	1.63	1.0532897	1079	0.027	0.001	66	9804	20	668	0.65	642	682	2.7E+10	2.5E+07	9.1E+07	0.6
Vernon.VernonburgDitch	0.15	0.0969285	107	0.002	0.001	43	9804	0	417	1		417	1.5E+09	1.4E+07	5.2E+07	0.0
Casey.Hospital	3.1	2.003189	2114	0.051	0.001	19	2022.4	5	349	1		349	2.6E+10	1.3E+07	4.5E+07	0.5
Vernon.WhiteBluffDitch	0.15	0.0969285	109	0.002	0.001	41	6131	0	359	1		359	1.3E+09	1.2E+07	4.4E+07	0.0
Vernon.Vernonburg	60.5	39.094495	4770	1.000	0.008	89	144	0	25	0.03	25	35	5.1E+10	1.1E+07	3.9E+07	1.0
Casey.Sallie	10.6	6.849614	5972	0.175	0.001	33	2022.4	10	238	1		238	6.2E+10	1.0E+07	3.7E+07	1.3
Harmon.9	4.1	2.649379	2354	0.068	0.001	39	1850	10	304	0.5	400	208	2.1E+10	8.9E+06	3.2E+07	0.4
Hayners.Halcyon	0.11	0.0710809	73	0.002	0.001	77	1741	10	293	0.32	400	67	1.8E+08	2.5E+06	8.9E+06	0.0
Casey.Delesseps	2.1	1.356999	1410	0.035	0.001	3	109	10	53	1		53	2.7E+09	1.9E+06	7.0E+06	0.1
Hayners.Mont	11	7.10809	6597	0.182	0.001	41	860	20	189	0.65	500	21	5.8E+09	8.8E+05	3.2E+06	0.1

Dry Weather FC

Site	Average Flow (cfs)	One Day Volume (MG)	Contributing Acres	% of Freshwater Discharge	MG/acre	Number of Samples	Highest Recorded (MPN/100ml)	Lowest Recorded (MPN/100ml)	Mean (MPN/100ml)	Dilution Ratio	Estimated Saltwater Mean (MPN/100ml)	Estimated Freshwater Mean (MPN/100ml)	Estimated Dry Weather Mass	Estimated mass/acre	Estimated EC Equivalent mass/acre	Potential FC MPN Contribution at Vernonburg with Dilution
Casey.Delesseps	2.1	1.356999	1410	0.035	0.001	3	110	45	67	1		67	3.4E+09	2.4E+06	1.5E+06	0.1
Casey.Hospital	3.1	2.003189	2114	0.051	0.001	19	2200	9	590	1		590	4.5E+10	2.1E+07	1.3E+07	0.9
Casey.Sallie	10.6	6.849614	5972	0.175	0.001	33	1700	9	185	1		185	4.8E+10	8.0E+06	5.1E+06	1.0
Coffee.LS18	0.03	0.0193857	20	0.000	0.001	2	130	18	74	1		74	5.4E+07	2.7E+06	1.7E+06	0.0
Coffee.Plantation	0.39	0.2520141	258	0.006	0.001	3	160000	2300	62100	1		62100	5.9E+11	2.3E+09	1.4E+09	12.0
Harmon.9	4.1	2.649379	2354	0.068	0.001	3	17000	2100	7167	0.5	476	13857	1.4E+12	5.9E+08	3.7E+08	28.2
Harmon.Edgewater	2.25	1.4539275	1495	0.037	0.001	2	4900	1700	3300	0.95	953	3424	1.9E+11	1.3E+08	7.9E+07	3.8
Hayners.Halcyon	0.11	0.0710809	73	0.002	0.001	36	4900	9	675	0.32	476	1097	3.0E+09	4.0E+07	2.6E+07	0.1
Vernon.Bougainvillea	1.9	1.227761	1238	0.031	0.001	26	4900	18	1118	0.4	1823	61	2.8E+09	2.3E+06	1.4E+06	0.1
Vernon.Rendant	4	2.58476	1680	0.066	0.002	22	1700	9	325	0.15	476	-531	-5.2E+10	-3.1E+07	-1.9E+07	-1.1
Wilshire.Elks	1.09	0.7043471	725	0.018	0.001	24	17000	40	1546	1		1546	4.1E+10	5.7E+07	3.6E+07	0.8
Wilshire.Largo	0.57	0.3683283	378	0.009	0.001	2	2400	490	1445	1		1445	2.0E+10	5.3E+07	3.4E+07	0.4
Wilshire.WhiteBluff	1.63	1.0532897	1079	0.027	0.001	29	54000	18	3397	0.65	533	4939	2.0E+11	1.8E+08	1.2E+08	4.0

Dry Weather EC

Site	Average Flow (cfs)	One Day Volume (M	Contributing Acr	% of Freshwater Discharg	MG/acre	Number of Sampl	Highest Recorded (MPN/100ml)	Lowest Recorded (MPN/100ml)	Mean (MPN/100ml)	Dilution Ratio	Estimated Saltwater Mean (MPN/100n	Estimated Freshwater Mean (MPN/100ml	Estimated Dry Weather Ma	Estimated mass/acre	Potential EC MPN Contribution at Vernonburg with Dilution
Coffee.Plantation	0.39	0.2520141	258	0.006	0.001	4	241960	2010	63818	1		63818	6.1E+11	2.4E+09	12.3
Coffee.Arlington	0.14	0.0904666	91	0.002	0.001	4	241960	200	61340	1		61340	2.1E+11	2.3E+09	4.3
Coffee.Stillwood	0.3	0.193857	200	0.005	0.001	4	241960	1990	62468	1		62468	4.6E+11	2.3E+09	9.3
Casey.1W	0.6	0.387714	398	0.010	0.001	3	410	200	303	1		303	4.5E+09	1.1E+07	0.1
Harmon.2	0.38	0.2455522	249	0.006	0.001	4	51270	1890	15417	1		15417	1.4E+11	5.8E+08	2.9
Habersham.Habersham	1.27	0.8206613	618	0.021	0.001	2	7330	5380	6355	1		6355	2.0E+11	3.2E+08	4.0
Harmon.5	0.92	0.5944948	606	0.015	0.001	3	7710	1986.3	4275	1		4275	9.6E+10	1.6E+08	2.0
Harmon.4A	0.32	0.2067808	210	0.005	0.001	2	7440	488.4	3964	1		3964	3.1E+10	1.5E+08	0.6
Harmon.6	1.03	0.6655757	681	0.017	0.001	3	3550	980	1981	1		1981	5.0E+10	7.3E+07	1.0
Coffee.Golf	0.07	0.0452333	47	0.001	0.001	3	3500	200	1717	1		1717	2.9E+09	6.3E+07	0.1
Harmon.7	2.31	1.4926989	1533	0.038	0.001	2	1210	1060	1135	1		1135	6.4E+10	4.2E+07	1.3
Harmon.8	3.55	2.2939745	2260	0.059	0.001	2	1340	31.1	686	0.65	479	797	6.9E+10	3.1E+07	1.4
Harmon.9	4.1	2.649379	2354	0.068	0.001	2	630	328.2	479	0.5	300	658	6.6E+10	2.8E+07	1.3
Harmon.1	0.16	0.1033904	104	0.003	0.001	3	980	275.5	669	1		669	2.6E+09	2.5E+07	0.1
Harmon.3	0.52	0.3360188	344	0.009	0.001	3	980	307.6	533	1		533	6.8E+09	2.0E+07	0.1

Appendix D – Guidance for Implementing a Public Education Process to Address Pathogen Impaired Streams within a 319h Grant

Guidance for Implementing a Public Education Process to Address Pathogen Impaired Streams within a 319h Grant

Developed by Southeastern Natural Sciences Academy in collaboration with GAEPD and the Augusta-Richmond County Engineering Department; September 2013

1. **Educational Program Goals** – This guidance is intended to help communities put together a customized education program for their unique situation that will address issues related to pathogen impairment in streams. We use three particular issues here in order to exemplify the educational approach. Perhaps your situation calls for other educational goals, but we hope that much of the material covered will still be helpful.

   1.1. **Septic System Maintenance and Inspections –** While people often look at municipal wastewater treatment plants as potential entry points for pathogen impairment in streams, there are also thousands of tiny wastewater treatment plants dotted all over the landscape that, if failing, could be contributing significantly to water quality degradation. We are referring to septic systems. Really, the large municipal systems are just an extension of everyone who sends waste to them anyway; they significantly decrease the potential impact of these wastes on the environment, and they are typically monitored much more closely than septic systems. When a septic system is installed and maintained properly it can be extremely effective at preventing illness and water quality detriments. But, if a system is not being maintained, has been damaged, or is not used appropriately, it can begin to leach untreated waste to the surface causing fouls smells, exposing people to raw waste, and allowing polluted runoff into streams. Also, even properly maintained systems that were installed improperly, or into improper soils, might be causing problems with no visual indications or foul smells whatsoever. In either case, it is important to educate the public about the great responsibility that comes with being the caretaker of their own wastewater treatment plant. They need to know the potential effects that failing to take responsible care of it can have on their neighbors and on the broader community.

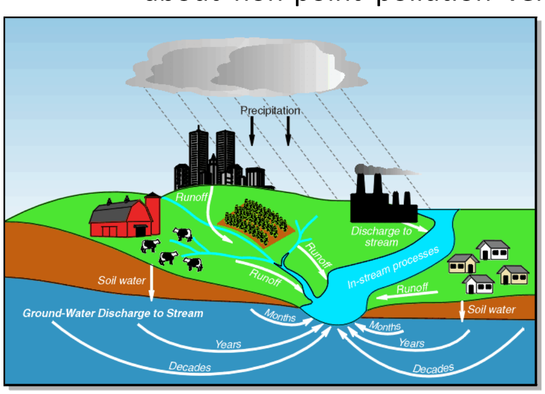
> "...it is important to educate the public about the great responsibility it is to be the caretaker of their own wastewater treatment plant ..."

   1.2. **Pet Waste Management –** It often seems that when it comes to pet waste, most people fall into one of two categories. They are either a crusader for proper pet waste

disposal who thinks that it is solely responsible for most water quality and sanitation problems or someone who wonders why in the world so much attention is paid to something that would seem to have such a minimal impact to water quality. Perhaps it is this kind of dividedness that leads to the rather poor overall acceptance that we see for pet waste management methods. Our local survey indicates that only about 50% of pet owners consistently pick up waste and that educational programming may not improve this much. For society to collectively do enough good on this issue, it is probably important to bring some information into the mix to help people coalesce around a more reasonable understanding and use facts to prioritize the behaviors with the greatest potential harm. Then we can determine what steps a majority of pet owners would be willing to take to decrease the contribution their pets may be making to the pathogen amounts in streams without sacrificing all convenience or dignity. Another big disconnect that we see in this issue is where behaviors are driven largely around aesthetics as opposed to water quality benefit. We have found that some people will pick up pet waste in public, never at home, and think they are fulfilling the ideals of pet waste management. Perhaps this is because the issue is often presented solely as an aesthetic concern for public spaces, which ignores the water quality issue. However, it is entirely possible that water quality is impacted more by pet waste management at home than management in public spaces. It may be necessary to shift our mentality on pet waste education more toward where it has been for some time on recycling, that best practice begins at home.

"Our surveys indicate that only about 50% of pet owners pick up waste anywhere."

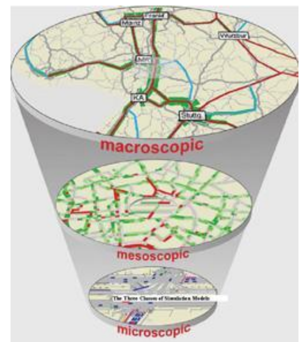
1.3. Storm Drainage System Fundamentals and Protection – We can't educate people about non-point pollution very well without starting from a basic understanding of stormwater drainage and watersheds. Doing so would be like trying to teach Shakespeare without first having a basic grasp of English. So, we have to take time, back up, and start with an understanding of basic watershed science. Some folks, maybe of older generations that were more intimately connected to the land, already know where the rain goes after it falls. But as we have become increasingly disconnected from our environment, many people need to create a framework of understanding in their minds before we can overlay information about how pathogens get into the streams and cause problems. Our



approach to creating this framework is to ask two simple questions regarding the water in streams. First, where did the water come from? Second, where does the water go? Answering and discussing these questions should provide enough watershed science foundation for most people to then conceptualize pathogen contamination. There is also a great deal of helpful guidance and materials for storm drainage fundamentals and for water science in general at the USGS Water Science School (ga.water.usgs.gov/edu/). Specifically, look at the water cycle and surface water topics for the most relevant information.

"Streams drain the rain and pick up stuff along the way, so whatever we put on the ground might be in the stream someday. Now they can handle some stuff but too much and their through; critters won't survive there and it's unhealthy for me and you."

2. **Targeting and Micro-targeting for the Audience** – Often the analysis that accompanies stream impairment is conducted only at a broad scale, which means that management practices must be implemented on a broad scale. This is probably most often the case when the management practice is educational programing. Programs on topics such as septic maintenance or pet waste disposal are applied with a broad brush. For instance, pet waste disposal signs might be placed in parks and public service announcements made on septic site maintenance. There are a couple potential problems with this approach. But first, let's back up to the assumption that drives the approach.
    2.1. **Where Educational Programing can be Optimized** – Oftentimes, we find that prior water quality assessment activities were done at a scale that is only able to indicate generalized problems over a general area, but this is likely not the true nature of the impairment. In reality, there are often several different problems contributing that are each concentrated in particular areas. Therefore, broad brush solutions may waste scarce resources in areas where even effective education won't benefit the stream. Secondly, since the educational campaigns are used over such a broad demographic, they can't be crafted to have the best chance of changing behavior in places where change is critically needed. So where we need to go from here?



    2.2. **How to Optimize Program Efforts** – The answer is micro-targeting and the political world is way out ahead of us. Instead of sticking to a particular track of generalized campaigning that might have varying appeal depending on the demographic, campaigns tailor specific messages to specific demographics in order to gather the most support cumulatively. We believe this model can transfer effectively to what we are trying to do with public education in water resources. After all, both are, in essence, behavior modification through education. In both cases, the first step is data mining or additional data collection to: (a) determine what behavioral change is needed in which areas and; (b) tailor the message for that issue to the demographics of that area. Specifically in the water resource world, we might find that one particular segment of the stream is impaired by several, older malfunctioning septic systems located near the stream in an urban area while another segment of the stream has a high density of dog owners with fenced backyards near the stream in an area of newer construction. Furthermore, we might gather some information about the demographic of the individuals that live in the particular neighborhoods. Then, we can tailor one educational message that will likely

> "...broad brush solutions will often waste scarce resources in areas where even effective education won't benefit the stream."

be well received by the demographic for septic maintenance and a separate message for the pet waste location. We can then target the particular issues that are most likely to be of benefit to the stream and concentrate our efforts toward getting the message out to just the folks in those critical neighborhoods. Yes, that message could influence behavior of a larger group of the community if presented more broadly, but if it doesn't help the stream then it is not a good use of program resources. In the end, we might message less than 10% of the watershed's population, but if it was the right 10% then the resources were better spent on a more effective message with a better chance of success for the stream. This approach might also be compared to the analytical strategy of managing a professional baseball team used by Oakland Athletics general manager Billy Beane and famously portrayed in the movie *Moneyball*. Like his focus on science and statistics instead of conventional wisdom and superstars, we want to focus in on getting the most pathogen reduction for our dollar, cumulatively. That might means forgoing one large and media-friendly educational program for a combination of smaller messages cobbled together across several specific geographical areas.

3. **Multi-sensory Educational Experiences –** I don't know about you but I believe that I have been almost "brochure-ed" and "flier-ed" to death. I even remember a time when I had been tasked with distributing a flier for a volunteer organization and I had become so jaded to the casual response that I started saying tongue-in-cheek to passersby, "Will you please throw this flier away for me!"

    3.1. **The Goal of the Message -** We must admit that a well-crafted written message can be of some value for communicating information; otherwise, this document is a waste of time. However, it is probably safe to say that only those who are most patient, least busy, and most receptive to the issue are likely to benefit from wordy wisdom. These might be the people that are most likely to join an organization, but that isn't really the goal of most public education messages. Our goal is not to inspire 5% of the audience to rearrange their life, but to inspire 95% of the people just enough to take responsibility for one less-than-exciting task.

    3.2. **The Method of the Message –** Studies of how we learn have found that there are several distinct learning modes. We all possess some mixture of them and different people tend to have different learning modes that are most effective for them. While some people are more auditory in learning, some are more visual, more kinesthetic, more tactile, and so on. Now, if our goal is to reach the most people possible with a message that is likely to influence their behavior in some small way, but do so even if our audience is a tired, busy, less-than-patient, and mostly auditory learner, then a flier is probably not our best option. Instead, we need to bring a

range of educational experiences to the table to best reach a range of people. We have suggested a few strategies below that cover different categories, but don't just use our ideas. Instead, reach for what makes the most sense for your situation.

3.2.1. **Posters –** This is a relatively low-cost media that can potentially reach a lot of people. Good designs could involve multiple avenues of visual learning, including written word, diagrams, pictures, and flow charts. Posters are also a way to capture an audience that has just a brief moment to absorb a small amount of information. A good poster can be compelling and reach us in a way that can bypass reasoning and go straight to instinct. In addition to water quality, this method can also be a suitable way to get the fundamental ideas of stormwater drainage across.

3.2.2. **Creek Walks –** Culturally, we have become much less connected to the land and water outside our backdoor than were prior generations by necessity. In order to reconnect, we need to get out there and physically spend time in these environments. We can then absorb information in a way that simply cannot be achieved from a brochure or a video. We can see, touch, hear, and experience the entire picture put together all around us. This type of experience is excellent for a tactile or kinesthetic learner. It is also a great platform for learning storm drainage fundamentals, especially if it rains!

3.2.3. **Socials –** We are, for the most part, social creatures, and most of us will be more likely to attend a social event than a lecture. Now we are not suggesting a bait-and-switch, but a real social that gives an opportunity for conversation and connection. Water resources issues are, at their core, social issues. We likely cannot and will not make the connections that help us care about where our waste goes if we aren't looking around at others. So a social event that brings people together to talk about shared resources can set the perfect context for the kind of message that we have to deliver. Then, it can be delivered in a pleasant, conversational way that asks for feedback and discussion. This is likely going to appeal most to a demographic that already does these types of activities and will work well with the auditory and also the kinesthetic learner.

3.2.4. **Targeted Mailers –** When a message needs to be in word form, you can still optimize the effort. Target the recipients and content of the message with mailers that are directed to critical neighborhoods for a particular issue, such as septic maintenance. This method will also get the educational material into their hands while they are at home, potentially with more time to sit down and absorb it.

Another opportunity to optimize written material is to place it in locations where you have a captive and bored audience. Examples might include a driver's license office or medical waiting room. These options will likely work best for visual learners, but most of us have had to learn to tolerate some information intake by way of reading. The targeted mailer can also be used primarily for something other than education, such as an invitation to a separate educational event.

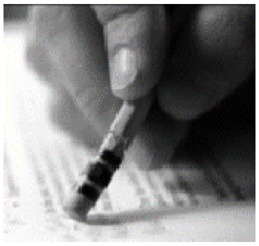
3.2.5. School Programs – Even busy people take time to know what their kids are doing. Our organization has been doing primary school educational programing for

years and we have found that it can be a great way to reach both children and adults with educational messages about water quality issues. This type of programming can be geared to a wide range of learning styles and we often receive comments that student who do not perform well in the classroom thrive in our teaching environment. Our programing takes place at a nature park where we are able to get students out into streams and wetlands to learn about how then work, what they provide, and how to protect them. This is a great platform for teaching stormwater drainage fundamentals. For older kids, opportunities to engage in data collection and stream assessment activities can be a great opportunity for learning and instilling resource value.

3.2.6. Display Booth – A display booth can be set up at fairs, festivals, and various similar events at scales ranging from neighborhood to county-wide. While the opportunities for this type of presentation will often exceed the scale of a micro-targeted approach to public education, it can sometimes be a good method nonetheless. Compared to creek walks it provides a similar though diminished experience of seeing and touching things that relate to water quality such as aquatic macroinvertebrates, while not requiring the participant to come to a more time-intensive event. This type of activity is inherently multisensory and can appeal to kinesthetic, auditory, tactile, and visual learning styles. It might also be capable of creating just enough interest to point someone toward another type of learning tool, such as a creek walk, brochure, or website.

4. **Measuring Success –** When a new structural BMP is installed, it is relatively easy to measure the concentrations of pollutants in and out and decide whether it is effective. With education as a strategy, there is another layer of measurement needed to verify whether the strategy is working. In addition to monitoring changes in bacterial concentration in the stream, we need to measure whether behaviors are changing as a result of the education. Below are some ideas to do just that but note that with any measurement of the effectiveness of education it is important to specify what the educational experience entailed.

4.1. Survey – Sampling the population you are reaching out to both before and after the education can provide a measure of the efficacy of the educational program. Include carefully constructed questions about the behavior that you are trying to influence and/or the knowledge base you are trying to improve. Surveys can also be a good way to gauge the need for education or its potential efficacy. They can also guide the direction of educational material. For instance, if people already know that dog waste can pollute streams and still don't dispose of it properly, then the educational program may be a waste of money unless you can figure out just the right way to approach it. Probably the most critical aspect of survey development and implementation is to make relatively certain that your sample group is representative of the population and that there is no inherent bias in the survey questions or process. While we don't go into further detail on this topic here, we suggest an NSF article on the subject (http://www.nsf.gov/news/special_reports/survey/index.jsp?id=trust).



4.2. Observation – In some cases you might be able to quantify changes in behavior directly by observation. We have two examples. First, in a local park, you could observe the percentage of people that pick up their dog's waste on the particular morning before and then after an educational program is implemented in that neighborhood. Second, you could ask septic tank pumping companies to record the number of calls that they get from a particular neighborhood over a certain period of time before and after an educational program.

4.3. Voluntary Response – One of the simplest ways to gauge the efficacy of a program at changing behavior is to simply ask people to tell you, often they will! As a part of the educational material presentation, you can ask for some sort of response from the audience if they have found the material helpful and believe they might make different choices now that they have the information. An email or text-message-based response might be easiest, but response cards and phone calls are also possibilities.

5. **Some Things we've learned about Public Education Efforts –** Through our own 319(h) program work and specifically through surveys conducted as a part of that work, we have discovered some information about water quality education that might be of interest to you.

   5.1. **It does stick after all! –** Our survey results indicate that education, in this case a general watershed science and water quality session for teachers of primary school children, reduced "I don't know" responses on the survey by at least half. It also increased the level of concern for various pollutants.

   5.2. **Where's it go? I don't know** – About 25% of our survey respondents had no idea where their wastewater goes beyond the drain.

   5.3. **No, a septic tank doesn't have treads and a turret** – We have found that people are widely uninformed about their septic systems. Fully 1 in 3 survey respondents didn't know they require any service at all.

   5.4. **Poor pet poop progress** – Our survey indicated that overall pet waste disposal behavior in our area is poor, with only 50% of respondents disposing of pet waste properly. Also, the poor behavior may be somewhat intractable, with interest in picking it up increasing only to 60% following the educational program mentioned above.

   5.5. **Would you like fries with that? -** When asked how they would prefer to receive information about water quality and ways to improve water quality our respondents indicated websites, fact sheets, and a one day educational or volunteer experience, in that order.

   5.6. **The stream is being treated horribly but it's still in great shape! –** One of the most interesting and also confusing results from our survey was an apparent disconnect between a high level of concern over various pollutants paired simultaneously with a relatively high assessment of the current health of the stream. Educational programming raised concerns over pollutants even further among respondents but also further increased their impression of water body health. Our only theory to explain this apparent paradox is that the relatively high assessment of stream health is a consequence of the limited proximity most respondents have to the stream and their lack of daily reliance on it. This theory is generally supported by the responses to the question of how often they visit the stream and the uses for which they value it.

   5.7. **Relationships win the day –** Oftentimes efforts at community involvement are derailed by mistrust and misinformation. While this learning extends well beyond public education to many other aspects of water quality initiatives, we have certainly found that the most good is accomplished where relationships with the stakeholders involved are proactively fostered. This involves a range of specific actions to collectively accomplish the goal, including:

- take time for the people involved, hear their concerns, and consider out where their perspective is coming from
- build trust by having a consistent message and honoring commitments
- be willing to give and take to achieve the most good for the watershed
- share data, share resources, share information, share lunch
- provide unbiased, third-party facilitation for group discussions involving multiple stakeholders

6. Sample Materials

6.1. Pet Waste Poster-

6.2. Storm Drainage Fundamentals Poster-

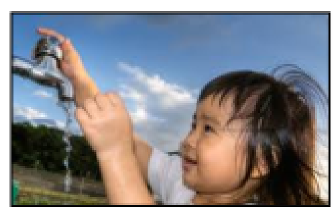
6.3. Septic Maintenance Poster-

You can be a septic system **superhero**! 1-2-3-4

1 - **Use** just a few sheets, so we don't have clogs

2 - **Flush** ONLY toilet paper and waste, no chemicals please

3 - **Turn off** the water, so we don't waste a drop



4 - **Call** an inspector for funny smells or after 5 years

6.4. Creek Walks Learning Modules-

What do you expect of your stream? *Stream ecosystem services* • Direct – provisional and cultural (fishing, drinking, irrigation, recreation) • Indirect – regulatory and supporting (flood mitigation, waste processing, photosynthesis and nutrient cycling) *How do aquatic ecosystems function?* • Water cycle and how it's affected by development • Nutrient cycle with emphasis on eutrophication • Food web and importance of macroinvertebrates	**How is it doing?** *Bioindicators* • Characteristics of good bioindicators • Unique advantages of biomonitoring • Sample zooplankton, macroinvertebrates, amphibians, and fish *Pathogens and bacteria* • General coliforms vs. fecal coliforms vs. E. coli • Sources of contamination and associated health risks • Take bacteriological sample *Abiotic measures* • Measure temperature, DO, pH, conductivity, nutrients, and chloride • Describe what each measure indicates
What's holding it back? *Processes that alter water quality* • Erosion and sedimentation • Temperature changes • Nutrient and chemical application • Waste disposal practices *Physical alterations* • Dams – Impact on flows, temperature, and organic input • Channelization – Impact on flow and risk of extreme events downstream • Development and impervious surfaces – Urban runoff, loss of riparian zones	**How do we fix it?** *Storm water discharge* • Behaviors that generate pollution – Hazardous household waste, landscaping, pest control, car washing, pool discharge, pet waste, soil management, etc. • Methods to reduce pollution – Water conservation, low impact development, best management practices *Septic system* • Causes of malfunction • Care and maintenance *Trash collection*

Appendix E - Soils (https://soilseries.sc.egov.usda.gov/)

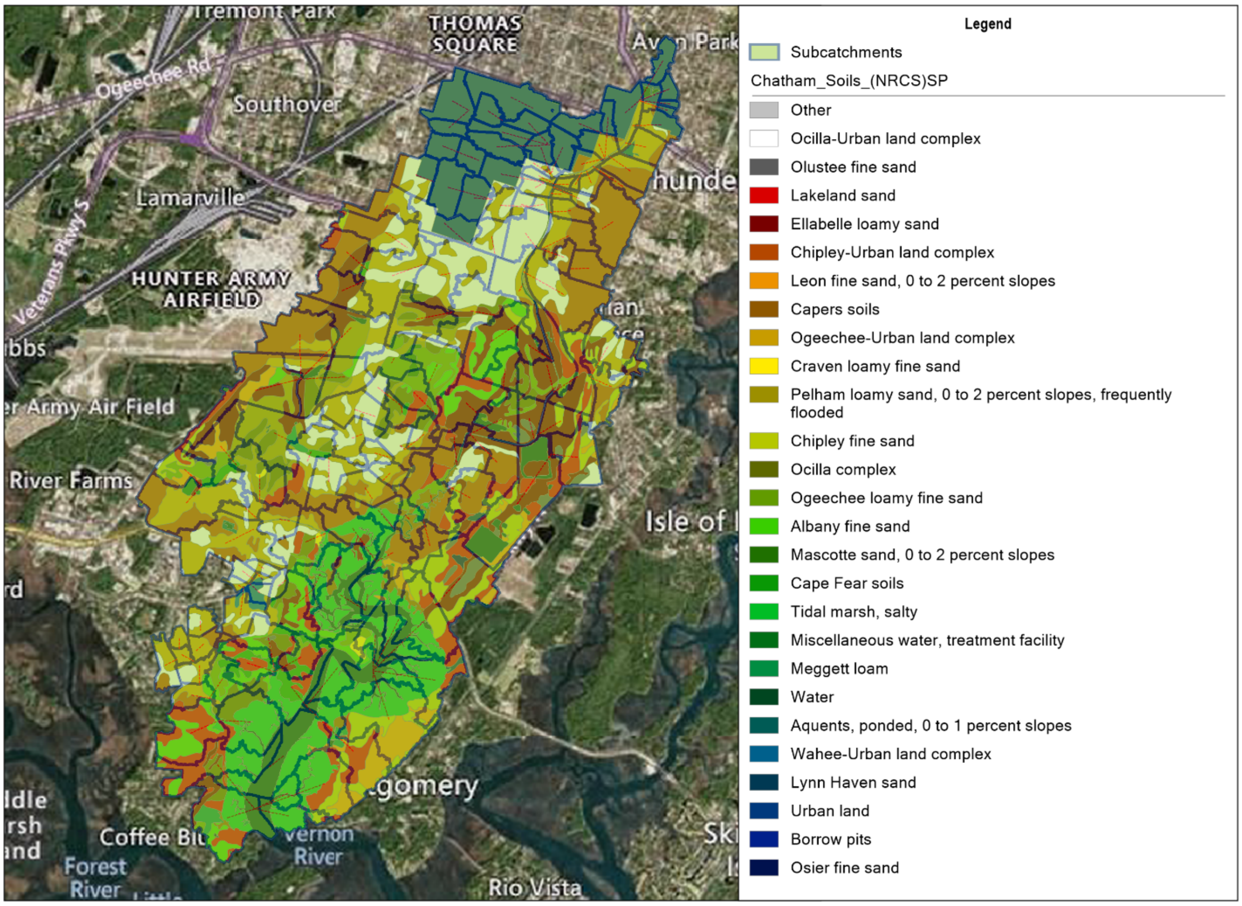


Figure A. Area Soil Map

CHIPLEY SERIES

The Chipley series consists of very deep, somewhat poorly drained, very rapid or rapidly permeable soils on uplands in the lower Coastal Plain. They formed in thick deposits of sandy marine sediments. Near the type location, the mean annual temperature is about 68 degrees F., and the mean annual precipitation is about 55 inches. Slopes range from 0 to 8 percent.

TAXONOMIC CLASS: Thermic, coated Aquic Quartzipsamments

TYPICAL PEDON: Chipley sand--wooded. (Colors are for moist soil.)

A1--0 to 3 inches; very dark gray (10YR 3/1) sand; single grained; loose; many fine roots; strongly acid; gradual smooth boundary.

A2--3 to 6 inches; dark gray (10YR 4/1) sand; single grained; loose; many fine roots;

strongly acid; gradual irregular boundary. (Combined thickness of the A horizons range from 3 to 16 inches.)

C1--6 to 16 inches; light yellowish brown (10YR 6/4) sand; common fine and medium distinct yellowish brown coats and few medium distinct dark gray (10YR 4/1) streaks along the root channels; single grained; loose; few fine roots; strongly acid; gradual irregular boundary. (8 to 13 inches thick)

C2--16 to 32 inches; brownish yellow (10YR 6/6) sand; single grained; loose; few fine roots; common fine and medium faint strong brown (7.5YR 5/6) masses of iron accumulation; few fine faint streaks of light gray (10YR 7/1) iron depletions; strongly acid; gradual wavy boundary. (14 to 24 inches thick)

C3--32 to 55 inches; 34 percent brownish yellow (10YR 6/6), 33 percent light gray (10YR 7/2) and 33 percent strong brown (7.5YR 5/6) sand; single grained; loose; few fine roots; the areas in colors of brownish yellow and strong brown are masses of iron accumulation and the areas in colors of light gray are iron depletions; strongly acid; gradual irregular boundary. (10 to 24 inches thick)

Cg--55 to 77 inches; light gray (10YR 7/2) sand; single grained; loose; very few fine roots; many coarse distinct very pale brown (10YR 7/4) and common medium distinct yellowish brown (10YR 5/6) masses of iron accumulation; strongly acid; gradual smooth boundary.

TYPE LOCATION: Washington County, Florida, approximately 0.75 mile southwest of Greenhead Community, NW1/4, NW1/4, sec. 17, R. 14 W., T. 1 N.

RANGE IN CHARACTERISTICS: Silt plus clay content between depths of 10 and 40 inches is 5 to 10 percent. Reaction ranges from extremely acid to moderately acid in the A horizon except where limed and from very strongly acid to slightly acid in the C horizon.

The A or Ap horizon has hue of 10YR, value of 2 to 5, and chroma of 1 to 3. Where value is 3.5 or less, thickness is less than 10 inches. Texture is sand or fine sand.

The C horizon has hue of 10YR to 5Y, value of 4 to 8, and chroma of 1 to 8. Redoximorphic features in shades of gray, red, brown or yellow range from few to many. Some pedons have a few streaks of gray to light gray uncoated sand grains along root channels in the upper part of the C horizon. Texture is sand or fine sand.

The Cg horizon has hue of 10YR to 5Y, value of 4 to 8, and chroma of 2 or less; or it is neutral with value of 4 to 8. Redoximorphic features in shades of red, brown, yellow or gray range from few to many. Some pedons have a few streaks of gray to light gray uncoated sand grains along root channels in the upper part of the C horizon. Texture is sand or fine sand.

COMPETING SERIES: These include the Kawah, Lotus, and Pactolus series. Kawah soils have some development in the profile. Lotus soils are on flood plains and have buried A horizons. Pactolus soils have 10 to 25 percent silt plus clay in the control section.

GEOGRAPHIC SETTING: Chipley soils are on uplands of the Southern Coastal Plain. They formed in thick sandy marine sediments. Slopes range from 0 to 8 percent. The average annual precipitation ranges from 50 to 60 inches and the average annual temperature ranges from 65 to 70 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These include the Alaga, Albany, Alpin, Foxworth, Lakeland, Kershaw, Leon, Plummer, and Rutlege series. Alaga, Alpin, Lakeland, and Kershaw soils do not have water tables. Albany soils have Bt horizons between depths of 40 to 80 inches. Foxworth soils are moderately well drained to somewhat excessively drained. Leon and Plummer soils are poorly drained and Rutlege soils are very poorly drained. In addition, Leon soils are Spodosols, Plummer soils have Bt horizons between depths of 40 to 80 inches, and Rutlege soils have umbric epipedons.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained; very rapid or rapid permeability.

USE AND VEGETATION: Many areas of Chipley soil have been cleared and are used for cropland, pasture, and hayland. Natural vegetation consists of slash pine, longleaf pine, blackjack oak, turkey oak, post oak, several bluestem species, low panicums, and purple lovegrass.

DISTRIBUTION AND EXTENT: Florida, southeastern Alabama, southern Georgia, eastern North Carolina, and South Carolina. These soils are of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Auburn, Alabama.

SERIES ESTABLISHED: Pitt County, North Carolina; 1969.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from the surface to 6 inches (A1, A2 horizons).

Chipley soils have a seasonal high water table between the depths of 18 to 36 inches for 2 to 4 months during most years.

SOI-5 Soil Name Slope Airtemp FrFr/Seas Precip Elevation
FL0046 CHIPLEY 0-8 65-70 230-310 50-60 30-150

SOI-5 FloodL FloodH Watertable Kind Months Bedrock Hardness
FL0046 None 1.5-3.0 Apparent Dec-Apr >60 N/A

SOI-5 Depth Texture 3-Inch No-10 Clay% CEC
FL0046 0-6 S FS 0-0 100-100 1-5 3-8

FL0046 6-77 S FS 0-0 100-100 1-7 2-3

SOI-5 Depth pH O.M Salin Permeab Shnk-Swll
FL0046 0-6 3.6-6.0 2-5 0-2 >6.0 LOW
FL0046 6-77 4.0-6.5 0-.5 0-2 >6.0 LOW

National Cooperative Soil Survey
U.S.A.

ELLABELLE SERIES

The Ellabelle series consists of deep, very poorly drained soils of Coastal Plain depressions and drains. These soils have black loamy sand A horizons over thick gray sandy clay loam Bt horizons. Slopes are 0 to 2 percent. Near the type location the mean annual temperature is 66 degrees F., and the mean annual precipitation is 49 inches.

TAXONOMIC CLASS: Loamy, siliceous, semiactive, thermic Arenic Umbric Paleaquults

TYPICAL PEDON: Ellabelle loamy sand--forested. (Colors are for moist soil unless otherwise stated.)

A--0 to 27 inches; black (N 2/) loamy sand; weak fine granular structure; very friable; many fine roots; small pockets of uncoated sand grains; strongly acid; clear wavy boundary. (23 to 38 inches thick)

Btg1--27 to 31 inches; gray (10YR 5/1) sandy clay loam; common fine distinct strong brown and dark brown mottles; weak very fine subangular blocky structure; friable; few fine roots; pockets of sandy loam; very strongly acid; gradual wavy boundary. (0 to 10 inches thick)

Btg2--31 to 64 inches; gray (10YR 5/1) sandy clay loam; many fine and medium distinct strong brown (7.5YR 5/6, 5/8) and yellowish brown (10YR 5/6, 5/8) mottles; weak fine subangular blocky structure; friable; common distinct clay films on faces of peds; common fine root channels; very strongly acid; gradual wavy boundary. (20 to 33 inches thick)

Bt--64 to 72 inches; mottled brownish yellow (10YR 6/8), yellowish brown (10YR 5/6), and gray (10YR 5/1) sandy clay loam; weak coarse subangular blocky structure; firm; few faint clay films on faces of peds; very strongly acid.

TYPE LOCATION: Bryan County, Georgia; 0.6 mile northeast of Bryan County high school on Georgia Highway 119, 100 feet west of highway in canal bank.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 70 to 96 inches. Reaction is strongly acid or very strongly acid in all horizons, except where the soil has been limes.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2; or it is neutral with a value of 2. It is loamy fine sand, loamy sand, loamy coarse sand or sand. It has a minimum thickness of 10 inches where the E horizon is present.

The horizon, where present, has hue of 10YR or 2.5Y, value of 4, 5, 6 or 7, and chroma of 1 or 2. It has the same texture as the A horizon.

The Btg1 and Btg2 horizons have hue of 10YR or 2.5Y, value of 4, 5, 6, or 7, and chroma of 1 or 2. Few to common mottles are brownish, yellowish, and grayish. The upper 20 inches of the Bt horizon has 18 to 35 percent clay with less than 20 percent silt. The lower Bt horizon has same colors as above horizons or it is mottled brownish, yellowish and grayish. It is sandy clay loam or sandy clay.

The C horizon has colors and textures like the lower Bt horizon.

COMPETING SERIES: These include the Surrency series of the same family and the Bayboro, Byars, Cape Fear, Hyde, Kanapaha, Kiawah, Pantego, Paxville, Pelham, Plummer, Portsmouth, Riceboro and Wadmalaw series. Bayboro, Byars, and Cape Fear soils have more than 35 percent clay in the control section. Hyde, Pantego and Paxville soils lack sandy epipedons more than 20 inches thick. Kanapaha and Plummer soils are grossarenic. Kanapaha soils have a mean annual soil temperature of more than 72 degrees F. Kiawah and Wadmalaw soils have Bt horizons with base saturation of more than 35 percent. Portsmouth soils have sola less than

40 inches thick. Pelham and Riceboro soils have an ochric epipedon. Surrency soils have 10 to 18 percent clay in the control section.
GEOGRAPHIC SETTING: Ellabelle soils are in depressions and drainageways in the Coastal Plain. Slopes are less than 2 percent. The soil formed in thick beds of medium textured marine and fluvial deposits. Mean annual air temperature is 60 to 70 degrees F., and mean annual precipitation is 45 to 55 inches.
GEOGRAPHICALLY ASSOCIATED SOILS: In addition to the competing Bayboro, Pelham, Plummer, Riceboro and Surrency series, these include the Alapaha, Albany, Johnston, and Ocilla soils. Alapaha, Albany, and Ocilla soils lack umbric epipedons and are better drained than Ellabelle soils. Johnston soils lack Bt horizons.
DRAINAGE AND PERMEABILITY: Very poorly drained. Runoff is ponded or very slow; permeability is moderate. Water table is at or near the surface for more than 5 months each year.
USE AND VEGETATION: Most of the areas are in forest with a small portion in pasture and truck crops. The forest vegetation is chiefly blackgum, cypress, red maple, water oak, willow, with a few pond and slash pines and an undergrowth of fetter bush, southern wax myrtle, and inkberry (gallberry).
DISTRIBUTION AND EXTENT: Coastal Plains from Alabama to Virginia. The series is extensive.
MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Raleigh, North Carolina
SERIES ESTABLISHED: Bryan County, Georgia; 1969.
REMARKS: Diagnostic horizons and features recognized in this pedon are:
Umbric epipedon - the zone from the surface of the soil to about 27 inches with value 2 colors (A horizon).
Arenic epipedon - the zone from the surface to about 27 inches with loamy sand texture (A horizon).
Argillic horizon - the zone from approximately 27 to 72 inches (Btg1, Btg2, and Bt horizons).
TABULAR SERIES DATA:

SOI-5	Soil Name	Slope	Airtemp	FrFr/Seas	Precip	Elevation
GA0044	ELLABELLE	0- 2	60- 70	240-285	45- 55	10- 350
GA0097	ELLABELLE	0- 2	65- 70	230-310	50- 60	120- 155

SOI-5	FloodL	FloodH	Watertable	Kind	Months	Bedrock	Hardness
GA0044	FREQ		0-0.5	APPARENT	NOV-APR	60-60	
GA0097	NONE		-	APPARENT	-	60-60	

SOI-5	Depth	Texture	3-Inch	No-10	Clay%	-CEC-
GA0044	0-27	LS LFS	0- 0	95-100	5-10	3- 7
GA0044	27-64	SCL	0- 0	95-100	18-35	4- 7
GA0044	64-72	SCL SC	0- 0	95-100	20-45	4- 7
GA0097	0- 8	LS LFS	0- 0	95-100	5-10	3- 6
GA0097	0- 8	MK-FS MK-S	0- 0	95-100	2- 8	5- 15
GA0097	8-28	FS S	0- 0	95-100	5-10	3- 6
GA0097	28-48	FSL SL SCL	0- 0	95-100	18-35	5- 20

GA0097 48-80 SCL   0- 0 95-100 22-35   5- 30

SOI-5	Depth	-pH-	O.M.	Salin	Permeab	Shnk-Swll
GA0044	0-27	4.5- 5.5	1.-5.	0- 0	2.0- 6.0	LOW
GA0044	27-64	4.5- 5.5	0.-.5	0- 0	0.6- 2.0	LOW
GA0044	64-72	4.5- 5.5	0.-.5	0- 0	0.2- 2.0	LOW
GA0097	0- 8	3.6- 5.5	1.-5.	0- 2	2.0- 6.0	LOW
GA0097	0- 8	3.6- 5.5	10-20	0- 2	6.0- 20	LOW
GA0097	8-28	3.6- 5.5	.5-1.	0- 2	2.0- 20	LOW
GA0097	28-48	3.6- 5.5	-	0- 2	0.6- 2.0	LOW
GA0097	48-80	3.6- 5.5	-	0- 2	0.2- 0.6	LOW

National Cooperative Soil Survey
U.S.A.

LAKELAND SERIES

The Lakeland series consists of very deep, excessively drained, rapid to very rapidly permeable soils on uplands. They formed in thick beds of eolian or marine and/or fluvio-marine sands in the Southern Coastal Plain MLRA (133A), the Carolina and Georgia Sandhills (MLRA 137), the Eastern Gulf Coast Flatwoods (MLRA 152A) and the Atlantic Coast Flatwoods (MLRA 153A).Near the type location, the mean annual temperature is about 67 degrees F., and the mean annual precipitation is about 52 inches. Slopes are dominantly from 0 to 12 percent but can range to 85 percent in dissected areas.

TAXONOMIC CLASS: Thermic, coated Typic Quartzipsamments

TYPICAL PEDON: Lakeland sand, in a forested area (Colors are for moist soil).

A--0 to 3 inches; very dark grayish brown (10YR 3/2) crushed and rubbed sand; single grain; loose; common uncoated sand grains; common fine and medium roots; strongly acid, clear wavy boundary. (2 to 9 inches thick)

C1--3 to 10 inches; yellowish brown (10YR 5/4) sand; common medium faint yellowish brown (10YR 5/6) mottles; single grain; loose; common fine and medium roots; few uncoated sand grains; strongly acid; gradual wavy boundary.

C2--10 to 43 inches; yellowish brown (10YR 5/8) sand; single grain; loose; few fine roots; few uncoated sand grains; strongly acid; gradual wavy boundary.

C3--43 to 64 inches; yellowish brown (10YR 5/8) sand; few medium faint very pale brown (10YR 7/3) mottles and streaks; single grain; loose; many uncoated sand grains; strongly acid; gradual wavy boundary.

C4--64 to 80 inches; very pale brown (10YR 7/4) sand; single grain; loose; many uncoated sand grains; few medium distinct yellowish red (5YR 5/8) masses of iron accumulation; strongly acid. (Combined thickness of the C horizons ranges from 71 to more than 98 inches)

TYPE LOCATION: Calhoun County, Florida; approximately 6.0 miles west of Chason on Florida State Highway 274; NE1/4, NE1/4, Sec. 3l, T. 2 N., R. l0 W.

RANGE IN CHARACTERISTICS: Thickness of the sand exceeds 80 inches. Silt plus clay in the 10 to 40-inch control section ranges from 5 to 10 percent. Reaction ranges from very strongly acid to moderately acid throughout except where the surface has been limed.

The A or Ap horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of l to 4. Uncoated sand grains with hue of 10YR or 2.5Y, value of 7 or 8, and chroma of 1 or 2 ranges from none to many. Texture is sand or fine sand.

Some pedons have an A/C horizon that is a mixture in shades of gray, yellow, and brown. Texture is sand or fine sand.

The C horizon has hue of 5YR to 2.5Y, value of 4 to 8, and chroma of 2 to 8. Horizons with chroma of 2 are not indicative of wetness. Small pockets of sand grains in shades of gray not related to wetness or masses of iron accumulation in shades of yellow or brown may occur in some pedons below depths of 40 inches.

COMPETING SERIES: These include the Alaga, Bigbee, Cainhoy, Darden, Foxworth, McNeely, Tonkawa, Turkey, and Wando series. Alaga and Darden soils have 10 to 25 percent silt plus clay in the 10 to 40-inch control section. In addition, Darden soils have weakly expressed cambic horizons. Bigbee soils are on lower adjacent positions that are subject to flooding and have a water table 20 to 40 inches below the surface for short periods. Cainhoy soils have a spodic horizon below 80 inches. The moderately well to somewhat excessively drained Foxworth soils are on lower positions. McNeely soils have weakly developed cambic horizons. Tonkawa soils have a moisture control section that is dry for 125-150 cumulative days for most years. The somewhat excessively drained Turkey soils have 10 to 18 percent silt plus clay in the 10 to 40-inch control section. The well drained Wando soils have 5 to 20 percent silt plus clay in the 10 to 40-inch control section.

GEOGRAPHIC SETTING: Lakeland soils are on broad to narrow uplands in the Southern Coastal Plain. They formed in eolian or marine and/or fluvio-marine sands. Slopes are dominantly 0 to 12 percent but may range up to 85 percent in highly dissected areas. The climate is humid subtropical. The average annual air temperature ranges from 62 to 71 degrees F., and the average annual precipitation ranges from 45 to 60 inches.

GEOGRAPHICALLY ASSOCIATED SOILS: These include the competing Bigbee and Foxworth soils along with the Albany, Alpin, Blanton, Bonifay, Centenary, Chipola, Chipley, Eglin, Hurricane, Kershaw, Kureb, Lucknow, Lucy, Osier, Plummer, Troup and Wakulla soils. The somewhat poorly drained Albany soils are on lower adjacent positions and have an argillic horizon 40 to 80 below the surface. Alpin soils are on similar positions and have lamellae that are generally less than 5 mm in thickness below a depth of 40 inches. The moderately well to somewhat excessively drained Blanton and the well-drained Bonifay soils have an argillic horizon in shades of yellow 40 to 80 inches below the surface. The moderately well drained Centenary soils are on lower positions and have spodic horizons. The well drained Chipola and Lucy soils have an argillic horizon 20 to 40 inches below the surface. The somewhat poorly drained Chipley soils are on lower positions. The somewhat excessively drained Eglin soils have a spodic horizon 68 to 80 inches below the surface. Kershaw and Kureb soils have less than 5 percent silt plus clay in the 10 to 40-inch control section. In additions, Kureb soils have weakly developed spodic horizons. The well to somewhat excessively drained Lucknow soils are on lower positions and have a seasonal high water table between 40 and 72 inches below the surface. The poorly drained Osier and Plummer soils are in lower adjacent drainageways. In addition, Plummer soils have an argillic horizon 40 to 80 inches below the surface. The somewhat excessively drained Troup soils occur are on similar to lower positions and have an argillic horizon within 40 to 80 inches of the surface. The somewhat excessively drained Wakulla soils have a weakly expressed argillic horizon within the control section.

DRAINAGE AND PERMEABILITY: Excessively drained; rapid to very rapid permeability; slow runoff.

USE AND VEGETATION: Many areas are cleared and used for peanuts, watermelons, peaches, corn, tobacco, and improved pasture. The natural vegetation consists of blackjack oak, turkey oak, post oak; scattered long leaf pine with an understory of creeping bluestem, sandy bluestem, lopsided indiangrass, hairy panicum, fringeleaf paspalum, and native annual forbs.

DISTRIBUTION AND EXTENT: Atlantic and Gulf Coastal Plain and sand hills of the thermic belt from Mississippi to Virginia. The series is of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Auburn, Alabama.

SERIES ESTABLISHED: Alachua County, Florida; 1947.

REMARKS: Diagnostic horizons and features recognized in this pedon:

Ochric epipedon - 0 to 3 inches (A horizon).

Coated feature - The fine-earth fraction contains 5 to 10 percent by weight silt plus clay.

Depth to seasonal water table is more than 80 inches.

Lakeland soils are in MLRAs 133A, 137, 152A and 153A.

ADDITIONAL DATA: Laboratory data is available on the National Soil Survey website at: http://ncsslabdatamart.sc.egov.usda.gov/querypage.aspx

Laboratory data is provided by Auburn University, Soil Characterization Laboratory, Auburn AL, National Soil Survey Laboratory, Lincoln, NE. and the University of Florida, Department of Soil and Water Science, Gainesville, FL.
http://soils.ifas.ufl.edu/flsoils/index.asp

National Cooperative Soil Survey
U.S.A.

LEON SERIES

The Leon series consists of very deep, very poorly and poorly drained, moderately rapid to moderately slowly permeable soils on upland flats, depressions, stream terraces and tidal areas. They formed in sandy marine sediments of the Eastern Gulf Coast Flatwoods (MLRA 152A), the Atlantic Coast Flatwoods (MLRA 153A) and to a lesser extent in the Southern Coastal Plain (MLRA 133A) and the North-Central Florida Ridge (MLRA 138). Near the type location, the mean annual temperature is about 68 degrees F., and the mean annual precipitation is about 65 inches. Slopes range from 0 to 5 percent.

TAXONOMIC CLASS: Sandy, siliceous, thermic Aeric Alaquods

TYPICAL PEDON: Leon sand, in a forested area (Colors are for moist soil).

A--0 to 4 inches; 70 percent black (10YR 2/1) and 30 percent light gray (10YR 7/1) sand; weak fine granular structure; very friable; many fine, medium, and large roots; many clean sand grains give a salt-and-pepper appearance; very strongly acid; clear smooth boundary. (2 to 9 inches thick)

Eg1--4 to 10 inches; gray (10YR 6/1) sand; common medium faint very dark gray (10YR 3/1) streaks and splotches of organic matter accumulations deposited in former root channels and krotovinas, ranging from about 20 percent in upper part to 0 percent in lower part; single grain; loose; many fine, medium, and large roots; very strongly acid; clear wavy boundary.

Eg2--10 to 15 inches; gray (10YR 6/1) sand; 20 percent faint light gray (10YR 7/1) oval splotches of organic matter depletions; single grain; loose; few fine and medium roots; very strongly acid; abrupt smooth boundary. (Combined thickness of the Eg horizons range from 2 to 22 inches)

Bh1--15 to 18 inches; 50 percent dark brown (7.5YR 3/3) and 50 percent black (7.5YR 2.5/1) sand; weak medium and coarse subangular blocky structure; firm; common fine and medium roots; many fine and medium pores; more than 95 percent of sand grains have organic coatings; extremely acid; clear smooth boundary.

Bh2--18 to 22 inches; dark brown (7.5YR 3/4) sand; weak medium and coarse subangular blocky structure; firm; few fine and medium roots; common fine and medium pores; more than 95 percent of sand grains have organic coatings; extremely acid; clear wavy boundary. (Combined thickness of the Bh horizons ranges from 4 to 50 inches)

Bw and Bh--22 to 25 inches; 80 percent (Bw) dark yellowish brown (10YR 4/4) and 20 percent (Bh) dark brown (10YR 3/3) sand; very weak medium and coarse subangular blocky structure; very friable; common fine and medium pores; very strongly acid; clear wavy boundary. (0 to 15 inches thick)

Eg and Bh--25 to 30 inches; 95 percent (Eg) weak red (2.5YR 5/2) and 5 percent (Bh) dark brown (7.5YR 3/3) sand; single grain; loose; common fine and medium pores; very strongly

acid; diffuse irregular boundary. (0 to 10 inches thick)

E'g--30 to 42 inches; pinkish gray (7.5YR 7/2) sand; single grain; loose; very strongly acid; clear wavy boundary. (0 to 36 inches thick)

B'h--42 to 77 inches; 50 percent very dark brown (10YR 2/2) and 50 percent dark yellowish brown (10YR 3/4) sand; weak medium and coarse subangular blocky structure; friable; common fine and medium pores; very strongly acid; clear wavy boundary. (0 to 50 inches thick)

B'w and B'h--77 to 108 inches; 60 percent (Bw) brown (10YR 4/3), 40 percent Bh of very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) sand; very weak medium and coarse subangular blocky structure; very friable; common fine and medium pores; very strongly acid.

TYPE LOCATION: Bay County, Florida. USGS Panama City Beach topographic quadrangle. Approximately 1.2 miles north of U.S. Highway 98, about 2.7 miles south of West Bay in Panama City Beach, Florida. SW 1/4, Sec. 20; T. 3 S., R. 15 W. 30 degrees 12.0 minutes 19.9 seconds N.; 85 degrees 46.0 minutes 20.4 seconds W.

RANGE IN CHARACTERISTICS: The Bh horizon is within 30 inches of the soil surface. Reaction ranges from extremely acid to slightly acid throughout. In tidal areas, the soil reaction ranges from very strongly acid to moderately alkaline throughout.

The A or Ap horizon has hue of 7.5YR or 10YR, value of 2 to 4, and chroma of 1 or 2; or is neutral with value of 2 to 4. When dry, this horizon has a salt-and-pepper appearance due to mixing of organic matter and sand grains. A thin O horizon of muck is present in some pedons. Texture is sand, fine sand, mucky fine sand, or mucky sand.

The E horizon, where present, has hue of 7.5YR to 2.5Y, value of 4 to 8, and chroma of 3 to 4; or is neutral with value of 5 to 8. Streaks and splotches of organically enriched material in shades of black to gray range from common to many. Texture is sand or fine sand.

The Eg or E'g horizons, where present, have hue of 7.5YR to 2.5Y, value of 4 to 8, and chroma of 1 to 3. Redoximorphic features of oval faint splotches (depletions) range from none to many. Streaks and masses of organic matter accumulation (Bh material) in shades of black to brown range from none to common. Texture is sand or fine sand.

A transitional horizon may be present between the lower E horizon and the Bh1 horizon. Where present, it has hue of 10YR or 2.5Y, value of 2 to 5, and chroma of 1 to 4. Thickness ranges from 0.5 to 7.0 inches. Texture is sand or fine sand.

The Bh horizon has hue of 5YR to 10YR, value of 2 to 6, and chroma of 1 to 4; or is neutral with value of 2 to 4. This horizon burns white on ignition. Texture is sand, fine sand, loamy sand or loamy fine sand.

The Bw horizon, where present, has hue of 5YR to 10YR, value of 2 to 6, and chroma of 1 to 4; or is neutral with value of 1 to 5. Streaks and masses of organic matter accumulation (Bh material) in shades of black to brown range from none to common. Texture is sand or fine sand.

B'h, B"h. B'"h horizons, where present, have similar colors and textures as the Bh horizon but occurs below the BE, E', E" and E'" horizons.

The C horizon, where present, has hue of 7.5YR to 2.5Y, value of 4 to 8, and chroma of 1 to 6. Texture is sand or fine sand.

COMPETING SERIES: The Talquin and Witherbee series are the only known series in the same family. They are on similar to slightly higher positions. In addition, Talquin soils have a spodic horizon less than 6 inches in thickness and the somewhat poorly drained Witherbee soils have less than 0.06 organic carbon in the upper 12 inches of the spodic horizon.

GEOGRAPHIC SETTING: Leon soils are on upland flats, depressions, stream terraces and tidal marshes of the lower Atlantic and Gulf Coastal Plain. They formed in thick beds of acid sandy marine sediments. The climate is humid subtropical. Slopes range from 0 to 5 percent. The average annual temperature ranges from 66 to 70 degrees F., and the average annual precipitation ranges from 61 to 69 inches at the sample location.

GEOGRAPHICALLY ASSOCIATED SOILS: These include the Allanton, Chaires, Chipley, Croatan, Dorovan, Foxworth, Hurricane, Kershaw, Kureb, Lakeland, Lynn Haven, Mandarin, Mascotte, Olustee, Ortega, Osier, Pactolus, Pamlico, Pantego, Pickney, Plummer, Portsmouth, Pottsburg, Resota, Ridgeland, Ridgewood, Rutlege, Sapelo, Scranton, Surrency and Wesconnett series. Allanton, Hurricane and Pottsburg soils have a spodic horizon at depths greater than 50 inches. In addition, Allanton soils are on lower positions and have umbric epipedons, Hurricane soils are somewhat poorly drained and on higher positions and Pottsburg soils are somewhat poorly to poorly drained and on similar to slightly higher positions. Chaires, Mascotte, Olustee and Sapelo soils are on similar positions but are underlain by argillic horizons under the Bh horizon. Chipley, Foxworth, Kershaw, Lakeland, Ortega and Ridgewood soils are on higher positions and lack spodic horizons. In addition, Chipley and Ridgewood soils are somewhat poorly drained, Foxworth soils are moderately well drained to excessively drained, Kershaw, Kureb and Lakeland soils are excessively drained and Ortega soils are moderately well drained. The very poorly drained Croatan, Dorovan and Pamlico soils are on lower positions and are organic. Lynn Haven soils are on similar positions but have an umbric epipedon. The somewhat poorly drained Mandarin soils are on higher positions. Osier soils are on flood plains and lack spodic horizons. The somewhat poorly to moderately well drained Pactolus soils are on higher positions and lack spodic horizons. The very poorly drained Pantego, Pickney, Portsmouth, Rutlege and Surrency soils are on lower positions and lack spodic horizons. In addition, Pantego, Pickney, Rutlege and Surrency soils have umbric epipedons. Plummer soils are on similar to lower positions and are grossarenic. Ridgeland and Wesconnett soils and lack E horizons between

the A and Bh horizons. In addition, Ridgeland soils are on slightly higher positions and are somewhat poorly drained while Wesconnett soils are in lower depressional areas and are very poorly drained. The moderately well drained Resota soils are in higher positions and have weakly expressed spodic horizons. The poorly drained Scranton soils are on similar to slighter higher positions and lack spodic horizons.

DRAINAGE AND PERMEABILITY: Poorly drained and very poorly drained; moderate to moderately rapid permeability in the A and E horizons, moderate to moderately slow permeability in the Bh horizons, and rapidly permeable in the other layers.

USE AND VEGETATION: Most areas of Leon soils are used for forestry, rangeland and pasture. Areas with adequate water control are used for cropland and vegetables. The natural vegetation consists of longleaf pine, slash pine, water oak, myrtle, with a thick undergrowth of sawpalmetto, running oak, fetterbush and other lyionia, inkberry (gallberry), wax myrtle, goldenrod, ligustrina, dog fennel, chalky bluestem, lowbush blueberry, creeping bluestem and pineland threeawn (wiregrass). In depressions, the vegetation is dominated by brackenfern, smooth sumac and swamp cyrilla are common. Vegetation in the tidal marshes includes bushy seaoxeye, marshhay cordgrass, seashore saltgrass, batis, and smooth cordgrass.

DISTRIBUTION AND EXTENT: The Atlantic and Gulf Coastal Plain from Mississippi, Alabama, Florida, Georgia, South Carolina, North Carolina, Virginia and Maryland. The series is of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Auburn, Alabama.

SERIES ESTABLISHED: Leon County, Florida; 1905.

REMARKS: Diagnostic horizons and features recognized in this pedon:

Ochric epipedon - the zone from 0 to 15 inches (A, E and Eg horizons).

Albic horizons - the zones from 4 to 15 inches (E and Eg horizons) and from 30 to 42 inches (E'g horizon).

Spodic horizon within 30 inches - the zones from 15 to 22 inches (Bh1 and Bh2 horizons) and from 42 inches to 77 inches (B'h horizon).

Aquic conditions - endosaturation throughout.

The water table is at depths of 6 to 18 inches for 1 to 4 months during most years. In low flats or sloughs it is at a depth of 0 to 6 for periods of more than 3 weeks during most years. It is between depths of 18 and 36 inches for 2 to 10 months during most years. It is below 60 inches during the dry periods of most years. Depressional areas are covered with standing water for periods of 6 months or more in most years.

Leon soils are in MLRAs 133A, 138, 152A and 153A.

ADDITIONAL DATA: IFAS Soil Characterization Data: S2-1-(1-9), S2-2-(1-8), S3-3-(1-5), S4-8-(1-9), S10-12-(1-7) S12-17-(1-7), S16-9-(1-7), S19-6-(1-5), S33-24-(1-7), S37-28-(1-8), S45-27-(1-7), S46-2-(1-6), S57-46-(1-6), S66-24-(1-8); samples by IFAS, University of Florida, Gainesville, FL.

NSSL Soil Characterization Data: S08FL-005-1 (1-10); sample by NSSL, Lincoln, NE.

Soil Name Slope Airtemp FrFr/Seas Precip Elevation
LEON 0-5% 65-70F 230-310 60-69 in 8-135 ft

FloodL FloodH Water table Kind Months Bedrock
Fl0051 NONE 0.5-1.5 APPARENT MAR-SEP 60-60
FL0093 NONE 0 - 0.5 APPARENT FEB-SEP 60-60
FL0406 RARE COMMON 0 - 1.0 APPARENT MAR-SEP 60-60
FL0501 NONE - APPARENT - 60-60
FL0508 FREQ 0 - 0.5 APPARENT JAN-DEC 60-60

Depth Texture 3-Inch No-10 Clay% -CEC-
FL0051 0- 3 S FS 0- 0 100-100 1- 5 2 - 12
FL0051 3-15 S FS 0- 0 100-100 0- 3 .3- 1
FL0051 15-30 S FS LS 0- 0 100-100 2- 8 8 - 30
FL0051 30-66 S FS 0- 0 100-100 1- 4 .5- 3
FL0051 66-80 0- 0 100-100 2- 8 8 - 30

FL0093 0- 4 MK-S MK-FS 0- 0 100-100 1- 6 12 - 30
FL0093 0- 4 S FS 0- 0 100-100 1- 5 2 - 12
FL0093 4-16 S FS 0- 0 100-100 0- 3 .3- 1
FL0093 16-25 S FS LS 0- 0 100-100 2- 8 8 - 30
FL0093 25-80 S FS 0- 0 100-100 1- 4 .5- 3

FL0406 0- 3 FS S 0- 0 100-100 1- 5 2 - 12
FL0406 0- 3 MK-FS MK-S 0- 0 100-100 1- 6 12 - 30
FL0406 3-15 FS S 0- 0 100-100 0- 3 .3-1
FL0406 15-23 FS S LS 0- 0 100-100 2- 8 8 - 30
FL0406 23-80 FS S 0- 0 100-100 1- 4 .5-3
Depth Texture 3-Inch No-10 Clay% CEC

FL0501 0- 3 MUCK 0- 0 90-200 --- ---
FL0501 3-17 S FS 0- 0 100-100 0- 3 .3- 2
FL0501 17-80 S FS LFS 0- 0 100-100 2- 8 8.0- 30

FL0508 0-26 S FS 0- 0 100-100 1- 3 1.0- 12
FL0508 26-40 S FS 0- 0 100-100 2- 8 12 - 30

FL0508 40-80 S FS 0- 0 100-100 2-10 .5- 3

SOI-5 Depth pH O.M. Salin Permeab Shnk-Swll
FL0051 0- 3 3.6- 6.5 0.5-4.0 0- 2 6.0-20 LOW
FL0051 3-15 3.6- 6.5 0.0-0.5 0- 2 6.0-20 LOW
FL0051 15-30 3.6- 6.5 2.0-4.0 0- 2 0.6- 6.0 LOW
FL0051 30-66 3.6- 6.5 0.0-0.5 0- 2 2.0-20 LOW
FL0051 66-80 3.6- 6.5 1.0-3.0 0- 2 0.2- 2.0 LOW

FL0093 0- 4 3.6- 6.5 10-20 0- 2 6.0- 20 LOW
FL0093 0- 4 3.6- 6.5 2.-5. 0- 2 6.0- 20 LOW
FL0093 4-16 3.6- 6.5 0.- .5 0- 2 6.0- 20 LOW
FL0093 16-25 3.6- 6.5 1.-4. 0- 2 0.6- 6.0 LOW
FL0093 25-80 3.6- 6.5 0.- .5 0- 2 2.0- 20 LOW

FL0406 0- 3 3.6- 5.5 0.5-4. 0- 2 6.0- 20 LOW
FL0406 0- 3 3.6- 5.5 10-20 0- 2 6.0- 20 LOW
FL0406 3-15 3.6- 5.5 0.- .5 0- 2 6.0- 20 LOW
FL0406 15-23 3.6- 5.5 1.-4. 0- 2 0.6- 6.0 LOW
FL0406 23-80 3.6- 5.5 0.- .5 0- 2 0.6- 20 LOW

FL0501 0- 3 3.6- 5.5 20-80 0- 2 6.0- 20 LOW
FL0501 3-17 3.6- 5.5 0.-.5 0- 2 6.0- 20 LOW
FL0501 17-80 3.6- 5.5 1.-4. 0- 2 0.6- 6.0 LOW

FL0508 0-26 4.5- 8.4 1.-3. 8-16 2.0- 6.0 LOW
FL0508 26-40 4.5- 8.4 1.-4. 8-16 0.6- 6.0 LOW
FL0508 40-80 4.5- 8.4 0.-.5 2- 8 0.6- 6.0 LOW

National Cooperative Soil Survey
U.S.A.

OCILLA SERIES

The Ocilla series consists of very deep, somewhat poorly drained moderately permeable soils formed in sandy and loamy marine sediments. These soils are on low uplands and stream terraces. Slopes range from 0 to 10 percent.

TAXONOMIC CLASS: Loamy, siliceous, semiactive, thermic Aquic Arenic Paleudults

TYPICAL PEDON: Ocilla loamy sand--on a nearly level slope in forest. (Colors are for moist soil.)

A--0 to 4 inches; very dark gray (10YR 3/1) loamy sand; weak medium granular structure; very friable; many fine roots; strongly acid; clear wavy boundary. (3 to 10 inches thick)

E1--4 to 15 inches; light brownish gray (2.5Y 6/2) loamy sand; single grained; very friable; common fine and medium roots; common root holes filled with very dark gray loamy sand; common clean sand grains; strongly acid; clear irregular boundary.

E2--15 to 28 inches; pale brown (10YR 6/3) loamy sand; weak medium granular structure; very friable; few fine roots; many medium distinct brownish yellow (10YR 6/6) soft masses of iron accumulation; strongly acid; gradual wavy boundary. (Combined thickness of the E horizon is 14 to 34 inches)

Bt1--28 to 49 inches; brownish yellow (10YR 6/6) sandy loam; common medium pockets of sandy clay loam; weak medium subangular blocky structure; very friable; sand grains coated and bridged with clay; common medium prominent light gray (10YR 7/1) iron depletions; very strongly acid; gradual wavy boundary.

Bt2--49 to 59 inches; brownish yellow (10YR 6/6) sandy clay loam with many large pockets of light gray (10YR 7/1) sandy loam; weak medium subangular blocky structure; friable; sand grains coated and bridged with clay; common medium prominent yellowish red (5YR 4/8) soft masses of iron accumulation; very strongly acid; gradual irregular boundary.

Bt3-- 59 to 67 inches; multicolored strong brown (7.5YR 5/6) and yellowish red (5YR 4/8) sandy clay loam containing common medium pockets of light gray (10YR 7/1) sandy loam; weak coarse angular blocky structure; friable; about 2 percent plinthite; very strongly acid.

TYPE LOCATION: Irwin County, Georgia; 2.6 miles east of Irwinville on Georgia Highway 32, and 2 miles north on county road in wooded area.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 6O to more than 80 inches. The A and E horizons of some pedons have pebbles of ironstone up to 5 percent. The subsoil of some pedons contain up to 3 percent plinthite. All horizons are strongly acid, or very strongly acid, except those surface soils that have been limed.

The A horizon has hue of 10YR or 2.5Y, value of 3 through 5 and chroma of 1 or 2; or it is neutral with value of 3 through 5. Where the value is 3, the horizon is less than 7 inches thick. Texture is sand, fine sand, loamy coarse sand, loamy sand or loamy fine sand.

The E horizon has hue of 10YR, 2.5Y or 5Y, value of 4 through 8, and chroma of 1 through 4. Texture is sand, fine sand, loamy coarse sand, loamy fine sand or loamy sand.

The BE horizon, where present, has hue of 10YR or 2.5Y, value of 5 through 7, and chroma of 3 through 8. Texture is loamy sand or loamy fine sand.

The Bt1 horizon has hue of 7.5YR, 10YR or 2.5Y, value of 5 through 7 and chroma of 2 through 8. Texture is fine sandy loam, sandy loam or sandy clay loam. The Bt2 and Bt3 horizons are multicolored in shades of gray, yellow, brown and red; or the matrix has hue of 10YR, 2.5Y or 5Y, value of 5 through 8, and chroma of 1 through 8; or the matrix is neutral with value of 7, and with redoximorphic features in shades of gray, red, or brown. They are

dominantly sandy clay loam, but include coarse sandy loam, sandy loam, fine sandy loam and sandy clay. Pockets of sandy loam or fine sandy loam occur in some subhorizons. Some pedons contain Btg horizons in the lower part. The weighted average clay content of the upper 20 inches of the argillic horizon ranges from 15 to 35 percent. Plinthite ranges from none to about 3 percent.

The Btg, BC and BCg horizons, where present, have color and textures comparable to the Bt2 and Bt3 horizons.

The C horizon, where present, has the same colors as the lower Bt horizon. It is sandy loam, sandy clay loam, sandy clay or clay.

COMPETING SERIES: There are no competitors in the same family. Albany, Ardilla, Coosaw, Garcon, Leefield, and Lynchburg soils are in similar families, somewhat poorly drained, nearly level, and low lying. Albany soils have a grossarenic epipedon. Ardilla soils have fragic properties in the lower B horizons. Coosaw soils have mixed mineralogy and a decreasing clay content in the lower part of the argillic horizon above 60 inches. Garcon soils have a solum less than 60 inches thick. Leefield soils have horizons which contain 5 to 20 percent plinthite ranging from 30 to 60 inches deep. Lynchburg soils lack an arenic epipedon.

GEOGRAPHIC SETTING: Ocilla soils are on level or nearly level landscapes; slopes commonly are less than 2 percent but range to 10 percent. Elevation ranges from 15 to 400 feet. The soils formed in deposits of sandy and loamy sediments largely of marine origin. Average annual precipitation is about 40 to 50 inches and average annual temperature is 63 to 71 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These included the competing Albany, Ardilla, and Leefield soils and Alapaha, Bladen, Blanton, Clarendon, Cowarts, Dothan, Fuquay, Goldsboro, Grady, Herod, Kinston, Norfolk, Osier, Pelham, Plummer, Rains, Stilson, Tifton, and Wagram soils. Alapaha, Bladen, Pelham, Plummer, and Rains soils are poorly drained, nearly level, and occur on low lying broad flats along drainageways and around the head of the streams. Blanton, Clarendon, Goldsboro, and Stilson soils are moderately well drained on nearly level or very gently sloping upland or low ridges. Cowarts, Dothan, Fuquay, Norfolk, Tifton, and Wagram soils are well drained on nearly level or gently sloping upland ridges and divides. Grady soils are poorly drained and in depressions. Herod, Kinston, and Osier soils are poorly drained alluvial soils on flood plains.

DRAINAGE AND PERMEABILITY: Somewhat poorly drained; slow runoff; moderate permeability. Depth to the water table ranges from 12 to 30 inches for periods of 2 to 6 months.

USE AND VEGETATION: Native vegetation is forest of slash and longleaf pine, scattered oaks, and a few blackgum, with an understory of wax myrtle, gallberry, scattered palmetto, and wiregrass. These soils are used mostly for forestry, but some are cleared and planted to bahiagrass, coastal bermudagrass, corn, tobacco, soybeans, rye, and vegetables.

DISTRIBUTION AND EXTENT: Georgia, Alabama, Florida, North Carolina, Mississippi, and South Carolina. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Auburn, Alabama

SERIES ESTABLISHED: Irwin County, Georgia; 1965.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from the surface to approximately 28 inches. (A, E1 and E2 horizons)
Arenic feature - the zone from the surface to approximately 28 inches. (A, E1, E2 horizons)
Argillic horizon - the zone from approximately 28 to 67 inches. (Bt1, Bt2, Bt3 horizons)
SIR = GA0006, GA0087
MLRA = 133A, 153A
REVISED = 2/6/96, MHC

National Cooperative Soil Survey
U.S.A.

OGEECHEE SERIES

The Ogeechee series consists of very deep, poorly drained, moderately permeable soils that formed in thick beds of loamy fluvial and marine sediments. The soils are on nearly level broad flats, drainageways, and slight depressions on the lower Coastal Plain generally below about 50 feet elevation. Slopes are from 0 to 2 percent.

TAXONOMIC CLASS: Fine-loamy, siliceous, subactive, thermic Typic Endoaquults

TYPICAL PEDON: Ogeechee loamy fine sand--forested. (Colors are for moist soil.)

A--0 to 8 inches; very dark gray (10YR 3/1) loamy fine sand; weak fine granular structure; very friable; many fine roots and pores; very strongly acid; clear smooth boundary. (5 to 9 inches thick)

Btg1--8 to 23 inches; dark grayish brown (10YR 4/2) sandy clay loam; weak fine subangular blocky structure; friable; many fine roots and pores; few fine distinct yellowish brown (10YR 5/4) masses of iron accumulation; very strongly acid; gradual wavy boundary.

Btg2--23 to 42 inches; dark grayish brown (10YR 4/2) sandy clay with pockets of gray (10YR 5/1) sandy clay loam; moderate fine subangular blocky structure; firm; friable in sandy clay loam portion; thin patchy clay films on faces of peds; few fine and medium roots; many medium prominent strong brown (7.5YR 5/6) masses of iron accumulation; very strongly acid; gradual wavy boundary.

Btg3--42 to 65 inches; grayish brown (10YR 5/2) sandy clay loam; weak coarse subangular blocky structure; firm; few medium and large roots; common medium prominent light olive brown (2.5Y 5/4) and common medium distinct strong brown (7.5YR 5/6) masses of iron accumulation; very strongly acid; gradual wavy boundary. (Combined thickness of the Btg horizons ranges from 20 to 60 inches)

Cg--65 to 80 inches; grayish brown (10YR 5/2) clay loam; massive; firm; few medium roots; few medium prominent gray (5Y 5/1) and few medium distinct light gray (10YR 7/2) iron depletions, and few medium distinct yellowish brown (10YR 5/6) masses of iron accumulation; very strongly acid.

TYPE LOCATION: Bryan County, Georgia; 1.2 miles north of Liberty-Bryan County line on U.S. Highway 17; 1.2 miles east on Jones Loop Road; 1.2 miles south on Mt. Hope Road; 100 yards west of end of road and 50 feet west of canal. (USGS Quadrangle, Limeric SE., Georgia (1958); lat. 31 degrees 52 minutes 05 seconds N., and long. 81 degrees 22 minutes 30 seconds W.)

RANGE IN CHARACTERISTICS: Solum thickness ranges from 40 to 80 inches. Reaction of the soil is extremely acid to strongly acid, except where limed and some pedons may have moderately acid reaction in the lower B and C horizons. Some pedons may contain few fine flakes of mica throughout.

The A horizon has hue of 2.5Y or 10YR, value of 2 through 4, and chroma of 1 or 2. It is loam, fine sandy loam, sandy loam, loamy fine sand, loamy sand, or loamy coarse sand.

The Eg horizon, where present, has hue of 2.5Y or 10YR, value of 4 through 7, and chroma of 1 or 2. The range in texture is the same as the A horizon.

The BEg horizon, where present, has hue of 2.5Y or 10YR, value of 4 through 7, and chroma of 1 or 2, or the horizon is neutral with value of 4 through 7. Masses of iron accumulation are few to many in shades of yellow and brown. It is sandy loam or fine sandy loam.

The Btg horizon has hue of 2.5Y or 10YR, value of 4 through 7, and chroma of 1 or 2, or the horizon is neutral with value of 4 through 7. Masses of iron accumulation are common or

many in shades of yellow, brown, or red. Some pedons may have a lower Bt sub horizon without dominant matrix hue and have masses of iron accumulation in shades of yellow, brown or red and iron depletions. It is commonly clay loam or sandy clay loam, but some pedons have subhorizons of clay or sandy clay. The upper 20 inches of the horizon has an average clay content of 20 to 35 percent, and less than 20 percent silt. Some pedons may have pockets of gray coarser textured material 2 to 6 inches in diameter.
The BCg horizon, where present, has colors the same as the Btg horizon. It is sandy loam or sandy clay loam.
The Cg horizon, where present, has hue of 5Y, 2.5Y, or 10YR, value of 5 through 8, and chroma of 1 or 2 or the horizon is neutral with value of 5 through 8. It ranges from sand to clay loam and commonly is stratified with sand, loamy sand, sandy clay loam, or clay.
COMPETING SERIES: (This section not updated this date; 6/16/97) These are the Gourdin and Myatt series of the same family and the Augusta, Coxville, Dunbar, Grady, Lumbee, Lynchburg, Pooler, Rains, Roanoke, Wahee, Worsham, and Yemassee series of closely related families. Augusta soils have mixed mineralogy. Coxville, Dunbar, Grady, Pooler, Roanoke, Wahee, and Worsham soils have more than 35 percent clay in the control section. Gourdin soils have slow permeability. Myatt soils have more than 20 percent silt in the control section. Lynchburg and Rains soils lack a 20 percent clay decrease within 60 inches of the surface. Lumbee soils have sola 40 inches thick or less. Yemassee soils have higher chroma between the base of the A or Ap horizons and a depth of 30 inches.
GEOGRAPHIC SETTING: Ogeechee soils are on nearly level flats, drainageways, and slight depressions on the Lower Coastal Plain. Slopes are 0 to 2 percent. Elevation is 10 to 50 feet. The mean annual temperature is 62 to 70 degrees F. and mean annual precipitation is 45 to 55 inches.
GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Lumbee, Pooler, and Wahee series, and the Alapaha, Bayboro, Cape Fear, Pelham, and Portsmouth series. Alapaha and Pelham soils have loamy sand A horizons 20 to 40 inches thick and in addition Alapaha soils are found on slightly higher elevations. Bayboro, Cape Fear, and Portsmouth soils have umbric epipedons.
DRAINAGE AND PERMEABILITY: Ogeechee soils are poorly drained; slow runoff; moderate permeability. Depth to water table is from +1.0 to 1.0 foot.
USE AND VEGETATION: Most of the soil is in forest of mainly loblolly pine and hardwoods. Cleared areas are used for growing corn, soybeans, hay, and pasture.
DISTRIBUTION AND EXTENT: Widely distributed over the Lower Coastal Plain of Georgia, Alabama, Florida, North Carolina, South Carolina, and possibly Virginia. The series is extensive.
MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Raleigh, North Carolina
SERIES ESTABLISHED: Bryan County, Georgia; 1969.
REMARKS: The type location was visited in 8/93 and profile redescribed to 80 inches to answer endo vs epi saturation question.
Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon - the zone from the surface to approximately 8 inches (A horizon)
Argillic horizon - the zone from approximately 8 to 65 inches (Btg1, Btg2, and Btg3 horizons).

MLRA=153A, 153B

ADDITIONAL DATA:

TABULAR SERIES DATA:

SOI-5	Soil Name	Slope	Airtemp	FrFr/Seas	Precip	Elevation
GA0036	OGEECHEE	0- 2	62- 70	240-285	45- 55	10- 50
GA0081	OGEECHEE	0- 2	62- 70	240-285	45- 55	10- 50

SOI-5	FloodL	FloodH	Watertable	Kind	Months	Bedrock	Hardness
GA0036	NONE	COMMON	0-1.0	APPARENT	DEC-MAY	60-60	
GA0081	NONE		-	APPARENT	-	60-60	

SOI-5	Depth	Texture	3-Inch	No-10	Clay%	-CEC-
GA0036	0- 8	LFS LS LCOS	0- 0	95-100	5-10	-
GA0036	0- 8	SL FSL	0- 0	95-100	5-10	-
GA0036	8-23	SCL CL	0- 0	95-100	20-35	-
GA0036	23-42	SC SCL C	0- 0	95-100	30-45	-
GA0036	42-80	SCL CL SL	0- 0	90-100	15-30	-
GA0081	0- 8	LFS LS LCOS	0- 0	95-100	5-10	-
GA0081	0- 8	SL FSL	0- 0	95-100	5-10	-
GA0081	8-23	SCL CL	0- 0	95-100	20-35	-
GA0081	23-42	SC SCL C	0- 0	95-100	30-45	-
GA0081	42-60	SCL SL	0- 0	90-100	15-30	-

SOI-5	Depth	-pH-	O.M.	Salin	Permeab	Shnk-Swll
GA0036	0- 8	4.5- 5.5	1.-2.	0- 0	2.0- 6.0	LOW
GA0036	0- 8	4.5- 5.5	1.-2.	0- 0	0.6- 2.0	LOW
GA0036	8-23	4.5- 5.5	-	0- 0	0.6- 2.0	LOW
GA0036	23-42	4.5- 5.5	-	0- 0	0.6- 2.0	LOW
GA0036	42-80	4.5- 6.0	-	0- 0	0.6- 2.0	LOW
GA0081	0- 8	4.5- 5.5	1.-2.	0- 0	2.0- 6.0	LOW
GA0081	0- 8	4.5- 5.5	1.-2.	0- 0	0.6- 2.0	LOW
GA0081	8-23	4.5- 5.5	-	0- 0	0.2- 0.6	LOW
GA0081	23-42	4.5- 5.5	-	0- 0	0.6- 2.0	LOW
GA0081	42-60	4.5- 5.5	-	0- 0	0.6- 2.0	LOW

National Cooperative Soil Survey
U.S.A.

CONNECT SAVANNAH
NEWS | ARTS | ENTERTAINMENT

August 14, 2013

Living under the bridge

A peek at a homeless camp

By Sinjin Hilaski

Scouting from a distance, the search for an exit from the homeless camp under the Truman Parkway was my initial concern. If things took a turn for the worse, I intended to have a fully formed 'bug out' plan.

I pushed past the brush to find the worn dirt trail that bypassed the stagnant pool of rainwater, human byproduct and a forsaken grocery cart.

Shuffling through the first 50 feet of the camp, I gazed down the underbelly of the bridge attempting to see if any of the camp's inhabitants were up and about that Tuesday morning. Sidestepping through the daily debris of empty bottles and bags, I began to traverse one of Savannah's most forgotten areas.

Eerie and surreal can only begin to describe how it felt. I snuck through, ignoring makeshift spray-can "No Trespassing" signs and the ubiquitous

pitchfork sign of the Folk Nation gang at times, less than two feet from the entrance of their tent.

As I became more comfortable — or just less scared — I took my moments of bravery as opportunities to get close and take photographs.

Each camera click sounded like a cannon.

While my shooting didn't wake up the campers, when I attempted to venture further back beyond the woods and into what seemed a sprawling homeless encampment less than a hundred feet away, I was pulled aside by a worn —though relatively well-kept given the circumstances — white, middle-aged male who curtly informed me that regardless of intention I needed to leave immediately.

The Chatham-Savannah Homeless Authority reports that at least 12 such encampments exist throughout the Chatham area at both respective ends of the Truman Parkway, off Louisville road and throughout Garden City. The location of all other camps wasn't disclosed.

"There's a lot of campsites down there near President Street," says Ronnie Flournoy, a formerly homeless individual now working with the Chatham-Savannah Homeless Authority.

The 2012 numbers of homeless individuals are still being compiled, reports Herb Smith of the Chatham-Savannah Homeless Authority.

At least 344 veterans are currently homeless in Savannah.

The forces that lead to homelessness are many and vary case to case, but with a Homeless Authority and various shelters, one wonders why individuals are still camping underneath a bridge.

"Typically to avoid rules and regulations," says Smith.

While the Chatham-Savannah Homeless Authority attempts to provide services and help reintegrate homeless individuals into the system, often after receiving medical care the homeless tend to then sever any connection with the Authority.

"I have a person that might come to me ten times saying 'I need help'," says Flournoy.

"I help them whether they're lying or whatever the case may be. I try to help them 'cause you never know that tenth time or eleventh time might be the last time."

A typical response to the plight of the homeless is to question why they don't simply go and find employment or stay at shelters as opposed to makeshift tent villages like the one I visited.

While shelters seem to be a viable option, there are stipulations — including a ban on alcohol and other intoxicants — that limit a homeless person's ability to use these facilities.

For example, in order to stay at Grace House of Union Mission, clients must be drug- and alcohol-free or they agree to a detox program as well as show income.

The Salvation Army and the Inner City Night Shelter require identification (though the Inner City shelter is one of the few shelters that accepts individuals actively using drugs or alcohol and is the only shelter housing sex offenders.)

"A lot of the homeless don't have IDs or Social Security cards, and to get in you have to have an income, but you have to have an ID to get a job," says Flournoy.

"It's discouraging to them."

With an increasing homeless population and a Homeless Authority with a shrinking budget, the future for those living on the street, under the bridge and by the river is uncertain and precarious.

"The city does what they can do, but they don't want to touch that situation," says Flournoy.

ABOUT THE AUTHOR
Sinjin Hilaski

Sinjin Hilaski is a student at Armstrong Atlantic State University. He's also Connect's social media intern and a pretty happening cat all around.

Retrieved Mar 24, 2023

'We are completely overloaded': Local animal shelters seeing an uptick in pet returns

At the beginning of the COVID-19 pandemic, many pet shelters saw a massive uptick in adoptions. Now, over a year

Updated: 8:23 PM EDT Jul 14, 2021

Brooke Butler
Anchor/Reporter

Some of our local animal shelters are currently seeing a staggering number of pet surrenders.

"For the last two months, we've been inundated with owner surrender requests," said Lisa Scarborough, director and founder of Coastal Pet Rescue. "We are completely overloaded. Most of our foster homes are doubled up right now. Every room in our shelter is completely full."

We're told some people are returning their pets due to financial struggles or complicated living situations.

"We're getting a lot of people who are having to move because they lost their jobs here or they could no longer afford their rent or wherever they were living, so they had to move in with somebody," Scarborough said.

Other people are returning their pets because of behavioral issues.

Cofounder of One Love Animal Rescue Dana Bertagnolli said, "People were home and had a lot of time [during the pandemic] and now people have gone back to work and maybe that pet is experiencing separation anxiety. There could be a multitude of reasons why they are returning that pet, and those are things that can be worked through."

For those who are thinking about returning a pet due to behavioral issues, One Love Animal Rescue urges you to consider trying out a trainer first.

"If it's for behavioral reasons, reach out to a behavioral trainer because they're a lot more affordable then you can imagine, number one. Number two, if the dog is tearing up things, [a trainer] is a lot less expensive than a torn up piece of furniture," Bertagnolli said.

One Love Animal Rescue adds that if you're having trouble paying for your pet's vet bills, food, etc., there are always people and groups willing to help. You just have to reach out.

For those looking to help out shelters during this tough time, both One Love Animal Rescue and Coastal Pet Rescue strongly encourage you to consider fostering.

Robin Fay, a foster parent with One Love Animal Rescue said, "It's such a rewarding thing to do to know you're saving a little life and that you're also adding to someone else's life. When they adopt this dog, they're going to get a family member."

If you're interested in fostering or adopting from One Love Animal Rescue, click here.

If you're interested in fostering or adopting from Coastal Pet Rescue, click here.

Retrieved Mar 24, 2023

NEWS

‘Invisible homeless’ continues to be an issue in Chatham County, SCCPSS

by: Chase Justice
Posted: Dec 6, 2021 / 07:30 PM EST
Updated: Dec 6, 2021 / 07:30 PM EST

SAVANNAH, Ga. (WSAV) — For nearly 4,000 individuals in the Hostess City, homelessness continues to be a problem that just can’t be shaken.

“I think a lot of people’s minds go to the Truman parkway because that is definitely our most visible homeless camp in the community, but there’s also an invisible homeless population that doesn’t get a lot of coverage, and that’s families living in hotels and motels,” said Latacia Avila, Executive Director of Social Apostolate.

They’re known as the invisible homeless.

It’s the population of people who bounce around from extended stays at motels, to homeless camps, shelters and everywhere in-between. Oftentimes, bringing their children along with them, which can make life difficult on both the kids and the school system.

“Our goal at the school district, just to rewind for a second, is to make sure that children remain in one school for the entire school year,” said Sharon Hill, Homeless Liaison at

SCCPSS. “Because, if you can imagine being a mom who’s going from house to motel to car to emergency shelter, that’s a lot on a family. But imagine being a 6-year-old who’s trying to do homework or a 16-year-old who’s studying for the PSAT’s.”

According to the Chatham Savannah Authority for the Homeless, over 800 K-12 students currently enrolled in the Savannah Chatham County Public School System experience homelessness at some point in the school year.

For many families, it’s the lack of affordable housing available in the city that has led them down this route.

“My son doesn’t even know that he’s in a shelter. Everybody says he’s the happiest baby of all time and he really is. Bu you know, I still struggle because I worry at night, what’s my next step? What door is God going to open for me,” said Hollie Dixon, a local mother experiencing homelessness.

It’s recommended that families spend no more than 30% of their income on housing, but due to the rising costs of rent in the area, that puts more than 40% of households at risk for becoming homeless.

“All of us, we’re one tragedy away, one hurricane away, one tornado away, one job loss away, one death away, one paycheck being taken away, that we find ourselves in that same situation,” explained Mayor Van Johnson.

Retrieved Mar 24, 2023

LOCAL NEWS

Chatham County Animal Services partners with Renegade Paws Rescue to help expand its foster network

Posted: Aug 26, 2021 / 11:21 PM EDT
Updated: Aug 27, 2021 / 12:33 PM EDT

SAVANNAH, Ga. (WSAV) – Chatham County Animal Services is seeing an uptick in owners surrendering their pets, especially dogs.

This past July, animal services saw a 20 percent increase in owner's surrender and a 10 percent overall increase in intake.

That's why Chatham County partnered with Renegade Paws Rescue to help expand its foster network. Since Jan. 1, animal services has had nearly 450 dogs placed in foster homes. However, animal services is still near full capacity.

Renegade and animal services are looking for more families to foster pets as the intake of animals hasn't slowed down since the start of the pandemic.

There are plenty of furry friends to choose from. If you want to find out how to adopt or foster a pet visit animalservices.chathamcountyga.gov.

Retrieved Mar 24, 2023

TO BE ADDED – 2017 Savannah Now Article on “organic waste landfill” on Thomas Avenue