FOWL RIVER WATERSHED MANAGEMENT PLAN

Submitted to: Mobile Bay National Estuary Program
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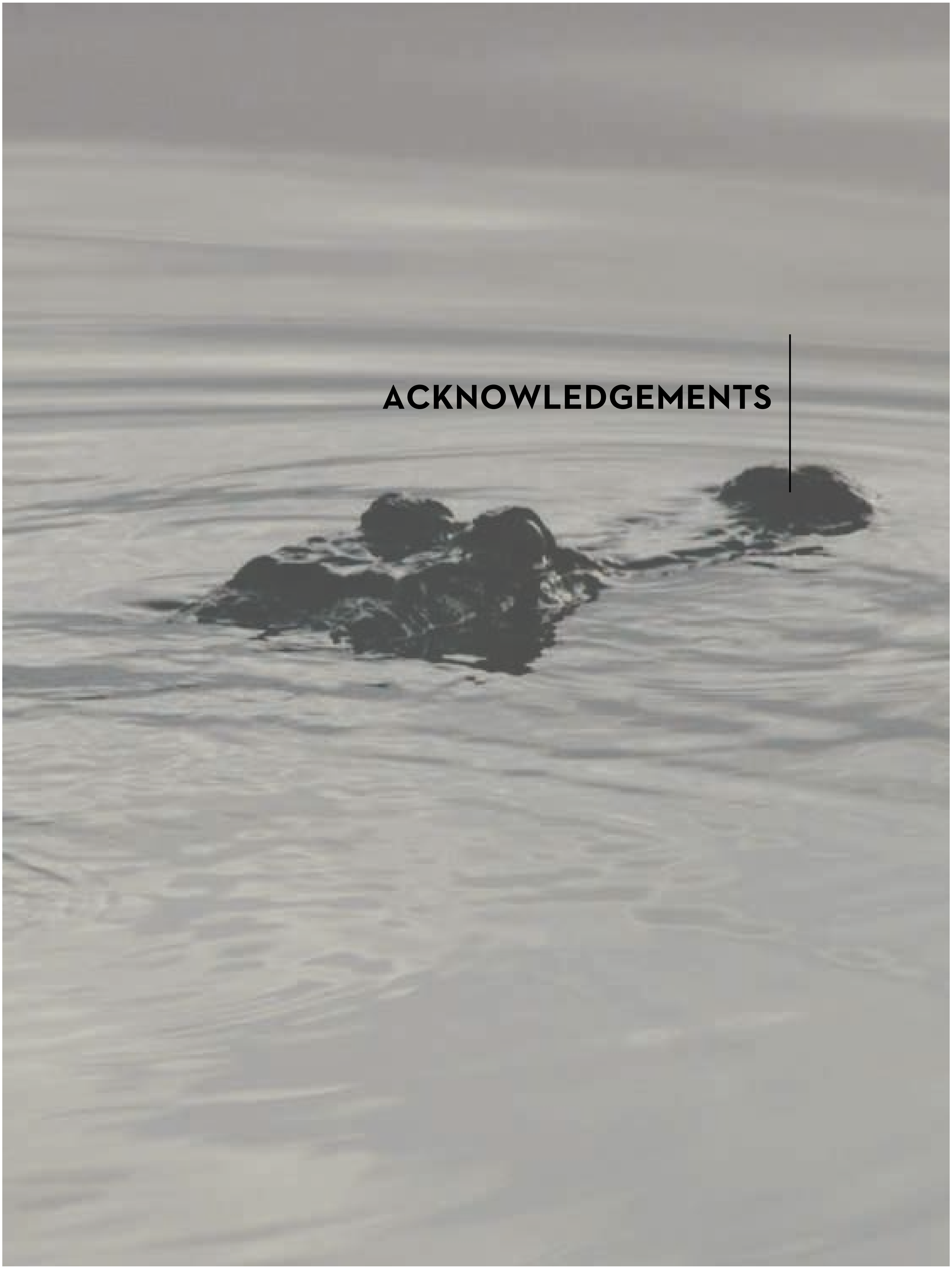
ACKNOWLEDGEMENTS



ACKNOWLEDGEMENTS

In recent years, the Mobile Bay National Estuary Program (MBNEP) facilitated efforts to address problems in watersheds within the Mobile Bay drainage. This involved establishing watershed working groups, which are a coalition of federal, state, and local agencies; county and local governments; property owners; developers; and commercial interests. These entities work together to complete comprehensive watershed management plans (WMP). The Fowl River Watershed is the third watershed within the Mobile Bay system to be evaluated in the past five years. Preparation of this WMP was made possible by collaborative funding provided by the National Fish and Wildlife Foundation (NFWF) through the MBNEP.

Goodwyn, Mills and Cawood, Inc. (GMC) was selected to organize and manage the work of the consultant team. GMC personnel were responsible for helping in the evaluation of watershed problems, developing conceptual management measures to address the issues, and identify possible funding sources to finance implementation of the management measures contained in the WMP. Other members of the Watershed Management Team included the following personnel: Dr. David Tomasko and Doug Robison of Environmental Science Associates (ESA), Dr. Scott Douglass and Dr. Bret Webb of South Coast Engineers (SCE), Jamie Greene and Sarah Kelly of Planning Next, Dr. Eve Brantley and Alex James of the Alabama Cooperative Extension System (ACES), Dr. Just Cebrian and Josh Goff of the Dauphin Island Sea Lab (DISL), Melissa Ruiz and Ken Carper of Stantec, and Dr. Greg Jennings of Jennings Environmental. The consultant team would like to recognize the following individuals, organizations, and agencies that assisted in the conduct of various phases of work on the WMP:

FOWL RIVER STEERING COMMITTEE:

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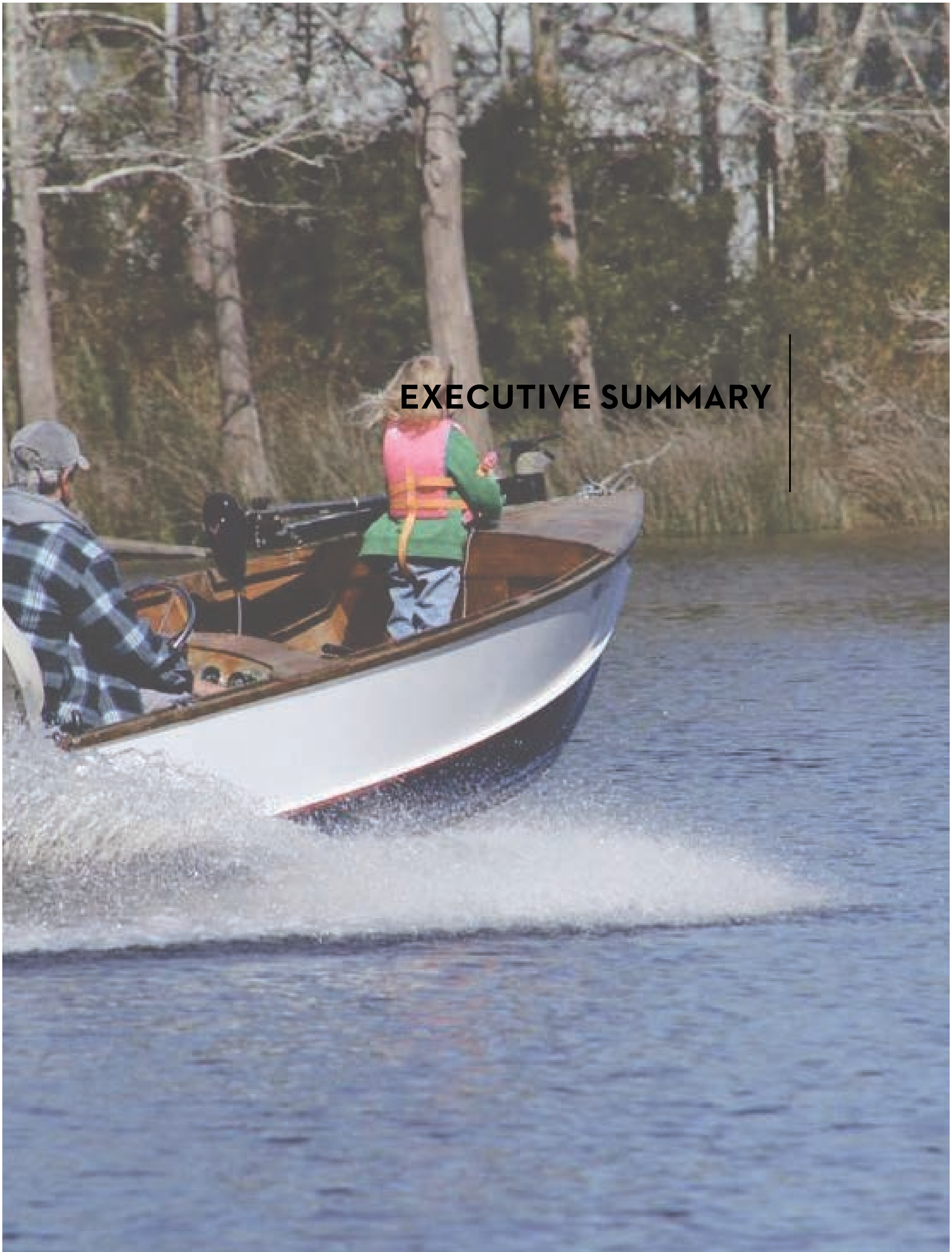
The consultant team would also like to recognize Patti Hurley of the Alabama Department of Environmental Management (ADEM), Marlon Cook of the Geological Survey of Alabama (GSA), the Fowl River Area Civic Association (FRACA), Joyce Nicholas of the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), Dave Armstrong of the Alabama Department of Conservation and Natural Resources (ADCNR), Mobile County, the City of Mobile, Sam St. John, Dr. Judy Stout, the Southwest Alabama Regional Planning Commission, and Brandon Jarvis and John Lehrter of the U.S. Environmental Protection Agency (EPA) for sharing data and research results, and Dr. Maury Estes for providing advice and guidance in the use and interpretation of the land use and land cover database compiled by his research. Finally, the Watershed Management Team wishes to acknowledge the MBNEP staff for their dedicated efforts during the preparation of the WMP.

EXECUTIVE SUMMARY



Source: Sam St. John

EXECUTIVE SUMMARY

In 2014 the Mobile Bay National Estuary Program (MBNEP) contracted with Goodwyn, Mills and Cawood, Inc. (GMC) to prepare a comprehensive Watershed Management Plan (WMP) for the Fowl River Watershed. The Fowl River Watershed is one of several intertidal watersheds along the Alabama coast identified for restoration. This plan will chart a conceptual course for improving and protecting what people living along the Alabama coast value most (Comprehensive Conservation and Management Plan for Alabama's Estuaries and Coast 2013-2018, MBNEP):

- **Water quality:** Identify actions to reduce point and non-point source pollution (including stormwater runoff and associated trash, nutrients, pathogens, erosion and sedimentation) and remediate past effects of environmental degradation thereby reducing outgoing pollutant loads into Mobile Bay, Mississippi Sound, and the Gulf of Mexico
- **Fish:** Identify actions to reduce the incidence and impacts of invasive flora and fauna and improve habitats necessary to support healthy populations of fish and shellfish.
- **Environmental health and resiliency:** Identify vulnerabilities in the watershed from increased sea level rise, storm surge, temperature increases and precipitation and improve watershed resiliency through adaptation strategies.
- **Access:** Characterize existing opportunities for public access, recreation, and ecotourism and identify potential sites to expand access to open spaces and waters within the watershed.
- **Culture and heritage:** Characterize customary uses of biological resources and identify actions to preserve culture, heritage and traditional ecological knowledge of the watershed
- **Shorelines:** Assess shoreline conditions and identify strategic areas for shoreline stabilization and fishery enhancements.

In addition to the six values identified above, this plan provides a strategy for conserving and restoring coastal habitat types that provide critical ecosystem services and are identified by the MBNEP's Science Advisory Committee as most threatened by anthropogenic stressors. These habitat types—freshwater wetlands; streams, rivers and riparian buffers; and intertidal marshes and flats—were classified as most stressed from dredging and filling, fragmentation, and sedimentation, all related to land use change. These habitats and the ecosystem services they provide are related to many, if not all, of the six identified values.

SUMMARY

The Fowl River Watershed encompasses approximately 39,769 acres in southern Mobile County, Alabama. The headwaters of Fowl River begin near Theodore, Alabama and flow south to Bellingrath Gardens where the split between East Fowl River and West Fowl River occurs. East Fowl River flows northeast directly into Mobile Bay, and West Fowl River flows south into Mississippi Sound. Land use and land cover within the Fowl River Watershed is predominantly undeveloped: the five greatest land uses are forests and vegetative cover (37.1 percent), wetlands (29.6 percent), agriculture (17.4 percent), and urban (13.7 percent). Together these five major land use and land cover classifications comprise 97.8 percent of the Watershed.

Although Fowl River is overall a healthy watershed, there are some issues that need to be addressed and monitored. The Watershed Management Team identified nutrient loading, excessive stormwater runoff, and habitat loss as critical issues. Excessive nitrogen and phosphorous loading could have negative impacts on water quality within the streams, rivers, and estuary of Fowl River. PLOAD modeling identified urbanized and agricultural areas within the Watershed as primary sources of nutrients. In addition to nutrient pollution, stormwater management/flood protection was determined to be a critical issue. The causes of large volume stormwater flows are altered hydrology, intense rainfall events, and to a lesser degree, impervious surfaces created by urban development. The loss of wetlands and the channelization/clearing of streams has altered the natural hydrologic regime of the Watershed, which has increased runoff, stormwater flows, and flooding, and negatively affected the water quality of the Watershed. Unless new urban development is properly managed, stormwater runoff will become a greater concern because urbanized land and impervious surfaces increase stormwater runoff.

EXECUTIVE SUMMARY

While best management practices are more routinely utilized today, older developments were not built to the same standards. For this reason, retrofits of existing developments utilizing stormwater best management practices is recommended. In addition, excessive stormwater flows have contributed to habitat loss and shoreline erosion in the lower Fowl River Watershed. The islands, spits, marshes, and shorelines in the lower portions of the Watershed where the environment transitions from a fresh water river system to an estuarine system have been especially hard hit.

Residents of the Fowl River Watershed and other stakeholders were engaged in a public outreach and education effort as part of the WMP process. In addition to the generic purpose and specific goals of the WMP, stakeholders identified the following 16 priority issues: (1) habitat management, (2) habitat protection, (3) litter, (4) erosion and sedimentation, (5) ordinances, (6) sustainable development, (7) citizen participation, (8) shorelines, (9) stormwater management, (10) habitat acquisition, (11) islands, (12) chemical management, (13) signage, (14) enforcement, (15) boat wakes, and (16) recreation.

The Watershed Management Team received 43 reviews of the WMP from individual citizens, government agencies, and non-governmental organizations during the public review period. Overall, the WMP was rated as good to excellent by reviewers. Individual reviews are included in Appendix F.

RECOMMENDED INITIAL MANAGEMENT MEASURES:

The Watershed Management Team, working in cooperation with stakeholders, developed the following management measures to address the purpose of the WMP, specific goals, and priority issues.

1. **Establish a Fowl River Watershed Management Task Force (WMTF)**
2. **Pursue funding opportunities**
3. **Advocate for updating subdivision regulations and encourage retrofitting of existing developments**
4. **Restore and stabilize shorelines in the coastal zone of the Watershed**
5. **Expand and improve safety signage**
6. **Advocate for improved household waste management**
7. **Establish a public outreach and education program**
8. **Emphasize leveraging of funding sources**
9. **Establish a Watershed monitoring program**
10. **Expand habitat conservation**
11. **Engage farmers in improving water quality**
12. **Implement habitat restoration and stormwater project opportunities**

Implementation of the recommended management measures should begin immediately after approval of the WMP. Initial implementation should focus on the most critical issues and the prioritized management measures identified in the WMP. Many of the management measures can occur concurrently as soon as the necessary funding is available.

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Successful implementation of the recommended management measures will require the long-term commitment of significant financial resources and community support. The jurisdictional areas of political entities that might provide funding do not follow or encompass the Watershed boundaries; therefore, a public-private partnership may be the most effective way to accomplish the management goals. To acquire the funding necessary to undertake significant restoration, preservation, and/or management projects, political and private entities will have to consider and compare all available funding options. Many financial assistance opportunities, primarily in the form of federal grants and cooperative agreements, are available to help restore, enhance, and preserve the Fowl River Watershed. However, increases in Watershed recovery efforts by communities around the nation have substantially increased the competition for these resources. The following funding sources were identified and discussed in the WMP, and should all be pursued by the Watershed Management Task Force (WMTF):

- **Water use service fees (i.e., stormwater utility fees);**
- **Property, sales, or other taxes paid into general funds;**
- **Federal grants, loans, and revenue sharing;**
- **"Green" stimulus funding;**
- **Non-governmental organizations/other private funding;**
- **Mitigation banks;**
- **Impact fees;**
- **Special assessments;**
- **System development charges;**
- **Environmental tax shifting;**
- **Capital improvement cooperative districts;**
- **Alabama improvement districts;**
- **Regional collaborative opportunities;**
- **Gulf Coast Restoration Act;**
- **National Fish and Wildlife Foundation (NFWF) Gulf Environmental Benefit Fund (GEBF);**
- **Gulf Coast Conservation Grants Program;**
- **Natural Resources Conservation Service (NRCS) Agricultural Conservation Easement Program (ACEP) and Healthy Forest Reserve Program (HFRP);**
- **Coastal Ecosystem Resiliency Grants Program;**
- **Gulf of Mexico Energy Security Act (GOMESA);**
- **U.S. Environmental Protection Agency (EPA) Healthy Watersheds Consortium Grant; and**
- **U.S. Fish and Wildlife Service (USFWS) National Coastal Wetlands Conservation Grant Program**

EXECUTIVE SUMMARY

RECOMMENDED PROJECT/PROGRAM PRIORITIZATION:

1. Restore and stabilize shorelines in the lower Watershed. Coastal zone projects were prioritized on the basis of threat to the natural resource, cost benefit analyses, and access. A combination of historical aerial imagery available from the University of Alabama, Google Earth's timeline feature, Steering Committee imagery provided by Sam St John and others, and community input all indicate that coastal shorelines are the most threatened. Several priority projects in the lower Watershed were selected based on the severity of the threat, the ability to preserve/protect the habitat, ecological value, and cost (Section 8). The top four priority coastal zone projects include the following:

Priority (Zone)	Location Name	Length (feet)/ Area (acres)	Est. Cost	Brief Description	Location Diagram
1 (I)	Lightcap	1800 / 1.7	$2.1M	Proposed salt marsh enhancement and protection would include structural stabilization, fill, and appropriate vegetation.	
2 (I)	Tapia	2800 / 4.2	$3.2M	Proposed salt marsh enhancement and protection would include structural stabilization, fill, and appropriate vegetation.	
3 (I)	Strout	1300 / 0.8	$1.5M	Proposed spit and salt marsh enhancement and protection would include structural stabilization, fill, and appropriate vegetation.	
4 (1)	Closing Hole	1700 / 3.2	$2.0M	Proposed spit and salt marsh enhancement and protection would include structural stabilization, fill, and appropriate vegetation.	

2. Implement habitat restoration and stormwater project opportunities. Habitat preservation, restoration, and stormwater projects in the upper Watershed are dependent on willing landowners and available funding. Prioritization of these projects in terms of benefit to the Watershed is possible, but cannot be used to determine an order of implementation.

3. Prioritize public outreach and education. Perhaps the most important program will be the public outreach and education initiative. Most of the management measures recommended in the WMP depend on public support and willing participation. Management of any natural resource is enhanced by public understanding, support, and participation of the stakeholders, and the successful implementation of the recommended management measures may not be possible without public education and outreach. A consistent and targeted education and outreach program will raise public awareness and support for the recommended management measures needed to protect and improve the health of the Fowl River Watershed.

SECTION 1.0
Introduction

1

1.0 INTRODUCTION

1.1 WATERSHED MANAGEMENT PLAN OVERVIEW

In 2014, Goodwyn, Mills and Cawood (GMC) was contracted by the Mobile Bay National Estuary Program (MBNEP) through its Project Implementation Committee (PIC), to conduct a comprehensive Watershed Management Plan (WMP) for the Fowl River Watershed located in Mobile County, Alabama. The Watershed is identified by the hydrologic unit code (HUC) 031602050206 and encompasses approximately 39,769 acres within southern Mobile County as shown in **Figure 1.1.** The headwaters of Fowl River begin near Theodore, Alabama and flow south to Bellingrath Gardens where the split between East Fowl River and West Fowl River occurs. East Fowl River flows northeast directly into Mobile Bay, and West Fowl River flows south into Mississippi Sound **(**see **Figure 1.2).**

1.2 WATERSHED MANAGEMENT PLAN PURPOSE

The MBNEP PIC identified three goals in the Comprehensive Conservation Management Plan (CCMP) as part of their five-year strategy (2013-2018): Improve trends in water quality in priority watersheds that discharge into priority fishery nursery areas; improve ecosystem function and resilience through protection, restoration, and conservation of habitats, including beaches, bays, backwaters, and rivers; and restore and/or expand human connections to Alabama's coastal resources.

To achieve these goals, the PIC has identified a need for comprehensive watershed planning within the Mobile Bay estuary. To assist the PIC in achieving this objective, the MBNEP has received funding from the National Fish and Wildlife Foundation (NFWF) Gulf Environmental Benefit Fund to develop a comprehensive management plan for the Fowl River Watershed. The purpose of this plan is to guide watershed resource managers, policy makers, community organizations, and citizens to protect the chemical, biological, and cultural integrity of the Fowl River Watershed, and specifically its waters and habitats supporting healthy populations of fish, shellfish, and wildlife and providing recreation in and on these waters of coastal Alabama.

Although currently only minimally to moderately developed, the Fowl River Watershed is experiencing rapid development as a "bedroom community" for Mobile, Alabama. Increasing population, traffic, and impervious surfaces could have detrimental effects on the health of the ecosystem unless proper planning is performed. Realizing this, the Fowl River Watershed was identified as a high priority for planning to preserve and improve its existing environmental quality.

The purpose of this plan is to guide watershed resource managers, policy makers, community organizations and citizens to protect the chemical, biological, and cultural integrity of the Fowl River Watershed, and specifically its waters and habitats supporting healthy populations of fish, shellfish, and wildlife and providing recreation in and on these waters of coastal Alabama.

FIGURE 1.1: FOWL RIVER WATERSHED GENERAL LOCATION MAP

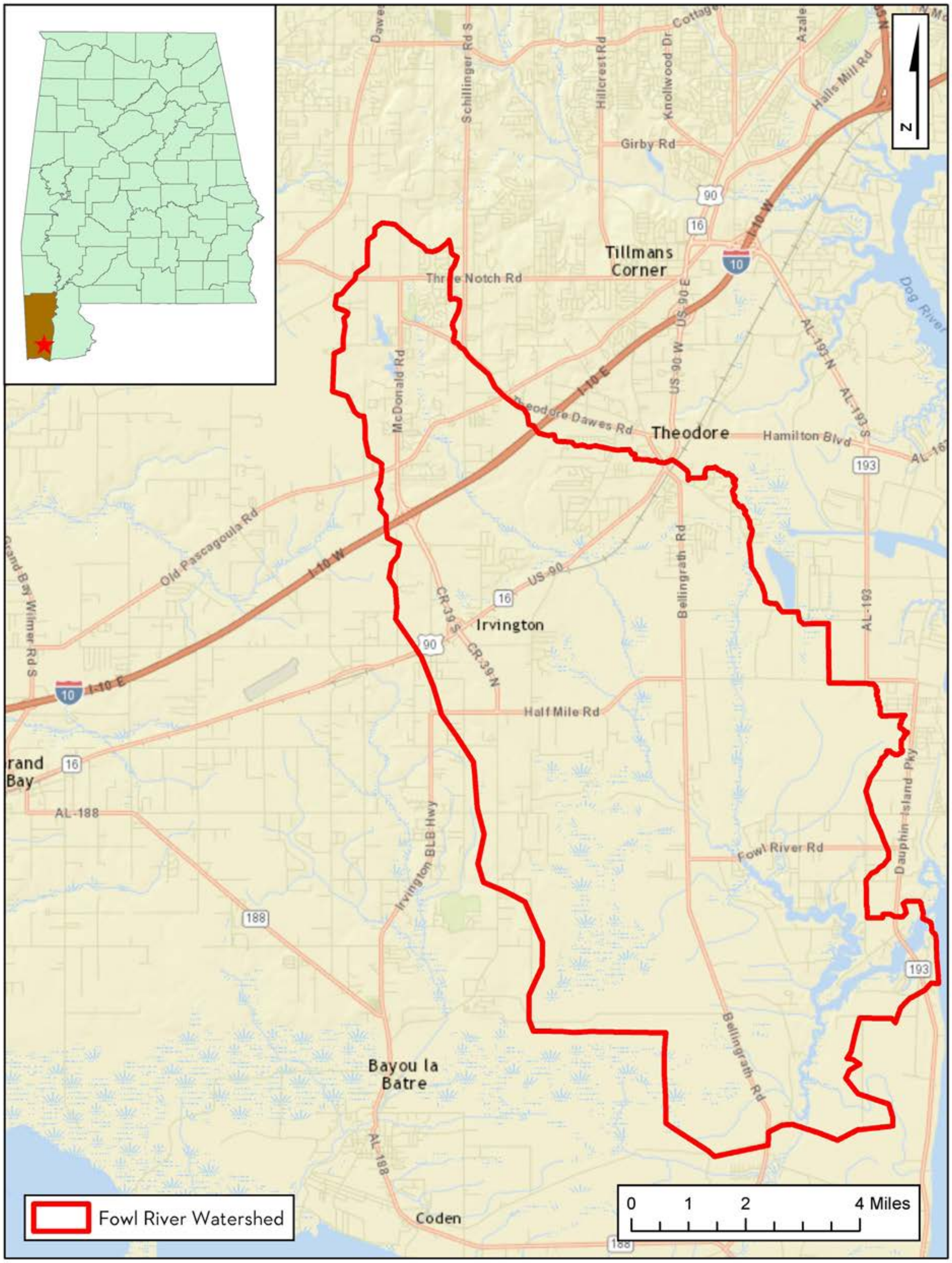
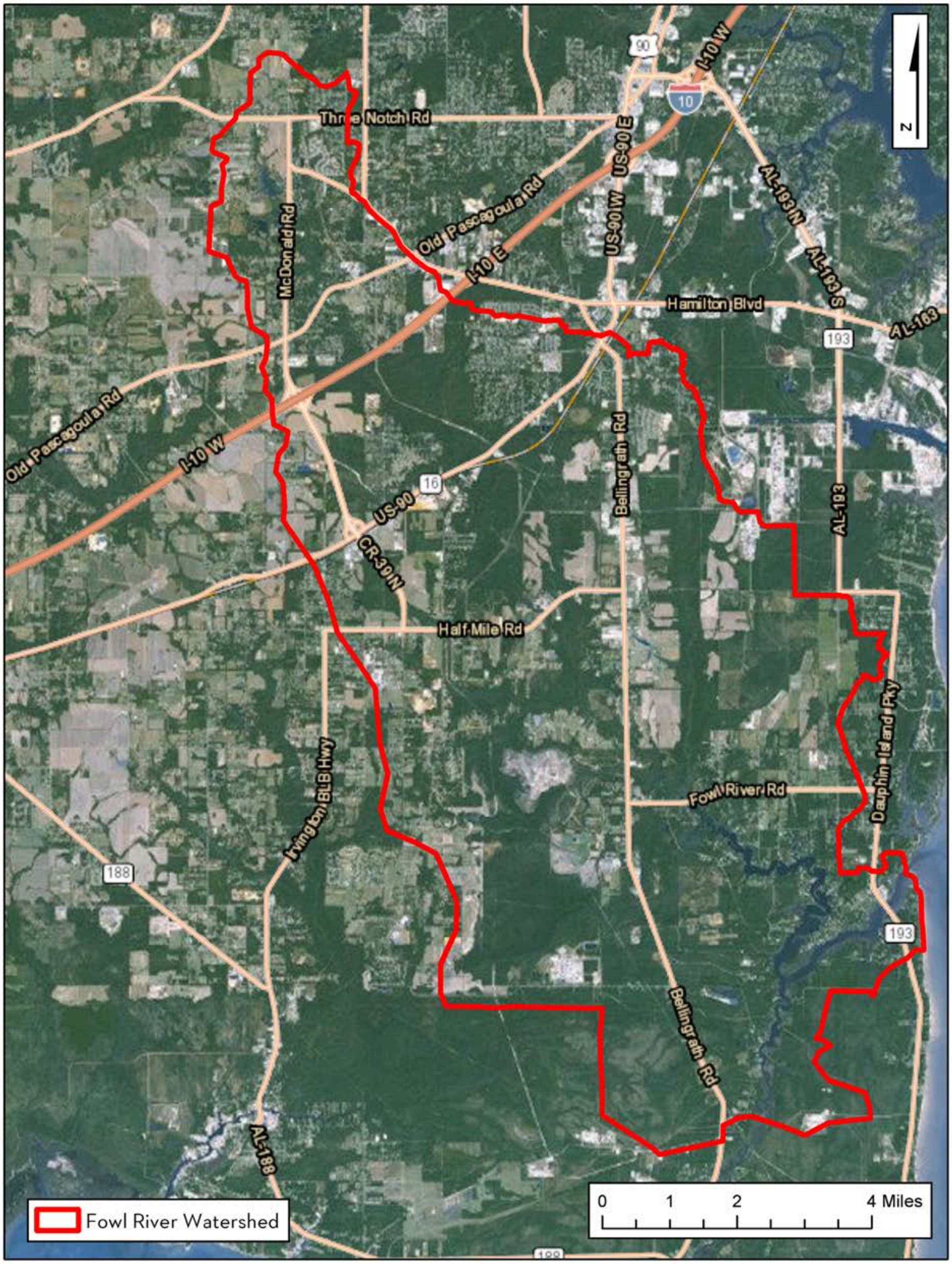


FIGURE 1.2: FOWL RIVER WATERSHED 2013 AERIAL PHOTOGRAPH



EPA's NINE KEY ELEMENTS OF A WATERSHED PLAN

The U.S. Environmental Protection Agency (EPA) has identified nine key elements of watershed planning that are critical for achieving improvements in water quality. These nine elements and their relevant sections in this WMP are as follows:

1. **Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan** (Section 4).

2. **An estimate of the load reductions expected from management measures** (Section 8).

3. **A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in paragraph 2** (Section 6)**, and a description of the critical areas in which those measures will be needed to implement this plan** (Section 5).

4. **Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan** (Section 8, Section 10).

5. **An information and education component used to enhance public understanding of the project and encourage the public's early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented** (Section 8).

6. **Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious** (Section 8).

7. **A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented** (Section 10).

8. **A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards** (Section 4, Section 10).

9. **A monitoring component to evaluate the effectiveness of implementation efforts over time, measured against criteria established under item 8 immediately above** (Section 10).

1.0 INTRODUCTION

1.3 GOALS AND OBJECTIVES

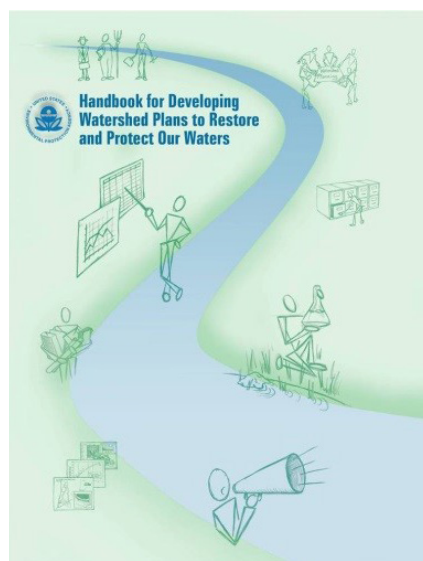
GOALS identified by the MBNEP for the Fowl River Watershed plan are to:

1. **Improve water quality** to support healthy populations of fish and shellfish.
2. **Improve habitats** necessary to support healthy populations of fish and shellfish.
3. **Protect continued customary uses of biological resources** to preserve culture, heritage, and traditional ecological knowledge of the Watershed.
4. **Improve watershed resiliency** to sea level rise and changing climate impacts.
5. **Expand opportunities for community access** to the open spaces and waters of the Watershed.

Source: Sam St. John

OBJECTIVES of Fowl River Watershed planning are to conform to the nine key elements of watershed planning defined by the EPA and are indicated parenthetically below:

1. **Build partnerships,** including identification of key stakeholders and solicitation of community input and concerns.
2. **Characterize the Watershed,** including creation of a natural and cultural resource inventory, identification of causes and sources of impairments, identification of data gaps and estimation of pollutant loads (1).
3. **Set goals and identify solutions,** including determination of pollutant loads needed and management measures to achieve goals (2-3).
4. **Design implementation program,** including schedule, interim milestones, criteria to measure progress, monitoring component, information/education program, and identification of technical and financial assistance needed to implement plan (4-9).



The EPA Handbook for Developing Watershed Plans to Restore and Protect Our Waters
water.epa.gov/polwaste/nps/handbook_index.cfm

1.4 STEERING COMMITTEE

A Steering Committee comprising diverse stakeholders was established to guide the planning process. This group represented a cross-section of the community and included residents from different geographic locations across the Watershed as well as representatives from businesses, civic groups, environmental organizations, and government agencies. The Committee acted as a working group serving as advocates and helped to make recommendations about the process and the substance of the vision.

The Fowl River Watershed Steering Committee was established to be a working group with a number of critical responsibilities related to 1) the planning process and 2) development of recommendations for the plan. These responsibilities include:

- Attend monthly committee meetings (12-month project anticipated).
- Represent residents and other stakeholders in the planning process.
- Provide guidance and direction to the staff and consultants.
- Act as spokespersons for the planning effort.
- Serve as hosts at public events during the process.
- Identify volunteers to support the process (i.e., distributing promotional materials, serving on outreach sub-committees, etc.).
- Volunteer to assist with community meetings.
- Disseminate information during the planning process (using individual networks).
- Participate in formalizing and presenting the recommendations.
- Serve as stewards of the WMP once it is adopted.

FOWL RIVER STEERING COMMITTEE MEMBERS:

Johnnie Adams
Kelley Barfoot
Richard Becker
Jack Boatman
Casi Callaway
Jerry Carl
Richard Craig
David Evans
Elizabeth Evans
Julius Foster
Frank Gardner
Ken Granger
Gene Grantham
Rose Grantham
Steve Green
Rob Harris
Ted Henken
Brian Hewes
Bill Hightower
Jeremiah Kolb
Greg Landry
Belinda Lott (Co-chair)
Lamar Lott
Nayyer Mahdi
Ray Mayhall (Co-chair)
Cindy McLendon
Christian Miller
Coy Morgan
Joyce Nicholas
Barbara Nolan
Stan Nolan
Matt Orrell
Bruce Pfeiffer
Jon Porthouse
Ray Richardson
Ronald Rowell
David Sessions
Randy Shaneyfelt
Sam St. John
Judy Stout
Roberta Swann
Bonnie Tully
Oliver Washington
Harold White
Bill Withers
Jenny Zimlich

SECTION 2.0
Public Participation and Education

2

2.0 PUBLIC PARTICIPATION AND EDUCATION

2.1 STAKEHOLDER INVOLVEMENT

Stakeholder involvement was important to the creation of the Watershed Management Plan (WMP) because it allowed the community to share its aspirations for the future. This is critical to generating a shared understanding about the value of the plan, informing its priorities, and providing the broad base of support necessary to ensure its implementation. Stakeholder involvement included leadership from a Steering Committee that guided the process from start to finish and input from the general public through workshops, a survey, and an open house.

It was important to the Steering Committee to establish an identity for this effort. The "Fowl River Forever - safeguarding our watershed for future generations" logo, shown in **Figure 2.1**, was created and used in all marketing and/or outreach efforts.

Fowl River FOREVER safeguarding our watershed for future generations

Figure 2.1: Fowl River Forever logo

2.2 COMMUNITY WORKSHOPS

Two workshops were held in two different areas of the Watershed (but covering the same content) on February 24 and 26, 2015 at St. Rose of Lima Church and Theodore High School, respectively. The purpose of the workshops was to create a shared understanding about the condition of the Fowl River Watershed and to share ideas about what will make it better.

2.2.1 Outreach and Publicity

The Mobile Bay National Estuary Program (MBNEP) staff, Watershed Management Team and Steering Committee pursued a comprehensive outreach and publicity plan for the workshops in an effort to attract a wide range of interested individuals. Outreach and publicity efforts included the following:

- Establishment of a website (fowlriverforever.org)
- Distribution of print collateral (project business cards, rack cards, etc.)
- Promotion on the MBNEP website
- Production and distribution of a video commercial
- Printed messages on water bills
- Advertisement on a prominently-located billboard on Highway 90, shown in **Figure 2.2**
- Advertisement on a prominently-located digital billboard managed by the Fire Department
- Display of banners at marinas
- Email blasts to lists from relevant area organizations
- Social media posts of relevant area organizations
- Requests to local school principals to include a message in their regular "robocalls" to parents
- Promotion through church bulletins
- Promotion through online media (AL.com, NextDoor.com)
- Local radio and television news interviews (WKRG TV5, Fox10)

Figure 2.2: Fowl River Forever billboard advertisement on Highway 90

Figure 2.3: Community involvement table discussions

Figure 2.4: Community involvement mapping exercise

2.2.2 Workshop Program

Workshop participants learned about watershed planning and components of the scientific research being conducted on the River's water quality. They were invited to engage in two activities related to the future of the Watershed. The first consisted of small group conversations, shown in **Figure 2.3**, prompted by the question, "What needs to be done to make the Fowl River Watershed better?" with leaders at each table recording the responses. The group discussions were followed by a mapping exercise, as seen in **Figure 2.4**, during which individuals were asked to identify strong and weak areas across the Watershed.

2.2.3 Results

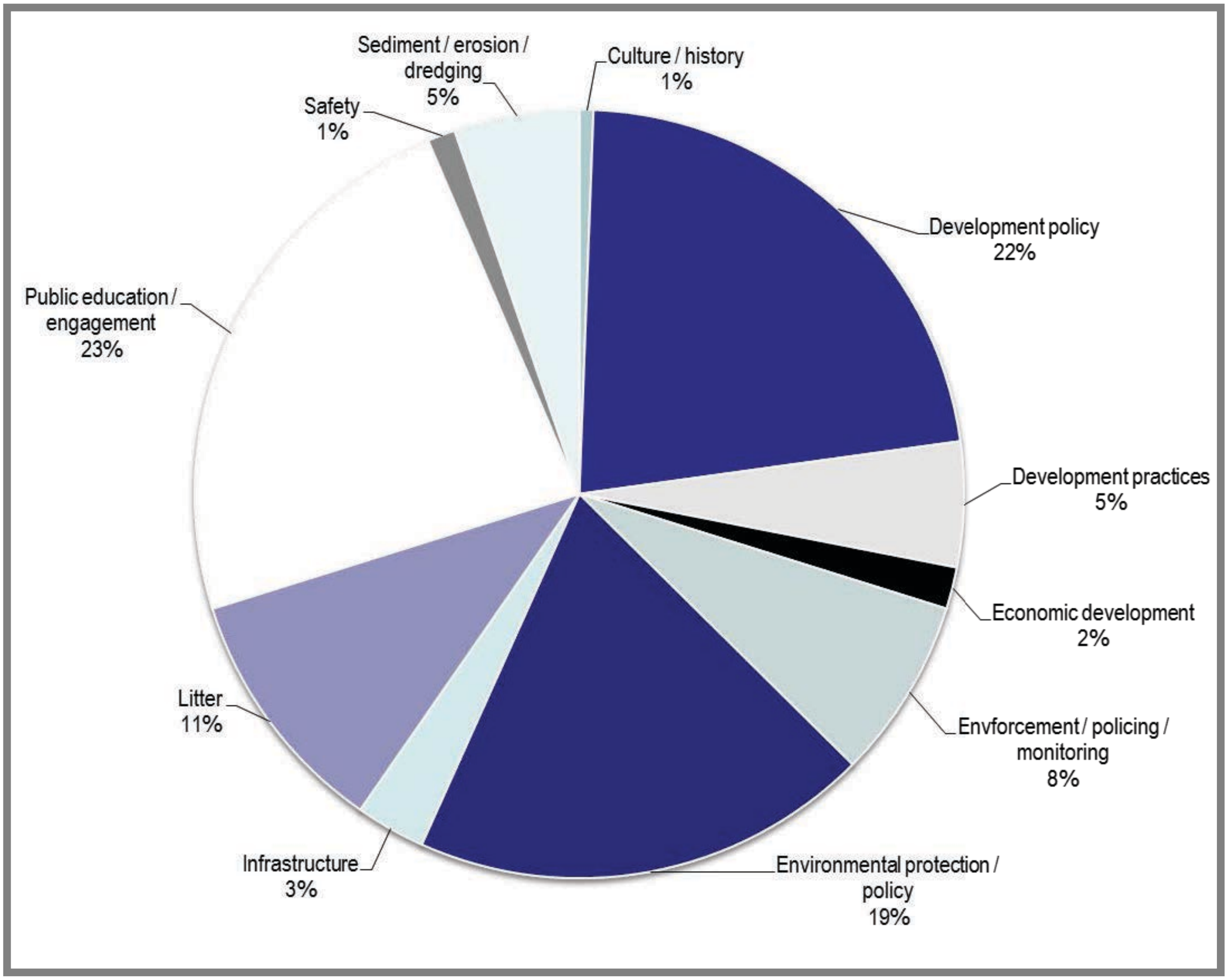
An estimated 140 people attended the two workshops, at which approximately 200 ideas were recorded, spanning a wide range of topics. **Figure 2.5** is a visual depiction of the topics shared, with the larger words representing issues mentioned most frequently among the comments.

Figure 2.5: Topics raised at community involvement meetings

2.0 PUBLIC PARTICIPATION AND EDUCATION

The responses were organized into similar categories and graphed to depict the issues most important among stakeholders. As **Figure 2.6** illustrates, 23 percent of the responses fell within the **public education/engagement** category, followed by 22 percent of the responses concerning the **development policy**. These two categories accounted for 45 percent of all responses. Continuing with the results, 19 percent of the responses addressed the **environmental protection/policy,** 11 percent pertained to **litter,** and 8 percent pertained to **enforcement/policing/monitoring.** The **sediment/erosion/dredging** category and the **development practices** category each accounted for 5 percent of the responses. Lastly, the **infrastructure** category accounted for 3 percent of the responses, the **economic development** category accounted for 2 percent, and the **safety** and **culture/history** categories each accounted for 1 percent of responses collected from the meetings.

Figure 2.6: Graphical depiction of stakeholder responses by category



2.0 PUBLIC PARTICIPATION AND EDUCATION

2.3 ONLINE SURVEY

In addition to public workshops, the Fowl River Steering Committee advertised and provided an online survey to stakeholders in the Watershed (see **Figure 2.7**).

Survey participants were asked to consider 16 categories and rate the importance of each as it applied to them. The 16 categories and their definitions were as follows:

1. CITIZEN PARTICIPATION: Specific activities or events to engage the public to get involved in the care and long-term protection of the Fowl River Watershed. What better group to get involved than those that live, work and play within the Watershed and call it home? Activities could include organized clean-ups, kayak trips, tree plantings, etc.

2. EROSION/SEDIMENT MANAGEMENT: A natural process that transports soil/sediment from one location to another. Rainfall/surface runoff, tidal currents/waves, flood events, soil conditions, topography, and vegetative cover are all factors affecting erosion. In addition, human activities can significantly increase erosion rates and are factors that can be best managed. Best management practices (BMPs) are erosion control measures implemented to control erosion during construction or at sites of active erosion to limit sediment discharge into local waterways.

3. RECREATION: Many people (residents and non-residents) enjoy spending time boating, skiing, swimming, fishing, bird watching, etc., within the Watershed. We want to ensure Fowl River remains a location that provides public access opportunities for future generations.

4. SIGNAGE: Signs are used to provide information to the public. Public input identified the following signage needs: notification of safety concerns, navigational signs along the River and tributaries, educational signs about watershed management, signs notifying the public when they enter the Fowl River Watershed, etc.

5. HABITAT MANAGEMENT: This includes preservation and restoration of critical areas to maintain or enhance the living resources of the Watershed. These activities include shoreline protection, wetland and stream restoration/preservation, tree plantings, invasive species control, installing osprey platforms, remediation of bulkheads, etc.

Figure 2.7: Fowl River Watershed online survey

6. ISLANDS: Many islands throughout the southern portion of the Watershed (along the River) have experienced significant erosion and habitat loss. Aerial photographs show these islands are becoming submerged and are disappearing. This loss can be attributed to upstream development, sea level rise, boat wakes, etc.

7. PROTECTION: This item is closely related to habitat management. Critical habitats exist within the Fowl River Watershed, and active management (proper restoration and preservation) will protect water quality and prevent key habitat loss or degradation.

8. ACQUISITION: Critical habitat areas around Fowl River can be purchased and placed in long-term conservation easements to ensure no future development will occur. Strategic land acquisition will allow these areas to remain preserved and can help balance development activities.

9. SHORELINE RESTORATION: Fowl River has more than 47 miles of shoreline. Land use changes, boat wakes, and sea level rise have stimulated erosion and habitat loss. Restoration and protection of these areas will allow for long-term habitat management for species that exist within interfaces between land and water.

10. LITTER/RECYCLING/WASTE: Litter and household trash along the roadways finds its way into the streams, River, and, ultimately, Mobile Bay. Education programs, public clean-ups, ordinances, and waste management programs can help reduce the litter/waste throughout the Watershed.

11. ORDINANCES: Ordinances are related to a suggested change of a law set forth by a governmental authority or a municipal regulation to increase stormwater management and erosion/sedimentation controls.

12. SUSTAINABLE DEVELOPMENT: Sustainable development encourages the implementation of wise building practices to limit impacts on the natural environment in the Fowl River Watershed. Many of these practices manage stormwater in a manner that limits downstream impacts to habitat and water quality. Development will increase in the Watershed, but proper water management techniques, erosion control, and other targeted actions can minimize the ecological impact.

13. BOAT WAKES: Boats moving through the water create waves or wakes that impact shorelines. This repeated impact damages critical coastal habitat.

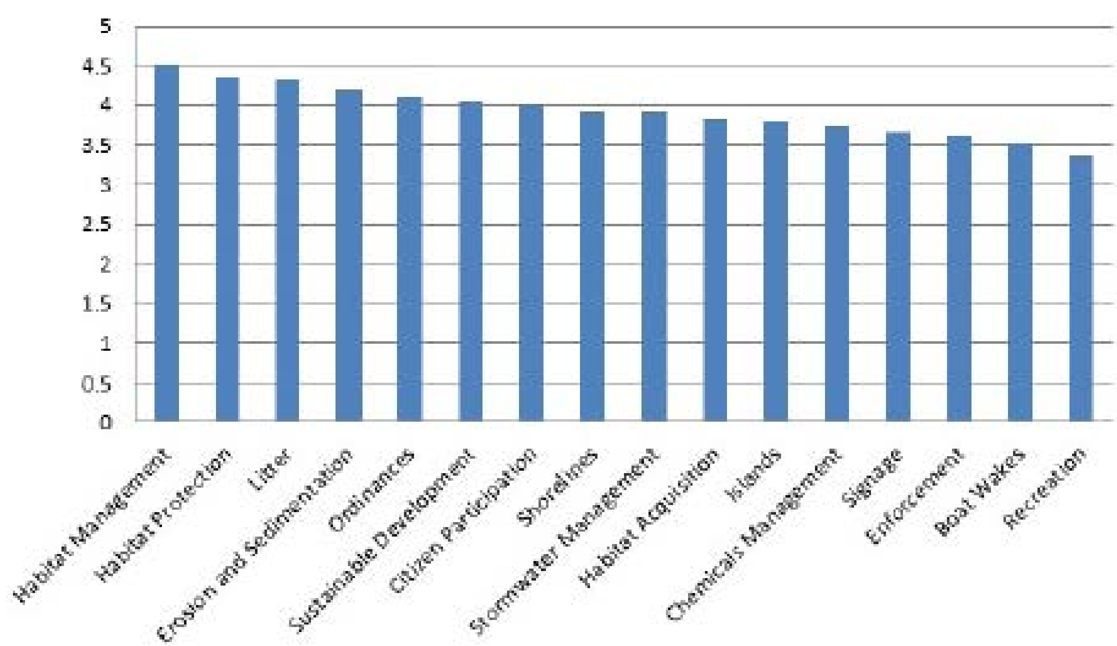
14. ENFORCEMENT: Enforcement is related to effective regulatory oversight and compliance to stormwater management and development regulations.

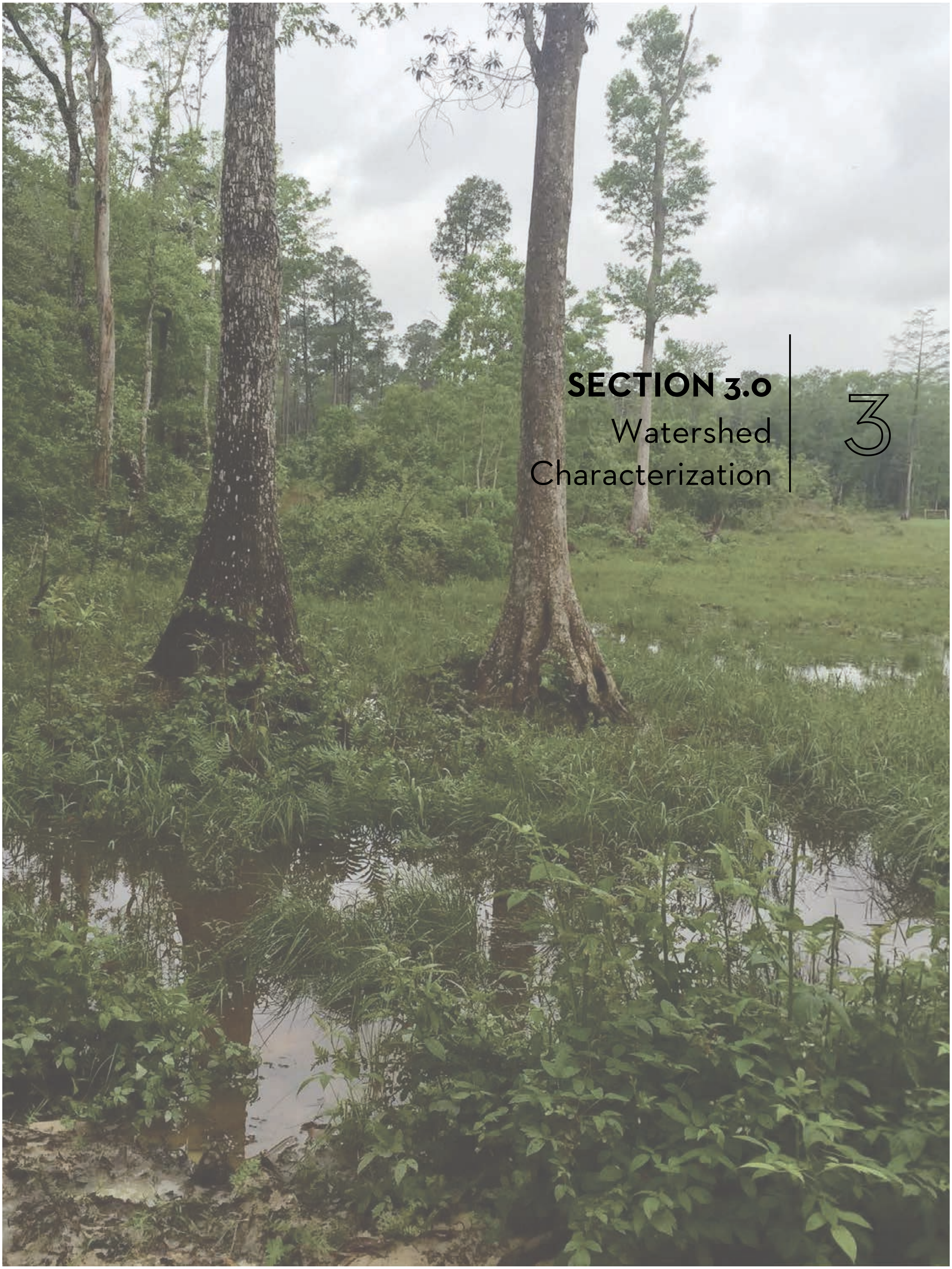
15: CHEMICALS MANAGEMENT: Chemicals (herbicides/fertilizers) are used by residents, cities, and counties to promote or control (grass killer/defoliants) grasses. These efforts could potentially kill grasses and shrubs/trees and result in increased erosion along road right-of-ways.

16. STORMWATER: In one of the wettest climates in the U.S., rain causes surface water movement down and through the Watershed. Stormwater can either soak into the soil, pool on the surface until it evaporates, or be transported into nearby streams, rivers, and ultimately Mobile Bay. Proper stormwater management helps to reduce runoff, control flooding, minimize water pollution, reduce erosion, and balance the flow of water throughout the Watershed.

Participants were asked to rank the level of importance for each of the 16 categories (1 = lowest; 5 = highest) from their individual perspectives. Most respondents felt that habitat management and habitat protection were critical to proper management of the Watershed. The small spread in rankings suggests that respondents felt strongly about the importance of each category. The results of the survey are shown in **Figure 2.8.**

Figure 2.8: Online Survey Results





SECTION 3.0 Watershed Characterization

3

3.0 WATERSHED CHARACTERIZATION

3.1 WATERSHED BOUNDARY

The Fowl River Watershed lies within southeastern Mobile County. The Watershed drains southeast into southwestern Mobile Bay. Previous publications (USDA 1995; ADEM, 2006) using the U.S. Geological Survey (USGS) Hydrologic Unit Code (HUC) 12 Watershed map list the area of the Fowl River Watershed as 52,782 acres. For the purpose of this study, the watershed boundary was reevaluated utilizing LiDAR data and field reconnaissance. The field-checked watershed boundary, shown in **Figure 3.1** along with the USGS HUC 12 Watershed map, encompasses approximately 39,769 acres, or 62 square miles (DISL and Stantec, 2015).

3.2 GEOLOGIC SETTING

3.2.1 Physiographic Provinces

The Watershed lies within parts of two physiographic districts: the Southern Pine Hills and the Coastal Lowlands. The Southern Pine Hills is an upland area (Sapp and Emplaincourt, 1975). The Coastal Lowlands is a flat to very gently undulating area that is locally swampy. Many streams are tidally influenced. The landward edge of the Coastal Lowlands, the boundary with the Southern Pine Hills, is defined by the Pamlico marine scarp at an elevation of approximately 25-30 feet (Sapp and Emplaincourt, 1975).

3.2.2 Geology

Two geologic units underlie the Fowl River Watershed. Most of the northern and western portions of the Fowl River Watershed are underlain by the Citronelle Formation (Szabo and Copeland, 1988). The Citronelle Formation is primarily composed of brown, red, and orange sand. Locally-gravel beds and gray, orange, and brown lenses of sandy clay also occur. The southeastern two-thirds of the Watershed is underlain by coastal deposits and alluvium. These sediments consist of white, gray, orange, and red sand with gravel and sandy clay.

3.2.3 Soils

The geologic sediments underlying the Fowl River Watershed have developed into numerous soil types. Soils are grouped into soil associations and complexes (see **Figure 3.2**). A soil association is made up of soil types that are geographically associated and are shown as one unit on a map (Hickman and Owens, 1980).

TABLE 3.1: STATISTICAL DATA FOR FOWL RIVER AT HALF MILE ROAD NEAR LAURENDINE, AL

Period of record: March 1995 - current year

Drainage area (square miles)	16.5
Peak flow (cubic feet per second)	6,940
Greatest mean daily flow (cubic feet per second)	2,480
Average annual flow (cubic feet per second)	41.3
Lowest mean daily (cubic feet per second)	11
Annual runoff (inches)	34.03

Source: U.S. Geological Survey

Soil associations have regularity in geographic pattern and in the kind of soil that is present. A soil complex consists of two or more soil types that are intermixed and cannot be shown separately on a map.

There are five major soil associations present in the Fowl River Watershed. Soils developed from the Citronelle Formation include the Troup-Heidel-Bama and Notcher-Saucier-Malbis soil associations. These soils are nearly level to undulating, well drained, with loamy subsoils. Soils present in the Watershed that developed from the coastal deposits and alluvium include the Dorovan-Johnston-Levy, Bayou-Escambia-Harleston, and Axis-Lafitte soil associations. The Dorovan-Johnston- Levy soils are nearly level, very poorly drained, and mucky and loamy and contain thick deposits of organic residues and alluvial sediments on bottomlands. The Bayou-Escambia- Harleston soils are nearly level to gently undulating, poorly to moderately well drained, with loamy subsoils. The Axis-Lafitte soils are nearly level, very poorly drained formed from loamy marine sediments and the organic debris from decayed plants in the coastal marshes. Each soil association contains multiple soil types. Soil types are described in detail in the Soil Survey of Mobile County, Alabama publication (USDA, 1980).

FIGURE 3.1: FOWL RIVER WATERSHED BOUNDARY

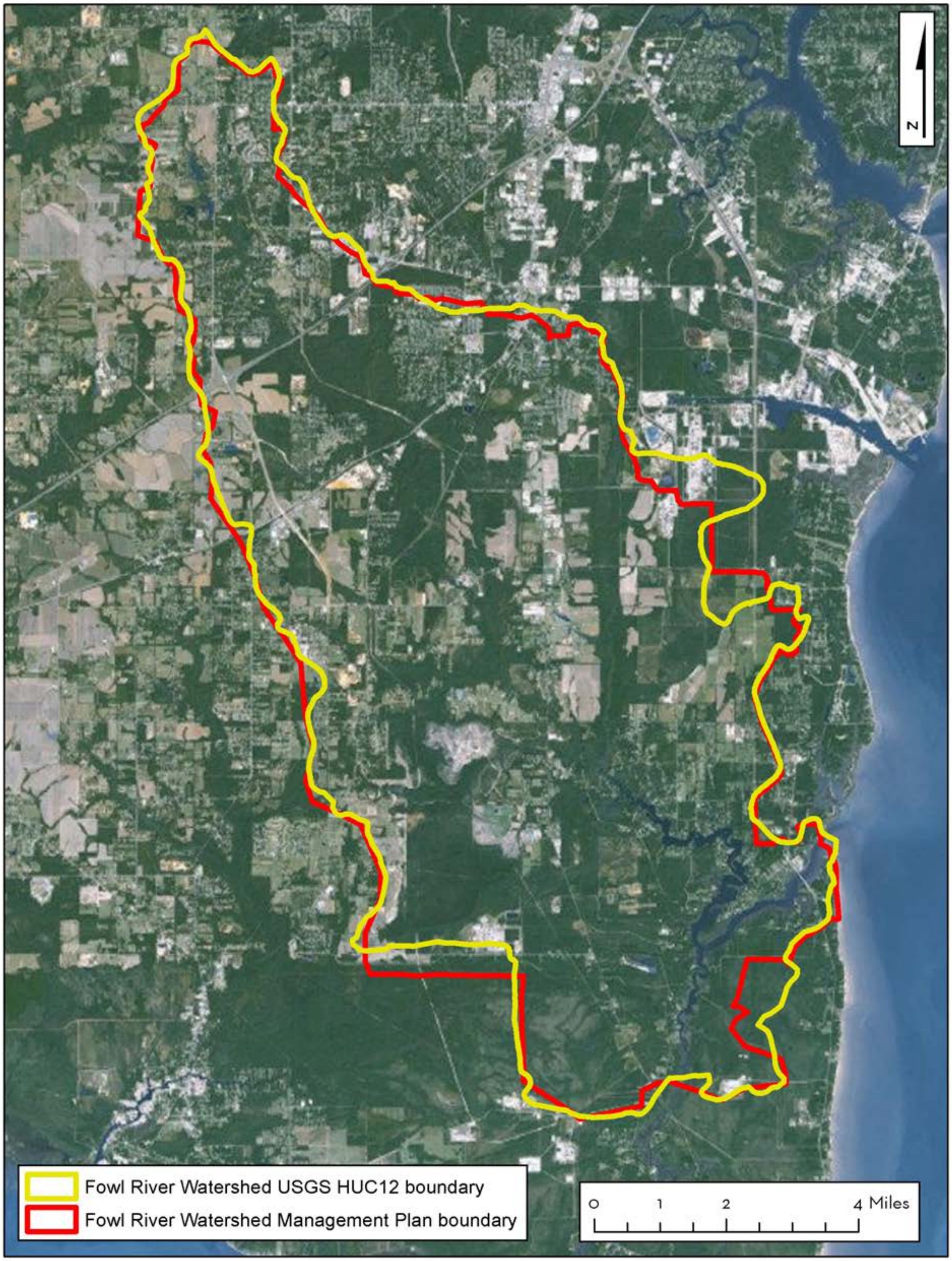
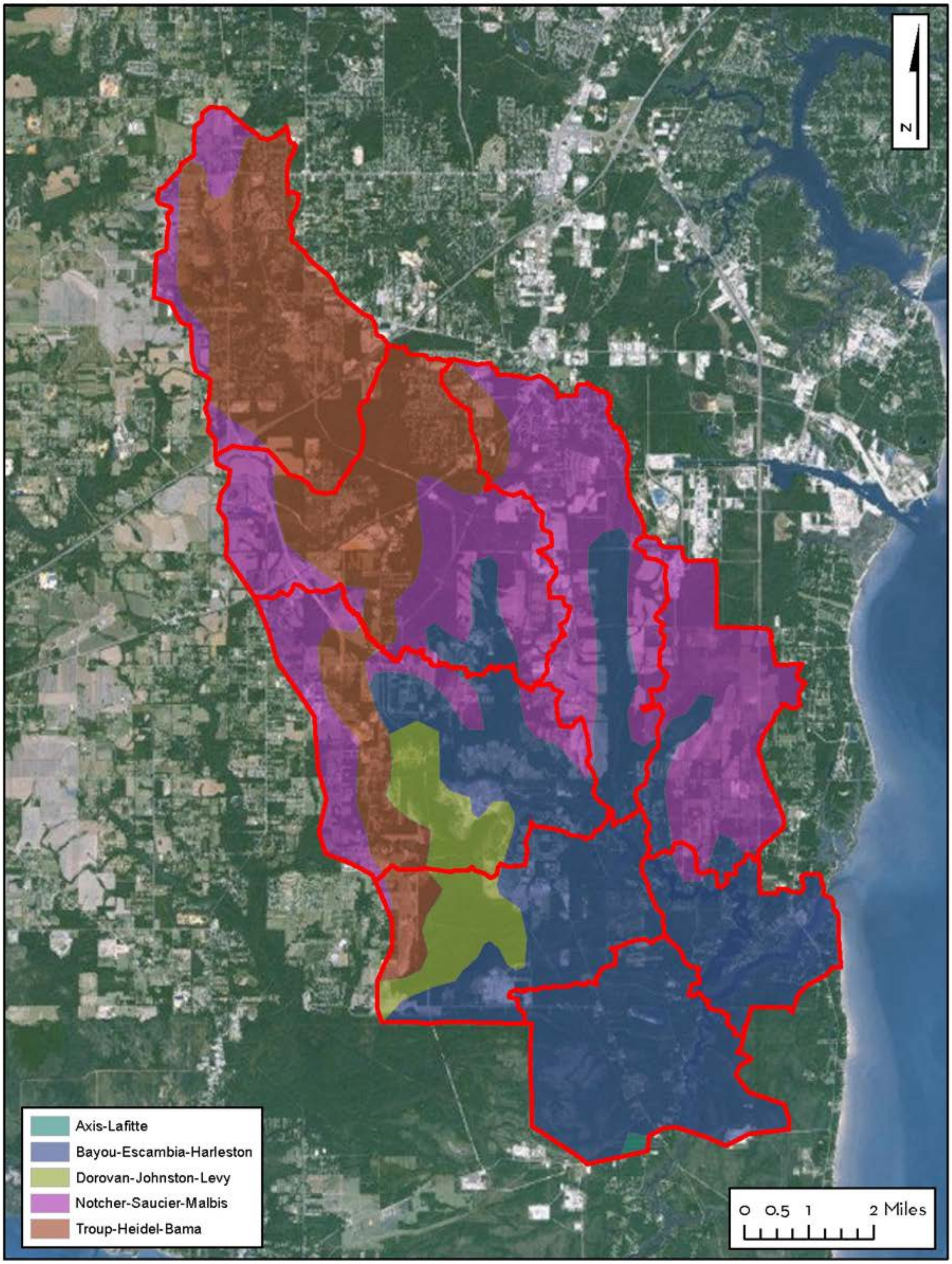


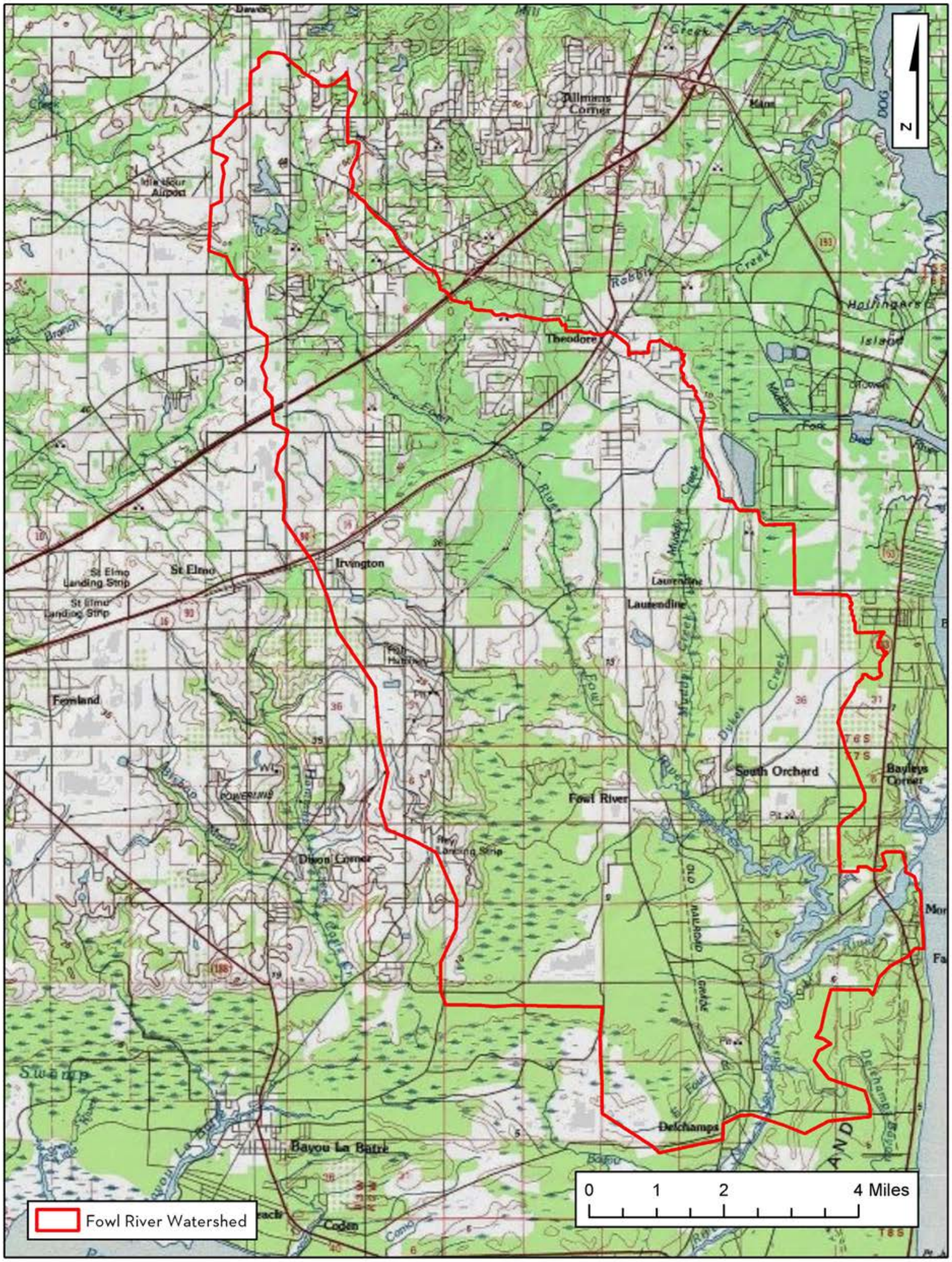
FIGURE 3.2: FOWL RIVER WATERSHED SOIL MAP



3.2.4 Topography

From its origin to its confluence with East Fowl River, the relief along Fowl River is less than 150 feet, as shown in the topographic map in **Figure 3.3**. The majority of that relief occurs in the upper third of the Watershed within the Southern Pine Hills physiographic district. Most tributaries to Fowl River originate in the Southern Pine Hills. Tributary drainages are well-defined within the Southern Pine Hills district because of its greater topographic relief, but become ill-defined with indeterminate channels as they flow across the Coastal Lowlands district. The gentle topography and abundant rainfall create extensive floodplains and wetland areas along the tributaries and the main stem of Fowl River.

FIGURE 3.3: FOWL RIVER WATERSHED TOPOGRAPHIC MAP



3.3 HYDROLOGY

3.3.1 Rainfall and Climate

Mobile County has a hot, subtropical climate with abundant rainfall. Rainfall and climate data from March 1900 through April 2012 are available from the Southeast Regional Climate Center database for the Mobile WSO Airport, Alabama (weather station 015478). Precipitation within the Fowl River Watershed is usually in the form of showers with long periods of continuous rain being rare. Exceptions occur during tropical storms and hurricanes, when rainfall may be long and intense. Thunderstorms may occur at any time of the year. Annual rainfall totals for the last seven years are shown in **Table 3.2**. Precipitation has exceeded 10 inches during at least one month every year for the past seven years.

Average annual precipitation at the Mobile WSO Airport is 65.29 inches. Of that, snow accounts for less than half an inch. Average monthly precipitation ranges from 2.93 inches in October to 7.53 inches in July. Rainfall is only slightly seasonally distributed. October and November are the only months when rainfall averages less than 5 inches. The months of March and July through September all average greater than 6 inches of rainfall per month. Monthly mean maximum temperatures range from 91 degrees Fahrenheit (°F) in July to 60.9°F in January. Monthly mean minimum temperatures range from 72.9°F in July to 40.8°F in January. The lowest temperature recorded was 3°F on January 21, 1985. The highest temperature recorded was 104°F on July 25, 1952.

TABLE 3.2: MONTHLY PRECIPITATION DATA AT THE MOBILE AIRPORT WSO (Station No. 015478)

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Year	**Precipitation in inches**												
2009	3.54	3.81	**12.34**	1.73	5.29	2.45	5.68	**10.18**	6.69	4.91	4.48	**15.37**	76.47
2010	**11.03**	5.51	4.06	1.72	8.98	3.45	4.42	7.25	2.06	4.08	5.92	1.39	59.87
2011	3.38	2.94	4.74	1.02	0.42	1.85	8.92	6.49	**15.80**	0.09	2.89	1.88	50.42
2012	2.24	7.25	6.69	2.51	7.82	**13.50**	6.74	**13.12**	4.13	0.19	1.43	3.48	69.1
2013	2.87	**11.31**	0.80	5.48	7.99	4.20	9.10	9.95	4.59	2.19	3.43	7.37	69.28
2014	2.92	4.20	6.50	**18.09**	9.79	5.15	7.92	2.83	5.53	3.03	1.48	5.27	72.71
2015	3.89	2.16	*3.96	***13.90**	*8.05	*5.06	*6.84	*3.21	*9.88	*6.69	*5.35	***12.38**	*81.37

blue = precipitation exceeding 10 inches; *preliminary data subject to revision

3.3.2 Surface Water Resources

Fowl River originates in south central Mobile County, and flows south and east for approximately nine miles to its confluence with East Fowl River. Fowl River has only two named tributaries: Muddy Creek and Dykes Creek, both located in the central portion of the Watershed. Muddy Creek originates east of Bellingrath Road about two miles north of Laurendine Road. It travels almost due south about 4.5 miles to its junction with Fowl River at Fowl River Road. Dykes Creek originates less than a mile east of Muddy Creek and about two miles north of Fowl River Road. It travels south and west about 2.5 miles to its confluence with Fowl River about 0.5 miles south of Fowl River Road.

The U.S. Geological Survey (USGS) operates a continuous surface water discharge gage on Fowl River at Half Mile Road near Laurendine, Alabama (station number 02471078, period of record March 1995 to current year shown in **Table 3.1**). The drainage area of Fowl River at this location is 16.5 square miles (10,560 acres). Annual average flow during that time was 41.3 cubic feet per second (308.9 gallons per second). Monthly average flows varied from a low of 32.3 cubic feet per second in December to a high of 55.4 cubic feet per second in July. The lowest daily mean measured was 11 cubic feet per second on August 30, 2000; and the greatest daily mean measured was 2,480 cubic feet per second on April 1, 2005. Maximum peak flow was 6,940 cubic feet per second on July 19, 1997.

The relative permeability of the sediments in the Fowl River Watershed allows rapid infiltration of rain water. Annual estimated runoff at the USGS gage on Fowl River is approximately 34-inches. The balance of the annual average precipitation (65 – 34 = 31-inches) enters the underlying aquifers as recharge, or is returned to the atmosphere via evaporation and transpiration of trees and other plants. Some shallow ground water flows towards and discharges to the nearest body of surface-water. This ground-water seepage is included in the estimated 34-inches of runoff. Some ground-water moves deeper into the subsurface to recharge the aquifers underlying the Watershed.

The USGS collected limited water quality data on a sporadic basis for Fowl River at Half Mile Road near Laurendine, Alabama from 1966 to 2005. The specific conductance of the water was uniformly less than 75 uS/cm, indicating that the River water at that point is not brackish or influenced by saltwater intrusion. Water temperature is a major influence on water quality metrics such as dissolved oxygen (DO), biological oxygen demand (BOD), and bacteria concentrations. Average water temperatures for Fowl River at that location, by month, are listed in **Table 3.3.**

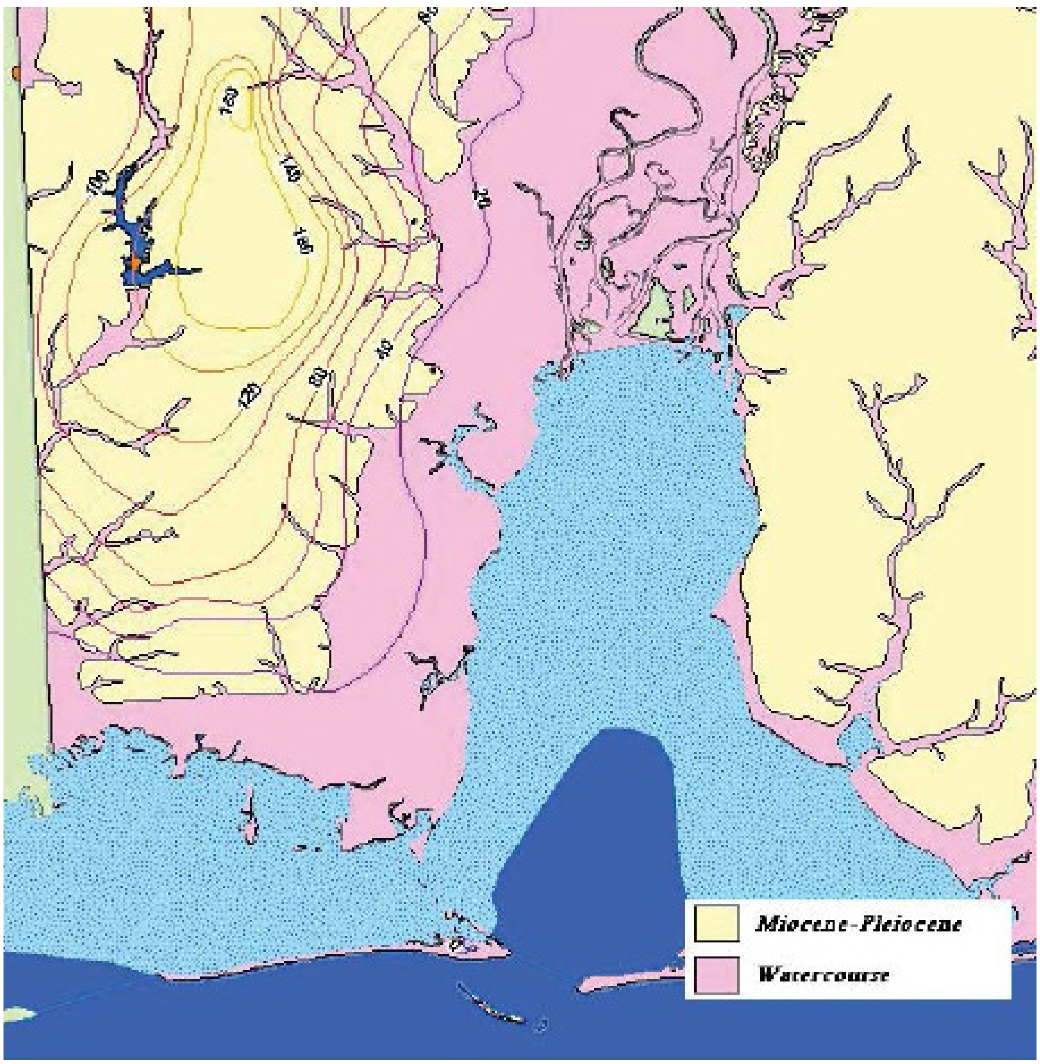
TABLE 3.3: WATER TEMPERATURE OF FOWL RIVER AT HALF MILE ROAD NEAR LAURENDINE, AL

Month	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Average temperature (°F)	58.1	59.0	62.24	61.0	73.3	73.0	75.9	75.6	75.2	67.1	64.8	58.1
Count	4	2	4	4	5	6	4	2	3	5	3	6

3.3.3 Ground Water Resources

The Fowl River Watershed is underlain by a thick sequence of consolidated and unconsolidated sediments to depths in excess of 15,000 feet (Davis, 1987). The near-surface sediments are part of the Tertiary and Quaternary Systems (**Figure 3.4**). They are primarily composed of sand, silt, clay, and gravel. Along the coastal margins recent alluvial and marine sedimentary deposits of sand and gravel comprise the alluvial-coastal (USGS) or Watercourse (Geological Survey of Alabama, GSA) aquifer. The Tertiary System (Citronelle Formation and the Miocene Series undifferentiated) directly underlies the land surface inland of the alluvial-coastal sediments. The Miocene-Pliocene aquifer comprises permeable layers of sand and gravel within these older formations.

Figure 3.4: Graphical representation of underlying aquifers of the Fowl River Sub-Watershed



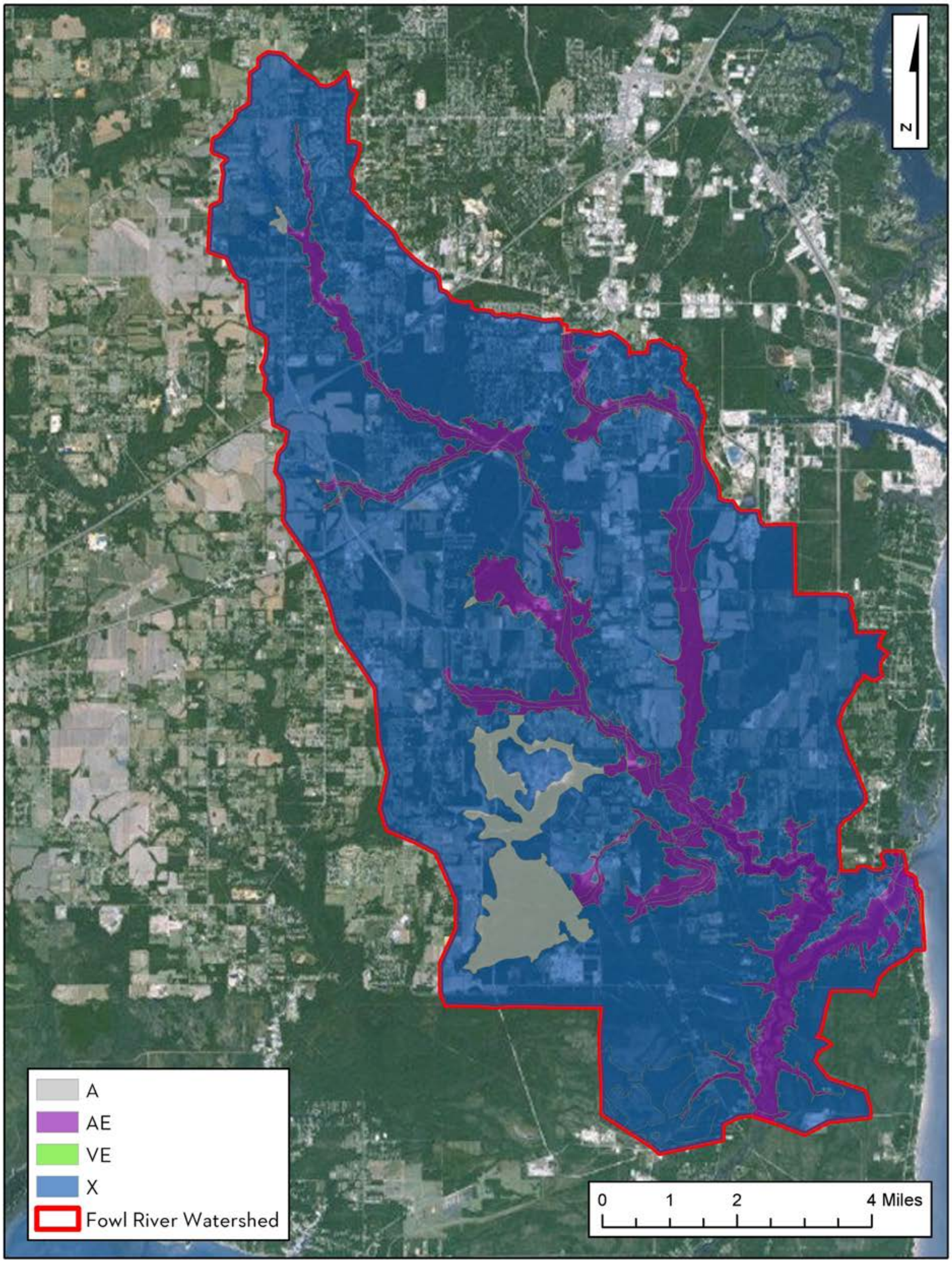
Source: Geological Survey of Alabama

Both the USGS and GSA report that no continuous confining layers are present to create hydraulic separation between the deeper Miocene-Pliocene aquifer and the shallow Watercourse aquifer. When pumped, these two units act as a single hydraulic unit. Discontinuous lenses of clay in the formations retard the vertical movement of water on a local basis, but they do not hydraulically separate the various aquifers. In the deeper portions of the Miocene Series, clayey sediments are semi-confining and reduce the vertical infiltration of water which causes this aquifer to respond to short-term pumping as a confined system (Mooty, USGS, 1988). Wells constructed in the Miocene-Pliocene aquifer typically yield 0.5 to 2.0 million gallons per day. Wells constructed in the alluvial-coastal aquifer yield from 0.5 to 1.0 million gallons per day (Mooty, USGS, 1988).

3.4 FLOODPLAINS

With the exception of a short stretch of stream at the headwaters of Fowl River, all of Fowl River, East Fowl River and tributaries within the Fowl River Watershed lie within the 100-year floodplain for a distance of several hundred feet along both banks (ADEM 2006). Floodplains within the Watershed and their flood hazard area designations are identified in **Figure 3.5**. The flood hazard areas shown are designated by the Federal Emergency Management Agency (FEMA) and include Zone A (subject to inundation by the 1-percent-annual-chance flood event with no base flood elevation (BFE) determined), Zone AE (subject to inundation by the 1-percent-annual-chance flood event with BFE determined) and Zone VE (subject to inundation by the 1-percent-annual-chance flood event with additional hazards due to storm waves with BFE determined.

FIGURE 3.5: FOWL RIVER WATERSHED FLOODPLAINS WITH FEMA HAZARD ZONE DESIGNATIONS



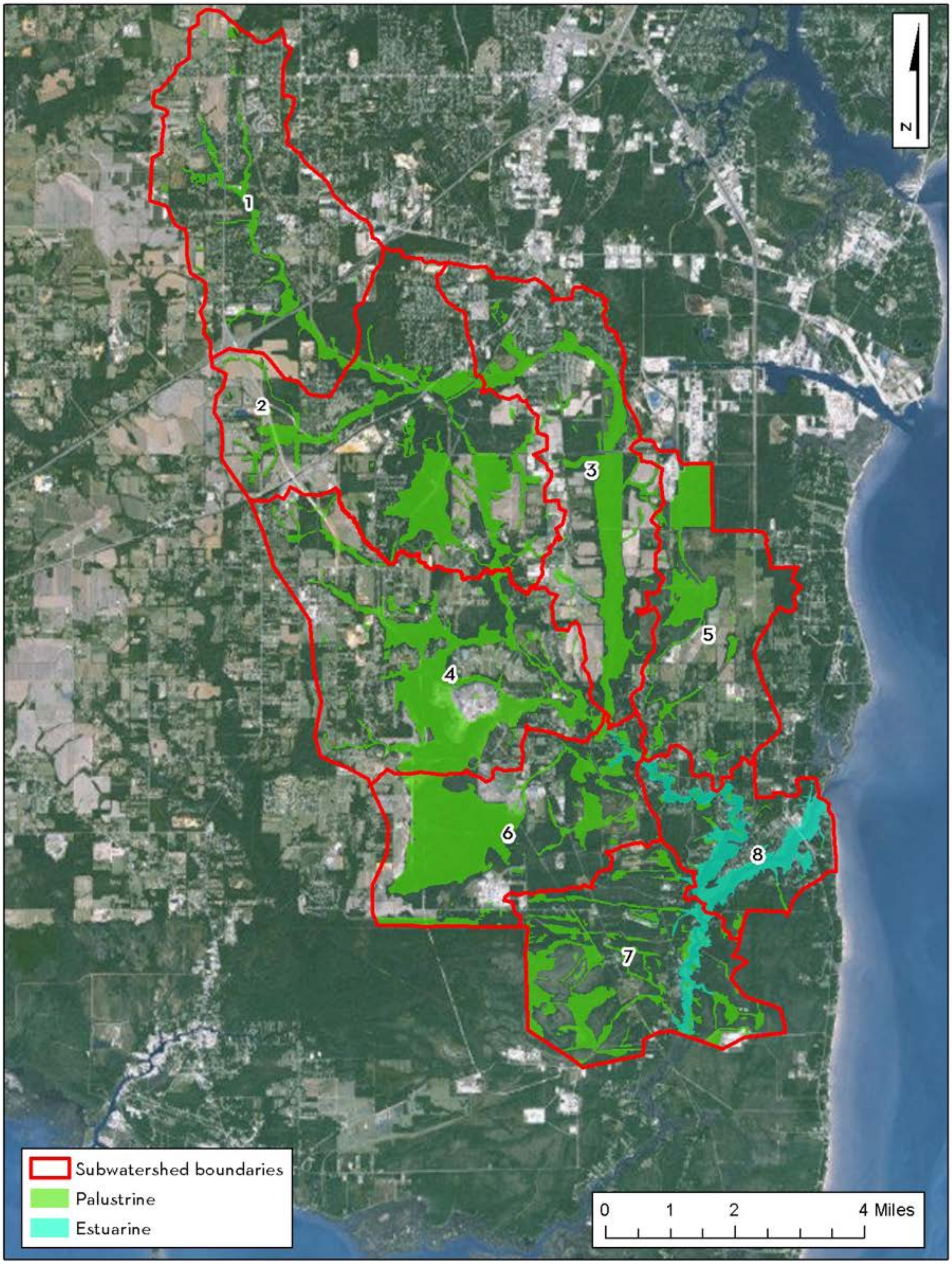
Zone A: 1-percent-annual risk of flooding but no BFE has been determined
Zone AE: 1-percent-annual risk of flooding and BFE has been determined
Zone VE: 1-percent-annual risk of flooding with additional hazards due to storm waves; BFE has been determined
X: outside the 1-percent-annual risk of flooding

3.5 WETLANDS

Using National Wetland Inventory (NWI) data to characterize wetlands within the Fowl River Watershed, it was estimated the Watershed contains approximately 9,000 acres of wetlands that account for more than 20 percent of the Watershed's area, as shown in **Figure 3.6**. This NWI data was produced with satellite imagery in the 1980s. Wetland acreage in the 2011 land-use data was derived from a different set of imagery, therefore accounting for an acreage discrepancy (11,800-acres of wetlands in Table 3.4).

The overall health of the Fowl River Watershed is in large part due to the existence of wetlands. Wetlands contribute to the vitality of an ecosystem by storing, filtering and cleaning, and transmitting surface water and groundwater. Through this process pollution is filtered, nutrients are recycled, groundwater is recharged, and biodiversity is enhanced through provision of habitats for a wide variety of fish, wildlife, and plants. Wetland composition varies extensively; thus five distinct categories are used for classification: estuarine, lacustrine, marine, palustrine, and riverine systems (Cowardin, 1979). The two major wetland classification types located within the Fowl River Watershed are Palustrine and Estuarine, as defined by Cowardin (1979) in the following sections.

FIGURE 3.6: FOWL RIVER WATERSHED WETLAND MAP

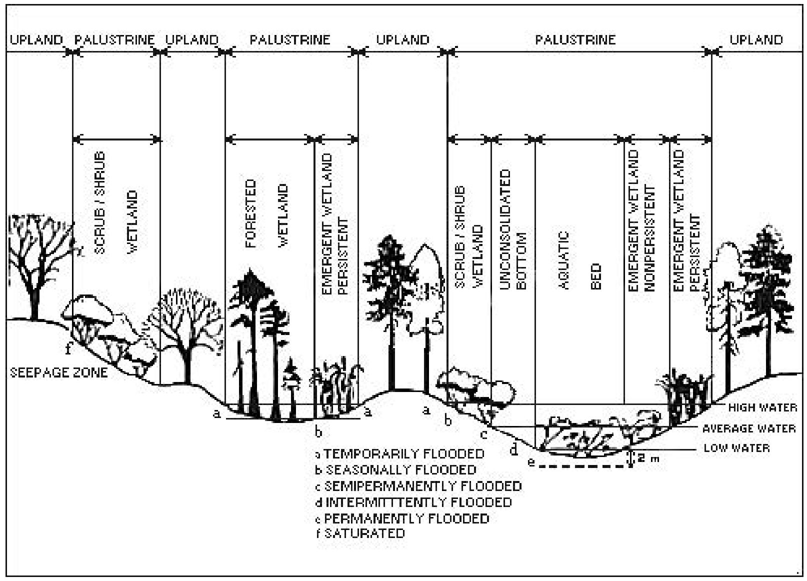


3.0 WATERSHED CHARACTERIZATION

THE PALUSTRINE SYSTEM:

The Palustrine (freshwater) System, illustrated in **Figure 3.7**, includes all non-tidal wetlands dominated by trees, shrubs, persistent emergent vegetation, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 percent (or 5 parts per thousand). The Palustrine System is bounded by uplands.

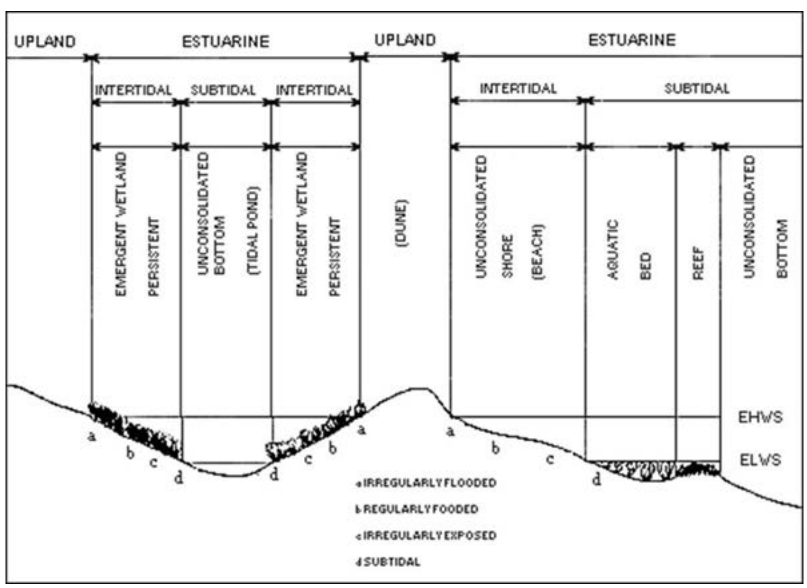
Figure 3.7: The Palustrine System (Cowardin, 1979)



THE ESTUARINE SYSTEM:

The Estuarine System, illustrated in **Figure 3.8**, consists of deep-water tidal habitat and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly-obstructed or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The Estuarine System extends (1) upstream and landward to where ocean-derived salts measure less than 0.5 percent during the period of average annual low flow; (2) to an imaginary line closing the mouth of a river, bay, or sound; and (3) to the seaward limit of wetland emergent, shrubs, or trees that are not included in the previously identified areas. It also includes offshore areas of continuously diluted sea water. It contains two sub-systems: (1) subtidal—substrate is continuously submerged, and (2) intertidal—substrate is exposed and flooded by tides, and includes the associated splash zone.

Figure 3.8: The Estuarine System (Cowardin, 1979)



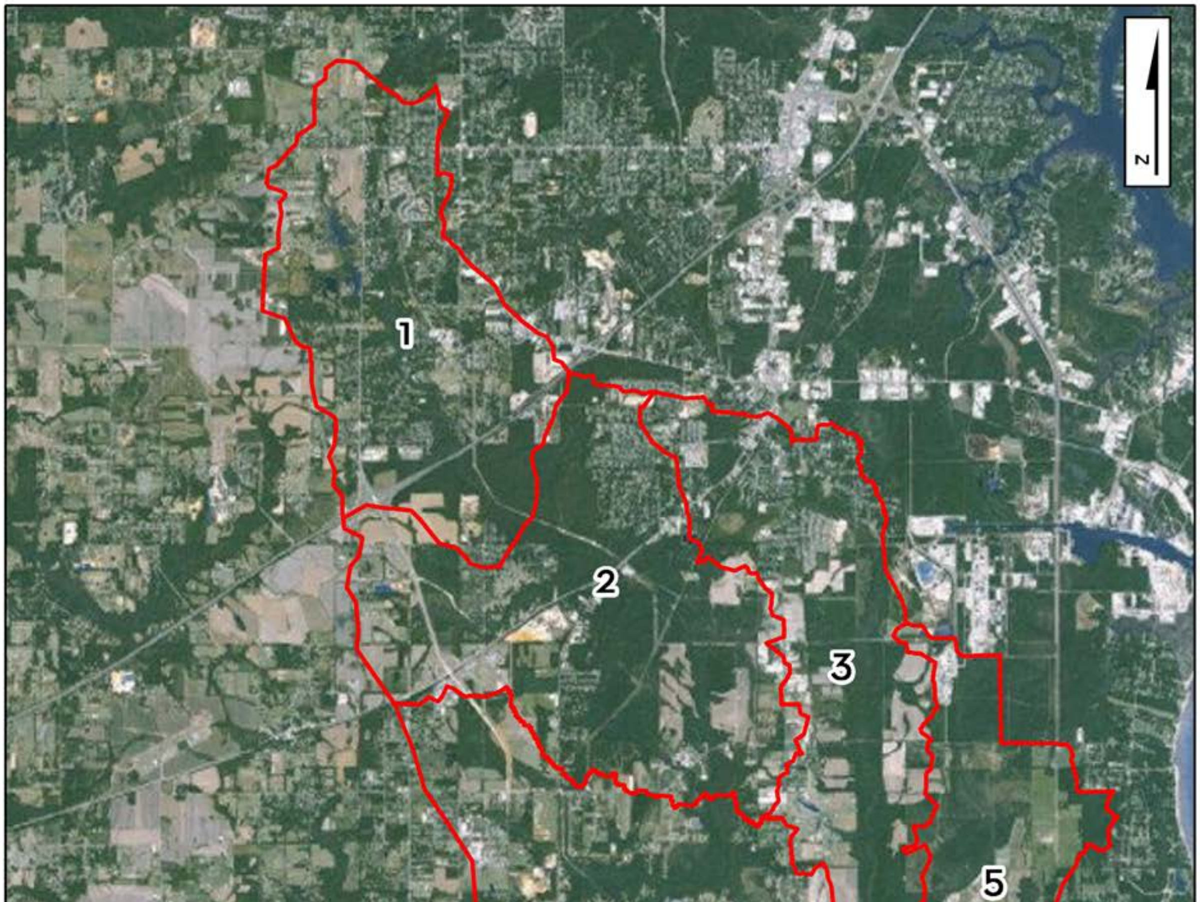
3.6 SUB-WATERSHEDS

The Fowl River drainage basin was divided into eight sub-watersheds based on the National Hydrography Stream Dataset, catchment basin, flow data, topography, land use, and vegetative cover (see **Figure 3.9**). Acreages of each quantified land use for each sub-watershed are listed in **Table 3.4**. A detailed description of each sub-watershed follows.

TABLE 3.4: ESTIMATED ACRES OF LAND USE/LAND COVER WITHIN THE FOWL RIVER SUB-WATERSHEDS

Sub-watershed	Urban/ Developed	Agriculture	Wetlands	Forested	Vegetated	Open Water	Barren	Total	Percentage of Watershed
1	1,425.34	1,664.86	600.92	1,049.93	941.63	42.90	80.51	5,806.09	14.6
2	1,250.98	977.88	1,779.84	1,797.19	1,224.52	12.67	104.08	7,147.16	17.97
3	1,195.38	1,060.83	1,511.18	579.79	834.21	16.90	23.13	5,221.42	13.13
4	566.89	1,751.60	1,869.02	1,041.26	1,365.51	36.70	26.91	6,657.89	16.74
5	241.74	932.73	1,117.77	572.89	860.01	2.44	4.45	3,732.03	9.38
6	260.20	481.93	1,825.88	1,214.29	698.10	10.23	4.00	4,494.66	11.30
7	167.02	25.13	2,298.69	1,269.88	453.91	40.03	3.56	4,258.22	10.71
8	349.83	34.03	796.18	674.31	199.71	367.40	30.02	2,451.49	6.16
Total	5,457.38	6,928.99	11,799.48	8,199.54	6,577.6	529.27	276.66	39,768.96	100

FIGURE 3.9: FOWL RIVER SUB-WATERSHED LOCATION MAP



3.6.1 Sub-watershed 1

Sub-watershed 1 encompasses approximately 5,806 acres in the northern section of the Fowl River Watershed, as shown in **Figure 3.10**. It is underlain by the Citronelle Formation. Soils are primarily of the Troup-Heidel-Bama and the Notcher-Saucier-Malbis soil associations (see **Figure 3.11**). The area is hilly in the western and northern portions, and the Fowl River floodplain is just a few hundred feet wide in most places (see **Figure 3.12**). Land surface elevation in Sub-watershed 1 ranges from approximately 57 to 180 feet with a total relief of approximately 123 feet. Approximately 3,090 acres of land (53 percent of the sub-watershed) are developed for use in some way (see **Figure 3.13**). This is the greatest percentage of developed land of all the sub-watersheds. Sub-watershed 1 comprises approximately 390 acres of freshwater wetlands, or 4 percent of total wetlands area within the Watershed (**Figure 3.14**).

Major transportation routes through Sub-watershed 1 are Three Notch Road, I-10, Old Pascagoula Road, and Theodore Dawes Road. Land use typically is uniform within sections of the Sub-watershed (see **Figure 3.15**), and numerous or different land uses in close proximity are not common.

Figure 3.15: Pecan orchard, now used as a cow pasture, in Sub-watershed 1

FIGURE 3.10: SUB-WATERSHED 1 LOCATION MAP

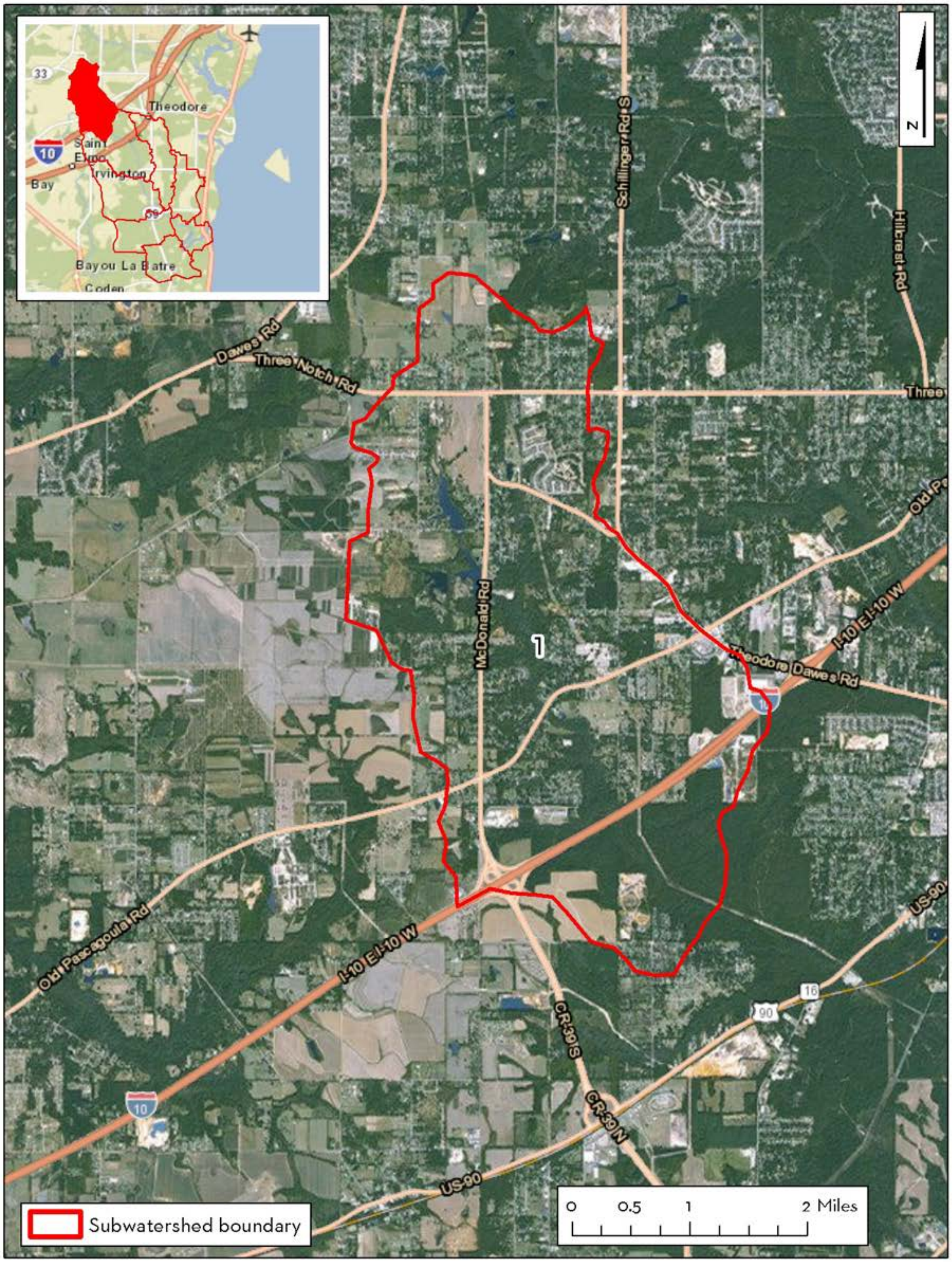


FIGURE 3.11: SUB-WATERSHED 1 SOIL TYPES

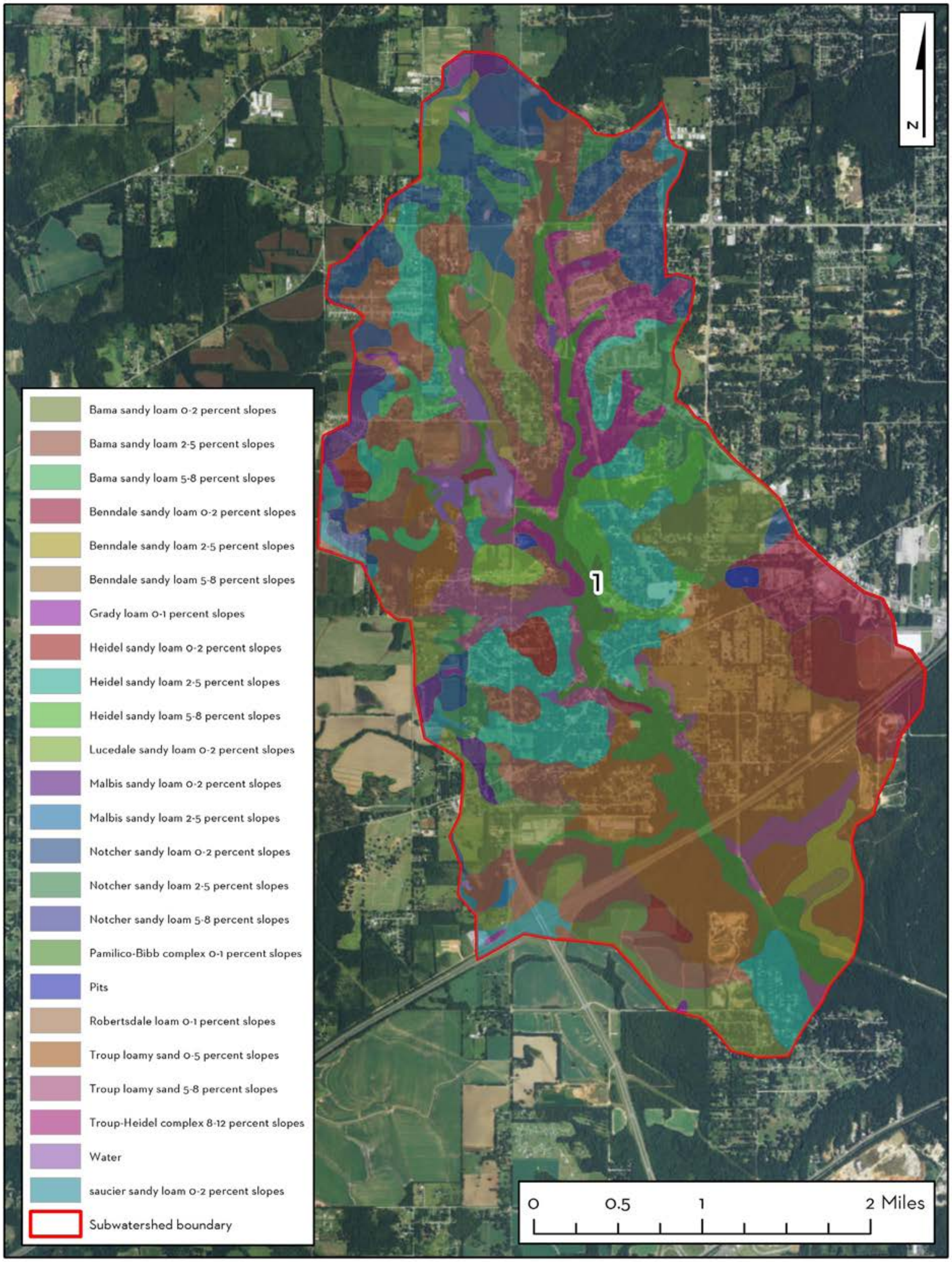
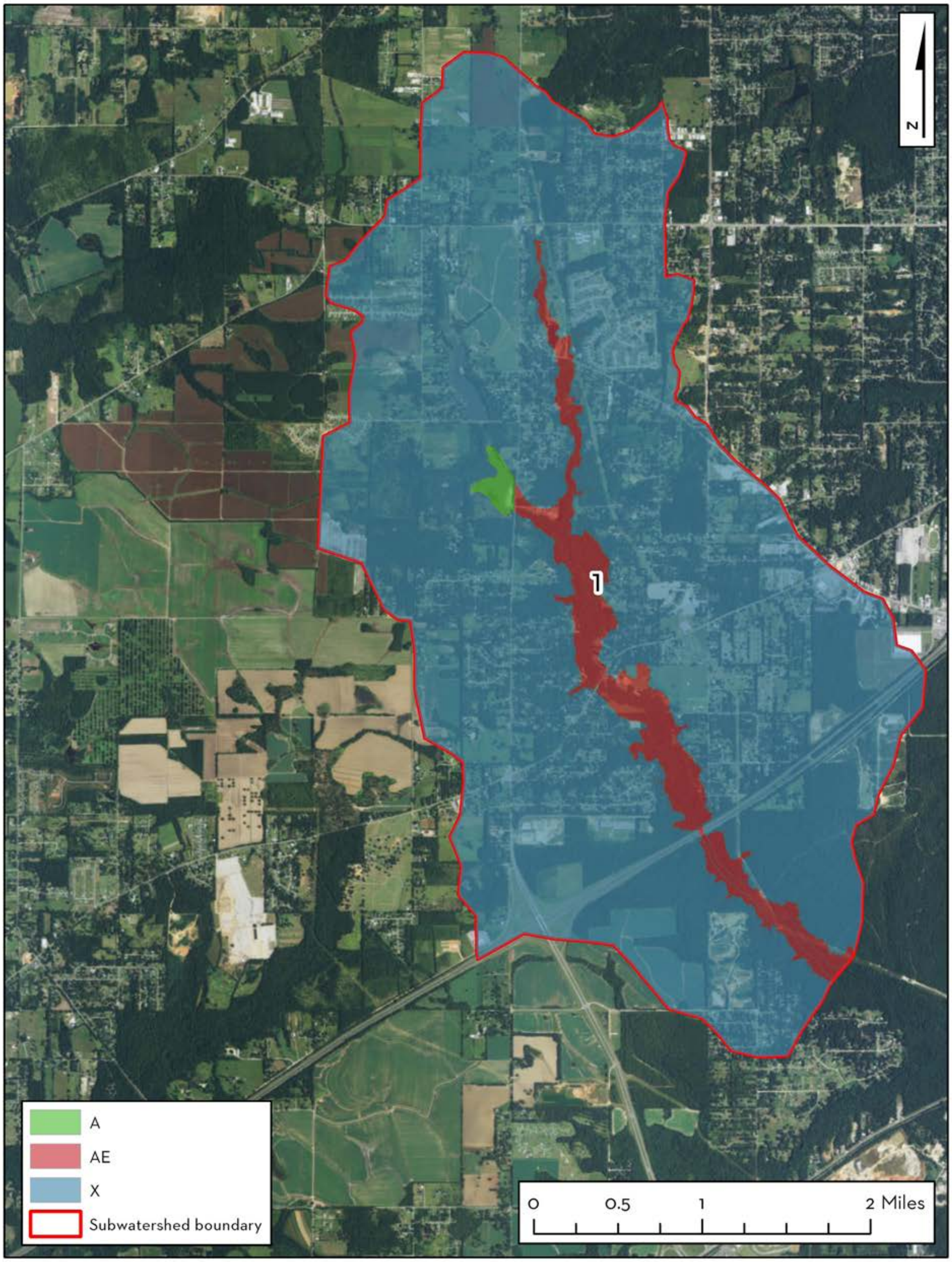


FIGURE 3.12: SUB-WATERSHED 1 FLOODPLAIN LOCATIONS



Zone A: 1-percent-annual risk of flooding but no BFE has been determined
Zone AE: 1-percent-annual risk of flooding and BFE has been determined
X: outside the 1-percent-annual risk of flooding

FIGURE 3.13: SUB-WATERSHED 1 LAND USE MAP

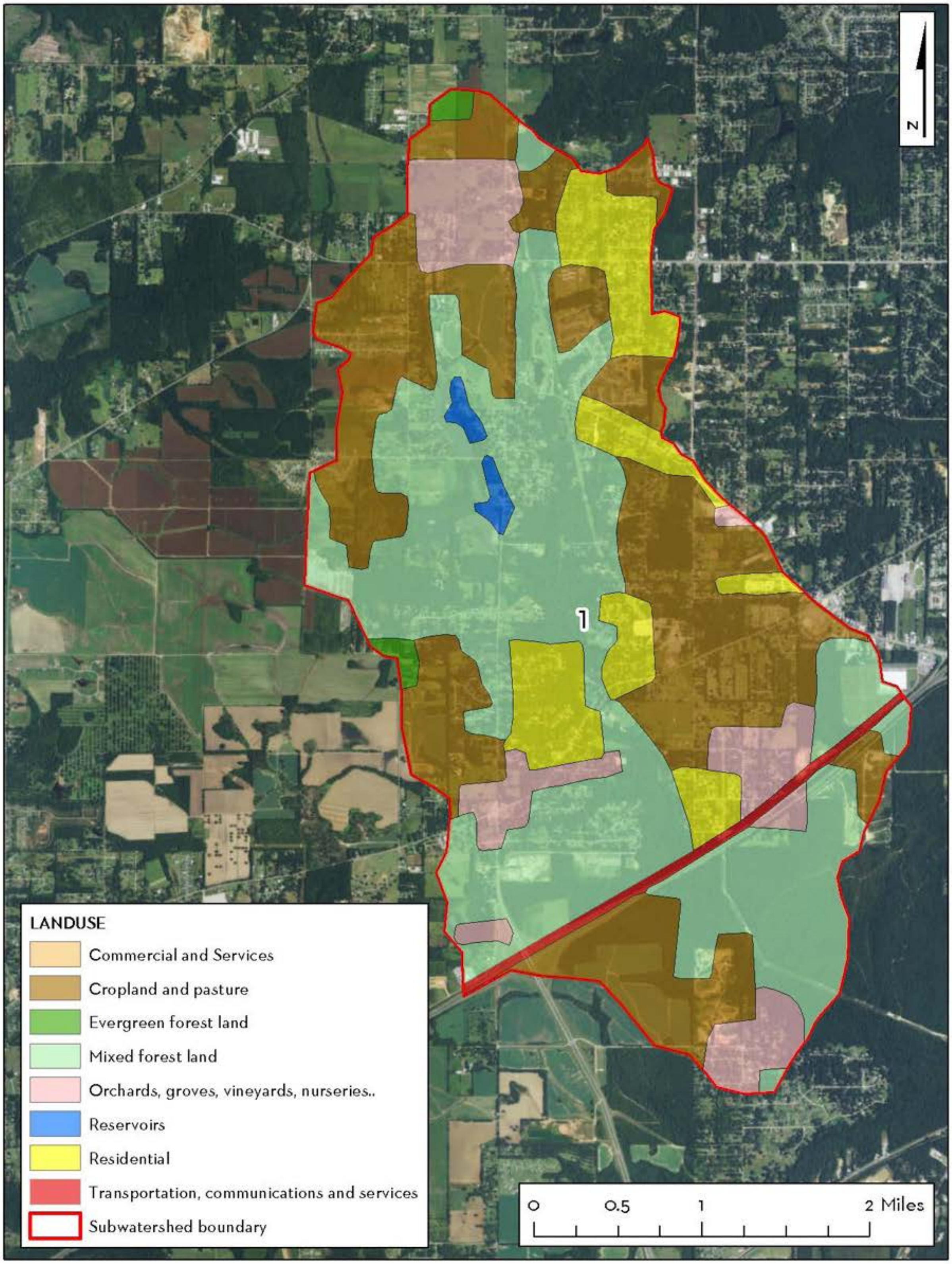
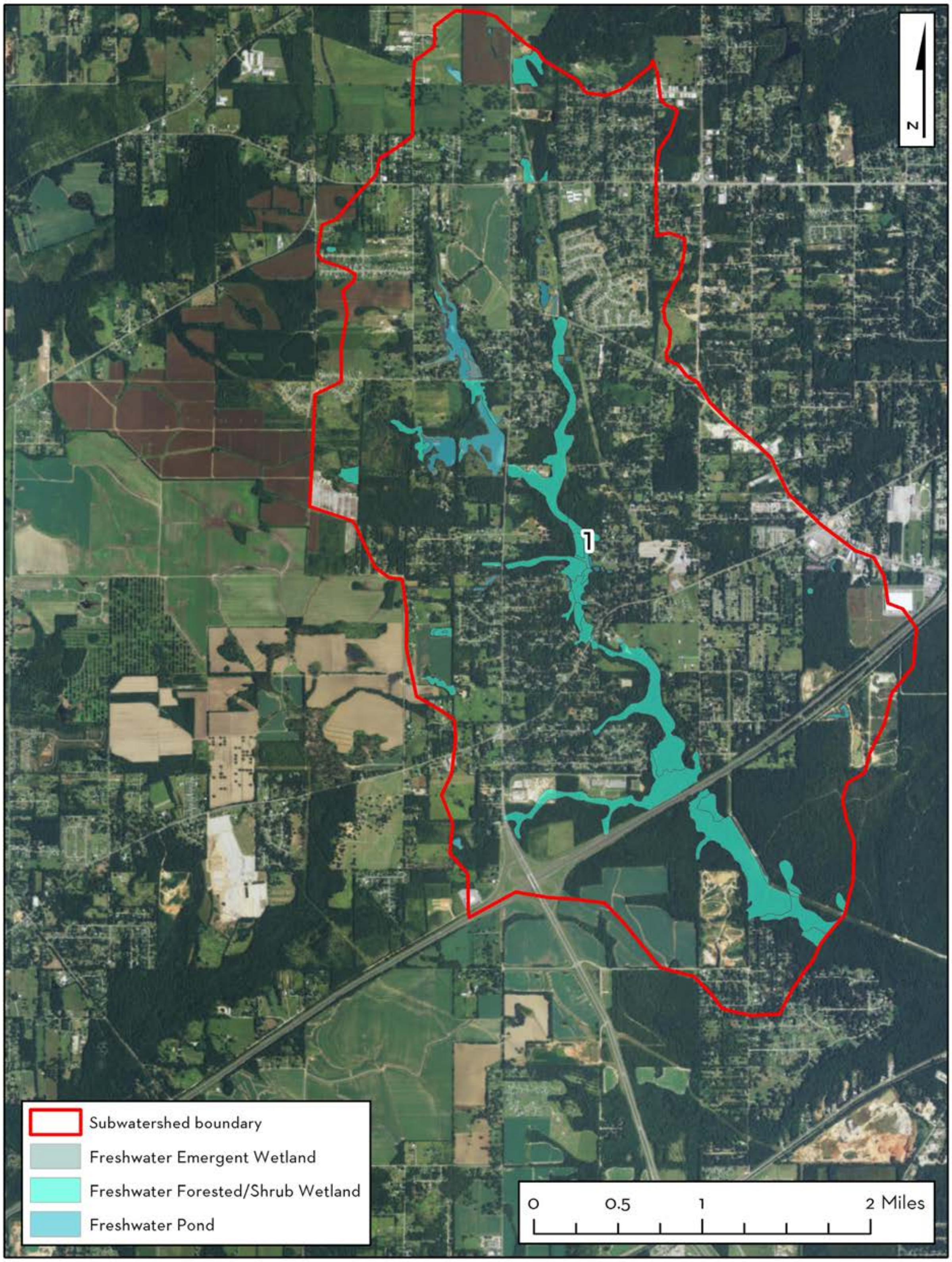


FIGURE 3.14: SUB-WATERSHED 1 WETLAND MAP



3.6.2 Sub-watershed 2

Sub-watershed 2 encompasses approximately 7,147 acres in the north central section of the Fowl River Watershed, as shown in **Figure 3.16**. It is in underlain by the Citronelle Formation in the north, and the coastal and alluvial deposits to the southeast. Soils are primarily of the Troup-Heidel-Bama and Notcher-Saucier-Malbis soil associations, but the southeastern portion of the sub-watershed contains soils of the Bayou-Escambia-Harleston soil association (see **Figure 3.17**). Sub-watershed 2 is hilly in the western portions of the sub-watershed and just west of Theodore. Low marshes are found bordering the main stem of Fowl River, and the floodplain of Fowl River is slightly broader than in Sub-watershed 1 (see **Figure 3.18**). Land surface elevation in this area ranges from approximately 15 to 160 feet with a total relief of approximately 145 feet. Approximately 2,228 acres of land (31 percent of the sub-watershed) are developed for use in some way (see **Figure 3.19**). Sub-watershed 2 comprises approximately 1,470 acres of freshwater wetlands or 16 percent of the total wetlands area within the Watershed (see **Figure 3.20**).

Major transportation routes through Sub-watershed 2 are US 90, MacDonald Road, Murray Hill Road, County Farm Road, Padgett Switch Road, Laurendine Road, Nan Gray Davis Road, and Swedetown Road. Land use typically is uniform within sections of the sub-watershed (see **Figure 3.21**); numerous or different land uses in close proximity are not common.

Figure 3.21: Nursery near Irvington, Alabama in Sub-watershed 2

FIGURE 3.16: SUB-WATERSHED 2 LOCATION MAP

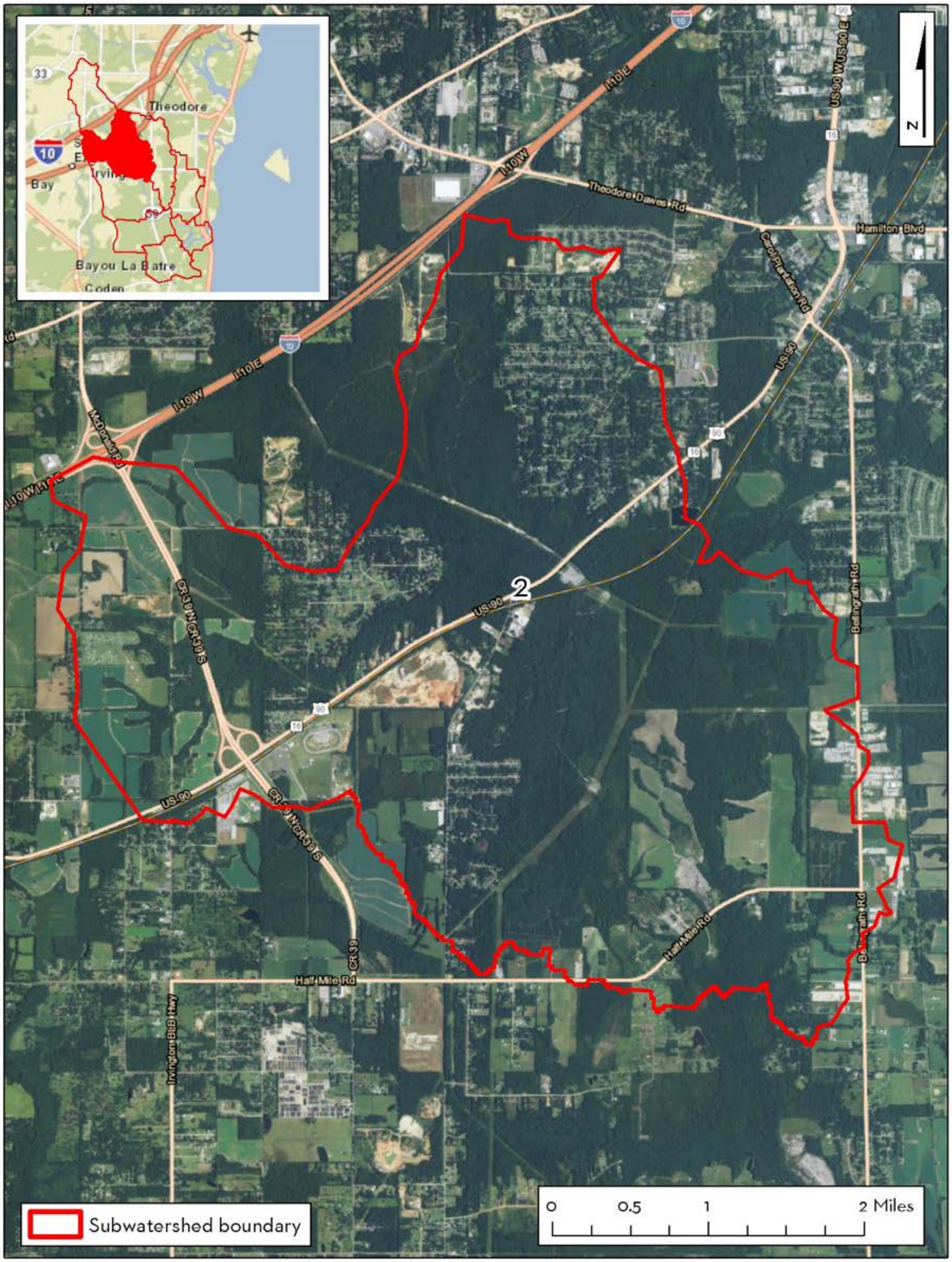


FIGURE 3.17: SUB-WATERSHED 2 SOIL TYPES

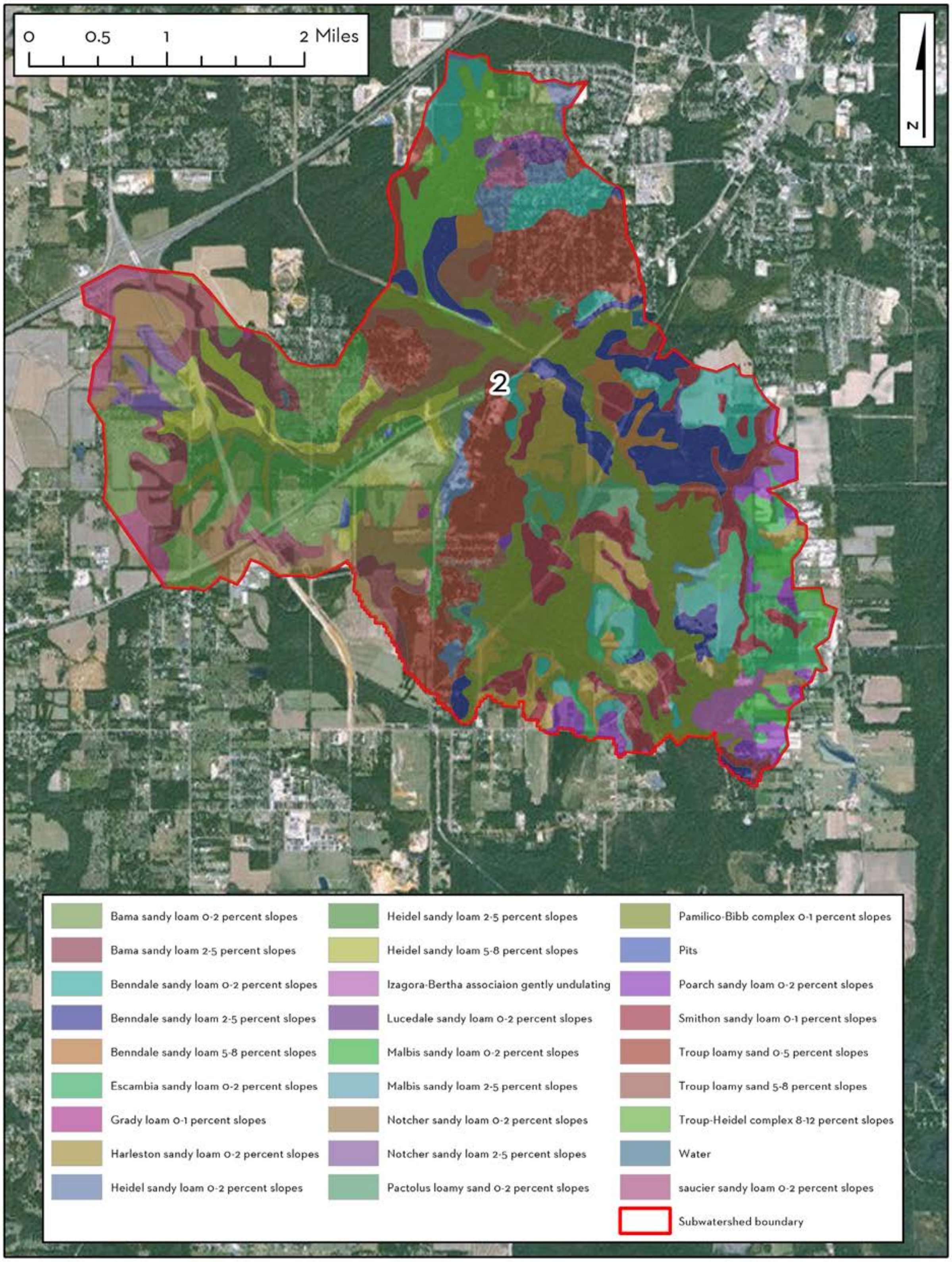
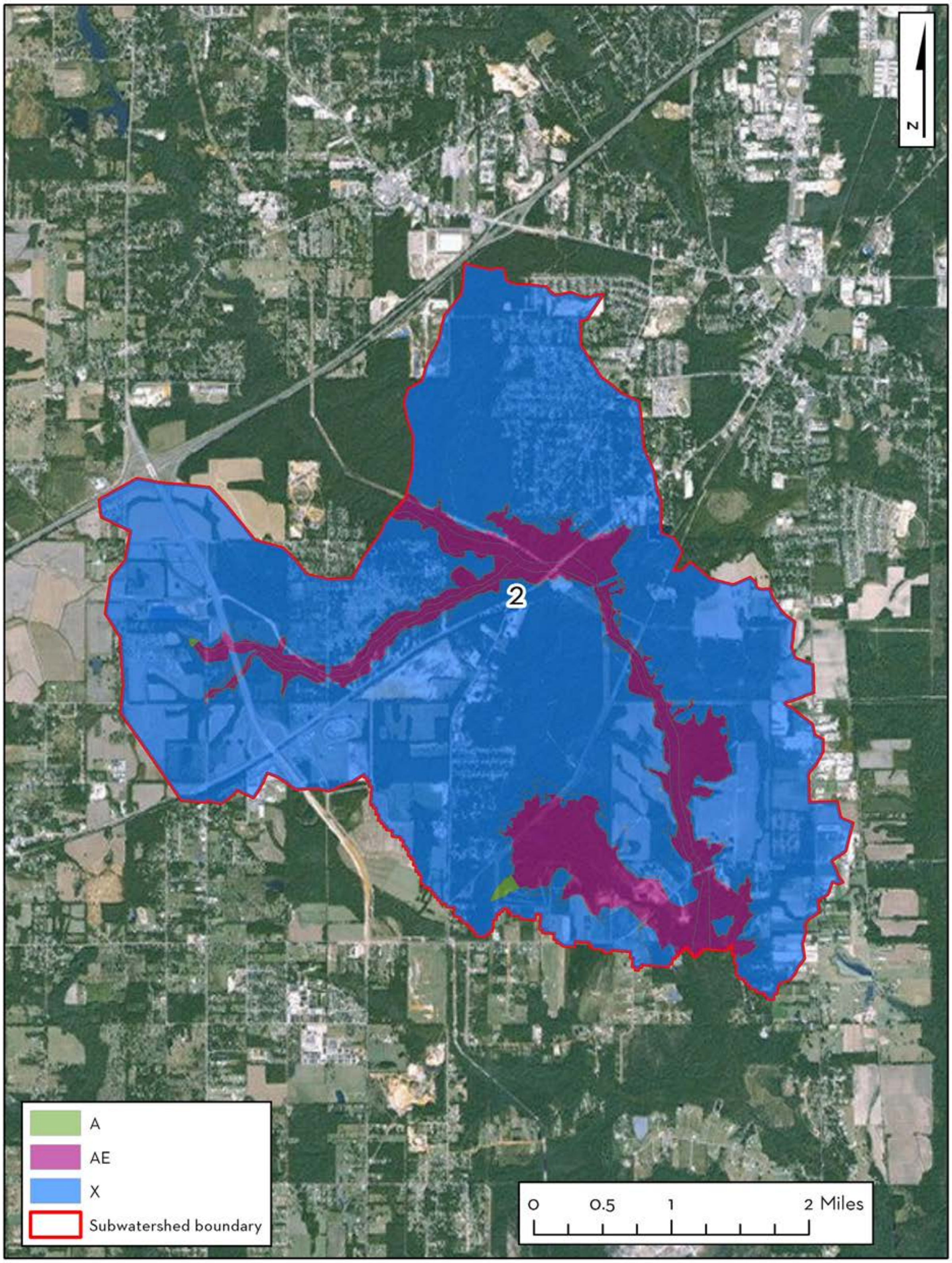


FIGURE 3.18: SUB-WATERSHED 2 FLOODPLAIN LOCATIONS



Zone A: 1-percent-annual risk of flooding but no BFE has been determined
Zone AE: 1-percent-annual risk of flooding and BFE has been determined
X: outside the 1-percent-annual risk of flooding

FIGURE 3.19: SUB-WATERSHED 2 LAND USE MAP

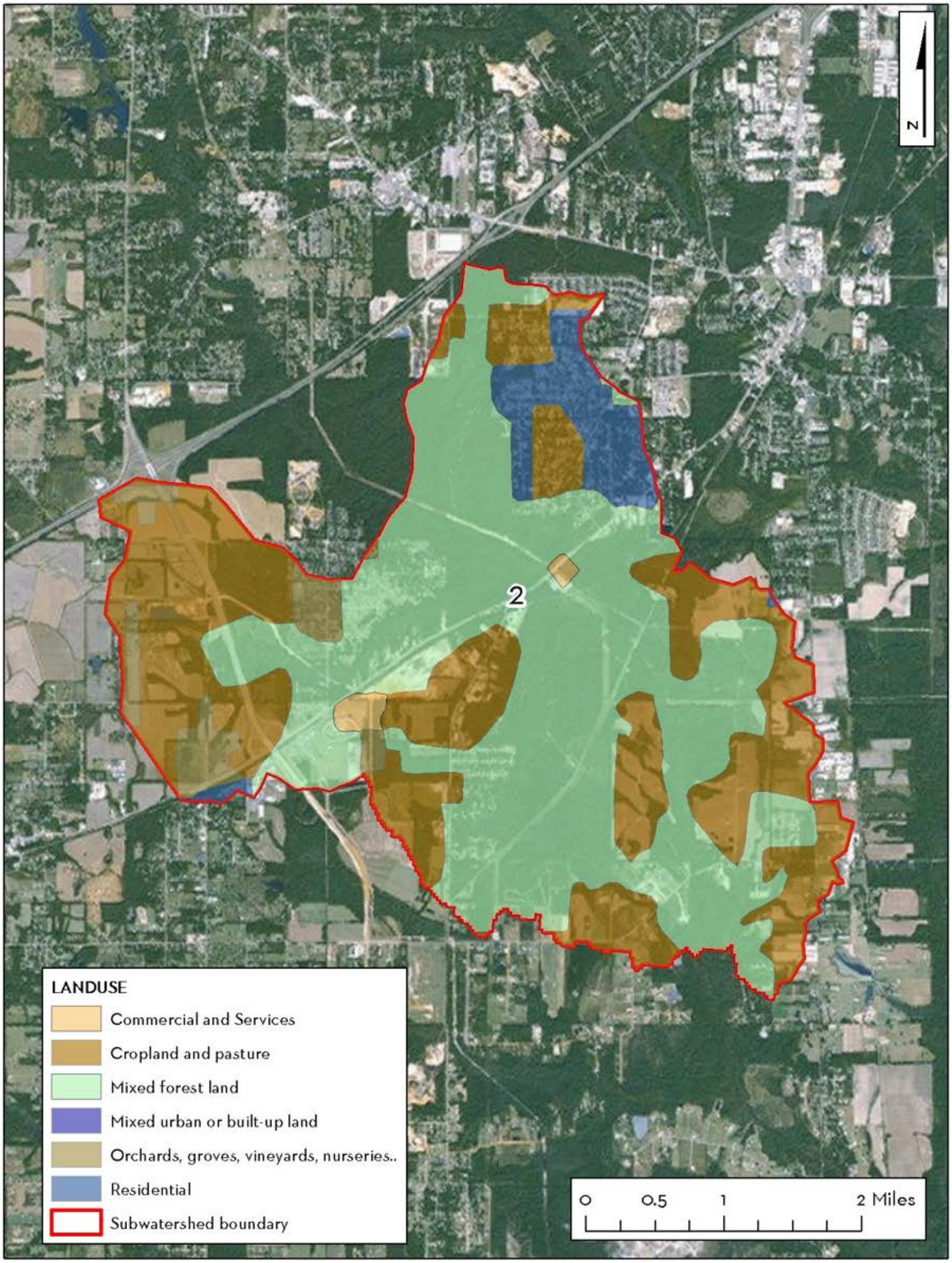
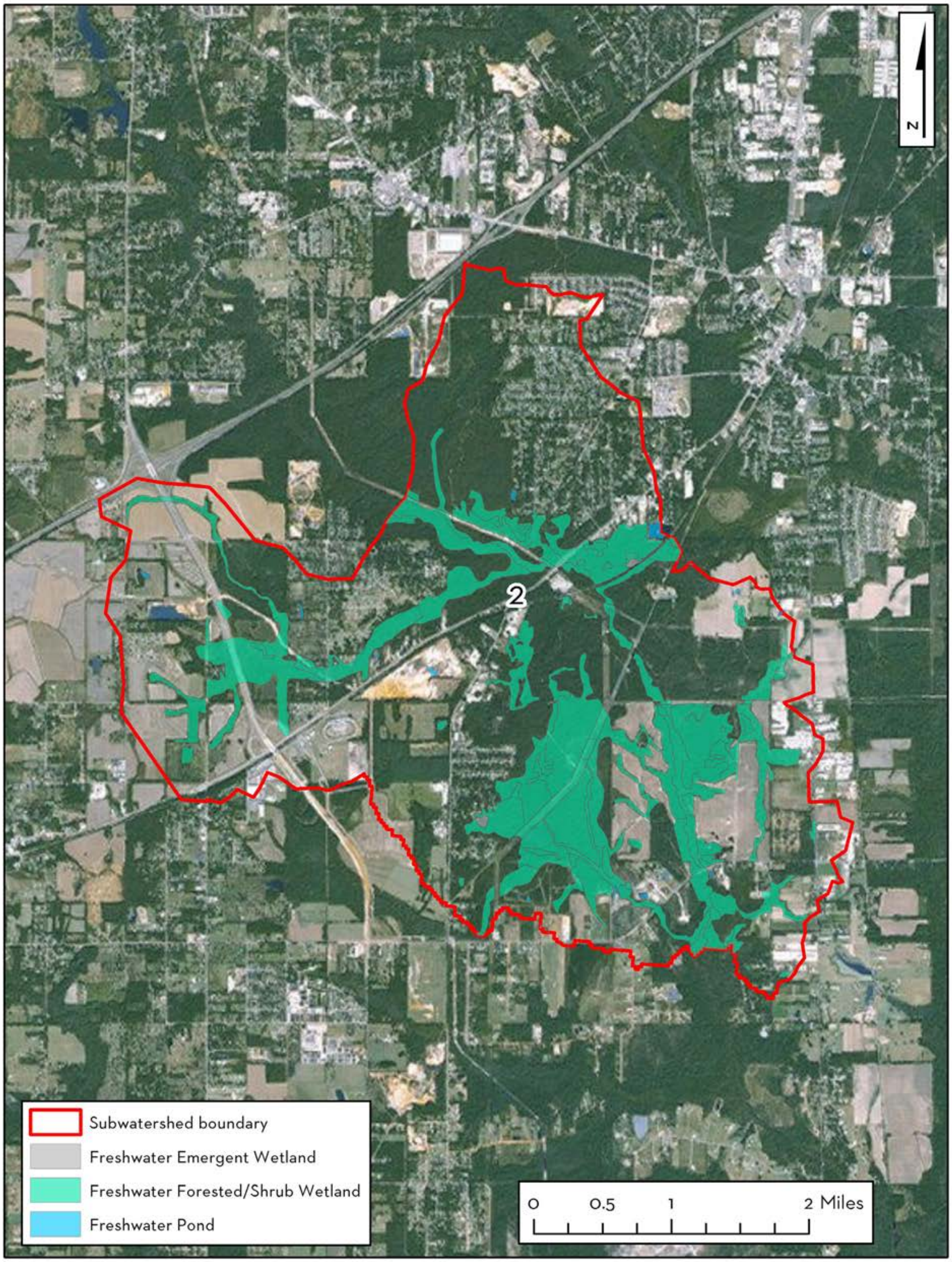


FIGURE 3.20: SUB-WATERSHED 2 WETLAND MAP



3.6.3 Sub-watershed 3

Sub-watershed 3 encompasses approximately 5,221 acres in the northeast central section of the Fowl River Watershed, as shown in **Figure 3.22**. It is underlain primarily by the coastal and alluvial deposits, and a small corner in the extreme northeastern sub-watershed is underlain by the Citronelle Formation. Soils are primarily of the Troup-Heidel-Bama and Notcher-Saucier-Malbis soil associations, but the south-central portion of the sub-watershed contains soils of the Bayou-Escambia-Harleston soil association (see **Figure 3.23**). The majority of Sub-watershed 3 is flat and low lying with little relief. Low marshes are found bordering Muddy Creek. Land surface elevation in this area ranges from approximately 3 to 150 feet with a total relief of approximately 147 feet (see **Figure 3.24**). Approximately 2,255 acres of land (43 percent of the sub-watershed) are developed for use in some way (see **Figure 3.25**). Sub-watershed 3 comprises approximately 1,140 acres of freshwater wetlands, or 13 percent of the total wetlands area within the Watershed (see **Figure 3.26**).

Major transportation routes through Sub-watershed 3 are US 90, Bellingrath Road, Industrial Road, Laurendine Road, Old Military Road, Lancaster Drive, and Bay Road. Major land uses include residential, commercial/industrial, and agricultural, as shown in **Figure 3.27**. Land use typically is uniform within sections of the sub-watershed; numerous or different land uses in close proximity are not common.

Figure 3.27: Agricultural field south of Theodore, Alabama in Sub-watershed 3

FIGURE 3.22: SUB-WATERSHED 3 LOCATION MAP

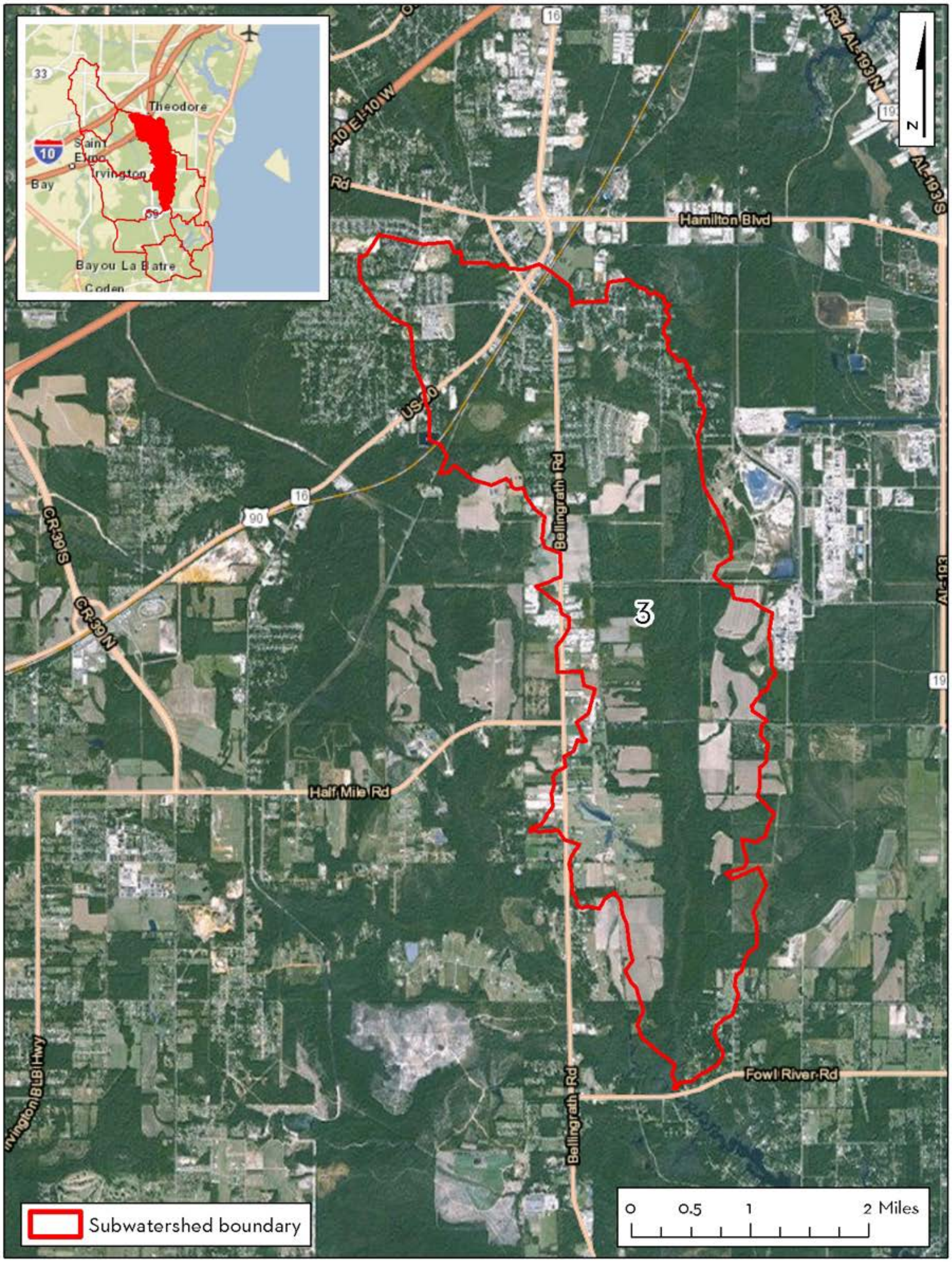


FIGURE 3.23: SUB-WATERSHED 3 SOIL TYPES

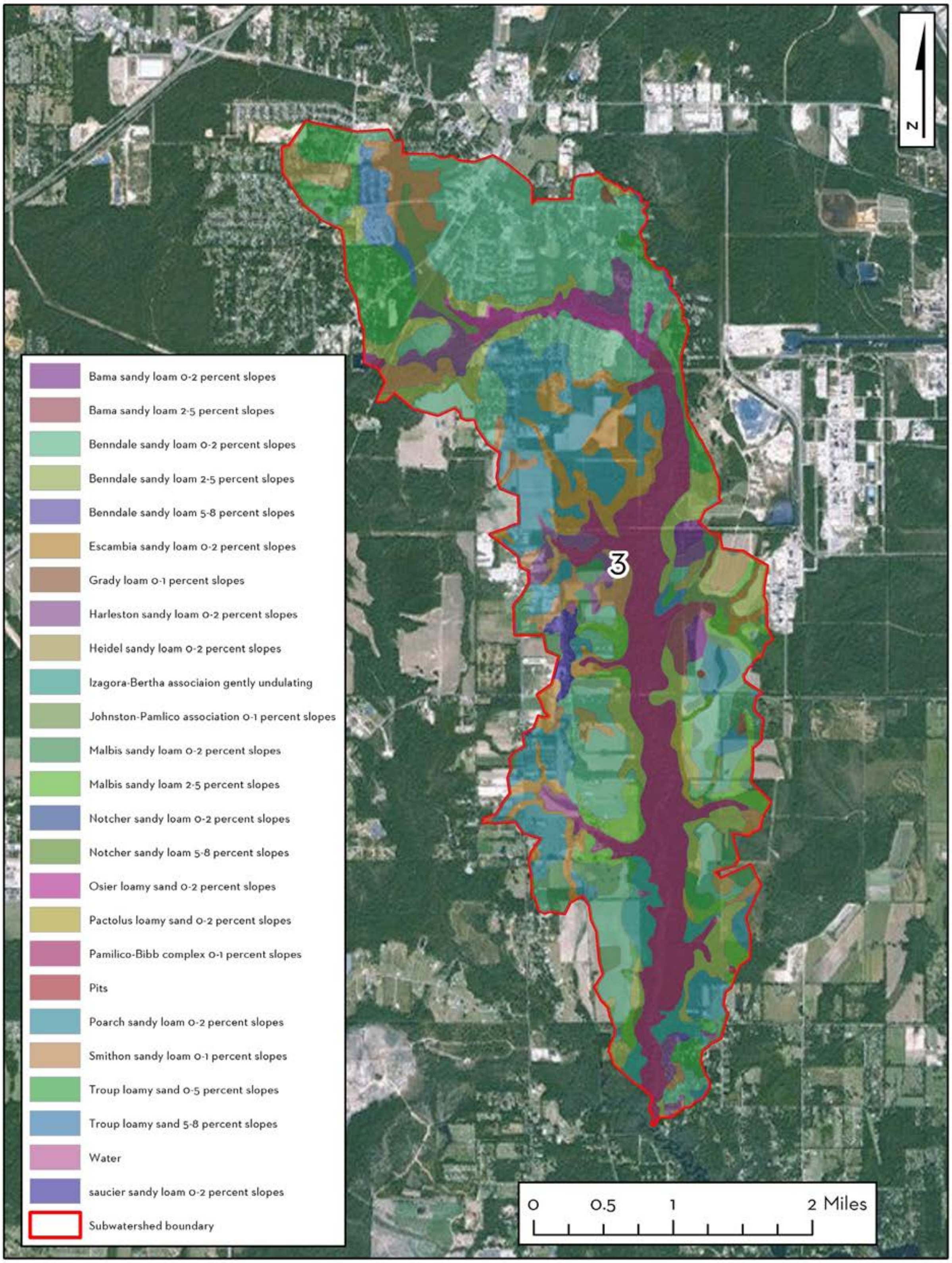
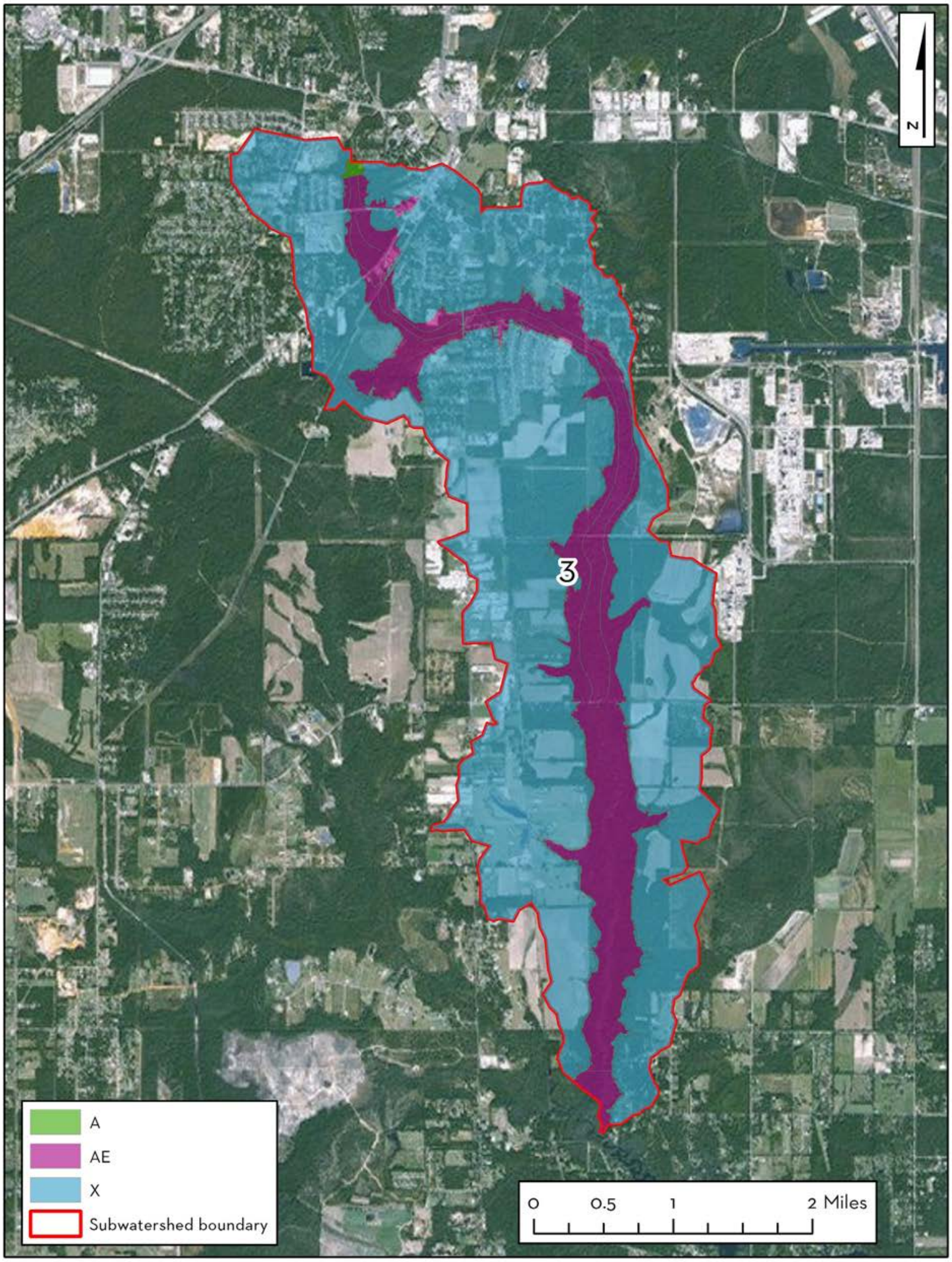


FIGURE 3.24: SUB-WATERSHED 3 FLOODPLAIN LOCATIONS



Zone A: 1-percent-annual risk of flooding but no BFE has been determined
Zone AE: 1-percent-annual risk of flooding and BFE has been determined
X: outside the 1-percent-annual risk of flooding

FIGURE 3.25: SUB-WATERSHED 3 LAND USE MAP

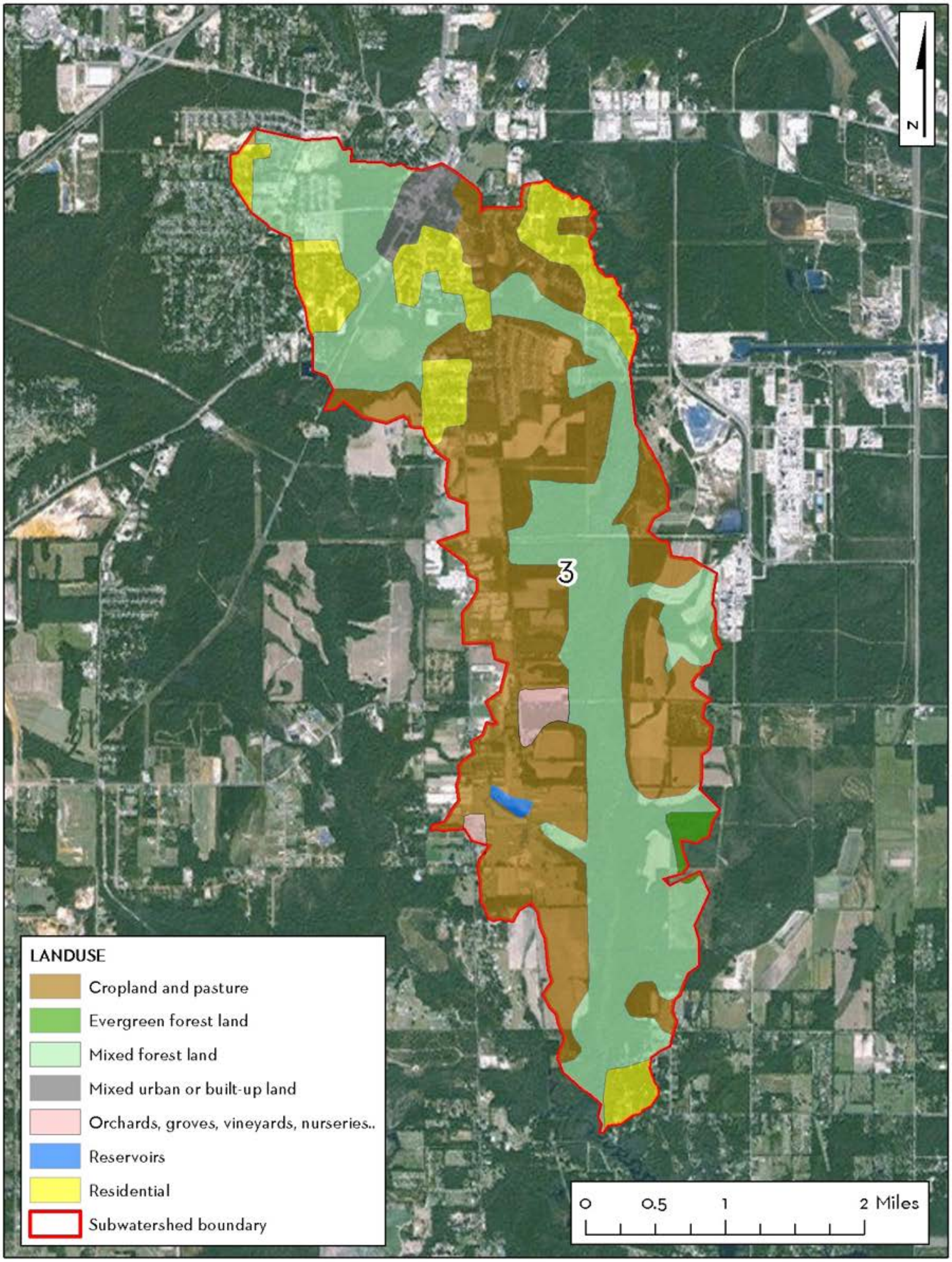
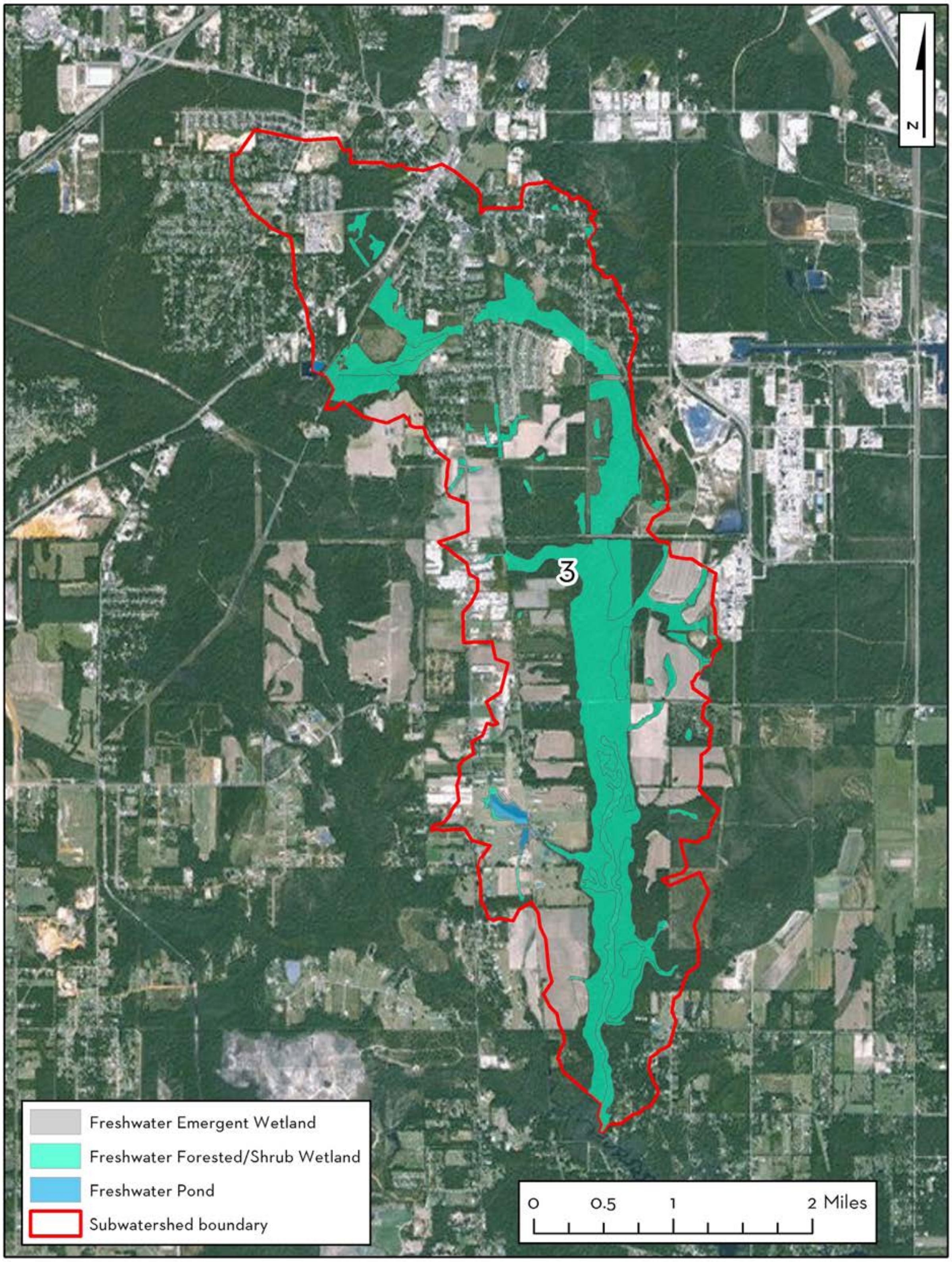


FIGURE 3.26: SUB-WATERSHED 3 WETLAND MAP



3.6.4 Sub-watershed 4

Sub-watershed 4 encompasses approximately 6,658 acres in the west central section of the Fowl River Watershed, as shown in **Figure 3.28**. It is underlain by the Citronelle Formation in the west and by coastal and alluvial deposits in the rest of the sub-watershed. Soils consist of the Troup-Heidel-Bama, Dorovan-Johnston-Levy, and the Bayou-Escambia-Harleston soil associations (see **Figure 3.29**). Sub-watershed 4 is hilly in the western portions of the sub-watershed with low marshes in the central portion (see **Figure 3.30**). Land surface elevation in Sub-watershed 4 ranges from approximately 4 to 130 feet with a total relief of approximately 126 feet. Approximately 2,318 acres of land (35 percent of the sub-watershed) are developed for use in some way (see **Figure 3.31**). The area comprises approximately 1,745 acres of freshwater wetlands or 20 percent of the total wetlands area within the Watershed (see **Figure 3.32**).

Major transportation routes through Sub-watershed 4 are Padgett Switch Road, Laurendine Road, Bellingrath Road, Cleveland Avenue, Wisteria Street, Taylor Avenue, Cook Avenue, and Plantation Woods Drive. Major land uses include residential, forested, transportation, horticulture, and agriculture (see **Figure 3.33**). Land use can be diverse with different land uses in close proximity to one another (e.g., agriculture and residential sharing common borders, or small businesses located in residential areas).

Figure 3.33: Nursery south of Irvington in Sub-watershed 4

FIGURE 3.28: SUB-WATERSHED 4 LOCATION MAP

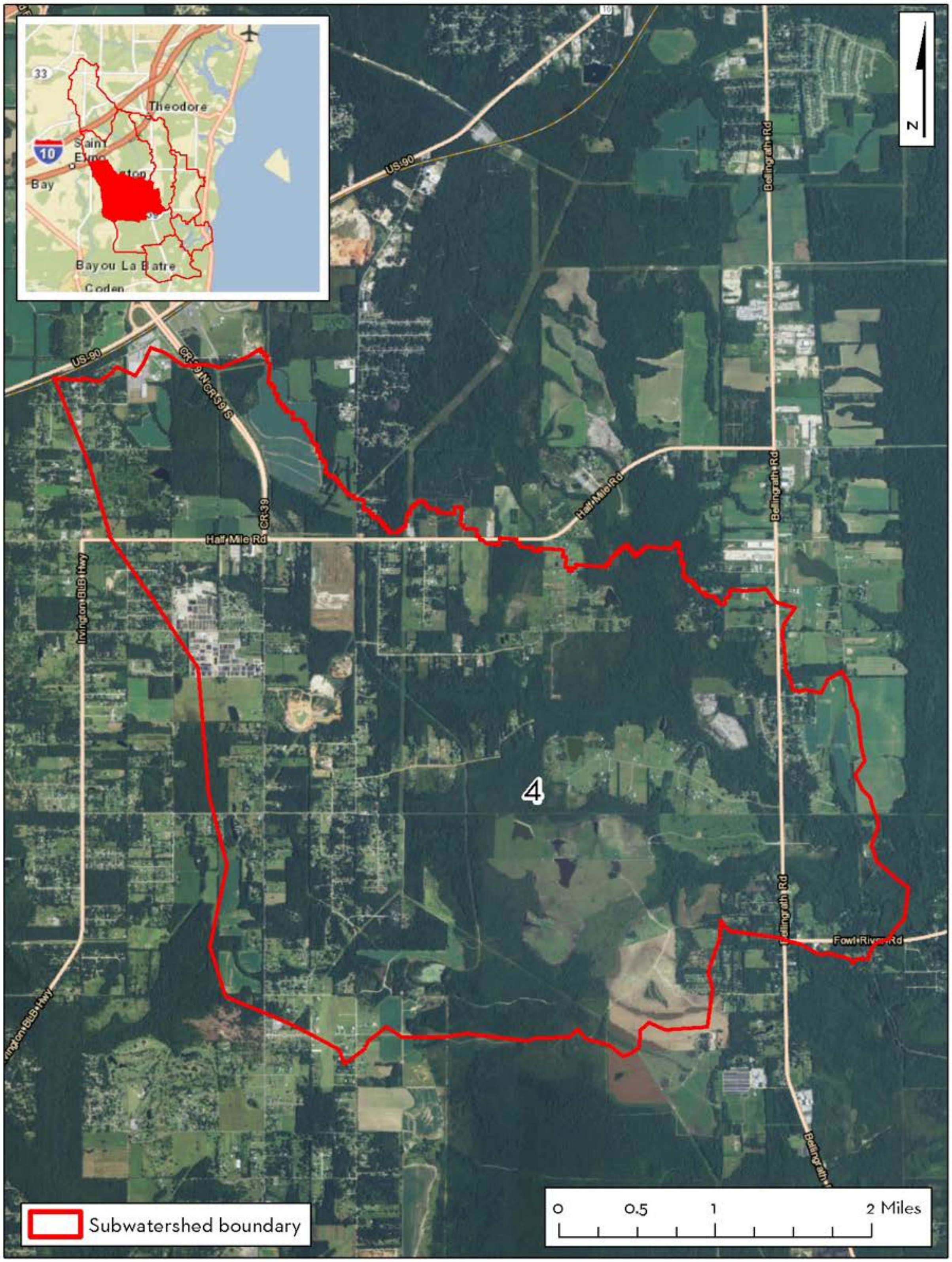


FIGURE 3.29: SUB-WATERSHED 4 SOIL TYPES

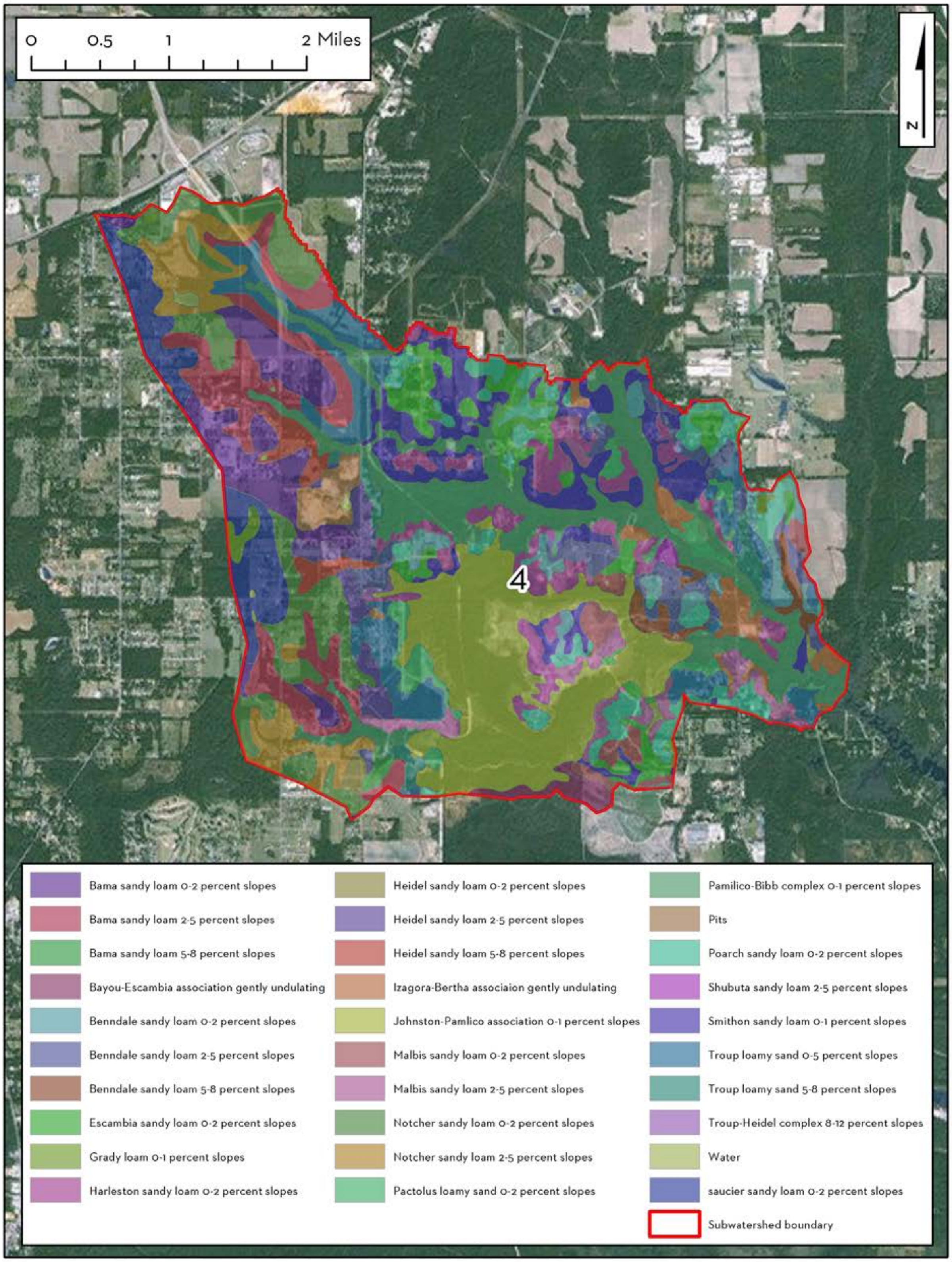
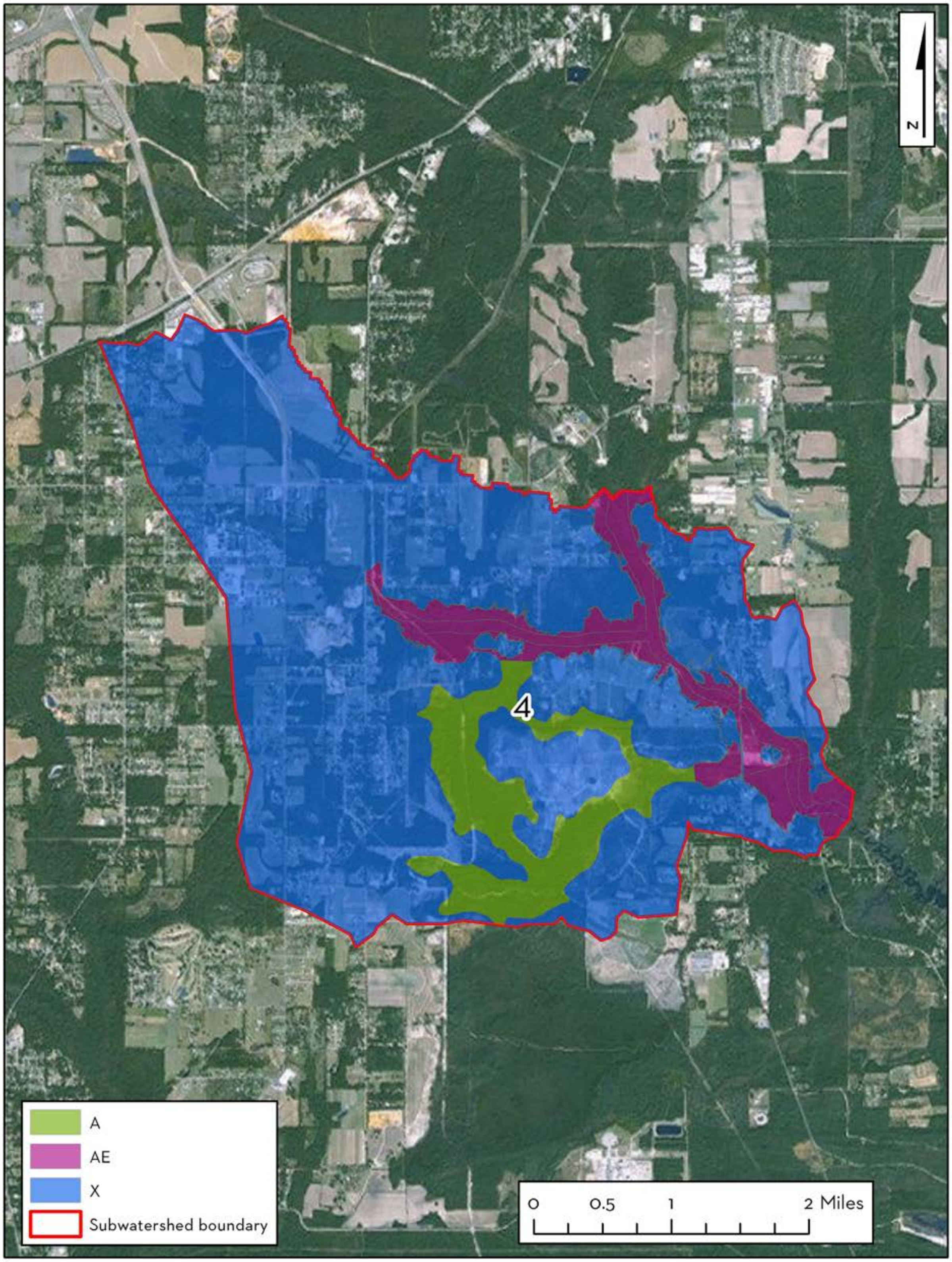


FIGURE 3.30: SUB-WATERSHED 4 FLOODPLAIN LOCATIONS



Zone A: 1-percent-annual risk of flooding but no BFE has been determined
Zone AE: 1-percent-annual risk of flooding and BFE has been determined
X: outside the 1-percent-annual risk of flooding

FIGURE 3.31: SUB-WATERSHED 4 LAND USE MAP

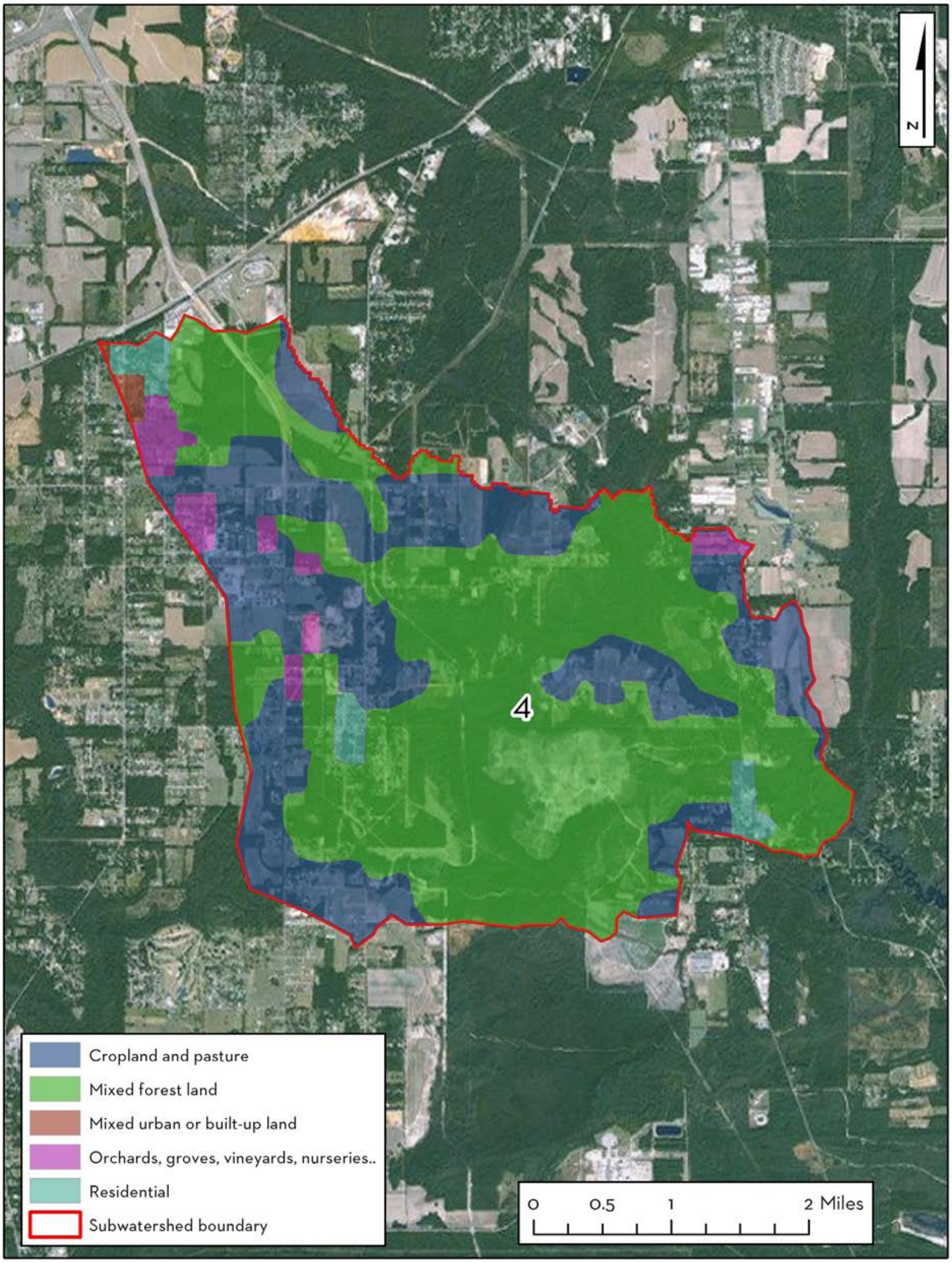
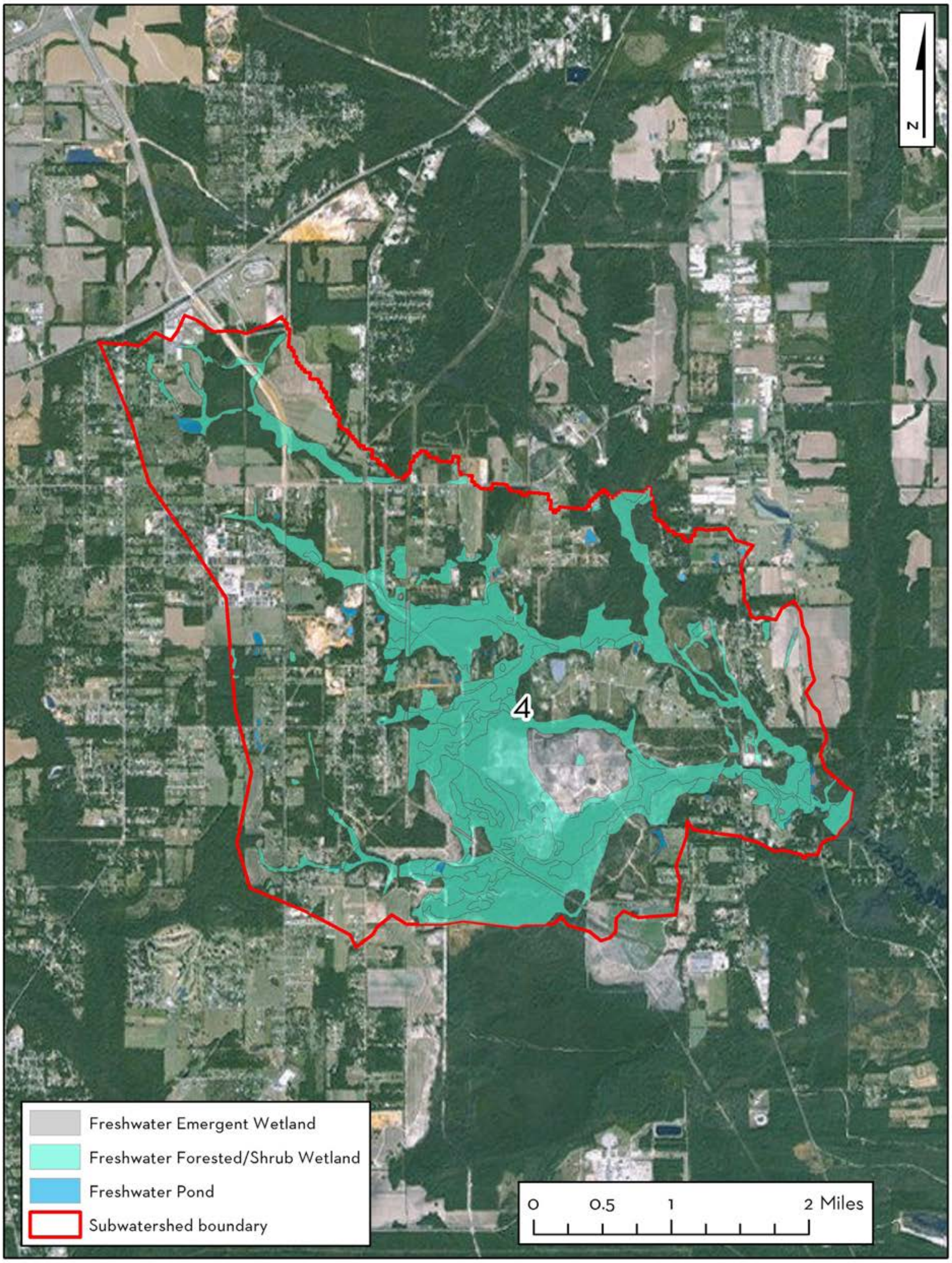


FIGURE 3.32: SUB-WATERSHED 4 WETLAND MAP



3.6.5 Sub-watershed 5

Sub-watershed 5 encompasses approximately 3,732 acres in the northeast section of the Fowl River Watershed, as shown in **Figure 3.34**. It is underlain by coastal and alluvial deposits. The soils present belong to the Notcher-Saucier-Malbis and Bayou-Escambia-Harleston soil associations (see **Figure 3.35**). Sub-watershed 5 is flat and low lying with very little relief (see **Figure 3.36)**. Low marshes are found bordering Dykes Creek. Land surface elevation in Sub-watershed 5 ranges from approximately 0 to 55 feet with a total relief of approximately 55 feet. Approximately 1,174 acres of land (31 percent of the sub-watershed) are developed for use in some way (see **Figure 3.37**). This area comprises approximately 655 acres of freshwater wetlands, or 7 percent of the total wetlands area within the Watershed, with a slight estuarine transition (see **Figure 3.38**).

Figure 3.39 shows a wooded area near Bay Road, which is one of the major transportation routes through Sub-watershed 5. Other major transportation routes through this area are Laurendine Road, Fowl River Road, Thomas Road, and Pioneer Road. Major land uses include residential and agriculture. Land use typically is uniform within sections of the sub-watershed; numerous or different land uses in close proximity are not common.

Figure 3.39: Woods near Bay Road in Sub-watershed 5

FIGURE 3.34: SUB-WATERSHED 5 LOCATION MAP

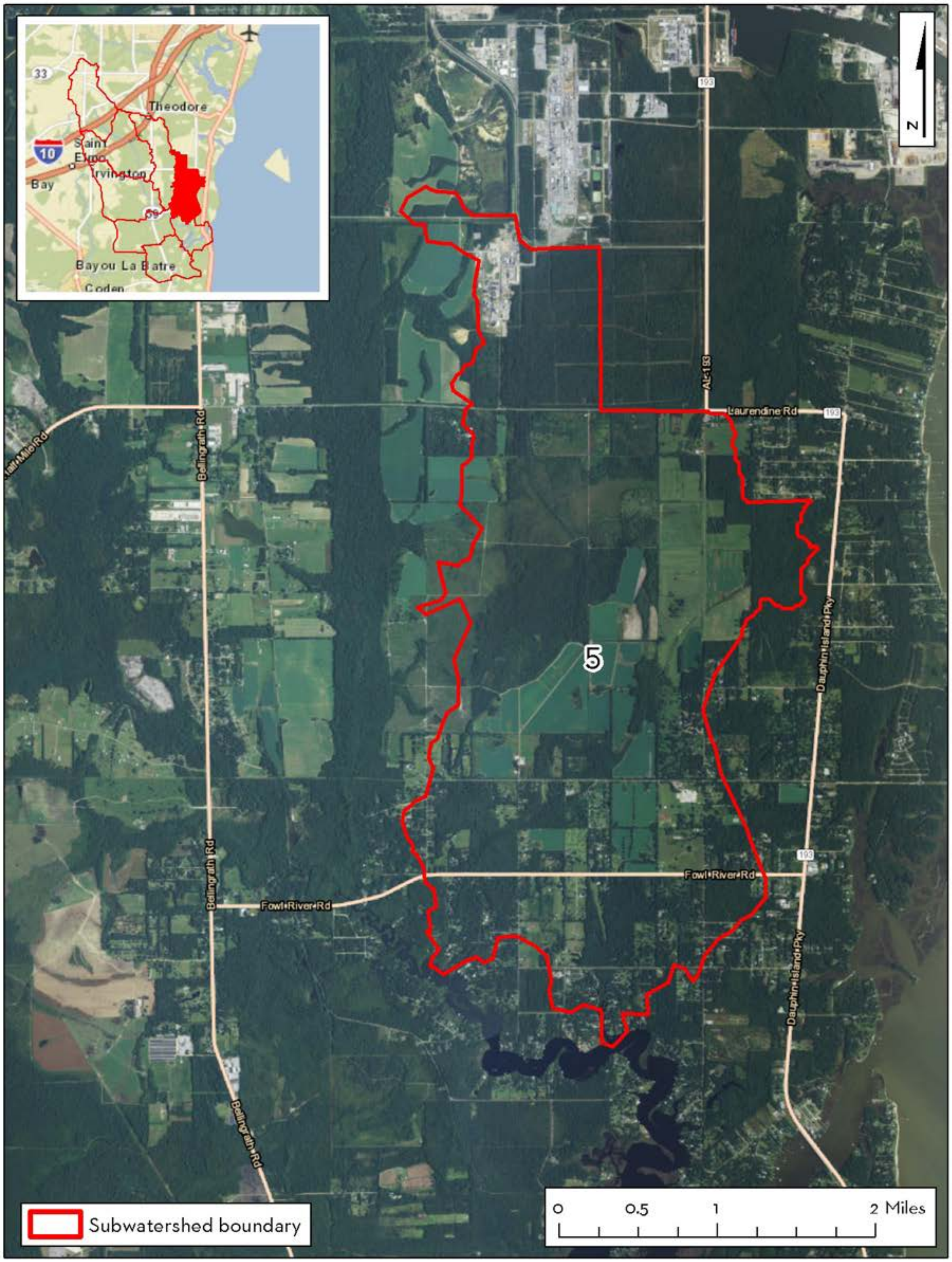


FIGURE 3.35: SUB-WATERSHED 5 SOIL TYPES

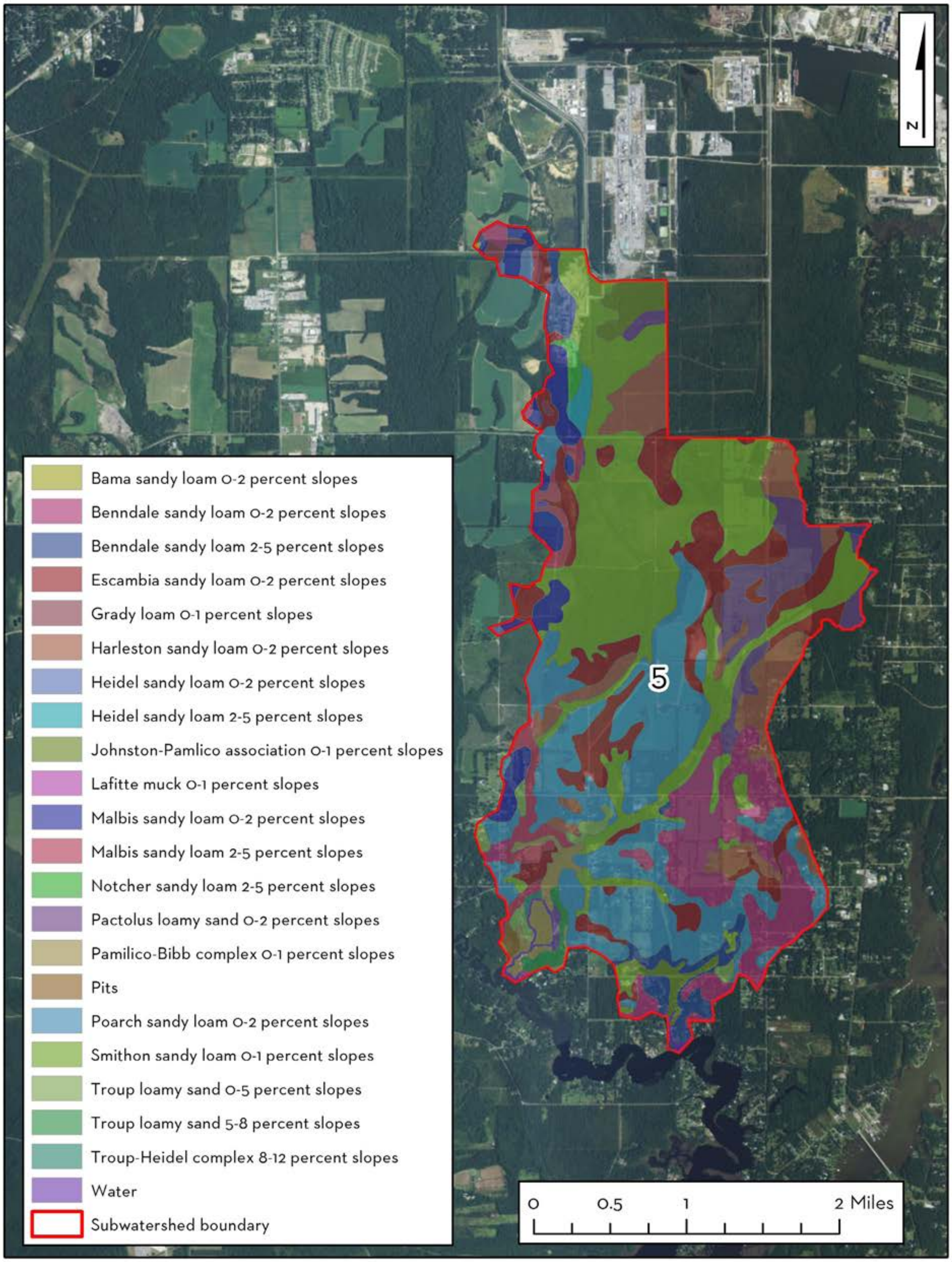
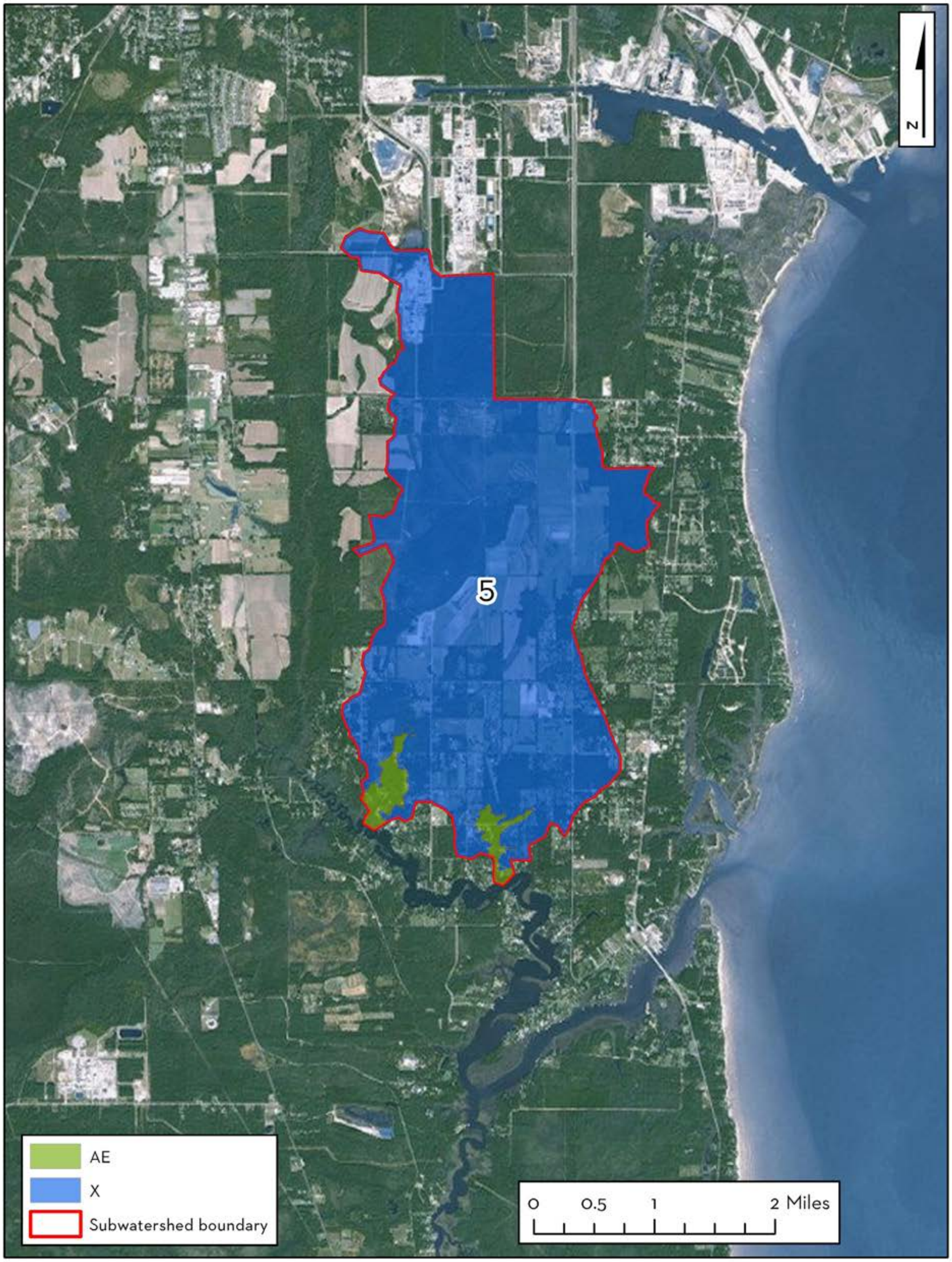


FIGURE 3.36: SUB-WATERSHED 5 FLOODPLAIN LOCATIONS



Zone AE: 1-percent-annual risk of flooding and BFE has been determined
X: outside the 1-percent-annual risk of flooding

FIGURE 3.37: SUB-WATERSHED 5 LAND USE MAP

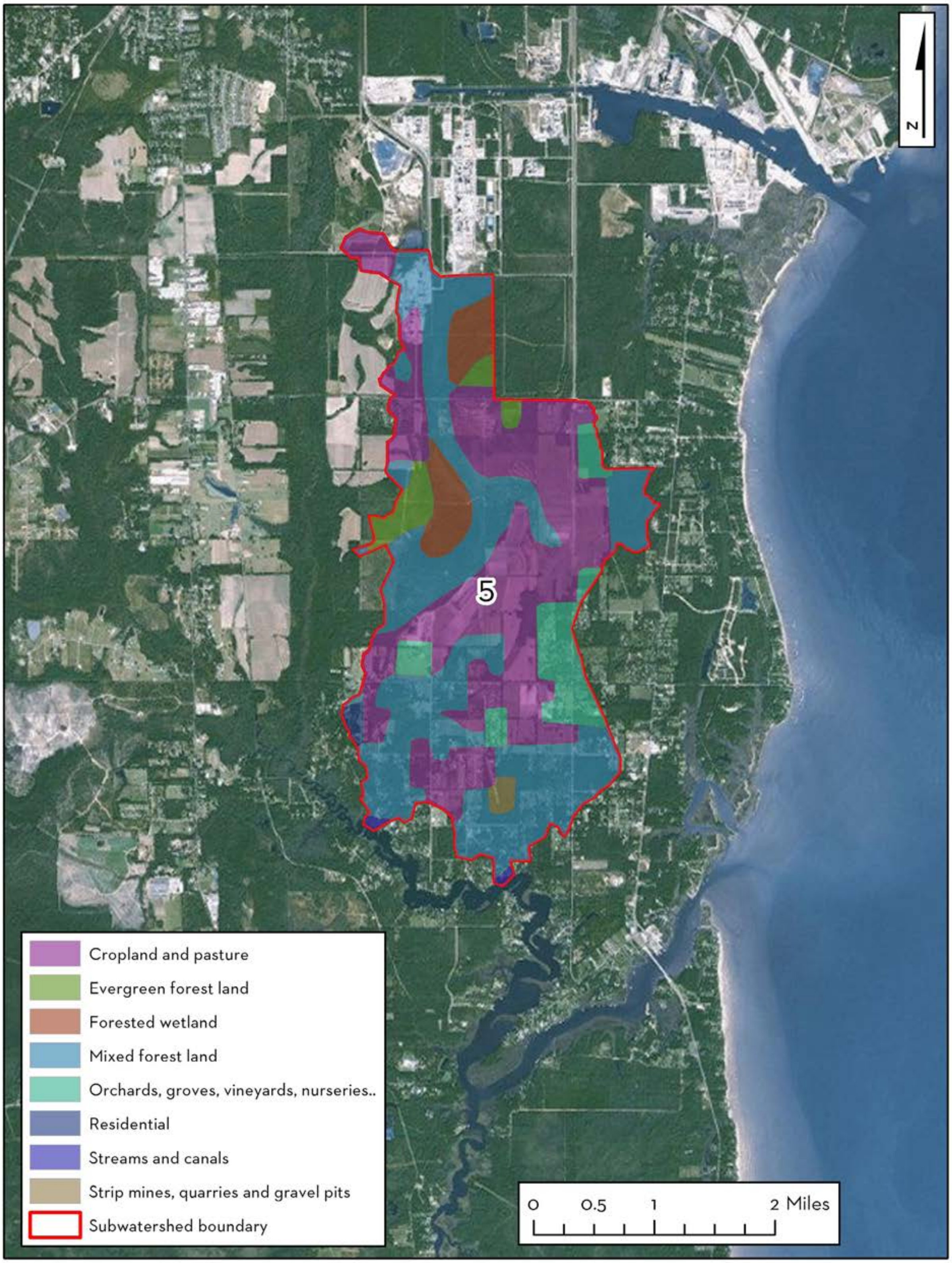
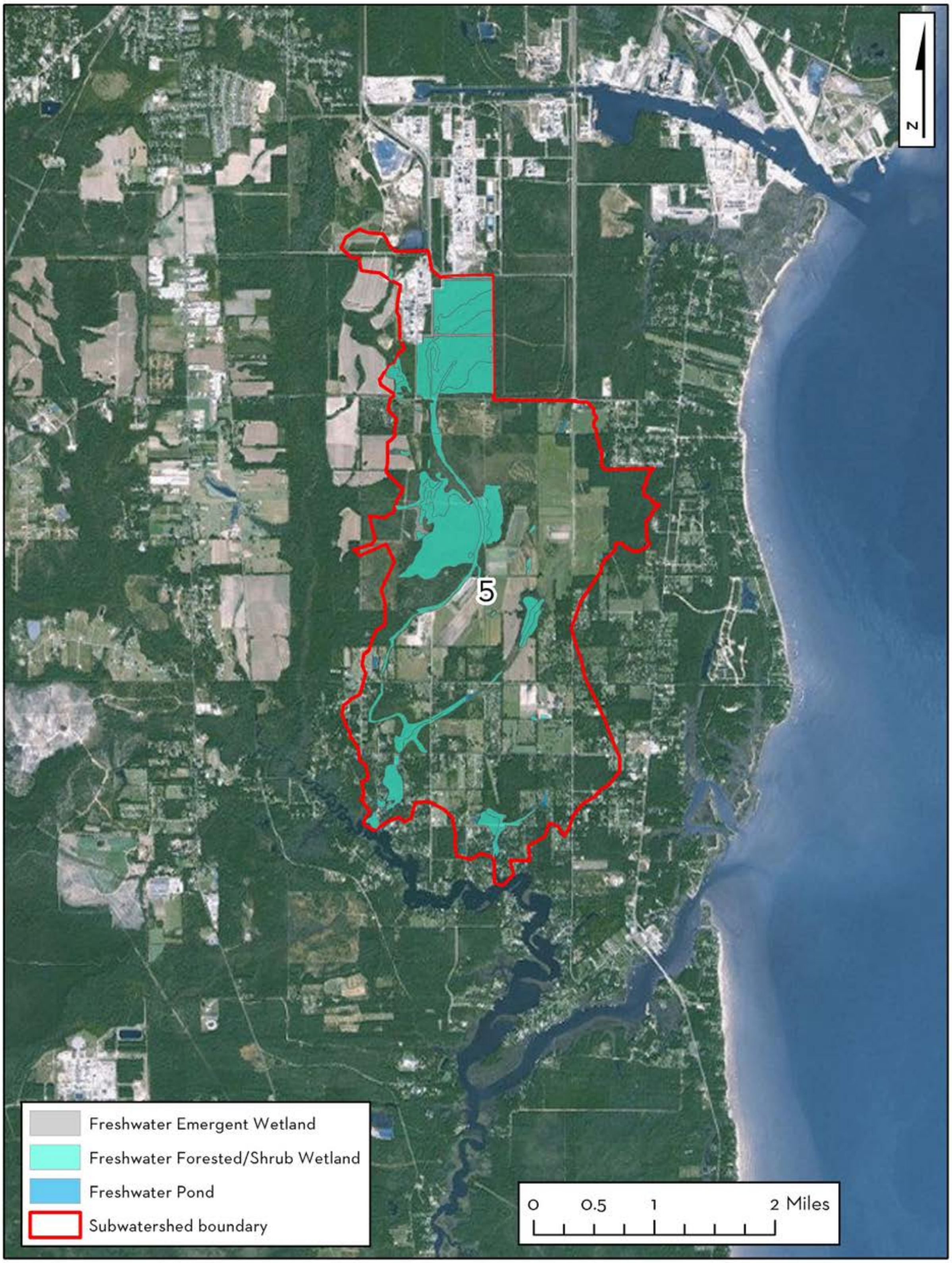


FIGURE 3.38: SUB-WATERSHED 5 WETLAND MAP



3.6.6 Sub-watershed 6

Sub-watershed 6 encompasses approximately 4,495 acres in the southwest section of the Fowl River Watershed, as shown in **Figure 3.40**. It is underlain by the Citronelle Formation in the extreme western portion of the area, and by coastal and alluvial deposits in the majority of the sub-watershed. The soils present belong to the Dorovan-Johnston-Levy and Bayou-Escambia-Harleston soil associations (see **Figure 3.41**). Sub-watershed 6 is hilly in the western portions of the sub-watershed with low marshes found in the flatter central and eastern portions (see **Figure 3.42**). Land surface elevation ranges from approximately 1 to 100 feet with a total relief of approximately 99 feet. Approximately 742 acres of land (16 percent of the sub-watershed) are developed for use in some way (**Figure 3.43**). Sub-watershed 6 comprises approximately 1,600 acres of freshwater/estuarine wetlands, or 18 percent of the total wetlands area within the Watershed (see **Figure 3.44**).

Major transportation routes through Sub-watershed 6 are Deakle Road, Walker Road, Bellingrath Road, and Windsor Road. Major land uses include residential, forested, agriculture and industrial, as depicted in **Figure 3.45.** Land use is typically uniform over large areas.

Figure 3.45: Industry along Deakle Road in Sub-watershed 6

FIGURE 3.40: SUB-WATERSHED 6 LOCATION MAP

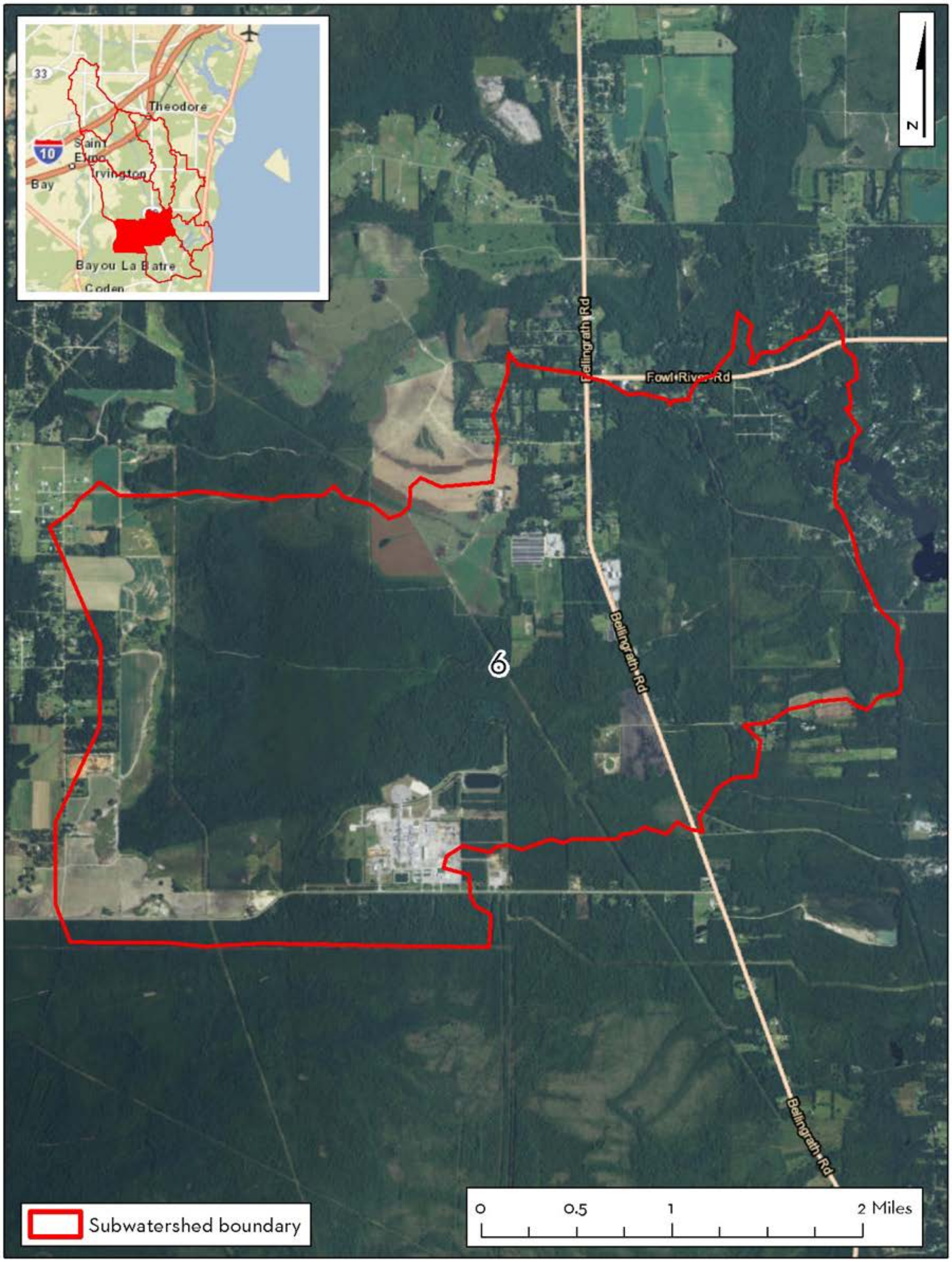


FIGURE 3.41: SUB-WATERSHED 6 SOIL TYPES

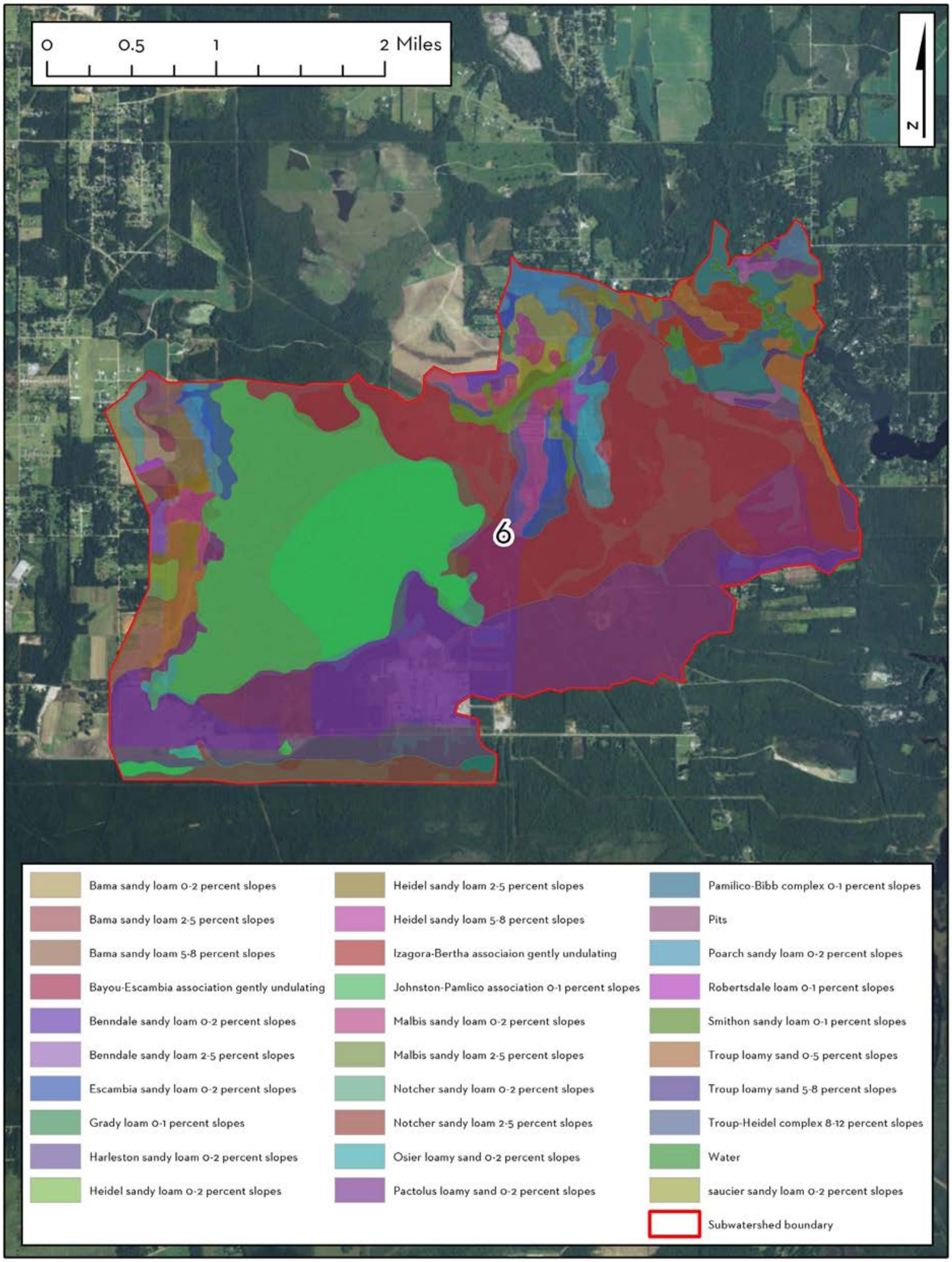
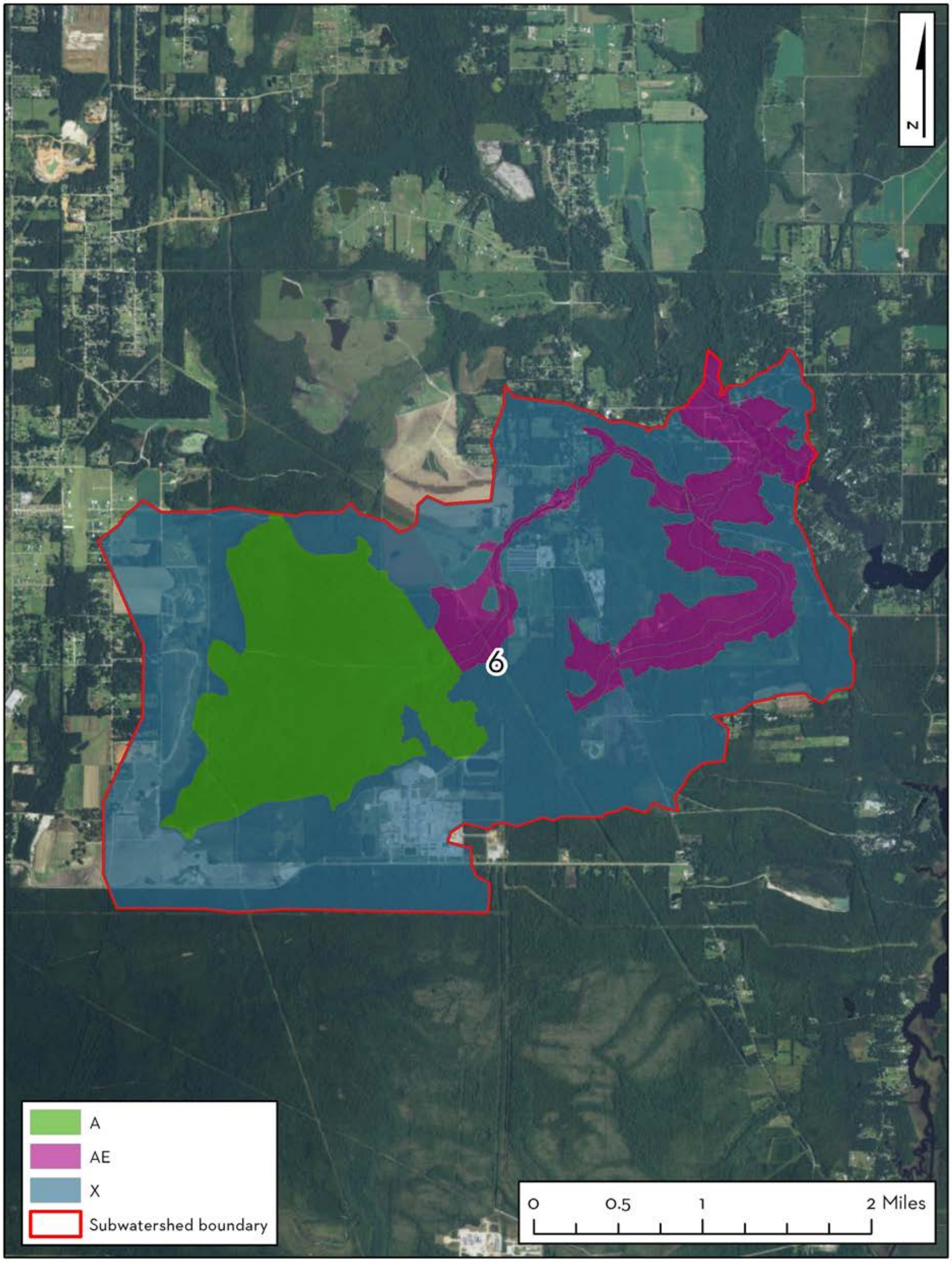


FIGURE 3.42: SUB-WATERSHED 6 FLOODPLAIN LOCATIONS



Zone A: 1-percent-annual risk of flooding but no BFE has been determined
Zone AE: 1-percent-annual risk of flooding and BFE has been determined
X: outside the 1-percent-annual risk of flooding

FIGURE 3.43: SUB-WATERSHED 6 LAND USE MAP

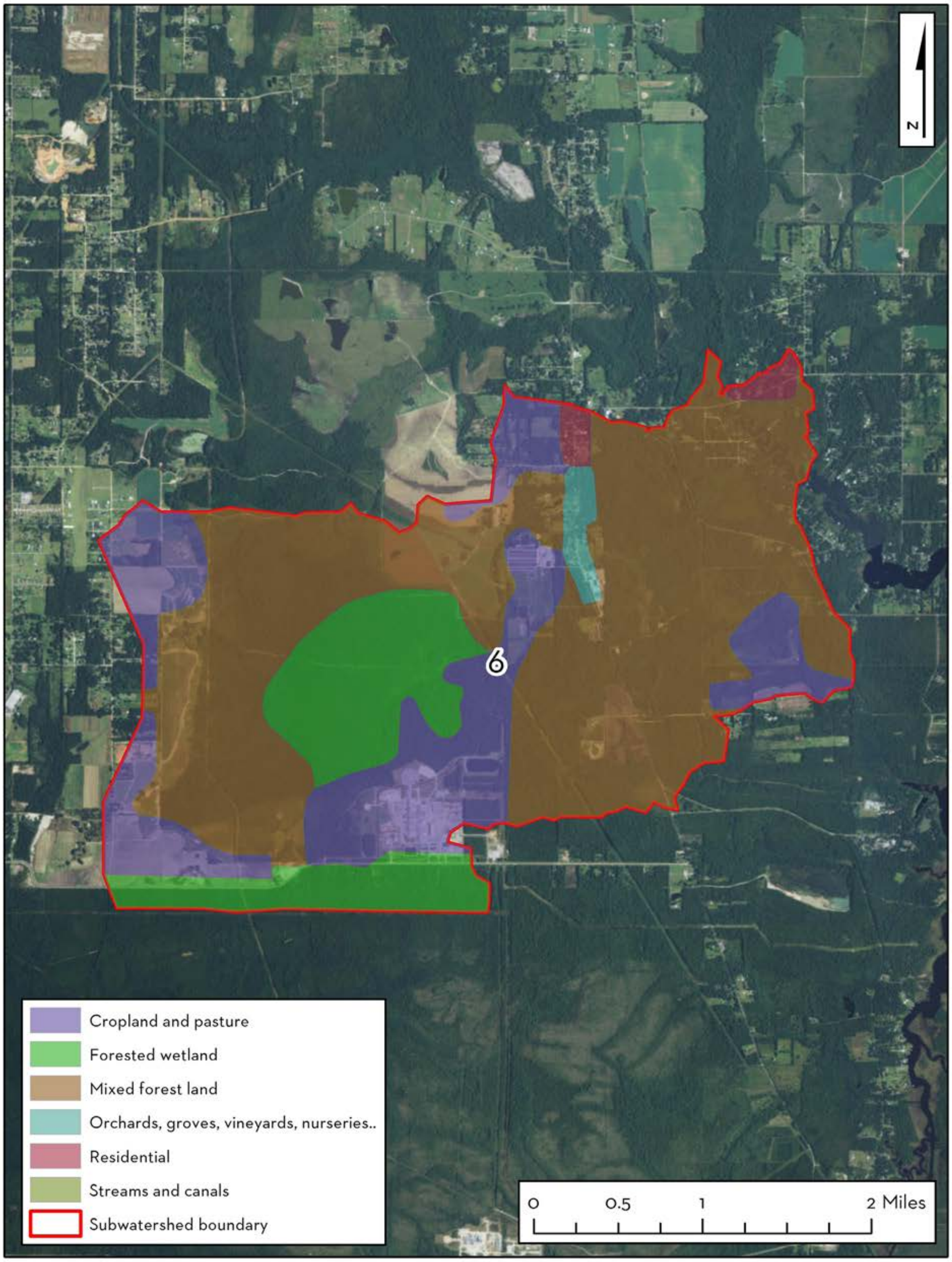
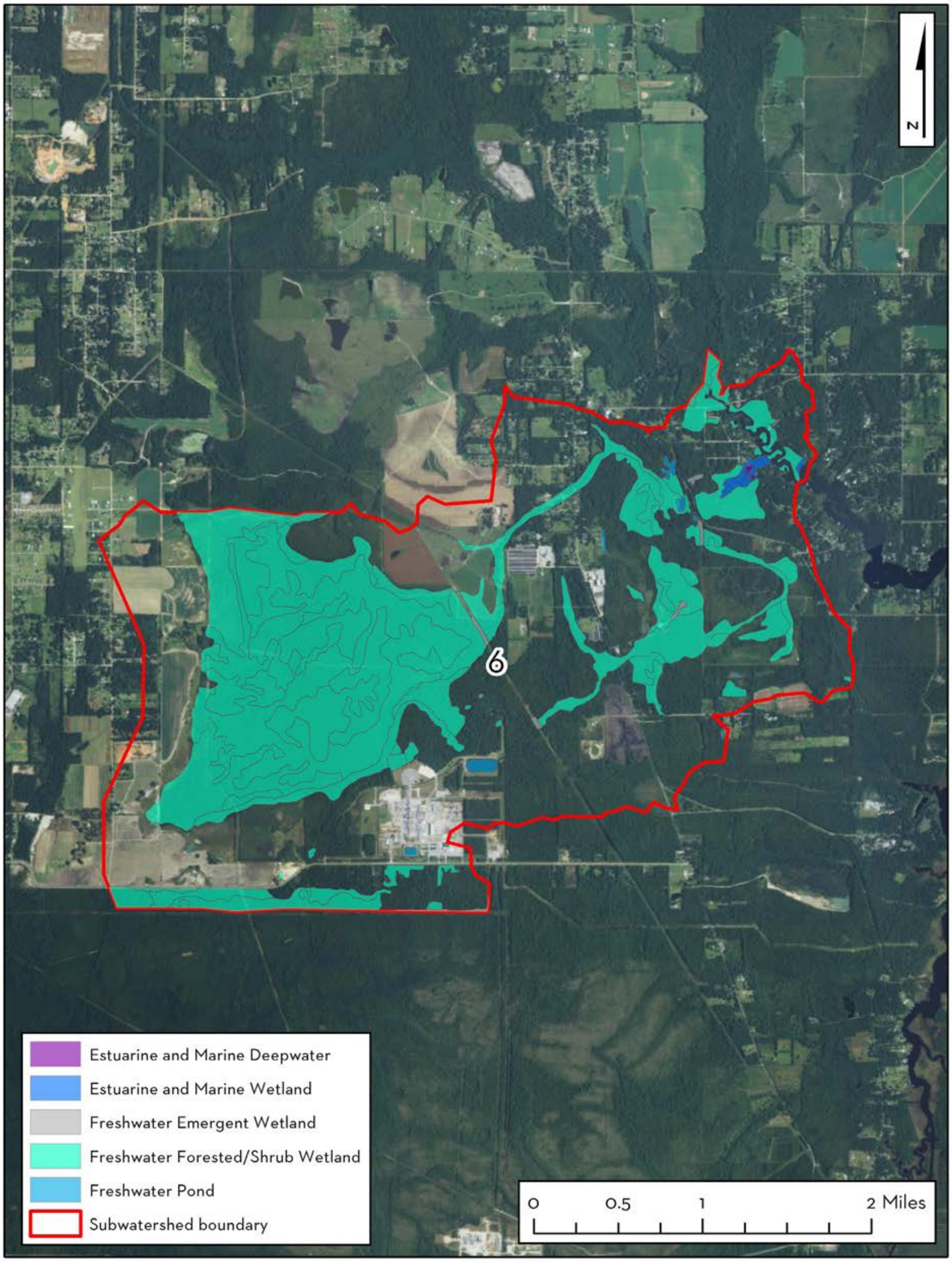


FIGURE 3.44: SUB-WATERSHED 6 WETLAND MAP



3.6.7 Sub-watershed 7

Sub-watershed 7 encompasses approximately 4,258 acres in the southern section of the Fowl River Watershed, as shown in **Figure 3.46**. It is underlain by coastal and alluvial deposits in the majority of the sub-watershed. The soils present belong to the Bayou-Escambia-Harleston and Axis-Lafitte soil associations (see **Figure 3.47**). Sub-watershed 7 is flat and low lying with very little relief (see **Figure 3.48**). Low marshes are found throughout Sub-watershed 7. Land surface elevation ranges from approximately 0 to 20 feet with a total relief of approximately 20 feet. Approximately 192 acres of land (5 percent of the sub-watershed) are developed for use in some way (see **Figure 3.49**). This is the lowest percentage of developed land use within any of the sub-watersheds. Sub-watershed 7 comprises approximately 1,200 acres of freshwater/ estuarine wetlands, or 13 percent of the total wetlands area within the Watershed (see **Figure 3.50**).

Major transportation routes through Sub-watershed 7 are Deakle Road, Bellingrath Road, Bay Woods Drive, Rock Road, and Rebel Road. Major land uses include horticulture, commercial (tourism), and silviculture. Land use typically is uniform within sections of the sub-watershed; numerous or different land uses in close proximity are not common. The Yellowhammer Natural Gas Plant, shown in **Figure 3.51**, is also located within Sub-watershed 7.

Figure 3.51: Yellowhammer Plant entrance on Dauphin Island Parkway in Sub-watershed 7

FIGURE 3.46: SUB-WATERSHED 7 LOCATION MAP

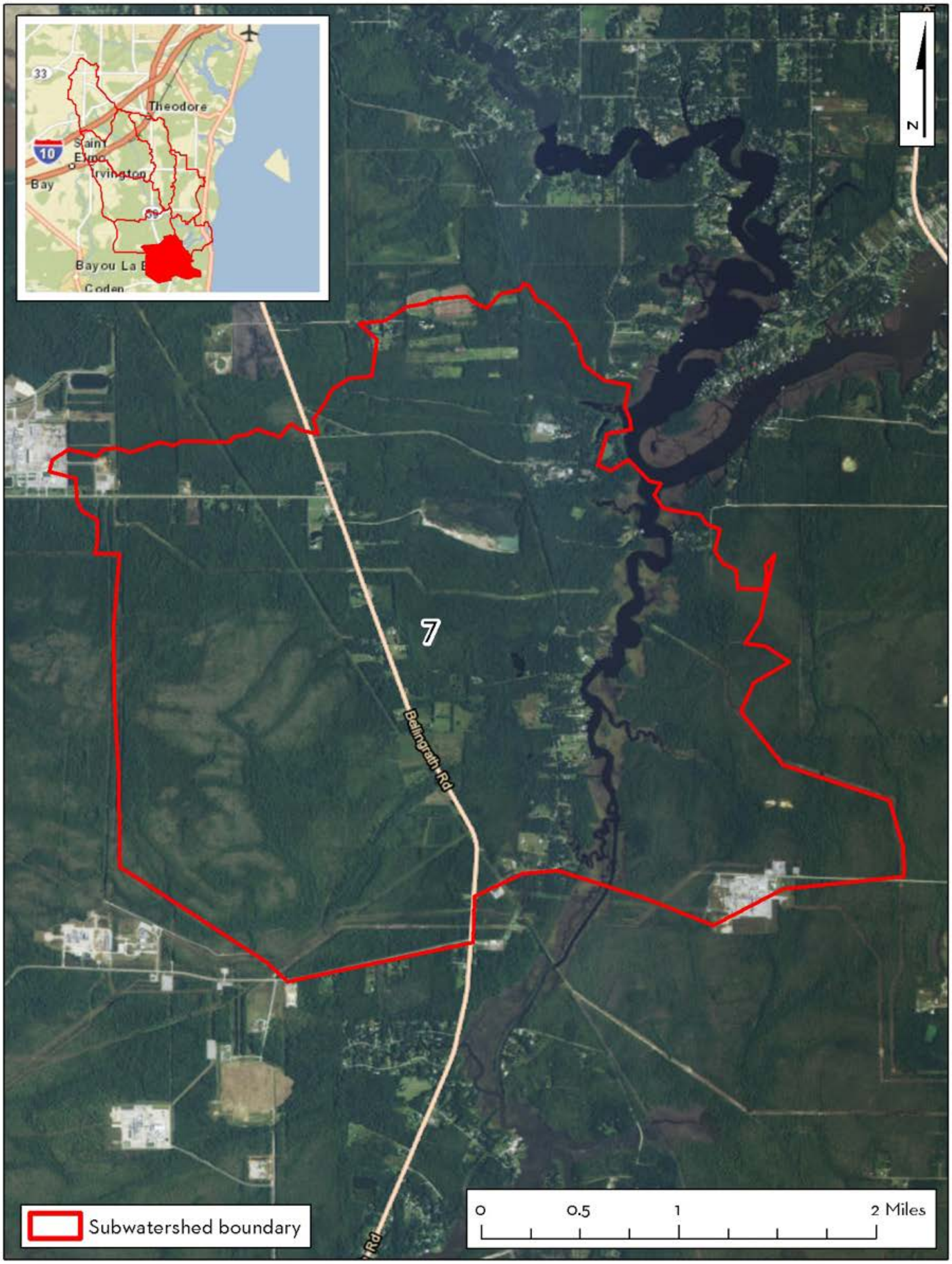


FIGURE 3.47: SUB-WATERSHED 7 SOIL TYPES

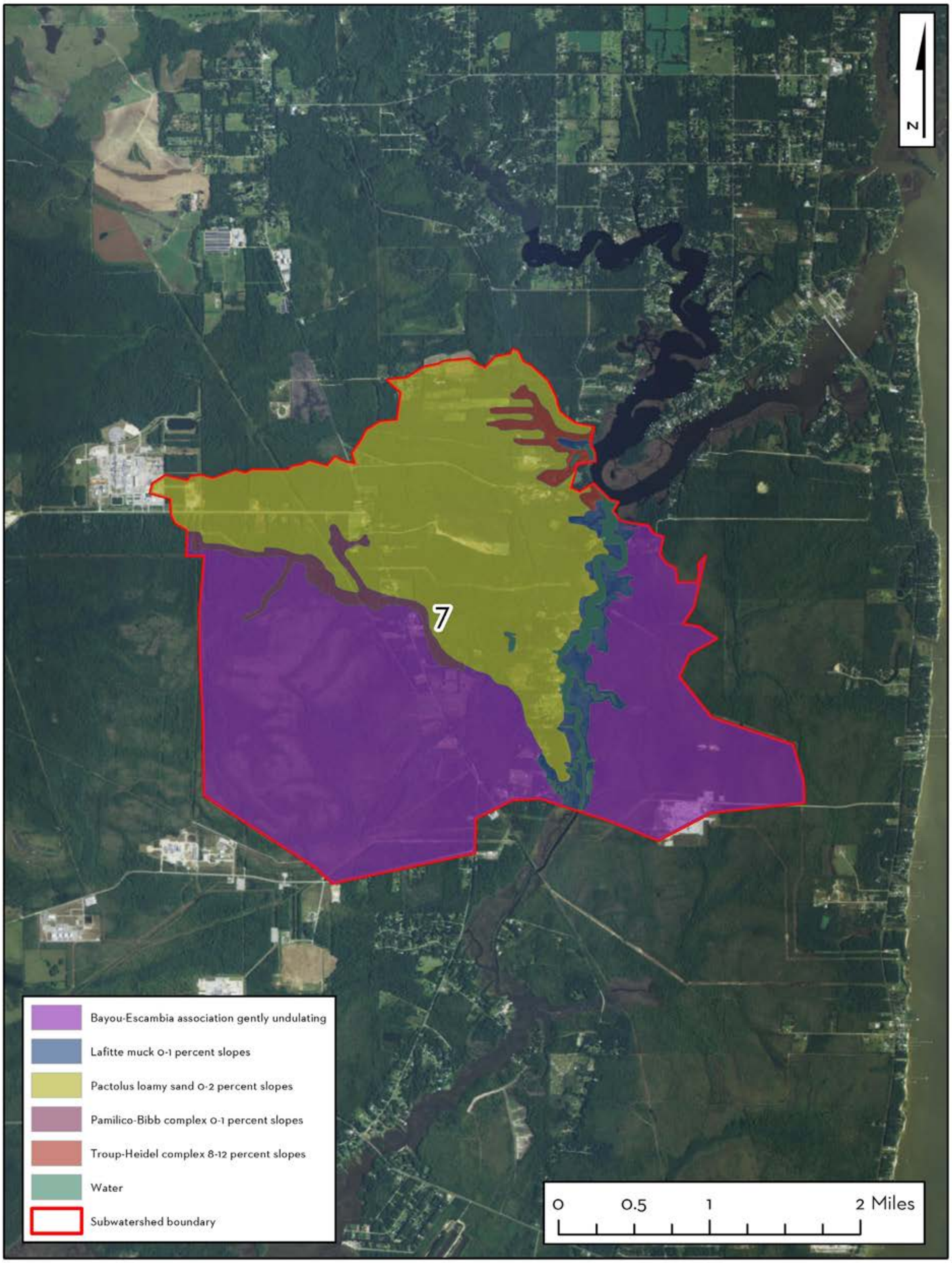
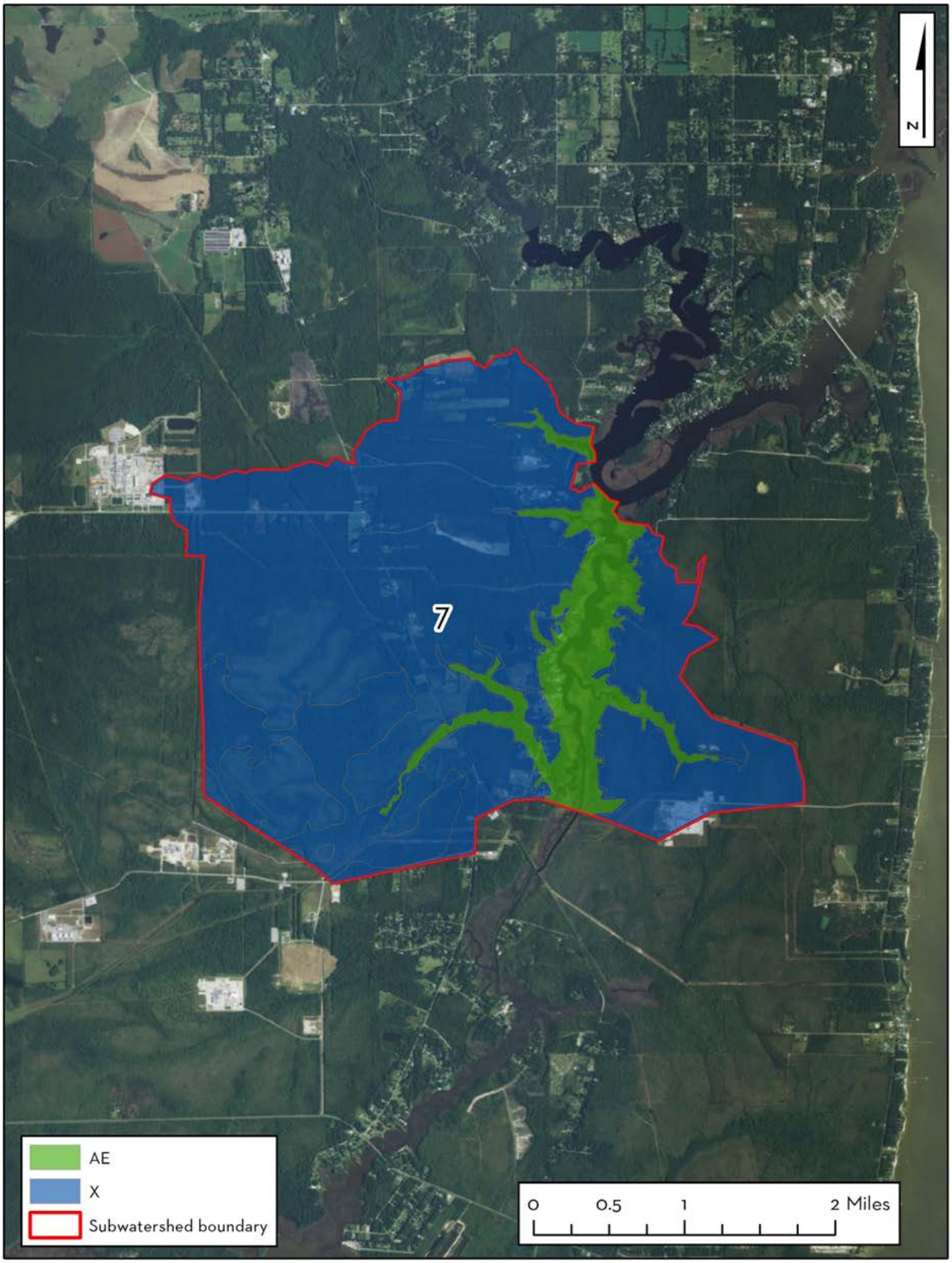


FIGURE 3.48: SUB-WATERSHED 7 FLOODPLAIN LOCATIONS



Zone AE: 1-percent-annual risk of flooding and BFE has been determined
X: outside the 1-percent-annual risk of flooding

FIGURE 3.49: SUB-WATERSHED 7 LAND USE MAP

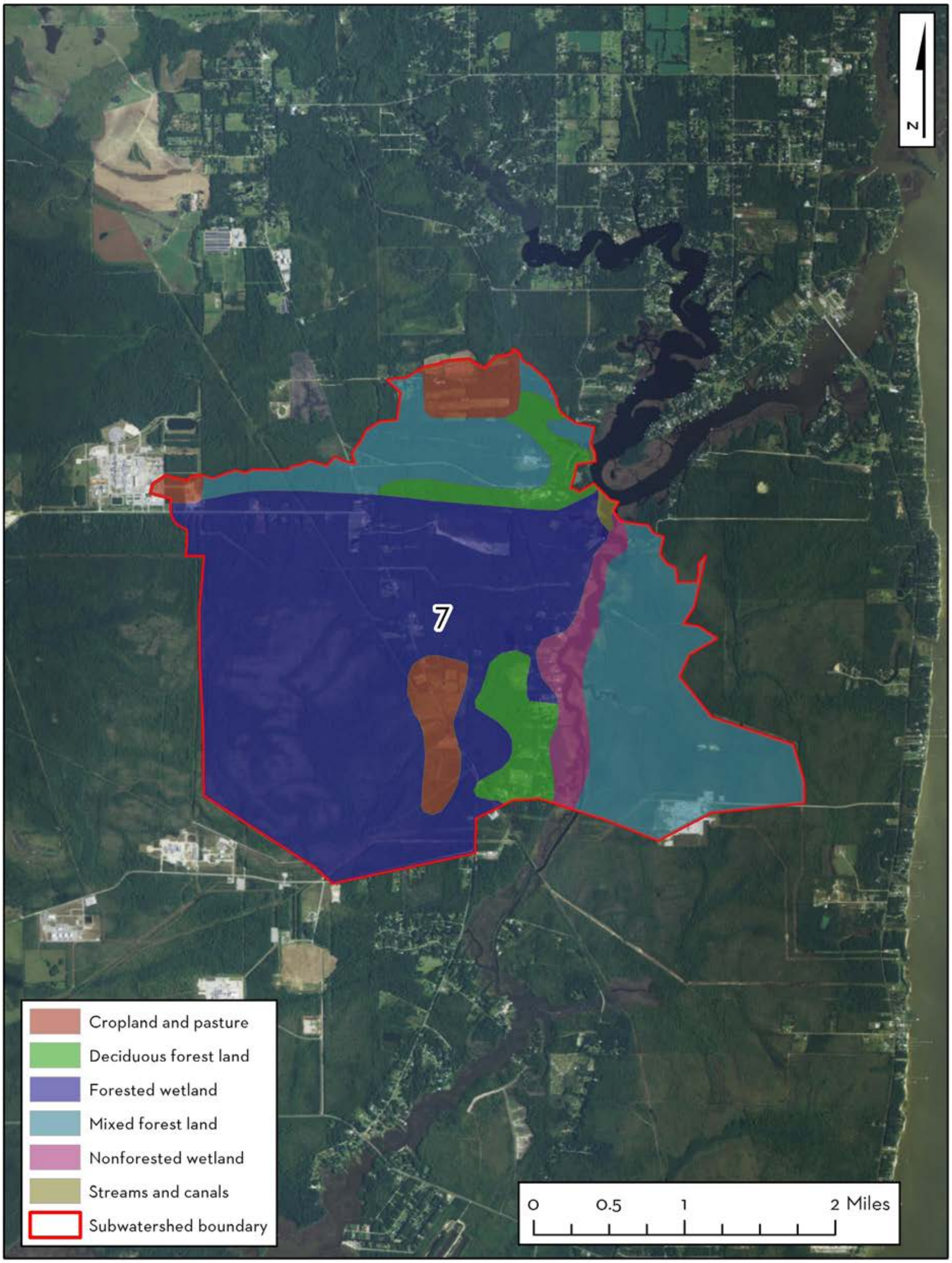
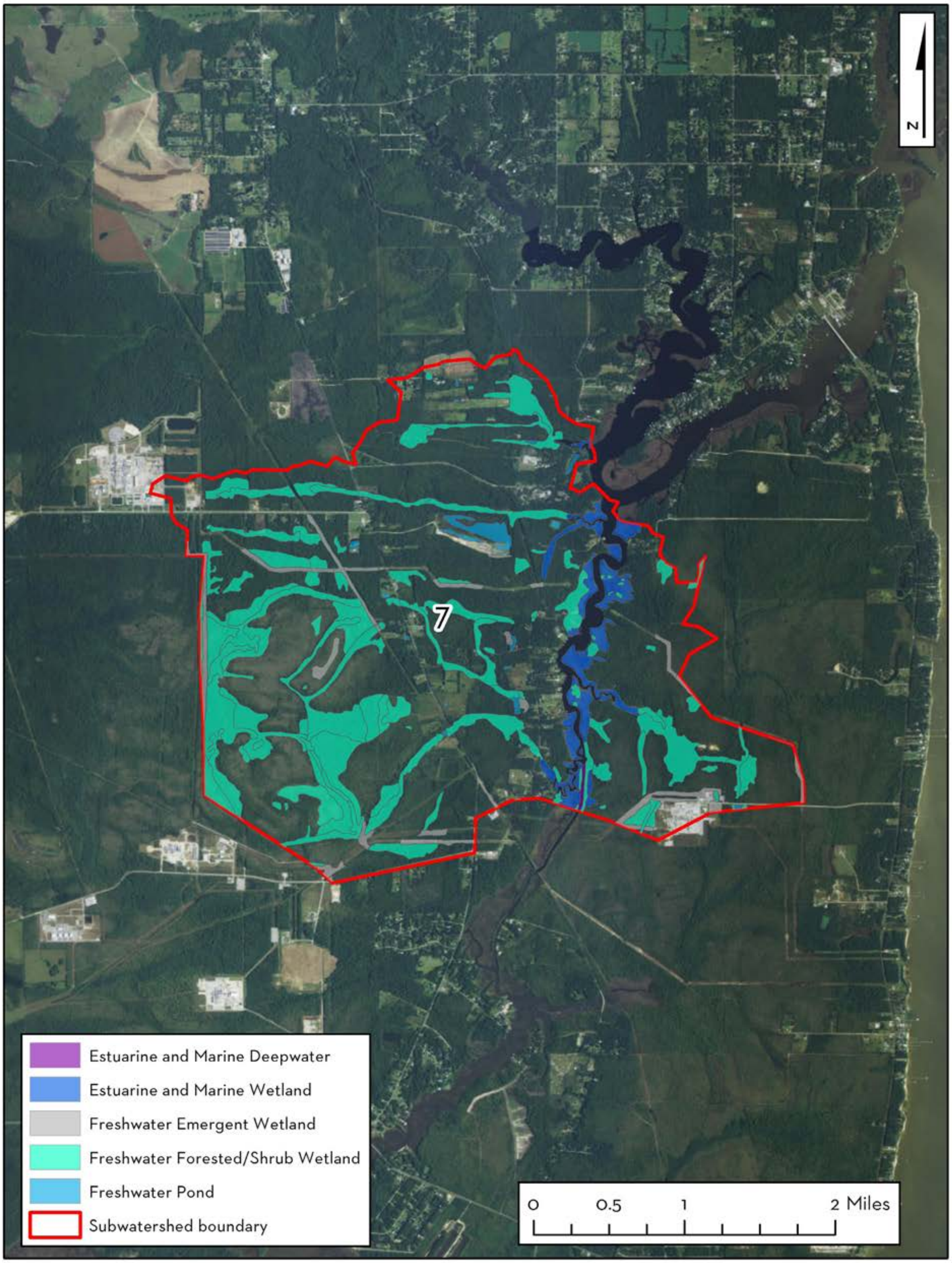


FIGURE 3.50: SUB-WATERSHED 7 WETLAND MAP



3.6.8 Sub-watershed 8

Sub-watershed 8 encompasses approximately 2,451 acres in the east central section of the Fowl River Watershed, as shown in **Figure 3.52**. It is underlain by coastal and alluvial deposits. The soils present belong to the Bayou-Escambia-Harleston soil associations (see **Figure 3.53**). Sub-watershed 8 is flat and low lying with very little relief (see **Figure 3.54**). Low marshes are found bordering Fowl River. Land surface elevation ranges from approximately 0 to 35 feet with a total relief of approximately 35 feet. Approximately 384 acres of land (15 percent of the sub-watershed) are developed for use in some way (see **Figure 3.55**). Sub-watershed 8 comprises approximately 816 acres of predominately estuarine wetlands, or 9 percent of the total wetlands area within the Watershed (see **Figure 3.56**).

Figure 3.57 shows the Fowl River estuary near Dauphin Island Parkway (State Highway 193), which is one of the major transportation routes in Sub-watershed 8. Other major transportation routes through this area are River Road, Windsor Drive, Baumhauer Road, Riverview Road, and Pinetop Road. Major land uses include residential, commercial, agriculture, open water, and recreation. Land use typically is uniform within sections of the sub-watershed; numerous and different land uses in close proximity are not common.

Figure 3.57: Fowl River estuary near Dauphin Island Parkway in Sub-watershed 8

FIGURE 3.52: SUB-WATERSHED 8 LOCATION MAP

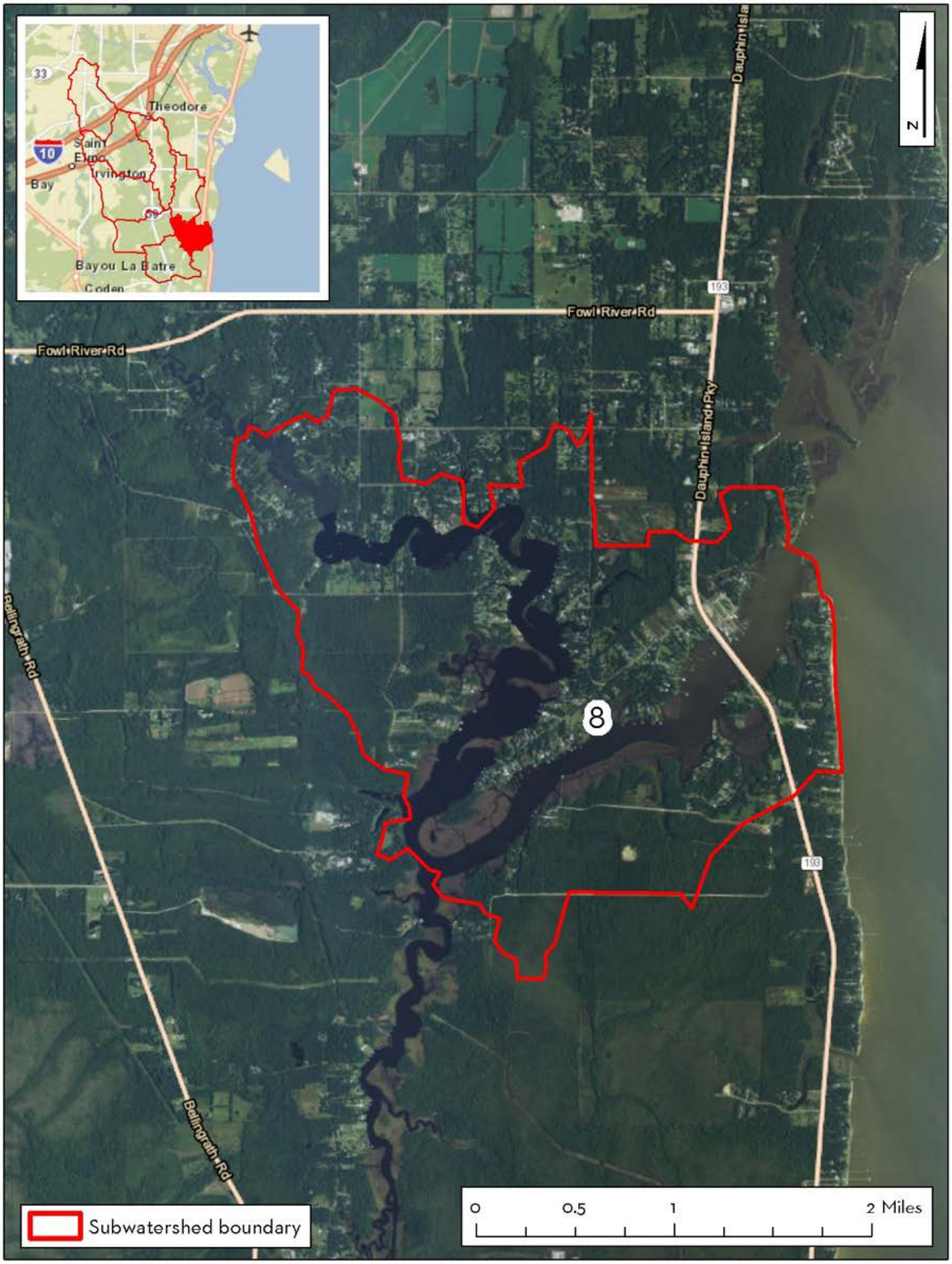


FIGURE 3.53: SUB-WATERSHED 8 SOIL TYPES

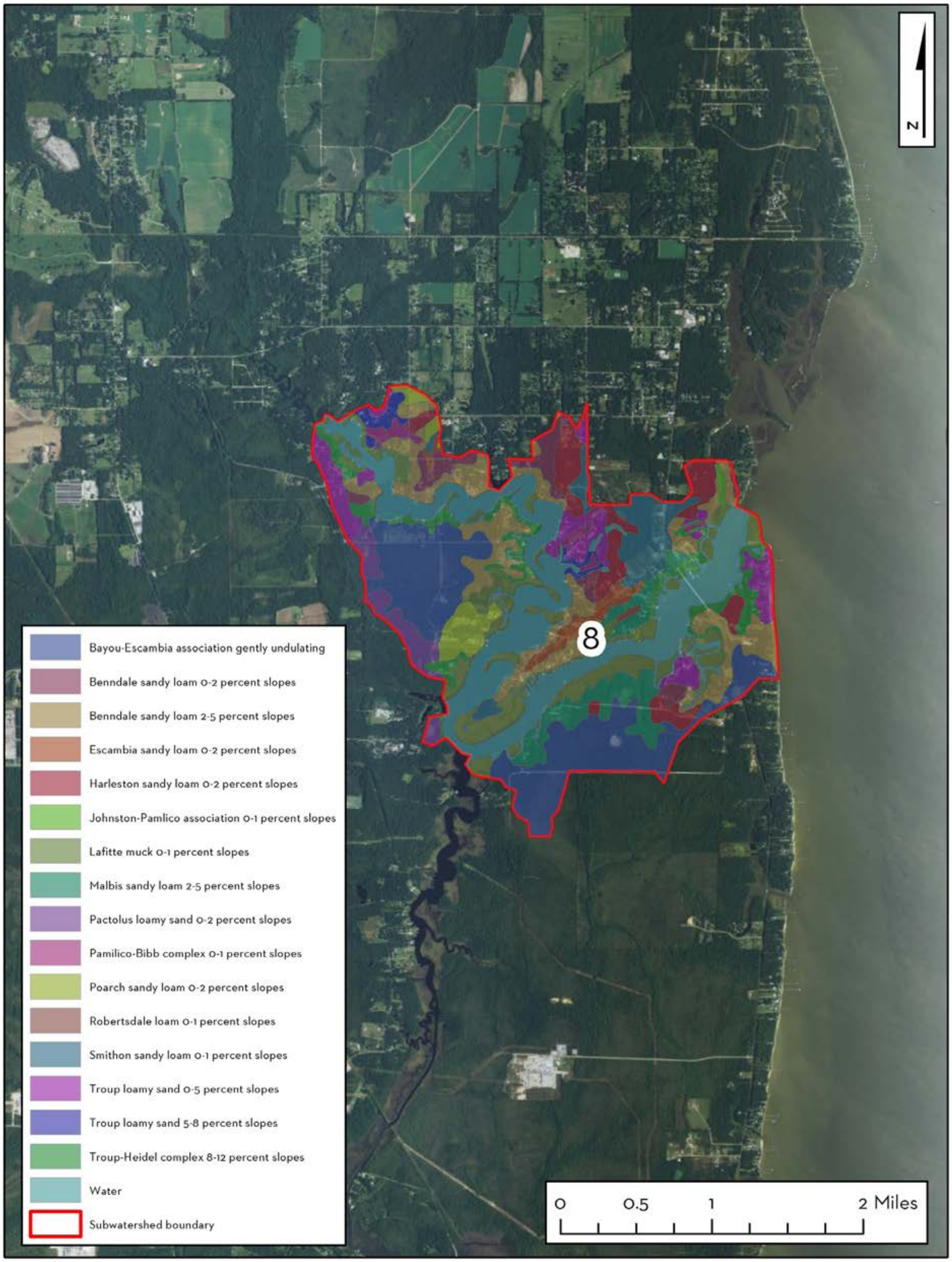
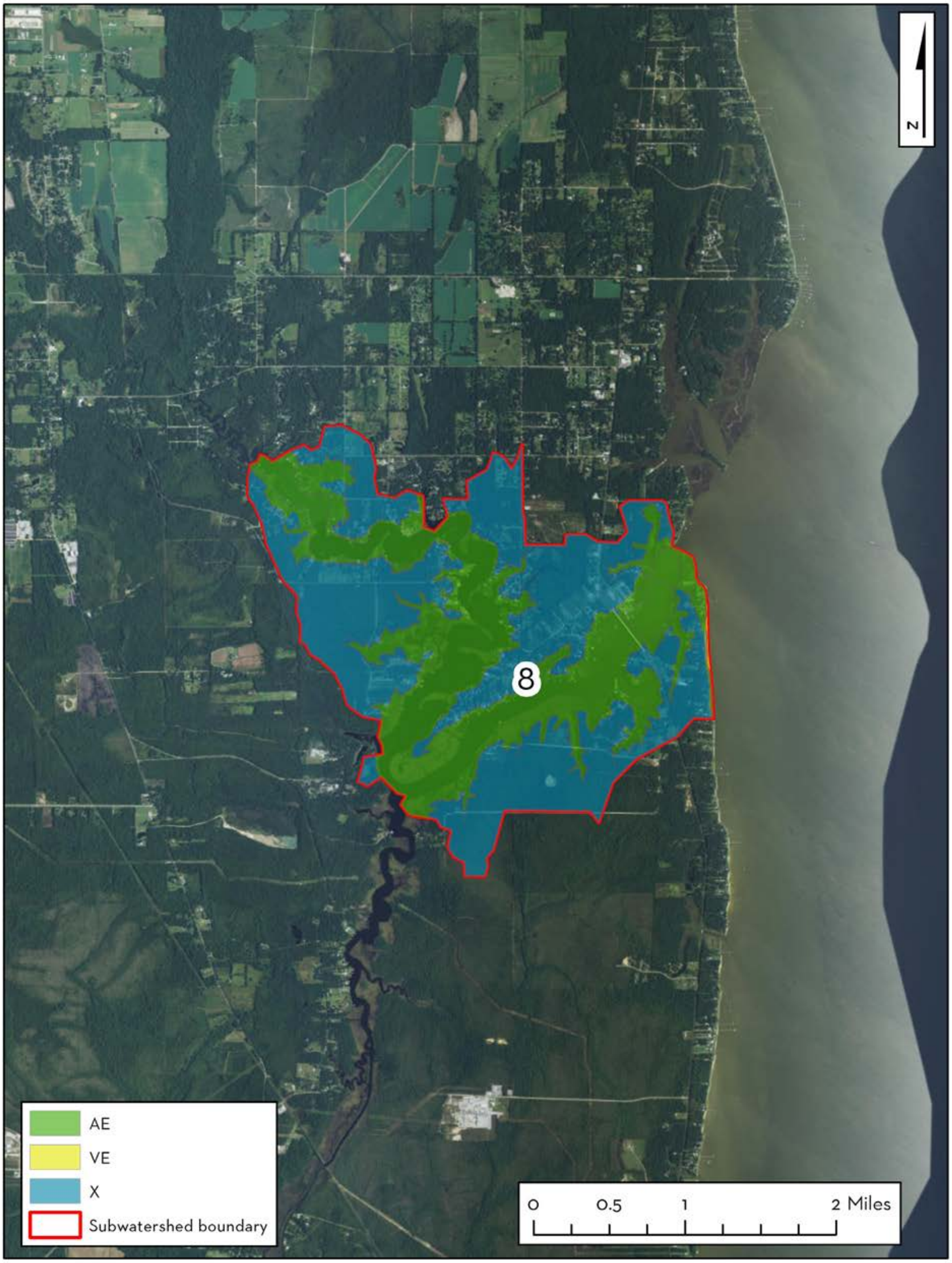


FIGURE 3.54: SUB-WATERSHED 8 FLOODPLAIN LOCATIONS



Zone AE: 1-percent-annual risk of flooding and BFE has been determined
Zone VE: 1-percent-annual risk of flooding with additional hazards due to storm waves; BFE has been determined
X: outside the 1-percent-annual risk of flooding

FIGURE 3.55: SUB-WATERSHED 8 LAND USE MAP

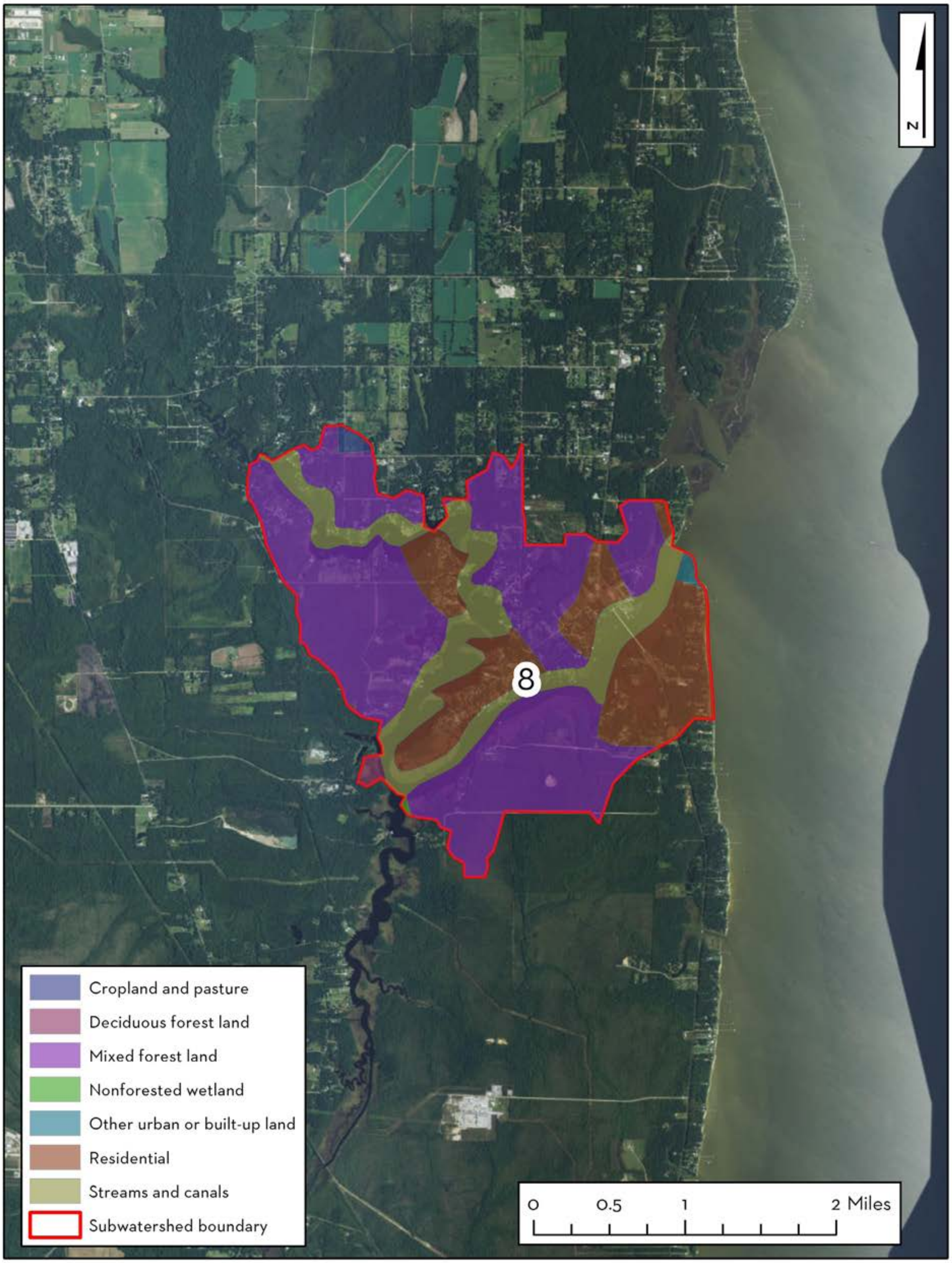
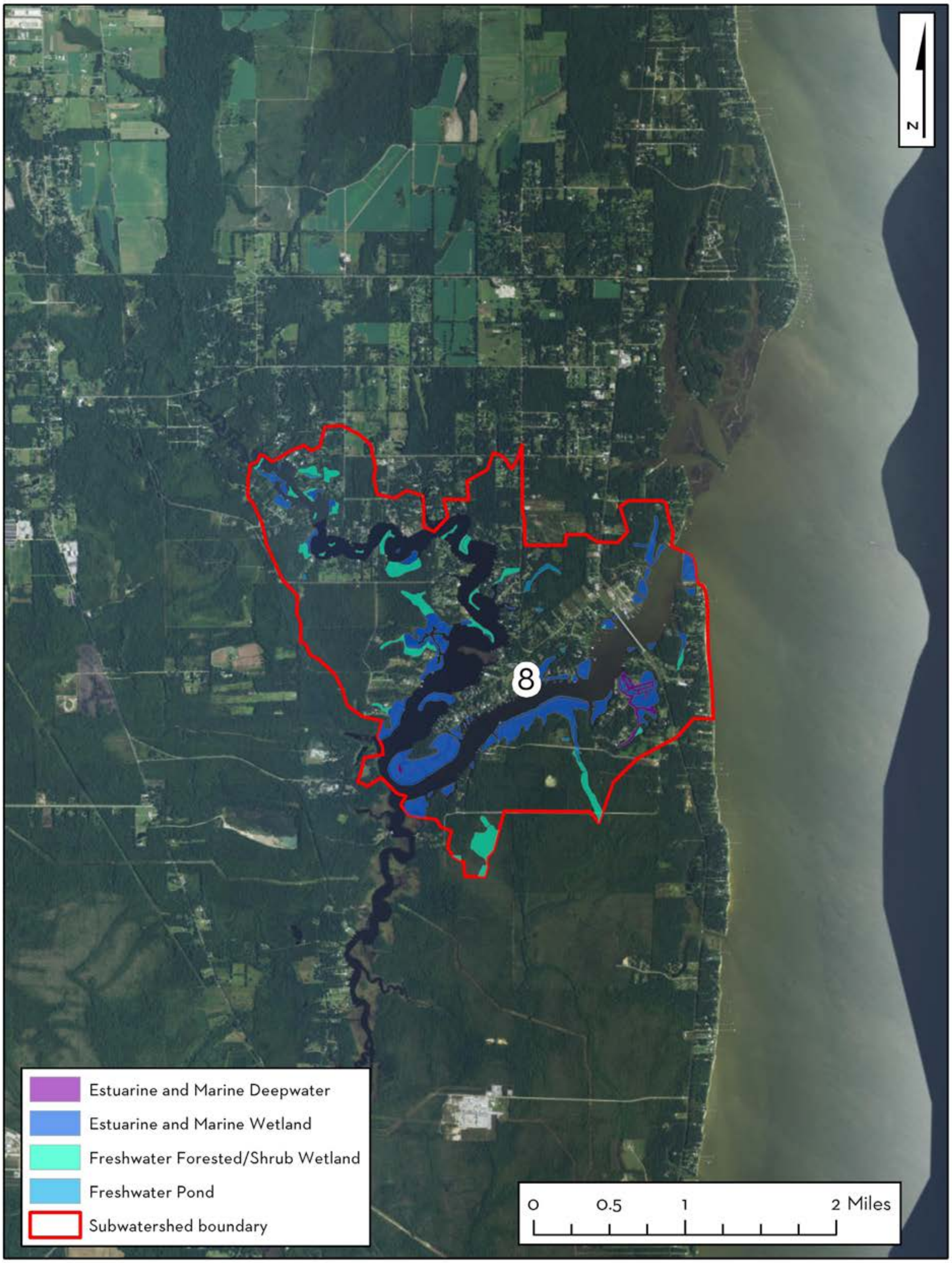


FIGURE 3.56: SUB-WATERSHED 8 WETLAND MAP



3.0 WATERSHED CHARACTERIZATION

3.7 POLITICAL JURISDICTIONS

Two political entities exercise governmental authority within the Fowl River Watershed: the City of Mobile and Mobile County. **Figure 3.58** illustrates the areas within the Watershed that fall under the jurisdiction of each of these governmental entities. **Table 3.5** lists the Watershed acreages controlled by each entity.

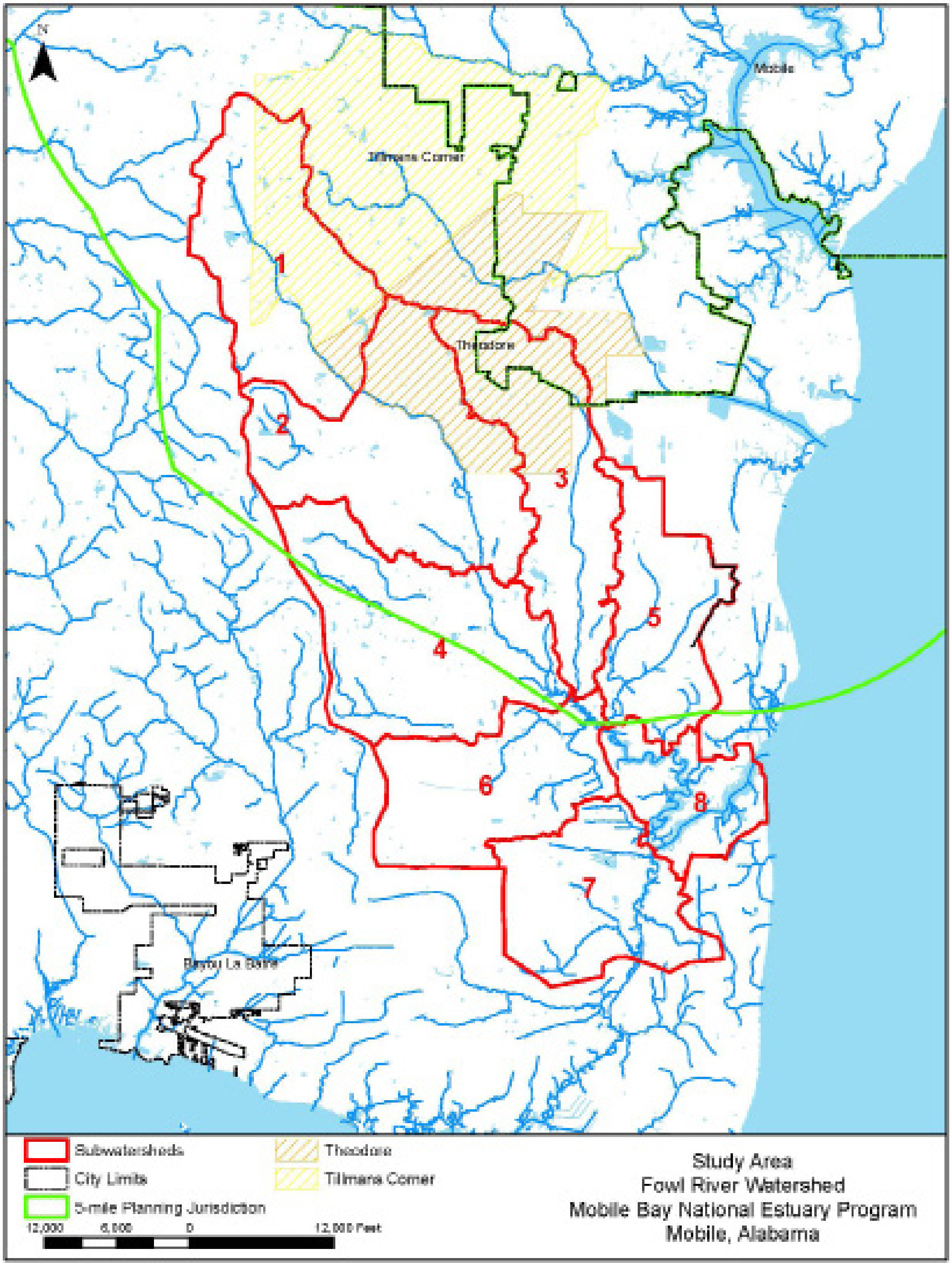
With the exception of I-10, US 90, and State Road 193 and their associated rights-of-ways, there are essentially no significant state or federal land holdings within the Watershed. Again, with the exception of the highways, all publicly-owned lands are controlled by the City of Mobile or Mobile County. Approximately 71.6 percent of the Watershed is located within municipal jurisdictional boundaries. It is important to note that municipal control includes areas outside the municipal boundaries, but within the City's jurisdictional control.

The planning jurisdiction of the City of Mobile extends beyond the boundary as allowed by the extraterritorial jurisdiction (ETJ) provision of Alabama State Law. The ETJ provision allows cities the authority to review all planned subdivision developments within their ETJ, which extends a maximum of five miles outside their corporate limits. Therefore, all developments within the neighboring unincorporated lands of Mobile County within five miles of municipal boundaries are subject to review by the City of Mobile. The remaining 11,291 acres of unincorporated Mobile County lands located within the Watershed are contained within Mobile County's Planning District No. 3. Theodore and Tillman's Corner are not incorporated.

TABLE 3.5: ACREAGES WITHIN FOWL RIVER WATERSHED UNDER JURISDICTIONAL CONTROL

	Acres	Square Miles	Percent of Watershed
City of Mobile (within City Limits)	720	1.12	1.80
City of Mobile (within ETJ)	27,758	43.37	69.80
Mobile County Planning District No. 3	11,291	17.64	28.40
Total	39,769	62.13	100

FIGURE 3.58: POLITICAL JURISDICTIONS WITHIN THE FOWL RIVER WATERSHED



3.8 POPULATION

3.8.1 History and Culture of Fowl River

Mobile County, Alabama was created by proclamation of Governor David Holmes of the Mississippi Territory in December 1812. Both the City and the County derive their name from Fort Louis de la Mobile, a French fortification erected near Mount Vernon in 1702. The word "Mobile" is believed to have been derived from a Choctaw Indian word for "paddlers." Prior to 1812, the area was occupied by the French from 1702-1763, the British from 1763-1780, and the Spanish from 1780-1812/13.

The first recorded European exploration of what was to become Mobile County occurred during the early 1500s. In 1519, Alonzo Alvarez de Pineda sailed the Gulf of Mexico from Florida to Mexico, including Mobile Bay (Alabama Department of Archives and History, 2015, accessed at http://www.archives.alabama.gov/timeline/al1519.html). Early Spanish maps designated the area around Mobile Bay as Bahia del Espiritu Santo – Bay of the Holy Spirit. For the next 50 years, Spain repeatedly tried and failed to establish a permanent colony on the Gulf Coast.

Robert Cavalier, Sieur de La Salle, navigated the Mississippi River in 1682, claiming the region for France and naming it Louisiana in honor of King Louis XIV. Sometime around 1698, Jean Baptiste Lemoyne de Bienville and his brother, Pierre Le Moyne d'Iberville, came to Mobile and began to explore. The brothers discovered a freshwater spring along the beaches and named it Belle Fontaine. They moved French colonists from Louisiana, built settlements on the western shore of Mobile Bay, and established a deep water port on Dauphin Island.

Early settlers to the region faced the daunting prospect of converting virgin territory into farmland in the face of privation, uncertain relations with the Native Americans, and intermittent warfare between the Spanish, French, and English. The main occupations of settlers were shipbuilding, fishing, farming, raising livestock, and cutting timber. The dependents of many early settlers still live in the Fowl River Watershed and proudly trace their heritage to the earliest era of French settlement.

Not surprisingly, one of the oldest industries in the area is shipbuilding. The shipyard on Mon Luis (now spelled Louis) Island was founded in the 1850s. Those working at the shipyard built all kinds of boats from cypress trees they cut themselves. They also built ships used by the Confederate Navy to "run" the Union blockade at the mouth of Mobile Bay. The shipyard closed in 1954 after operating for nearly a century, but the tradition continues in boatyards located along Bellingrath Road just south of Theodore.

By the mid-1800s, horticulture had become a very important part of the local economy. Gardens and various types of fruit trees were cultivated. Records indicate that fig, pear, orange, grapefruit, satsuma, and pecan trees were common (Fowl River Women's Club, 2010). Sassafras trees grew on Mon Louis Island, and locals would harvest the leaves to make the spice filé powder, also called gumbo filé. By the early 1900s, Fowl River, Belle Fontaine (just north of the Watershed), and Mon Louis Island were nationally recognized as citrus-producing regions. Pecan and satsuma orchards became widespread in the early 1900s. The citrus trees were destroyed by freezing in the mid-1930s, but the remains of aged pecan orchards can still be found throughout the Fowl River Watershed.

3.0 WATERSHED CHARACTERIZATION

Bellingrath Gardens was being created just as the citrus industry was being destroyed by freezing winters. Bellingrath Gardens and Home began in 1917 when Walter Bellingrath, president of the local Coca-Cola bottling plant, purchased land for a fishing camp. Mr. Bellingrath and his wife Bessie were loved and well-respected for their charitable works during the years of the Great Depression. Mrs. Bellingrath began developing the gardens in 1927 with architect George Bigelow Rogers. Their home was completed several years later in 1935. It encompasses 10,500 square feet and features hand-made brick salvaged from the 1852 birthplace of Alva Smith Vanderbilt Belmont in Mobile. Bellingrath Gardens and Mansion was officially listed in the Alabama Register of Landmarks and Heritage on September 14, 1977 and in the National Register of Historic Places on October 19, 1982.

The success of Bellingrath Gardens, along with the suitable climate and soils, encouraged entrepreneurs to establish nurseries throughout the Fowl River Watershed, such as the Washington family. In 1932, the Washingtons began selling azaleas out of the back of their truck. Today this fourth-generation business extends across the Gulf Coast states. There are numerous nurseries currently operating within the Watershed.

Early travel within the Watershed must have challenged the ability of farmers and merchants to take produce to market. In 1836, the area now known as Bellingrath Road was described as piney woods and swamps by a traveling minister. Travel was improved somewhat by the building of the Old Bay Shore Railroad Line that the modern Bellingrath Road follows. By the 1860s, the Orrell family had begun using the improved access provided by the railroad to settle the area along Bellingrath Road just north of Fowl River. The Orrell family has a long and dignified history in the area with members serving in the Civil War and still shaping the land today as developers and builders. The family cemetery is listed in the Alabama Register of Historic Cemeteries.

Travel within the Watershed continued to be a challenge through the early to mid-1900s. In 1932, nearly 100 years after the area was described as woods and swamp, Bellingrath Road was still made of red clay and gravel. Around that time, local resident Mary Walker described the road as “an awful mess” when it rained, and Mr. Bellingrath finally had the road paved. The State of Alabama “farm-to-market” road project paved other roads in the Watershed from 1946-1970; however, many of its roads remain unpaved today.

In the northern and central portion of the Watershed are the communities of Dawes, St. Elmo, Irvington, and Theodore. Located at the extreme northern tip of the Fowl River Watershed, Dawes originated around 1910 as a farming operation run by the Mobile Farm Company. The Company built homes to house the local officers and workers, in addition to building and selling houses to those who came to live in the area. The population of the area grew rapidly, and the first school was built in 1911. Large pecan and satsuma groves were planted. The satsuma orchards were so successful that in 1914 the O and M Railroad extended a line to transport the harvest from the area. In 1922, a packing plant was erected by the Citrus Exchange Company. Freezing weather destroyed the satsuma groves, but many pecan groves remain today. The land beneath the trees is commonly used as cattle pasture.

St. Elmo proper lies just outside the Fowl River Watershed, but the community extends well into the Watershed. St. Elmo was originally known as Summit, presumably a reference to the low rise that the community is built upon. The community farmed the land, and was best known for the potatoes, cabbage, and cotton grown there in the late 1800s. Satsumas were added later during the citrus boom. Exploitation of the heavy timber in the area resulted in the founding of turpentine stills and sawmills. Logs were processed by the sawmill, and fuel wood was shipped to Mobile. A two-room schoolhouse was used until the St. Elmo-Irvington School was completed in 1927. It is rumored that Jesse James and his gang hid out in St. Elmo after one of their robberies, assuming different names to disguise themselves. This rumor has yet to be confirmed, and likely will remain legend due to the passage of time and memory. An airfield located just north of Highway 90 west of St. Elmo was an outlying field of Brookley Air Base in Mobile. It was used for training flights during WWII and is now owned by the State of Alabama.

3.0 WATERSHED CHARACTERIZATION

Early in the 20th century, Irvington was a thriving farm community and the center of a lucrative tung oil business from the mid-1950s through the late 1970s. Theodore is a "census-designated place," and had a population of 6,130 when the 2010 census was taken. It is part of the Mobile metropolitan statistical area. Prior to 1900 this area was known as Clements, but is now named for William Theodore Hieronymous, a sawmill operator and postmaster.

The residents of Fowl River have always joined together to help one another, work on common projects, and fellowship. This tradition is reflected today in the many area churches, clubs, and organizations that seek to care for, encourage, and benefit the people and environment of Fowl River. One historic chapel on Mon Louis Island, constructed around 1853, served as a gathering point for the Collins family and other local residents until 1900 when St. Rose of Lima Church was built nearby. St. Rose of Lima Church still serves the local people as a place of worship and a community meeting place.

There are several area clubs and organizations in the Fowl River Watershed, including the Fowl River Women's Club (founded in 1941 and responsible for publishing the book from which most of this history was gleaned), the Belle Fontaine Garden Club (founded in 1949), the Fowl River Area Civic Association (FRACA) (founded in 1972), the Fifty Plus Club (founded in 1987), the Fowl River Volunteer Fire District (founded in 1964), the Fowl River Community Watch (founded in 1977), American Legion Post 250 (founded in 1995), the Rabbit Club (founded in 1972), the Fowl River Chapter of Mobile Baykeeper/Fowl River Protective Association, and the Fowl River Olympic Team.

The mission of FRACA is to "develop community spirit and activities in the Fowl River and Belle Fontaine areas, and to provide a voice for the community to gain the attention of elected officials for resolving local problems." The organization meets at the Fowl River Community House, which was placed on the Alabama Register of Landmarks and Heritage by the Alabama Historic Commission in 1990. The Association greatly enhanced the efforts of the Fowl River Watershed Management Team by allowing the Steering Committee to meet at the Fowl River Community House throughout the planning process.

3.8.2 County Population Trends

Mobile County is currently ranked 27th in the state with a population growth rate of 3.3 percent between 2000 and 2010. This modest growth rate is similar to the growth rate the County has experienced since 1980. County population increased by 3.7 percent between 1980 and 1990, and 5.6 percent between 1990 and 2000, as shown in **Table 3.6**. The Center for Business and Economic Research at the University of Alabama predicts a total growth rate of 6.2 percent for 2010 to 2040 (Center 2014). The 6.2 percent growth rate reflects an average for the County and takes into account both areas that are losing population and also those that are growing. The next two sections address the current population within the Watershed and how it is predicted to change before 2040. Current and future populations for the Watershed were each calculated using available Census data, as described below.

TABLE 3.6: PAST, CURRENT AND PROJECTED POPULATION FOR MOBILE COUNTY (1980-2040)

	Population						
	1980	**1990**	**2000**	**2010**	**2020** (projected)	**2030** (projected)	**2040** (projected)
Population	364,980	378,643	399,843	412,992	426,597	434,968	438,667
Percent Change*	--	3.7%	5.6%	3.3%	3.3%	2.0%	0.9%

*percent change calculated for each decade

3.8.3 Fowl River Watershed Current Population

The U.S. Census is conducted every 10 years, and the data is available for a variety of geographic units including counties, cities, tracts, and census blocks. Blocks are the smallest geographic unit from which data is collected from all residences. In 2010, Mobile County had a population of 412,992 people. To determine 2010 watershed population, block level statistics were used (U.S. Census Bureau 2010). For census blocks that extended outside of the watershed boundary, aerial imagery was used to estimate the percent of the population in the block that could be attributed to the Watershed. According to this method, the 2010 population within the Watershed was estimated to be 19,356.

Population projections available on the Census tract level were used to determine the current (2015) population for the Watershed. The Center for Business and Economic Research at the University of Alabama calculated projections for tracts in Mobile County (Center 2014). The tract projection data was used to determine a percent increase in population over the past five years (2010 to 2015), which was similarly applied to Census blocks in the Watershed to estimate the 2015 population to be 19,842 (**Table 3.7**). The majority of the population is located around US 90 and I-10 in the upper half of the Watershed (Sub-watersheds 1, 2, and 3).

3.8.4 Fowl River Watershed Projected Future Population Growth

Population projections by Census tract are also available in five-year increments up to 2040. Similar to the 2015 population calculation, the percent increase in population at the tract level for the 2020, 2025, 2030, 2035, and 2040 population projections were applied to 2010 Census block population data for the Watershed to estimate population projections for the Fowl River Watershed. The results are presented in **Table 3.7**. Current population projections estimate a 10.8 percent increase of the population within the Watershed by 2040. Two areas will see the greatest percent increase. The first is the area north of I-10 and the second is bounded by Bayou La Batre-Irvington Highway, Three Mile Road, and Padgett Switch Road.

TABLE 3.7: CURRENT AND PROJECTED POPULATION FOR THE FOWL RIVER WATERSHED (2010-2040)

	Population						
	2010 (actual)	**2015** (projected)	**2020** (projected)	**2025** (projected)	**2030** (projected)	**2035** (projected)	**2040** (projected)
Population	19,356	19,842	20,294	20,676	20,985	21,235	21,444
Percent Change*	--	2.5%	4.8%	6.8%	8.4%	9.7%	10.8%

*percent change over 2010

Sources: U.S. Census Bureau. 2010 Census; Center for Business and Economic Research. The University of Alabama, Sept. 2014.

3.0 WATERSHED CHARACTERIZATION

3.9 LAND USE AND LAND COVER

Land use and land cover (LULC) in the Fowl River Watershed were assessed to understand what the Watershed looked like in the past, its current condition, and what it may look like in the future. Because it affects stormwater runoff volumes, velocities, and the pollutant load it carries. LULC is a significant factor in watershed health. A variety of data was reviewed and analyzed as described in the following sections.

3.9.1 Transportation and its Influence on the Watershed

Infrastructure, including railroads and roads, greatly influences how land is developed. Many of the small communities located within or adjacent to the Watershed are located along roads and railroads that have been around for more than a century.

Historical maps were reviewed to determine how development began in the Fowl River Watershed and the surrounding areas, and how it has changed over the years. The earliest map available at a scale to include the Watershed is from 1837. At this time there were fragments of roads that generally follow today's US 90 from Mobile to Mississippi. This road is labeled as "Road to St. Elmo" in subsequent years. There was also a road parallel to Muddy Creek that extends down to Mon Louis Island (LaTourette, 1837 and Fonde, 1895). This road is labeled as "Cedar Point Road" on later maps.

The New Orleans, Mobile & Texas Railroad Company constructed a line between Mobile and New Orleans in 1869 that remains in the same location to this day (Lachaussee and Lamb, 1987). By the late 1800s there were additional rail lines, including one from Theodore south towards the coast that was labeled "Dauphin Island Railroad."

While the communities of Theodore and Bellefontaine were likely established much earlier, they begin to be labeled on maps from 1907. Theodore is located in the northern portion of the Watershed next to the railroad and Bellefontaine is adjacent to the eastern edge of the Watershed along the Bay. The railroads and road parallel to Muddy Creek are still intact. In addition, there is a road to Bellefontaine that generally follows the path of Dauphin Island Parkway (with a crossing of the Deer River) (Widell, 1907). By 1911 there was a road parallel to the Dauphin Island Railroad in the current location of Bellingrath Road (USDA, 1911).

The Alabama Department of Transportation (ALDOT) has maps of the county from 1937 to the present. By 1937, a road network had been developed across the Watershed that included Bellingrath Road, Laurendine Road, and Dauphin Island Parkway, along with portions of Fowl River Road and River Road. South Orchard and Laurendine appear as crossroad communities.

The transportation maps were reviewed over a number of years to understand growth patterns of the previous 75 years (Alabama Highway Department (subsequently ALDOT in the 1990s), 1937-2011). The series of maps reveal that the roads and railroads constructed in the past century are almost identical to the current road network with relatively few exceptions. Over time, a few roads were abandoned including a bridge over Fowl River near Delchamps Road. Dauphin Island Parkway was altered with the development of the Theodore Industrial Park in the latter half of the century. A few additions occurred, most notably I-10, which was under construction when the 1962 version of the map was prepared and Deakle Road, which connects the Fowl River Watershed with Bayou La Batre and appears on the 1966 map.

In general, transportation infrastructure established prior to 1937 has influenced the location of growth and development within the Watershed, including development within crossroads communities such as Theodore and Bellefontaine. The construction of I-10 allowed for an easier commute into Mobile, which led to increased development around the highway instead of along the more established infrastructure. The interstate facilitated the growth of Tillman's Corner, which is labeled on the 1982 map. This populous area is located at the junction of I-10 and US 90.

3.9.2 Historic Land Use

As noted in the previous section, roads and railroads have been present in almost the same pattern for almost 100 years. Access to transportation usually means there will be residential, commercial, and industrial land-use development. However, further examination of the Watershed is necessary to understand the density of this development and current activity in areas lacking main roads.

Two sources, the Landsat-based Assessment of Mobile Bay Land Use and Land Cover Change (Spruce 2009) and the National Land Cover Database (NLCD), were used to evaluate LULC changes within the Fowl River Watershed. Each dataset was derived from existing information, such as remote sensing and aerial photography, to compare and reveal changes in land use over a specified period of time. The results can also be used to reveal how the Watershed has changed during the allotted time period. Examining LULC changes can help determine the impact on water resources over time and how the area may continue to develop in the future.

For each source, the original data layers were obtained and then clipped to the Fowl River Watershed boundary and sub-watershed file that was created for this study. Clipping the data layers to the Watershed boundary ensures that the acreage is the same for each. However, discrepancies still exist among the data layers. All of the layers used were grids with pixels measuring between 28 and 30 meters per side. Each pixel represents between 812 to 900 square meters, depending on the source. Other potential discrepancies are described in the following sections.

3.9.2.1 Landsat-based Assessment of Mobile Bay Land Use and Land Cover Change

In 2008, NASA Stennis Space Center led a pilot project undertaken to quantify and assess LULC changes from 1974 to 2008 in the Mobile Bay region (Spruce 2009). Other participants in the project included the MBNEP, the U.S. Army Corps of Engineers, the National Oceanic and Atmospheric Administration's (NOAA) National Coastal Data Development Center (NCDDC), and the NOAA Coastal Service Center. The project involved using Landsat images to create LULC layers over a 34-year time frame that includes layers from 1974, 1979, 1984, 1988, 1991, 1996, 2001, 2005, and 2008 (see **Figures 3.59** and **3.60**). A simplified classification scheme was used to categorize all areas as upland herbaceous, upland forest, barren, woody wetland, non-woody wetland, open water, and urban. The overall accuracy of the classification compared to reference data was between 83 and 89 percent, depending on the year. In addition, the data layers were used to assess urban LULC change at decadal time scales. The project results indicated an urban increase of 55.37 percent over the 34 years (1.63 percent annum) for the Mobile Bay Watershed including most of Baldwin and Mobile counties. A change analysis was created for a selection of the watersheds draining to Mobile Bay, including Fowl River. For this report, the data were analyzed again using the watershed boundary established for this assessment.

The Fowl River Watershed has experienced similar growth compared to Mobile Bay as a whole with an increase of 58.8 percent over the 34 years (1.73 percent annum). Growth has been steady over the years with the exception of 1996 to 2005 when no growth occurred. However, growth between 2005 and 2008 was similar to pre-1996. This exception could be due to the Landsat data available for the 2005 NLCD or the methodology used to create it.

Also similar to Mobile Bay, the Fowl River Watershed has experienced a fluctuation between the upland herbaceous and upland forest landscapes. It appears that when one increases the other decreases. This could be due to forest harvesting cycles (Spruce 2009). When combined, the percent of upland forest and herbaceous cover overall has declined from 70 percent to approximately 62 percent while urban land has increased from 7.5 percent to almost 12 percent (see **Figure 3.61**).

Also of note is the slight increase in water, non-woody wetland, and woody wetlands acreage. It is unclear if this increase in water resources is due to the differences in data sources and interpretation, but the discrepancy is noted.

FIGURE 3.59: LAND USE/LAND COVER FOR 1974 AND 1984

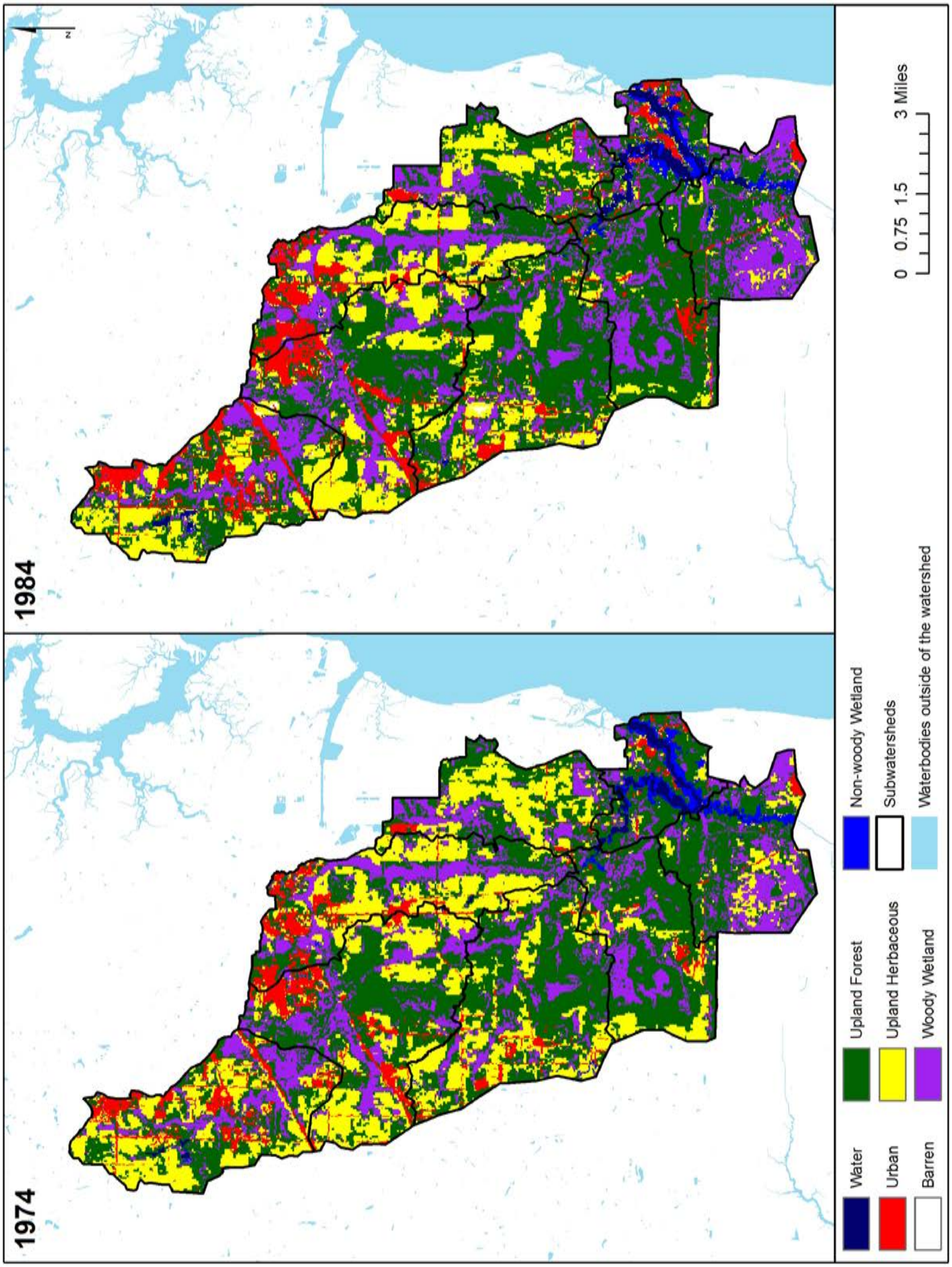


FIGURE 3.60: LAND USE/LAND COVER FOR 1996 AND 2008

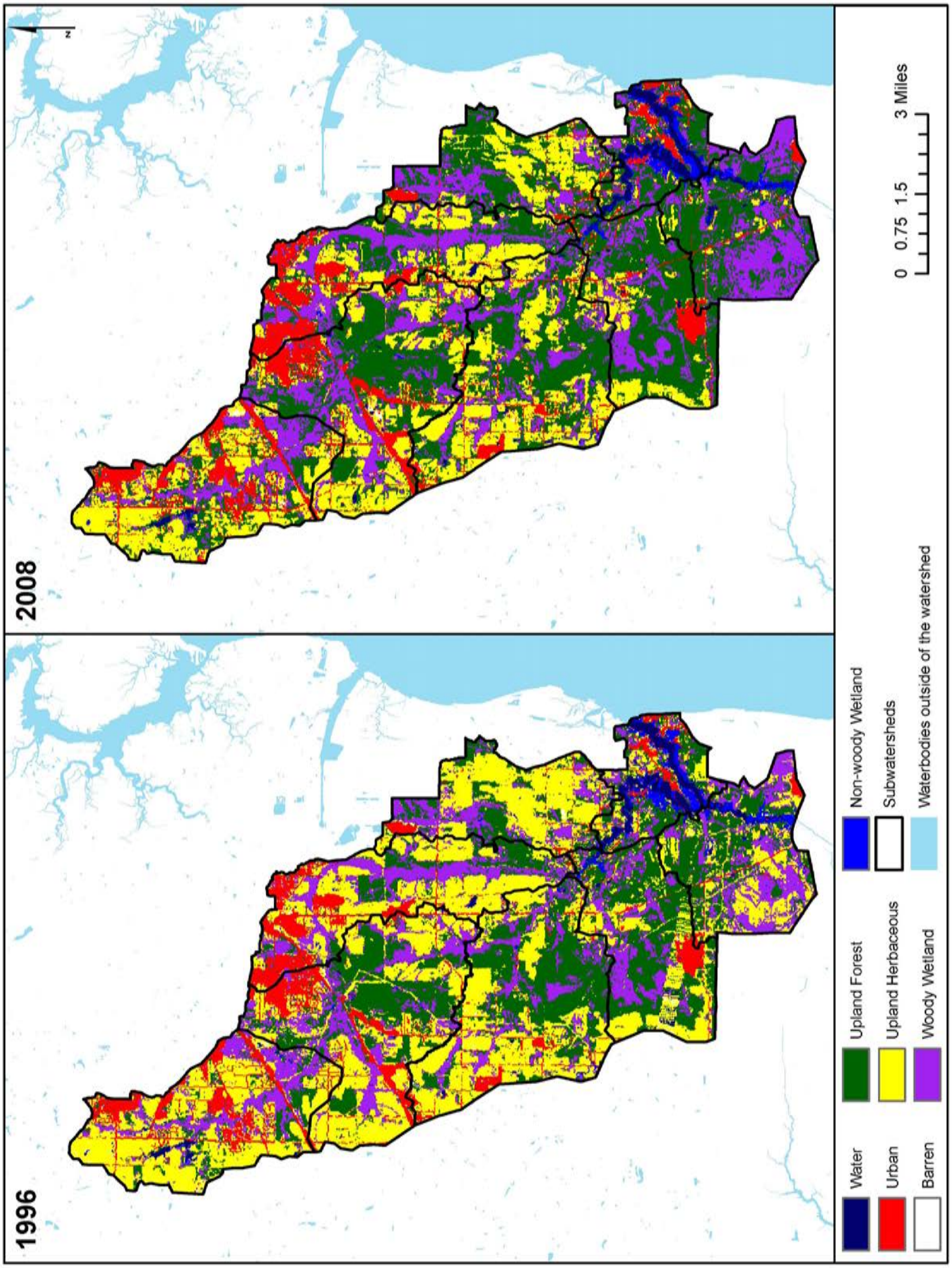
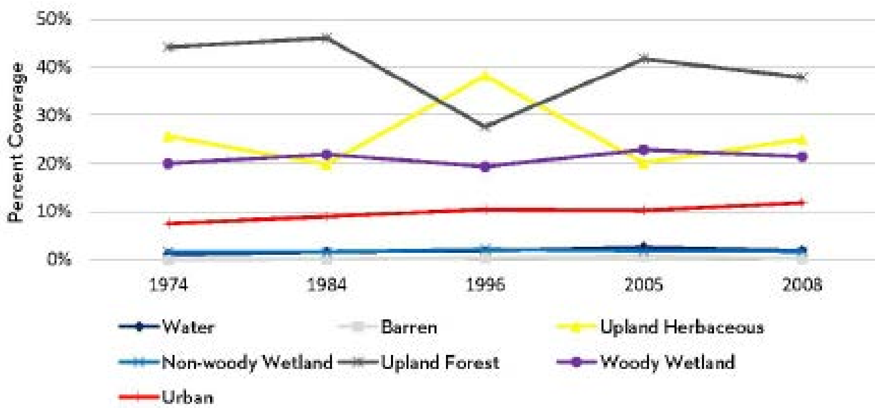
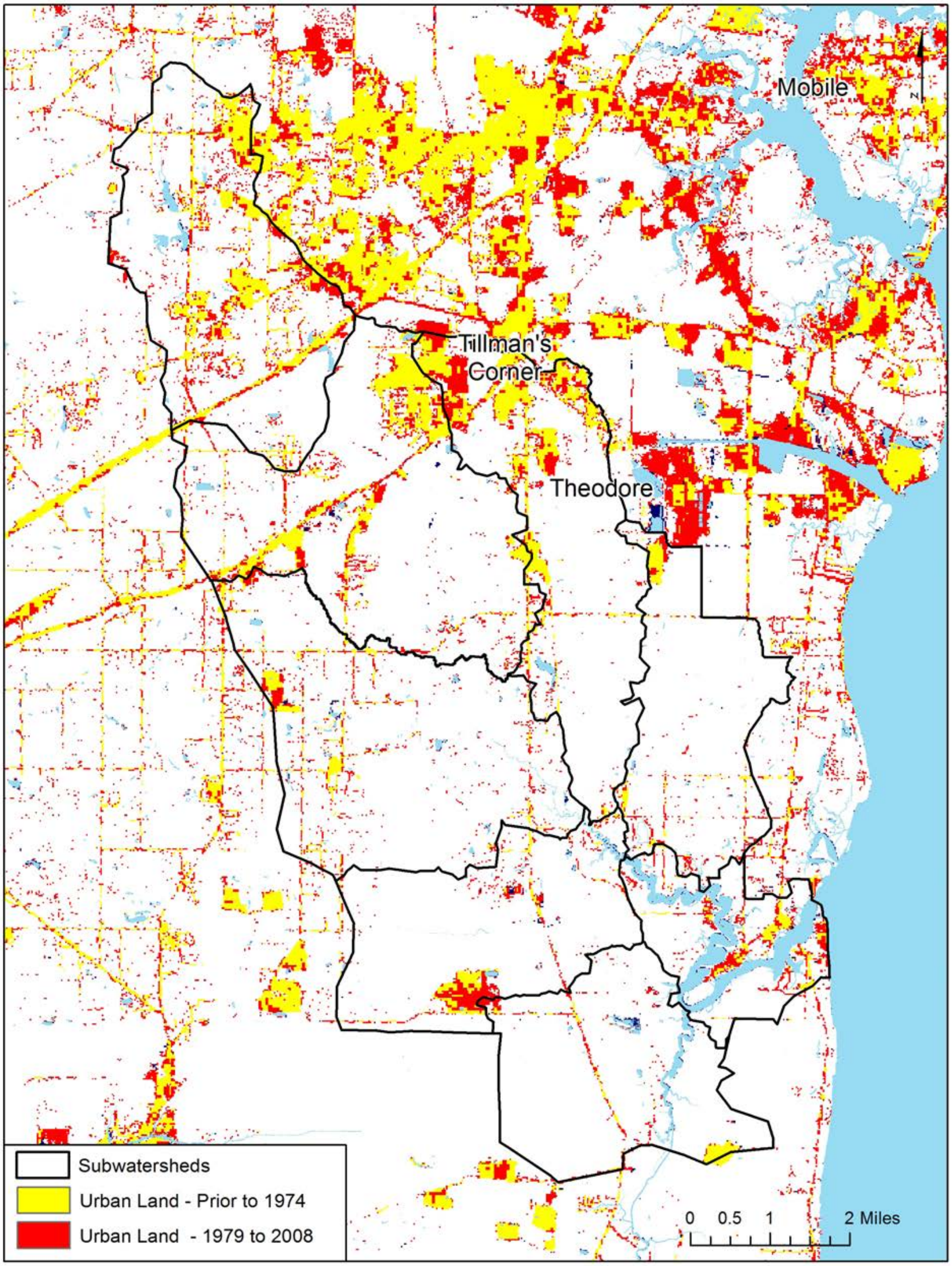


Figure 3.61: 1974 to 2008 Land Use/Land Cover Change



A review of the decadal scale maps of urban expansion shows that development prior to 1974 occurred in the northern half of the Watershed around Theodore and the southern border of Tillman's Corner (see **Figure 3.62**). Other development prior to 1974 included the unincorporated town of Irvington, as well as a number of industrial plants, including one on an industrial area north of Deakle Road and another on Bay Woods Drive. Residential growth occurred around the mouth of the River. Since 1974, new development has continued in the same areas. These growth patterns explain the development and construction of new transportation routes discussed in Section 3.9.1.

FIGURE 3.62: DECADAL MAP OF URBAN EXPANSION IN THE FOWL RIVER WATERSHED



3.9.2.2 National Land Cover Database (NLCD) Study

The NLCD study was conducted for the Mobile Bay Watershed to examine LULC changes from 1948 to 2001 as well as to project and create a future land cover dataset for 2030. Data layers were used for a variety of watershed modeling studies to understand human impacts on natural ecosystems including submerged aquatic vegetation or seagrass (Estes et al. 2014). The LULC data layers were created for 1948, 1992, 2001, and 2030. The 1948 dataset was obtained from the State of Alabama and limited to four major classes (crop, crop/pasture, urban, and timber). No wetland data exists for that time period, so the 1992 wetland layer was combined with the 1948 dataset. The data layer also does not include water or barren land as categories.

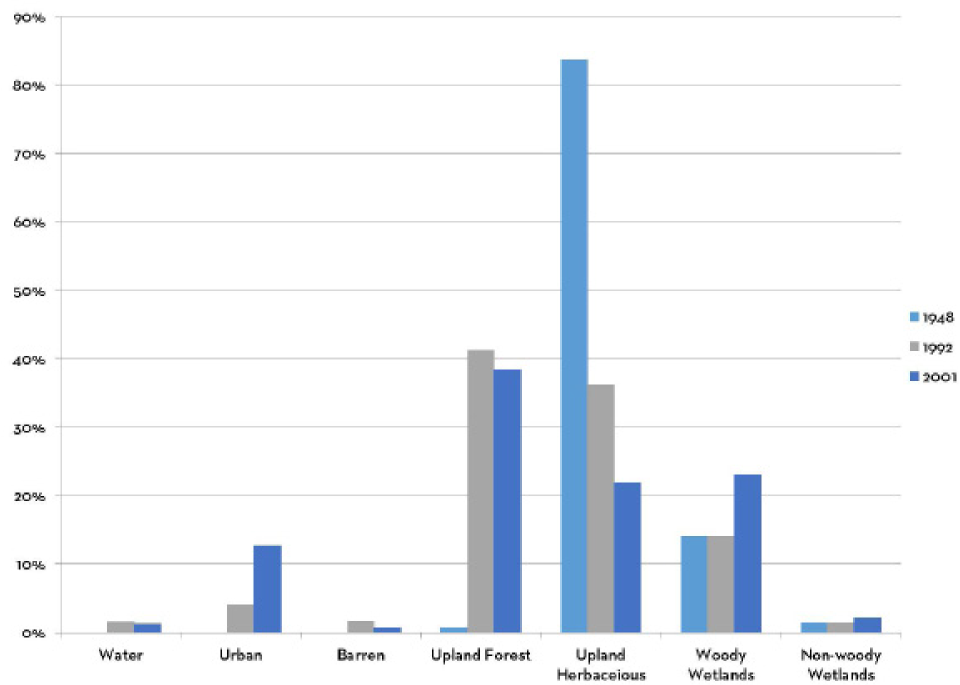
The 1992 and 2001 layers were based on the NLCD datasets available for those years. Each dataset was reclassified using a common classification scheme as shown in **Table 3.8**. In order to more readily compare the 1948 data layer with the 1992 and 2001 layers, the results were further simplified by combining classes. In addition, this simplification allows for results of this LULC study to be compared with the NASA study.

TABLE 3.8: REMAPPING LAND COVER LAND USE CLASSES OF 1992 AND 2001 NATIONAL LAND COVER DATA TO A COMMON CLASSIFICATION (Estes, et al. 2014)

1992 Land Use Name	2001 Land Use Name	New Class Name	Simplified Classification
Water	Water	Water	Water
Low-Intensity Residential, Urban Recreational Grasses	Developed Open Space, Developed Low Intensity	Urban Low-Density Residential/Recreational	Urban
High-Intensity Residential	High-Density Residential	Urban Medium/High Density Residential	
Comm/Ind/Transportation	Developed High Intensity	Urban Commercial	
Bare Rock/Sand/Clay Quarries/Strip Mines/Gravel Pits Transitional	Barren Land	Bare Soil/Transitional	Barren
Deciduous Forest	Deciduous Forest	Deciduous Forest	Upland Forest
Evergreen Forest	Evergreen Forest	Evergreen Forest	
Mixed Forest, Shrubland	Mixed Forest, Shrubs/Scrub	Mixed Forest/Shrub	
Grassland/Herbaceous, Fallow, Orchards, Pasture/Hay, Row Crops	Grassland, Pasture Hay, Cultivated Crops	Agriculture/Pastures	Upland Herbaceous
Woody Wetlands	Woody Wetlands	Woody Wetlands	Woody Wetland
Emergent Herb. Wetlands	Emergent Herb. Wetlands	Emergent Herb. Wetlands	Non-Woody Wetland

The simple bar chart shown in **Figure 3.63** depicts LULC in 1948, 1992, and 2001 and indicates a decrease in herbaceous upland cover over the years. Of note is the small percentage (1 percent) of upland forest in the 1948 data layer. The forests that once covered the watershed and the county were continuously harvested in the 1800s and early 1900s. Harvested timberland was also repeatedly burned, so that in many areas trees did not immediately return. However, by 1992, upland forests and upland herbaceous cover were more evenly distributed with both around 40 percent. Water and barren land were not categories included in the 1948 layer so these do not appear in the chart. While urban was a category in 1948, there was not enough development or the density of development was too low to be classified as such. Urban cover accounts for 13 percent by 2001.

Figure 3.63: 1948, 1992, 2001 Land Use/Land Cover Change



The results of the two LULC studies were in agreement. Both show urban land slightly greater than 10 percent by 2000, along with a loss of herbaceous upland, and to a smaller degree, upland forest. Also of note, both studies show an increase in wetland acreage.

3.9.3 Current Land Use

Based on aerial imagery, neither Mobile County nor the City of Mobile had a detailed classification of LULC within the Watershed. Therefore, as with the historic land use analyses, remote sensing data in the form of the NLCD was used to determine the current LULC within the Watershed. The most current NLCD for the Fowl River Watershed was created in 2011. The data layer was clipped to the Watershed boundary in order to summarize current LULC of the Watershed in **Table 3.9**.

In 2011, over one-third of the Watershed was classified as upland herbaceous (34 percent), while just under one-third was woody wetlands (27 percent). The woody wetland coverage is much greater than that shown in the historic LULC analysis. This increase is once again unexpected. It is possible that forested areas in previous Landsat images were mistakenly labeled as upland forest instead of wetland forests. Urban land, accounting for 13.7 percent of the Watershed, is only slightly higher than urban coverage in 2001 (12.6 percent).

3.0 WATERSHED CHARACTERIZATION

The 2011 NCLD data layer was clipped to the eight sub-watersheds to get a better understanding of the spatial distribution of LULC within the Watershed, as shown by **Table 3.9** and **Figures 3.64** and **3.65**. The largest area of open water is found within Sub-watershed 8, which contains the mouth of the Fowl River along with the confluence with West Fowl River. Over 70 percent of the urban development is concentrated in the upper Watershed in Sub-watersheds 1, 2, and 3. While barren land makes up just a fraction of the Watershed land use, most of it is concentrated in Sub-watersheds 1 and 2 where there has been more growth, and land has been used for borrow pits. Upland forest is found in all of the sub-watersheds, with over 20 percent within Sub-watershed 2. Upland herbaceous is also found in all sub-watersheds. The smallest quantities are found in Sub-watersheds 7 and 8, in which the largest acreage of non-woody wetlands (in the form of marshes along the river) is located. Woody wetlands are found in high quantities in all sub-watersheds except 1 and 8. Urban growth and a number of small lakes likely impacted the acreage of woody wetlands in Sub-watershed 1.

TABLE 3.9: 2011 ACRES CURRENT LAND USE/LAND COVER BY SUB-WATERSHED

Category	1	2	3	4	5	6	7	8	Watershed	% Total
Water	43	13	17	37	2	10	40	367	529	1.3%
Urban	1425	1251	1195	567	242	260	167	350	5457	13.7%
Barren	81	104	23	27	4	4	4	30	277	0.7%
Upland Forest	1050	1797	580	1041	573	1214	1270	674	8200	20.6%
Upland Herbaceous	2606	2202	1895	3117	1793	1180	479	234	13507	34.0%
Woody Wetlands	561	1744	1483	1811	1071	1704	2027	382	10782	27.1%
Non-Woody Wetlands	40	36	28	58	47	121	272	414	1017	2.6%
Total Sub	5806	7147	5221	6658	3732	4495	4258	2451	39769	100%
Total Watershed Area = 39, 769 acres										
Source: NLCD 2011 Coverage										

Figure 3.64: Percent coverage per land use/land cover category within each sub-watershed.

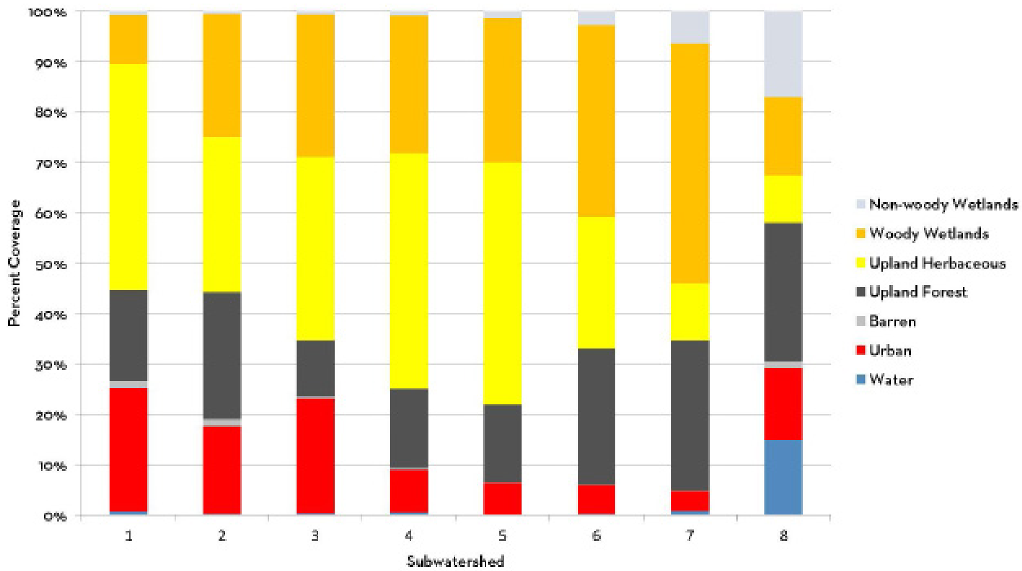
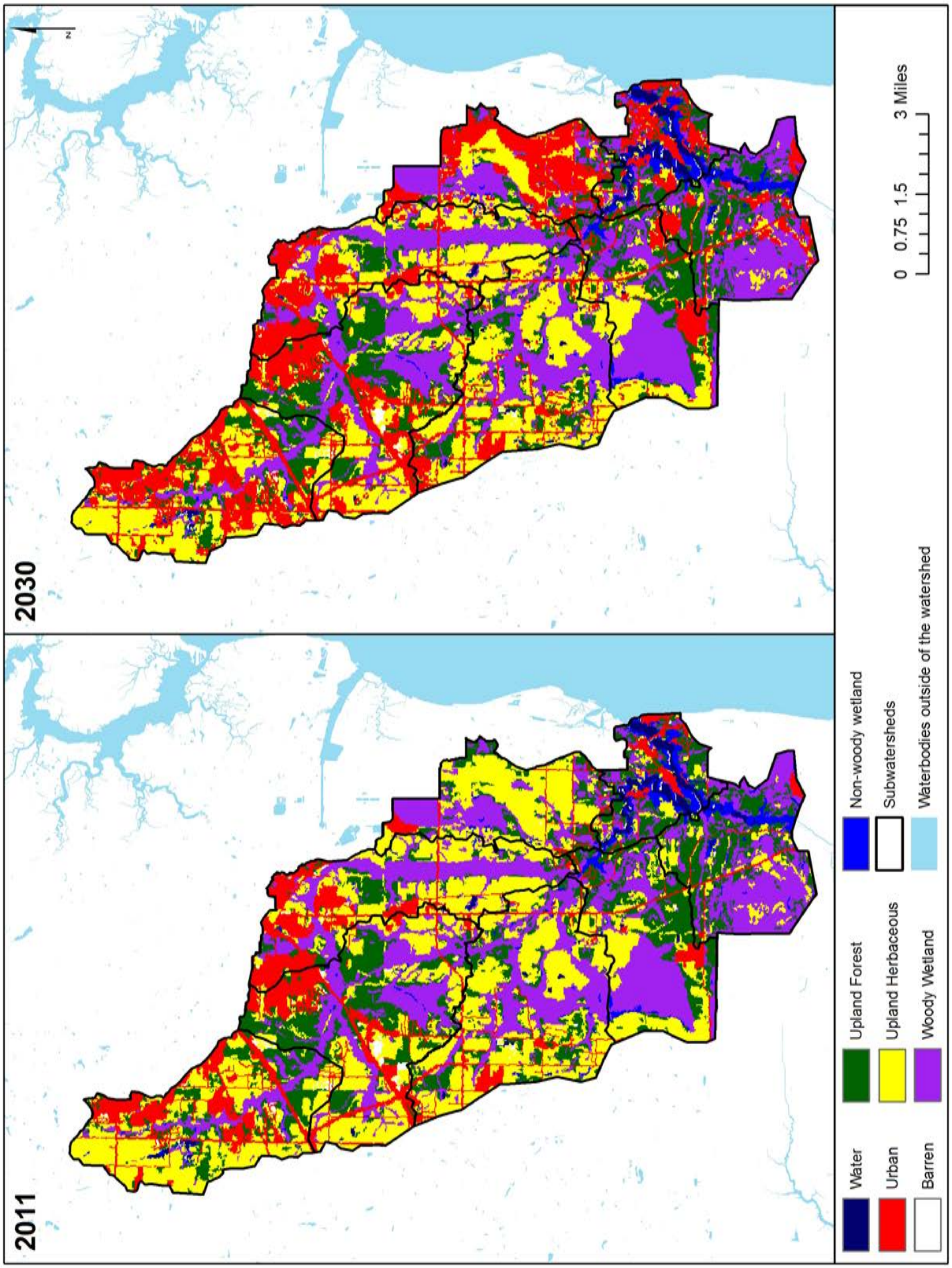


FIGURE 3.65: LAND USE/LAND COVER MAP OF CURRENT AND FUTURE CONDITIONS



The urban land category was created in order to have a simplified set of land use categories for comparison with previous years of data. As shown in **Table 3.10**, for 2011 data, urban land is a combination of four categories: developed, open space; developed, low intensity; developed, medium intensity; and developed, high intensity. More than two-thirds (3,636 acres) of the 5,457 acres of urban land within the Watershed is in the developed, open space category. Approximately 27 percent or 1,208 acres are classified as developed, low intensity. The other two categories account for 9 percent (medium intensity) and 2 percent (high intensity). The first three categories are mainly single family residential areas found in the northern portion of the Watershed. There are also schools and churches mainly located around I-10 and US 90. Common examples of medium and high intensity development include small industrial and commercial areas. It is important to note that the high density development is not concentrated in one area but scattered throughout the Watershed. Small industrial areas are found in almost every sub-watershed regardless of surrounding LULC.

The type of urban land is important when considering stressors to watershed health. It also helps determine what best management practices should be undertaken to improve or preserve water resources within the Watershed.

TABLE 3.10: BREAKDOWN OF URBAN LAND IN THE FOWL RIVER WATERSHED

Land Cover Category	**Description**
Developed, open space	Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Examples include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
Developed, low intensity	Areas with a mixture of constructed materials and vegetation. These areas usually include single-family housing units.
Developed, medium intensity	Areas with a mixture of constructed materials and vegetation. These areas usually include single-family housing units.
Developed, high intensity	Highly-developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial.

3.9.4 Future Land Use

A future land use data layer was created as part of a larger study that also included a review of historical land use (Section 3.9.2.2) (Estes et. al. 2012). The study involved the application of a spatial growth model, the Prescott Spatial Growth Model (PSGM), to the 2001 NLCD to predict a future LULC for 2030 throughout Mobile Bay.

> "PSGM is an Arc geographic information system (GIS) compatible application that allocates future growth into available land based on user-defined parameters. The purpose of the PSGM is to help users develop alternative future patterns of LULC based on socio-economic projections such as population, employment and other controlling factors. When creating scenarios based on future development, the PSGM requires several inputs.
>
> - ***Developable land*** must be provided as an input grid that represents areas suitable for accepting future growth.
> - ***Growth projections*** quantify the demand for land area to be developed for each time horizon for each LULC type. These projections are derived from socio-economic drivers using a PSGM utility that determines the growth for each urban LULC category (industrial, high-density residential, etc.).
> - ***Suitability rules*** for location of future growth are specified using a PSGM table interface. When the PSGM runs, it allocates the new growth onto the developable land grid, in the order of most to least suitable land. The output of the PSGM is a series of growth grids, one for each time step and LULC type, showing the anticipated future growth pattern."

Estes, et al. 2012 predicted future land needs for residential development by using census population data for the counties in the study area along with population projections available from 2005 to 2025 at five-year intervals. Future commercial land use was determined using employment data for the counties. Estes, et al. (2012) also assumed current LULC trends would not change and that people would be drawn to development along shorelines without infringing upon wetland areas. The resulting demand for land did not exceed the amount of land suitable for development.

Since the study was completed, additional NLCD data has been released including the 2011 NLCD (Section 3.9.3.3). This 2011 NLCD was used to represent the current LULC conditions within the Watershed. To compare current and future data layers, the 2011 NLCD was used as a base for the future layer. Developed areas of the 2030 data layer from Estes, et al. 2012 were then applied to the 2011 data. All areas where development is not predicted to occur maintain the same classification between 2011 and 2030. This normalizes the data and allows for analysis of the loss of acres of different land covers in the future.

By 2030, it is predicted that a little over a quarter of the Watershed will be classified as upland herbaceous (27 percent) and an additional 26 percent as woody wetlands as shown in **Table 3.11**. The urban land category could be as much as 25 percent, and upland forest could account for 18 percent. These four categories account for over 95 percent of the Watershed LULC. The same four categories accounted for the majority of the LULC in the current condition as well. Most of the predicted urban development will occur on upland herbaceous land, which will decrease by 7 percent. Land use percentages of water, barren, and non-woody wetlands are relatively unchanged.

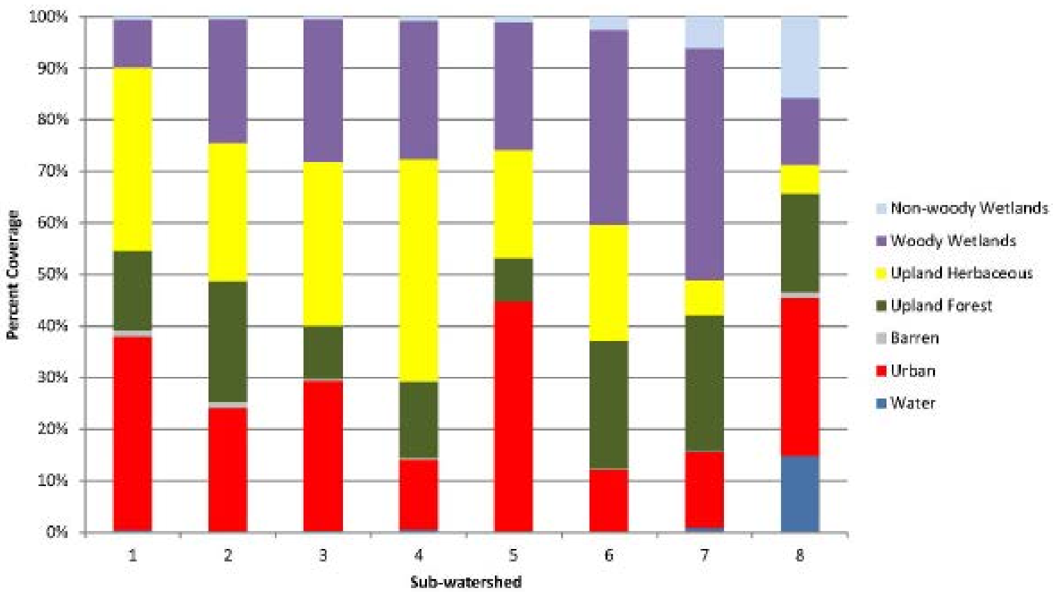
As with the current land use layer, the future condition data layer was clipped to the eight sub-watersheds, shown in **Figure 3.66**. to better understand the spatial distribution of predicted LULC within the Watershed, as shown in **Table 3.11** and **Figure 3.67** The majority of urban development remains concentrated in the upper Watershed in Sub-watersheds 1, 2, and 3. However, new growth is anticipated in Sub-watersheds 1, 2, and 5, while very little new growth is anticipated in Sub-watershed 3. Almost one-third of the new urban development is predicted to occur in Sub-watershed 5 as development around Mobile continues to expand. According to the results in this predicted data layer, this Sub-watershed could experience an increase of urban land from the exisiting 242 acres to 1,661 acres in the future. Sub-watersheds 7 and 8 will also experience growth but at a slower rate than in the northern portion of the Watershed. Sub-watersheds 4 and 6 will experience very little new development.

The type of urban development that is expected to be dominant in the future is developed, open space. Developed, low intensity and developed, medium intensity also increase slightly while the developed, high intensity land remains the same.

Figure 3.66: Fowl River sub-watershed locations

TABLE 3.11: 2030 ACRES FUTURE LAND USE/LAND COVER BY SUB-WATERSHED										
Category	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Watershed**	**% Total**
Water	28	11	16	36	2	8	40	362	501	1.3%
Urban	2175	1716	1515	897	1661	542	623	751	9880	24.9%
Barren	68	82	17	24	3	4	3	27	228	0.6%
Upland Forest	893	1678	544	983	316	1115	1125	467	7121	17.9%
Upland Herbaceous	2055	1906	1654	2875	775	1017	288	135	10704	27.0%
Woody Wetlands	536	1716	1442	1778	921	1686	1909	320	10308	26.0%
Non-Woody Wetlands	35	34	26	57	40	119	258	383	953	2.4%
Total Sub	5790	7143	5214	6651	3718	4489	4247	2444	39696	100%
Total Watershed Area = 39, 696 acres										
Estimated based on Estes, 2014 data										

Figure 3.67: Future percent coverage per land use/land cover category within each sub-watershed.



3.9.5 Growth Management

The previous sections focused on population and LULC and how they may change over the next 15 years. Urban land use is predicted to almost double between 2011 and 2030. This could have a major impact on watershed health, including a decrease in water quality and loss of habitat. However, the predicted future land use model may be an overestimate of the growth that will occur in the Watershed. In the case of Fowl River, future land use was extracted from a larger future land use model of the entire Mobile Bay Watershed, which includes the City of Mobile and rapidly growing Baldwin County. Future population and land use needs were calculated for the entire Watershed and then distributed proportionately over the two-county area of study.

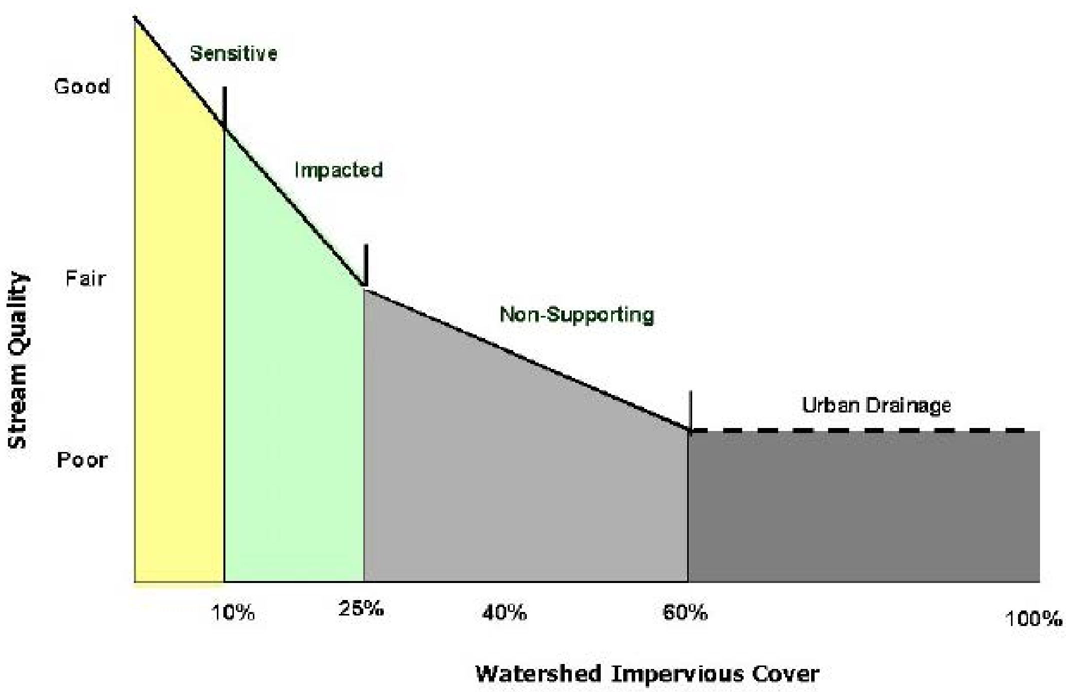
However, the population analysis for Fowl River indicates that population will continue to grow at a slow but steady pace. The predicted increase in population by 2030 is 2,088. With an average household size of 2.6, an additional 803 housing units would be needed to accommodate the increased population. Currently in the Watershed, houses occupy approximately two-thirds of an acre on average; therefore, less than 600 acres of land would be needed to accommodate 803 housing units. Considering many people live outside of urban areas such as Mobile to take advantage of the land available for housing and the ability to have more space, it is possible that lots may trend to larger than two-thirds of an acre in the future. However, even if two-acre parcels are used for predictions, the demand for land would be around 1,600 acres. The future land use analysis in the previous section estimates 4,422 new acres of developed land. It is unlikely the predicted population will need that many acres of development.

Because of the lack of zoning and regulations on how, where, or when an area will be developed in the Watershed, it is difficult to predict the actual impact of future land use on watershed health; however, it is certain that some growth will continue to occur and will likely impact between 1,000 and 4,400 acres of land.

3.9.6 Impervious Cover

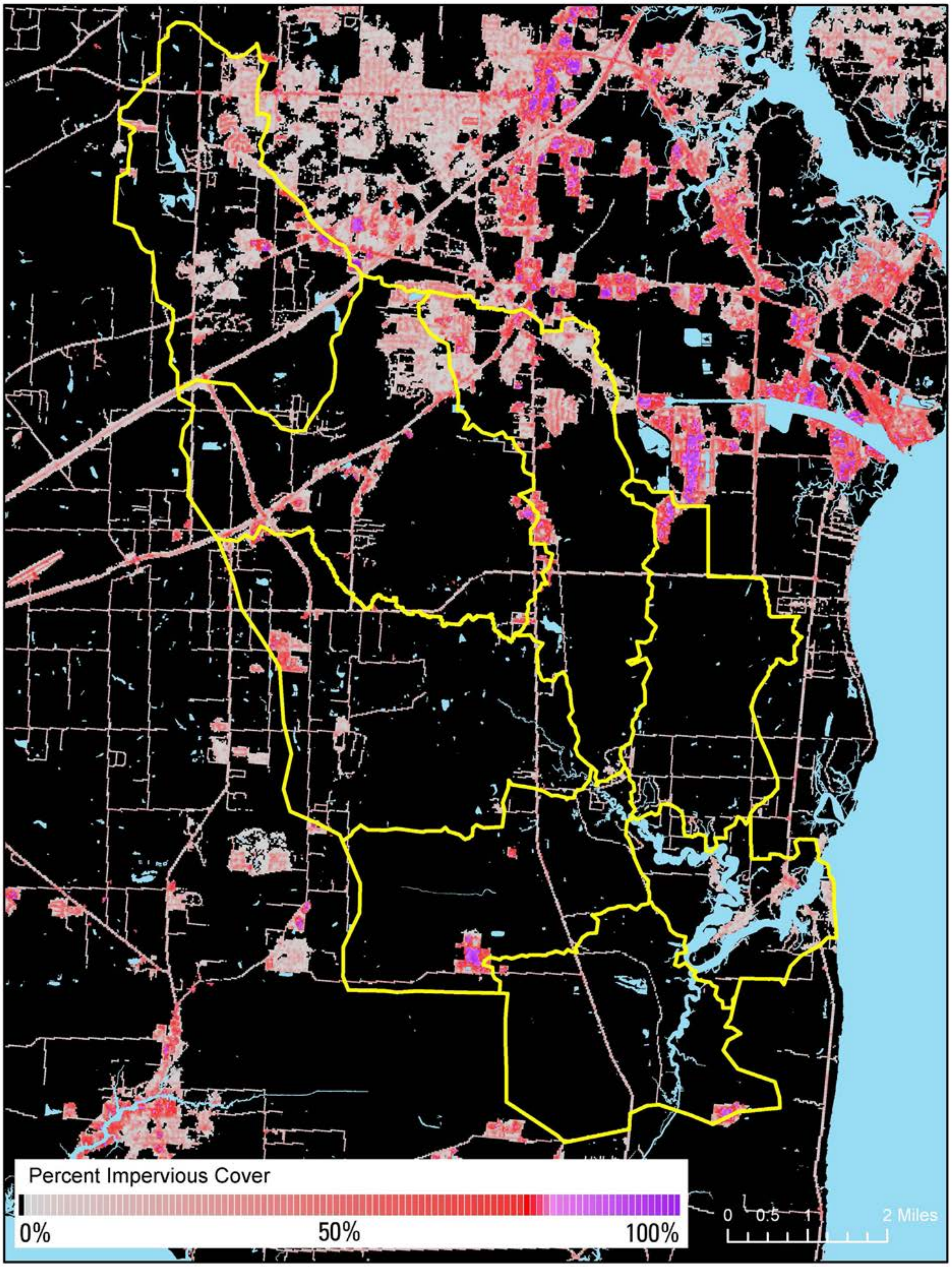
Impervious surface cover, including roads, parking lots, sidewalks, rooftops, and other impermeable surfaces, is a useful indicator for understanding the impacts of development. Increases in imperviousness in a watershed are associated with increases in the volume and velocity of stormwater, increased pollutant loading, and the loss of both terrestrial and aquatic habitats. The Center for Watershed Protection's Impervious Cover Model (ICM) indicates that streams are likely to be adversely impacted when impervious cover within their watershed reaches 10 percent or more and that the level of degradation becomes significantly more likely and more severe at impervious cover levels of 25 percent or more (Schueler, 1994). The Center reviewed 225 studies that measured a number of indicators of stream health relative to the amount of impervious cover, as shown in **Figure 3.68** (Schueler, 2003). The review reaffirmed that impervious cover in the ranges of 10-25 percent is a strong predictor of stream degradation, and at levels of 25 percent or more, degradation is almost inevitable. While impervious cover is a more robust and reliable indicator of overall stream quality beyond the 10 percent impervious cover threshold, several studies cited in Schueler (2003) have documented stream degradation at levels of watershed imperviousness below the 10 percent threshold.

Figure 3.68: Impervious cover model (Scheuler, 2003).



The NLCD 2011 Percent Developed Imperviousness data layer was used to assess impervious surfaces within the Watershed. The data layer is made up of 30 meter pixels and each pixel is assigned a value of 0 to 100. The values represent percent impervious. A pixel with a value of zero has no impervious surface while one with a value of 100 is completely covered with impervious surfaces. Pixels with values in between are only partially covered with impervious surfaces. This occurs when the impervious surface covers less than a 30x30-meter area. The data can be used to estimate the impervious surface area of the Watershed by calculating the imperviousness proportion in each 30-meter pixel.

FIGURE 3.69: IMPERVIOUS COVER MAP



Based on the results of the calculation, the impervious surface area of the Fowl River Watershed was 2.76 percent, or approximately 1,100 acres of the 39,769-acre Watershed. As shown in **Table 3.12** and **Figure 3.69**, the highest percentages of imperviousness are found in the northern portion of the Watershed (Sub-watersheds 1-3), where most of the development has occurred around I-10, Theodore, and Tillman's Corner. However, even these more developed areas fall well under the threshold of 10 percent where impervious cover begins to impact stream quality. The remaining sub-watersheds all have less than 2 percent impervious cover.

Figure 3.70: Fowl River sub-watershed locations

TABLE 3.12: FOWL RIVER WATERSHED IMPERVIOUS COVER

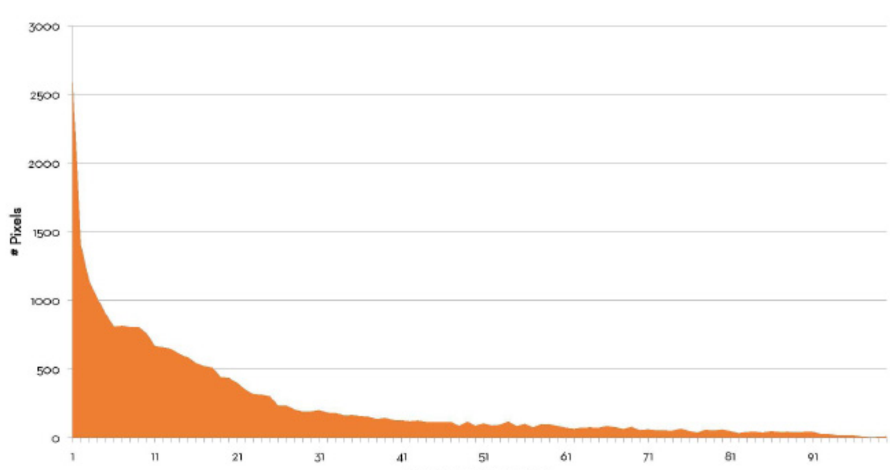
Subwatershed	% Impervious
1	4.2%
2	3.5%
3	5.2%
4	1.6%
5	1.7%
6	1.8%
7	1.0%
8	1.8%
TOTAL	**2.76%**

A 2006 study of the Fowl River Watershed (ADEM 2006) estimated impervious surfaces within the Watershed at approximately 7.9 percent. To reach this estimate, a standard grid was placed over aerial imagery and the impervious areas were then roughly measured using the grid. The result was approximately 4,160 acres of impervious surface in the 52,782-acre watershed.

The actual percentage of impervious surface is likely somewhere in between the two reported values of 2.76 percent (NLCD) and 7.9 percent (ADEM). It is hard to make a direct comparison between the two numbers. The ADEM study used a different watershed boundary. The Fowl River Watershed boundary established for the current study is only 75 percent of the area ADEM investigated. However, we are uncertain how much the reduction in watershed size affects the amount of impervious surface.

The NLCD data relies on satellite imagery and uses light signatures to determine LULC. Investigations of the validity of NLCD products have shown that the results underestimate the percentage of impervious cover. In the case of Fowl River, impervious areas are small due to the large-lot, residential type of land use. Average houses are much smaller than the 30-meter pixels that can be categorized as impervious. Each pixel can be assigned a fraction of impervious cover ranging from 1 to 100 percent. Approximately 13.9 percent of pixels in the Fowl River Watershed NLCD impervious layer have some fraction of impervious surface. As shown in **Figure 3.71**, most of the pixels have a level of IC less than 10 percent. The most accurate way to calculate impervious surfaces is to digitize the surfaces using the most up to date aerial imagery available.

Figure 3.71: Percent impervious of the pixels



SECTION 4.0
Watershed Conditions

4

4.0 WATERSHED CONDITIONS

4.1 WATER QUALITY STANDARDS

Fowl River carries the water use classification of Swimming and Other Whole Body Contact Water Sports and Fish and Wildlife along its entire course (Alabama Department of Environmental Management (ADEM), 2006). Likewise, East Fowl River carries the water use classification of Swimming and Other Whole Body Contact Water Sports and Fish and Wildlife along its entire course. Muddy Creek and Dykes Creek are not specifically listed within Division 6 of the Department's Administrative Code and, therefore, carry a water use classification of Fish and Wildlife (ADEM, 2006).

Swimming and Other Whole Body Contact Water Sports:

Criteria	Standard
pH	6.0 to 8.5 s.u.
Water Temperature	< 90°F
Dissolved Oxygen	> 5.0 mg/l (at mid depth or 5 ft dependent on total depth)
Fecal Coliform Bacteria	< 200 colonies/100 ml (geometric mean)
Fecal Coliform Bacteria Coastal*	< 100 colonies/100ml (geometric mean)
Turbidity	< 50 ntu above background

Fish and Wildlife:

Criteria	Standard
pH	6.0 to 8.5 s.u.
Water Temperature	< 90°F
Dissolved Oxygen	> 5.0 mg/l (at mid depth or 5 ft dependent on total depth)
Fecal Coliform Bacteria	< 200 colonies/100ml (geometric mean June – Sept.)
	< 1000 colonies/100ml (geometric mean Oct. - May)
	< 2000 colonies/100ml (single sample max.)
Fecal Coliform Bacteria Coastal*	< 1000 colonies/100ml (geometric mean Oct. - May)
	< 2000 colonies/100ml (single sample max.))
	< 100 colonies/100ml (geometric mean June –Sept.)
Turbidity	< 50 ntu above background

** Pre -2004 criteria and standards*
Source: ADEM Admin. Code R. 335-6-10-.09)

4.0 WATERSHED CONDITIONS

4.1.1 Clean Water Act Section 303(d) Impaired Waters and TMDL Program

The term “303(d) list” refers to the list of impaired and threatened waters (stream/river segments, lakes) that the Clean Water Act requires all states to submit for U.S. Environmental Protection Agency (EPA) approval every two years on even-numbered years. Each state identifies all waters in which the required pollution controls are insufficient to attain or maintain applicable water quality standards. In addition, each state establishes priorities for developing total maximum daily loads (TMDL) based on the severity of the pollution and the uses to be made of the waters, among other factors (40C.F.R. §130.7(b)(4)). States then provide a long-term plan for completing TMDLs within eight to 13 years from the first listing.

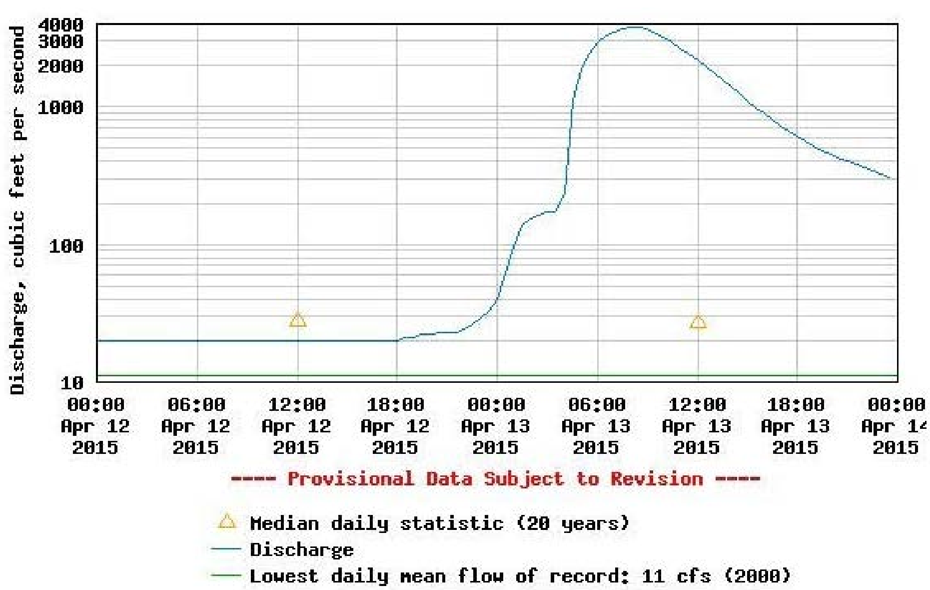
EPA policy allows states to remove waterbodies from the 303(d) list after a TMDL is developed or after other changes have been made to correct water quality issues. Occasionally, a waterbody can be taken off the list as a result of a change in water quality standards or removal of designated uses; however, designated uses cannot be deemed unattainable and removed until a thorough analysis clearly shows that they are unattainable.

Fowl River is listed on the State of Alabama 303(d) list for its mercury concentrations. The source of the mercury found in fish appears to be atmospheric deposition. Thus, there is no local corrective action that can be performed within the Watershed. In 2002, the State Health Department issued a fish consumption advisory warning people not to consume fish from Fowl River, which remains in effect as of 2015.

4.2 FLOW DATA

The U.S. Geological Survey (USGS) operates one continuous-discharge monitoring station on Fowl River at Half Mile Road. Discharge records at that location, shown in **Figure 4.1**, indicate bimodal flow conditions. The hydrograph of the River typically exhibits slow increases in discharge over several days. However, under some conditions, the flow within Fowl River increases rapidly in the span of only a few hours. These sudden increases in flow are correlated with intense rainfall events recorded at the Mobile Airport weather station. As noted in **Table 3.2** of Section 3.3.1, annual rainfall records for Mobile County include months where rainfall exceeds 10 inches. Under these conditions, flow patterns in Fowl River tend to exhibit rapid increases in flow. These high-volume flow events reflect natural rainfall rather than abnormally high runoff resulting from excessive impervious surfaces. Nonetheless, high volume flows and the velocities associated with them result in localized erosion of stream banks, and short-term transport of sediment within the channel.

Figure 4.1: USGS 02471078 at Half-Mile Road Near Laurendine, AL



4.3 SEDIMENT TRANSPORT AND SEDIMENTATION CONDITIONS

The Geological Survey of Alabama (GSA) completed an analysis of discharge, sediment transport, and water quality in tributaries of Fowl River during the course of the preparation of the Watershed Management Plan (WMP). The report produced for the study can be found in Appendix A. A key takeaway summary is included here:

- The predominantly rural setting, extensive wetlands and forests, and use of winter crops on agricultural fields limits the sediment loads in Fowl River and helps maintain an overall very good water quality;
- The largest sediment loads observed occurred in basins with the largest percentages of agricultural land use;
- Nitrate loading that exceeded the critical concentration of 0.5 mg/L associated with excessive algal growth was attributed to both nonpoint sources (cumulative loading from a large sub-basin) and point sources (greenhouse nurseries, row cropping, and areas of harvested timber);
- Phosphate and total organic carbon loading was attributed to point sources (plant nursery operations and row cropping);
- Concentrations of heavy metals in sediments increased from upstream to downstream and their occurrence is attributed to pervasive anthropogenic sources; and
- To preserve the health of the Fowl River ecosystem, the GSA recommends best management practices that preserve wetlands, prevent erosion and sediment transport from timbered and row crop areas, and control runoff from construction sites and impervious surfaces.

4.0 WATERSHED CONDITIONS

4.4 WATER QUALITY

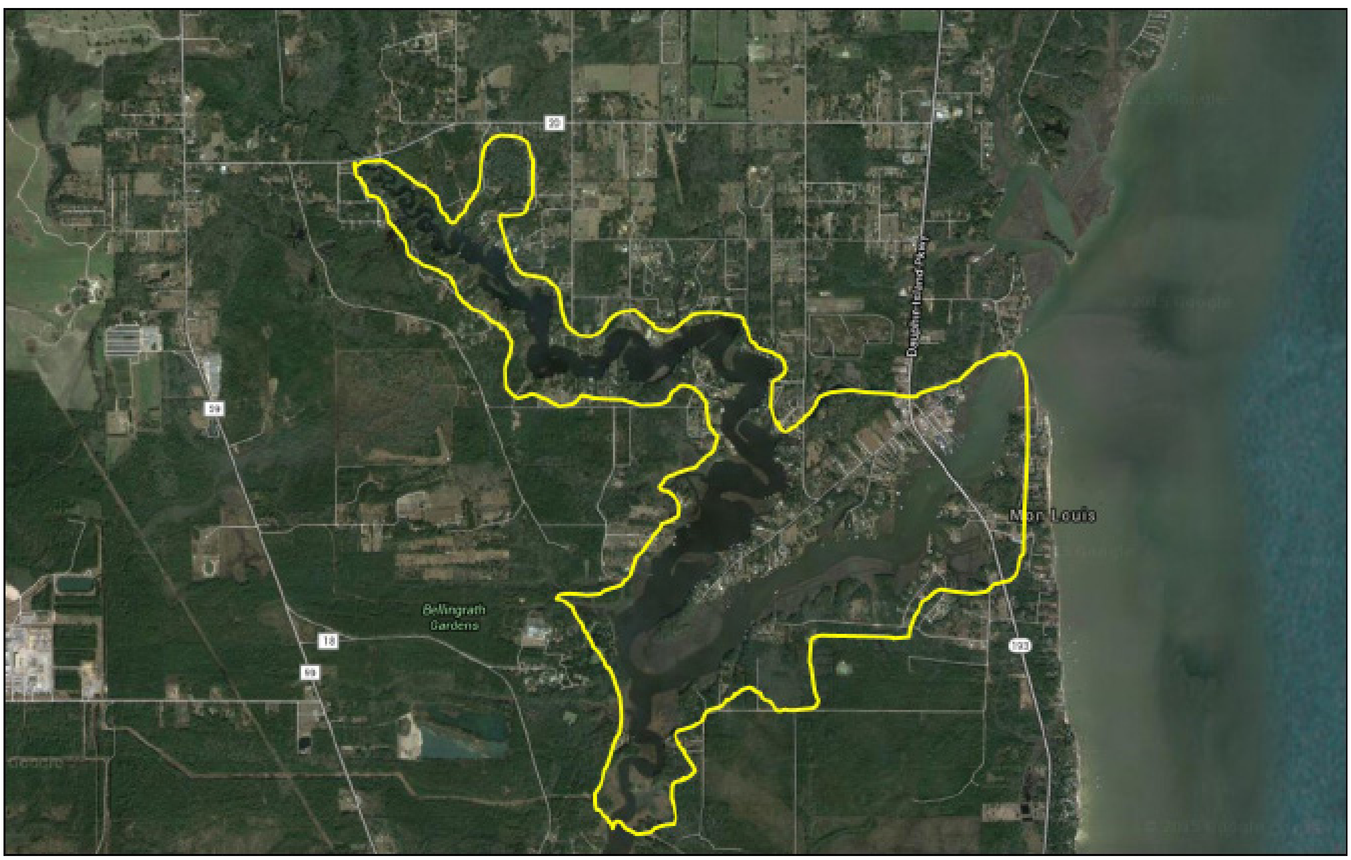
Existing Water Quality

This section presents a narrative summary of existing ambient surface water quality conditions in Fowl River. A full suite of summary plots of data collected as part of this study, as well as data provided by others, are located in **Appendix D**.

Introduction

In characterizing existing water quality conditions, it is important to make distinctions between freshwater and tidal segments of the Fowl River system. In Fowl River, the dividing line between freshwater and tidal segments is generally considered to be Fowl River Road. Downstream of this point, the River is tidally influenced, both physically (e.g., tidal elevation fluctuations) and chemically (e.g., salt wedge intrusion), and this portion of the river is referred to as the Fowl River estuary. **Figure 4.2** shows the approximate delineation of the Fowl River estuary. Upstream of this point the river main stem and tributaries are neither physically, nor chemically, influenced by tide.

Figure 4.2: Approximate extent of the Fowl River estuary



4.0 WATERSHED CONDITIONS

These distinctions are important for two reasons. First, the chemistry and biology of freshwater streams and rivers are very different from those of tidal estuaries. Accordingly, the ecosystem functions and services provided by freshwater rivers and estuaries are also distinctly different. However, there is also an intimate relationship between the freshwater and tidal portions of a water body in that quality, quantity, and timing of freshwater deliveries essentially determines the overall health of the estuary. Secondly, concentrations and standards imposed by regulatory agencies differ between freshwater and tidal segments for many water quality parameters. Therefore, in relating existing data to various measures of water quality, the applicable criteria are different in most cases.

In addition to distinguishing between the freshwater and tidal segments of a water body, characterization of existing water quality should be broken down into the general classes of water quality parameters. These include the following:

- **Physicochemical parameters:** These are measures of the general physical and chemical properties of a water body related to water column mixing and density stratification, in estuaries, including:
    - o Temperature
    - o Salinity

- **Geochemical parameters:** These are measures of geological inputs into a water body that affect water clarity and sedimentation, including:
    - o Total suspended solids
    - o Turbidity
    - o Specific conductance
    - o pH

- **Trophic parameters:** These are measures of primary production (e.g., algal and macrophytic photosynthesis), related processes (e.g., respiration), and drivers (nutrients) in a water body, including:
    - o Chlorophyll-a
    - o Dissolved oxygen
    - o Nitrogen – both total and inorganic
    - o Phosphorus - both total and inorganic

- **Pathogens:** These are bacterial constituents that are used as indicators of more noxious pathogens associated with animal waste products (e.g., viruses, disease causing bacteria), including:
    - o Fecal coliform
    - o Enterococci

- **Contaminants:** These are chemical constituents that are potentially toxic to aquatic organisms and humans, including:
    - o Heavy metals
    - o Organics.

4.0 WATERSHED CONDITIONS

While there is some overlap in the classes of water quality parameters listed, they are measures and/or indicators of different characteristics. The cumulative assessment of these parameters can be used to determine the overall water quality of a particular water body with regard to its designated uses. In the sections that follow, water quality conditions in Fowl River are evaluated with regard to both the freshwater and tidal portions, as well as the various classes of water quality parameters.

4.4.1 Data Sources

The data sources used to determine water quality conditions include the following:

- **Dauphin Island Sea Lab (DISL):** data collected specifically to support the development of the Fowl River WMP
    - o Physicochemical and trophic data collection in both the Fowl River estuary and freshwater segments during the period 2014-2015
    - o Supplemental physicochemical and trophic data collection in the Fowl River estuary provided by two student thesis projects (Brandon Jarvis and John Lehrter, EPA).
- **ADEM:** programmatic ambient monitoring and assessment data
    - o Physicochemical, trophic, pathogen, and contaminant data collection in both the Fowl River estuary and freshwater segments during the period 1999-2015
- **GSA:** special study conducted for the Mobile Bay National Estuary Program (MBNEP) in support of the Fowl River WMP
    - o Geochemical, trophic, and contaminant data collected in the freshwater segments of Fowl River during 2014-2015
- **Environmental Science Associates (ESA):** data collected specifically to support development of the Fowl River WMP
    - o Pathogen microbial source tracking study completed in 2014.

Tables 4.1 and **4.2** provide a summary of the data collected by DISL as part of this study, and period of record programmatic data collected by ADEM in the Fowl River Watershed, respectively.

TABLE 4.1: DISL WATER QUALITY DATA EVALUATED FOR DEVELOPMENT OF THE FOWL RIVER WMP

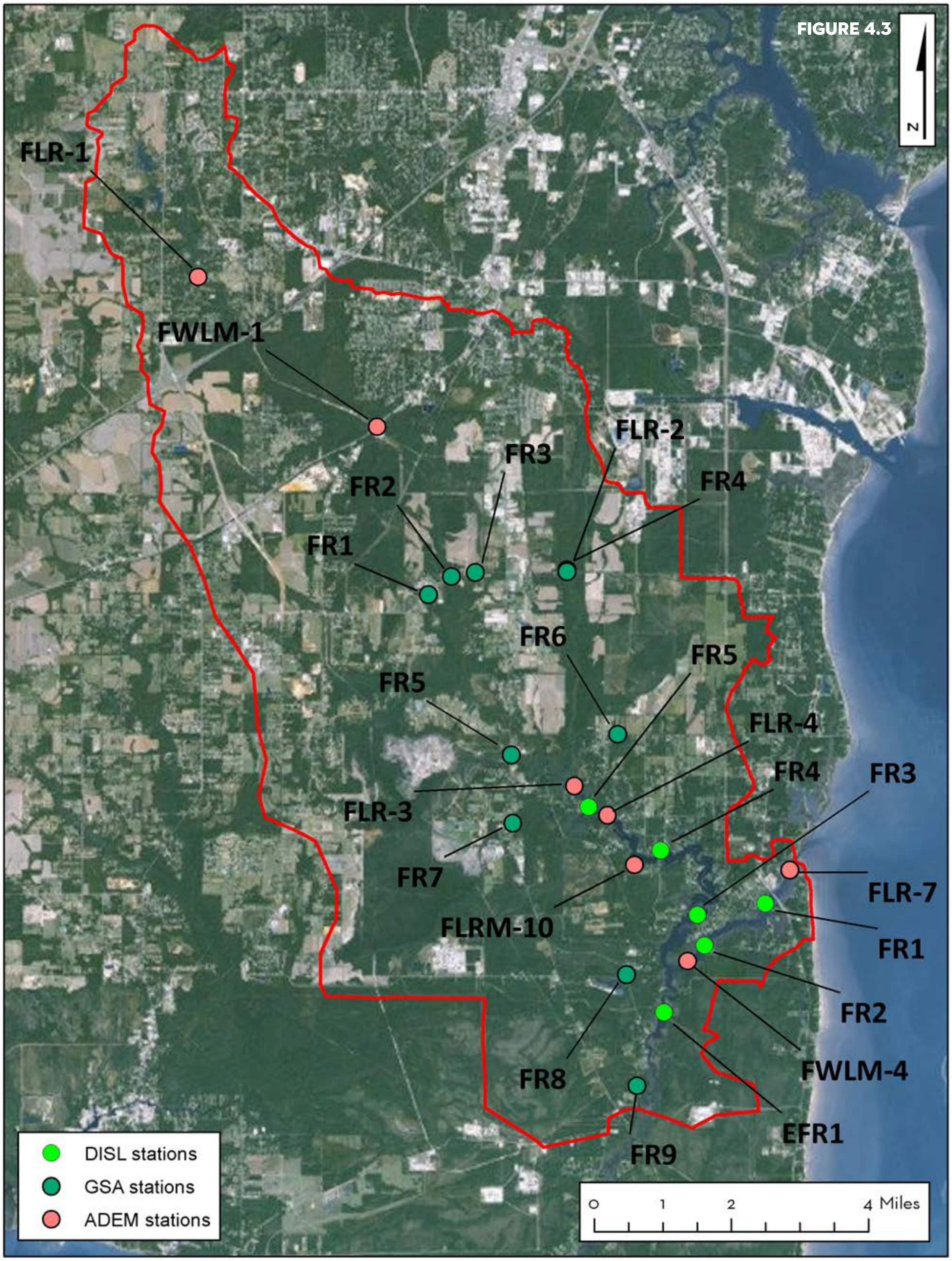
Station Name	EFR01	FR01	FR02	FR03	FR04	FR05	FR06	FR09
First Sampling Date	9-Dec-14	11-Dec-00	11-Dec-00	11-Dec-00	9-Dec-14	11-Dec-00	21-May-14	21-May-14
Last Sampling Date	22-May-15	22-May-15	22-May-15	22-May-15	22-May-15	22-May-15	7-Oct-14	7-Oct-14
Number of Samples	4	17	11	11	4	10	6	6
Chl a (ug/L)	4	4	4	4	4	4	-	-
DIN (mg/L)	4	4	4	4	4	4	-	-
DO	4	17	11	11	4	10	6	6
PO4 (mg/L)	4	4	4	4	4	4	-	-
POM (mg/L)	4	4	4	4	4	4	-	-
Sal	4	17	11	11	4	10	6	6
TDN (mg/L)	4	4	4	4	4	4	-	-
TSS (mg/L)	4	4	4	4	4	4	-	-
Temp	8	34	22	22	8	20	12	12

TABLE 4.2: SUMMARY OF ADEM DATA COLLECTION IN THE FOWL RIVER WATERSHED

Station Name	FLR_1	FLR_2	FLR_3	FLR_4	FLR_7	FR_1	FWLM_1	FWLM_2	FWLM_3	FWLM_4	WFRM_1	FLRM_10
First Sampling Date	16-Mar-06	16-Mar-06	15-Mar-06	15-Mar-06	15-Mar-06	17-Oct-85	28-Mar-06	15-Mar-11	12-Mar-13	12-Mar-13	12-Mar-13	30-Aug-99
Last Sampling Date	29-Mar-06	29-Mar-06	28-Mar-06	28-Mar-06	28-Mar-06	22-Sep-14	10-Oct-06	5-May-15	8-Oct-13	12-Mar-13	8-Oct-13	30-Aug-99
Number of Samples	2	2	2	2	2	198	8	29	8	1	8	1
Chlorophyll a	4	4	4	4	4	140	16	39	14	2	14	-
Dissolved Aluminum	-	-	-	-	-	13	3	11	3	-	3	-
Dissolved Arsenic	-	-	-	-	-	5	-	5	2	-	2	-
Dissolved Cadmium	-	-	-	-	-	13	3	10	3	-	3	-
Dissolved Chromium	-	-	-	-	-	13	3	11	3	-	3	-
Dissolved Copper	-	-	-	-	-	13	3	11	3	-	3	-
Dissolved Iron	-	-	-	-	-	13	3	11	3	-	3	-
Dissolved Lead	-	-	-	-	-	13	3	10	3	-	3	-
Dissolved Manganese	-	-	-	-	-	13	3	11	3	-	3	-
Dissolved Mercury	-	-	-	-	-	9	3	5	-	-	-	-
Dissolved Nickel	-	-	-	-	-	13	3	11	3	-	2	-
Dissolved Silver	-	-	-	-	-	13	3	10	3	-	3	-
Dissolved Thallium	-	-	-	-	-	13	3	10	3	-	3	-
Dissolved Zinc	-	-	-	-	-	5	-	5	3	-	3	-
Enterococcus	-	-	-	-	-	43	-	25	6	1	5	-
Escherichia coli	-	-	-	-	-	-	-	-	-	-	-	-
Fecal Coliform	2	2	2	2	2	162	6	-	-	-	-	1
Inorganic nitrogen (nitrate & nitrite) as N	2	2	2	2	2	196	8	16	6	1	-	1
Kjeldahl nitrogen	2	2	2	2	2	192	8	16	6	1	-	-
Orthophosphate	2	2	2	2	2	42	8	16	6	1	-	-
Total Aluminum	-	-	-	-	-	12	3	11	3		3	-
Total Ammonia-nitrogen as N	2	2	2	2	2	106	8	16	6	1	-	-
Total Cadmium	-	-	-	-	-	5	-	1	-	-	-	-
Total Calcium	-	-	-	-	-	1	-	2	-	-	-	-
Total Chloride	-	-	-	-	-	186	8	17	6	1	6	1
Total Chromium	-	-	-	-	-	5	-	-	-	-	-	-
Total Copper	-	-	-	-	-	5	-	-	-	-	-	-
Total Iron	-	-	-	-	-	13	3	11	3		3	
Total Lead	-	-	-	-	-	5	-	1	-	-	-	-
Total Magnesium	-	-	-	-	-	1	-	2	-	-	-	-
Total Manganese	-	-	-	-	-	13	3	11	3		3	
Total Mercury	-	-	-	-	-	4	-	-	-	-	-	-
Total Nickel	-	-	-	-	-	4	-	-	-	-	-	-
Total Phosphorus	2	2	2	2	2	199	8	16	6	1		1
Total Silver	-	-	-	-	-	4	-	1	-	-	-	-
Total Thallium	-	-	-	-	-	4	-	1	-	-	-	-
Zinc	-	-	-	-	-	12	3	6	-	-	-	-

4.0 WATERSHED CONDITIONS

Figure 4.3 shows the locations of the water quality sampling stations of these various programs throughout the Fowl River Watershed.



4.0 WATERSHED CONDITIONS

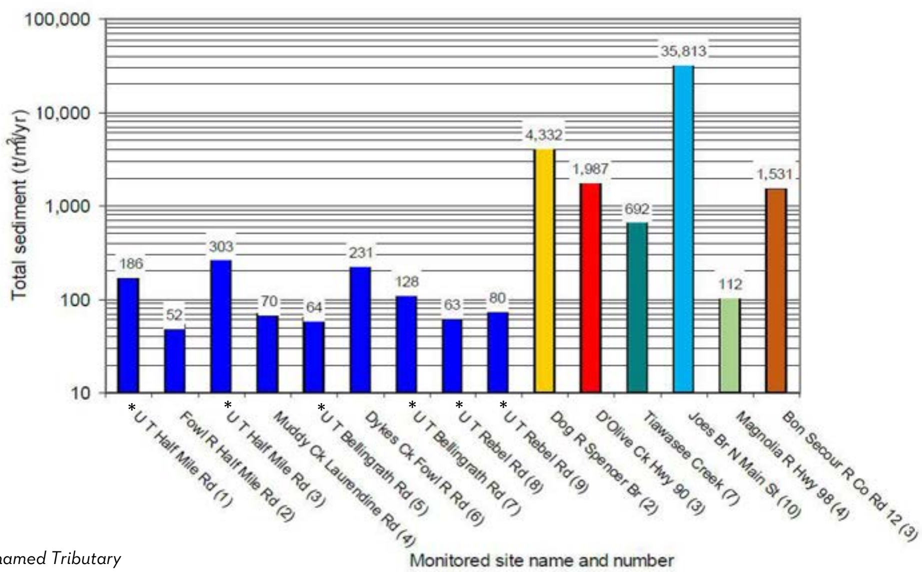
4.4.2 Water Quality Assessment of Fowl River Freshwater Segments

This section provides an overview of existing water quality conditions in the freshwater segments of Fowl River with respect to the various classes of water quality parameters listed above.

4.4.2.1 Geochemical and Trophic Parameters

Data collected by the GSA (2015) in support of the Fowl River WMP provides the most current and thorough assessment of water quality conditions in the freshwater segments of Fowl River. With regard to sediment loads, results from the GSA study indicate that Fowl River has amongst the lowest total sediment loads of any monitored watershed in the State of Alabama. **Figure 4.4** shows total normalized sediment load (tons/mi2/year) for the nine Fowl River Watershed sites versus results from other Mobile Bay sub-watersheds.

Figure 4.4: Total sediment loads in Fowl River vs. other Mobile Bay sub-watersheds (GSA, 2015)

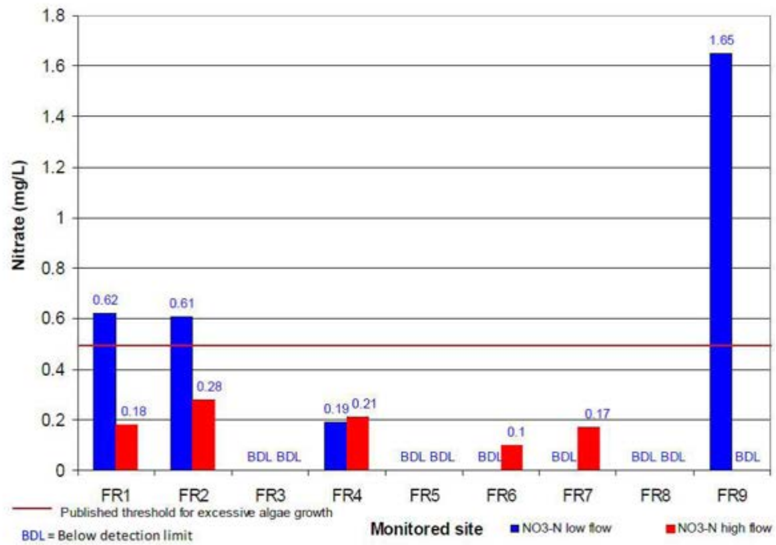


**UT = Unnamed Tributary*

4.0 WATERSHED CONDITIONS

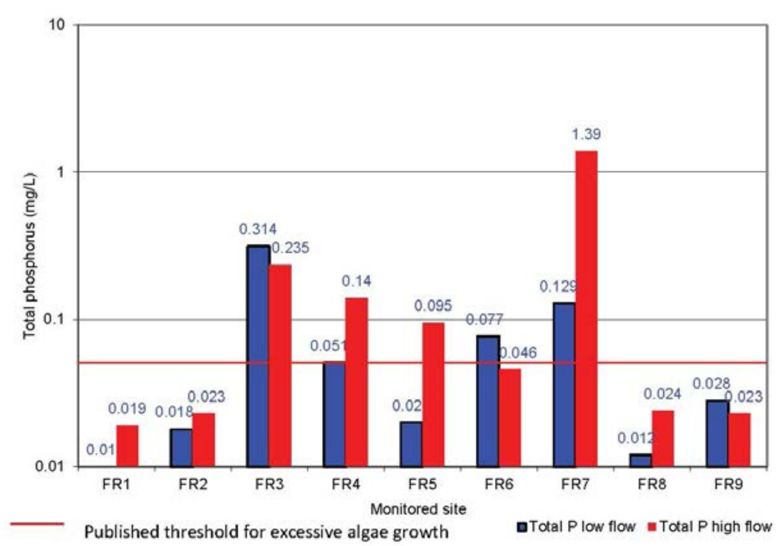
With regard to nutrients, results from the GSA study indicate that Fowl River has moderate concentrations of both nitrogen and phosphorus. Concentrations of nitrate (NO_3), a driver of excess algal growth, occasionally exceed guidance values in Fowl River, especially during low flow periods. **Figure 4.5** shows nitrate concentrations by station in Fowl River, with results differentiated by high and low river flows. A published nitrate guidance concentration for excessive algal growth in freshwater southeastern streams is indicated with the horizontal red line.

Figure 4.5: Nitrate concentrations in Fowl River (GSA, 2015)



Likewise, total phosphorus concentrations in Fowl River also occasionally exceed published guidance concentrations for excessive algal growth. However, converse to nitrate, phosphorus concentrations tend to be higher during high flow periods. **Figure 4.6** shows total phosphorus concentrations by station in Fowl River, with results differentiated by high and low river flows. A published total phosphorus guidance concentration for excessive algal growth in freshwater southeastern streams is indicated with the horizontal red line.

Figure 4.6: Total phosphorus concentrations in Fowl River (GSA, 2015)



One possible explanation for the converse relationships of nitrate and total phosphorus concentrations to river flows is that the higher nitrate values could be related to leaking wastewater infrastructure crossing or adjacent to Fowl River. High nitrate and ammonia nitrogen concentrations are associated with human wastewater, and water quality signatures from leaking infrastructure (e.g., pump stations, sewer lines, septic tanks) are most evident during low flows. During high river flows, nitrate and ammonia nitrogen concentrations from wastewater inputs are diluted and typically not as evident.

It should be noted that as part of this study, DISL collected dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) data from the freshwater segments of Fowl River. While these results are not directly comparable to the GSA data due to the different nutrient species analyzed, they were used to assess concentrations delivered to the Fowl River estuary.

With regard to algal production, available data from DISL and ADEM indicate that the freshwater segments of Fowl River typically exhibit very low concentrations of chlorophyll-a (<5 ug/l), with a few exceptions during very low river flows. Although nutrients concentrations appear to be more than adequate for stimulating algal growth, tree shade and tannins in the river water reduce water clarity and the ability of phytoplankton to assimilate and photosynthesize available nutrients. In addition, under most flow conditions, velocities are such that there is not adequate residence time for nutrient assimilation. Likewise, dissolved oxygen concentrations in the freshwater segments are generally above the freshwater regulatory standard of 5 mg/l, and are more than adequate to support aquatic organisms in the River.

4.4.2.2 Pathogens

The Watershed Management Team investigated sources of bacteria by collecting samples from five locations in the main channel of Fowl River and using microbial source tracking (MST) analysis to determine whether human waste was a source of bacteria. The results, which are discussed further in this section, indicate no evidence of human fecal waste in the River.

Measured concentrations of certain bacteria, specifically *Escherichia coli* (*E. coli*) and *Enterococcus sp.* (common name - *enterococcus*) are used as indicators of the presence of fecal material in drinking and recreational waters. Both indicate the possible presence of other disease-causing bacteria, viruses, and protozoans. Such pathogens may pose health risks to people fishing and swimming in a water body. Sources of bacteria include improperly functioning wastewater treatment plants, leaking septic systems, stormwater runoff, animal carcasses, and runoff from animal manure and manure storage areas.

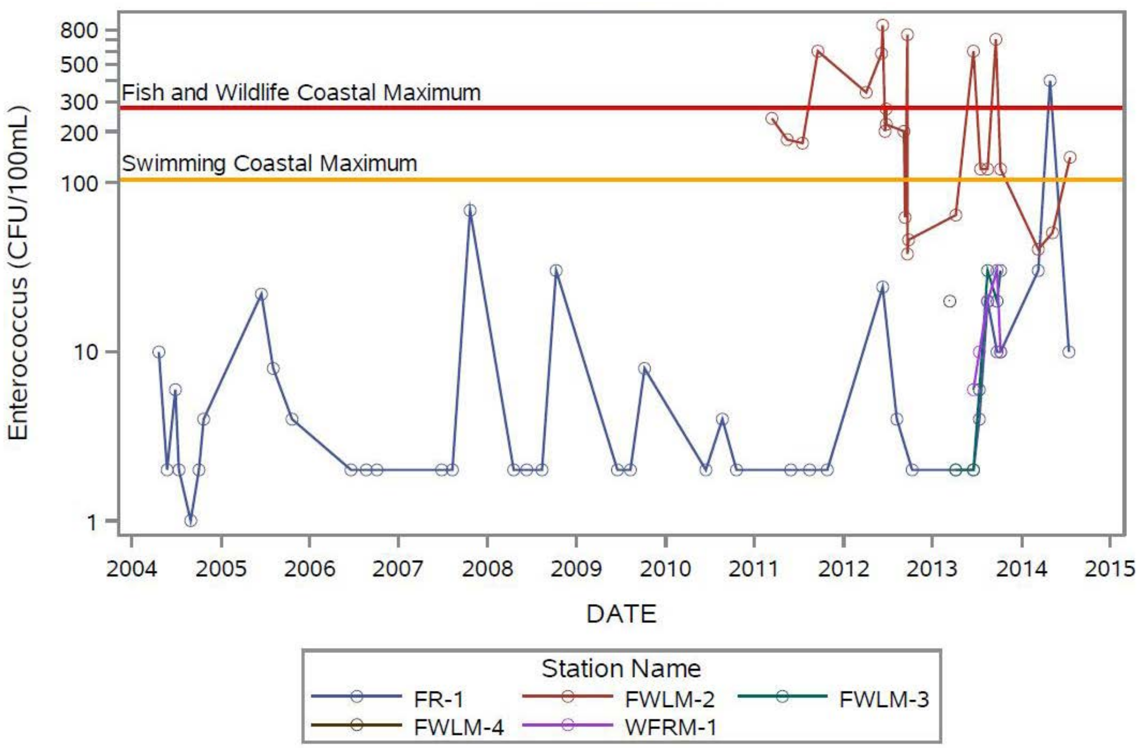
The presence of pathogens can cause cloudy water, unpleasant odors, and decreased levels of dissolved oxygen. Enterococci levels should be measured in marine and fresh waters while *E. coli* should only be measured in fresh waters. Acceptable levels of both *E. coli* and enterococci are measured in cfu (colony forming units) and commonly include both a 30-day mean and a single sample maximum. As defined by the EPA, suitable levels for enterococci in marine waters are 35 cfu/100ml for a 30-day mean and 104 – 501 cfu/100ml for a single sample. Levels in fresh water should be less than 33 cfu/100ml for a 30-day mean and 61 – 151 cfu/100 ml as a single sample reading.

Data collected by ADEM indicate that freshwater and tidally influenced segments of Fowl River are periodically impaired for bacteria, as measured by *enterococcus*, particularly in middle and lower segments of the River (e.g., Half Mile Road downstream to below Fowl River Road).

Figure 4.7 shows a time series of *enterococcus* concentrations along with both the Alabama coastal swimming and coastal fish and wildlife regulatory standards (104 and 275 cfu/100ml, respectively).

It should be noted that bacterial concentrations in surface waters can be notoriously sporadic and variable, with occasional spikes associated with large rains events. Since there are many potential sources of bacterial pollution in surface waters, it is important to clearly identify the sources of greatest concern with regard to the specific management objectives for the subject water body.

Figure 4.7: Enterococcus concentrations in Fowl River (ADEM ambient data)



To further investigate these impairments, ESA conducted a microbial source tracking (MST) study in the Fowl River Watershed. The study was conducted specifically to determine if human waste was a source of observed bacterial concentrations.

The MST methodology differs substantially from methods that count colony forming units of *E. coli* and *enterococcus* upon which current regulatory limits are based. The MST methodology involves the detection and quantification of DNA from human-specific bacteria of the genus *Bacteroides*. Fecal *Bacteroides* are considered for several reasons to be a more accurate indicator of human waste pollution than are the traditional indicator organisms *E. coli* and enterococci. First, they are more abundant in the feces of warm-blooded animals than are *E. coli* and enterococci. Second, *Bacteroides* are strict anaerobes; whereas *E. coli* and enterococci are facultative anaerobes and as such are able to proliferate in soil and sediments. Therefore, the presence of *Bacteroides* in surface waters is a strong indicator of fecal contamination. Finally, certain strains of the *Bacteroides* genus, such as *B. dorei*, have been found to be specific to humans, and as such can be used as very reliable indicators of human fecal contamination.

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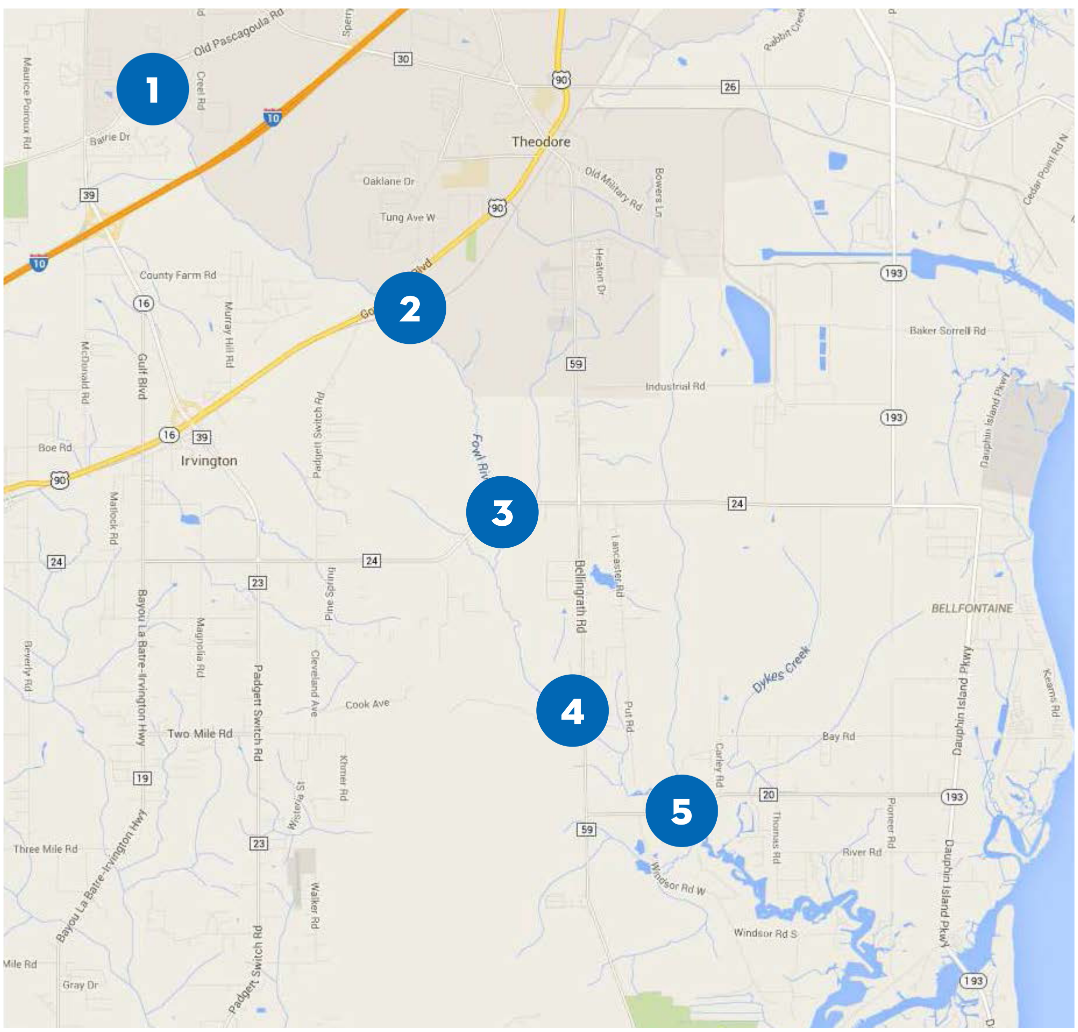
The MST methodology involves filtering the entire portion of a water sample for *Bacteroides*, which avoids the randomness effect of culturing and selecting bacterial isolates. This is an advantage for highly-contaminated water systems with known potential multiple sources of fecal contamination. Next, the methodology uses quantitative polymerase chain reaction (PCR) DNA technology to determine the presence of human gene biomarkers from human-specific strains of *Bacteroides*. The methodology is considered to be much more definitive than traditional methods in terms of determining the presence of human fecal contamination in surface waters.

For the Fowl River MST study, surface water samples were collected during a period of low river flow on December 10, 2014, from five locations identified in **Figure 4.8** along the River main stem:

1 - Fowl River @ Old Pascagoula Road
2 - Fowl River @ SR-90
3 - Fowl River @ Half Mile Road
4 - Fowl River @ Bellingrath Road
5 - Fowl River @ Fowl River Road

Figure 4.8: Location of MST sampling sites on Fowl River



Samples collected from Fowl River were sent via overnight delivery to Source Molecular in Miami, Florida for MST analysis. Samples were analyzed for two *Bacteroides* human gene biomarkers to improve the confidence in the results. In addition, for comparison with regulatory criteria and associated methods, the samples were also analyzed for *Enterococcus*. The results are shown in **Table 4.3**. These results indicate that while there were bacteria present in Fowl River surface waters at the time of sampling, there is no evidence that the sources of those bacteria included human fecal waste.

TABLE 4.3: SUMMARY OF FOWL RIVER MST STUDY RESULTS

Station	1	2	3	4	5
Indicator					
Enterococcus sp. (cfu)	40	60	200	80	40
Human *Bacteroides* ID-1 (Dorei)	ND	ND	ND	ND	ND
Human *Bacteroides* ID-2 (EPA)	ND	ND	ND	ND	ND

ND = not detected

The range of species-specific DNA indicators continues to increase with the advancement of the MST technology, and it is now possible to analyze water samples for indicators of fecal waste from cattle, horses, pigs, dogs, deer, and various species of birds. However, given the recreational uses of Fowl River, the MST study focused on human fecal waste indicators because they are best correlated with human pathogens and threats to human health from water contact recreation. While bacteria inputs from other warm-blooded animals can be effectively addressed through best management practices (e.g., cattle exclusion from stream crossings), human wastewater infrastructure improvements typically require costly capital investments.

As noted above, the Fowl River MST study was conducted during a dry period with low river flows. These conditions were preferred to better isolate any inflows from human wastewater infrastructure including leaking sewer lines, pump stations, and septic tanks. During wet periods with higher river flows, inputs from human wastewater infrastructure are typically diluted and/or masked by other inputs from stormwater runoff. Despite the selection of these conditions, the *Enterococcus* analysis indicated concentrations exceeding the swimming coastal maximum criteria at Station 3, which is located at the Half Mile Road bridge crossing over the river main stem. This location corresponds with ADEM long-term Station FWLM-2 where bacterial criteria have been frequently exceeded. It should be noted that this location generally corresponds with tributary inflows draining agricultural land uses – particularly cattle grazing - in the western portion of the Watershed. While the Fowl River MST study did not specifically identify cattle as the source of elevated bacteria concentrations in this location, it did show that human fecal waste was not present.

4.4.2.3 Contaminants

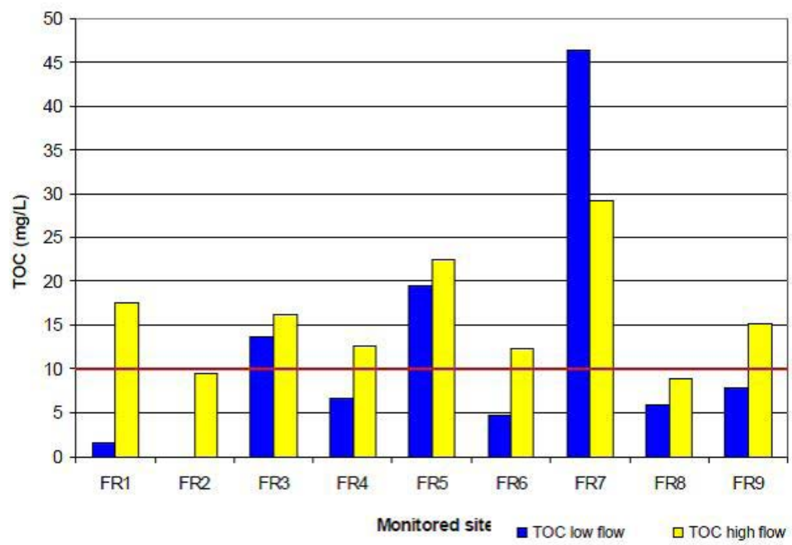
As shown in **Table 4.2**, ADEM has routinely monitored metals in the Fowl River Watershed for more than three decades, and the GSA recently completed a study of Fowl River that included the assessment of metals and organics (GSA, 2015).

As noted in the GSA study (GSA, 2015), metals detected in Alabama streams are normally a result of the erosion of fine grained sediments, as evidenced by the pervasive concentrations of aluminum and iron observed in Fowl River. Generally, the largest concentrations of aluminum occur during the high flows indicating erosion of aluminum-rich clays. Conversely, the largest iron concentrations generally occur during low flows, indicating major accumulations of iron hydroxide, the waste product of natural iron-consuming bacteria. Other metals exceeding regulatory criteria in Fowl River were cadmium at site FR9 (East Fowl River at Rebel Road) and copper at site FR6 (Dykes Creek at Fowl River Road). Lead is also pervasive in all monitored watersheds and exceeded the criterion at all sites except FR1 (Unnamed Tributary at Half Mile Road) and FR2 (Fowl River at Half Mile Road). Lead is pervasive in streams throughout the Alabama coastal plain and is thought to originate from atmospheric deposition. However, detection of cadmium and copper are relatively rare and may be from local sources. ADEM metals data essentially show the same patterns of elevated aluminum and iron, and the detection and occasional exceedance of regulatory criteria for other metals generally considered to be of anthropogenic origin.

4.0 WATERSHED CONDITIONS

The GSA study (GSA, 2015) also assessed organic compounds in Fowl River, focusing primarily on total organic carbon (TOC) as a potential surrogate for organic compounds (e.g., petrochemicals, solvents, pesticides), as well as naturally occurring organic production. While TOC analysis does not give specific information about the nature or source(s) of organic contaminants, identifying changes in TOC can be a good indicator of potential threats to a hydrologic system (GSA, 2015). Typical TOC values for natural waters vary from 1 to 10 mg/L (Mays, 1996, as cited in GSA, 2015). Results from the GSA study indicate elevated TOC values at most stations sampled in Fowl River, as shown in **Figure 4.9**.

Figure 4.9: Total organic carbon concentrations in Fowl River (GSA, 2015)



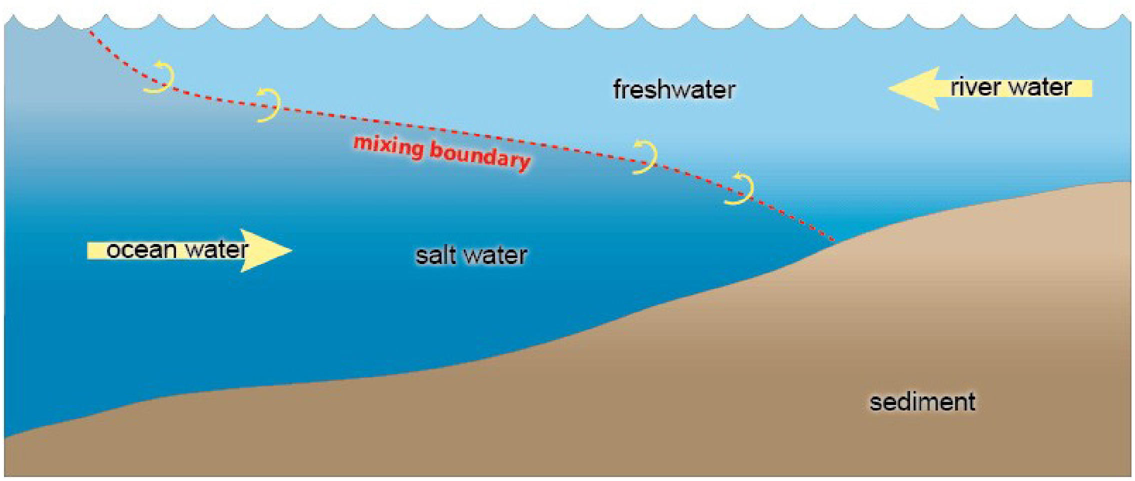
These results indicate relatively high TOC values throughout Fowl River. The sources of the elevated organic carbon are not known, but could include both natural organic matter in the form of primary and secondary production (algae, leaf litter, etc.), as well as organic contaminants.

4.4.3 Water Quality Assessment of Fowl River Estuary

The chemistry, biology, and ecosystem functions of freshwater streams and rivers are very different from those of tidal estuaries; however, there is an intimate relationship between the freshwater and tidal portions of a water body with quality, quantity, and timing of freshwater deliveries essential for determining the overall health of the estuary. As discussed in the previous sections, water quality in freshwater Fowl River appears to be generally good, but loadings of both nutrients and organic matter delivered to tidal Fowl River are potentially problematic for the health of the estuary. For these reasons, the focus of the discussion that follows is on physicochemical and trophic parameters.

A feature common to all estuaries is the mixing of freshwater from the Watershed with salt water from the ocean. Within the physical boundaries of an estuary, this mixing is often uneven due to density differences between fresh and salt water. As a result, virtually all estuaries exhibit density stratification to some extent, where denser, saltier water flows upstream along the bottom, while fresh water flows downstream along the surface. **Figure 4.10** graphically illustrates this phenomenon.

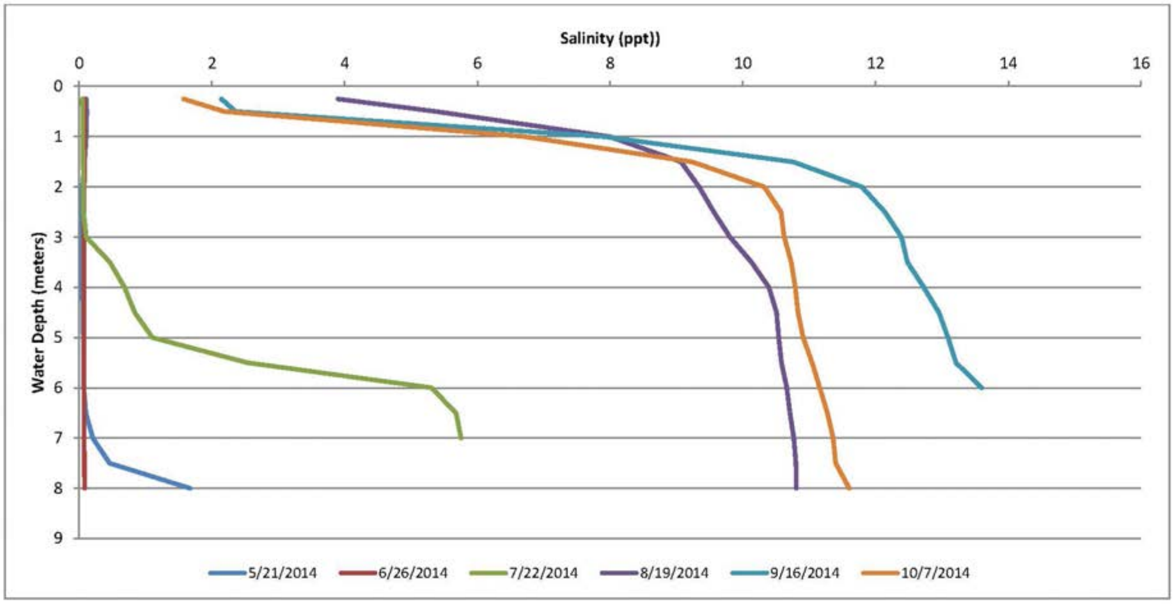
Figure 4.10: Graphic depiction of estuarine mixing and stratification



This stratification often prevents efficient chemical mixing between the fresh and salt water layers, which is normally not a problem. However, if too much bacterial respiration occurs in the bottom sediments due to the breakdown of excessive organic production (e.g., algae blooms; dissolved and particulate organic matter), stratification can result in dissolved oxygen deficits. This can adversely impact living resources such as fish and shellfish.

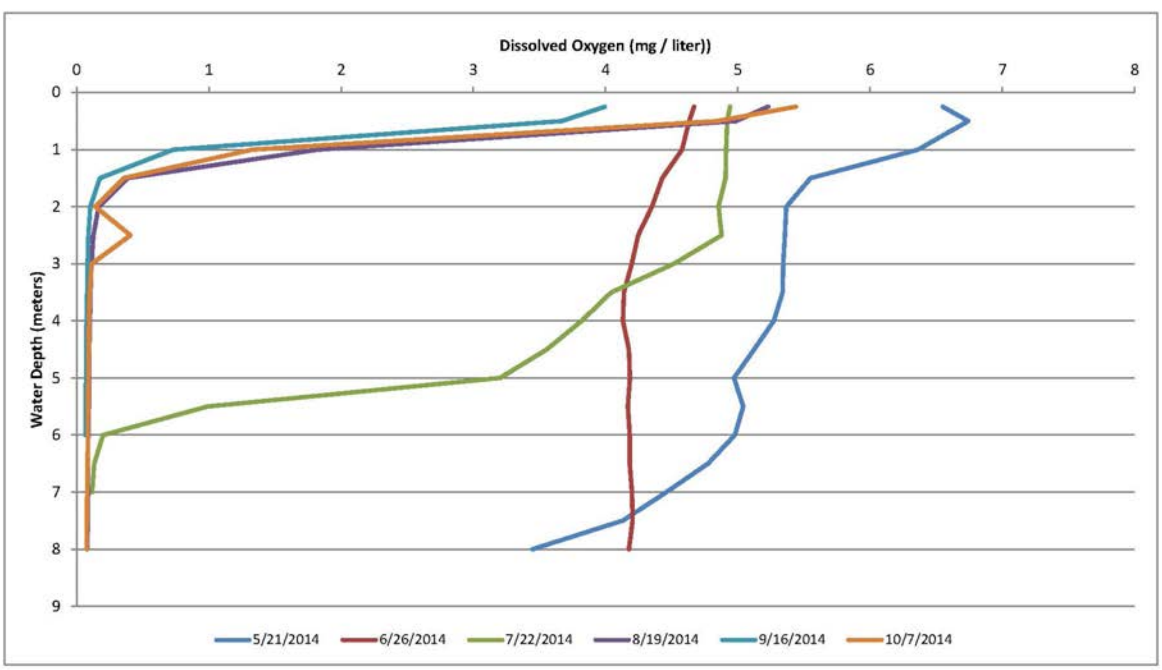
Data collected by DISL as part of this study, and ADEM, as part of a long-term monitoring program, indicates that the Fowl River estuary does exhibit density stratification, primarily during lower River flows, as shown in **Figure 4.11**. Refer to Table 4.2 and Figure 4.3.

Figure 4.11: Density stratification in the Fowl River estuary (ADEM Station FR-1 at river mouth)



Unfortunately, this stratification also results in significant dissolved oxygen deficits along the bottom as shown in **Figure 4.12**. As noted previously, such dissolved oxygen deficits result from excessive bacterial respiration along the bottom, which is indicative of the delivery of excessive organic matter from the freshwater river and/or excessive algal production within the tidal estuary itself. Estuarine algal production in turn is a function of nutrients delivered to the estuary from the freshwater river, with nitrogen and phosphorus being the most important.

Figure 4.12: Dissolved oxygen stratification in the Fowl River estuary (ADEM Station FR-1 at river mouth)



The EPA has developed national and regional criteria for estuarine trophic parameters that can be used as an index of general estuarine health as well as comparative measures between different estuaries (EPA, 2012). With regard to nutrients, EPA has developed criteria for DIN and DIP, as these forms are the most readily available to phytoplankton (e.g., algae). On the other hand, ADEM has developed criteria for total nitrogen (e.g., both particulate and dissolved forms) and total phosphorus. **Table 4.4** shows estuarine trophic criteria developed by both the EPA and ADEM.

TABLE 4.4: APPLICABLE ESTUARINE TROPHIC CRITERIA FOR FOWL RIVER

Parameter	Good	Fair	Poor	Source
Total N	0.4	0.4-0.8	>0.9	ADEM 2008
DIN	0.1	0.1-0.5	>0.5	EPA 2012
Total P	0.02	0.02-0.04	>0.04	ADEM 2008
DIP	0.01	0.01-0.05	>0.05	EPA 2012
Chlorophyll-a	5	5-20	>20	EPA 2012
Water clarity	>10%	5-10%	<5%	EPA 2012
DO (bottom waters)	5	2-5	<2	EPA 2012

As part of this study, composited water quality data from multiple sources were plotted with respect the above criteria (see **Appendix D**). With regard to nutrients, the data indicated that nitrogen concentrations delivered to the Fowl River estuary are potentially problematic, as shown in **Figures 4.13** and **4.14** for total nitrogen and DIN, respectively.

Figure 4.13: Time series of total nitrogen concentrations in Fowl River with EPA criteria

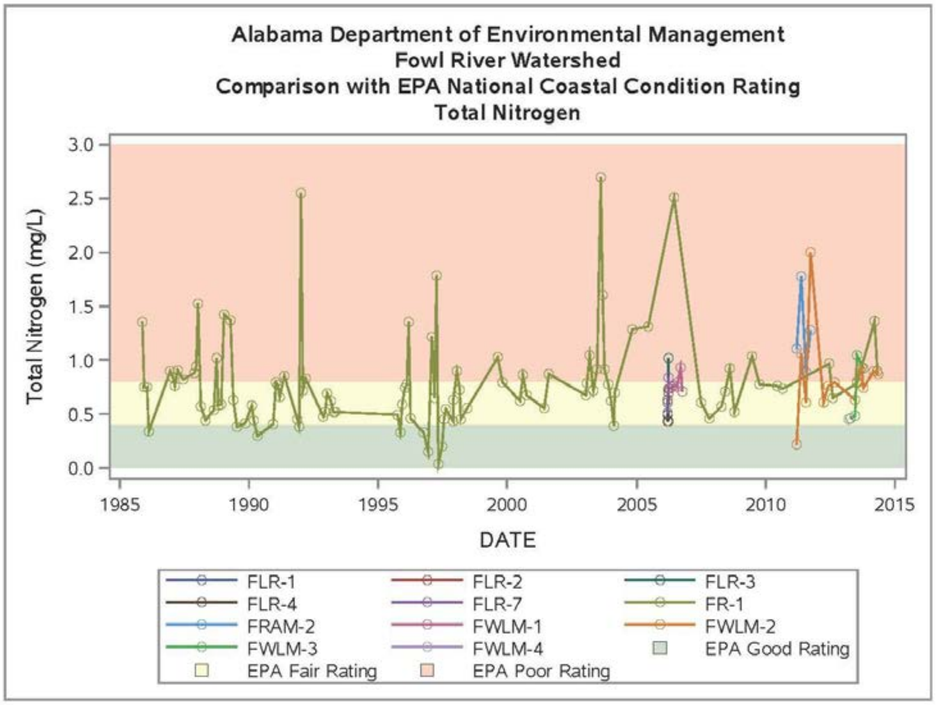
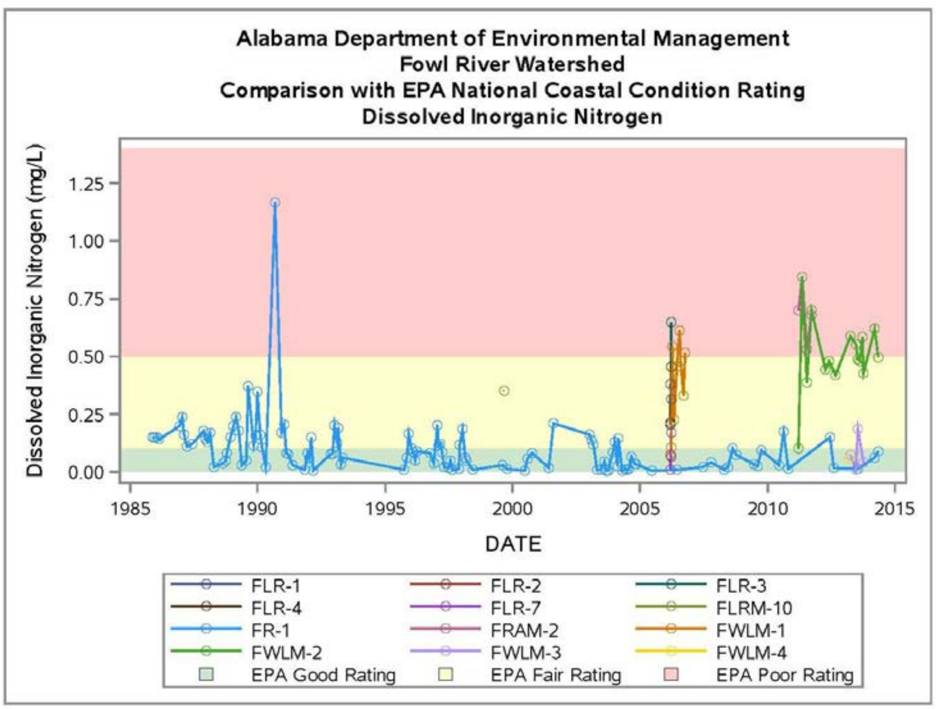


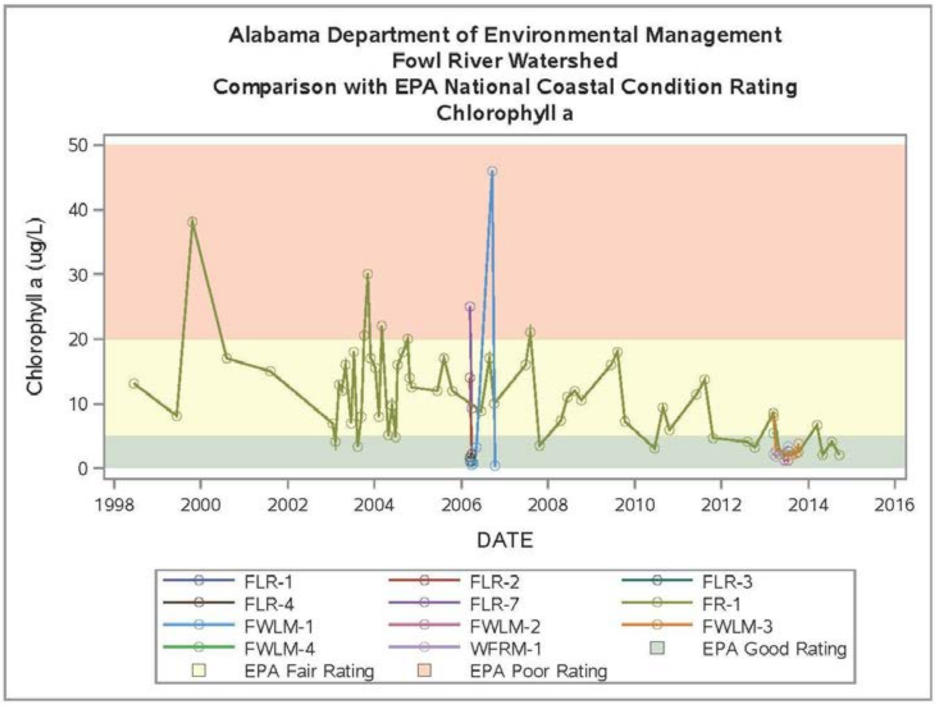
Figure 4.14: Time series of dissolved inorganic nitrogen concentrations in Fowl River with EPA criteria



4.0 WATERSHED CONDITIONS

Algal production is measured in terms of the concentrations of chlorophyll-a, the primary photosynthetic pigment contained in phytoplankton cells. Although nitrogen concentrations delivered to the Fowl River estuary appear to be enriched, nitrogen is not being assimilated into excessive algal production. As shown in **Figure 4.15**, chlorophyll-a concentrations in the Fowl River estuary fell within fair range in recent years.

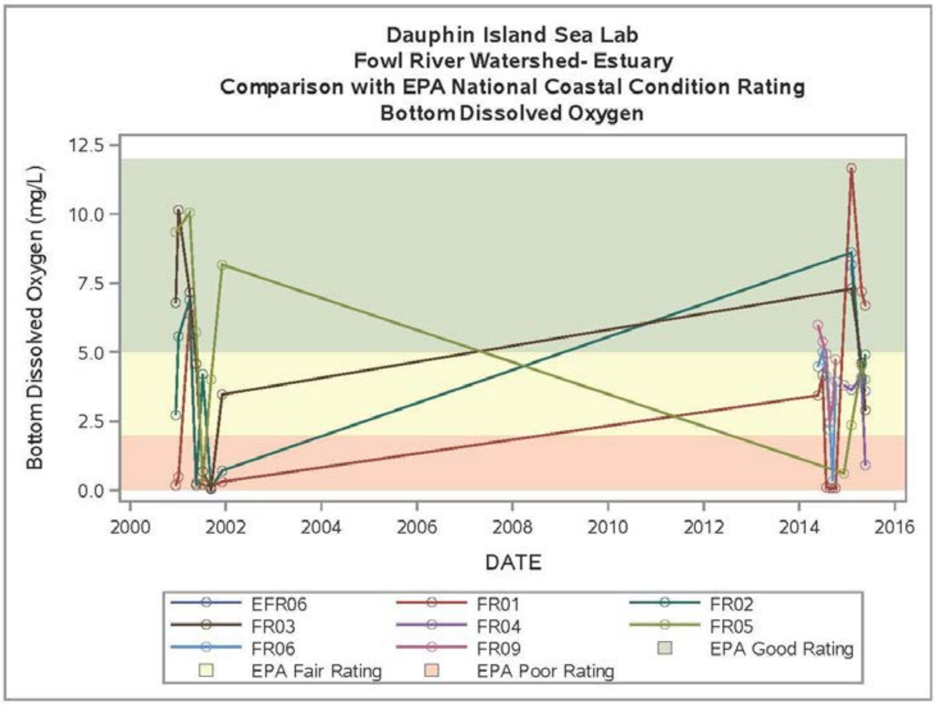
Figure 4.15: Time series of chlorophyll-a concentrations in Fowl River with EPA criteria



4.0 WATERSHED CONDITIONS

As discussed above, the bacterial breakdown of excessive organic matter along the bottom during periods of density stratification can lead to dissolved oxygen deficits. Furthermore, excessive algal production during daylight hours can result in supersaturated dissolved oxygen concentrations. Therefore, a typical signature of water bodies with enriched nutrient and/or organic inputs are wide fluctuations in dissolved oxygen concentrations. **Figure 4.16** shows this pattern in bottom dissolved oxygen concentrations.

Figure 4.16: Time series of bottom dissolved oxygen concentrations in Fowl River with EPA criteria



The Fowl River estuary is somewhat enriched with regard to nitrogen and TOC inputs, and periodically exhibits excess algal production. Continued monitoring is recommended to document status and trends in the health of the estuary.

4.0 WATERSHED CONDITIONS

Summary Conclusions

In consideration of the information presented above, the following summary conclusions have been developed for the freshwater and tidal segments of Fowl River, respectively.

Freshwater Fowl River

- Total suspended solids and sediment loads in Fowl River are relatively low compared to other Mobile Bay sub-watersheds.
- Nitrate and total phosphorus concentrations in Fowl River are elevated above guidance criteria for southeastern streams, and appear to be enriched by anthropogenic activities in the Watershed.
- Bacteria concentrations in Fowl River frequently exceed applicable regulatory criteria; however, the MST study did not show any evidence of human fecal waste inputs to the River.
- Fowl River is relatively enriched with regard to aluminum and iron, which are naturally occurring metals associated with the erosion and chemical breakdown of clayey sediments. However, elevated concentrations of other metals including cadmium and copper, indicate anthropogenic sources in the Watershed.
- Total organic carbon concentrations in Fowl River exceed applicable guidance criteria and may be indicative of both natural organic production as well as anthropogenic sources of organic chemicals.
- The freshwater segments of Fowl River do not exhibit excessive algal production and are generally indicative of a healthy aquatic ecosystem.

Fowl River Estuary

- The Fowl River estuary exhibits significant density stratification during periods of low flow; whereas, during periods of high flow the River is well-mixed and mostly fresh from surface to the bottom.
- When the Fowl River estuary is stratified, dissolved oxygen concentrations on the bottom frequently drop below both regulatory and guidance criteria, potentially resulting in adverse impacts to living resources including fish and shellfish.
- The Fowl River estuary appears to be enriched with regard to both nitrogen and organic matter inputs. Nutrient enrichment is sometimes assimilated into excessive algal production.
- The Fowl River estuary appears to be generally healthy; however, periodic dissolved oxygen deficits may be indicative of excessive inputs of organic matter and inorganic nutrients.

4.5 BIOLOGICAL DATA

4.5.1 Flora and Fauna

From the bottomland hardwood wetlands in the headwaters to the salt marshes where Fowl River discharges into Mobile Bay, there is incredible species diversity of both flora and fauna within the Watershed. Not only do these habitats provide storm event/shoreline protection and nutrient removal, they provide critical habitat for freshwater and tidal species. Its ecosystem is part of the Mobile Bay estuary, which provides habitat for more than 300 species of birds, 310 species of fish, 68 species of reptiles, 57 species of mammals, 40 species of amphibians, and 15 species of shrimp (MBNEP, 1997).

Both human-induced (increased development, population growth, etc.) and natural (sea level rise, erosion, etc.) impacts have affected species and their respective habitats. The Alabama Natural Heritage Program (ALNHP), established in 1989, provides an ongoing ecological inventory database to help establish conservation priorities in Alabama. Their mission is to provide the best available scientific information on biological diversity of Alabama to guide conservation actions while promoting stewardship practices. The Watershed Management Team collected information from ALNHP for rare, threatened, and endangered species and natural communities documented within Mobile County. A comprehensive list of these species is located within Appendix E. State and federal ranking and priority status of each species is provided for amphibians, birds, caddisflies, crayfishes, ferns, fishes, flowering plants, freshwater mussels, freshwater snails, mammals, reptiles, and natural communities. Due to the amount of natural habitat/undeveloped areas within the Watershed, and the existence of both freshwater and tidal habitats, many of the species occur within the Fowl River Watershed.

In addition, Dave Armstrong, Fisheries Supervisor for the Alabama Division of Wildlife and Freshwater Fisheries, provided the Watershed Management Team with fish data specific to Fowl River. The data provided was collected in response to potential fishery impacts caused by the Deepwater Horizon Oil Spill and included a group consisting of Auburn University, ADCNR, and GSA. Species documented included bluegill sunfish (*Lepomis macrochirus*), pinfish (*Lagodon rhomboids*), sheephead (*Archosargus probatocephalus*), striped mullet (*Mugil cephalus*), spotted sunfish (*Lepomis punctatus*), menhaden (*Brevoortia tyrannus*), warmouth (*Lepomis gulosus*), largemouth bass (*Micropterus salmoides*), orange-spotted sunfish (*Lepomis humilis*), croaker (*Sciaenidae*), and flounder (*Paralichthys*).

4.5.2 Threatened and Endangered Species

Mobile County provides habitat to more than 200 threatened and endangered species (ALNHP). Many of these species live in the Fowl River Watershed year-round or seasonally. Included in this rare but important list are populations of black bear (*Ursus americanus*), West Indian manatee (*Trichechus manatus*), gopher tortoise (*Gopherus polyphemus*), Wood Stork (*Mycteria americana*), and an abundance of plants, aquatic organisms, bats, and birds that all use the Watershed's natural resources for habitat. Table 4.5 lists a number of legally-protected species identified by the U.S. Fish and Wildlife Service (USFWS) as threatened, endangered, or in recovery in Mobile County:

TABLE 4.5: LEGALLY PROTECTED SPECIES LISTED BY THE USFWS AS THREATENED, ENDANGERED OR IN RECOVERY

Group	Name	Status
Birds	Bald Eagle (*Haliaeetus leucocephalus*)	Recovery
Birds	Wood Stork (*Mycteria americana*)	Threatened
Birds	Piping Plover (*Charadrius melodus*)	Threatened
Birds	Red Knot (*Calidris canutus rufa*)	Threatened
Fishes	Atlantic sturgeon (*Gulf subspecies*) (*Acipenser oxyrinchus* (=*oxyrhynchus*) *desotoi*)	Threatened
Mammals	West Indian manatee (*Trichechus manatus*)	Endangered
Reptiles	Hawksbill sea turtle (*Eretmochelys imbricata*)	Endangered
Reptiles	Leatherback sea turtle (*Dermochelys coriacea*)	Endangered
Reptiles	Kemp's ridley sea turtle (*Lepidochelys kempii*)	Endangered
Reptiles	Green sea turtle (*Chelonia mydas*)	Threatened
Reptiles	Loggerhead sea turtle (*Caretta caretta*)	Threatened
Reptiles	Alabama red-belly turtle (*Pseudemys alabamensis*)	Endangered
Reptiles	Eastern indigo snake (*Drymarchon corais couperi*)	Threatened
Reptiles	Black pine snake (*Pituophis melanoleucus lodingi*)	Proposed Threatened
Reptiles	Gopher tortoise (*Gopherus polyphemus*)	Threatened

4.5.3 Invasive Species

Invasive species are plants or animals that have been introduced to an area outside of their original range. Typically these species spread incredibly fast due to their quick reproduction rates and ability to outcompete native species for resources. In many cases, the ecological integrity and biodiversity of an area is threatened when homogenous stands of invasive species are established. In addition to the threat to natural resources, invasive species cause significant costs to forestry, fisheries, and agricultural industries. According to the University of Georgia Center for Invasive Species and Ecosystem Health, with 361 species, Mobile County has reported the most invasive species of any county within Alabama. Throughout the site reconnaissance conducted by the Watershed Management Team, four species were predominately noted as invasive species of significant concern. The following information was provided by the Alabama Cooperative Extension System (ACES) (http://www.aces.edu/natural-resources/invasive-species/plants-trees.php#):

Figure 4.17: Cogongrass

Cogongrass *(Imperata cylinrica)*

Cogongrass, shown in **Figure 4.17**, has exhibited extensive growth within the Fowl River Watershed over the last decade. This aggressive grass is difficult to eradicate even under strict management practices. Burning and site mowing can remove the standing plants; however these alone can actually increase expansion. Seed transport occurs when infested areas are mowed or when dirt, hay, etc., are transported from land containing cogongrass.

Figure 4.18: Chinese privet in headwaters of the Watershed

Chinese privet *(Ligustrum sinense)*

A shade tolerant, evergreen shrub, Chinese privet, shown in **Figures 4.18** and **4.19**, is known for its ability to propagate in almost all habitat types including urban areas, upland forests, bottomland hardwood wetlands, etc. The distribution is almost the entire southeastern U.S. and throughout the Fowl River Watershed. This fast growing species outcompetes native vegetation and therefore inhibits native forest regeneration. Chinese privet is dense along stream channels due to seed transport to downstream areas and throughout the Watershed.

Figure 4.19: Dense Chinese privet stand

Chinese tallow or Popcorn tree *(Triadica sebifera)*

Native to Asia, the distribution of Chinese tallow trees is widespread throughout Alabama. Easily recognizable by its diamond-shaped leaves, it exhibits vibrant fall foliage. This fast growing species, combined with astonishingly high seed yields, allows for rapid expansion. In addition, it easily adapts to various soil types and conditions. Chinese tallow trees were observed throughout the Watershed predominately along stream channels and in clear-cut or areas of disturbance such as power-line easements, as shown in **Figure 4.20.**

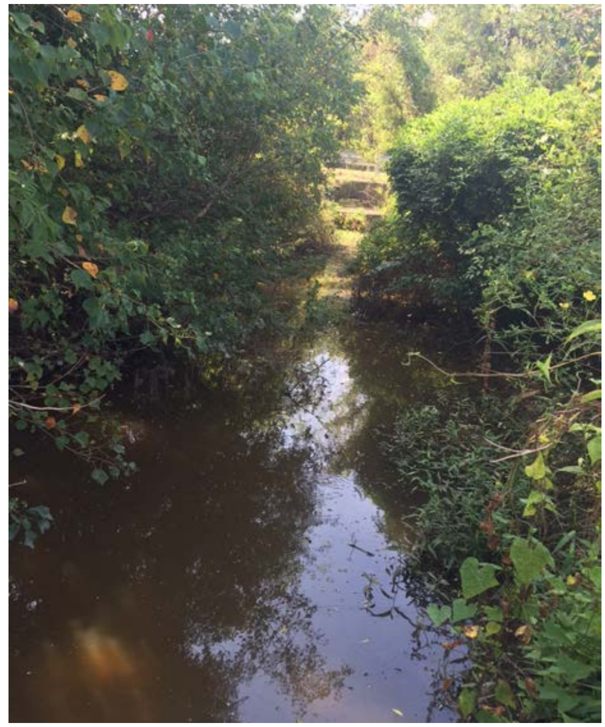


Figure 4.20: Chinese tallow or Popcorn tree

Common reed *(Phragmites australis)*

Phragmites **(Figure 4.21)**, although found naturally throughout coastal Alabama, in many instances it is considered an invasive species. It grows in dense populations that easily outcompete native vegetation. Located within the tidal portion of Fowl River, it dominates the landscape of shorelines along the bay. Native marsh plants such as bulrush (*Schoenoplectus spp.*), cord grass (*Spartina alterniflora*), and black needle rush (*Juncus roemerianus*) within Fowl River are replaced with *Phragmites.*

Figure 4.21: ***Phragmites*** along shoreline of Mon Louis Island

4.6 COASTAL ZONE

4.6.1 Coastal Zone Assessment

South Coast Engineers, Inc., (SCE) performed an evaluation of the coastal zone and nearshore transitional environments within the Fowl River Watershed. Based on the river, shoreline, and channel characteristics along Fowl River, as well as the types of vegetation found there, the lower Watershed was divided into two distinct zones, with an ill-defined transition zone in between. These zones are the marine, transitional, and fresh zones. The shorelines along Fowl River have changed dramatically over the previous 80 years. The morphologic changes that have occurred in Fowl River are mostly due to natural processes, but have been perturbed by human interaction within the Watershed. These processes include changes in streamflow and sediment loading, high flow events, high water events, sea level rise, and wave action.

An evaluation of the extent of tidally-influenced shoreline in the Fowl River Watershed reveals that approximately 47 miles of shoreline are found below the Mean Higher High Water (MHHW) tidal datum elevation. The coastal zone corresponds to the portion of Fowl River below Fowl River Road. Although nearly all Fowl River shoreline is privately-owned, and much of it has been settled and developed since 1938, only about 25 percent of the total shoreline length is armored. The Jones & Tidwell (2012) GSA report provides a detailed classification of shoreline armoring type and extent along Fowl River. The report reveals that of the approximately 25 percent of shoreline that is armored, 80 percent is steel or wood bulkhead. Use of rock and riprap accounts for the remaining extent of shoreline armoring along Fowl River.

Historical Site Conditions

The shorelines along Fowl River have changed dramatically over the previous 80 years. Using a combination of historical aerial imagery provided by the University of Alabama (http://alabamamaps.ua.edu/index.html) and Google Earth's timeline feature, imagery dating back to 1938 captures both development of the Fowl River Watershed and changes to the River's shorelines, spits (point bars), islands, and marshes. These changes, evident in the timeline of aerial imagery including the years 1938, 1960, 1966, 1974, 1997, 2003, 2008, 2012, and 2013, are further supported by community input and their recollection of these alterations. The critical processes affecting shorelines of Fowl River are described more fully in subsequent sections.

Figures 4.22 - 4.26 demonstrate some of these morphologic changes through a selection of comparative aerial photographs from different parts of the Watershed. Each figure includes images of Fowl River from 1938, 1974, and 2013, and is cropped to show similar spatial extents. The figures start in the upper part of Fowl River near Fowl River Road **(Figure 4.22)** and conclude in the lower portion of Fowl River near Bellingrath Gardens **(Figure 4.26).**

> *Changes include narrowing and breaching of spits and point bars; loss of emergent habitat; and fragmentation of marshes.*

The primary morphologic changes shown in **Figures 4.22 – 4.26** include narrowing and elongation of recurved spits (e.g., **Figures 4.22** and **4.25**); breaching of recurved spits (e.g., **Figures 4.23 – 4.25**); reduction, or loss, of emergent island area (e.g., **Figures 4.22 – 4.25**); and fragmentation of marshes (e.g., **Figures 4.24** and **4.26**). This photographic evidence is supported by anecdotal community stakeholder knowledge of shoreline loss and change in Fowl River, which is demonstrated on the annotated aerial image shown in **Figure 4.27**. That image shows portions of spits, shoreline, and islands that have become submerged shoals (yellow) or are in the process of breaching and fragmenting (red). The agreement between local knowledge and the historical aerial imagery suggests that major (known) morphologic changes in Fowl River are captured in this historical analysis.

a. 1938 b. 1974 c. 2013

Figure 4.22: Aerial imagery of Fowl River from the years (a) 1938, (b) 1974, and (c) 2013. Note the location of Fowl River Road in the upper left corner of each photo.

a. 1938 b. 1974 c. 2013

Figure 4.23: Aerial imagery of upper Fowl River from the years (a) 1938, (b) 1974, and (c) 2013. Note the location of Thomas Road oriented nearly top to bottom in the right one-third of each photo.

a. 1938 b. 1974 c. 2013

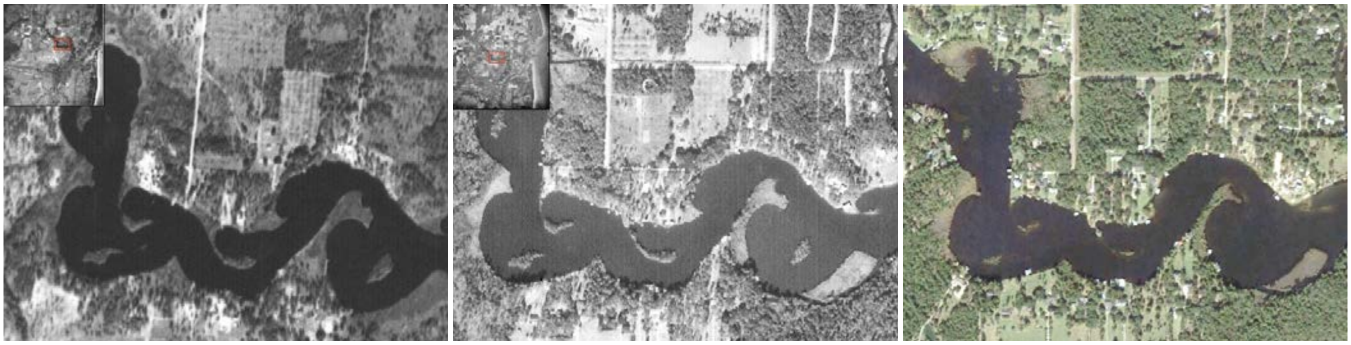


Figure 4.24: Aerial imagery of middle Fowl River from the years (a) 1938, (b) 1974, and (c) 2013. Note the location of Thomas Road oriented nearly top to bottom in the middle one-third of each photo.

a. 1938 b. 1974 c. 2013

Figure 4.25: Aerial imagery of lower Fowl River from the years (a) 1938, (b) 1974, and (c) 2013. Note the location of Pioneer Road oriented nearly top to bottom in the right one-third of each photo.

a. 1938 b. 1974 c. 2013

Figure 4.26: Aerial imagery of lower Fowl River from the years (a) 1938, (b) 1974, and (c) 2013. Note the location of Bellingrath lake/pond in the left one-third of each photo.

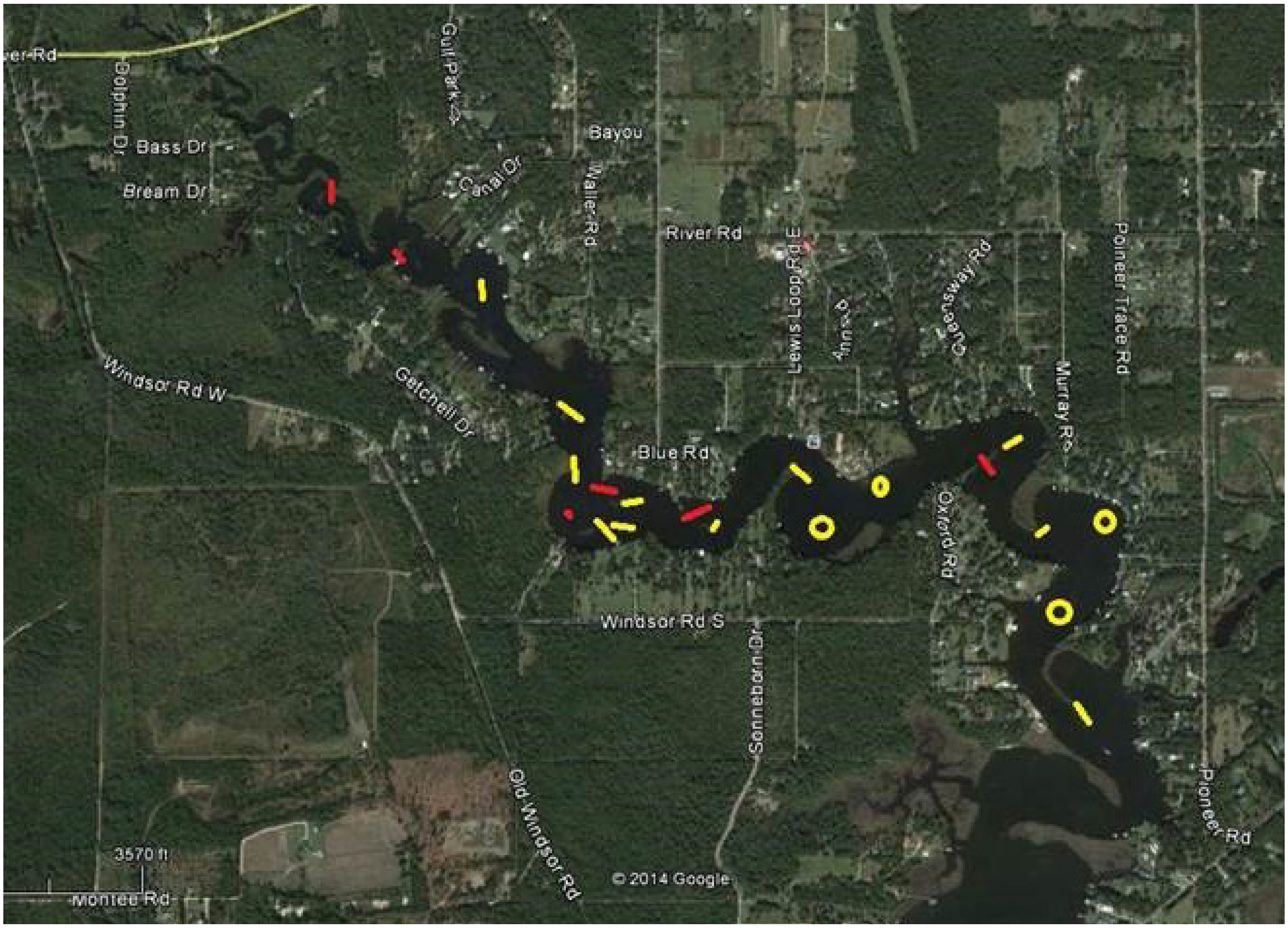


Figure 4.27: Annotated aerial imagery of lost (yellow) or breaching (red) shorelines, spits, and islands along Fowl River. (Aerial imagery and initial interpretation provided by Sam St John. Erosional areas were confirmed by South Coast Engineers through comparison of historical and current photographs.)

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4.0 WATERSHED CONDITIONS

Existing Site Conditions

The existing condition of shorelines, point bars, spits, marshes, and islands along Fowl River were assessed using multiple methods. Recent aerial imagery was viewed to capture large-scale features, evaluate the spatial extent of submerged shoals (old islands and spits), and assess the density of vegetation in marshes and along heavily wooded shorelines. Two boat trips along Fowl River provided an opportunity to evaluate and photograph shoreline conditions from the water. Finally, existing data (e.g., LiDAR, GIS, etc.) and reports were used to supplement our characterization of tidally-influenced shoreline length, shoreline type, and use, as well as the extent of shoreline armoring.

Of the 47 miles of tidally influenced shoreline, only 25 percent is armored. The most common armoring is vertical bulkhead.

An evaluation of the extent of tidally-influenced shoreline in the Fowl River Watershed reveals that approximately 47 miles of shoreline are found below the MHHW tidal datum elevation. This approximate length is determined by extracting the +0.7-foot (NAVD88) contour from a digital elevation model of the Watershed and measuring its length using GIS software. The +0.7-foot contour corresponds to the height of the MHHW tidal datum above NAVD88 at the NOAA/CO-OPS tide gauge on Dauphin Island (http:// tidesandcurrents.noaa.gov/ datums.html?id=8735180). The +0.7-foot contour is shown as the white line in **Figures 4.28** and **4.29**.

The resolution of the digital elevation model (~30 feet) likely prevented some smaller features, like spits and islands, from being captured in the length estimation. However, the 47-mile estimate agrees somewhat with the 39 miles of shoreline that were classified and evaluated in the 2012 shoreline mapping report by the GSA (Jones & Tidwell, 2012).

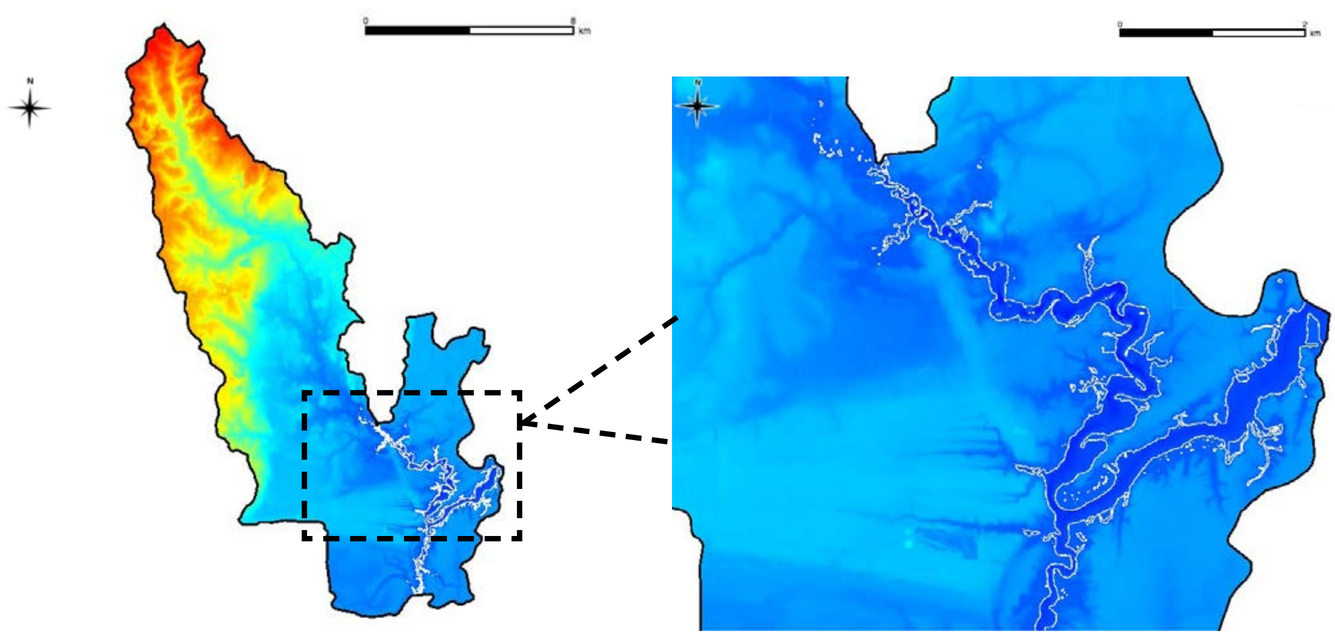

Figure 4.28 (left): Digital elevation contours within the Fowl River Watershed boundary. The MHHW contour is highlighted in white and the spatial extent of Figure 4.29 is denoted by the black dashed line. Figure 4.29 (right): The approximate extent of tidally-influenced shoreline in the Fowl River Watershed, shown as the white line in the color contours of land elevation. The spatial extents of this image correspond to the black dashed line in Figure 4.28.

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The 2012 shoreline mapping report prepared by the GSA provides a classification of shoreline types and their lengths along Fowl River. Approximately 39 miles of shoreline were classified along Fowl River, with the largest general category, or type, being organic (marsh, fringe, swamp) constituting approximately 60 percent of the total shoreline length. Low and high vegetated bank accounted for approximately 37 percent of the total shoreline length. The least common shoreline types were low sediment bank (1.3 percent) and artificial (1 percent). An annotated map of shoreline types is shown in **Figure 4.30**, and the tabulated shoreline lengths and percentages are provided in **Table 4.6.**

The GSA Phase III mapping report of Jones & Tidwell (2012) provides a detailed classification of shoreline armoring type and extent along Fowl River. The report reveals that of the approximately 25 percent of shoreline that is armored, the single most common type is steel or wood bulkhead, which constitutes 80 percent of all shoreline armoring. The 25 percent includes what would have been some natural shoreline type, i.e., armored organic or armored vegetated bank. Use of rock and riprap accounts for the remaining extent of shoreline armoring along Fowl River. An annotated map of shoreline armoring in Fowl River is shown in **Figure 4.31**, and the tabulated shore protection lengths and percentages are given in **Table 4.7**.

The assessment of existing conditions reveals that much (approximately 75 percent) of the Fowl River shoreline is natural and unretained. The lack of shoreline armoring has allowed some natural morphologic processes to occur along the riverbanks, which partially explains the breaching of point bars and/or spits and their subsequent life cycle as islands that have now mostly become submerged shoals. However, completely natural morphologic processes do not appear able to maintain the integrity of shorelines, spits, and islands, possibly owing to longstanding increases in watershed contributions (streamflows) and related reductions in sediment loading consisting of good quality sediments. Many of the coastal marshes are of poor or declining health as indicated by low plant density throughout their interior. The degradation of marshes and islands may be related to a combination of wave action, long-term sea level rise, and fluctuations in the salinity regime. Further characterization of the existing conditions is given in the following section.

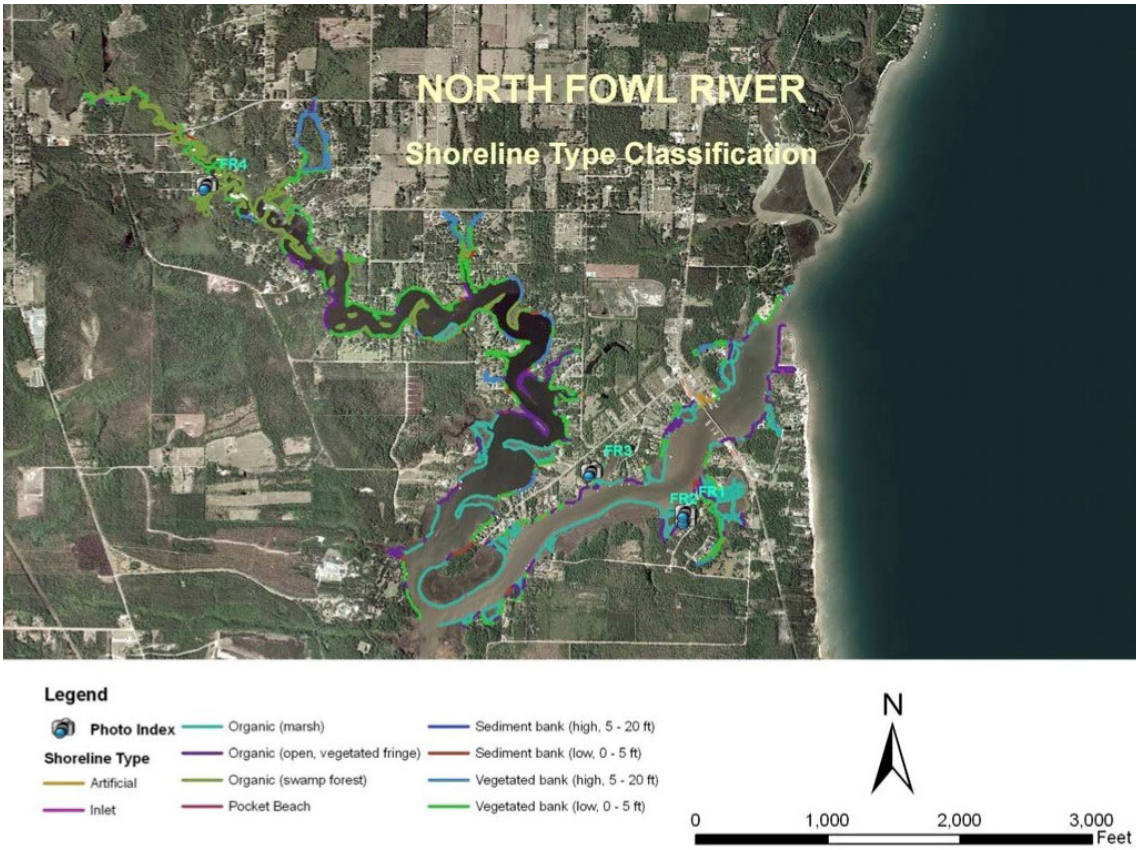

Figure 4.30: Shoreline classification map and legend for Fowl River.
Source: Jones & Tidwell, 2012

TABLE 4.6: SHORELINE CLASSIFICATION LENGTHS BY SHORELINE TYPE FOR NORTH FOWL RIVER

Shoreline type classification	Length (ft)	Percent
Artificial	1,947	1.0
Inlet	1,153	0.6
Organic (marsh)	51,779	25.6
Organic (open, vegetated fringe)	29,295	14.5
Organic (swamp forest)	40 626	20.1
Pocket Beach	255	0.1
Sediment bank (high, 5 - 20 ft)	91	0.0
Sediment bank (low, 0 - 5 ft)	2,720	1.3
Veqetated bank (high, 5 - 20 ft)	18,237	9.0
Veqetated bank (low, 0 - 5 ft)	56,088	27.7
Total	**202,192**	**100.0**

Source: Jones & Tidwell (2012).

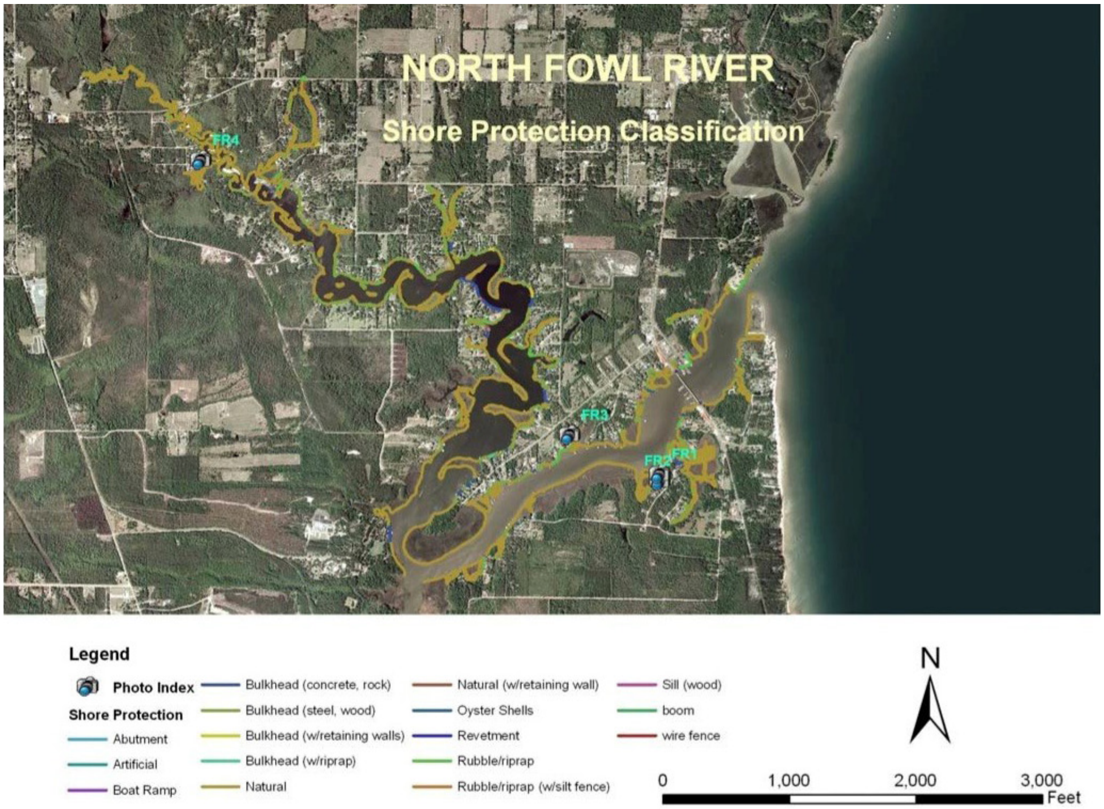

Figure 4.31: Shore protection classification map and legend of Fowl River
Source: Jones & Tidwell, 2012

TABLE 4.7: NORTH FOWL RIVER SHORE PROTECTION CLASSIFICATION LENGTHS BY TYPE

Shoreline protection classification	Length (ft)	Percent
Abutment	203	0.1
Artificial	118	0.1
Boat Ramp	830	0.4
Boom	33	0.0
Bulkhead (concrete, rock)	4,534	2.2
Bulkhead (steel, wood)	40,491	20.0
Bulkhead (w/ retaining walls)	886	0.4
Bulkhead (w/riprap)	232	0.1
Natural, unretained	147,326	72.8
Natural, unretained (w/ retaining wall)	171	0.1
Oyster Shells	375	0.2
Revetment	280	0.1
Rubble/riprap	6,163	3.0
Rubble/riprap (w/ silt fence)	67	0.0
Sill (wood)	384	0.2
Wire fence	170	0.1
Total	**202,263**	**100.0**

Source: Jones & Tidwell, 2012

Reach Assessments

Considering the river, shoreline, and channel characteristics along Fowl River, as well as the types of vegetation found there, the Fowl River coastal zone can be divided into two distinct zones, with an ill-defined transition zone in between. These zones are identified in **Figure 4.32**.

The lower 40 percent of Fowl River below Fowl River Road can best be described as the marine zone (Zone I). This portion of the River is characterized by coastal marshes and areas of low topographic relief. The tributary has low sinuosity; a well-defined and relatively-wide channel; and established saltwater marshes and fringe marshes consisting mainly of smooth cord grass and saltwater rushes, with some pine savannah at higher elevations. Representative photos of this portion of Fowl River are shown in **Figure 4.33**.

Erosion and degradation of shorelines, islands, and marshes in the marine zone are due to wave action, high flow events, sea level rise, and salinity fluctuations.

Shorelines and banks in Zone I are characterized by gradual topographic relief. There was no strong evidence that shorelines, islands, or marshes were accretional in Zone 1. In fact, there was more evidence that these features were recessional and erosional, as witnessed by marsh scarps, dead or dying trees along the waterline, and near-vertical bank cuts and scarps. As stated previously, many of the marshes in this area of Fowl River have low plant density throughout their interior. The erosion and degradation of shorelines and marshes in this zone are likely due to wave action, high flow events, long-term sea level rise, and fluctuations in the salinity regime.

The upper 40 percent of the Fowl River coastal zone (near Fowl River Road) can best be described as the fresh, or terrestrial, zone (Zone III). Here we are limiting the discussion to only the portion of the tributary that has a substantial width, a defined channel, and little overhead canopy. This upper portion of the River is characterized by woody uplands. The tributary has high sinuosity; point bars (spits); a poorly-defined and narrow channel; low and high vegetated banks of moderate to high steepness; and vegetative communities dominated by freshwater rushes, pine and cypress trees, and other hardwoods indicative of upland areas. In many places there are dead or dying trees leaning out over the tributary, which is generally a sign of slope failure along steep banks. Representative photos of this portion of Fowl River are shown in **Figure 4.34**.

Approximately 20 percent of the Fowl River coastal zone, found near the middle reaches of the River, has some overlap with the marine and fresh zones adjacent to it and is best described as a transition zone between the two. This portion of the tributary has moderate sinuosity; some point bars; fringe marshes; a defined channel of moderate width; and supports both fresh and saltwater vegetation including smooth cord grass, rushes, pine, and cypress. Representative photos of this portion of Fowl River are shown in **Figure 4.35**.

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The transition zone exhibits a high degree of plant variation, possibly caused by changes in salinity regulated by tides, sea levels, and watershed contributions. According to one community stakeholder, salinity in the middle and upper portions of (East) Fowl River increased after West Fowl River was dredged, providing a conduit to Mississippi Sound (personal communication from Sam St. John). Previous attempts at marsh restoration in this transition zone have experienced varying levels of success with some transplanted saltwater rushes surviving while other species did not (personal communication from Sam St. John). Almost all of the marshes in this transition zone are fragmented and have a low density of plants throughout the marsh's interior. It is unknown whether salinity, erosion, or long-term sea level rise (or a combination of the three) are the controlling factors in this transition zone. Previous work in this area documented eight to 10 inches of soil loss based on existing clumps of marsh and old tree stumps and/or root crown locations (personal communication from Sam St. John).

Marshes in the transition zone are fragmented and have a low density of plants throughout the interior.

Figure 4.32: Representation of the marine, transition, and fresh zones along Fowl River

Figure 4.33: Representative photos from the marine area (Zone I) of Fowl River. The photos show established coastal marsh with dead or dying trees near the marsh edge.

Figure 4.34: Representative photos from the fresh area (Zone III) of Fowl River. The photos show vegetated high banks (left) and deteriorating islands (right) that were once point bars or spits.

Figure 4.35: Representative photos from the transition area (Zone II) of Fowl River. The photos show eroding steep banks (left) and a deteriorating marsh with dead or dying cypress trees (right).

Critical Coastal and Fluvial Processes

A combination of fluvial and coastal processes is responsible for much of the morphologic change along Fowl River, with some exacerbation by human interaction and use. The critical processes include 1) watershed contributions, 2) waves, and 3) long-term sea level rise. These critical processes were identified based on historical imagery, an evaluation of existing conditions, and knowledge of how fluvial systems respond to changes in flow and sediment loading and how coastal systems respond to waves and water levels.

Critical processes include flow volume and intensity, wave action, and sea level rise.

Flow Volume and Intensity

Changes in watershed hydrology and function can often be discerned from stream gage records having relatively comprehensive spatial and temporal resolution. Unfortunately, there is only one established gage on Fowl River (USGS 02471078) and its record length is relatively short at just under 20 years. Statistically significant changes in streamflow magnitude cannot be determined from this record, nor can the flood frequency. However, some useful information about the nature of the system can be surmised from the streamflow data.

The constriction of floodplains and increase in impervious area increase peak flow while decreasing event duration, leading to higher intensity events.

The approximate long-term average annual peak streamflow at the USGS Fowl River gage is about 1,000 cfs, but some years show values that are four to seven times the long-term average. The annual peak streamflow magnitudes for Fowl River are shown in **Figure 4.36**. Daily discharge data and the median daily discharge statistics for Fowl River are shown in **Figure 4.37**. The 18-year median daily discharge magnitude is approximately 20 to 30 cfs, which is likely the stream's baseflow condition. There are numerous discharge events in the record that are a full order of magnitude larger (~300 cfs), and even some that are two full orders of magnitude larger (~3,000 cfs).

Such an example is shown in **Figure 4.38** using data from the USGS Fowl River gage for the months of April and May 2014. Note the rapid increase in streamflow (from 30 cfs to 4000 cfs) during the period April 28 – 30, 2014. This increase in streamflow occurred over the period of a few hours during a +20-inch rainfall event.

The morphologic changes along Fowl River are indicative of fluvial systems characterized by moderate sinuosity and a mixed load channel (see **Figure 4.39**). The upper two-thirds of Fowl River (Zones II and III) are defined by a relatively narrow channel, point bars, and isolated islands that were disconnected from adjacent point bars along the channel. **Figure 4.40** provides a definition diagram of a typical channel and point bar system.

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Fowl River has responded to changes in flow volume and intensity (watershed contributions), as well as changes in sediment loading (volume and sediment characteristics), by modifying the point bars (spits) and attempting to straighten the flow channel. This is particularly true of high flow events in the upper two-thirds of Fowl River. What we currently see as isolated islands in the waterway are portions of old relic point bar systems (or spits) that were detached through successive breaching and widening of the point bars during high flow events.

Fowl River is constantly trying to straighten the flow path by breaching point bars (spits) and deepening the flow channel.

During high flow and high water events, point bars are breached at their ends through a combination of overtopping and erosion exacerbated by accelerated flows. Once the initial or subsequent breaches support consistent water flow, they will expand through deepening and widening to establish a new, and more hydraulically-efficient, breach channel that bypasses the channel bend around the point bar. When portions of the point bar are detached from their ends, they persist as small islands in the waterway for some time. In some cases, the channel bends can become isolated from the newly formed breach channels through sediment transport along the banks. When this happens, the isolated channel bend forms what is called an oxbow lake. There are a few of these in the upper portions of Fowl River. A schematic showing the time progression of these processes is provided in **Figure 4.41.**

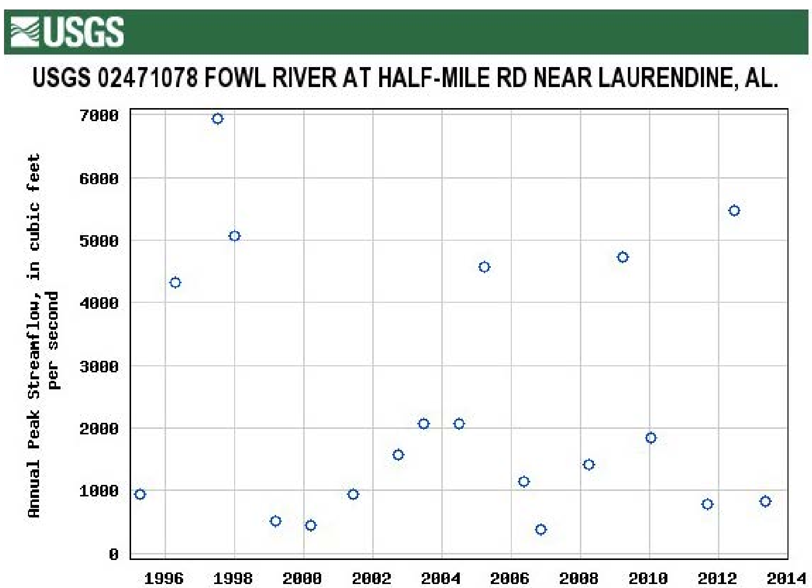


Figure 4.36: Record of annual peak streamflow (cfs) on Fowl River for the period 1995 to 2015

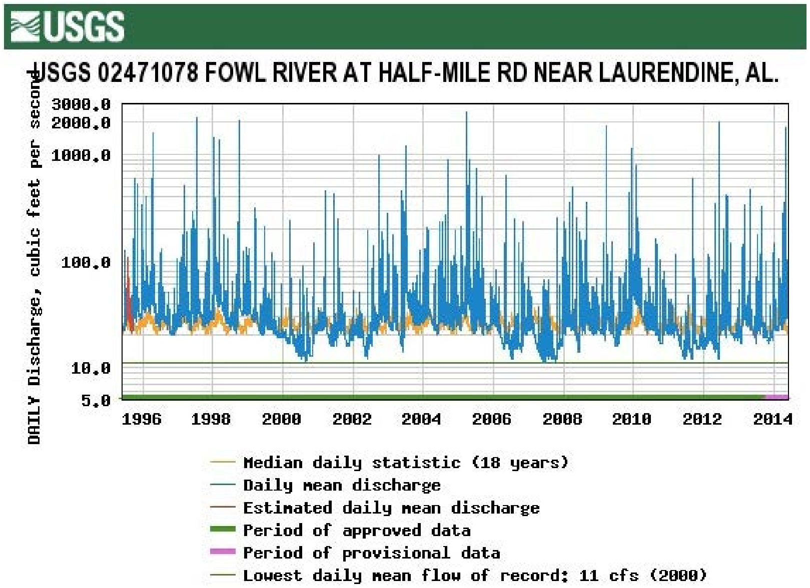


Figure 4.37: Record of daily discharge (cfs) on Fowl River for the period 1995 to 2015

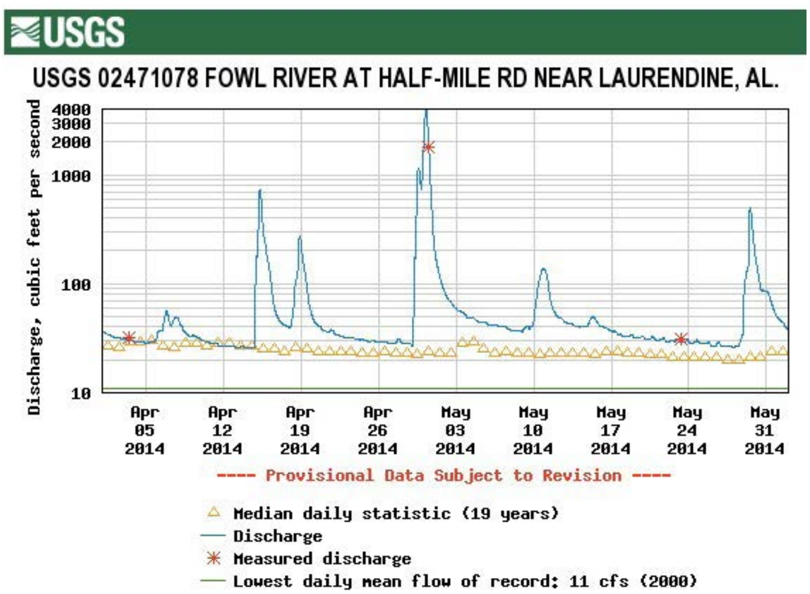


Figure 4.38: Streamflow behavior on Fowl River during successive high intensity rainfall events in April 2014

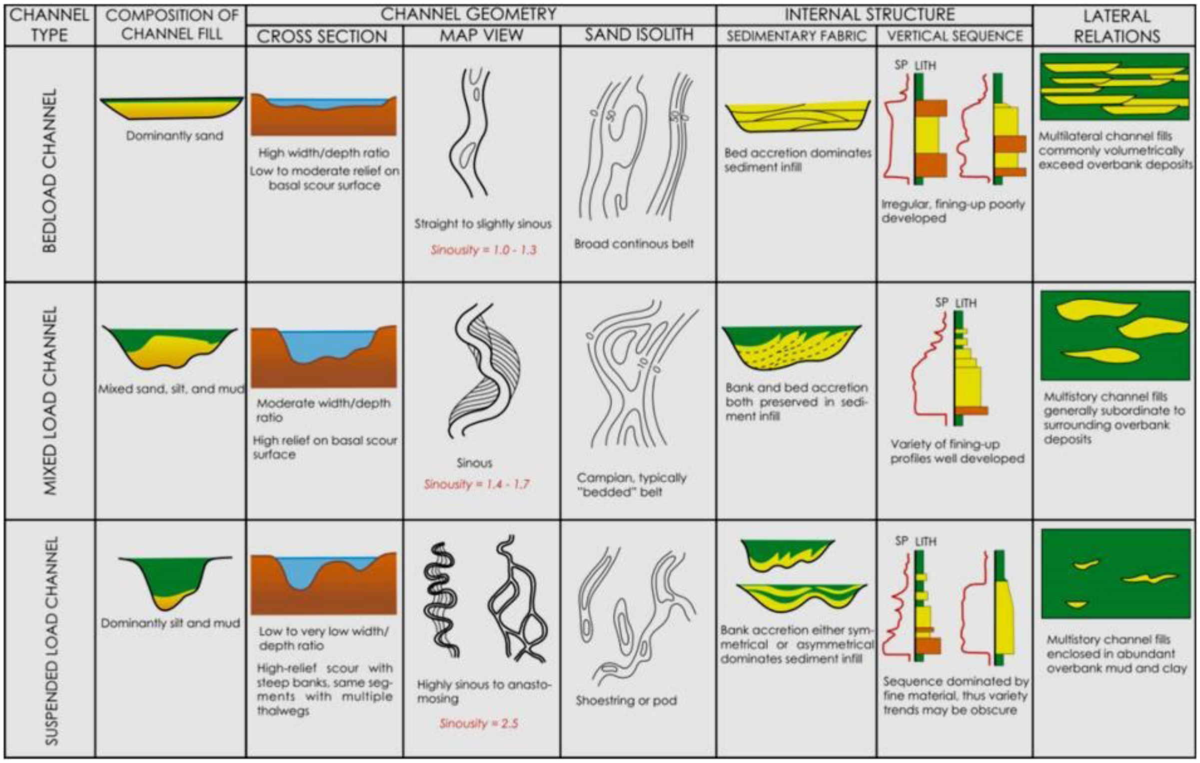


Figure 4.39: Classification of fluvial systems based on the fluvial-geomorphological classification of Schumm (1963), given in the left column (based on Galloway, 1981).

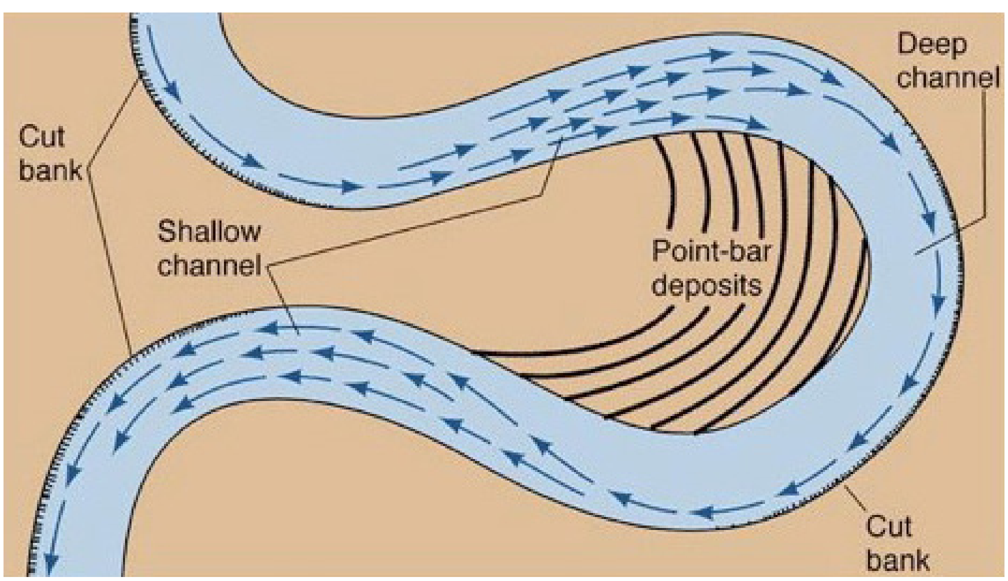


Figure 4.40: Point bar and channel diagram of a fluvial system. Source: http://www.geol.umd.edu/~jmerck/

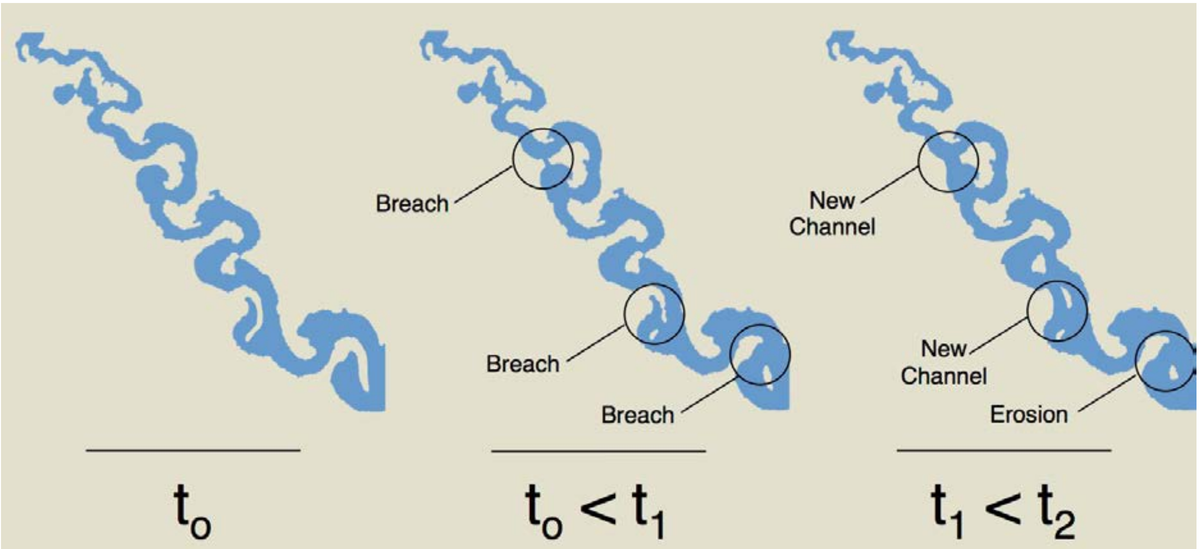


Figure 4.41: Progression of possible morphologic change along Fowl River at three time intervals. The middle and right diagrams show the initiation of breaching and the subsequent widening of channels, respectively, that attempt to straighten the waterway.

Wave Action

There are two forms of wave action contributing to the erosion of shorelines, marshes, and islands along Fowl River: wind generated waves and boat wakes. Wind waves in sheltered water bodies, like Fowl River, are limited by fetch, depth, and wind speed.

Boat wakes and wind waves each contribute to the erosion of shorelines, marshes, and islands along Fowl River.

Fetch is the unobstructed length of a water body over which wind can blow to generate waves. Typically, an average depth along the fetch is assumed when estimating wind-generated wave heights and periods in what are called "fetch limited" conditions. Since Fowl River is somewhat sinuous, the fetch distances are relatively minor and, therefore, will limit the growth of wind waves as opposed to the duration of the wind event being a limiting factor (which is more the case in the open ocean).

The estimated wind wave heights and periods in Fowl River range from 0.2 feet to 0.5 feet and 0.7 seconds to 1.4 seconds, respectively. Fetch lengths were determined in each of the three reaches, or zones, of Fowl River, with the marine zone having the longest fetches, the fresh zone having the shortest, and the transition zone having intermediate fetch lengths. For the purpose of estimating wind wave heights and periods, an average depth of 6 feet was assumed for all fetches, along with a typical wind speed of 20 mph. The estimated wave characteristics in each zone are provided in **Table 4.8**.

TABLE4.8: ESTIMATED WIND WAVE CHARACTERISTICS BY ZONE FOR AN ASSUMED DEPTH OF 6 FT AND WIND SPEED OF 20 MPH

Zone	Fetch	Wave Height	Wave Period
Zone I (marine)	0.5 mi < F < 1.0 mi	0.4 ft < H < 0.5 ft	1.1 s < T < 1.4 s
Zone II (transition)	0.3 mi < F < 0.5 mi	0.3 ft < H < 0.4 ft	1.0 s < T < 1.1 s
Zone III (fresh)	0.1 mi < F < 0.3 mi	0.2 ft < H < 0.3 ft	0.7 s < T < 1.0 s

Wind waves are certainly a contributing factor, but are not likely the most damaging wave action along Fowl River. Although they occur less frequently than wind waves, boat wakes are more likely to be the damaging wave action along much of Fowl River. While in motion, vessels generate two different types of waves: divergent waves and transverse waves. A diagram of these wave patterns is provided in **Figure 4.42.**

While some studies on ship wakes have been conducted, there is generally no accepted standard for expressing boat wake characteristics as a function of vessel type, nor is there an accepted model for predicting them. Some examples of collected data and empirical model predictions are shown in **Figure 4.43.** A review of boat wake literature (e.g., Johnson, 1968; Glamore, undated; Sorensen, 1997; etc.) suggests a practical range of maximum boat wake heights is on the order of 0.2 feet < H < 2 feet, with periods ranging from 1 second < T < 1.8 seconds. These wave heights are on the order of two to four times larger than the wind wave heights described in **Table 4.8.**

Because of their potential size, boat wakes are likely the most damaging form of wave action along Fowl River.

Wave action along Fowl River is exacerbated by vertical armoring, which reflects wave energy instead of absorbing it.

Boat wake height is dependent upon, in order of importance: vessel speed, vessel draft, and water depth. Vessel speed is generally the single most important factor in determining the height and period of ship-generated waves. As such, regulating vessel speed or recreational activities can greatly reduce boat wake heights along the river channel.

Numerous community stakeholders expressed concern about the degree to which the River is used for recreational activities like fishing, water skiing, wakeboarding, and other similar watersports. With only two access points along East Fowl River (Pelican Landing and Memories), neither of which is a public boat launch, it is likely that boaters travel much of the length of Fowl River to reach their destination or recreational areas. Much of the River's channel is not speed controlled either. There are no-wake zones near the Fowl River Bridge and along a section of Fowl River just south of Fowl River Road.

Finally, boat wakes and subsequent wave action along Fowl River may be exacerbated by the most common type of shoreline armoring: vertical bulkheads. Vertical walls act as very efficient reflectors of wave energy, redirecting wave energy to other areas and increasing sediment erosion and scour at the base of the wall. Approximately 20 percent of the Fowl River shoreline is armored with vertical bulkheads.

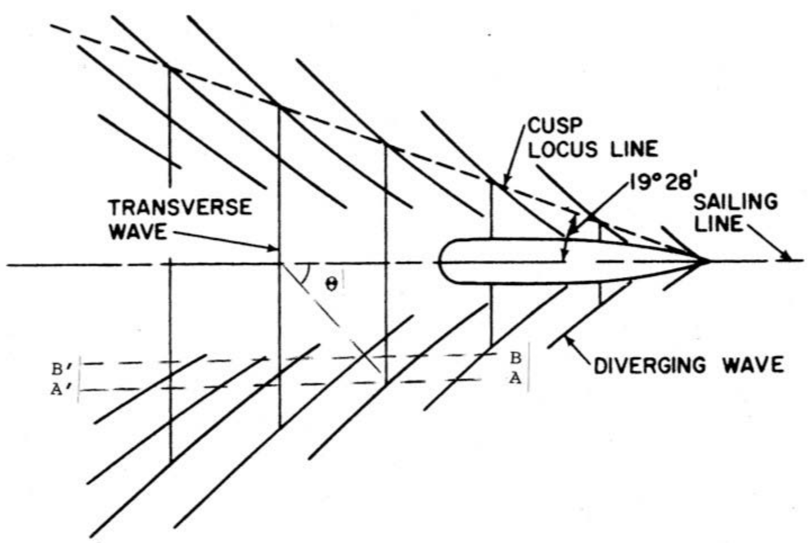


Figure 4.42: Diagram of divergent boat wake pattern. Source: Sorensen, 1997

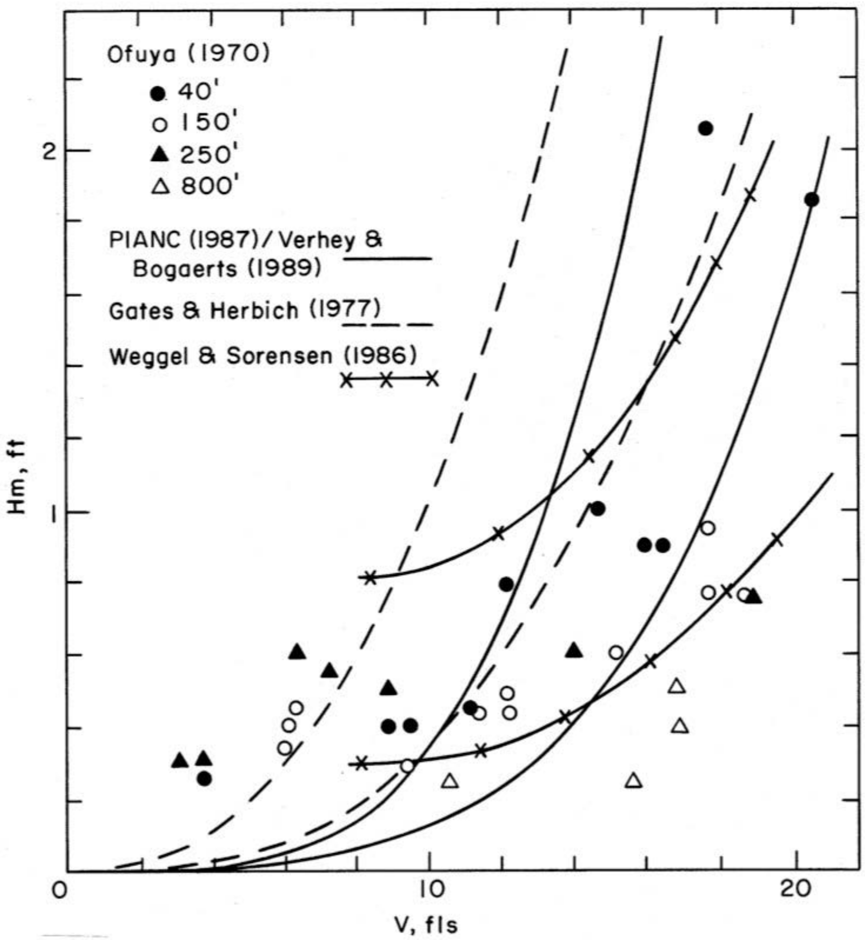


Figure 4.43: Boat wake (maximum) height as a function of boat velocity (Sorensen, 1997). Symbols denote data and the solid and dashed lines represent empirical models fit to the corresponding data sets.

Sea Level Rise

The fundamental control on all shoreline positions, over geologic timescales, is sea level. Sea level rise is certainly one important factor that has affected the shorelines, marshes, tides, and salinity of Fowl River. An evaluation of the effects of sea level rise on coastal environments was made by ESA, Inc., utilizing the Sea Level Affecting Marshes Model (SLAMM) (see **Appendix B**). Regardless of future changes in the rate of sea level rise, it is worth noting that sea level rise will continue to impact Fowl River for many years beyond the timeframe for which this report is appropriate. As such, opportunities for adaptive management of shorelines and marshes should be considered in all watershed projects and planning.

Like all other areas along the Gulf Coast, coastal Alabama is experiencing a combination of positive (upward) eustatic sea level rise and negative (downward) vertical land movement (VLM). Eustatic sea level rise is the change in sea level position with the effects of land removed and has an accepted average rate of approximately +2 mm/yr (~0.08 in/yr). The VLM tendency in much of coastal Alabama is negative indicating subsidence of the land surface. A typical VLM rate for coastal Alabama is approximately -1 mm/yr. The combination of the two rates yields a gross change of 3 mm/yr. This is what is referred to as relative sea level rise (RSLR). RSLR is of more concern than eustatic sea level rise since it accounts for the local subsidence rate.

RSLR rates along the Gulf Coast are determined using both fixed tide gages (with long records) and satellite telemetry. There are numerous fixed tide gages along the Gulf Coast maintained by the NOAA/CO-OPS program and the range of RSLR rates varies from as low as 1.9 mm/yr in some parts of Texas and Florida, to as much as 9.6 mm/yr in Louisiana. The long-term tide gage record at Dauphin Island, Alabama, reveals a local sea level rise rate of 3.2 mm/yr, as shown in **Figure 4.44.** The record indicates that when the gage was installed approximately 50 years ago, the local mean sea level (LMSL) was approximately 0.7 feet lower than it is today (2015).

Tide gage data indicate that 50 years ago, the sea level position in Fowl River was 0.7 feet lower than it is today.

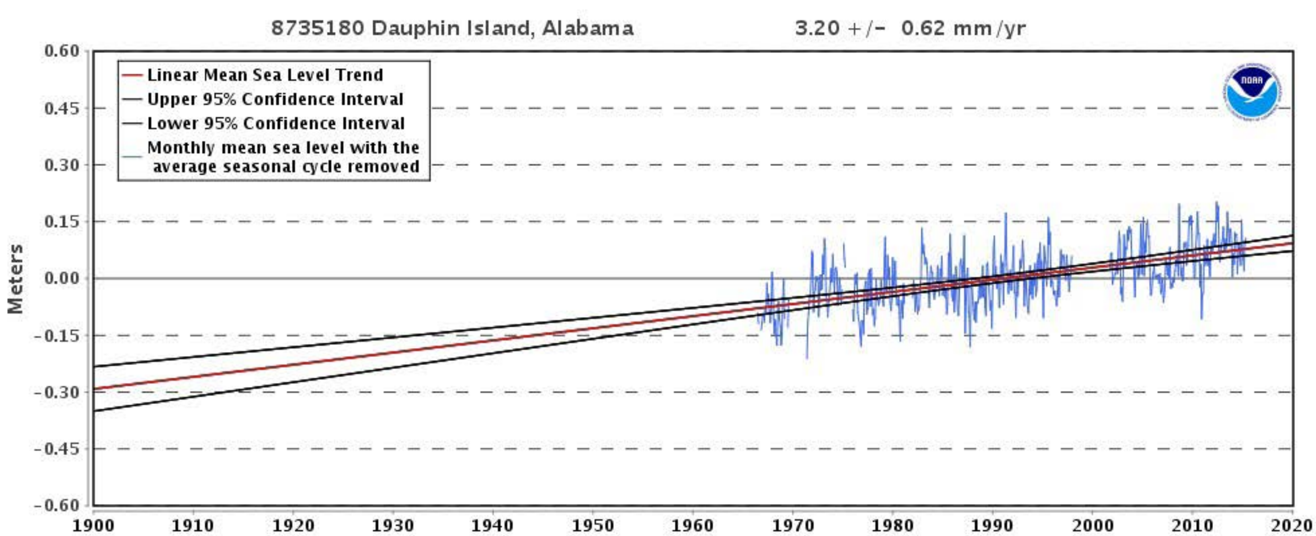


Figure 4.44: Long-term sea level trends at Dauphin Island, Alabama. Image courtesy NOAA.

Future rates of RSLR are widely debated in the scientific literature and depend on both changes in the eustatic RSLR rate governed by temperature as well as changes in local VLM rates. Most recommended RSLR guidance expresses future rates in terms of three scenarios: low, intermediate, and high. The "low" rate is not terribly different than existing rates. The "intermediate" scenario accounts for a modest acceleration in rate. The "high" scenario assumes rapid rate acceleration.

The US Army Corps of Engineers (USACE) provides guidance for incorporating sea level change planning in civil works projects through report EC 1165-2-212. In addition to this guidance, the USACE offers a sea level change curve calculator on a website (http://www.corpsclimate.us/ccaceslcurves.cfm). This calculator allows the user to select different sea level change rate scenarios, planning horizons, and incorporates user-selected tide gage data to account for local VLM rates.

Future sea levels and tidal datums in Fowl River were determined for the period 2015 to 2100 using an intermediate scenario in the USACE calculator. These results are shown in **Figure 4.45.** Two important elevations are denoted on this figure. One is the typical elevation of marshes in Fowl River, which is about +0.5 feet. The other is a typical elevation of high bank areas in Fowl River, or about +1.5 feet. The figure demonstrates the LMSL elevation will exceed the marsh and high bank elevations in 2045 and 2088, respectively. The figure also shows that the mean lower low water (MLLW) tidal datum will intersect the marsh and high bank elevations in 2071 and 2108, respectively. This means that existing marshes will be completely submerged almost all of the time by the year 2071, assuming their elevations do not change over time. Finally, the high bank elevations would be exceeded by the MHHW tidal datum by year 2062.

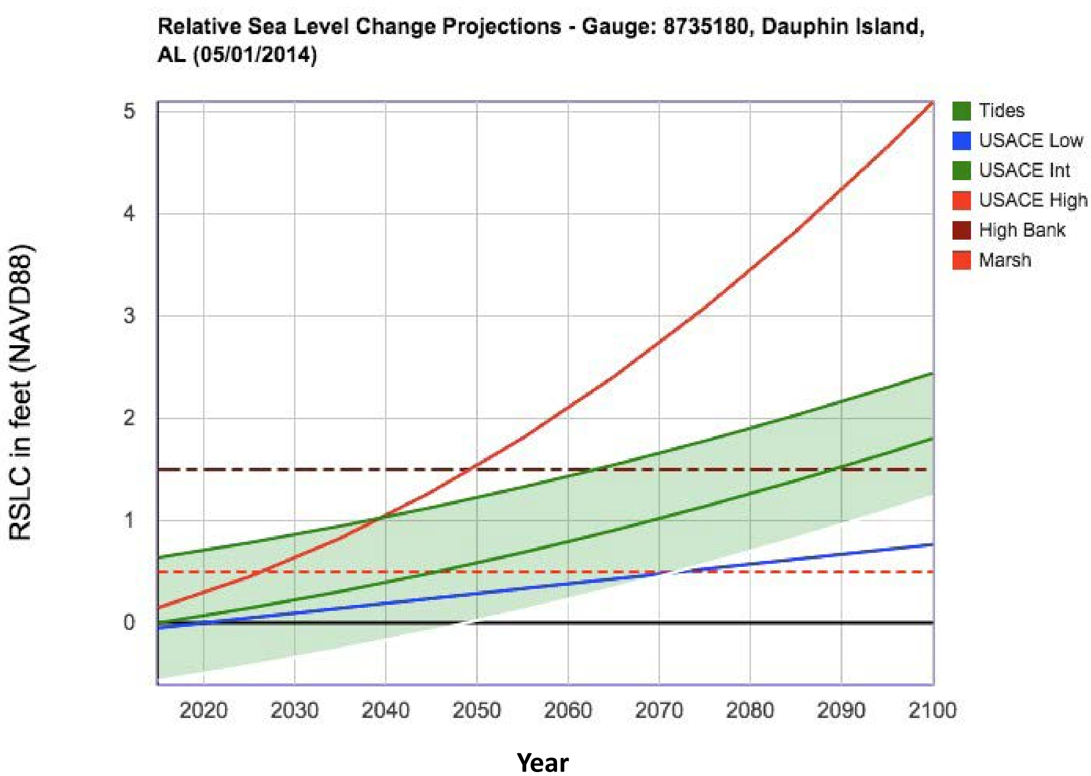


Figure 4.45: Estimated relative sea level rise scenarios in Fowl River for the period 2015 to 2100 using the Dauphin Island tide gage data. The red and maroon horizontal dashed lines indicate typical elevations of marsh and high banks, respectively, in Fowl River

One of the notable impacts of long-term sea level rise in Fowl River will be the conversion of marsh and land to open water and the subsequent loss of those habitats. Such conversions happen gradually over time, with periodic tidal inundation happening first, followed by persistent inundation. Inundation of existing marshes would cause them to drown in place, while inundation of low and high banks would likely lead to erosion and repetitive slope failures.

Fowl River may lose as much as 340 acres of emergent habitat by the year 2100 due to relative sea level rise alone. Associated erosion could make this value much larger.

Estimated ranges of inundated area, or habitat loss, were developed considering three future RSLR scenarios. **Figure 4.46** shows the estimated areas inundated by the year 2050. **Figure 4.47** shows the estimated areas inundated by the year 2100. By the year 2100 the marine zone may experience between 40 to 220 acres of land loss due to RSLR alone, while the transitional and fresh zones may see losses on the order of 10 to 60 acres each. When the losses in each zone are combined, Fowl River may potentially experience 60 to 340 acres of inundated marsh and bank habitat by the year 2100.

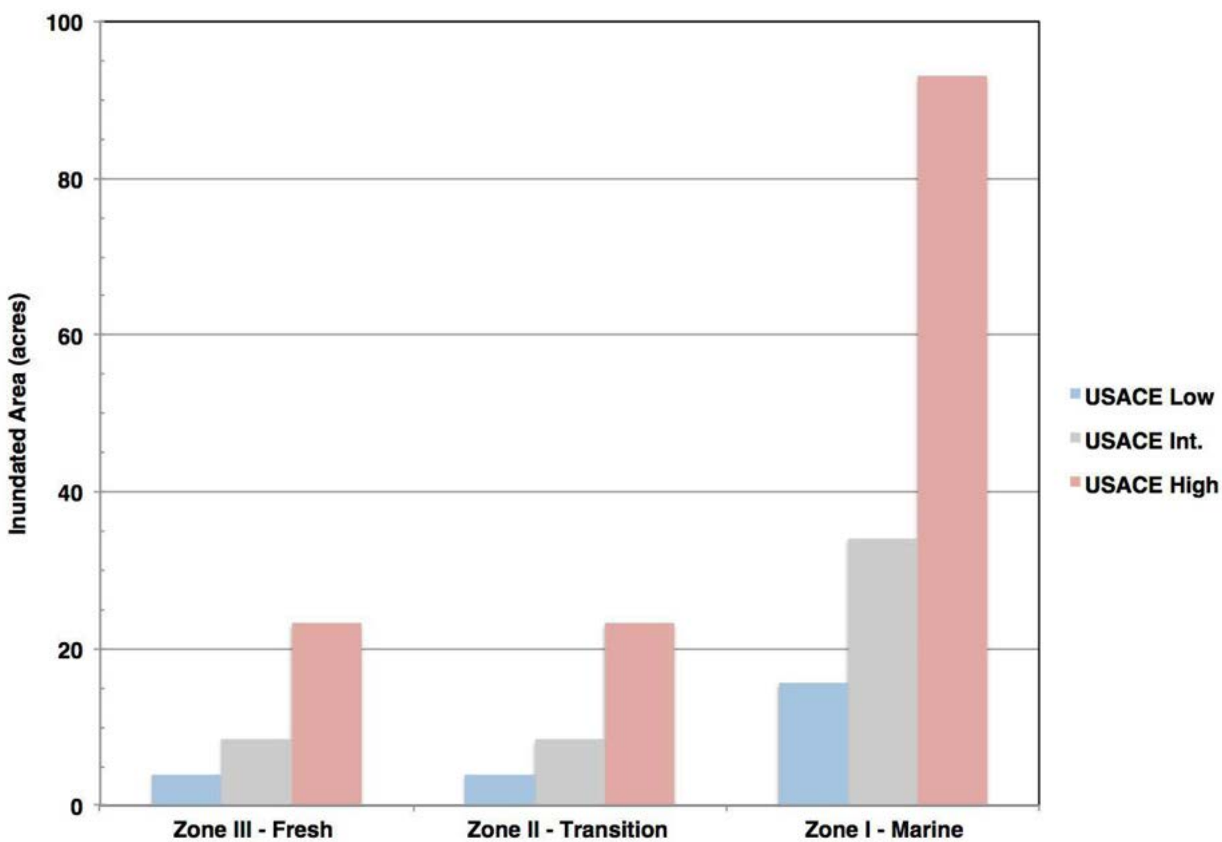


Figure 4.46: Estimated area inundated by RSLR in Fowl River by the year 2050. The USACE low, intermediate, and high RSLR rates for Dauphin Island were used to determine a range of potential land loss in each of the three zones.

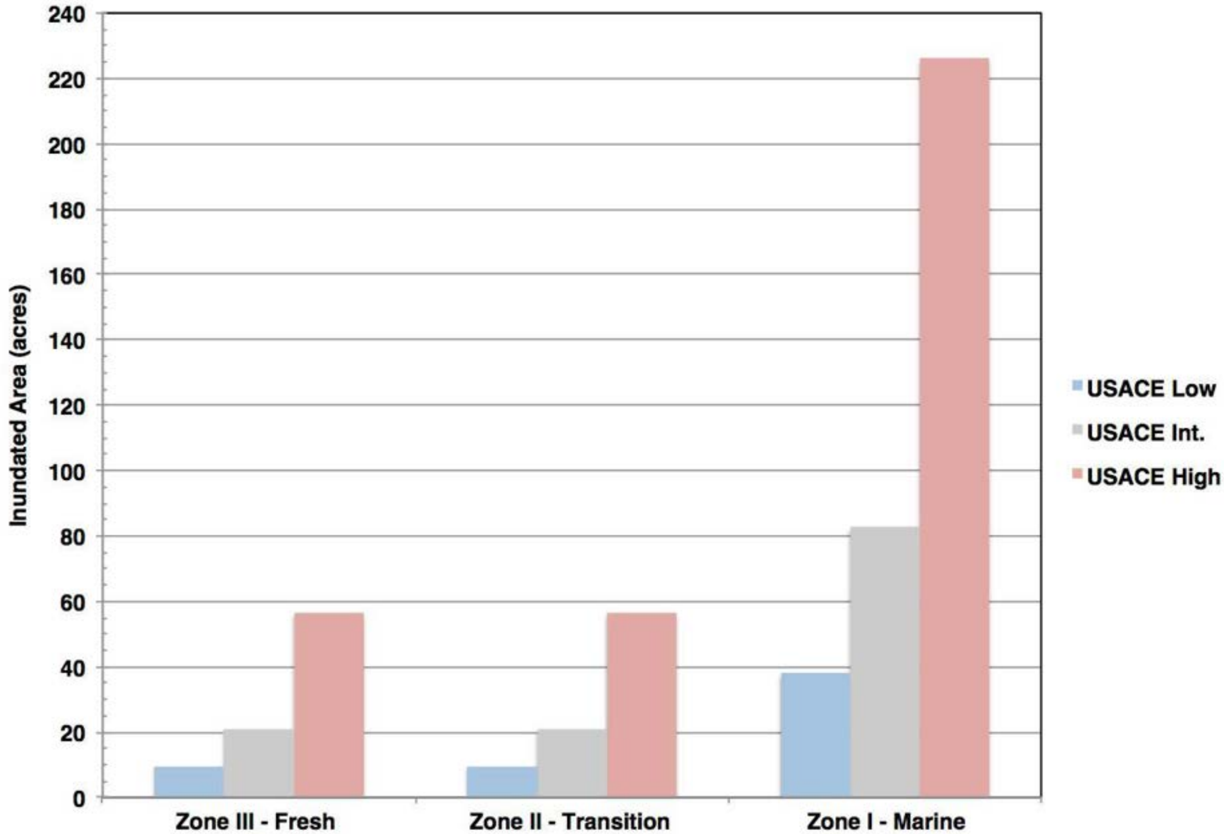


Figure 4.47: Estimated area inundated by RSLR in Fowl River by the year 2100. The USACE low, intermediate, and high RSLR rates for Dauphin Island were used to determine a range of potential land loss in each of the three zones.

4.6.2 Sea Level Affecting Marshes Model (SLAMM)

Tidal marshes are among the most susceptible ecosystems to the effects of accelerated sea level rise, and many coastal resource management agencies have become concerned about the long-term loss of tidal marshes and the ecosystem services they provide. The SLAMM model was developed in the 1990s by a contractor for the EPA (Warren Pinnacle Consulting, Inc.) to assist coastal resource management agencies in quantifying potential tidal marsh losses from sea level rise, and to support planning efforts to offset those losses.

SLAMM simulates the dominant processes involved in wetland conversions and shoreline modifications during long-term sea level rise. A complex decision tree incorporating geometric and qualitative relationships is used to represent transfers among coastal habitat classes. Each site is divided into cells of equal area; each cell has an elevation, slope, and orientation. **Figure 4.48** below conceptually illustrates the SLAMM grid structure.

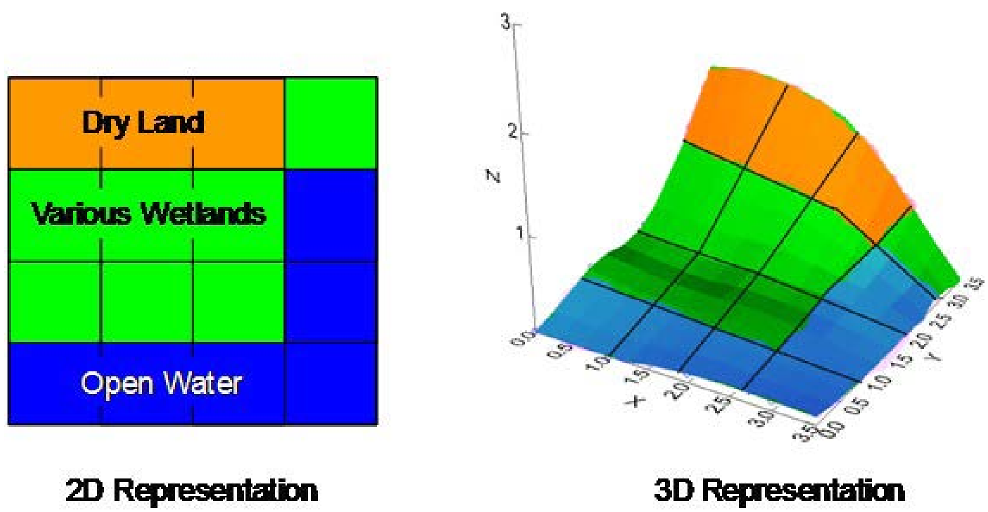


Figure 4.48: Conceptual grid structure of the SLAMM

4.0 WATERSHED CONDITIONS

Relative sea level change is computed for each site for each time step. It is the sum of the historic eustatic trend, the site-specific rate of change of elevation due to subsidence and isostatic adjustments, and the accelerated rise depending on the scenario chosen (Titus et al., 1991; IPCC, 2001). Once the relative sea level change is computed, SLAMM simulates five primary processes that affect tidal marshes under various sea level rise scenarios. These processes are described below.

- **Inundation:** The rise of water levels and the salt boundary are tracked by reducing elevations of each cell as sea levels rise, thus keeping mean tide level (MTL) constant at zero. Spatially variable effects of land subsidence or isostatic rebound are included in these elevation calculations. The effects on each cell are calculated based on the minimum elevation and slope of that cell.
- **Erosion:** Erosion is triggered based on a threshold of maximum fetch and the proximity of the marsh to open estuarine waters. When these conditions are met, horizontal erosion occurs at a rate based on site-specific data.
- **Overwash:** Barrier islands of under 500-meters width are assumed to undergo overwash at a user-specified interval. Beach migration and transport of sediments are calculated.
- **Saturation:** Tidal and freshwater wetlands can migrate onto adjacent uplands as a response to increased saturation of the water table in response to rising sea level.
- **Accretion:** Sea level rise is offset by sedimentation and vertical accretion using average or site-specific values for each wetland habitat category. Accretion rates may be spatially variable within a given model domain.

Successive versions of the model have been used to estimate the impacts of sea level rise on various regions of the U.S. coastline (Titus et al., 1991; Lee et al., 1992; Park et al., 1993; Galbraith et al., 2002; National Wildlife Federation et al., 2006; Glick et al. 2007; Craft et al., 2009). SLAMM version 6.0 is the latest version of the SLAMM model, developed in 2009 and closely based on SLAMM 5. SLAMM 6 is the first open-source version of SLAMM, and this update also provided a number of refinements.

4.0 WATERSHED CONDITIONS

Application of SLAMM to the Fowl River Estuary

A modified version of SLAMM 6 was used to simulate tidal habitat changes in the Fowl River estuary through the year 2100. The full report on the model setup, verification, results, discussion and conclusions are located in **Appendix B.**

The Fowl River SLAMM model integrates three factors into the various model scenarios. These factors and their range of values include:

- **Sea Level Rise** through 2100 (low = 21 inches; high = 29 inches);
- **Accretion Rates** (low = 0.12 inches/year; high = 0.52 inches/year); and
- **Protect Development** (no or yes).

In the model, sea level rise is added to each datum over time. To test the sensitivity of the model to sea level rise, the model was run with predicted low and high rates of sea level rise up to the year 2100 as reported by the International Panel on Climate Change (IPCC, 2013).

The term "accretion" refers to the net land elevation changes resulting from the processes of sedimentation and erosion. Accretion rates are highly locally-specific; therefore, literature values derived from the Fowl River area were used in the development of accretion rates for the model. Smith et al (2013) took sediment cores of marsh sediments in Mobile Bay to estimate sedimentation rates. Near Fowl River, they found sedimentation rates of 0.45 – 0.58 inches/year (11.5 – 14.8 mm/year) for fringing marshes and 0.11 – 0.13 inches/year (2.9 – 3.3 mm/year) for interior marshes. To test sensitivity to sedimentation rates, the model was run with marsh accretion rates of 0.12 inches/year (3.1 mm/year, based off of interior marsh data) and 0.52 inches/year (13.2 mm/year, based off fringing marsh data).

Table 4.9 below presents the four scenarios that were run in SLAMM to test the model sensitivity and to simulate habitat conversions in the Fowl River estuary.

TABLE 4.9: FOWL RIVER SLAMM MODEL SCENARIOS

Run	Sea Level Rise	Accretion Rates	Protect Development
Run 1	Low (21 in)	Low (0.12 in/yr)	No
Run 2	High (29 in)	Low (0.12 in/yr)	No
Run 3	High (29 in)	High (0.52 in/yr)	No
Run 4	High (29 in)	Low (0.12 in/yr)	Yes

4.0 WATERSHED CONDITIONS

Results

The SLAMM model generates tabular and graphical output that quantifies changes in habitat types resulting from the various interacting factors. Habitat change maps and acreage plots were generated for each model run, and are provided in the full SLAMM modeling report (see **Appendix B**). Examples of the model output are shown in **Figures 4.49** and **4.50**.

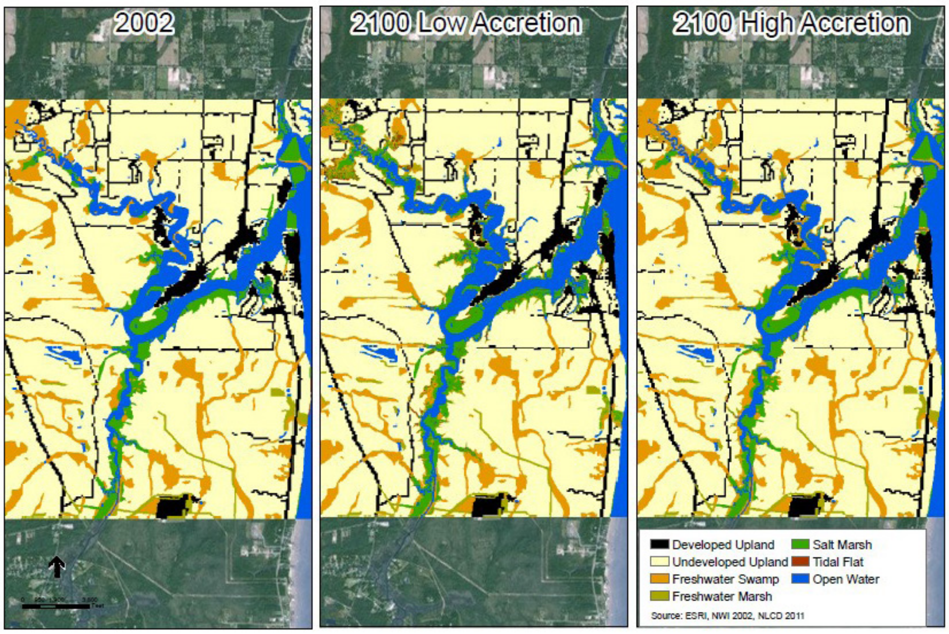


Figure 4.49: Fowl River habitat change map

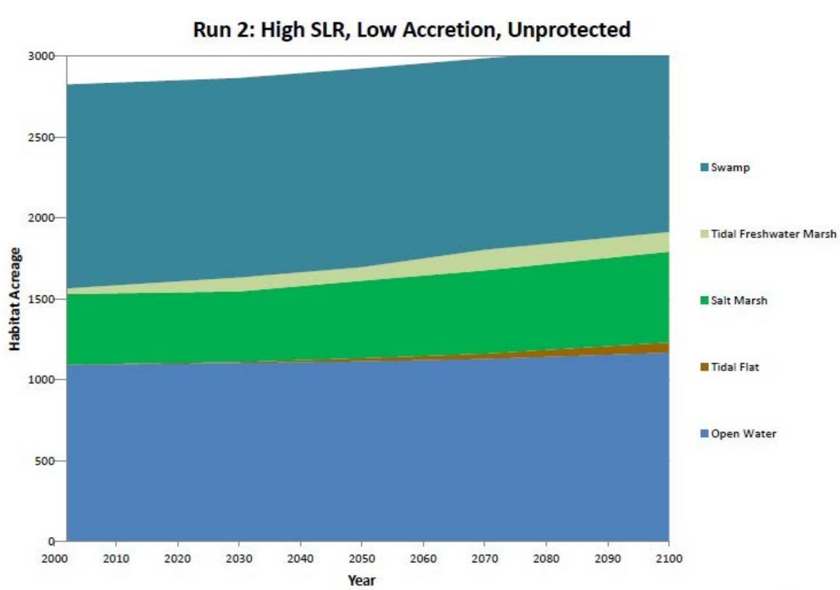


Figure 4.50: Fowl River habitat change plot

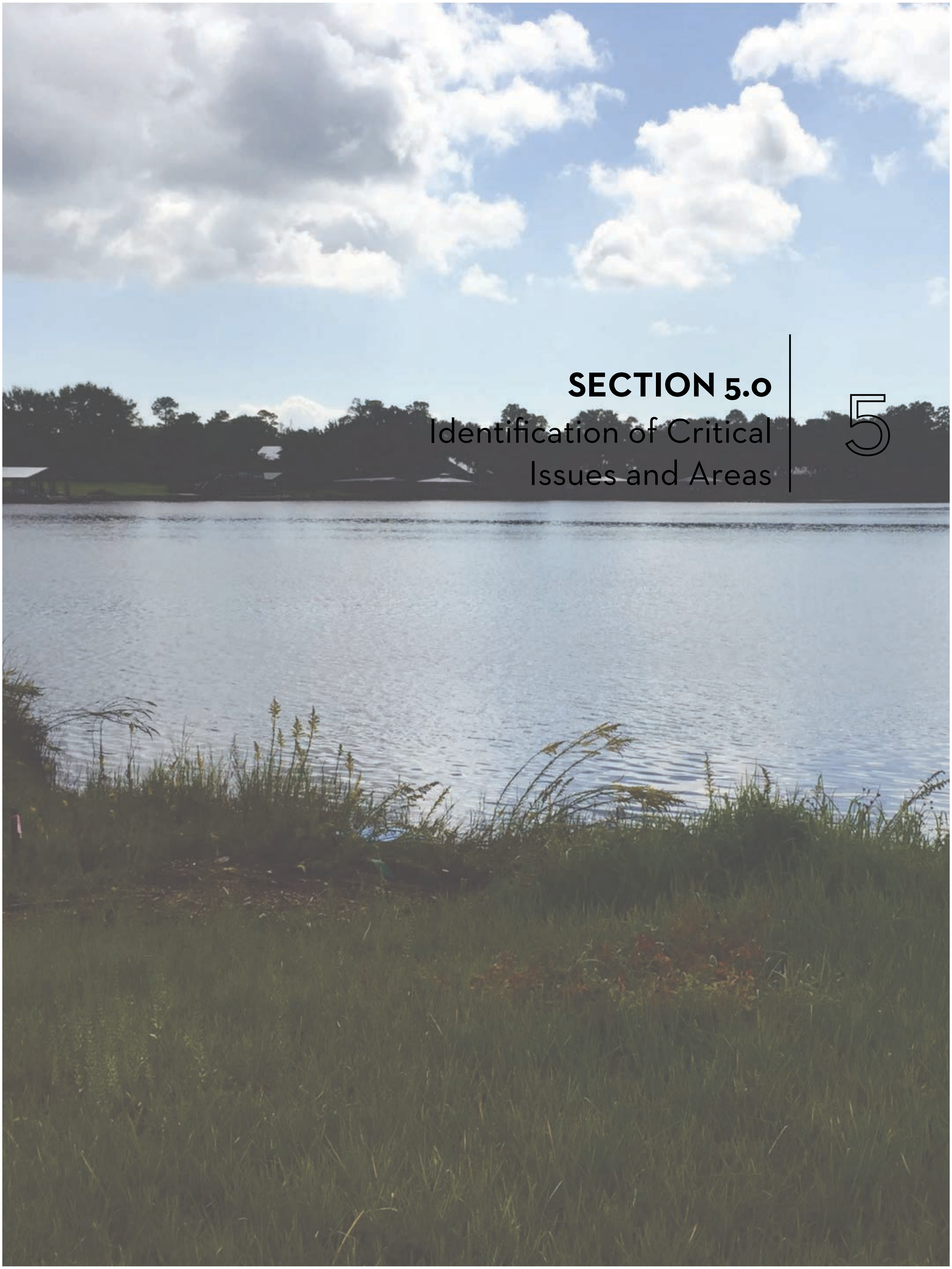
Of the three factors integrated in the Fowl River SLAMM model, these results suggest the model is most sensitive to accretion rates. Over 100 years, the higher accretion rate would result in 52 inches of accretion on the coastal floodplain. By contrast, the high sea level rise estimate only increases water levels by 29 inches, so there is a net elevation gain of 23 inches by 2100. This scenario (high sea level rise + high accretion) results in a substantial gain in freshwater swamp as the floodplain area increases. Conversely, freshwater swamps decrease under the low accretion scenario. Both freshwater and salt marshes increase in total acreage under both the high and low accretion rates; however, they increase substantially more under the low accretion rate. While somewhat counterintuitive, these results indicate that the total acreage of tidal marsh habitat in the Fowl River estuary will better keep pace, and even increase, with sea level rise at low to moderate rates of sedimentation and accretion. It should be noted that the gains in salt marsh acreage occur mostly in freshwater wetland habitats and uplands, and that these gains will be partially offset by losses in existing salt marshes.

The low and high accretion rates provide a bookend of possible future scenarios. Given that the Fowl River SLAMM model was most sensitive to accretion rates compared to other factors, it is recommended that site-specific sedimentation and accretion data be collected in the Fowl River estuary to improve the modeling of habitat conversions resulting from sea level rise within this system.

Conclusions

The Fowl River SLAMM model was used to simulate macro-level habitat conversions in response to sea level rise and related geomorphologic processes. The results of this modeling effort indicate that the total acreage of tidal marsh habitat in the Fowl River estuary will keep pace, and even increase, with projected sea level rise through the year 2100. However, it should be noted that gains in marsh acreage over this time period will take place through the conversion of existing freshwater wetland habitats and uplands, and that these gains will be partially offset by losses in existing salt marshes. The model also indicates that the maintenance and expansion of the overall gross acreage of tidal marsh habitat in the Fowl River estuary would be better supported by lower rates of sedimentation and accretion. At high rates of accretion, sediment deposition in the coastal floodplain will result in net elevation gains that ultimately convert to freshwater swamp, rather than tidal marsh habitat. These findings support recommendations for sediment management in the upper Watershed.

Since the lower Fowl River Watershed is relatively sparsely developed, the modeling results show that tidal marsh habitats have adequate space to migrate into low lying undeveloped upland areas as sea levels rise. With existing development, the “holding-the-line” management scenario only impacts 24 acres of potential tidal marsh habitat. Accordingly, it is recommended that the Fowl River WMP identify large undeveloped tracts in the lower Fowl River Watershed for potential public acquisition, conservation easements, or to ensure adequate land area for the upland migration of tidal marsh habitats with future sea level rise.



SECTION 5.0
Identification of Critical Issues and Areas

5

5.0 IDENTIFICATION OF CRITICAL ISSUES & AREAS

Critical issues and areas affecting the health of the Fowl River Watershed were identified by multiple lines of approach including Steering Committee input, public workshops, field reconnaissance and inspection by the Watershed Management Team, interpretation of historic data, additional data collection, analyses of historic aerial photography and maps, and computer modeling.

5.1 STORMWATER RUNOFF, EROSION, AND HIGH FLOW EVENTS

Stormwater runoff, erosion, and sediment transport within the Watershed were initially identified as priority issues based on public perception and input. However, the investigation completed by the Geological Survey of Alabama (GSA) (see **Appendix A**) indicates that erosion and sediment transport rates within the Watershed as a whole are not greater than the calculated background geologic erosion rate. Nevertheless, runoff carries trash, nutrients, and chemicals into the water. Also, specific areas within the lower Watershed were identified where high flow events are eroding the banks of Fowl River, overtopping spits and islands, and degrading salt marshes (see **Section 4.6**). Runoff carrying chemicals and trash, as shown in **Figures 5.1** and **5.2**, affects the entire Watershed. Because the lower Watershed contains critical habitats that serve as feeding grounds and nurseries for many species, stormwater runoff, erosion, and high flow events are serious issues that must be addressed.

Stormwater runoff is greatest in developed areas with impervious surfaces. Trash, nutrient loading, and chemicals are also delivered from developed areas. Maps of land use and land cover within the Watershed were created utilizing the GIS database of the Watershed (see **Section 3**), which help to identify these critical areas. Urbanized lands with impervious surfaces are also critical areas where the control and mitigation of runoff should be addressed. Sub-watersheds where stormwater best management practices are needed can be prioritized on the basis of the GSA sediment study, and based on developed areas with impervious surfaces. Sub-watersheds 1, 3, 5, and 7 had the greatest sediment loads, and Sub-watersheds, 1, 2, 3, and 4 have the greatest urban land use.

Figure 5.1: Dump site on dirt road in Sub-watershed 2

Figure 5.2: Trash in Muddy Creek in Sub-watershed 3

5.0 IDENTIFICATION OF CRITICAL ISSUES & AREAS

5.2 NUTRIENT LOADING

Data presented in Section 4 and Appendix D, input from the Steering Committee, the results of the GSA investigation (see **Appendix A**), and data collected by the Alabama Department of Environmental Management (ADEM) and the Dauphin Island Sea Lab (DISL) (see **Appendix D**) indicate nitrate and phosphate concentrations in some of the surface waters of the Watershed exceed concentrations that could create excessive algae growth. Excessive algae growth leads to not only unsightly and odiferous conditions, but also, and more importantly, low dissolved oxygen levels in the water, as shown in **Figure 5.3**. Low dissolved oxygen levels can occur naturally, but negatively impact aquatic life when created artificially. This is especially harmful to benthic biota, which are a critical link in the food chain, and to juvenile fish that cannot easily escape low dissolved oxygen conditions.

Figure 5.3: Algae bloom resulting from excessive nitrate and phosphate concentrations in surface waters

According to ADEM (2006), fecal coliform bacteria exceeded the established one-time water use criteria on numerous occasions and in multiple areas throughout the Watershed. The presence of fecal coliform bacteria is an indicator of a potential health risk to people exposed to the water. Data collected by the Watershed Management Team (see **Section 4** and **Appendix D**) indicate that fecal coliform bacteria most likely originate from cattle with access to the River (see **Figure 5.4**), or from wildlife. The nutrients in the cattle manure may create algae blooms and result in low dissolved oxygen conditions. Because of the negative impacts to wildlife and the health risk to humans, nutrient and bacteria loading are critical issues that must be addressed.

Figure 5.4: Cattle with access to Fowl River in the Watershed

Potential source areas of nutrient loading were identified using the Pollutant Loading (PLOAD) computer model, which was run using the BASINS environmental analysis interface developed by the EPA (2013). The detailed results of the PLOAD model are presented in Appendix C. The PLOAD model analyzes existing and future nutrient loading rates on a local scale. Forty-one drainage basins were delineated within the Fowl River Watershed based on topography and hydrography. Mapping the PLOAD model results by drainage basin indicates which areas currently have high pollutant loads, where pollutant loads are low, and where they are predicted to change in the future. This information, combined with results from other data collected during the course of this watershed assessment, can help determine where preservation and restoration activities should occur, and where to prioritize Watershed projects.

5.0 IDENTIFICATION OF CRITICAL ISSUES & AREAS

Figure 5.5 illustrates the current nutrient loading rates, with predicted future loading rates illustrated in **Figure 5.6**. The community of Theodore, located in the Sub-watershed 3, has the highest loading rates. This area is characterized by residential neighborhoods as well as institutional and commercial land uses. The northern portion of the Watershed (Sub-watersheds 1, 2, and 4), as well as areas along Laurendine Road/Half Mile Road (County Road 24) where residential neighborhoods are located, have somewhat high loading rates in the existing condition. The northern portion of the Watershed is predicted to experience new development, which will lead to even higher loading rates in the future condition. Other areas in the northern portion had moderate loading rates in the existing condition and are predicted to experience enough development to create high loading rates in the future condition.

Pollutant loads in existing and future conditions are relatively low in almost all areas south of Laurendine Road/Half Mile Road (County Road 24) and along the main stem of Fowl River south of US Highway 90. In conclusion, the areas with high existing loading rates are generally located north of Laurendine Road/Half Mile Road, while areas with low loading rates are located south of Laurendine Road/ Half Mile Road. This loading pattern is expected to generally continue in the future as most of the development, and subsequently additional loading, is expected to occur in the north or northeast.

Figure 5.5: Existing nitrogen loading rates determined by PLOAD model

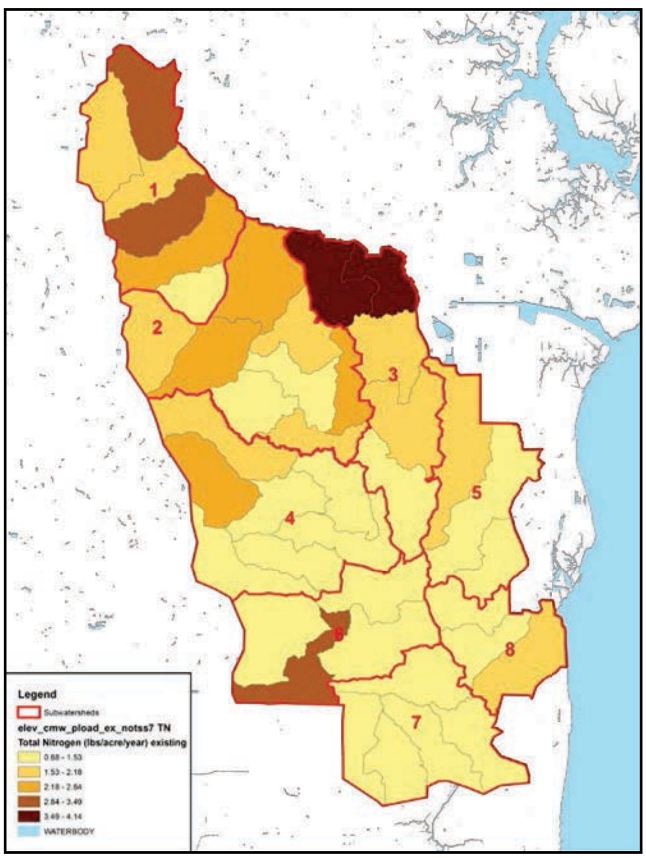
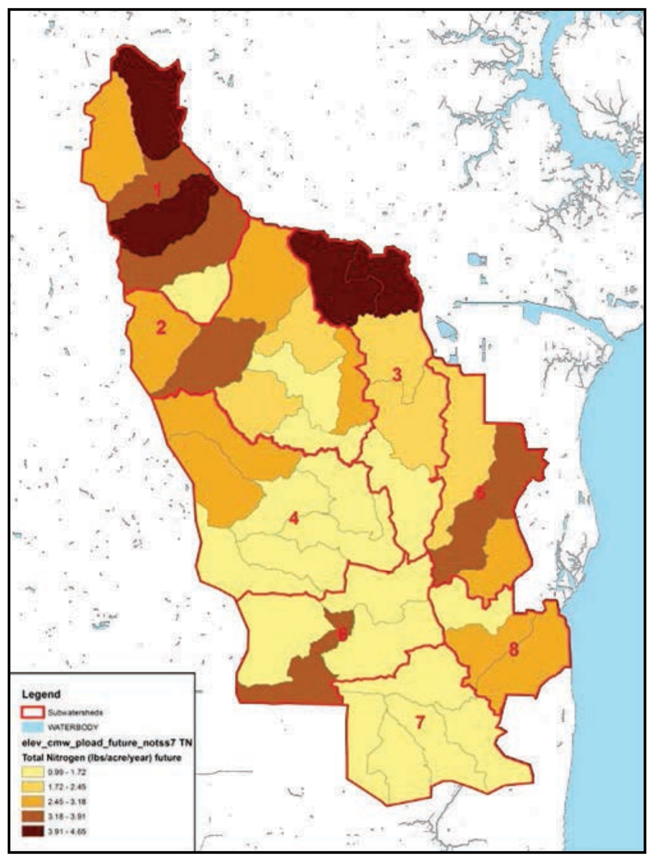


Figure 5.6: Future nitrogen loading rates determined by PLOAD model



5.0 IDENTIFICATION OF CRITICAL ISSUES & AREAS

5.3 HABITAT LOSS

Loss of habitat within the Watershed was identified utilizing historic photographs, maps, land-use coverages, and computer modeling. The greatest loss of historic habitat has occurred as a result of draining wetlands for row cropping, ranching, and development. Additional habitat loss has occurred in the coastal zone of Fowl River (see **Figures 4.2** and **4.32**) as a result of erosion caused by high flow events, boat wakes, and sea level rise. Because of the importance of wetlands, shorelines, and marshes to water quality and as aquatic nursery areas, loss of habitat is a critical issue that must be addressed.

Critical areas of habitat loss were identified based on their relevance to maintaining or improving water quality within the Fowl River Watershed and/or their importance to the many species that live there. An overlay of wetlands and agricultural land use/land cover, shown in **Figure 5.7**, depicts priority wetland preservation areas. Previous wetland areas, now drained and developed for agricultural land use, are identified as critical wetland restoration areas, illustrated in **Figure 5.8**. Additional wetland preservation and restoration areas are delineated based upon PLOAD modeling results and the nutrient loading source areas which they would help to mitigate (see **Figure 5.9**). Critical habitat loss areas in the coastal zone of Fowl River (see **Figures 4.24 - 4.26** and **4.33 - 4.35**) were delineated on the basis of historical photography, flow mechanics, Watershed Management Team reconnaissance and inspection, SLAMM modeling, and importance to the ecosystem (see **Section 4.6** and **Appendix B**).

FIGURE 5.7: EXISTING WETLANDS AND AGRICULTURAL LAND USE/LAND COVER AREAS

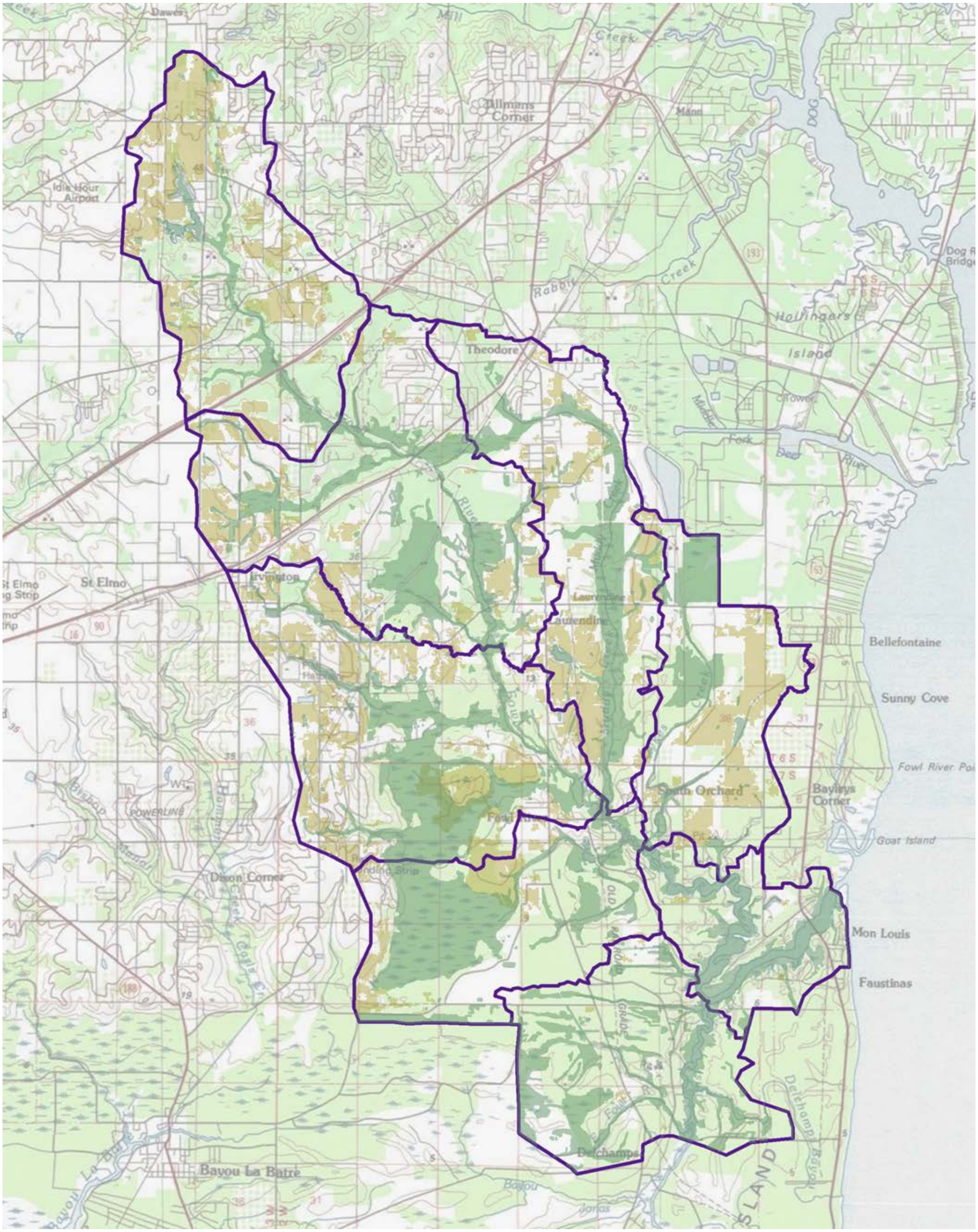


FIGURE 5.8: PREVIOUS WETLANDS NOW DEVELOPED FOR AGRICULTURAL LAND USE

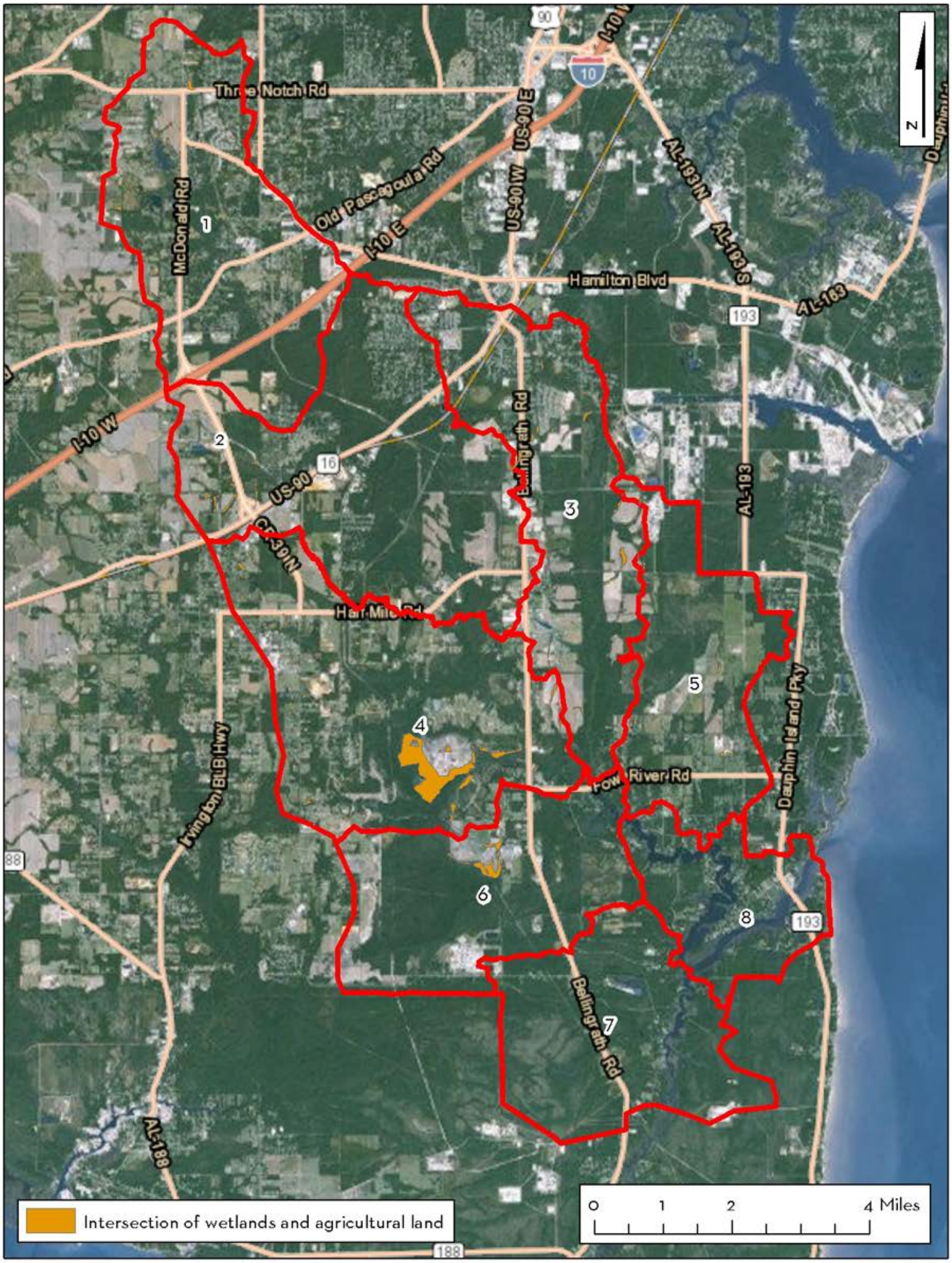
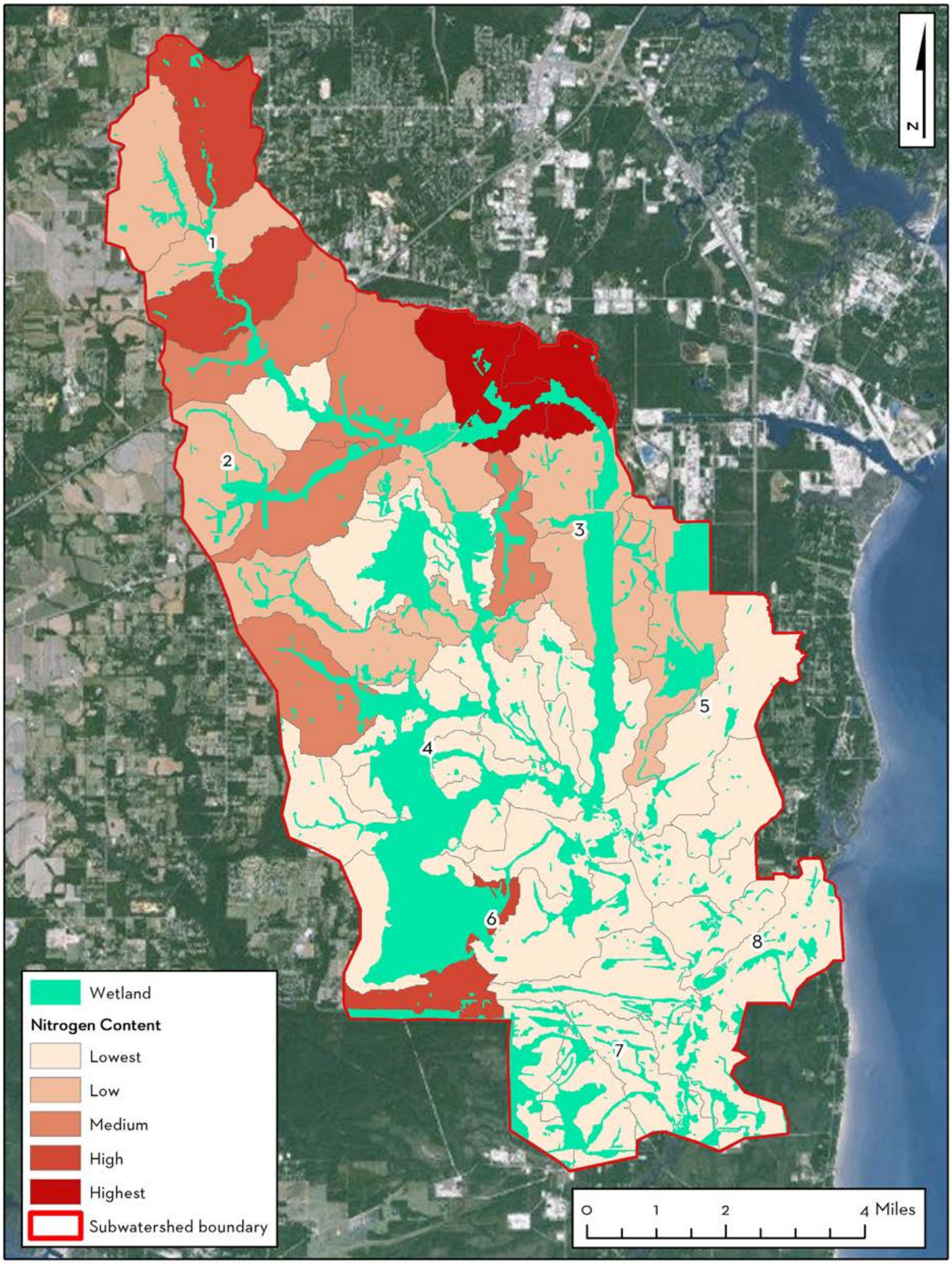


FIGURE 5.9: EXISTING WETLANDS AND PLOAD MODELING RESULTS



SECTION 6.0
Management Measures

6

6.0 MANAGEMENT MEASURES

6.1 COASTAL ZONE PROTECTION STRATEGIES

Eroding shorelines and marshes in the Fowl River Watershed are vulnerable to wave action, high flow events, storm surge, and long-term sea level rise. Although the shorelines themselves are unique, as are the specific combinations of vulnerabilities found there, many can be protected, preserved, enhanced, and/or restored using a range of measures. This concept is demonstrated through a collection of conceptual diagrams shown in **Figures 6.1 - 6.5**. Note that these diagrams are not provided for the purposes of design, permitting, or proposal preparation. These concepts are provided solely for the purpose of demonstration and discussion.

The general, and transferable, approach to shoreline and marsh protection in the Fowl River Watershed is a slightly modified form of the standard rock sill. This approach, used for decades in similar estuarine environments around the United States, is known to be successful, cost-effective, and resilient. The traditional rock sill approach is modified here in two ways. First, the crest of the structure is truncated and left broad to allow placement of additional stone over time to keep pace with future tidal datums in the watershed. This is considered a form of adaptive management that increases the resiliency of the structure and the shoreline or marsh it protects. Second, the rock sill does not necessarily need to be (and probably should not be) continuous. As shown, the proposed gaps allow ingress/egress of juvenile finfish and shellfish on the ebb/flood tide as well as flushing and circulation. The gap placement and width is designed with the local wave climate in mind such that a suitable and stable shoreline or marsh edge is established and maintained by wave action and sea level position over time.

When designed properly, rock structures provide a cost-effective and resilient means of shoreline protection. Proper design requires, at a minimum, specification of proper stone size and gradation, structure geometry including appropriate crest elevation, and consideration of the geotechnical stability of the underlying soils. Varying specifications are common within a specific project, and they are most certainly unique for each individual project.

In addition to being cost-effective and resilient, rock structures provide ancillary benefits. Characterized by high porosity, when rock structures are emergent they provide excellent attenuation and absorption of wave action, including boat wakes. Their porosity also greatly reduces wave reflections that damage adjacent shorelines and lead to a progressive lowering of the bed elevation over time. Also, the composition of the rock structure provides excellent habitat for juvenile finfish and shellfish species. Additionally, rock structures are resilient and tend to “fail gracefully” when their stability is exceeded during storm events.

The proposed concept diagrams in **Figures 6.1 - 6.5** cover a range of possible scenarios, including protection of eroding shorelines along spits, protection and enhancement of eroding marshes, protection and restoration of marshes, and options for preserving healthy marshes. While each potential project requires thorough consideration of the overall goals, site-specific needs, budget, and regulatory constraints, these general concepts represent transferable and repeatable approaches that are easily adapted to meet different needs. For example, the structure geometry and rock size, fill characteristics, and/or marsh plants must be considered for each project and will likely be unique to each design.

6.0 MANAGEMENT MEASURES

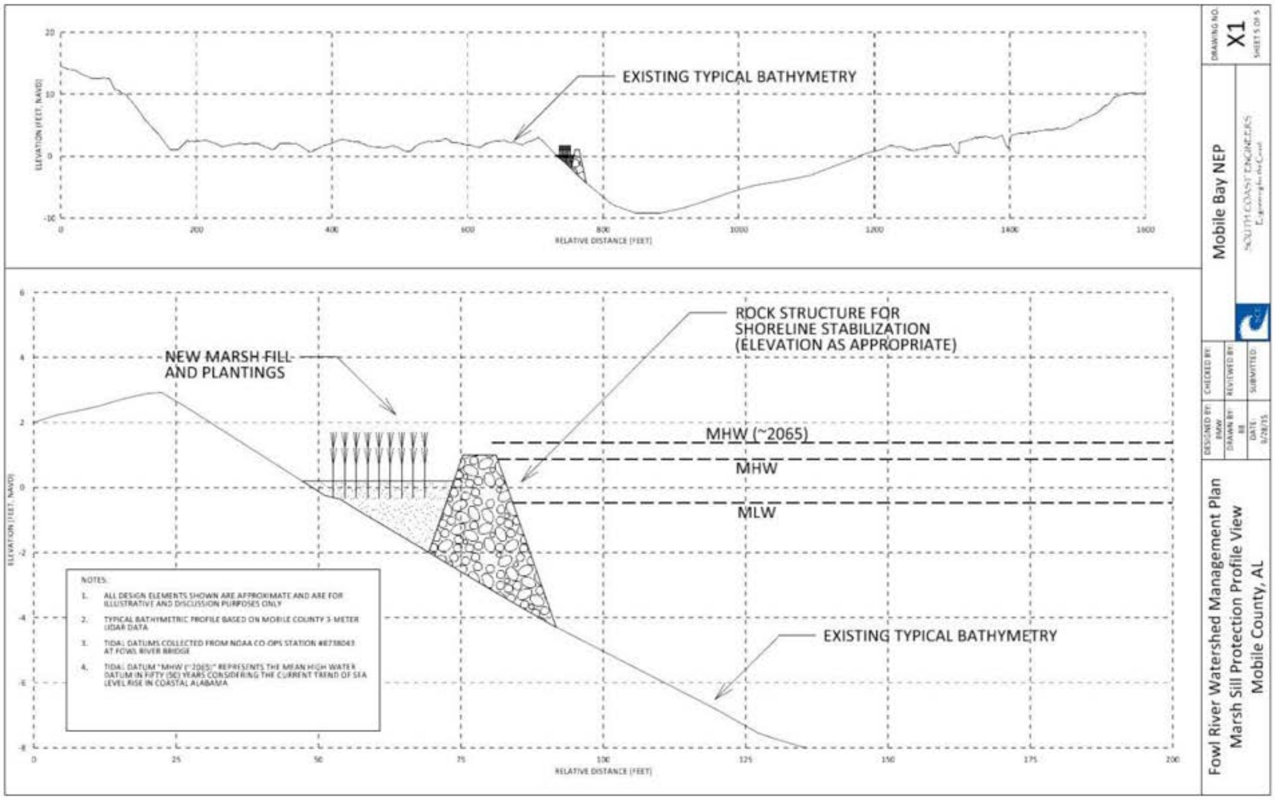


Figure 6.1: Conceptual diagram of a typical rock structure cross-section with addition of fill and plants on the shoreward side. A representative elevation profile is shown for reference, as are existing tidal datums (MLW, MHW) and the projected MHW datum in 50 years (2065) due to historic relative sea level rise.

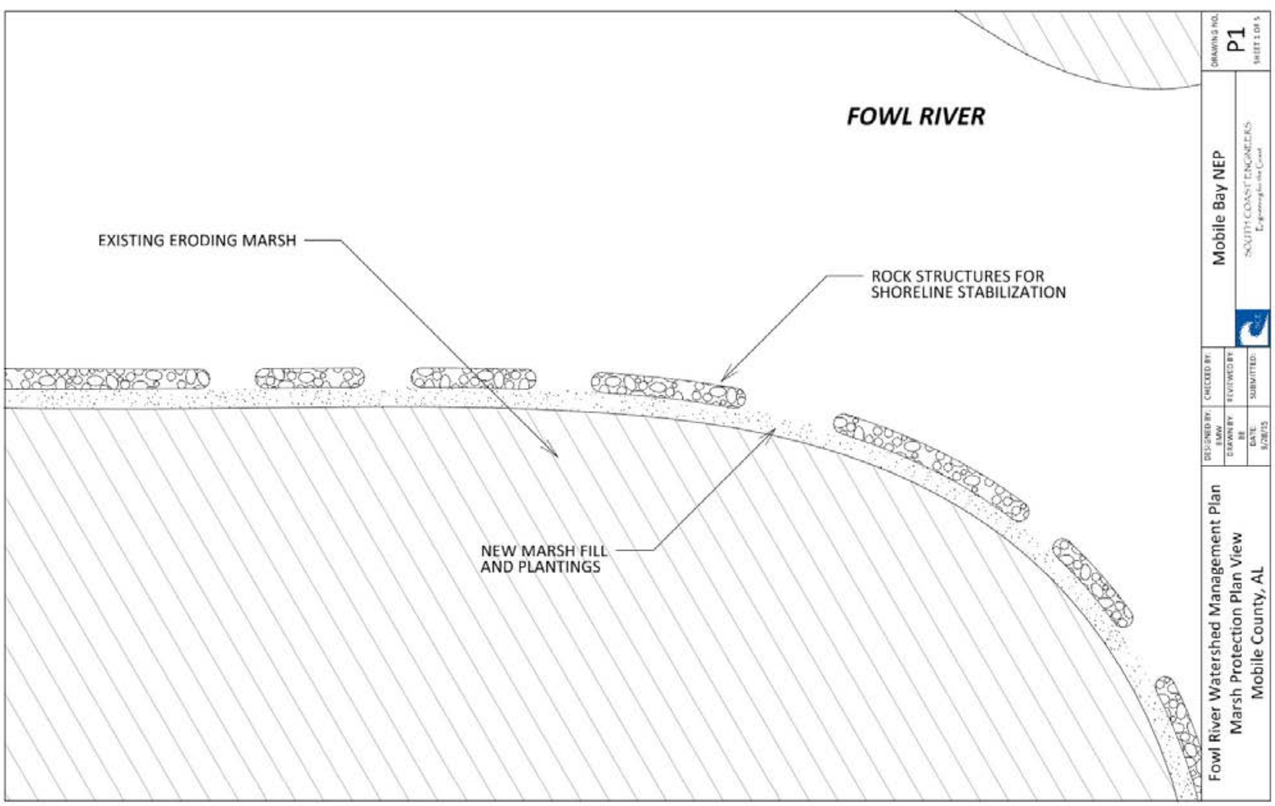


Figure 6.2: Conceptual diagram of marsh shoreline protection showing segmented rock structures, as well as suitable fill and marsh plants where appropriate.

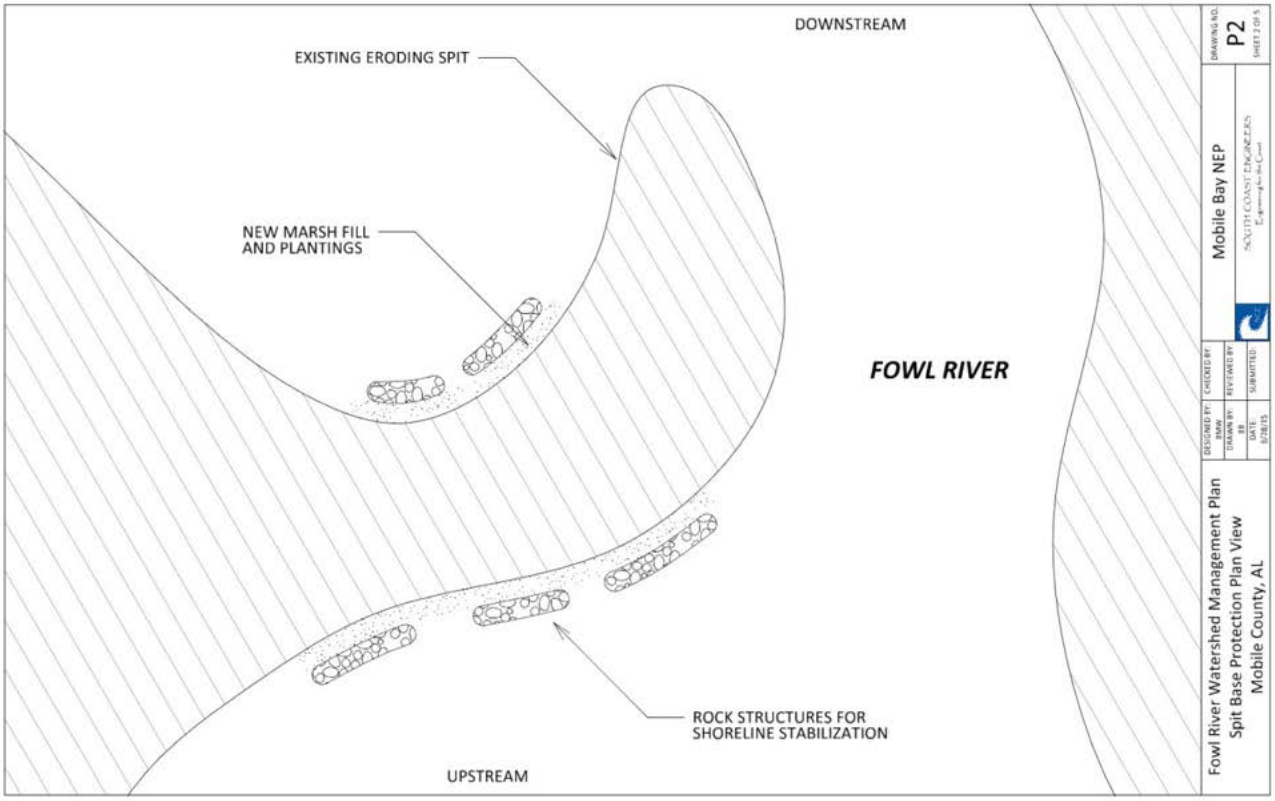


Figure 6.3: Conceptual diagram of potential marsh/spit protection and enhancement including limited use of rock structure, suitable fill, and marsh plantings where appropriate.

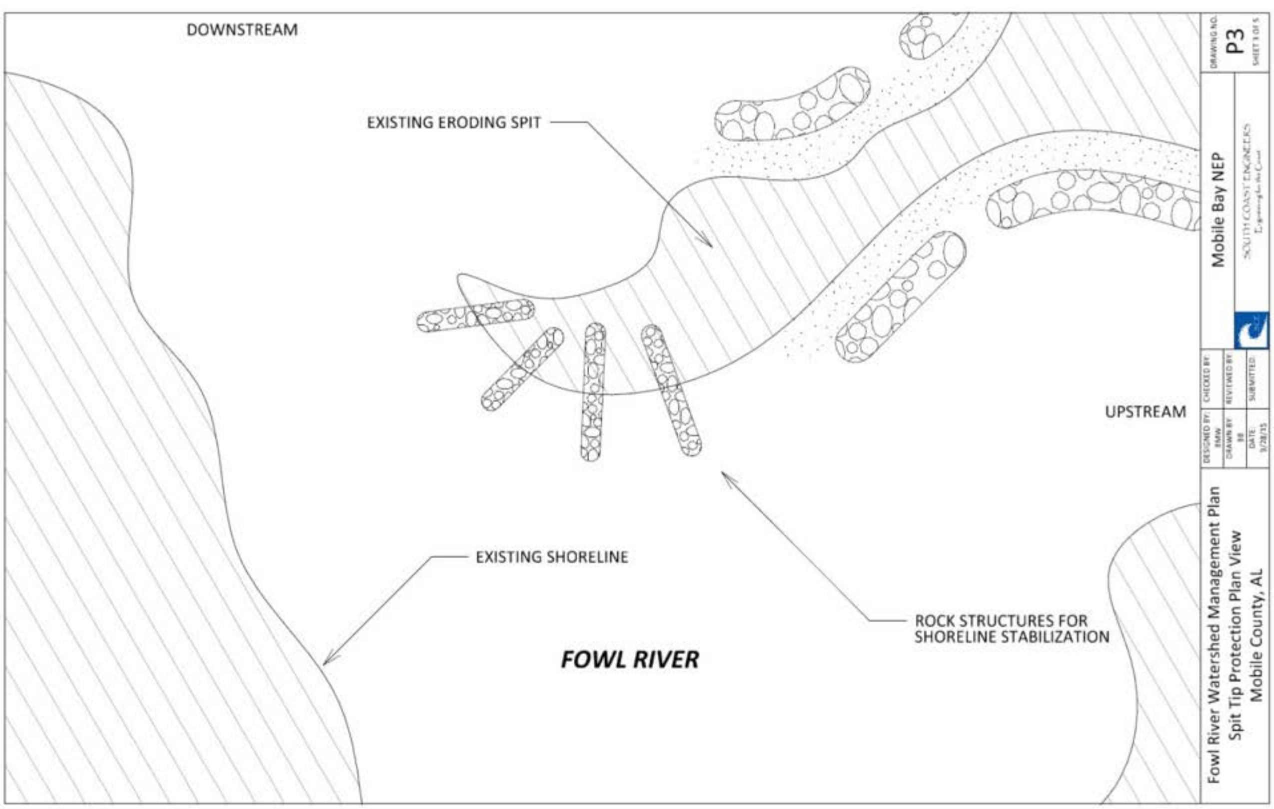


Figure 6.4: Conceptual diagram of spit and/or shoreline protection and enhancement project including limited use of rock structure (or rock revetment along banks) and suitable fill.

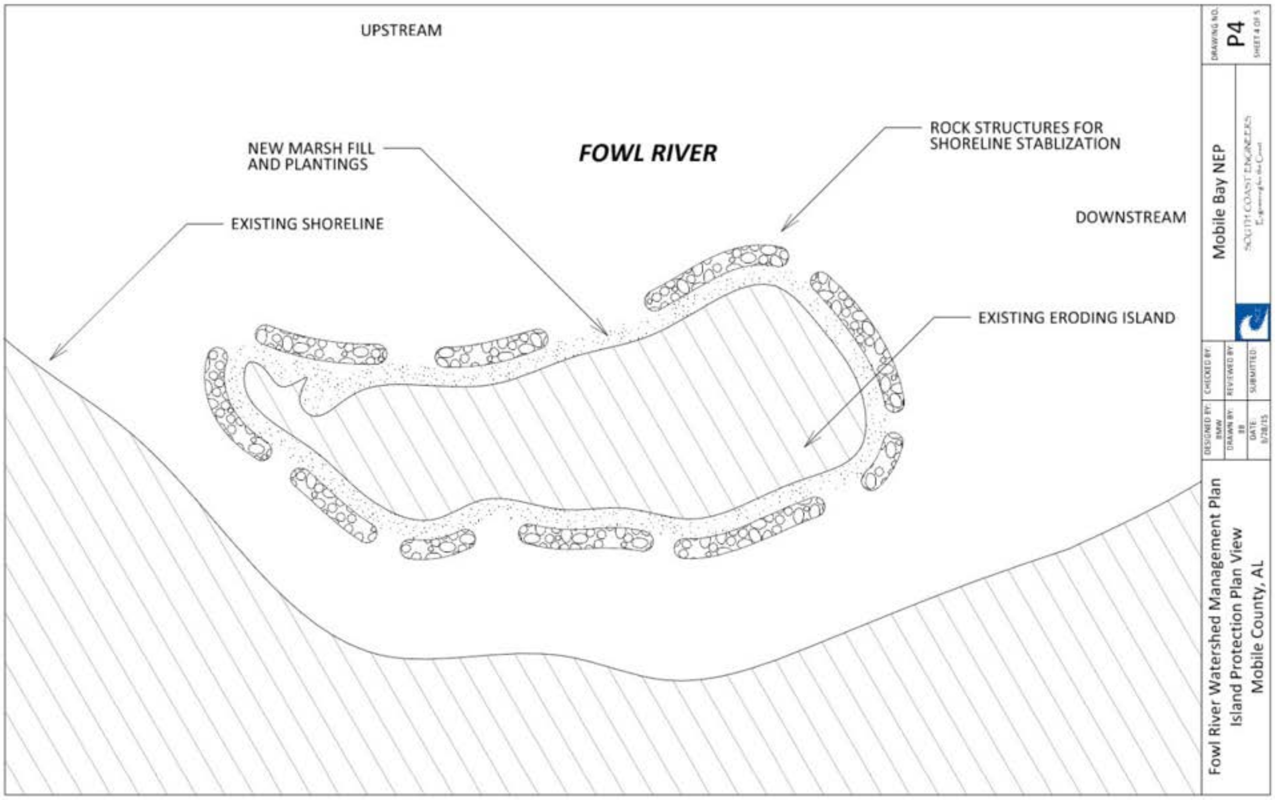


Figure 6.5: Conceptual diagram of a marsh protection and enhancement project including potential use of rock structures with gaps, suitable fill material, and marsh plantings.

6.2 WETLAND RESTORATION

Wetland Restoration #1 (WR1): WR1 lies in the extreme headwaters of the Fowl River Watershed. This project restoration area is approximately 75 acres and is currently used for row crops and cattle grazing. Historically WR1 was predominately bottomland hardwood wetlands and, over time, has been altered through human activities. Wetland restoration opportunities exist not only through hydrologic restoration, but also through re-establishment of native vegetation. The plugging of drainage ditches would increase the hydroperiod and subsequently allow the historic wetland regime to return to more natural conditions. In addition, native bottomland hardwood species could be planted. This potential project would result in increased flood capacity and decreased nutrients currently entering the adjacent streams. The small stream channel flowing southeast from the pond located on-site is shown in **Figure 6.6**.

Figure 6.6: Wetland Restoration #1

Wetland Restoration #2 (WR2): Located northwest of the Bellingrath Road and Industrial Road intersection, WR2 is approximately 60 acres currently being used as a cattle operation. The historic wetlands are predominately located in the southern portion of the tract, but additional historic maps show the remaining low-lying property could be jurisdictional wetlands. Cattle exclusion and native hardwood plantings could provide additional flood capacity to an area in close proximity to existing residential developments (see **Figures 6.7 - 6.9**).


Figure 6.7: Wetland Restoration #2


Figure 6.9: Wetland Restoration #2


Figure 6.8: Wetland Restoration #2

Wetland Restoration #3 (WR3): The largest wetland restoration area identified within the Watershed is WR3, with an area of approximately 225 acres. Located off Raybon Road, this property is currently farmland in cattle production. Cattle have free access to the adjacent streams, therefore affecting bacterial counts. A portion of this property, as identified using the National Wetland Inventory mapping data, consists of bottomland hardwood wetlands; this wetland area, however, extends beyond the forested portion and into the adjacent pasture (see **Figures 6.10 - 6.12**). Cattle exclusion and planting of native hardwood species would increase water quality primarily through increased plant uptake and decreased fecal coliform (bacteria).

Note: This site is currently listed for sale and has previously been presented to the NFWF as a potential project/acquisition opportunity.

Figure 6.10: Wetland Restoration #3

Figure 6.11: Wetland Restoration #3

Figure 6.12: Cattle in Wetland Restoration #3

6.3 STREAM RESTORATION

6.3.1 Stream Restoration Techniques

Introduction

The process of stream restoration through natural channel design involves a multiple step approach that includes data collection, engineering and scientific assessment, design, construction, monitoring, and maintenance. The success of stream restoration is contingent upon sound design methodology and implementation. The restoration approach follows specific published guidelines and methods endorsed by numerous institutions and regulatory agencies, including the U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife Service (USFWS), and the North Carolina Stream Restoration Institute.

Identification of Impaired Stream

The identification and assessment of an impaired stream is the first step in the stream restoration and design process. The stream is classified through the Rosgen Classification of Natural Rivers based on collected data. The data obtained from the project stream also provides details regarding stream channel stability, potential for further degradation, and health of habitat. At this point, certain goals and a preliminary design approach may be identified as the stream design process continues.

Identification of Reference Streams

Following evaluation of the impacted stream reach, streams in close proximity to and within the same watershed as the impacted stream are identified and assessed with regard to their quality and value to the restoration project. From an engineering standpoint, these reference streams are judged based on apparent channel stability and certain morphological parameters. Similarities in surrounding topography and soil substrate are also compared between the reference streams and the impacted stream. Certain factors help identify reference stream suitability in the design approach. These factors include low-impact watershed use, bankfull at the top of the bank, well-vegetated stream banks, and properly located bed features.

Data collected from the reference streams include, but are not limited to, feature spacing, length and slope, bankfull width and depth, stream sinuosity, and radius of curvature. This data is then processed to develop target dimensions, patterns, and profiles for the design of the impacted stream. Collecting and processing data from streams of varying watershed sizes, or drainage areas, helps to determine "trends" in channel dimensions for the geophysical region. These reference streams can be scaled to match the drainage area of the stream channel being designed.

From a biological standpoint, reference streams are assessed based on habitat diversity, biota, and overall ecological quality. Ecologists assess the diversity of available habitat types including riffle/run sequences, woody debris, nutrient availability, and riparian buffer establishment. Baseline data is collected to identify the presence of biota in the reference stream and project reach. This data is used to gauge the long-term ecological success of the restoration project.

Design Development

Once data describing existing conditions has been collected from the impaired stream and reference data has been collected from reference streams, detailed restoration design of the impacted stream can commence. One crucial parameter of design is bankfull discharge. Bankfull discharge is calculated based on the anticipated one- to two-year rainfall event, drainage area for the project reach, land use within the drainage area, and substrate characteristics. This data is entered into a hydrology model, which provides a bankfull flow rate target. Regional trend data collected from the reference streams should be used to corroborate the hydrology model. Utilizing the calculated flow rate, anticipated channel slope for the restored stream, and projected channel "roughness," the size of the channel can be calculated to ensure overbank flow on an approximate annual frequency. Elevating the stream channel to meet its floodplain is important to make sure the channel is stable. Regional curves generated from recorded data are used in the validation of certain design criteria.

The layout of the stream design is then prepared using available topographical data and data obtained from the reference streams. Taking into account the characteristics of the land and the potential constraints in the surrounding area, the layout design can follow four different approaches. The four priorities for restoration of impaired and incised streams were developed by Dave Rosgen and include the following:

- **Priority 1:** Establish bankfull stage at the historical floodplain elevation.
- **Priority 2:** Create a new floodplain and stream pattern with the streambed remaining at the present elevation.
- **Priority 3:** Widen the floodplain at the existing bankfull elevation.
- **Priority 4:** Stabilize existing stream banks in place.

Priority 1 Restoration: Establish bankfull stage at the historical floodplain elevation. For a Priority 1 restoration, the incised channel is re-established on the historical floodplain using the relic channel or by way of construction of a new morphologically-stable channel. The channel is "lifted" to a higher elevation in order to connect with the historical floodplain, as illustrated in **Figure 6.13**. The new channel has the dimension, pattern and profile characteristic of a stable form, and its floodplain is on the existing ground surface. The existing, incised channel is either completely filled, or partially filled to create discontinuous oxbow lakes and offline wetlands level with new floodplain elevation.

The surrounding land use may be prohibitive of this restoration approach. Priority 1 restorations typically result in higher flood elevations and require sufficient land for meandering, which can be a problem where flooding and land use issues exist. Constraints such as permanent culverts, upstream and downstream of the restoration reach, can also render this approach infeasible.

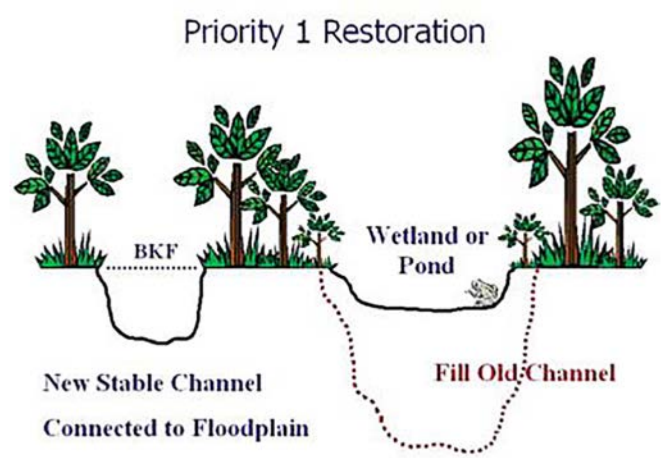


Figure 6.13: Conceptual cross section of Priority 1 restoration (Doll et al. 2003)

6.0 MANAGEMENT MEASURES

Priority 2 Restoration: Create a new floodplain and stream pattern with the stream bed remaining at the present elevation. In a Priority 2 restoration, a new, stable channel with the appropriate dimension, pattern, and profile is constructed at the elevation of the existing channel. A new floodplain is established, typically at a lower elevation than the historical floodplain, as depicted in **Figure 6.14**. The new channel is typically a meandering channel with bankfull at the elevation of the new floodplain. This type of project can be constructed in dry conditions while streamflow continues in its original channel or is diverted around the construction site.

Figure 6.14: Conceptual cross section of Priority 2 restoration (Doll et al. 2003)

A major advantage of the Priority 2 approach is that flooding does not increase and may in some cases decrease as the floodplain is excavated at a lower elevation. Riparian wetlands in the stream corridor created by the excavation may be enhanced with this approach. Priority 2 projects typically produce more cut material than is needed to fill the old channel. This means that designers must consider the expense and logistics of managing extra soil material excavated from the floodplain. Surrounding land uses can limit the use of this approach if there are concerns about widening the stream corridor.

Priority 3 Restoration: Widen the floodplain at the existing bankfull elevation. Priority 3 restorations entail converting the existing unstable stream to a more stable stream at the existing elevation and with the existing pattern of the channel but without an active floodplain, illustrated in **Figure 6.15**. This approach involves establishing proper dimension and profile by excavating the existing channel to modify the Rosgen stream classification. This restoration concept is implemented where streams are confined (laterally contained) and physical constraints limit the use of Priorities 1 and 2 restoration. A Priority 3 restoration can produce a moderately stable stream system but may require structural measures and maintenance. For these reasons, it may be more expensive and complex to construct, depending on valley conditions and structure requirements.

Figure 6.15: Conceptual cross section of Priority 3 restoration (Doll et al. 2003)

Priority 4 Restoration: Stabilize existing stream banks in place. In a Priority 4 restoration approach, the existing channel is stabilized in place utilizing stabilization materials and methods that have been used to decrease streambed and stream bank erosion, including riprap, gabions, and bio-engineering methods. Because this method does not address existing, excessive shear stress and velocity, which may have caused the impaired channel, it is considered high risk. This approach also limits aquatic habitat and is the least desirable option from a biological and aesthetic standpoint.

6.0 MANAGEMENT MEASURES

TABLE 6.1: ADVANTAGES AND DISADVANTAGES OF STREAM RESTORATION OPTIONS FOR INCISED STREAMS		
Priority	**Advantages**	**Disadvantages**
1	Results in long-term stable stream Restores optimal habitat values Enhances wetlands by raising water table Minimal excavation required	Increases flooding potential Requires wide stream corridor Cost associated with excess soil disposal May disturb existing vegetation
2	Results in long-term stable stream Improves habitat values Enhances wetlands in stream corridor May decrease flooding potential	Requires wide stream corridor Requires extensive excavation May disturb existing vegetation
3	Results in moderately stable stream Improves habitat values May decrease flooding potential Maintains narrow stream corridor	May disturb existing vegetation Does not enhance riparian wetlands Requires structural stabilization measures
4	May stabilize stream banks Maintains narrow stream corridor May not disturb existing vegetation	Does not reduce shear stress May not improve habitat values May require costly structural measures May require maintenance

The severity of impairment, land-use constraints, and availability of resources are assessed in the selection of the appropriate priority type for the restoration approach.

In-stream structures are also integrated into the design to serve multiple purposes. The structures, which are typically constructed of log and/or rock material, may be used to protect stream banks by directing flow towards the center of the channel, provide grade control where the stream might be prone to headcutting, and enhance stream habitat by creating riffles, plunge pools, and other habitat features. Bioengineering techniques can also be implemented that utilize both woody debris and living vegetation to armor stream banks and provide growing roots for soil stabilization along the bank.

Once the design has been prepared, the functionality of the stream is assessed. The Hydrologic Engineering Centers River Analysis System (HEC-RAS) surface-water hydraulic model is run to predict water levels within the stream during bankfull and other high-flow events if necessary, based on calculated flow regimes. The model will indicate whether the current design parameters will allow for bank topping during a predicted bankfull flow event. The model can illustrate the impact of the proposed stream design on flood events during periods of greater flow to make sure the design does not adversely affect the surrounding area. It can also demonstrate anticipated stresses and velocities within the stream and on the floodplain to determine if these factors exceed the project's ability to perform. The results are reviewed to examine the effectiveness of the design and any needs for revision. Consequently, additional design iterations may be necessary to ensure the best final stream restoration design.

6.0 MANAGEMENT MEASURES

Construction

Upon approval of the final stream design by the client and regulatory agencies, the project moves into the construction phase. Any site preparation needed prior to construction, including mobilization, staging, creating temporary access, clearing and grubbing, and stockpiling, is performed. The project site is staked for construction by incorporating Global Positioning System (GPS) and conventional surveying techniques. Project engineers ensure the stream design is constructed in accordance with the design plans, and are available to field engineer any modifications required. Project scientists work with the engineers and construction team to incorporate habitat features that lead to the overall ecological success of the project. Best management practices are incorporated to minimize unnecessary pollution to the stream during the construction phase. Eco-friendly materials are used to stabilize the stream channel until vegetation can be established. This includes coconut fiber coir matting and wooden eco-stakes along the slopes of the stream bank.

Vegetation is vital to the stability of a newly-constructed channel and floodplain. Temporary seeding is critical upon construction completion to provide instant stability to the construction zone and prevent excessive erosion and sedimentation. Permanent vegetation, which includes native herbaceous wetland plants, trees, and shrubs, is installed on the project site to provide long-term stream bank and floodplain stability and streamside habitat.

Monitoring and Maintenance

The final stage of restoration includes long-term monitoring of the restoration project. The success of a stream restoration is based on several factors, including regulatory requirements, channel stability, ecological diversity, and client satisfaction. Periodic maintenance should be considered a requirement for stream restoration projects. Supplemental seeding, in-stream structure repair, resetting or replacement of erosion control matting, and vegetation replacement are some of the potential maintenance requirements. Providing regular maintenance that addresses stream issues helps prevent or mitigate potential large-scale, long-term failures.

6.3.2 Stream Buffer Restoration

Riparian buffers are essentially streamside forests that are vitally important to the overall health of a stream. The natural vegetation increases nutrient uptake, infiltration, and absorption, therefore reducing nonpoint source pollution. Buffers are the transition zones that connect uplands (agricultural, urban, natural, etc.) to floodplain wetlands and ultimately to creeks, streams, and rivers. There are areas in the Fowl River Watershed that exhibit little or no riparian buffers.

The establishment of a riparian buffer zone will greatly enhance the environment of the channel and its surrounding areas. Riparian buffers decrease stream velocity, improve diffuse flow, and reduce nonpoint source pollution concentrations through nutrient cycling. They are also vital in the stabilization of streambanks and provide habitats that attract and improve biodiversity. As identified in **Figure 6.16**, construction of a riparian buffer includes the following zones:

- **Zone 1:** closest to the water body and 25-30 feet wide. A mix of wetland herbaceous and woody vegetation that has floodplain and/or wetland characteristics.
- **Zone 2:** the area between Zone 1 and the upland with a primary function of infiltration of runoff and filtration of pollutants. Zone 2 is 25-50 feet wide with woody vegetation.
- **Zone 3** *(optional)***:** a 25-foot strip of native grasses that creates diffuse flow to Zone 2.

Riparian buffers can range from 25-150 feet, depending on state-specific regulations, but are typically 100 feet or greater.

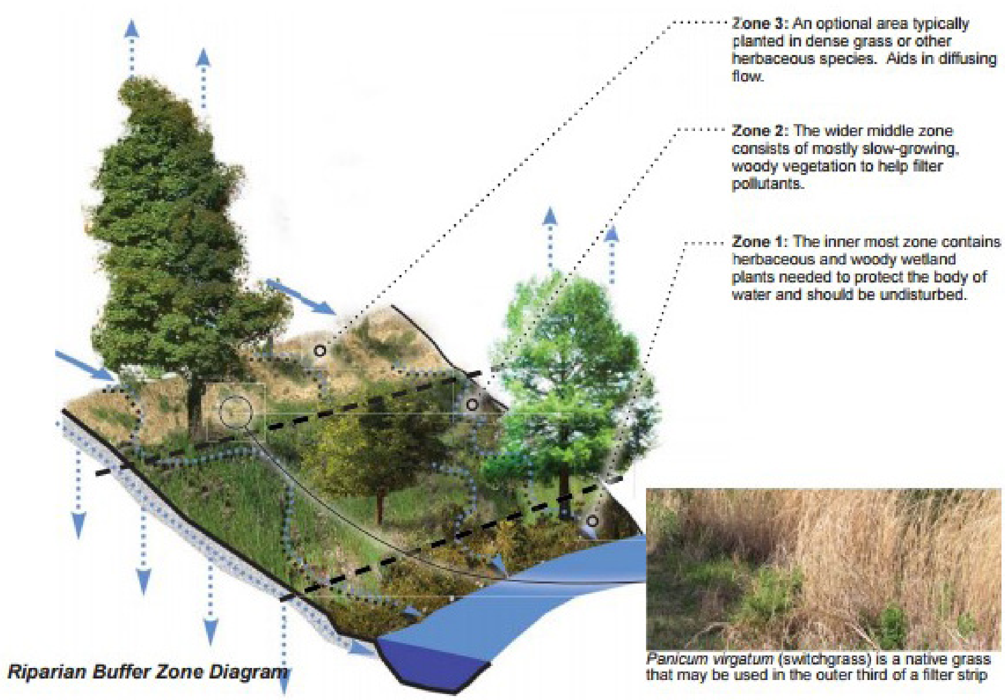


Figure 6.16: Riparian buffer zone diagram (LID Handbook for Alabama, 2014)

Proposed projects, Buffer Restoration #1 (BR1) and Buffer Restoration #2 (BR2), are examples of stream systems that have lost adequate riparian buffer habitat (see Section 8, Table 8.3).

6.3.3 Stream Restoration Through Natural Channel Design

Stream Restoration #1 (SR1): SR1 is located west of Pearl Haskew Elementary School off McDonald Road and runs west to east. This stream system is predominately forested and in its natural state, with the exception of an approximate 600-linear-foot section shown in **Figure 6.17**. This segment of stream appears to be straight and has no riparian buffers. Its location near a construction stockpile area increases the likelihood of sediment runoff entering the stream and being transported downstream. The manipulated channel and lack of riparian buffer leaves the system fragmented and susceptible to natural and artificial impacts. Stream restoration could likely include the installation of in-stream habitat structures and re-establishment of the natural riparian buffer. This unnamed tributary flows directly into Fowl River.

Stream Restoration #2 (SR2): SR2 is located west of Bellingrath Road and adjacent to Payne's RV Park. The headwaters of this stream originate to the north in a small residential area and flow south into the area shown in **Figures 6.18** and **6.19**. This stream channel is too wide and deep for its drainage area and has been channelized to speed the movement of water from the site. The length of the current channel is approximately 700 linear feet.

Figure 6.17: General area of Stream Restoration #1 facing southeast. After further discussion, the landowner does not intend to have this area restored based on the current land-use purpose.

Figure 6.18: Stream Restoration #2

Figure 6.19: Stream Restoration #2

The property to the west of the stream channel is currently listed for sale and is cleared and undeveloped. Priority 1 restoration could be used to create a new, free-flowing, and meandering stream channel properly sized to match its drainage area. A riparian buffer could then be planted along the new stream channel to provide additional habitat.

Stream Restoration #3 (SR3): SR3 is located southeast of SR2 and east of Bellingrath Road. This 820-foot section of stream flows east to west and was channelized through prior land management (see **Figure 6.20**). There is currently no riparian buffer to the north of the channel with varying widths of riparian buffers to the south. Restoration efforts would likely entail a combination of Priority 1 and Priority 2 restoration that would not only add sinuosity to the channel, but provide greater connection to the floodplain. This strategy would increase flood retention, decrease nutrient transport, and provide increased wildlife habitat.

Figure 6.20: Stream Restoration #3

Stream Restoration #4 (SR4): SR4 is directly downstream of SR3 but on the west side of Bellingrath Road and is approximately 1,200 linear feet (see **Figure 6.21**). The impacts to this portion of the stream are similar to SR3 and include channelization with very little riparian buffer. Adjacent row crops in close proximity to the channel are sources of increased nutrients. Restoration efforts would likely be a combination of Priority 1 and Priority 2 restoration with re-establishment of a native hardwood riparian buffer.

Figure 6.21: Stream Restoration #4

Stream Restoration #5 (SR5): SR5 is another reach of the same unnamed tributary as SR3 and SR4 and is approximately 1,100 linear feet. Man-made impacts, including channelization, have occurred over the years. This was likely done to speed up the movement of water from the property and allow additional acreage to be used for farming. Row crops are planted on-site directly adjacent to the channel. No riparian buffer currently exists within this 1,100-foot section. Restoration would likely include Priority 1 restoration with a newly-constructed (and meandering) stream channel situated east of the existing stream channel, shown in **Figure 6.22**; the existing channel would be abandoned. Restoration of this tributary, which flows directly into Fowl River, could provide benefit through nutrient reduction, increased flood capacity, and increased wildlife habitat.

Figure 6.22: Stream Restoration #5

Stream Restoration #6 (SR6): SR6 is located east of Bellingrath Road and southeast of Lancaster Road (see **Figure 6.23**). This approximately 3,400-linear foot segment is another unnamed tributary to Fowl River. Stream restoration projects typically begin on the headwaters portion of the stream as the flow of water into the channel is controlled. This restoration area is the headwaters of the unnamed tributary and has been altered over time through both channelization and replacement of native vegetation with row crops. In-stream restoration of approximately 3,400 linear feet of channel would provide improvements to water quality through nutrient reduction. An approximately 400-foot riparian buffer planted adjacent to the newly-constructed channel could provide additional cover, shade, and nutrient uptake.

Figure 6.23: Stream Restoration #6

Stream Restoration #7 (SR7): SR 7 is the longest stream restoration opportunity identified, consisting of more than 3,700 linear feet of impaired channel. This stream, shown in **Figure 6.24**, is situated on a parcel currently listed for sale. Man-made impacts, including channelization, and access to the system by cattle have resulted in stream bank erosion. Current channel dimensions indicate the stream is too wide and should be narrower and shallower based on its drainage area. A likely combination of Priority 1 and Priority 2 stream restoration would create a new meandering stream channel with increased connection to the surrounding floodplains and wetlands. Cattle exclusion from the stream would decrease stream bank erosion and bacterial contamination, while a re-established riparian buffer would provide added habitat.

Figure 6.24: Stream Restoration #7

6.0 MANAGEMENT MEASURES

6.4 STORMWATER MANAGEMENT

The State of Alabama has more than 77,000 miles of diverse water resources that underlie rich biodiversity, supply drinking and irrigation water, and provide avenues of transportation and ecotourism opportunities. With increasing development across the state, stormwater runoff must be managed to properly and innovatively protect waterways.

Stormwater runoff is rainwater that collects and flows off streets, lawns, and other impervious surfaces. According to the Alabama Department of Environmental Management (ADEM) and the EPA, as much as 55 percent of rainfall runs off an urban landscape, causing a host of environmental problems. Debris, chemicals, sediment, metals, pathogens, and other nonpoint source pollutants are carried by runoff into surrounding water bodies and wetlands, impacting plants, animals, fish, and humans. Runoff also causes flooding, erosion, and infrastructure damage. Sedimentation increases turbidity which impairs submerged aquatic vegetation growth. Excess nutrients stimulate algae blooms, resulting in low dissolved oxygen levels that are dangerous for aquatic organisms.

Implementing stormwater management practices reduces stormwater runoff and increases infiltration of stormwater into the ground, restoring adequate quality. Low impact development (LID), or green infrastructure, includes sustainable stormwater management and utilizes natural hydrologic cycles through multiple measures or practices that include:

- Green roofs
- Rain barrels and cisterns
- Permeable pavements
- Bioretention areas
- Vegetated swales/dry swales
- Curb and gutter eliminations
- Vegetated filter strips
- Sand and organic filters
- Constructed wetlands
- Riparian buffers

Furthermore, LID elements emphasize improved aesthetics, creation of wildlife habitats, and community involvement and engagement and, as noted by the EPA, typically have lower initial investment with the ability to be maintained similarly to other landscaped areas.

Stormwater Management #1 (SWM1): SWM1 is a channelized stream reach located near an existing neighborhood off Dawes Lane, south of Dawes Oak Drive and north of Dawes Creek Drive. Stormwater from the neighborhood flows directly into the channel pictured in **Figure 6.25**, which has a bare-soil bottom with some riprap located downstream. Conversion to a grass swale or offline constructed wetland would increase stormwater capacity while providing nutrient removal through natural attenuation and plant uptake (see **Figures 6.26** and **6.27**).

Figure 6.25: Stormwater Management #1

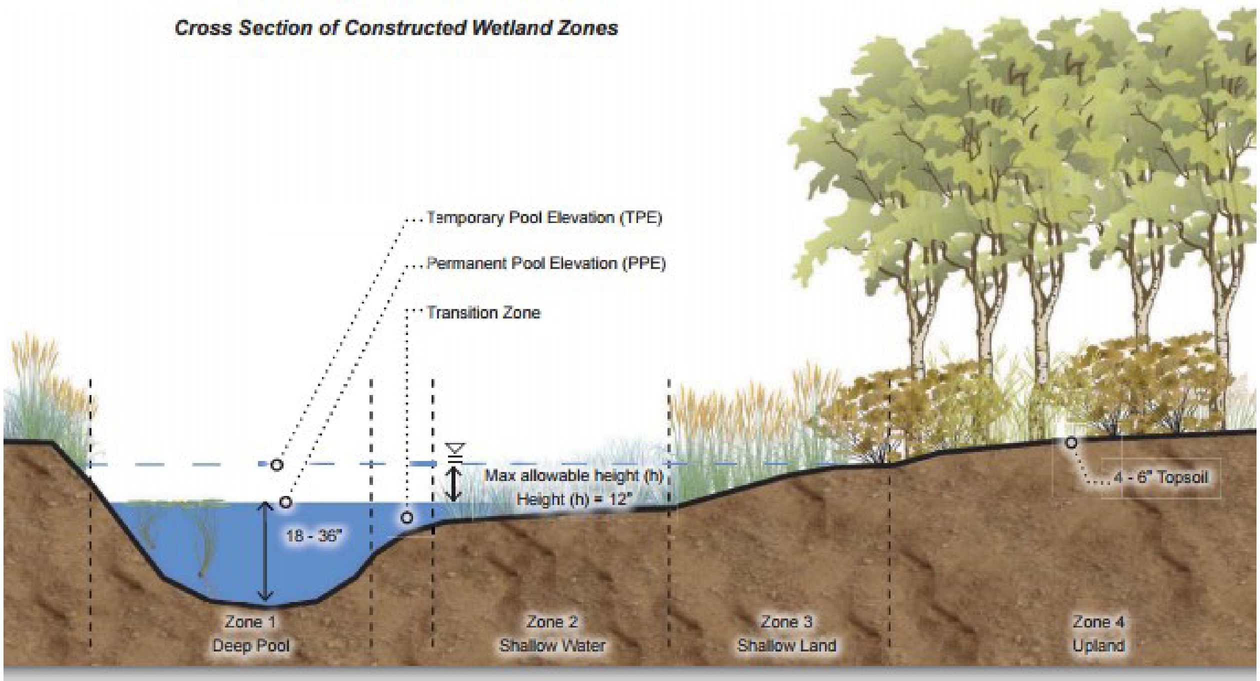


Figure 6.26: Cross section of constructed wetlands (LID Handbook for Alabama, 2014)

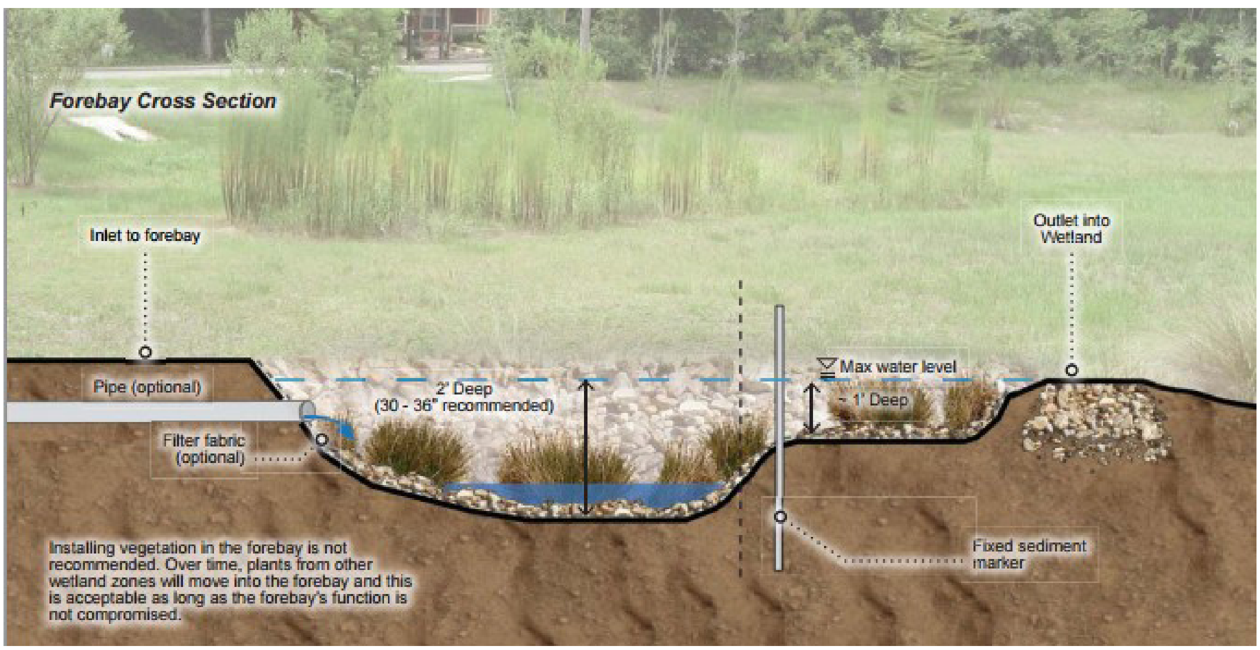


Figure 6.27: Forebay cross section of constructed wetlands (LID Handbook for Alabama, 2014)

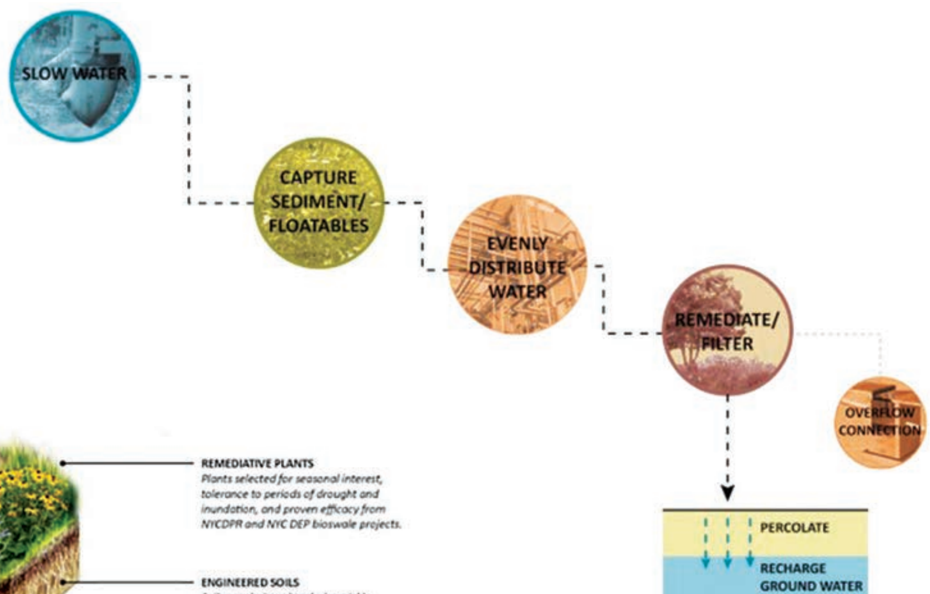
Stormwater Management #2 (SWM2): SWM2 is located at the intersection between Macdonald Road and Interstate-10 (see **Figure 6.28**). Because SWM2 includes a freeway overpass, nontraditional means of stormwater management must be implemented to account for the absence of soil below and along this section. Utilizing two basins—a sedimentation basin, which captures suspended sediments and debris, and a filtration basin, which uses selected plants and engineered soils to removes toxins—water is released through an outflow pipe via groundwater recharge to neighboring water bodies as **Figure 6.29** illustrates. The layers of the system are depicted in **Figure 6.30** (from top to bottom) and include:

- Vegetation - selected in concurrence with seasonality & efficacy in bioswale projects
- Engineered soils - designed to drain quickly & support plant life
- Sand layer - filtration
- Gravel layer - increase water storage time
- Outflow pipe - release remediated water
- Concrete basin

Allowing water to percolate through this system will improve water quality in streams and other adjoining waterways.

Figure 6.28: Stormwater Management #2

Figure 6.29: Nontraditional stormwater management strategy (dlandstudio, 2014)



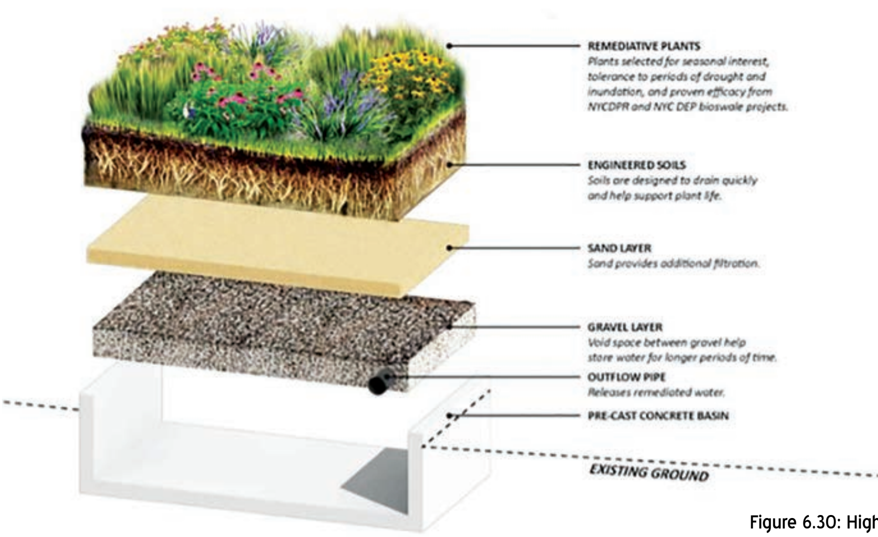


Figure 6.30: Highway Overpass Landscape Detention System layers (dlandstudio, 2014)

6.0 MANAGEMENT MEASURES

Stormwater Management #3 (SWM3): SWM3 is a channelized stormwater conveyance that includes headwaters of a tributary to Muddy Creek. The stream is located east of the intersection of Bellingrath Road and Will Cashier Lane near a dirt access road (see **Figure 6.31**). Potential restoration strategies could include creation of an offline constructed wetland to the north (currently a vacant lot) that would allow for increased flood capacity in peak flows.

Figure 6.31: Stormwater Management #3

Stormwater Management #4 (SWM4): SWM4 is a relatively small area (0.19 acres) that includes a section of Muddy Creek located directly west of Bellingrath Road, south of Ann Street and north of Helen Drive. The stream section has a substantial amount of large rocks for stabilization and armoring of the south side, where it connects to a concrete culvert that collects and drains stormwater into the creek (see **Figure 6.32**). Restoration efforts would include implementation of an offline constructed stormwater wetland in the floodplain of the stream. Benefits would include effective management and recharge of stormwater, pollutant removal, and habitat creation.

Figure 6.32: Stormwater Management #4

Stormwater Management #5 (SWM5): SWM5 is a straight channel that discharges directly into Muddy Creek. It is located northwest of Willard Drive North, east of Kelcey Court, and west of Broome Court (see **Figure 6.33**). This ditch captures the stormwater from the residential development and provides little to no treatment. Undeveloped property directly to the east would allow adequate area for construction of a retention pond or constructed stormwater wetlands. This would provide proper treatment of stormwater runoff prior to its discharge into Muddy Creek.

Figure 6.33: Stormwater Management #5

6.0 MANAGEMENT MEASURES

Stormwater Management #6 (SWM6): SWM6 is a partially channelized reach south of Muddy Creek (see **Figure 6.34**) It is located north of the west end of Willard Drive North and east of Braxton Court. Similarly to SWM5, it is possible to construct an offline constructed wetland in the floodplain of Muddy Creek. Installation of an offline constructed wetland would increase stormwater capacity while providing nutrient removal through natural attenuation and plant uptake.

Figure 6.34: Stormwater Management #6

Stormwater Management #7 (SWM7): SWM7 is a man-made channel that was likely created for stormwater conveyance for the Heaton Drive East cul-de-sac. The channel is directly connected south-southeast to an unnamed tributary to Muddy Creek. This conveyance is predominately a channelized ditch that transports stormwater runoff from the adjacent residential neighborhood (see **Figure 6.35**). In addition, this ditch is surrounded by active row crops. Installation of a constructed wetland would not only provide stormwater treatment from the adjacent neighborhood but would provide treatment to the nutrients generated from adjacent row crops.

Figure 6.35: Stormwater Management #7

Stormwater Management #8 (SWM8): SWM8 is located at the intersection between McDonald Road (County Road 39) and Government Boulevard and includes the cloverleaf overpass pictured in **Figure 6.36**. Restoration strategies will be similar to those described for SWM2.

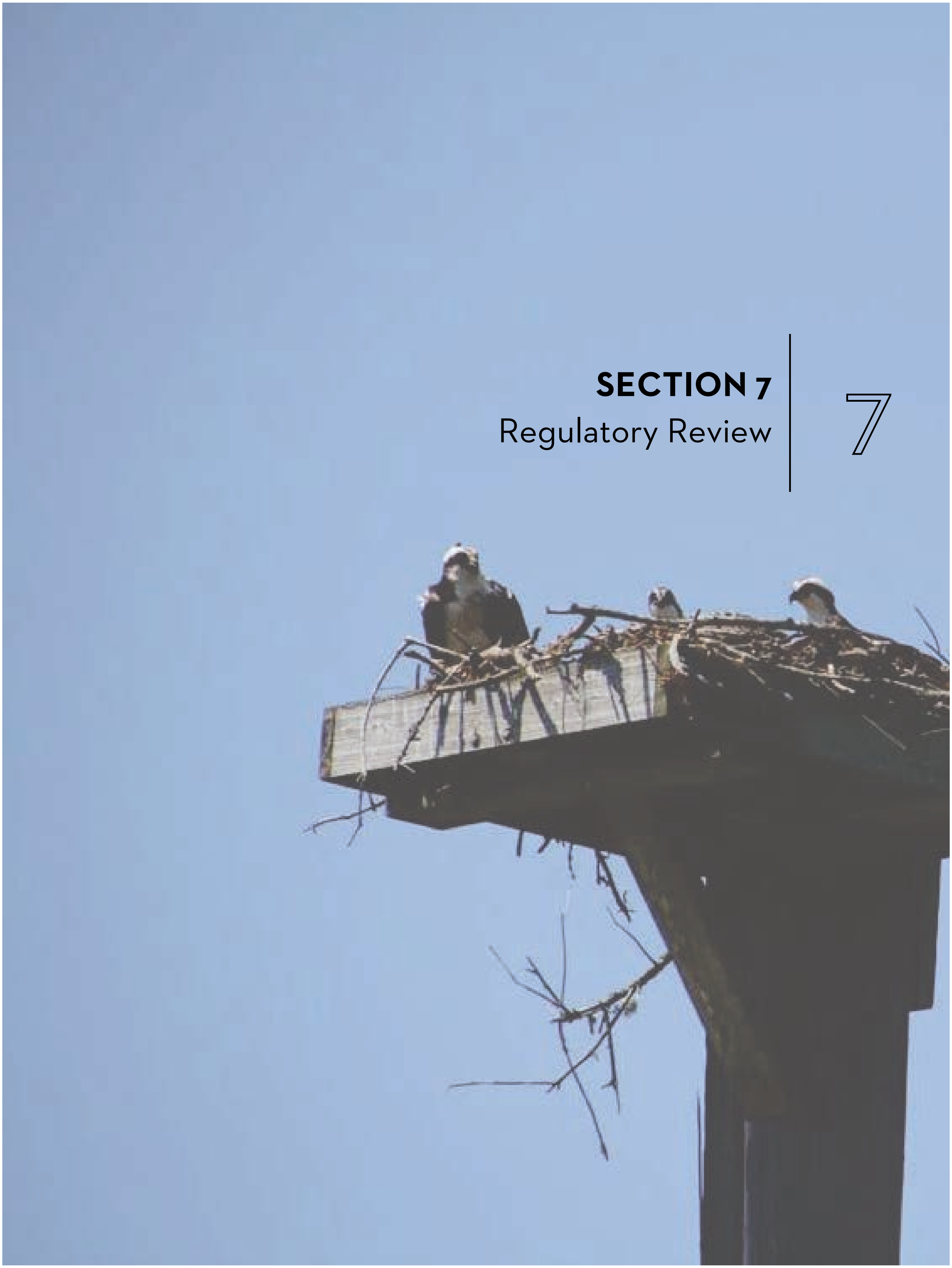
Figure 6.36: Stormwater Management #8

Stormwater Management #9 (SWM9): SWM9 is located northwest of the Bellingrath Road and Half Mile Road intersection in Section 21, approximately 0.7 miles north of Half Mile Road. The area lies between Fowl River and associated wetlands to the west and an unnamed tributary to Fowl River to the east. The site, shown in **Figure 6.37**, is approximately 36 acres and has been altered over time by man-made channels created to divert water from the area. Management of SWM9 would include plugging ditches to restore the natural hydrology and re-establishment of native hardwood species. Potential benefits of this restoration would include increased stormwater capacity, increased nutrient/sediment removal, and increased habitat/wildlife utilization. Although not classified as wetlands, according to the NWI mapping datasets, this area would routinely flood if hydrology were restored. Nutrient levels would decrease if existing row crops were replaced with native hardwood species.

Figure 6.37: Stormwater Management #9

SECTION 7
Regulatory Review

7



7.0 REGULATORY REVIEW

7.1 INTRODUCTION

As part of the development of the Watershed Management Plan (WMP) for the Fowl River Watershed in Mobile County, Alabama, a review of existing regulations at the federal, state, and local level was conducted. This review was conducted by Gary Brown, CPESC, of Goodwyn, Mills and Cawood (GMC).

The geopolitical boundaries of the Fowl River Watershed include overlapping jurisdictions and adjacent portions of Mobile County, the City of Mobile, and the City of Mobile five-mile planning jurisdiction with additional lands under State jurisdiction.

Past and current status of developments, ordinances, inspections, and compliance issues were discussed with local government officials; as well as, representatives of the Alabama Department of Environmental Management (ADEM), the U.S. Army Corps of Engineers (USACE), and the Fowl River Steering Committee.

The laws, regulations, and ordinances reviewed focus on water quality, stormwater, erosion and sediment control, coastal issues, wetlands and other "Waters of the U.S.," and land disturbance. The list includes:

- Clean Water Act, 33 USC § 1251, et seq.
- Alabama Water Pollution Control Act, Ala. Code § 22-22-1, et seq.
- ADEM Admin Code Reg. 335-6-6 (NPDES)
    - 335-6-10 (water quality criteria)
    - 335-6-6 (National Pollutant Discharge Elimination System)
    - 335-8-1 (Coastal area management)
- Mobile County Flood Damage Prevention Ordinance (March 11, 2010)
- Mobile City Code Chapter 17: Storm Water Management and Flood Control (June 2, 2014)
- City of Mobile Stormwater Management Program Plan (May 2014)
- Mobile County Stormwater Management Program Plan (October 2013)

Federal, state, and local regulations are regularly reviewed and updated. At this time, no known major regulation changes are planned; however, permits typically required for activities within the Watershed are regularly updated (typically every five years) and usually include some changes from the previously issued permits. Below is a summary of the current expiration dates for the federal, state, and local permits required for certain activities within the Watershed:

- USACE Nationwide Permits – March 18, 2017
- ADEM Construction Stormwater General Permit – March 31, 2016
- City of Mobile MS4 Individual Permit – September 30, 2019
- Mobile County Phase II MS4 General Permit – January 31, 2016

7.0 REGULATORY REVIEW

7.2 ALABAMA WATERSHED MANAGEMENT AUTHORITIES

In May 1991, the State of Alabama Legislature passed a law that provides for the creation of watershed management authorities in the state, with the expressed purpose of:

> *"Developing and executing plans and programs relating to any phase of conservation of water, water usage, flood prevention, flood control, water pollution control, wildlife habitat protection, agricultural and timberland protection, erosion prevention, and control of erosion, floodwater and sediment damages."*

This body is non-regulatory; however, the law provides numerous powers and authorities to the Board of Directors of a watershed management authority, including the power to:

- Acquire lands or rights-of-way by purchase, gift, grant, bequest, or through condemnation proceedings.
- Construct, improve, operate, and maintain such structures and projects as may be necessary for the exercise of any authorized function of the Authority.
- Borrow money as is necessary for the performance of its functions.
- Make and execute contracts and other instruments necessary to the exercise of its powers.
- Act as agent for the State of Alabama or any of its agencies, the United States or any of its agencies, or any county or municipality in connection with the acquisition, construction, operation ,or administration of any project within the boundaries of the Authority.
- Issue, negotiate, and sell bonds upon approval of the State Finance Director.
- Accept money, services, or materials from national, state, or local governments.

7.3 DISCUSSION OF LAWS, REGULATIONS, AND ORDINANCES

7.3.1 Federal

FEDERAL WATER POLLUTION CONTROL ACT: The Federal Water Pollution Control Act was enacted in 1948, and was significantly reorganized and expanded in 1977. The Clean Water Act (CWA) became the Act's common name with the amendments in 1972. The CWA establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating water quality standards for surface waters. The CWA and its amendments provide the basis for the primary federal regulatory and permitting procedures relating to stormwater management in the Fowl River Watershed. The most applicable sections of the CWA related to controlling stormwater runoff and erosion and sedimentation within the Watershed are listed below.

CWA § 404: This section establishes a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g., certain farming and forestry activities). The USACE is the primary permitting authority for impacts to waters of the U.S., including wetlands. Permit applications are reviewed and evaluated based on the environmental criteria set forth in the CWA Section 404(b)(1) Guidelines and regulations promulgated by the U.S. Environmental Protection Agency (EPA). The permits must also meet state water quality standards and coastal area requirements and must be consistent with each program.

CWA § 402: This section authorizes permitting under the National Pollutant Discharge Elimination System (NPDES) program with EPA having primary permitting authority. The NPDES program requires discharges to obtain permits prior to discharging pollutants into waters of the U.S. The NPDES program covers point source discharges from industrial facilities; municipal separate storm sewer systems (MS4s); concentrated animal feeding operations (CAFO); publically-owned treatment works (POTW); combined sewer overflows (CSO) and sanitary sewer overflows (SSO); and construction, non-coal/non-metallic mining and dry processing less than five acres, other land disturbance activities, and areas associated with these activities.

Through delegation from the EPA, ADEM has the authority to administer the NPDES program. Through ADEM Admin. Code Reg. 335-6-6 the Department regulates and permits certain point source discharge. Through ADEM Admin Code Reg. 335-6-6, ADEM regulates discharges from construction, non-coal/non-metallic mining and dry processing less than five acres, other land disturbance activities, and areas associated with these activities. This regulation also imposes requirements for controlling erosion, sedimentation, and other potential sources of pollution from these activities through the use of best management practices. This regulation also outlines requirements for inspections, reporting, and enforcement actions.

The EPA promulgated Effluent Limitations Guidelines and Standards for the Construction and Development Point Source Category in December 2009. The rule required owners and operators of permitted construction activities to adopt certain requirements including the implementation of erosion and sediment controls, the stabilization of soils, management of dewatering activities, the implementation of pollution prevention measures, provision and maintenance of a buffer around surface waters, prohibition of certain discharges, and utilization of surface outlets for discharges from basins and impoundments. The 2009 rule also included the establishment of numeric limitations on the allowable level of turbidity in discharges from certain construction sites. In 2014, the EPA made revisions to the 2009 rule that provided clarity to several of the rule requirements, but also removed the numeric turbidity effluent limitation and monitoring requirement.

In addition to the activities listed above, ADEM has also been delegated authority from the EPA to regulate discharges from MS4s. ADEM requires municipalities and other large operators of MS4s, such as the Alabama Department of Transportation (ALDOT), to obtain and comply with terms of an NPDES permit to control the discharges from such systems.

CWA § 303(D): Under Section 303(d) of the 1972 CWA, states, territories, and authorized tribes are required to develop lists of impaired waters. These impaired waters do not meet water quality standards that states, territories, and authorized tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop total maximum daily loads (TMDLs) for these waters. The TMDLs are used to establish limits for the amount and type of pollutant discharges that the receiving streams can handle without experiencing further degradation.

Fowl River is listed on the 2014 Alabama § 303(d) List for Metals because of its mercury concentrations, with the source being listed as atmospheric deposition. Fowl River was first listed in 2000, and the current draft TMDL date is 2020. Once a TMDL is established, additional research may be warranted to determine additional measures that can be implemented to meet the required TMDL.

COASTAL ZONE MANAGEMENT ACT: The Coastal Zone Management Act (CZMA), administered by the National Oceanic and Atmospheric Administration (NOAA), provides for the management of the nation's coastal resources, including the Great Lakes. The goal is to "preserve, protect, develop, and, where possible, to restore or enhance the resources of the nation's coastal zone." The CZMA outlines three national programs, the National Coastal Zone Management Program, the National Estuarine Research Reserve System, and the Coastal and Estuarine Land Conservation Program (CELCP). The National Coastal Zone Management Program aims to balance competing land and water issues through state and territorial coastal management programs, and the reserves serve as field laboratories that provide a greater understanding of estuaries and how humans impact them. The CELCP provides matching funds to state and local governments to purchase threatened coastal and estuarine lands or obtain conservation easements. Alabama's Coastal Area Management Program (ACAMP) was approved and has been in effect since 1979, and the federal provisions require that CWA Sections 404 and 402 permits comply with this program. Additional information related to ACAMP is found in the State Regulations section.

7.3.2 State

A comprehensive program of environmental management for the State was established in 1982 when the Alabama Legislature passed the Alabama Environmental Management Act. The law created the Alabama Environmental Management Commission and established the ADEM, which absorbed several commissions, agencies, programs, and staffs that had been responsible for implementing environmental laws. ADEM administers all major federal environmental laws, including the CWA. ADEM assumed these responsibilities only after demonstration that state laws and regulations are at least equivalent to federal standards and that the state has matching funds and personnel available to administer the programs. In addition, the Alabama Department of Conservation and Natural Resources (ADCNR) and the Alabama Department of Economic and Community Affairs (ADECA) Office of Water Resources (OWR) may also have jurisdiction over certain actions that affect State waters and State natural resources.

ALABAMA WATER POLLUTION CONTROL ACT: The Alabama Water Pollution Control Act (AWPCA), Alabama Code § 22-22-1, is the State's version of the CWA. The Act provides the framework for the adoption of rules establishing water quality standards, the adoption of effluent limitation guidelines, a system for issuance of permits, which shall include effluent limitations for each discharge for which a permit is issued, and such other rules as necessary to enforce water quality standards adopted by the Department.

WATER QUALITY CRITERIA: As outlined in CWA § 401(a), CWA § 404 permit applications must be reviewed by the ADEM to ensure that the proposed permitted action is consistent with the State's water quality program. This review is to ensure that any discharge of dredged or fill material will not cause or contribute to a violation of the State's water quality standards. State water quality standards are outlined in ADEM Admin. Code Reg. 335-6-10.

7.0 REGULATORY REVIEW

CONSTRUCTION SITE STORMWATER: The CWA and federal regulations require construction site operators to obtain NPDES permit coverage for regulated land disturbances and associated discharges of stormwater runoff to State waters. Effective April 1, 2011, ADEM established General NPDES Permit No. ALR100000 for discharges associated with regulated construction activity that will result in land disturbance equal to or greater than one acre, or from construction activities involving less than one acre, and, which are part of a common plan of development or sale equal to or greater than one acre. This permit replaced the previous "permit by rule" that was regulated under ADEM Admin. Code Reg. 335-6-12. The General Permit falls under the authority of ADEM Admin. Code Reg. 335-6-6, along with the other actions regulated by the NPDES program.

Construction site operators and/or owners seeking coverage under this general permit must submit a Notice of Intent (NOI) in accordance with the permit requirements. Operators and/or owners of all regulated construction sites must implement and maintain effective erosion and sediment controls in accordance with a Construction Best Management Practices Plan (CBMPP) prepared and certified by a Qualified Credentialed Professional (QCP). For priority construction sites, which include any sites that discharge to (1) a waterbody listed on the most recently EPA approved 303(d) list of impaired waters for turbidity, siltation, or sedimentation; (2) any waterbody for which a TMDL has been finalized or approved by EPA for turbidity, siltation, or sedimentation; (3) any waterbody assigned the Outstanding Alabama Water use classification in accordance with ADEM Admin. Code r. 335-6-10-.09; and (4) any waterbody assigned a special designation in accordance with ADEM Admin. Code r. 335-6-10-.10, the CBMPP must be submitted to ADEM for review along with the NOI. A Qualified Credentialed Inspector (QCI) or QCP must conduct regular inspections of regulated construction activities to ensure effective erosion and sediment controls are being maintained. In certain circumstances, the QCI or QCP must also monitor construction site discharges for turbidity.

On December 1, 2009, the EPA published effluent limit guidelines (ELGs) and new source performance standards (NSPS) for regulated construction sites. The regulation was effective on February 1, 2010. All permits issued by the EPA or states after this date must incorporate the final rule requirements. Although certain parts of the rule were since stayed, ADEM's General Permit incorporates those non-numeric effluent limits promulgated by EPA and which remain in effect.

MS4 NPDES PERMIT: The MS4 NPDES Program, administered by ADEM, requires certain designated municipalities and other entities to obtain an MS4 permit (either Phase I or Phase II). Portions of Mobile County are located within a Phase II MS4 permitted area and the corporate boundaries of the City of Mobile are covered under a Phase I MS4 permit. The Phase II MS4 General Permit was issued January 31, 2011 and coverage under that permit was granted to the Mobile County Commission, and became effective April 4, 2013 (Permit #ALR040043). The Phase II MS4 General Permit expires January 31, 2016. ADEM issued NPDES Permit No. ALS000007 to the City of Mobile for discharges from its MS4, which became effective on October 1, 2014 and expires on September 30, 2019.

CWA § 303(D): ADEM is required by the EPA to designate waters for which technology-based limits alone do not ensure attainment of applicable water quality standards. This list is to be submitted to the EPA on April 1 of each even-numbered year. Impairments include things such as nutrients, pesticides, pathogens, metals, organic enrichment, and siltation, among other things, and can be caused by point sources or non-point sources. The impaired waters must then be sampled and a TMDL amount or limit must be calculated.

Fowl River has been determined to be impaired, but a TMDL has not been calculated at this time. The current draft TMDL date is 2020. Any activity within the Fowl River Watershed should take into consideration the cause of the listing (mercury) and determine if the proposed action could potentially contribute to the impairment. If a proposed activity could contribute to the impairment, the best available technology should be considered to minimize the potential of contributing to the impairment of Fowl River.

7.0 REGULATORY REVIEW

COASTAL ZONE MANAGEMENT: ACAMP, Alabama Code § 9-7-1 et seq., requires approval by ADEM for most construction and development activities within the coastal area through regulations established in ADEM Admin. Code Reg. 335-8. The inland boundary of the coastal area in Alabama is the continuous 10-foot contour where the land surface elevation reaches 10 feet above sea level. The coastal area includes all land lying seaward of the 10-foot contour. ACAMP is a joint effort of the ADCNR State Lands Division (SLD) and the ADEM Coastal Program. The ADCNR-SLD is responsible for planning and policy development, while ADEM is responsible for permitting, monitoring, and enforcement activities. A significant portion of ADEM's permitting, monitoring, and enforcement activities in the coastal area are related to determining federal consistency for projects and activities that require federal permits, such as Section 404 permits issued by the USACE.

7.3.3 Mobile County

MOBILE COUNTY FLOOD DAMAGE PREVENTION ORDINANCE (March 2010): The Mobile County Flood Damage Prevention Ordinance applies to all areas of special flood hazard within the jurisdiction of Mobile County. Although the primary focus of the Ordinance is to regulate activities within designated flood hazard zones, the Ordinance does include regulations that also help protect water quality. The Ordinance includes measures to control the alteration of natural floodplains, stream channels, and natural protective barriers that are involved in the accommodation of floodwaters. The protection of these areas is important to the overall water quality of the Fowl River Watershed.

MOBILE COUNTY SUBDIVISION REGULATIONS (Amended April 2005): The Mobile County Subdivision Regulations are administered by the Mobile County Commission. These regulations apply to every subdivision of land in all unincorporated areas of Mobile County that do not lie within the planning jurisdiction of any municipal planning commission. The primary purpose of the regulations is to establish procedures and guidelines for the development of subdivision or proposed additions to existing subdivisions related to minimum size of lots; the planning and construction of streets, roads, and drainage features; and the installation of water and sewer facilities. Portions of Sections 4, 7, and 8 include provisions related to water quality. Section 4.12 requires the design of subdivisions to implement measures to protect streams and other water bodies. This section also requires a written statement that all applicable federal and state permits have been acquired prior to the approval of construction plans. Section 7.5 requires that good engineering practice, judgement, and criteria be employed to control stormwater runoff, and water detention shall be employed where required by such good engineering practice, judgement, and criteria. This section also requires that best management practices be used during construction. Section 8.1 includes stormwater detention requirements for any watershed that contains a public drinking water source. The detention requirements include a maximum release rate equivalent to the 10-year storm pre-development rate, and a minimum detention capacity for the volume of a 50-year post development storm.

MOBILE COUNTY MS4 PHASE II PERMIT (April 2013): The Phase II MS4 General Permit was issued January 31, 2011. Coverage under this permit was granted to the Mobile County Commission and became effective April 4, 2013 (Permit #ALR040043). The Phase II MS4 General Permit expires January 31, 2016. The MS4 permit for Mobile County requires the implementation, maintenance, and enforcement of a stormwater management program plan to reduce the discharge of pollutants to and from the MS4 to the maximum extent practical, thus protecting water quality.

MOBILE COUNTY STORMWATER MANAGEMENT PROGRAM PLAN (October 2013): The Mobile County Stormwater Management Program Plan was prepared by the Mobile County Commission as part of the requirements of the County's NPDES MS4 Permit. The plan was created to protect water quality by reducing, to the maximum extent practicable, the discharge of pollutants in stormwater. The plan documents that no state law, ordinance, or other regulatory mechanism exists to provide the Mobile County Commission the authority to inspect and enforce the implementation of proper erosion and sediment controls, controls for other wastes from construction sites or post-construction stormwater management controls. The plan states that if non-compliance with the standards established by ADEM regarding erosion and sediment controls are identified, a representative of the stormwater management program should contact ADEM for assistance with enforcement.

7.0 REGULATORY REVIEW

7.3.4 City of Mobile

MOBILE CITY CODE CHAPTER 17: STORMWATER MANAGEMENT AND FLOOD CONTROL (June 2, 2014): This ordinance includes measures to control land disturbance activities and stormwater drainage facilities within the corporate limits of the City of Mobile. The primary goal of the ordinance is to promote the public health, safety, and general welfare, and to comply with federal and state regulations and programs which regulate stormwater management and flooding. The ordinance includes land disturbance permit requirements for all residential sites that disturb 4,000 square feet or more. All subdivision, commercial, and industrial sites that disturb land are required to obtain a land disturbance permit. The permit requires the development and implementation of an erosion and sediment control plan and requires that post-construction runoff mimics pre-construction runoff.

The ordinance also includes regulations related to stormwater drainage within the City. This section includes the implementation of a storm drainage service charge for each lot or parcel within the City. The primary consideration in establishing the service charge is each property's contribution to runoff. Additional consideration is given for properties that provide their own stormwater management facilities, which may have their storm drainage service charges reduced.

CITY OF MOBILE STORMWATER MANAGEMENT PROGRAM PLAN (May 2014): The City of Mobile Stormwater Management Program Plan was prepared as part of the requirements of the City's NPDES MS4 Permit (Permit #ALS000007). The plan was created to control the quality of stormwater discharged from the City of Mobile's MS4 and includes pollution prevention measures, stormwater monitoring, use of legal authority, and other appropriate means. The plan provides detailed information of the requirements for obtaining a land disturbance permit, as well as goals for revising permit requirements to ensure the City is in compliance with the MS4 permit. The plan also includes requirements for post-construction runoff control. Post-construction runoff control requires that developers submit an As-Built Certification that includes flow calculations documenting that post-construction runoff mimics pre-construction runoff.

7.4 REGULATORY OVERLAP

Federal, state, and local regulations overlap within the Fowl River Watershed. Federal and state water quality regulations apply to all areas within the Watershed, and portions of the City of Mobile, and the Mobile County MS4 permits apply in the northeast portions of the Watershed. Land disturbance activities within the Watershed must have:

- A CWA §404 permit with review by all agencies and the public, if not authorized by a NWP (if disturbance activity proposes to fill jurisdictional waters of the U.S.)
- ADEM water quality certification (if disturbance activity proposes to fill jurisdictional waters of the U.S.)
- ADEM Coastal Program approval (if within the coastal area)
- ADEM General NPDES Permit No. ALR100000 (if disturbances are equal to or greater than 1 acre)
- City of Mobile Land Disturbance Permit (if located within the boundaries of the City of Mobile MS4 Permit)

The City of Mobile has extraterritorial jurisdiction that extends up to five miles beyond its boundaries for planning purposes, and overlap into the County, but not the adjacent municipality. This extraterritorial boundary is for planning purposes only; therefore, only the federal, state, and county water quality regulations apply to these areas. All regulations state that where there is an overlap in jurisdiction within the Watershed, the more stringent requirements apply.

The regulatory matrix shown in **Table 7.1** compares the current regulations within the Watershed and is based on several critical elements of effective stormwater management. The matrix considers four primary review categories: construction phase stormwater management, post-construction stormwater management, protection of jurisdictional waters of the U.S., and coastal area protection. The table summarizes the results of the review of regulations and ordinances for the three entities having jurisdiction within the Watershed. Footnotes are provided to reference the regulations and ordinances from which the information is derived.

Although the City of Mobile has regulations and ordinances to control land disturbance activities (including permitting, inspections, enforcement, and post-construction runoff control requirements), these regulations and ordinances are only applicable in the small portion of the Fowl River Watershed that lies within the City of Mobile corporate limits. The remaining area of the Watershed is within the jurisdiction of the County. Although portions of the Watershed are located within the boundaries of the Mobile County MS4, the County lacks authority to establish regulations and ordinances related to the inspection of construction sites and enforcement actions for non-compliance. The majority of the Watershed relies on federal and state agencies to set standards and enforce water quality regulations.

7.0 REGULATORY REVIEW

TABLE 7.1: CURRENT REGULATIONS WITHIN THE FOWL RIVER WATERSHED			
	ADEM	**Mobile County**	**City of Mobile**
Construction Phase Stormwater Management	Yes	No[6]	Yes
Design Standards	AL Handbook*[1]	N/A	AL Handbook**[10]
Design Storm Event	2yr - 24hr[1]	N/A	Not specified
Site Size	≥1 acre[2]	N/A	> 4,000 sqft[12]
Stabilization Times	13 days[1]	N/A	10 days[12]
Inspection Requirements	1/month or 3/4" rain[1]	N/A	Yes[13]
BMP Maintenance/Repair Times	5 days[1]	N/A	No
Non-Compliance Reporting	Yes[3]	N/A	No
Turbidity Monitoring	Yes[4]	N/A	No
Buffer Requirement	Yes - unspecified width[1]	N/A	No
Post-Construction Stormwater Management	No	In special† watersheds[7]	Yes
SW Quality	N/A	No	Yes
SW Quantity	N/A	Yes	Yes
Design Storm	N/A	10yr/50yr[7,8]	100yr[12]
Site Size	N/A	Any	> 1 acre[12]
Inspection Requirements	N/A	No	Annually[12]
Maintenance	N/A	Designated[7]	Developer/owner[12]
Reporting	N/A	5 yrs or ownership change	Annually[12]
Calculation Method	N/A	Not specified	Not specified
Waters of the U.S. Protection			
Permit Requirement	In coastal areas[5]	ADEM/USACE	ADEM/USACE
Setback Requirement	No	No	No
Buffer Requirement	No	Yes, variable[7,9]	No
Coastal Area Protection	Yes[5]	No	No

Footnotes:

1. ADEM NPDES General Permit #ALR100000, Part III
2. ADEM NPDES General Permit #ALR100000, Part I
3. ADEM NPDES General Permit #ALR100000, Part IV
4. ADEM NPDES General Permit #ALR100000, Part V
5. ADEM Admin. Code Reg. 335-8 (Coastal Area Management Program)
6. The Mobile County Stormwater Management Program Plan explains that the Mobile County Commission has no authority to inspect and enforce the implementation of proper erosion and sediment controls.
7. Mobile County Subdivision Regulations, Section 8 (†A special watershed is defined in Section 8 as any watershed which contains a public drinking water source, including, but not necessarily limited to, the J.B. Converse Watershed).
8. Maximum release rate equivalent to the 10-year pre-development rate/detention capacity to accommodate volume from a 50-year, post-development storm.
9. Buffer Zone is within 100 feet of public drinking water source; within 50 feet of perennial streams & their associated wetlands; & within 25 feet of natural drainage features & their associated wetlands. Only applies to Section 8 of the Mobile County Subdivision Regulations.
10. City of Mobile Engineering Department Land Disturbance Permit Checklist
11. City of Mobile Stormwater Management Program Plan
12. Mobile City Code Chapter 17: Storm Water Management and Flood Control (June 2, 2014)
13. The City of Mobile Stormwater Management Program Plan states that qualifying sites are inspected every two months at a minimum, and priority construction sites are inspected monthly at a minimum.

*Alabama Handbook for Erosion Control, Sediment Control, and Stormwater Management on Construction Sites and Urban Areas, March 2009
**Alabama Handbook for Erosion Control, Sediment Control, and Stormwater Management on Construction Sites and Urban Areas, Latest Version

7.4.1 Regulatory Inconsistencies

Due to a lack of state laws, ordinances, or other regulatory mechanisms, the Mobile County Commission does not have the authority to implement regulations and ordinances to inspect and enforce proper erosion and sediment controls, post-construction stormwater management controls, and controls for other construction site wastes; therefore, there is little potential for regulatory inconsistencies within the Fowl River Watershed. The Watershed is primarily regulated by federal and state regulations, and there are no major inconsistencies with those regulations.

Recommendation: Should state laws, ordinances, or other regulatory mechanisms be established that would provide the Mobile County Commission authority to implement regulations and ordinances, the County Commission should work closely with the City of Mobile and federal and state agencies to ensure consistency and minimize redundancy among regulations.

7.4.2 Regulatory Deficiencies

OBSERVATION 1: The City of Mobile Post-Construction Stormwater Regulations states that inspections of post-construction stormwater management best management practices shall be completed by a QCI or QCP. The QCI training programing only includes training on inspections during construction and does not include training of post-construction best management practices. In addition, not all individuals covered by the definition of a QCP are qualified to inspection post-construction best management practices.

Recommendation: The City of Mobile should consider revising post-construction regulations related to inspection of post-construction stormwater management best management practices to ensure that all inspections are conducted by qualified QCPs.

OBSERVATION 2: The City of Mobile Stormwater Management and Flood Control Ordinance provides the City regulatory authority to charge stormwater user fees. The City, however, does not currently charge these fees.

Recommendation: The City of Mobile should consider implementing a stormwater user fee; however, because City jurisdiction only covers a small portion of the Fowl River Watershed, charging these fees is not considered an immediate need.

OBSERVATION 3: Except as it relates to flood control, there are currently no federal or state post-construction stormwater management controls, which leaves these regulations to fall under local government jurisdiction. Since only a small portion of the Watershed is regulated by local ordinances and regulations, the majority of the Watershed has no post-construction stormwater control regulations. The majority of the Fowl River Watershed (approximately 86 percent) is currently undeveloped; therefore, post-construction stormwater controls are not likely an immediate need.

Recommendation: Although not considered an immediate need, federal and state agencies should consider updating their regulations to incorporate post-construction stormwater controls within the Watershed. In addition, should additional county authority become available, the County should consider implementing post-construction stormwater requirements based on the size of each development and its potential impact to the Watershed due to stormwater runoff.

7.4.3 Enforcement

Since the majority of the Watershed relies on federal and state entities to inspect sites and issue enforcement measures, stakeholders within the Watershed should consider forming a coalition and creating a collaborative initiative to routinely monitor activities within the Watershed. Providing additional support to the federal and state agencies with enforcement rights will help identify water quality concerns within the Watershed in a timely manner. These concerns can then be presented to the agencies authorized to implement the enforcement actions necessary.

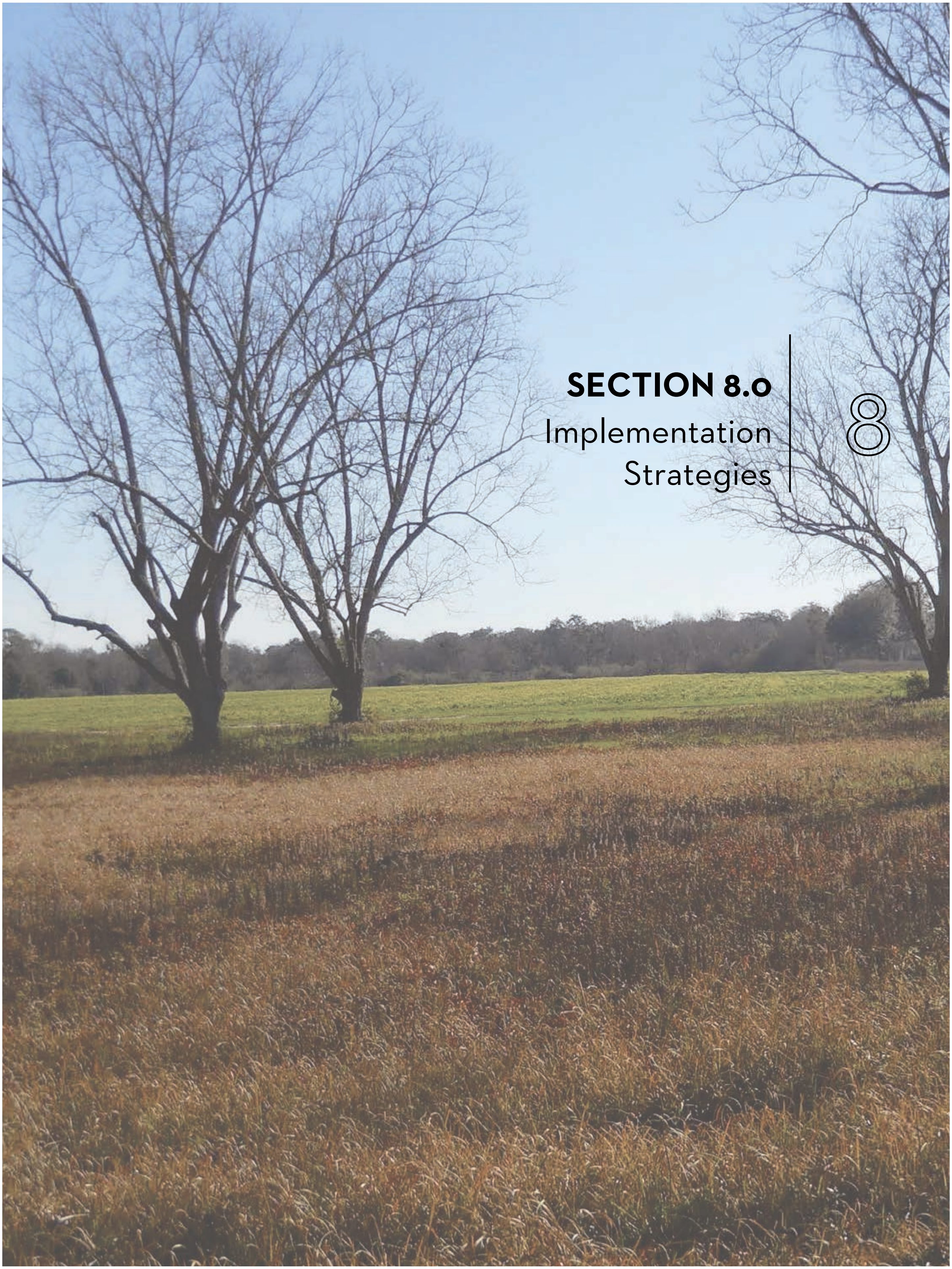
7.4.4 Protection of Wetlands and Riparian Buffers

Wetlands and riparian buffers within the Watershed are extremely valuable in the protection of Fowl River and its tributaries. These resources not only provide habitat for wildlife and aid in controlling floodwaters, they also play a vital role in protecting the water quality of Fowl River. These areas assimilate sediments and nutrients; provide organic material as food for invertebrates, fish, and wildlife; supply woody debris that provides fish habitat; and help moderate water temperatures. According to land use data within the Watershed, approximately two-thirds of the Watershed currently consists of wetlands and forested areas, and the majority of Fowl River and its tributaries are protected by these areas. The State of Alabama does not currently have established buffer or setback requirements related to wetlands and riparian buffers. Federal and state permits are regularly issued, allowing wetlands, streams, and riparian buffers to be impacted. Although mitigation for these impacts are typically required, mitigation measures often occur outside of an impacted watershed, creating a net loss of these valuable resources within the watershed.

Recommendation: Although wetlands and riparian buffers are not being significantly impacted within the Watershed currently, a proactive approach should be taken to protect and enhance these areas and preserve these resources. Federal and state agencies should consider updating their regulations to incorporate buffer and setback requirements, with emphasis on requiring implementation of mitigation measures where permitted impacts occur within the Watershed. In addition, should additional county authority become available, the County should consider incorporating buffer and setback requirements for wetlands and riparian buffers to provide increased protection of these resources.

SECTION 8.0
Implementation Strategies

8



8.0 IMPLEMENTATION STRATEGIES

A variety of management measures are needed to address the threats to the health of the Fowl River Watershed. To implement these measures successfully, a clear and concise strategic approach should be developed. The actions and strategies listed are recommended to successfully implement management measures recommended in this Watershed Management Plan (WMP). The following priority actions should be undertaken as soon as possible, many of which can be executed concurrently:

1. **Establish a Watershed Management Task Force (WMTF).** The WMTF should immediately seek funding, assess the current regulatory framework, and work with the Mobile County officials to include all best management practices and low impact development (LID) strategies for new development regulations;

2. **Advocate for the updating of subdivision regulations and encourage retrofitting of existing developments** to meet best management practices and LID standards;

3. **Implement projects to armor and protect spits in the coastal zone.** Study wetland function and hydrologic flow from the headwaters to the estuary;

4. **Install watershed signage**, especially no wake zone and safety signs to warn boaters and skiers of unsafe conditions;

5. **Advocate for improved household waste management** through consistent garbage collection, trash management via drop off and collection centers, and enforcement of illegal dumping laws;

6. **Emphasize a public outreach,education and community involvement program.** One aspect of this should be a Volunteer Monitoring Program modeled after, if not part of, the Alabama Water Watch Program (www.alabamawaterwatch.org). Community education and outreach should focus on reducing boat wakes, litter reduction campaigns, and reducing fertilizer use in the Watershed (see Smart Yard, Healthy Gulf Program http://masgc.org/smart-yard-healthy-gulf/fertilizer-guidelines);

7. **Emphasize leveraging funding sources** to address wetland and stream restoration projects and stormwater management projects in the upper Watershed with willing landowners. These potential funding sources should be considered:

    - U.S. Fish and Wildlife Service (USFWS)
    - Alabama Department of Environmental Management (ADEM)
    - Alabama Department of Conservation and Natural Resources (ADCNR)
    - U.S. Environmental Protection Agency (EPA)
    - Mobile County
    - U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS)
    - RESTORE Act
    - National Fish and Wildlife Foundation (NFWF)

8.0 IMPLEMENTATION STRATEGIES

The approach should involve all stakeholders within the Watershed, as well as city, county, state, and federal agencies, listed in **Table 8.1**. Coordination of these many stakeholders, including federal, state and county agencies such as the Mobile County Soil and Water Conservation District, which works toward improving private lands through the wise use of natural resources would be greatly enhanced by the establishment of a WMTF.

TABLE 8.1: FOWL RIVER WATERSHED STAKEHOLDERS:

Local residents
Fowl River Area Civic Association (FRACA)
Other local civic organizations
City of Mobile
Mobile County
Alabama Department of Environmental Management (ADEM)
Mobile Bay National Estuary Program (MBNEP)
U.S. Fish and Wildlife Service (USFWS)
Natural Resources Conservation Service (NRCS)
U.S. Army Corps of Engineers (USACE)
Alabama Department of Conservation and Natural Resources (ADCNR)
Alabama Cleanwater Partnership (ACP)
Alabama Forestry Commission (AFC)
ALFA Farmers Federation
Alabama Department of Transportation (ALDOT)
Mobile County Soil and Water Conservation District
Alabama Cooperative Extension

8.1 WATERSHED MANAGEMENT TASK FORCE

The issues and problems threatening the health of the Fowl River Watershed occur throughout the entire Watershed and extend across political boundaries. Because of the connectedness of the Watershed, even construction north of I-10 affects runoff, flows, and water quality south of Fowl River Road. Since a majority of the Watershed relies on federal and state entities to inspect sites and enforce management measures, stakeholders should consider forming a coalition and developing a collaborative initiative to routinely monitor activities within the Watershed. The most effective way is to create a public-private organization, a Fowl River WMTF, to promote, encourage, implement, and facilitate the recommended management measures. A crucial component for the WMTF would be a Community Relations and Public Awareness Program.

The WMTF should provide additional support to the federal and state agencies with enforcement rights within the Watershed. Routinely monitoring activities in the Watershed expedites the process of submitting water quality concerns to the appropriate regulatory agencies so that they can implement the enforcement actions necessary.

8.0 IMPLEMENTATION STRATEGIES

Establishment of a public-private partnership may provide additional funding options for watershed management measures, Additionally, this illustrates the community's resolve to serve as vested and committed partners in the watershed management process. This would significantly enhance the viability of applications for available federal, state, local, and private grant assistance needed for implementation of management measures.

The WMTF should consist of representatives of the stakeholder groups listed in **Table 8.1**. The MBNEP Project Implementation Committee (PIC) is an established group comprising many of the agencies and/or entities identified in **Table 8.1**. A local organization such as FRACA working alongside the PIC could champion implementation and management efforts. If feasible, a funded Watershed Coordinator position could also be established to provide one-on-one, full-time attention to the various issues affecting the Watershed. The WMTF would report to the Mobile County Commission, City of Mobile, and MBNEP.

8.2 PROJECT PRIORITY

Projects were prioritized based on the magnitude of threat to the natural resource, cost benefit analyses, and availability. A combination of historical aerial imagery available from the University of Alabama, Google Earth's timeline feature, Steering Committee imagery provided by Sam St. John and others, and community input all indicate that coastal shorelines are the most threatened.

8.2.1 Coastal Zone Projects

Figure 8.1 shows a number of shorelines and marshes along Fowl River that were identified as potential locations for protection, restoration, enhancement, and/or preservation. These locations generally include spits, marshes, sandy shorelines, vegetated banks, and the remnants of old spits, locally referred to as "islands."

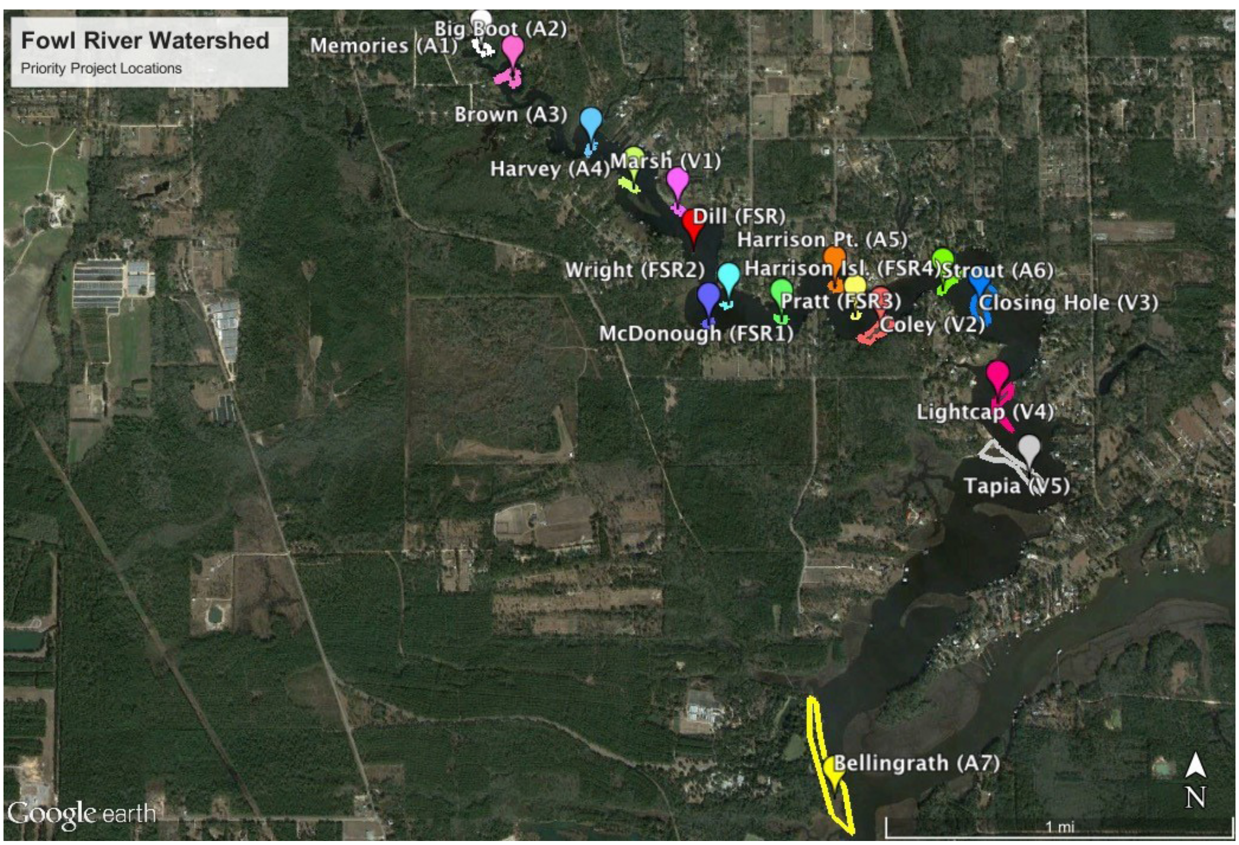


Figure 8.1: Location overview map of proposed shoreline and/or marsh project locations in the Fowl River Watershed

8.0 IMPLEMENTATION STRATEGIES

These proposed project locations and their characteristics are sensitive to a range of vulnerabilities and forces in each zone (see Section 4.6.1 and **Figure 4.32**), which are graphically represented in **Figure 8.2**. For example, spits have high vulnerability in Zone I (marine) caused by erosion from boat wakes and submergence from relative sea level rise. In Zone II (transition), the freshwater and saltwater marshes have a high vulnerability and are sensitive to relative sea level rise and salinity fluctuations. Steep vegetated banks are most vulnerable in Zone III (fresh) caused by their sensitivity to erosion during high flow events.

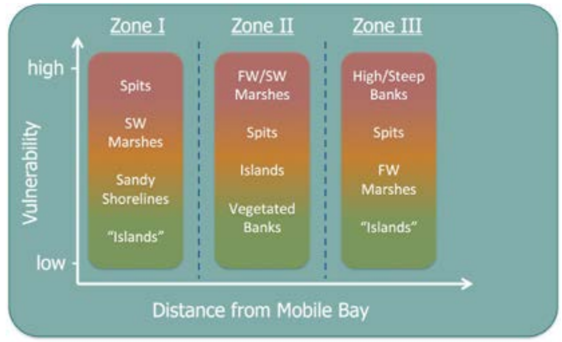


Figure 8.2

The strategies used to address shoreline and marsh vulnerability at the selected locations include preservation, enhancement, and stabilization. Based on the condition of the shoreline or marsh, one of these strategies will take priority for any number of reasons. For example, project locations in Zone I are generally characterized by healthy marshes and mostly stable shorelines. Strategies in these areas should focus on preservation with stabilization and/or enhancement considered over time. By contrast, strategies in Zone II may focus on enhancement of existing marshes or shorelines to address weaknesses in those locations. In Zone III, the steep and eroding banks may require stabilization first with enhancement and preservation as future considerations. The distribution of strategies in terms of priority and zone is depicted in **Figure 8.3**.

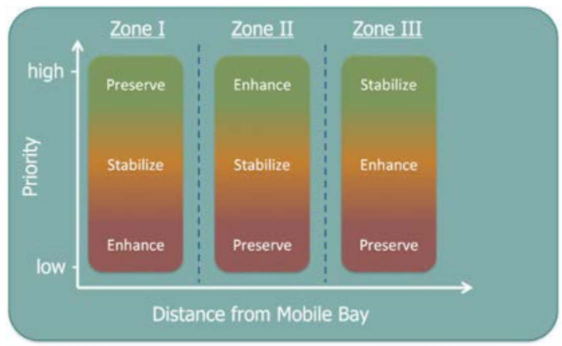


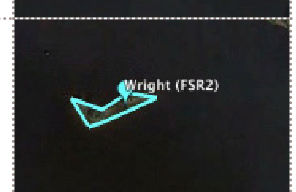
Figure 8.3

After considering the vulnerability and potential strategies for each of the identified project locations, the projects were ranked in terms of priority. The potential benefit of protection, preservation, or restoration in terms of watershed function and habitat value was also considered in the prioritization process. The prioritization of individual projects is listed in **Table 8.2**, along with supporting information and a location graphic for each. In some instances, several projects have been grouped together based on their functional dependence. These projects should be considered as a whole in planning for funding and design, but could potentially be pursued separately, or in phases, if necessary.

8.0 IMPLEMENTATION STRATEGIES

TABLE 8.2: PRIORITY COASTAL PROJECTS					
Priority (Zone)	**Location Name**	**Length (ft)/ Area (acres)**	**Est. Cost**	**Brief Description**	**Location Diagram**
1 (I)	Lightcap	1800 / 1.7	$2.1M	Proposed salt marsh enhancement and protection would include structural stabilization, fill, and appropriate vegetation.	
2 (I)	Tapia	2800 / 4.2	$3.2M	Proposed salt marsh enhancement and protection would include structural stabilization, fill, and appropriate vegetation.	
3 (I)	Strout	1300 / 0.8	$1.5M	Proposed spit and salt marsh enhancement and protection would include structural stabilization, fill, and appropriate vegetation.	
4 (I)	Closing Hole	1700 / 3.2	$2.0M	Proposed spit and salt marsh enhancement and protection would include structural stabilization, fill, and appropriate vegetation.	
5 (II)	Coley	1500 / 2.2	$1.7M	Proposed marsh protection and restoration with limited use of structure to re-establish edge, fill, and marsh plantings.	
6 (II)	Harrison Pt.	880 / 0.9	$1.0M	Proposed spit (tip) stabilization with some structure, sand fill, and appropriate vegetation.	
7 (III)	Marsh	1700 / 2.5	$2.0M	Proposed marsh restoration to include planting, fill, and structure as needed.	
8 (III)	Harvey	2800 / 2.5	$3.2M	Proposed spit stabilization to include fill, vegetation, structure; re-establish connection to downstream spit.	

8.0 IMPLEMENTATION STRATEGIES

Priority (Zone)	Location Name	Length (ft)/ Area (acres)	Est. Cost	Brief Description	Location Diagram
9 (III)	Brown	880 / 0.6	$1.0M	Proposed spit stabilization at base and tip with limited use of structure, some fill, and vegetation as appropriate.	
10 (III)	Big Boot	1300 / 1.4	$1.5M	Proposed spit stabilization at base and along north bank as needed. Actual length and cost of protection likely lower.	
11 (III)	Memories	940 / 1.0	$1.1M	Proposed stabilization and reinforcement of weak areas with limited use of structure, sand fill, and vegetation. Actual length and cost of protection likely lower.	
12 (I)	Bellingrath	2200 / 12.5	$2.5M	Proposed bank enhancement and protection would include (non-) structural stabilization, fill, and appropriate vegetation.	
13 (II)	Harrison Isl.	400 / 0.25	$0.4M	Proposed future submerged reef to include signage and supplemental structure for fish habitat.	
14 (II)	Dill	480 / 0.3	$0.5M	Possible restoration opportunity to include limited use of structure, fill, and vegetation.	
15 (II)	McDonough	540 / 0.4	$0.6M	Proposed future submerged reef to include signage and supplemental structure for fish habitat.	
16 (II)	Pratt	580 / 0.4	$0.7M	Proposed future submerged reef to include signage and supplemental structure for fish habitat.	
17 (II)	Wright	475 / 0.3	$0.5M	Proposed future submerged reef to include signage and supplemental structure for fish habitat.	

8.2.2 Coastal Zone Land-Purchase Program

Issues facing Coastal Zone 1 of lower Fowl River are sea level rise and loss of habitat. The Sea Level Affecting Marshes Model (SLAMM) analyses (see Section 4.6.2 and Appendix B) show that tidal marsh habitats have adequate space to migrate into low-lying undeveloped upland areas as sea levels rise. With existing development, the "holding-the-line" management scenario only impacts 24 acres of potential tidal marsh habitat. Accordingly, it is recommended that large undeveloped tracts in the lower Fowl River Watershed are identified for potential public acquisition as conservation easements to ensure adequate land area for upland migration of tidal marsh habitats with future sea level rise. These areas will primarily be adjacent to and immediately inland of existing tidal marshes.

8.2.3 No Wake Signage

The assessment of the coastal portions of the Fowl River Watershed indicate boat wakes contribute to the erosion of shorelines, coastal marshes, and grass islands. An appropriate management measure would be to designate portions of the lower River, where critically endangered shorelines are located, as "no wake" zones. Signs should be posted to inform recreational and commercial boaters.

8.2.4 Proposed Coastal Resiliency Program

The Geological Survey of Alabama (GSA) (2012) has determined approximately 75 percent of the coastal zone of Fowl River shoreline, which encompasses Fowl River below Fowl River Road (see Section 4.6.1), is natural, and 25 percent is armored, with 80 percent of the armored shoreline consisting of vertical bulkheads. Vertical bulkheads degrade habitat at their toes and reflect boat wake energy to nearby unprotected shorelines, causing erosion. A much better alternative is the Living Shoreline. Living shorelines combine engineered erosion controls that use living plant material, oyster shells, earthen material or a combination of natural structures with riprap or offshore breakwaters to protect property from erosion (Boyd, 2007). Living shorelines are designed to absorb and dissipate energy, rather than reflect it, while providing habitat for aquatic life.

The Nature Conservancy, in cooperation with the National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), Association of State Floodplain Managers, University of Southern Mississippi, and Center for Integrated Spatial Research, has developed the framework for the proposed Coastal Resilience Program (http://coastalresilience.org/). Through this program, partial funding would be made available to offset the costs of creating natural, erosion-resistant (living) shoreline for private landowners instead of habitat-degrading, vertical bulkheads. Training contractors on how to properly install living shorelines is important to ensure projects are completed successfully and to increase the number of qualified contractors. This training can be accomplished through professional workshops and training courses sponsored by public, private, and non-profit organizations. This ongoing program would help decrease the amount of armored shorelines, enhancing the aesthetics and increasing ecological diversity and habitat. A coordinated effort to identify potential bulkhead retrofit locations and willing landowners would allow longer and more contiguous shorelines to be converted from hardened bulkheads to living shorelines.

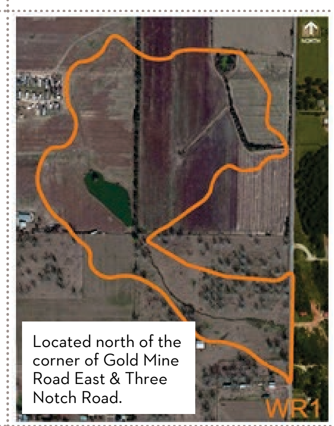
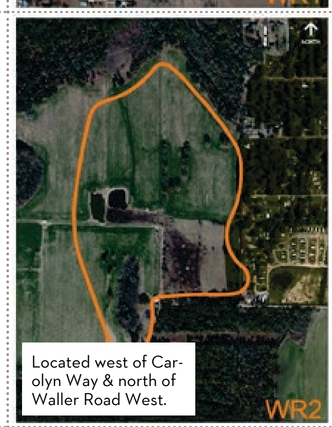
8.0 IMPLEMENTATION STRATEGIES

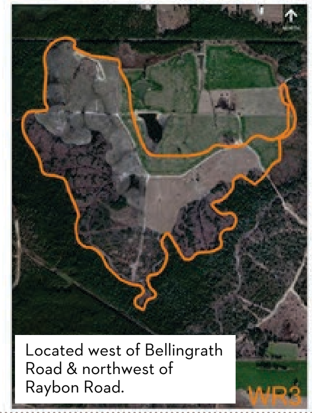
8.2.5 Headwaters Priority Projects

As discussed in the WMP, a watershed-based approach to restoration and preservation is needed to provide the greatest opportunity to mitigate current and future development and maintain high water quality. Activities within the upper portion (or headwaters) of the Watershed can positively or negatively affect downstream conditions. Analysis of water quality data (see Section 5) reveals that high bacterial (from cattle) and nutrient concentrations exist within the Watershed. Proper management of nutrients will reduce incidences of low dissolved oxygen and/or hypoxia and improve ecological conditions.

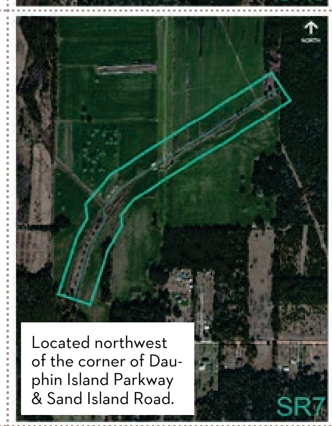
Headwaters priority projects include an assortment of opportunities to manage upstream flows, increase nutrient and bacteria uptake/removal, provide increased wildlife utilization, and offset future development within the Watershed. Partnerships with willing landowners will be required for all headwater projects, including restoration and preservation. Restoration of impaired wetlands and streams and implementation of stormwater management projects will have the greatest benefits to nutrient and sediment removal. Wetland restoration projects (WR1, WR2, and WR3) are wetlands that have experienced significant change in land use and likely have experienced various types of hydrologic alterations. Similarly, stream restoration projects (SR1 - SR7) have been altered through channelization and changes in land use (mostly forested riparian buffers converted to row crops). Implementation of projects such as those listed in **Table 8.3** will allow for increased flood capacity and increased nutrient uptake/sediment removal. The prioritization of these projects will be highly dependent upon landowners that are willing to allow restoration to occur on their property. Educating landowners about the various funding sources available will be critical. Although some landowners were consulted throughout the development of this plan, additional conversations are recommended to determine the likelihood of completing the projects outlined. It should be noted that all sites identified in this plan as projects for consideration are included solely due to their potential to have the greatest impact to the health of the watershed (not because of any regulatory deficiencies).

TABLE 8.3: HEADWATER PRIORITY PROJECT SITES WITH ESTIMATED COSTS

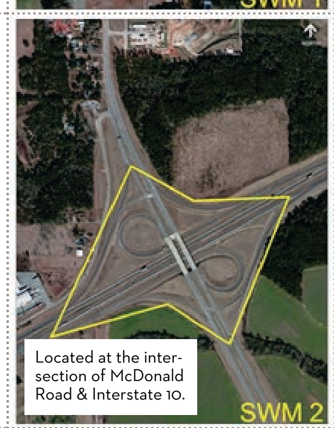
Name	Size	Est. Cost	Potential Funding Mechanism	Description	Location Diagram
WR1	75 acres	$110,000	Mitigation, NRCS, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Historic bottomland hardwood wetlands that have been altered over time. Restoration opportunities include plugging drainage ditches and planting bottomland hardwood species to restore the area back to its natural conditions, providing increased stormwater capacity.	
WR2	59 acres	$85,000	Mitigation, NRCS, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Historic wetland area that is currently being utilized for cattle operations. Restoration would include cattle exclusion and planting native hardwood species. Potential to provide additional flood capacity to nearby residential areas.	

Name	Size	Est. Cost	Potential Funding Mechanism	Description	Location Diagram
WR3	226 acres	$300,000	Mitigation, NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Currently farmland in cattle production. Cattle have free access to adjacent streams Restoration would include cattle exclusion and planting native hardwood species which would increase water quality. Additional benefits would be an overall increase in functional wetland areas with greater pollutant reduction.	 Located west of Bellingrath Road & northwest of Raybon Road.
SR1	630 LF	$150,000	Mitigation, NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Straight-lined/no riparian buffers. Restoration could likely include the installation of in-stream habitat structures & re-establishment of the natural riparian buffer.	 Located directly east of McDonald Road & south of Haskew Drive.
SR2	701 LF	$140,000	Mitigation, NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Straight-lined and overly wide/deep for its drainage area. Restoration would include creating a new, free flowing and meandering channel that is sized properly to match its current drainage area. Additional habitat could be provided by planting the riparian buffer.	 Located north of Waller Road West & west of Bellingrath Road.
SR3	818 LF	$185,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Straight-lined/no riparian buffers. Restoration efforts would include creating a more sinuous channel and creating a greater connection to its floodplain. The benefits would include increasing flood retention and wildlife habitat and decreasing nutrient transport.	 Located north of Waller Road West & east of Bellingrath Road.

8.0 IMPLEMENTATION STRATEGIES

Name	Size	Est. Cost	Potential Funding Mechanism	Description	Location Diagram
SR4	1,208 LF	$300,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Channel had been straight-lined with very little riparian buffers. Restoration would include creating a meandering channel and re-establishing it with a native hardwood riparian buffer.	
SR5	1,089 LF	$350,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Straight-lining of channel/no riparian buffer. Restoration would include a newly constructed, sinuous channel. Benefits would include downstream nutrient reduction and increased flood capacity.	
SR6	3,439 LF	$775,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Headwaters that have been altered through channelization and native vegetation removal. Restoration would include a newly constructed channel and planting the riparian buffer for nutrient reduction.	
SR7	3,734 LF	$1,100,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Straight-lined, too wide for drainage area, and streambank erosion from cattle. Restoration efforts would create a new meandering stream with increased connection to surrounding floodplains and wetlands and added habitat. Cattle exclusion with decrease bacterial contamination.	

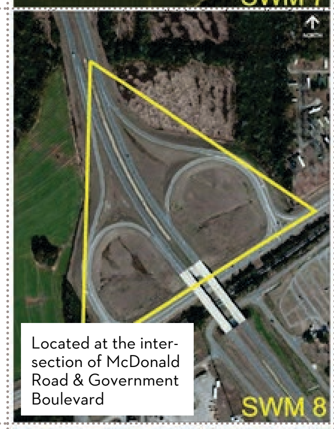
8.0 IMPLEMENTATION STRATEGIES

Name	Size	Est. Cost	Potential Funding Mechanism	Description	Location Diagram
BR1	1,018 LF	$15,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	No riparian buffer to the east of stream channel. Restoration would include planting native hardwood species.	
BR2	912 LF	$20,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Little riparian buffer. Restoration would include additional hardwood species planting.	
SWM1	0.5 acres	$20,000-$40,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Straight lined channel with no riparian buffer. Restoration efforts would include im-plementation of an offline constructed stormwater wetland in the floodplain of the stream. Benefits would include effective management and recharge of stormwater, pollutant removal, and habitat creation.	
SWM2	59.26 acres	$450,000-$1,600,000 (Range due to depth of engineered treatment me-dia and one year storm recurrence interval)	ALDOT, Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Intersection and overpass. Restoration would include utilization of sedimentation and filtration basins within the cloverleaf that house reten-tion layers, leading to water quality improvement through increased retention times.	

8.0 IMPLEMENTATION STRATEGIES

Name	Size	Est. Cost	Potential Funding Mechanism	Description	Location Diagram
SWM3	2.13 acres	$80,000-$170,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Headwaters of a channelized drain that connects to a tributary of Muddy Creek. Restoration efforts would include implementation of an offline constructed stormwater wetland in the floodplain of the stream. Benefits would include effective management and recharge of stormwater, pollutant removal, and habitat creation.	
SWM4	0.19 acres	$7,000-$16,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Section of Muddy Creek with large rocks armoring the south side. Restoration efforts would include implementation of an offline constructed stormwater wetland in the floodplain of the stream. Benefits would include effective management and recharge of stormwater, pollutant removal, and habitat creation.	
SWM5	1.56 acres	$60,000-$130,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Straight lined channel with a highly vegetated streambed connecting to Muddy Creek and surrounding area. Restoration efforts would include implementation of a constructed stormwater wetland for treatment prior to discharge into Muddy Creek. Benefits would include effective management and recharge of stormwater, pollutant removal, and habitat creation.	
SWM6	3.46 acres	$130,000-$280,000	Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Partially straight lined channel and surrounding area directly south of Muddy Creek. Restoration efforts would include implementation of an offline constructed stormwater wetland in the floodplain of the stream. Benefits would include effective management and recharge of stormwater, pollutant removal, and habitat creation.	

8.0 IMPLEMENTATION STRATEGIES

Name	Size	Est. Cost	Potential Funding Mechanism	Description	Location Diagram
SWM7	4.92 acres	$180,000-$400,000	ADEM, NRCS, Mitigation, NFWF, USFWS, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Manmade channel connected to an unnamed tributary. Restoration efforts would include implementation of a constructed stormwater wetland. Benefits would include effective management and recharge of stormwater, pollutant removal, and habitat creation.	
SWM8	33.13 acres	$250,000-$900,000 (Range due to depth of engineered treatment media and one year storm recurrence interval)	ALDOT, Mitigation NRCS, NFWF, USFWS, ADEM, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Intersection and overpass. Restoration would include utilization of sedimentation and filtration basins that house retention layers, leading to water quality improvement through increased retention times.	
SWM9	36.35 acres	$100,000	ADEM, NRCS, Mitigation, NFWF, USFWS, EPA, ADCNR, Mobile County Soil and Water Conservation District, Mobile County, RESTORE	Site with manmade ditches that lie between the Fowl River and associated wetlands. Restoration efforts would include the plugging of ditches to restore the natural hydrology to the area and the re-establishment of native hardwood species. Benefits would include increased stormwater capacity, increased nutrient/sediment removal and increased habitat/wildlife utilization.	

ADCNR = Alabama Department of Conservation and Natural Resources; ADEM = Alabama Department of Environmental Management; ALDOT = Alabama Department of Transportation; NFWF = National Fish and Wildlife Foundation;

8.0 IMPLEMENTATION STRATEGIES

8.3 LOW IMPACT DEVELOPMENT INCENTIVE PROGRAM

Currently 21 percent of the Fowl River Watershed is classified as developed land, and eight percent of the Watershed is covered with impervious surfaces. The population within the Watershed is projected to increase from 19,842 (2015) to 21,235 (2035) over the next 20 years. Numerous studies have documented the negative effects of unmanaged stormwater runoff from impervious surfaces. Unmanaged stormwater runoff increases peak stream discharges, causing flooding, erosion, and increasing sediment loads. Flooding and erosion are already an issue in the Watershed. Stormwater runoff also carries chemicals and trash into the surface water system. Each new home, driveway, patio, and parking lot will add to the amount of impervious surface within the Watershed unless LID techniques are utilized.

In the future, all new development within the Watershed should embrace LID techniques and concepts whenever possible, and existing developments should retrofit stormwater runoff collection points. Financial incentives may be necessary to encourage LID. These incentives could be in the form of tax incentives or outright financial grants to help fund construction. Suggested LID techniques for new residential developments are presented in **Table 8.4**, and recommended retrofits for existing developed areas are presented in **Table 8.5**.

TABLE 8.4: RECOMMENDED LOW IMPACT DEVELOPMENT PRACTICES

Practice	Pollutant Removal*			Cost*
	Sediment	Nitrogen	Phosphorous	
Bioretention Cells	80 - 85%	40 - 50%	45 - 60%	medium/high
Constructed Stormwater Wetlands	80 - 85%	30 - 40%	40%	medium/high
Permeable Pavement	99%	65 - 80%	42 - 80%	high
Swales	35 - 80%	20 - 50%	20 - 50%	low
Level Spreaders and Grassed Filter Strips	40 - 50%	20 - 30%	20 - 35%	low
Rainwater Harvesting	Reduces flooding and erosion			medium
Green Roofs	Decrease runoff and peak flows			high
Riparian Buffers	60 - 85%	30%	35 - 40%	medium
State of Alabama LID Handbook, ADEM, Auburn University, Alabama Cooperative Extension System				

TABLE 8.5: RECOMMENDED RETROFIT LOW IMPACT DEVELOPMENT PRACTICES

Practice	Pollutant Removal*			Cost*
	Sediment	Nitrogen	Phosphorous	
Rain Gardens	Phosphorus and nitrogen removal			low
Curb Cuts	Directs runoff to primary stormwater control measure			medium
Disconnected Downspouts	Directs runoff to primary stormwater control measure			low
Retention Cells (where land is available)	80 - 85%	40 - 50%	45 - 60%	medium/high
State of Alabama LID Handbook, ADEM, Auburn University, Alabama Cooperative Extension System				

8.4 CATTLE EXCLUSION PROGRAM

Cattle with direct access to surface water drainages are recognized as a critical factor in bank erosion (Russell, Iowa State University Extension Service, 2010). In the Fowl River Watershed, they are also suspected of being a primary source for bacteria in the water. Cow manure contains nitrogen and phosphorus (EPA, 2015, accessed at http:/www2.epa.gov/nutrient-policy-data/estimated-animal-agriculture-nitrogen-and-phosphorus-manure), and nitrogen and phosphorus loading are two of the major water quality issues impacting Fowl River.

Ranchers should be encouraged to install fencing to prevent direct access of cattle to surface water drainages. The surface water may be the primary or only source of water for the cattle, so alternate water sources may be necessary. Alternate water sources could include ground water from wells, pumping from streams to holding tanks, or supply by tanker trucks. Fencing and alternate water sources will require financial investment and maintenance costs. The USDA-NRCS, Alabama, has a cattle exclusion program that helps offset the price of limiting cattle access to surface water. Funded practices include fencing to exclude animals from streams, creeks, and rivers; rotational grazing; and watering systems such as pipelines, wells, and watering facilities.

8.5 EDUCATION AND OUTREACH PROGRAM

Management of any natural resource is enhanced by understanding, support, and participation of the stakeholders. Successful implementation of the recommended management measures may not be possible without public education and outreach, which is also one of the EPA's nine key elements for watershed planning. A consistent and targeted education and outreach program will raise public awareness and support for the recommended management measures necessary to protect and improve the health of the Watershed. The outreach program should include scheduled presentations to schools, civic organizations, the Mobile County Commission, the Mobile City Council, and others. Signage should be posted on major thoroughfares to inform drivers that they are entering the Fowl River Watershed. Informational signage at boat landings and public access points should encourage the public to help preserve and protect Fowl River through good stewardship. Trash containers and/or dumpsters with appropriate signage should be co-located at public access points and other strategic locations as a reminder to keep the Watershed clean and free of trash.

The following goals have been identified for the public education and outreach plan:

- Inform, educate, and engage key stakeholders in an effort to increase the public's awareness of the benefits provided by Fowl River, as well as the problems impacting the River and its watershed.
- Develop the public's sense of ownership of Fowl River, along with an understanding of the value of the Watershed resources to the community.
- Provide ways for the public to contribute to the restoration process, such as offering ideas for improving and preserving the Watershed.
- Educate community members so they increasingly value natural resources and recognize the importance of preserving and protecting them.
- Explore additional opportunities for public involvement.

8.5.1 Targeted Audiences

Specific community stakeholders must become the leaders in the WMP implementation process. These targeted audiences, and how implementing the WMP addresses the values important to each, are identified in this section. The following stakeholder groups have the ability to make changes through regulation or policy, participation in restoration activities, management of stormwater runoff, or communication of Fowl River WMP goals and objectives.

LOCAL GOVERNMENT OFFICIALS: Local elected officials and their staff are responsible for establishing priorities for local programs, developing policy, and setting annual budgets. These roles can influence the successful implementation of the Fowl River WMP. This stakeholder group should be informed of the opportunity presented by the WMP to unify the public around a concept – protecting Fowl River will engage local communities and provide access to a historic and productive waterway. The WMP also provides useful information for making decisions related to recreational access and economic development while ensuring protection of environmental resources.

Local government officials can vote to support the Fowl River WMP, develop and implement WMP recommendations and encourage stricter enforcement of regulations related to litter and stormwater management. Local officials should be encouraged to work with state and federal agencies to facilitate WMP projects. They can also promote a sense of watershed community through community-wide activities such as trash collection and tree-planting events. Local government may also provide funding for watershed signage, such as:

- Historic and cultural signage to commemorate significant events or milestones in history;
- "Keep Fowl River Clean," "Fowl River Forever," or "Create a Clean Water Future," signage to positively connect residents with the Watershed;
- Signage to identify the Watershed's biological richness.

PRIVATE INDUSTRY: Success is closely tied to financial support. Support from an active and diverse group of private stakeholders will attract and match sources of federal, state, and local funding. Major institutions within the Fowl River Watershed should be motivated to support the WMP, as all businesses within the Watershed will benefit from its restoration. Local residents will enjoy improved surroundings, a better living environment, and increased satisfaction and pride in their community. Businesses can enhance their public image by demonstrating their support for preservation and restoration of a local resource. The WMP recommends engagement opportunities for private industry in the implementation of projects to support the surrounding community, local workforce, and economy, while promoting their company image and fostering goodwill. Private industry can seize opportunities to become involved in recommended projects, such as installing stormwater retention ponds for their facilities or funding components of other projects and programs throughout the Watershed. Sponsors can be highlighted on signage or plaques.

ACADEMIA: Local schools and higher education institutions have an opportunity to inform students about issues in their community. Teachers and instructors can introduce students to the WMP goals and objectives. The extensive scientific and technical data presented in the WMP regarding the current status of the Fowl River Watershed, and measures to improve conditions, can be utilized as educational tools for all levels of curriculum. The WMP also identifies research opportunities for academic field work benefiting local resources.

Academic institutions can develop multiple curriculums for grades K-12 and beyond; create grade school field trip opportunities throughout the Watershed; identify research and implementation opportunities, including field work and/or data collection with relevant departments at local colleges and universities; and include preservation and restoration initiatives in curriculum when possible.

LOCAL RESOURCE MANAGERS: Local resource managers provide services related to water supply and wastewater treatment to Watershed residents and can assist in guiding water quality management within the Watershed. The WMP-recommended actions will improve water quality for Fowl River by reducing stormwater pollutants and trash in waterways and increasing public understanding of human impacts on water resources. Local resource managers can help by getting involved in Fowl River preservation and restoration efforts, assisting with outreach and communication, and sponsoring community events.

MEDIA: Newspapers, television news programs, online news sources, and radio stations are significant sources of information for the public. The WMP sets the stage for a better future for the Fowl River Watershed and a vision, supported by the public, to preserve the area and provide community-wide access to a beautiful natural resource. Local media can help by publishing stories that highlight the WMP and its recommendations, creating news series describing accomplishments of the Fowl River WMTF, advertising any cleanup or anti-littering events and/or campaigns, and sharing stories about the involvement of local leaders in the WMP.

COMMUNITY LEADERS: Community leaders have a vital role in implementing the WMP and its goals. They should be advocates of the WMP and encourage elected officials to prioritize the WMP recommendations. They should participate in education and outreach, litter reduction campaigns, and sharing restoration ideas. Community leaders should understand that the WMP represents a community-wide approach to protect water quality, habitat, and living resources of the Fowl River Watershed with the goals of improving recreational opportunities, beautifying the area, and highlighting historical and cultural aspects of the Watershed. Community leaders can host events, promote recreational and outreach activities, create and launch neighborhood anti-littering campaigns, and educate residents on the benefits of preservation and restoration to their properties.

8.5.2 Structuring the Fowl River Watershed Management Task Force

Many leaders and stakeholders have been identified through the process of developing the WMP, and some are already involved. The task for the future is not necessarily to identify additional leaders, but rather to determine how the leaders should structure the existing group moving forward into a WMTF. While the MBNEP has led the effort to initiate the work and will continue to support implementation efforts, future efforts and project implementation must be rooted within the community of stakeholders.

The mission of the MBNEP is to promote wise stewardship of the water quality and living resources of Mobile Bay and the Mobile-Tensaw Delta. To support its mission and role in the community, the MBNEP chooses to promote watershed planning and the development of this WMP. The MBNEP recognizes the critical importance of preserving the Fowl River Watershed, but an independent leadership organization should coordinate WMP implementation in close collaboration with the MBNEP.

The WMTF must develop a working coalition with local governmental officials and regulatory agencies to implement the WMP recommendations. The WMTF should provide opportunities for public involvement and membership, organize and coordinate the training of volunteer coordinators on a wide variety of environmental topics, host meetings with community groups and neighborhood associations to equip them with knowledge and materials for promoting the WMP goals and objectives, and collaborate with citizen groups to promote stewardship efforts in preserving and restoring the Watershed. The WMTF should schedule recurring meetings with area media to educate them about watershed management; provide information regarding upcoming events, photos, and other supporting materials; and update them on new developments and opportunities for public engagement by generating press releases on watershed activities. As stated above, the WMTF could consist of a consolidated group from the MBNEP collaborating with a local and active civic group, such as FRACA.

8.5.3 Litter Reduction Program

A Litter Reduction Program should be established as part of the public outreach and education program. Informational signage at boat landings and public access points should encourage the public to help preserve and protect the River through wise stewardship. Trash containers and/or dumpsters should be co-located at public access points and other strategic locations with appropriate signage as a reminder to keep the Watershed clean and free of trash. Community events, such as trash cleanup days, should be employed to both remove trash from the Watershed and reinforce the good stewardship message of "creating a clean water future."

8.5.4 Drainage Ditch Scraping Alternatives

Mobile County routinely removes debris, grass, and accumulated sediment from roadside drainage ditches. This facilitates stormwater drainage and helps prevent and/or decrease flooding. Unfortunately, dredging ditches to bare dirt encourages erosion and transport of sediments. It reduces stormwater infiltration, and adds to the increased stormwater surges and flooding experienced in the downstream portions of the Fowl River Watershed. As part of a stormwater best management practices program, the WMTF should encourage Mobile County to implement alternative ditch cleaning methods that do not expose bare dirt. Alternative methods include cutting grass and vegetation back to a very low level, and removal of debris without grass removal.

8.5.5 Chemical Spraying Management Program

Several entities (ALDOT, Mobile County, Alabama Power Company, and gas companies) routinely spray rights-of-way and transmission lines with chemicals to inhibit vegetative growth. As part of the public outreach and education program, the WMTF should encourage organizations utilizing chemicals to closely monitor the volumes and types of chemicals used, utilize the least amount possible, and remain up-to-date on research pertaining to the use of such chemicals.

Figure 8.4: Trash in Muddy Creek; Figure 8.5: Example of public awareness signage; Figure 8.6: Fowl River community cleanup event held in 2015; Figure 8.7: Recently cleared ditch; Figure 8.8: County maintenance crew at work

8.5.6 Volunteer Monitoring Program

An important part of the WMP Implementation Strategy is to create interest and encourage participation by watershed residents. One way to achieve this is to create a local volunteer monitoring program. The Alabama Water Watch (AWW) organization is an outstanding example of this type of program. It is a citizen-volunteer, water quality monitoring program that has data collection stations located on all of the major river basins in Alabama. The goals of the Fowl River Watershed volunteer monitoring program would be to:

- educate residents on water quality issues and create interest in the health of the Watershed;
- train citizens to use standardized equipment and techniques to gather water quality information of sound quality; and
- enable citizens to maintain and improve the health of the Watershed by using their data for environmental education, restoration and protection, and stewardship.

Volunteer monitoring locations should initially include all of the data collection stations listed in **Section 10.3** and **Table 10.1**. As data collection and analyses progress, additional and/or alternate monitoring locations should be selected to gather information about discrete portions of the Watershed, enhance understanding of potential contamination sources, and complement data collected at permanent monitoring locations. The volunteer monitoring program is primarily intended to collect field parameters as an ongoing reconnaissance to screen water quality for potential problems. Identified issues could then be more thoroughly investigated through in-depth sampling and analyses under the formal monitoring program addressed in Section 10.

8.6 MANAGEMENT OF INVASIVE SPECIES PROGRAM

The spread of invasive species is recognized as one of the major factors contributing to ecosystem change and instability. Invasive species have the ability to displace or eradicate native species, alter fire regimes, damage infrastructure, and threaten human livelihoods. These fast-growing species outcompete native vegetation and threaten the ecological diversity of uplands, wetlands, and riparian buffers. Without treatment, these areas can become homogenous stands, eradicating natural and native species. Predominant invasive species within the Fowl River Watershed are Chinese privet (*Ligustrum sinense*), popcorn tree (*Triadica sebifera*), cogongrass (*Imperata cylindrical*), and the common reed (*Phragmites australis*). The WMTF should establish a Management of Invasive Species Program based upon the following strategies: cooperation and collaboration between state, county, and local governments; inventory and monitoring of invasive species; prevention through early detection; constant monitoring and rapid response; treatment and control using physical and chemical means; and restoration of native species.

8.7 MONITORING PROGRAM

A monitoring program must be developed and used to determine the overall health of the Watershed. Specific monitored parameters, locations, and schedules are addressed in Section 10 of the WMP. A substantial database of information was compiled in the development of this WMP, which can provide baseline conditions to evaluate future conditions determined by the monitoring program. The data collected will also be used to evaluate the success of implemented management measures and indicate where additional management measures are needed. The monitoring should be conducted on a regular schedule, and should begin as soon as the necessary funding is available.

8.8 PUBLIC ACCESS PROGRAM

Public access to coastal resources is important to the people who live near the coast. Increasing and improving public access to the natural resource is a goal of the MBNEP Comprehensive Conservation and Management Plan (CCMP). Public access to the ecosystems people value most also exposes them to their surroundings and is critical to establishing a connection between people and the environment. "Access is an important component of coastal protection because the more connected people are to the resource, the more they will value and protect it" (MBNEP CCMP, 2013-2018). The WMTF should work closely with the USACE to provide channel dredging to enhance access. Dredging activities should be coordinated with potential beneficial re-use opportunities for coastal wetland/marsh replenishment.

Management of any natural resource is enhanced by public understanding, support, and participation of the stakeholders. Public access projects should include nature trails, scenic overlooks/boardwalks, historic markers, and new access points to Fowl River. Currently, there are only two public boat ramps on lower Fowl River, which are identified in **Figure 8.9**.

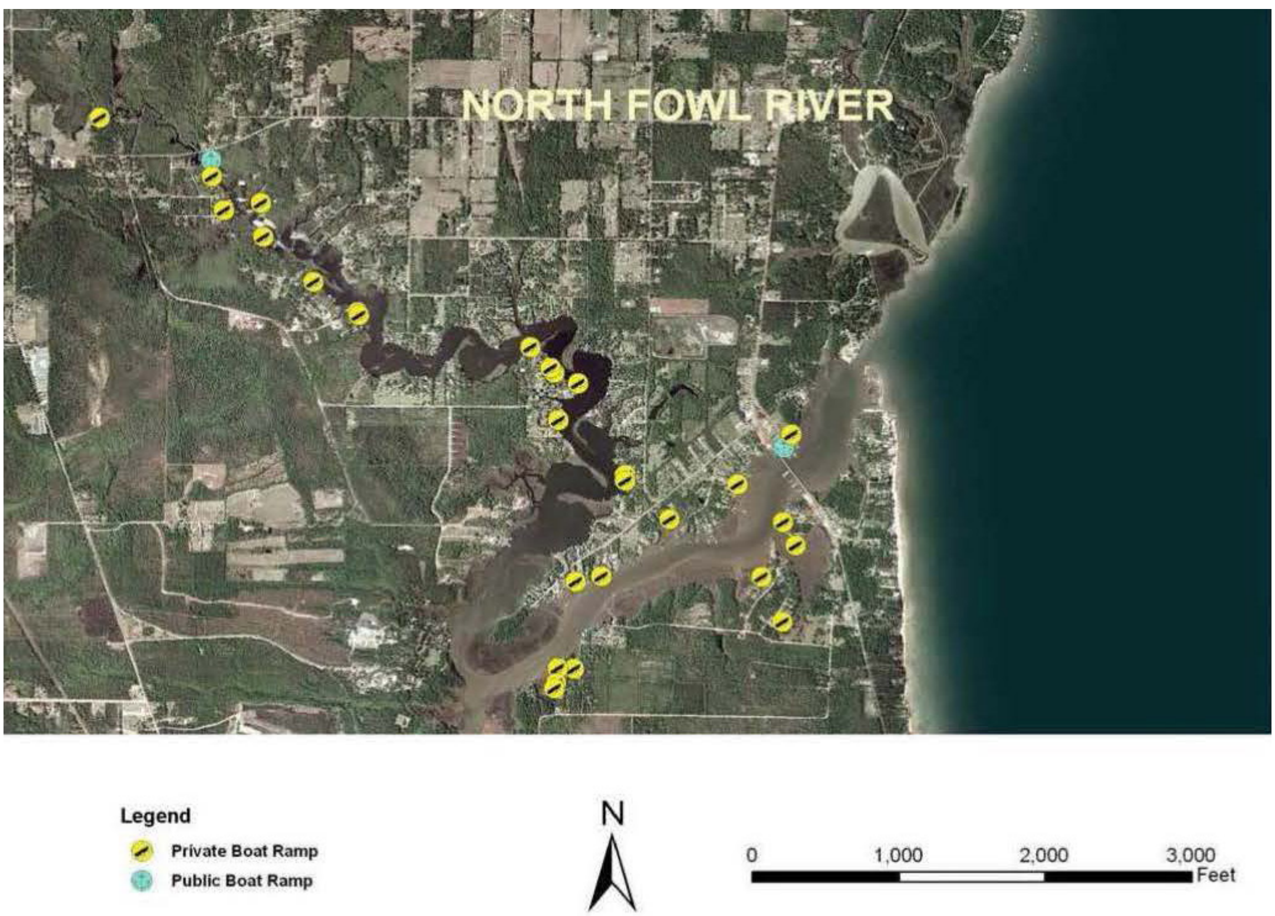


Figure 8.9: Current distribution of public and private boat ramps in lower Fowl River (after Jones and Tidwell, 2012).

8.0 IMPLEMENTATION STRATEGIES

Through the process of developing the Fowl River WMP, two potential locations were identified that could be used to increase and improve public access to the River. These potential access locations are pinpointed in **Figure 8.10** and include one located on Mon Louis Island, shown in **Figure 8.11**, and the other at the south end of Fowl River Bridge, shown in **Figure 8.12**. Both locations provide easy access to the lower estuary of Fowl River and would provide access for boating, fishing, picnicking, and bird watching.

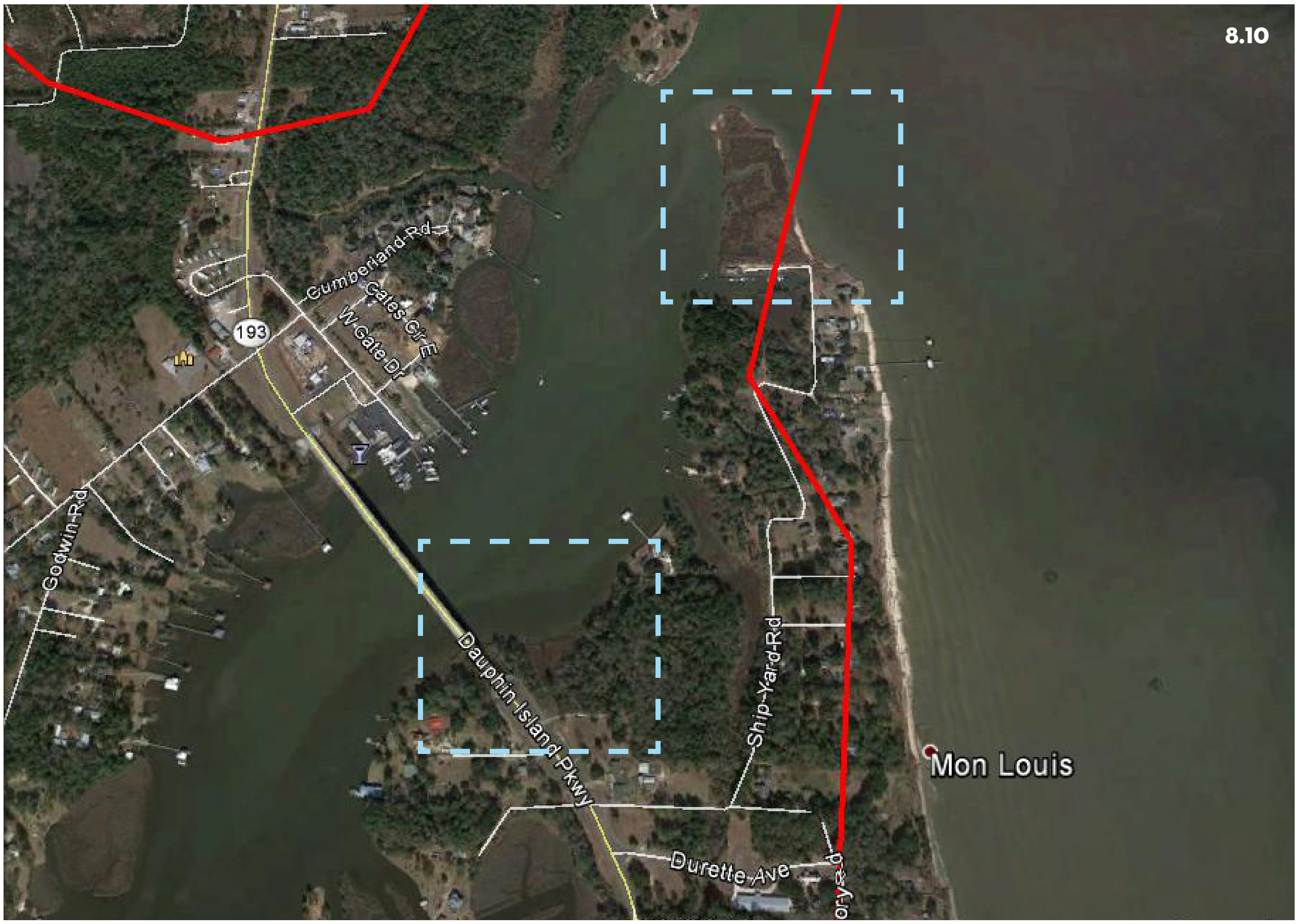


Figure 8.11: Potential public access location on Mon Louis Island
Source: Sam St. John

Figure 8.12: Potential public access location at the south end of Fowl River Bridge
Source: Sam St. John

8.0 IMPLEMENTATION STRATEGIES

8.9 CLEAN MARINA PROGRAM

Marinas and recreational boating are recognized as potential sources of nonpoint source pollution in coastal watersheds. The Alabama-Mississippi Clean Marina Program (AMCMP) is a voluntary, incentive-based, program developed and implemented by Mississippi-Alabama Sea Grant Consortium and partners to promote environmentally-responsible and sustainable marina and boating practices (http://masgc.org/clean-marina-program).

This program, created to reduce water pollution and erosion in state waterways and coastal zones, helps marina operators protect the very resource that provides them their livelihood: clean water. The AMCMP promotes boater education, coordination among state agencies, and better communication of existing regulations, as well as offering incentives to creative and proactive marina operators.

The AMCMP focuses on seven management measures identified by marina operators as priorities.

- Marina siting, design, and maintenance
- Sewage management
- Fuel management
- Solid waste and petroleum recycling and disposal
- Vessel operation, maintenance, and repair
- Stormwater management and erosion control
- Marina management and public education

Marinas in the Fowl River Watershed should be encouraged to participate in the AMCMP. Through participation, marina operators will receive technical assistance and promotional items identifying their facilities as “Clean Marinas.” Studies have shown that the most important criteria in choosing a marina for boat owners is cleanliness, and designated “Clean Marinas” may have an advantage in appealing to more environmentally-conscious consumers.

Additional needs include the establishment of a cost-share program providing incentives to marinas to retrofit existing infrastructures, including stormwater and waste management systems, to meet Clean Marina standards. Potential sources of funding for cost-share funds include ADEM 319, NFWF Gulf Environmental Benefit Fund (GEBF), and RESTORE.

8.0 IMPLEMENTATION STRATEGIES

8.10 INITIAL IMPLEMENTATION OF MANAGEMENT MEASURES

Implementation of recommended management measures should begin immediately following approval of the Fowl River WMP. Initial implementation should focus on the most critical issues and the prioritized management measures identified in the WMP.

1. **Restore and stabilize shorelines in the lower Watershed.** Shorelines in the lower Watershed bear the brunt of boat wake activity, storm surges, and sea level rise. This plan identifies stretches of shoreline appropriate for restoration through natural means, encourages monitoring of shoreline change, and promotes the retrofit of bulkheads to more natural living shorelines through collaboration with private property owners.

2. **Expand and improve safety signage** in the lower Watershed to alert boaters and others of the dangers of submerged islands, shallow water, areas and wildlife sensitive to excessive boat wakes (such as vulnerable habitat or the presence of manatees).

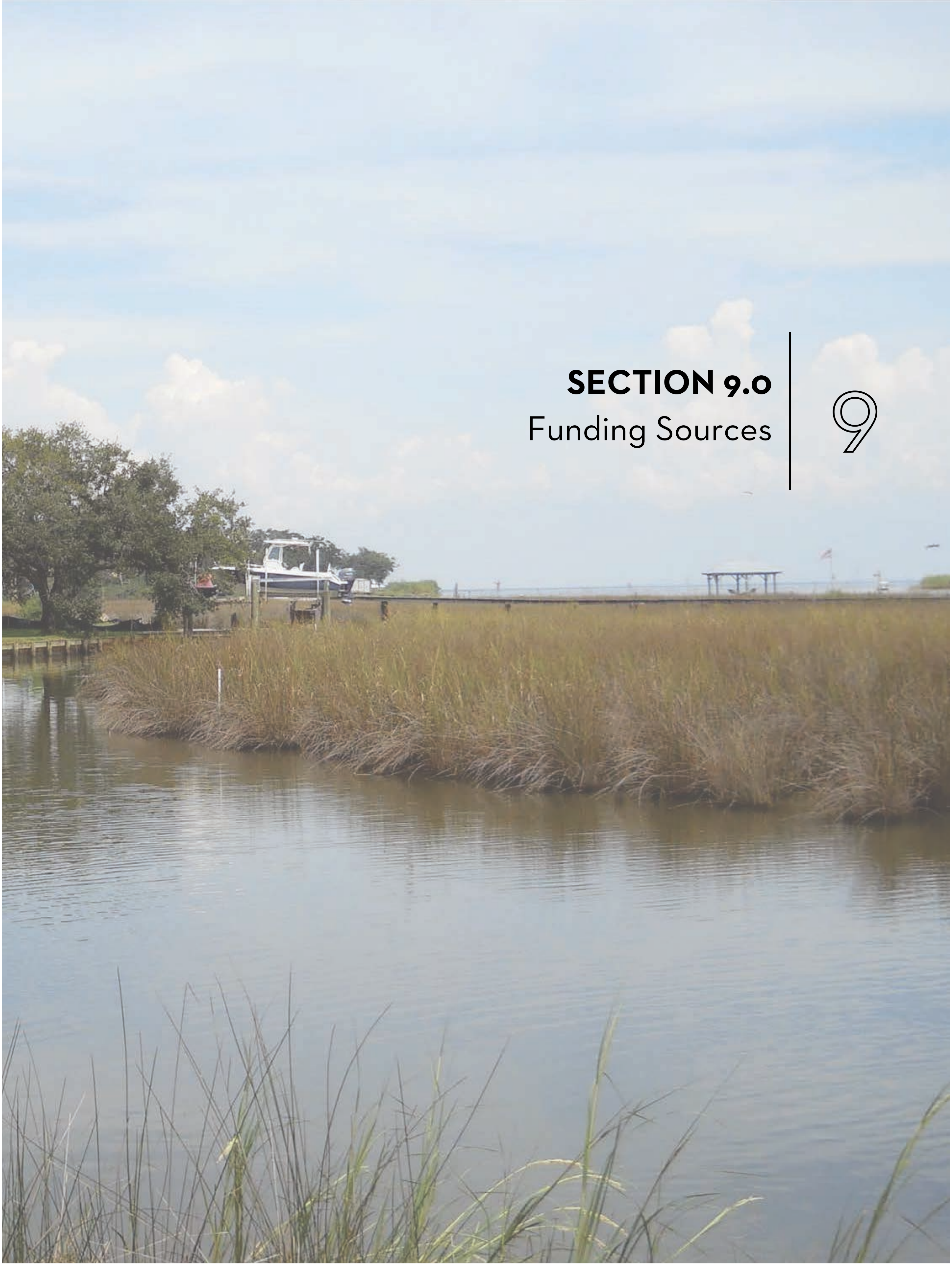
3. **Promote community awareness, education, and involvement** by installing signage throughout the Watershed, presenting the WMP to community groups and business associations, reducing litter on streets and in the water through community clean-ups and neighborhood education activities, increasing the number of volunteer water quality monitors at monitoring locations determined by the WMTF, and encouraging greater community participation in environmentally-focused events.

4. **Engage farmers in improving water quality** by encouraging cattle exclusion activities in vulnerable streams and employing agricultural best management practices to improve the quality and reduce the quantity of runoff from fields. It is vital to educate willing landowners on potential financial incentive programs available to protect wetlands and improve water quality, and to make these opportunities available to them.

5. **Expand habitat conservation** to improve the hydrology of the upper Watershed and the ability of salt marshes to migrate and become resilient to climate change. Recommendations include acquisition, conservation easements, and mitigation. Land sales should be monitored in areas adjacent to vulnerable wetlands in order to capitalize on acquisition opportunities. Priority preservation wetlands, identified in Figure 5.9, show existing nutrient sources and the wetlands that filter runoff water from those sources. In addition, the SLAMM model (see Appendix B) reveals the need to acquire sufficient property for the upland migration of tidal marsh habitats with future sea level rise.

   Activities that impact local jurisdictional wetlands and streams in the Watershed require permits from the USACE. These permits require impacts to be mitigated through the restoration of in-kind habitat (wetland and/or streams). Permitting activities should be monitored to seize opportunities for conserving and expanding wetland areas as compensatory mitigation to counter the negative impacts of watershed development required by these permits. Mitigation is required with these permits and could provide funding opportunities to restore impaired wetlands and streams within Fowl River.

6. **Improve public access to the water** for passive recreation enthusiasts such as kayakers, canoers, and paddle boarders.



SECTION 9.0
Funding Sources

9

9.0 FUNDING SOURCES

INTRODUCTION

Funding projects and activities throughout an entire watershed is not a simple undertaking. Successful implementation of the management measures recommended in this Watershed Management Plan (WMP) will require the long-term commitment of significant financial resources and community support. The design, construction, and maintenance of stormwater improvements; purchase of land for offline storage; modification and/or protection of shorelines to reduce erosion; or the purchase and preservation of tracts of land to create greenspace buffers, wetlands, or floodplains to protect stream quality will require significant and reliable funding. Because the jurisdictional areas of political entities that might provide funding do not follow or encompass the Watershed boundaries, a public-private partnership may be the most effective way to accomplish management goals.

To acquire the funding necessary to undertake significant restoration, preservation, and/or management projects, political and private entities will have to consider and compare all available funding options. Many financial assistance opportunities, primarily in the form of federal grants and cooperative agreements, are available to help restore, enhance, and preserve the Fowl River Watershed. However, increases in watershed recovery efforts by communities around the nation have substantially increased competition for these resources.

Financial structures and sources that could provide funding for management issues and projects identified in this WMP are discussed below. Some structures could be helpful across the entire Watershed and others within limited areas. Many would require public-private partnerships and cooperation among landowners, non-governmental organizations, and governments rather than being imposed by governmental entities.

The following alternatives for funding and financing projects in the Fowl River Watershed are discussed:

- **Water use service fees (i.e., stormwater utility fees) (9.1)**
- **Property, sales, or other taxes paid into general funds (9.2)**
- **Federal grants, loans, and revenue sharing (9.3)**
- **"Green" stimulus funding (9.4)**
- **Non-governmental organizations/other private funding (9.5)**
- **Mitigation banks (9.6)**
- **Impact fees (9.7)**
- **Special assessments (9.8)**
- **System development charges (9.9)**
- **Environmental tax shifting (9.10)**
- **Capital improvement cooperative districts (9.11)**
- **Alabama improvement districts (9.12)**
- **Regional collaborative opportunities (9.13)**
- **Gulf Coast Restoration Act (9.14)**
- **National Fish and Wildlife Gulf Coast Benefit Fund (9.15)**
- **Gulf Coast Conservation Grants Program (9.16)**
- **Natural Resources Conservation Service Agricultural Conservation Easement Program and Healthy Forest Reserve Program (9.17)**
- **Coastal Ecosystem Resiliency Grants Program (9.18)**
- **Gulf of Mexico Energy Security Act (9.19)**
- **Environmental Protection Agency Healthy Watersheds Consortium Grant (9.20)**
- **U.S. Fish and Wildlife Service National Coastal Wetlands Conservation Grant Program (9.21)**

9.0 FUNDING SOURCES

9.1 STORMWATER UTILITY FEES

The U.S. Environmental Protection Agency (EPA) indicates that the most stable source of funding for stormwater management is the stormwater utility (EPA, 2008). Stormwater utility fees provide an equitable and transparent source of funding for stormwater management. A stormwater utility would provide a stable, predictable, long-term funding mechanism dedicated to stormwater improvements. The stormwater utility could undertake planning and construction programs to enable resolution of chronic problems. Sustainable revenues would be generated based on consumption and user fee-based services (Spitzer, 2010).

Although stormwater utility authorities are used extensively in many areas of the country, the authority to create a local stormwater utility in Alabama must be granted by legislative statute. To study, establish, and begin operating a stormwater utility authority could potentially take years. Among the many issues to be considered in creating a stormwater utility are fee (rate) methodologies, billing and/or collection mechanisms, credits and surcharges, and fee exemptions (Spitzer, 2010).

The stormwater user fee typically appears as a separate line item on residential or commercial water and/or sewer bills, as a special assessment on property tax bills, or on a stand-alone bill. This makes these fees highly-visible to the general public. The concept of stormwater management is difficult for the average citizen to grasp, resulting in skepticism about the need for stormwater user fees. The user fee is often seen as a tax, which can be subject to legal challenges. Local stormwater ordinances must be carefully crafted to avoid or prevent such challenges.

Stormwater user fees can be based on parcel size and/or the impervious areas within the parcel. Fees for residential and commercial properties may be calculated differently (e.g., a fixed fee for each residential parcel versus a fee based on the amount of impervious area for commercial parcels). Credits may be allowed for on-site attenuation and/or treatment of stormwater or for watershed stewardship activities, and surcharges may be added for the type of land use or industrial activity present on the site. Stormwater fee collection is commonly enforced by utility shutoff or by tax liens on the owner's property. Most stormwater utilities allow exemptions for certain categories of property. Streets/highways, undeveloped land, and railroad rights-of-ways are typically exempt from paying stormwater user fees (Spitzer, 2010 and Leo, 2010).

The State of Florida has been aware of the critical importance of water management since the 1970s. In 1986, the City of Tallahassee, Florida implemented the first stormwater utility in the southeastern United States. There are approximately 300 stormwater utilities in the Southeast, about half of which are located in Florida. The nearest municipality to the Fowl River Watershed with a stormwater utility is the City of Pensacola, which assesses a monthly rate of $5.70 per 2,998 square feet. The stormwater management authority operating in Jefferson County, Alabama, which includes 21 cities located within the surrounding area, imposes a monthly rate of $0.42 per parcel (2013 Southeast Stormwater Utility Survey). A 2013 survey of stormwater utilities in the Southeast, excluding Florida-based stormwater authorities, revealed the following:

97 percent operate based on user fees;
79 percent use impervious surfaces as the basis for the fee;
the average stormwater utility rate was $3.59 per month;
the average revenue was $3,964,000 per year;
75 percent reported that a public information effort was essential or helpful to their mission;
47 percent are combined with a Departments of Public Works;
13 percent operated as a separate authority distinct from local government;
77 percent served only a municipality;
10 percent served a watershed or some other defined area;
the average population served was 97,500.

Source: 2013 Southeast Stormwater Utility Survey

9.2 PROPERTY, SALES, OR OTHER TAXES (GENERAL FUND)

The use of public “general funds” to finance projects is undesirable because it has no dedicated source of continuing and consistent funding. This limits the success of funding watershed management programs. Also, other projects then compete with maintenance and construction projects for funding. Environmental projects are often superseded by other priorities, such as police, fire, and emergency medical personnel, and are also vulnerable to budget cuts (Spitzer, 2010). Finally, because the Fowl River Watershed does not fall within one, but rather three governmental jurisdictions, one central authority to administer general funds does not exist.

9.3 FEDERAL GRANTS, LOANS AND REVENUE SHARING

The U.S. federal government provides numerous grants, loans, and revenue sharing that may be used by municipalities and non-profit groups to conduct studies and construct projects related to watershed protection, stream restoration, and stormwater management. A composite list of federal funding opportunities is included.

The Clearinghouse for Federal Grant Opportunities (also known as Grants.gov) is a central storehouse of information on more than 1,000 grant programs providing approximately $500 billion in annual awards. The EPA Catalog of Federal Funding Sources for Watershed Protection is a searchable database of financial assistance sources available to fund a variety of watershed protection projects. **Table 9.1** summarizes 53 funding programs offered by nine different federal agencies.

Table 9.1: Federal Agencies Offering Funding Programs

Acronym	Agency	Number of Programs
EPA	Environmental Protection Agency	12
FEMA	Federal Emergency Management Agency	2
NOAA	National Oceanic and Atmospheric Administration	2
USACE	U.S. Army Corps of Engineers	2
USDA	U.S. Department of Agriculture	12
NFWF	National Fish and Wildlife Foundation	12
USDOI	U.S. Department of the Interior	4
USFWS	U.S. Fish and Wildlife Service	6
USGS	U.S. Geological Survey	1

9.3.1 Advantages and Limitations of Grant Funding

Several of the potential funding sources are appropriate for projects, studies, or issues involving coastal and/or estuarine areas. These funding sources should be considered because of the intertidal nature of lower Fowl River, the estuary, and Mobile Bay. Cooperation with federal agencies that provide large grants and/or study opportunities should be pursued as this can lead to funding for additional construction projects.

Grants are popular because the funds received do not have to be repaid; however, grants discourage consideration of long-term costs such as maintenance and operation. Also, since grants are awarded on merit, the effort to produce a grant application may not pay off. Grants may also require difficult-to-obtain matching funds.

9.3.2 State Revolving Funds

The EPA State Revolving Fund (SRF) Loan program offers a reliable source of funding (Berahzer, 2010b). Separate SRF programs exist for Clean Water and Drinking Water. Funds are provided annually to each state by the federal government, with the states providing a 20 percent match. To receive funding, a project must be listed on the state's annual "Intended Use Plan" (IUP). The IUP contains a "comprehensive" list and a shorter "fundable" or "priority" list and requires a public comment process. Since 2007, the SRF has moved beyond the traditional "water treatment works" projects and has begun to emphasize nonpoint sources and estuary protection as funding priorities.

The following information regarding the State of Alabama Revolving Fund was accessed on June 1, 2015 on the Alabama Department of Environmental Management (ADEM) website (http://www.adem.state.al.us/programs/water/srf.cnt):

"The Clean Water State Revolving Fund (CWSRF) and the Drinking Water State Revolving Fund (DWSRF) are low interest loan programs intended to finance public infrastructure improvements in Alabama. The programs are funded with a blend of state and federal capitalization funds. ADEM administers the CWSRF and DWSRF, performs the required technical/environmental reviews of projects, and disburses funds to recipients."

BENEFITS OF AN SRF LOAN:

- The SRF offers a loan interest rate substantially lower than the prevailing municipal bond rate available to AAA-rated municipalities;
- the interest rate is fixed with a 20-year payback (extended term may be available);
- loan repayment does not begin until construction completion date (capitalized interest accrues); and
- the loan recipient is not required to pay any ongoing trustee expenses or rebate expenses normally associated with a local bond issue.

PROJECTS ELIGIBLE FOR FUNDING:

Projects that strengthen compliance with federal and state regulations and/or enhance protection of public health are eligible for consideration to receive an SRF loan. If a project qualifies, the engineering, inspection, and construction costs are eligible for reimbursement. Among the projects which qualify for funding are:

- Publicly-owned water or wastewater treatment works
- Sewer rehabilitation
- Interceptors, collectors, and pumping stations
- Decentralized wastewater treatment
- Drinking water storage facilities
- New/rehabilitated water source wells
- Water transmission/distribution mains
- Consolidation/water system interconnection
- Water conservation and reuse projects
- Green infrastructure
- Stream bank restoration
- Green roofs
- Permeable pavements
- Rain gardens and biofiltration products
- Brownfield remediation
- Watershed and estuary protection projects

9.0 FUNDING SOURCES

9.4 "GREEN" STIMULUS FUNDING

Under the 2009 American Recovery and Reinvestment Act (ARRA) (i.e., Stimulus Act), the EPA introduced a Green Project Reserve as a part of its SRF Loan Program and maintained this funding mechanism in FY2010. The Green Project Reserve stipulates that no less than 20 percent of the SRF shall be used by the states for projects that address green infrastructure, water or energy improvements, or other environmentally-innovative activities (Berahzer, 2010a). Some green infrastructure projects may fit into either the Clean Water or Drinking Water divisions of the SRF program. In general, a combination of the Green Project Reserve and additional subsidization could lead to better financing terms for stormwater projects.

ADEM has issued its FY2014 IUPs for both the Clean Water and Drinking Water SRFs. ADEM continues to accept applications, especially for green infrastructure projects. Applications received during this funding cycle will be held for standby funding, should any of the applicants on the funding list fail to comply with all requirements of the SRF and ARRA or should additional funding become available.

Many stormwater projects and low impact development (LID) strategies may be considered "green" under this funding category. Examples include porous pavement, bioretention facilities, rain gardens, green roofs/walls/streets, wetland restoration, constructed wetlands, urban retrofit programs, LID projects, infiltration basins, landscaped swales, downspout disconnection, and tree planting. Land acquisition services and the actual cost for the purchase of land or easements may also be included in the scope of this definition.

9.5 NON-GOVERNMENTAL ORGANIZATIONS AND OTHER PRIVATE FUNDING

Private foundations and corporations may be another source of funding for improvements. Seven selected funding sources available from non-governmental organizations (NGOs) and other private entities are included.

Three of these sources are searchable electronic databases of foundation and corporate grants in various fields: (1) the Chronicle of Philanthropy Guide to Grants, (2) the Community of Science Database, and (3) the Foundation Center. Local governmental entities and non- profit agencies involved with the Fowl River Watershed should investigate these databases with specific project objectives in mind.

The Kodak American Greenways Program, RBC Bank Blue Water Project Grants, and Surdna Foundation Sustainable Environmental Grants offer specific funding opportunities for environmental improvement projects related to watershed protection and green infrastructure (GI). These programs are listed because of their direct applicability to ongoing efforts in the Watershed.

9.6 MITIGATION BANKS

A mitigation bank is a designated and approved wetland or stream area that has been created, restored, enhanced, or preserved and set aside in perpetuity to compensate for future unavoidable impacts to wetlands and waters of the United States. Credits are purchased at the bank as compensatory mitigation for other development projects, ideally within the same watershed. Mitigation banking provides opportunities for a county or city to partner with landowners and land trusts, accrue financial resources for community improvements, create natural amenities in an urban setting, and enhance education about restoration and water quality (Leo and Tillery, 2010).

Authorized under federal environmental law and regulations, a mitigation bank provides an asset that can be sold to developers and government entities whose projects require mitigation of stream and/or wetland damage. If formed for all or part of an affected watershed, a mitigation bank effectively allows the sale of credits, which can be used to offset some portion of the costs of the initial set-aside area. The regulatory process involves a prospectus and public notice, development of a banking instrument, restrictive covenants, and coordination with various agencies that have jurisdiction over the process.

ADVANTAGES: Mitigation banks can be useful to fully- or partially-finance large-scale, expensive projects, and may generate funding from outside the affected area, rather than relying on local assessments, fees, taxes, or other public revenues. Mitigation banks would allow a municipality, county, or non-governmental entity to become a generator of mitigation credits instead of being a consumer of those credits. Credits may be used for internal needs or sold for external purposes to generate funds. In addition, mitigation banks may be used as a revenue source to implement restoration projects and maintain compliance with the requirements of National Pollutant Discharge Elimination System (NPDES) permits, such as total maximum daily loads (TMDL). Funds raised through the sale of mitigation credits may partially or completely offset the costs of some watershed management projects.

DISADVANTAGES: Mitigation banking effectively requires ownership or control of a large site on which to implement the mitigation bank. In most cases, this method of funding also requires regulatory approval and significant upfront capital to cover the initial costs of creating the improved streambeds and/or wetlands. It is unlikely that the projected flow of funds would support the initial financing without other credit support. Considerable time and effort may be required to properly set up and implement mitigation banks. Requirements include a credit release schedule, monitoring requirements, biotic success criteria, maintenance and adaptive management, monitoring, and reporting requirements.

POSSIBLE USE: If one or more public bodies are willing and able to bear the risk of financing, later sales of mitigation credits could offset their eventual out-of-pocket costs of paying off the debt. The mitigation bank site should be Watershed-based, have the potential to provide environmental benefits, and be located in a service area with potential for development to promote the sale of future credits.

9.7 IMPACT FEES

Impact fees are paid by developers (usually at the time of development) in order to obtain a building permit. The fee is designed to reimburse the government for the additional impact a given improvement may have on the community. Impact fees may be for transportation (i.e., increased impact on roads/bridges as a result of constructing a development), water/sewer (i.e., repaying the government for the impact of taking capacity out of the system), or other public infrastructure. Typically, a direct relationship must exist between the development and the impact fee. Impact fees, which often must be authorized by statute, are used for capital improvements and not for maintenance. They are paid one time, up front for new construction (Mustian, 2010).

Because impact fees are an unreliable and unstable long-term funding source for maintenance and improvements, they are not the most viable option for the Fowl River WMP and the associated projects. Developers dislike impact fees, and timely expenditure of funds can also be an issue. In addition, because the Fowl River Watershed falls within three governmental jurisdictions, it lacks a central authority to administer impact fees.

9.0 FUNDING SOURCES

9.8 SPECIAL ASSESSMENTS

A special assessment is a charge levied for the benefit a given property receives for a specific public improvement. The cost/benefit must be related to the property itself. Special assessments may be based on property area or frontage. Special assessments are distinguishable from taxes, but have been challenged in court. They may be used to fund capital and operating costs. In some states, special assessments may be placed on the tax rolls and achieve the same status as ad valorem taxes. However, assessing governmental property and property owned by non-profits that are not on the tax rolls may pose a challenge. Collection of special assessments can be spread over time.

Special assessment fees for the maintenance of public sewers and septic tanks have been assessed in some communities. In Chesapeake Bay, Maryland, the Bay Restoration Fund has a $2.50 per month wastewater fee that provides more than $65 million per year for upgrades to wastewater treatment plants and $12.6 million per year for septic tank repair and cover crops (Berahzer, 2010a).

9.9 SYSTEM DEVELOPMENT CHARGES

System development charges (also known as connection fees or tie-in charges) are one-time fees commonly charged to new customers to cover the costs for additional maintenance or for service extensions. The cost of the new customer's system development charge is typically calculated on the basis of the potential demand the new customer will place on the system. Stormwater system development charges can also be used. The cost of a stormwater system development charge is typically determined by the area of the customer's property (EPA, 2008).

9.10 ENVIRONMENTAL TAX SHIFTING

Environmental tax shifting is a creative concept that has been proposed by environmental groups to redirect tax code incentives to support energy conservation and sustain the environment. Examples include (1) a pay-to-pave tax levied on newly-paved surface on a per-square-foot basis, and (2) the discontinuance of the state tax exemptions for fertilizer and pesticide sales. The income from these measures could then be directed toward environmental projects (EPA, 2008). Environmental tax-shifting approaches may not receive the public or political support necessary for acceptance and implementation.

9.11 CAPITAL IMPROVEMENT COOPERATIVE DISTRICTS

Authorized under Chapter 99B of Title 11, Code of Alabama, capital improvement cooperative districts can be formed by one or more governmental entities, including counties, municipalities, public utilities, and public corporations, such as industrial or commercial development authorities. Once formed, the districts can finance and construct various capital improvements and then enter into arrangements, such as leases or contracts, to make the improvements available to users. The members of the district (i.e., the public bodies) can also contribute funding to finance the projects.

ADVANTAGES: Cooperative districts offer great flexibility and may comprise various public bodies with an interest in the project. They support projects that can be financed by any of its members, and therefore, may be able to acquire, construct, and improve a larger number of capital items for both public and private use. Cooperative districts can also help protect a governmental body from the potential liability of owning a particular improvement.

DISADVANTAGES: Cooperative districts lack the authority to assess private users. They can charge for services or facilities only on a bilateral basis, in which the benefiting parties agree upfront on the charges through a contractual arrangement. Thus, they are most effective when providing a service or facility (i.e., utilities or even buildings for private use) needed by potential users that agree to be assessed a fee for the service or facilities. Cooperative districts are not well-suited to situations in which the improvements to be financed, such as drainage improvements on public property, are not such that the property owners would be willing to pay voluntarily, unless another entity (such as a city or county) can assess for the improvements. For example, a cooperative district constructing a sewage treatment plant to serve multiple utilities would have contracts for payment of the costs. In the case of stream or drainage improvements, there is no obvious way to charge the benefited landowners without their consent.

If Mobile County and the cities of Mobile and Bayou La Batre wanted to create a vehicle to collectively finance and make improvements on a watershed basis, they could form a cooperative district to facilitate the effort. Each entity could contribute to the costs incurred, either directly, or through the payment of shares of the debt service on bonds issued by the district.

9.12 ALABAMA IMPROVEMENT DISTRICTS

Authorized under Chapter 99A of Title 11, Code of Alabama, improvement districts are formed by a county or municipality upon application by all of the affected landowners. Once formed, they can acquire, construct, install a wide range of public infrastructure, and assess the landowners for their *pro rata* shares of the improvement costs. The assessments constitute liens against the land. Depending on the range of projects undertaken, the improvement districts can effectively become sub-units of government for the purpose of providing services beyond those typically provided. Improvement districts have been widely-used for residential or multi-use developments as a means to provide for the initial and maintenance costs of infrastructure not provided by local government.

The authority to assess and create a liens on property provides a powerful financing alternative. Improvement districts are ideally suited to construct and own public infrastructure. However, landowner consent may be impossible across the area affected by the WMP.

If a project is proposed that affects one significant property, or one especially required for the development or redevelopment of the property, an improvement district could be used to finance the project and assess the landowners for the cost. For instance, if the lower Fowl River Watershed or a large shopping center were being developed and required drainage or retention facilities beyond the normal requirements, an improvement district could be a good vehicle.

9.13 REGIONAL COLLABORATION OPPORTUNITIES

There are five regional collaboration opportunities applicable to watershed projects. The EPA Region 4 sponsors the Green Infrastructure Partnership, Smart Growth Implementation Assistance, Southeastern Regional Water Quality Assistance Network (SERWQAN), and Watershed Protection and Restoration Assistance collaboration opportunities. The Gulf of Mexico Alliance is a partnership of the states of Alabama, Florida, Louisiana, Mississippi, and Texas.

The primary goal of the Green Infrastructure Partnership is to reduce runoff volumes and sewer overflow events through the widespread use of green infrastructure management practices that help maintain natural hydrologic functions by absorbing and infiltrating precipitation where it falls.

The Smart Growth Implementation Assistance program is an annual, competitive solicitation open to state, local, regional, and tribal governments (and non-profit organizations that have partnered with a governmental entity) that want to incorporate smart growth techniques into future developments.

9.0 FUNDING SOURCES

SERWQAN is committed to strengthening the capacity of communities to develop and successfully implement watershed protection efforts. The network is based at the EPA Region 4 Environmental Finance Center, which helps governments at the local, state, and federal levels answer the "how-to-pay" questions associated with environmental projects. SERWQAN, which is funded through the EPA Targeted Watershed Grant Program, currently provides technical, financial, community, and legal support to 13 communities in the Southeast. The network has developed interactive tools that help communities make financial projections for the revenues needed for watershed protection and has produced websites that help communicate environmental educational messages to the general public.

Through the Watershed Protection and Restoration Assistance Partnership, the staff of EPA Region 4 works with state and local governments and watershed organizations to facilitate protection and restoration efforts in targeted watersheds.

The goal of the Gulf of Mexico Alliance is to significantly increase regional collaboration in order to enhance the ecological and economic health of the Gulf of Mexico. Priority issues for this group include water quality, habitat conservation and restoration, ecosystem integration and assessment, nutrients and nutrient impacts, coastal community resilience, and environmental education.

9.14 GULF COAST RESTORATION ACT

The Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act (RESTORE Act) was signed into law on July 6, 2012, as part of the Moving Ahead for Progress in the 21st Century Act (Public Law 112-141) (http://www.restorealabama.org/Documents/RestoreAct.pdf). The legislation established a mechanism for providing funding to the Gulf region to restore ecosystems and rebuild local economies damaged by the Deepwater Horizon Oil Spill. The RESTORE Act established in the Treasury of the U.S. the Gulf Coast Restoration Trust Fund (Trust Fund), consisting of 80 percent of an amount equal to any administrative and civil penalties paid after the date of the RESTORE Act by the responsible parties in connection with the Deepwater Horizon Oil Spill to the U.S., pursuant to a court order, negotiated settlement, or other instrument in accordance with Section 311 of the Federal Water Pollution Control Act (FWPCA, 33 U.S.C. 1321).

The RESTORE Act divides the funds into five separate allocations and sets the parameters for how the funds are to be spent in each:

1. Thirty-five percent of the funds are divided equally among the five Gulf Coast states for ecological and economic restoration. Eligible activities include: restoration and protection of natural resources; mitigation of damage to natural resources; work force development and job creation; improvements to state parks; infrastructure projects, including ports; coastal flood protection; and promotion of tourism and Gulf seafood.

2. Thirty percent of the funds will be administered for restoration and protection according to the comprehensive plan developed by the Gulf Coast Ecosystem Restoration Council.

3. Thirty percent of the funds are dedicated to the Gulf Coast states based on a formula. This formula will be based on the number of miles of shoreline that experienced oiling, the distance from the Deepwater Horizon mobile drilling unit at the time of the explosion, and the average population as of the 2010 Census. Each state is required to have a Council-approved plan in place for use of these funds.

4. Two-and-a-half percent of the funds are dedicated to the Gulf Coast Ecosystem Restoration Science, Observation, Monitoring and Technology Program, which will be established by NOAA for marine and estuarine research, ecosystem monitoring and ocean observation, data collection and stock assessments, and cooperative research.

5. Two-and-a-half percent of the funds are dedicated to the Centers of Excellence Research Grants Program. The funding is distributed through the states to nongovernmental entities to establish Centers of Excellence that will focus on the following disciplines: coastal and deltaic sustainability; restoration and protection; fisheries and wildlife ecosystem research and monitoring; offshore energy development; sustainable and resilient growth; and comprehensive observation, monitoring, and mapping in the Gulf.

9.15 NATIONAL FISH & WILDLIFE FOUNDATION GULF ENVIRONMENTAL BENEFIT FUND

In early 2013, a U.S. District Court approved two plea agreements resolving certain criminal cases against British Petroleum and Transocean that arose from the 2010 Deepwater Horizon Oil Spill and explosion. The agreements directed a total of $2.544 billion to the NFWF to fund projects benefiting the natural resources of the Gulf Coast that were affected by the spill. Over the next five years, NFWF's newly-established Gulf Environmental Benefit Fund will receive a total of $1.272 billion for barrier island and river diversion projects in Louisiana; $356 million each for natural resource projects in Alabama, Florida, and Mississippi; and $203 million for similar projects in Texas.

Notwithstanding any other provision of law, the Secretary of the Treasury shall deposit into the Fund amounts equal to no less than 80 percent of any amounts collected by the U.S. as penalties, settlements, or fines under sections 309 and 311 of the Federal Water Pollution Control Act (33 U.S.C. 1319, 1321) in relation to the blowout and explosion of the mobile offshore drilling unit Deepwater Horizon that occurred on April 20, 2010, and resulting in hydrocarbon releases into the environment.

A qualifying state shall use all amounts received under this section, including any amount deposited in a trust fund that is administered by the state and dedicated to uses consistent with this section, in accordance with all applicable federal and state law, only for one or more of the following purposes:

(a) Projects and activities for the conservation, protection, or restoration of coastal areas, including wetlands.
(b) Mitigation of damage to fish, wildlife, or natural resources.
(c) Planning assistance and the administrative costs of complying with this section.
(d) Implementation of a federally-approved marine, coastal, or comprehensive conservation management plan.

The Alabama Gulf Coast Recovery Council (AGCRC) was created with the passage of the RESTORE Act (http://www.restorealabama.org/Documents/Summary of RESTORE Act.pdf). This legislation was passed by Congress to steer a percentage of the civil penalties levied against the responsible parties of the 2010 Deepwater Horizon incident directly to the Gulf Coast states to assist with recovery efforts. With the third phase of the trial beginning in late January 2015, the amount of penalties that may be available to the State of Alabama and the timing of their availability remain uncertain.

The law specifically states that Alabama's 10-member council will be chaired by Alabama's Governor and co-chaired by the Director of the Alabama State Port Authority. Other members will be the Chairman of the Baldwin County Commission, the President of the Mobile County Commission, and the mayors of Bayou La Batre, Dauphin Island, Fairhope, Gulf Shores, Mobile, and Orange Beach. The Act further stipulates that qualifying projects must reflect at least one of the following criteria:

- Restoration and protection of the natural resources, ecosystems, fisheries, marine and wildlife habitats, beaches, and coastal wetlands of the Gulf Coast region.
- Mitigation of damage to fish, wildlife, and natural resources.
- Implementation of a federally-approved marine, coastal, or comprehensive conservation management plan, including fisheries monitoring.
- Workforce development and job creation.
- Improvements to or on state parks located in coastal areas affected by the Deepwater Horizon Oil Spill.
- Infrastructure projects benefitting the economy or ecological resources, including port infrastructure.
- Coastal flood protection and related infrastructure.
- Planning assistance.
- Administrative costs (limited to not more than 3 percent of a state's allotment).
- Promotion of tourism in the Gulf Coast region, including recreational fishing.
- Promotion of the consumption of seafood harvested from the Gulf Coast region.

9.0 FUNDING SOURCES

On December 17, 2012, the Council adopted their By-laws (amended December 8, 2014). On May 10, 2013, they passed a resolution adopting a Strategy Map and tapped the Alabama Department of Conservation and Natural Resources (ADCNR) to serve as the Administrator. The Memorandum of Understanding with ADCNR was subsequently adopted by the Council during the August 15, 2013 meeting (amended December 8, 2014). The Council released their draft Project Submission Form Guide (http://www.alabamacoastalrestoration.org/pdfs/ProjectSuggestionFormGuide.pdf) for public comment on October 8, 2013, and the Project Submission portal (http://www.alabamacoastalrestoration.org/ProjectSubmit.aspx) went live on the Alabama Coastal Restoration website in late March 2014. The U.S. Department of Treasury issued the RESTORE Act Interim Final Rule on August 13, 2014, which allows the Council to move forward in determining a project selection process. The regulations became effective on October 14, 2014.

In Alabama, the Gulf Environmental Benefit Fund will be used to support projects that remedy harm to natural resources (habitats, species) where there has been injury to, destruction of, loss of, or loss of use of those resources resulting from the oil spill. Projects are expected to occur within reasonable proximity to where the impacts occurred, as appropriate.

9.16 GULF COAST CONSERVATION GRANT PROGRAM

The Gulf Coast Conservation Grants Program (GCCGP) (http://www.nfwf.org/gulfconservation/Pages/home.aspx) is a new program supporting priority conservation needs of the Gulf that are not otherwise expected to be funded under the NFWF Gulf Environmental Benefit Fund or other funding opportunities associated with the Deepwater Horizon Oil Spill (e.g., RESTORE, Natural Resources Damage Assessment). Unlike the other funding programs associated with the Deepwater Horizon Oil Spill, this program's overall annual funding level is relatively modest at approximately $3 million to $6 million. Individual grant awards are anticipated to range between $50,000 and $250,000.

The program seeks to advance innovative restoration concepts and approaches, build capacity through strategic engagement of youth and veterans, and fund species and habitat projects benefitting Gulf coastal ecosystems and communities. The GCCGP is supported with federal funding from Natural Resources Conservation Service (NRCS), and private funding from Southern Company Power of Flight, the Shell Marine Habitat Program, and other sources.

The NFWF is currently soliciting proposals to support conservation projects that enhance coastal watersheds of the Gulf Coast and bolster priority fish and wildlife populations, while strengthening resiliency within the coastal region.

9.17 NRCS AGRICULTURAL CONSERVATION EASEMENT PROGRAM & HEALTHY FOREST RESERVE PROGRAM

The Agricultural Conservation Easement Program (ACEP) consists of $10 million made available to the five Gulf States on a first-come, first-served basis. There are three easement types: farmland, ranch (cattle/livestock), and wetlands. Easement funding is available for any combination of the three easement types. All NRCS program rules apply. There are two component parts of the ACEP: the Agricultural Lands Easement (ALE), and the Wetlands Easement (WRE). The landowner must have an adjusted gross income, three-year average, of less than $900,000 to qualify for these programs.

NRCS will pay one-half of the easement costs for ACEP-ALE easement projects, and one-half must come from another source. ALE easements must be held by a third party such as a county or state. NRCS pays 100 percent of both the easement purchase price and any restoration price for wetlands easements. Wetland easements are held by the U.S. Government.

9.0 FUNDING SOURCES

The Healthy Forests Reserve Program (HFRP) assists landowners, on a voluntary basis, in restoring, enhancing and protecting forestland resources on private lands through easements, 30-year contracts, and 10-year cost-share agreements. The objectives of the HFRP are to:

1. Promote the recovery of endangered and threatened species under the Endangered Species Act;
2. Improve plant and animal biodiversity; and
3. Enhance carbon sequestration.

BENEFITS:

- Restoring and protecting forests contributes to the economy, provides biodiversity of plants and animal populations, and improves environmental quality.
- Protections will be made available to landowners enrolled in HFRP who agree, for a specified period to restore or improve their land for threatened or endangered species habitat. In exchange, they avoid certain regulatory restrictions under the Endangered Species Act on the use of that land.
- The HFRP provides financial assistance in the form of easement payments and cost-shares for specific conservation actions completed by the landowner.

PROGRAM ENROLLMENT OPTIONS:

1. A 10-year restoration cost-share agreement, for which the landowner may receive 50 percent of the average cost of the approved conservation practices.
2. A 30-year easement, for which the landowner may receive 75 percent of the easement value of the enrolled land plus 75 percent of the average cost of the approved conservation practices.
3. A 30-year contract on acreage owned by Indian Tribes.
4. Permanent easements, for which landowners may receive 100 percent of the easement value of the enrolled land plus 100 percent of the average cost of the approved conservation practices.

ELIGIBILITY:

To be eligible for enrollment, land must be private or tribal, and must restore, enhance, or measurably increase the likelihood of recovery of a threatened or endangered species, biological diversity, or carbon sequestration.

9.18 COASTAL ECOSYSTEM RESILIENCE GRANTS PROGRAM

NOAA developed the Coastal Ecosystem Resiliency Grants Program (http://www.habitat.noaa.gov/funding/coastalresiliency.html) to build resilience of coastal ecosystems and communities. Coastal Ecosystem Resiliency awards will fund projects that develop healthy and sustainable coastal ecosystems through habitat restoration and conservation. Priority will be given to projects that:

- restore habitat to support healthy fish populations and provide ecosystem functions that reduce hazards and risks associated with extreme weather events and changing climate;
- provide sustainable and lasting ecological benefits and resiliency to extreme weather events or changing climate, and allow for adaptation to known or potential climate change impacts;
- implement on-the-ground restoration actions that result in immediate beneficial impacts;
- demonstrate collaboration among multiple stakeholders;
- receive approval from the state governor; and
- result in socioeconomic benefits associated with restoration of healthy and resilient coastal ecosystems.

This grant program was developed to complement the Regional Coastal Resilience Grants Program, which focuses on the development of safe and productive coastal communities through the development of policies, incentives, regulations, standards, and other tools and strategies.

Coastal Ecosystem Resiliency Project Funding at a Glance

- Projects will primarily be funded through cooperative agreements.
- Up to $4 million was available in 2015 for one- to three-year projects.
- Typical awards are anticipated to range from $500,000 to $1 million.
- It is anticipated that similar grants will be available in the future.

9.19 GULF OF MEXICO ENERGY SECURITY ACT (GOMESA)

On December 20, 2006, the President signed into law the Gulf of Mexico Energy Security Act (GOMESA) of 2006 (Pub. Law 109-432) (http://www.boem.gov/Oil-and-Gas-Energy-Program/Energy-Economics/Revenue-Sharing/Index.aspx). The Act significantly enhances outer continental shelf (OCS) oil and gas leasing activities and revenue sharing in the Gulf of Mexico. GOMESA shares leasing revenues with Gulf oil and gas-producing states and the Land and Water Conservation Fund (LWCF) for coastal restoration projects. In addition, the Act bans oil and gas leasing within 125 miles of the Florida coastline in the eastern planning area and a portion of the central planning area, until 2022. Lastly, it allows companies to exchange certain existing leases in moratorium areas for bonus and royalty credits to be used on other Gulf of Mexico leases.

The Act created revenue-sharing provisions for the four Gulf oil- and gas- producing states of Alabama, Louisiana, Mississippi, and Texas, and their coastal political subdivisions. GOMESA funds are to be used for coastal conservation, restoration, and hurricane protection. There are two phases of GOMESA revenue sharing:

PHASE I: Beginning in FY2007, 37.5 percent of all qualified OCS revenues, including bonus bids, rentals, and production royalties, was shared among the four states and their coastal political subdivisions from those new leases issued in specific areas in the eastern and southern planning areas. Additionally, 12.5 percent of revenues was allocated to the LWCF.

PHASE II: The second phase of GOMESA revenue sharing begins in FY2017. It expands the definition of qualified OCS revenues to include receipts from Gulf of Mexico leases issued either after December 20, 2006, in the eastern planning area, or in Gulf of Mexico planning areas subject to withdrawal or moratoria restrictions. Revenue sharing is capped at $500 million.

9.0 FUNDING SOURCES

9.20 EPA HEALTHY WATERSHEDS CONSORTIUM GRANT

The EPA announced a $3.75 million grant to support local projects to protect and sustain healthy watersheds. The EPA has made an official award to the U.S. Endowment for Forestry and Communities, Inc. (Endowment) to support the coordinated efforts of the Endowment and its partner organizations. The Healthy Watersheds Consortium Grant Program goal is to accelerate strategic protection of healthy, freshwater ecosystems and their watersheds (http://www.epa.gov/hwp/healthy-watersheds-consortium-grant).

9.21 USFWS NATIONAL COASTAL WETLANDS CONSERVATION GRANT PROGRAM

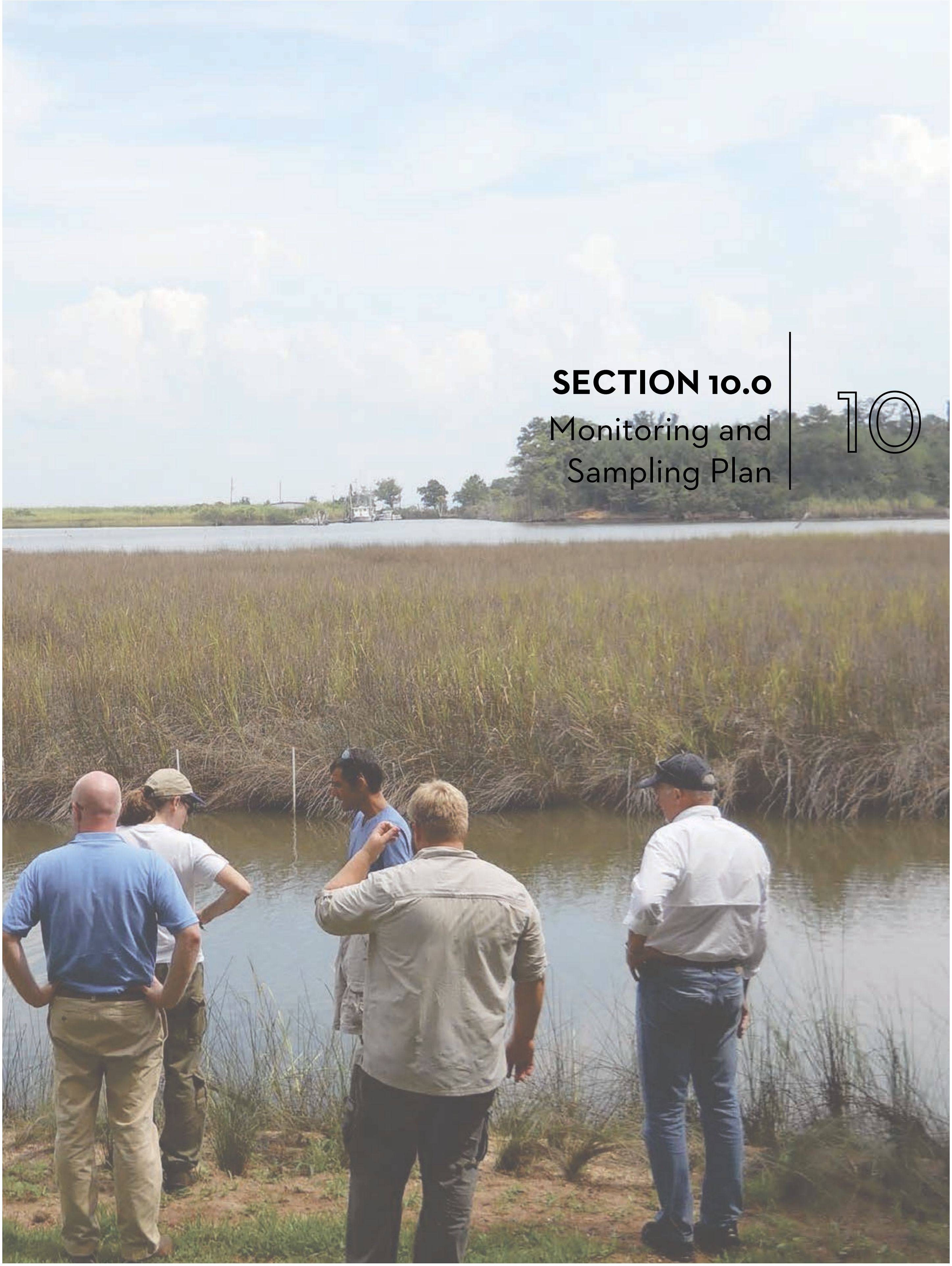
The Coastal Wetlands Planning, Protection, and Restoration Act (Section 305, Title III, Public Law 101-646, 16 U.S.C. 3954) (Act) established the National Coastal Wetlands Conservation Grant Program (NCWCG Program) to acquire, restore, and enhance wetlands in coastal states through competitive matching grants to state agencies. The primary goal of the NCWCG Program is the long-term conservation of coastal wetland ecosystems. State applicants must submit applications through www.grants.gov by the deadline of Wednesday, June 29, 2016. The U.S. Fish and Wildlife Service recommends submitting early enough to address any unforeseen technical complications. Awards are expected to be announced by January 2017 (http://www.fws.gov/coastal/pdfs/2017NCWCGP NOFOfinal01212016.pdf).

SUMMARY

There are considerable support opportunities to finance the management measures recommended by the Fowl River WMP. However, because the Fowl River Watershed falls within three governmental jurisdictions, it lacks a central authority to administer many of the potential funding sources. Establishment of a public-private partnership may provide additional funding options for watershed management. Additionally, it clearly illustrates to funders the community's active resolve to serve as vested and committed partners in the watershed management process. This endeavor would significantly enhance the viability of the Fowl River WMP and its competitiveness and position going forward as federal, state, local, and private grant assistance needed for implementation is pursued.

SECTION 10.0
Monitoring and Sampling Plan

10



10.0 MONITORING AND SAMPLING PLAN

A monitoring program is necessary to continue to document the overall health of the Fowl River Watershed, track the success or failure of the implemented management measures, and determine where additional measures are necessary. The monitoring plan should encompass the greatest possible portion of the Watershed with the least number of samples while providing sufficient detail to identify probable source areas for elements of concern.

The monitoring program should clearly define the objectives of the sampling and identify which known and potential issues within the Watershed are being evaluated. Standard sampling and analyses protocols accepted by state and federal agencies should be used to collect and analyze data. Data collected during monitoring should be used to assess the effectiveness of recommended management measures once completed, and the success of those measures in accomplishing the goals and objectives stated in Section 5 of this Watershed Management Plan (WMP). The monitoring program should include, at a minimum, the following described activities.

10.1 MONITORING

Following approval of the WMP and the formation of a Watershed Management Task Force (WMTF), the WMTF should implement a quarterly monitoring program for most water-quality parameters. To assure consistency, the quarterly sampling should occur during the same time frame each quarter and under similar flow conditions. Permanent sample locations should be established to assure consistency over the 20-year life of this WMP. Water-quality issues identified during the WMP study include nutrient and organic carbon enrichment, low dissolved oxygen, high bacteria counts, and elevated concentrations of some metals. In addition, some shoreline reaches and saltwater marshes within the coastal zone of the Watershed are rapidly eroding and "at risk." Extensive data collection and analysis during the WMP study established 2015 baseline conditions for most water-quality parameters and sediment loading. A biological assessment component should be added to the suite of parameters monitored to establish baseline conditions for condition of habitat and populations and diversity of aquatic organisms. The first monitoring events should be conducted as soon as the WMTF is formed and funding is available.

The objective of the initial sampling and analyses is to compare current conditions in watershed streams to 2015 baseline condition, document shoreline extent and stability in the coastal zone, and perform an initial biological assessment of specific reaches within the Watershed. Once watershed management measures are undertaken, the sampling will also be used to determine success of management measures in improving conditions within the Watershed and to indicate where additional measures are needed.

Data collected should be archived in both paper and electronic format. An interactive geographical information system (GIS) database should be developed that facilitates electronic mapping and data query. Data collected during monitoring should be documented and summarized in an annual report submitted to the Mobile Bay National Estuary Program (MBNEP), Mobile County Commission, Alabama Department of Environmental Management (ADEM), and Fowl River WMTF. When sufficient data is available, trend analyses should be included in the annual report.

10.0 MONITORING AND SAMPLING PLAN

10.2 WATERSHED CONDITIONS AND ANALYTICAL PARAMETERS

The following water-quality parameters can be used to indicate the overall health of the Fowl River Watershed: (1) sediment loading and turbidity, (2) total nitrogen, (3) dissolved inorganic nitrogen, (4) total phosphorus, (5) dissolved inorganic phosphorus, (6) chlorophyll-a, (7) dissolved oxygen, (8) bacteria, (9) total organic carbon, and (10) metals. In addition, standard field parameters such as temperature, pH, specific conductance, turbidity, and salinity should be collected. In locations where the depth of water is sufficient, field parameters should be collected at specific depth intervals to create depth profiles. Biological assessments should include population surveys of vertebrate and invertebrate species and habitat analyses. Analyses of coastal zone shoreline should be performed in a consistent manner using photographs taken year after year from the same location and orientation, and with time sequenced, geo-referenced aerial photographs as available. Refer to **Table 10.1** and **Figure 10.1** for data collection station location and agency.

10.2.1 Standard Field Parameters

Whenever water quality samples are collected, standard procedure should include collection of a suite of concurrent field measurements used to help interpret the analytical data. These are known as "field parameters." The exact suite of measurements will vary, but should include temperature, pH, specific conductance, salinity, dissolved oxygen, and turbidity.

10.2.2 Sediment Loading and Turbidity

The Geological Survey of Alabama (GSA) completed a sediment loading study of the Fowl River Watershed in 2015 (see **Appendix A**). As stated in the report, "Comparisons of sediment transport rates and water quality data in watersheds in Baldwin and Mobile counties indicate that Fowl River has relatively small sediment loads and very good water quality" (GSA, 2015). The report did note a positive correlation between agricultural land use and sediment load. Probable sources of sediment included bare agricultural fields, channelized drainages, and lack of vegetative buffers.

Over the next 20 years, total suspended solids, bed sediment, total sediment load and turbidity measurements should be measured quarterly at specific sampling locations. Turbidity measurements should be collected under a variety of flow conditions. All data collection and analyses should utilize GSA protocols. Management measure success will be assessed in part by the degree to which sediment loading rates are reduced or remain stable as the percentage of developed land in the Watershed increases.

10.2.3 Total Nitrogen

Total nitrogen concentration in water is a combined measure of inorganic nitrogen (nitrites, nitrates and ammonia) and organic nitrogen. Organic nitrogen levels derive from sewage runoff, animal manure, and decomposition of aquatic organisms, while inorganic nitrogen concentrations derive from erosion and residential runoff (fertilizers). Nitrogen concentrations in some areas of the Fowl River Watershed exceed the levels at which excessive algae growth may occur. Excessive algae growth causes low dissolved oxygen concentrations and odiferous, unsightly water. The success of management measures will be assessed in part by the degree to which total nitrogen concentrations in the Watershed are reduced or stabilized.

10.2.4 Dissolved Inorganic Nitrogen

Dissolved inorganic nitrogen (DIN) is needed by plants to grow and reproduce. DIN sources are primarily anthropogenic, including urban runoff and fertilizers. A measure of DIN provides an assessment of human sources of nitrogen, and correlates those sources to land use and observed water quality. The success of management measures will be assessed in part by the degree to which DIN concentrations in the surface water system are reduced or stabilized.

10.2.5 Total Phosphorus

The total phosphorus concentration is a measure of both organic and inorganic forms. Both organic and inorganic phosphorus can either be dissolved in the water or suspended (attached to particles in the water column). Natural and human sources of phosphorus include soil and rocks, wastewater, fertilizers, septic systems, animal manure, disturbed land areas, and drained wetlands (EPA). Since phosphorus is the nutrient in short supply in most fresh waters, even a modest increase in phosphorus can create accelerated plant growth, algae blooms, low dissolved oxygen, and mortality of fish, invertebrates, and other aquatic animals. The measured phosphorus concentrations in some water samples collected during the WMP study exceeded the concentrations that may cause excessive algae growth. The success of management measures will be assessed in part by the degree to which the concentration of phosphorus in the surface water system is reduced or stabilized.

10.2.6 Dissolved Inorganic Phosphorus

Dissolved inorganic phosphorus (DIP) is the form that plants need to grow and reproduce. The sources of inorganic phosphorus include soil and rocks, fertilizers, and disturbed land areas (EPA). The soils and rocks within the Fowl River Watershed are composed primarily of silica, iron, sodium, calcium, potassium, and magnesium. They would not be a major source of inorganic phosphorus. Cook, Moss, and Rogers (2015) discovered a correlation between phosphorus concentration in surface water samples collected from the Fowl River Watershed and agricultural land use. This indicates that an important source of inorganic phosphorus in the Fowl River Watershed may be fertilizers applied to agricultural fields. However, as urban development in the Watershed continues, runoff from lawns may constitute a greater source than at present. Collection and analyses of water samples for DIP will allow correlation between sources and land use, and can be used to indicate if management measures have been successful in reducing or controlling sources of phosphorus.

10.2.7 Chlorophyll-a

Measurements of nutrient concentrations (nitrogen and phosphorus) within the waters of the Fowl River Watershed provide insight into their availability for use by aquatic plants like algae. Additional monitored parameters, such as chlorophyll-a, are used to estimate algal biomass or the abundance of aquatic vegetation. Chlorophyll-a is an indirect measure of the ability of aquatic vegetation to utilize available nutrients, used because it is easier to measure than algal biomass. There is generally a good agreement between planktonic primary production and algal biomass. Available data from ADEM monitoring station FR-1 suggest a declining trend of chlorophyll-a concentration in the Fowl River estuary. Annual measurements should be made to determine if the decreasing trend continues. Changes in chlorophyll-a concentration in the estuary would indicate the effectiveness of management measures in limiting nutrient inputs into Fowl River.

10.2.8 Dissolved Oxygen, Salinity, and Temperature Profiling

The collection of routine field parameters has already been discussed. However, in addition to routine data collection, depth profiles of dissolved oxygen, salinity, and temperature should be determined at selected monitoring locations to provide data about the stratification of water in the estuary and portions of the Fowl River proper. Stratification of water quality is important to aquatic life, especially if dissolved oxygen levels are very low near the bottom of the water column. Typical reasons for low dissolved oxygen are algae blooms caused by excessive nutrient concentrations, high water temperature, and die-off and decomposition of aquatic vegetation (also driven by excessive nutrient levels).

10.2.9 Bacteria

There are natural and human sources of bacteria. Any warm-blooded animal is a potential source of coliform bacteria. Samples collected from Fowl River at five locations (see **Appendix D**, **Figure D.4**) by the Watershed Management Team were analyzed for human gene biomarkers and indicated that the bacteria detected were not anthropogenic. This suggests that cattle, birds, and other wildlife with access to streams are the primary sources of bacteria in Fowl River. One recommended management measure for the Fowl River Watershed is a cattle exclusion program. The objectives of the cattle exclusion program include limiting erosion of stream banks and reduction of cattle-derived bacteria entering the surface water. Sampling and analyses of bacteria concentrations can be used to determine the success of the cattle exclusion program.

10.2.10 Biological Assessments

The purpose of the biological assessment will be to characterize and grade the overall health of the ecosystem along specific reaches of Fowl River and its tributaries. Biological assessments should utilize a standard protocol established by a state or federal agency, such as the EPA's Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish.

Biological assessments should be performed at selected water quality monitoring stations and should include population surveys of fish communities and benthic invertebrate species and characterization of stream habitat. This information will be necessary to determine if the management measures recommended by the WMP are meeting the goals of the MBNEP Comprehensive Conservation Management Plan (CCMP) for 2013-2018, specifically to "improve ecosystem function and resilience through protection, restoration, and conservation of habitats." The information will also be necessary to assess whether goals 1 and 2 of the WMP, presented in Section 1.3, are being met, which are to:

1. Improve water quality to support healthy populations of fish and shellfish
2. Improve habitats necessary to support healthy populations of fish and shellfish

10.2.11 Total Organic Carbon

The results of the 2015 GSA Fowl River Watershed Sediment Loading Analysis indicate that total organic carbon (TOC) concentrations are greater than typical values for natural waters. Potential sources of TOC include natural organic matter and anthropogenic sources, like petrochemicals, solvents, and pesticides. Elevated TOC concentrations could spur excessive algae growth and create the potential for low dissolved oxygen in the Fowl River estuary. Monitoring TOC concentrations would indicate the effectiveness of the management measures in limiting unfiltered runoff into the surface waters of Fowl River. These management measures include the low impact development (LID) incentive program, LID retrofit program, stream and wetland restoration projects, and the cattle exclusion program.

10.2.12 Metals

As with many other potential contaminants, metals in the environment derive from both natural and anthropogenic sources. For example, aluminum and iron detected in samples from the Fowl River Watershed probably originate from eroding sediments and iron bacteria (GSA, 2015). Conversely, lead, cadmium, copper, and nickel, detected in samples from the Fowl River Watershed, are not typically from natural sources in the Alabama coastal plain. The presence of these metals is most likely due to human activities. Aluminum concentrations sampled exceeded chronic screening levels set by the EPA for protection of aquatic life at all nine locations monitored during the 2015 GSA study. Concentrations of lead and nickel also exceeded the chronic screening levels, but at fewer locations.

Monitoring metal concentrations would indicate the success or lack thereof of the management measures in limiting unfiltered urban runoff into the surface waters of Fowl River as the percentage of developed land in the Watershed increases. These management measures include the LID incentive program, LID retrofit program, and stream and wetland restoration projects.

10.2.13 Coastal Shoreline Assessment

Analyses of at-risk coastal zone shorelines should be performed on an annual basis using photographs taken periodically from the same location and orientation, and with time-sequenced, geo-referenced aerial photographs. These techniques will allow evaluation of the success of implemented coastal zone projects and programs (e.g., no wake zones, resilient shorelines, shoreline enhancement and protection, revegetation, etc.), and identification of shorelines that continue to experience erosion.

The lower coastal estuarine shorelines in Zone I (see **Figure 4.32**) are currently considered to be “healthy” and show little to no signs of habitat loss. Monitoring of the lower estuarine shoreline should continue on an annual basis. If shoreline erosion or other habitat/ vegetative loss is discovered, plans to restore and preserve at-risk habitats should be undertaken and implemented.

10.0 MONITORING AND SAMPLING PLAN

10.3 SAMPLE COLLECTION LOCATIONS

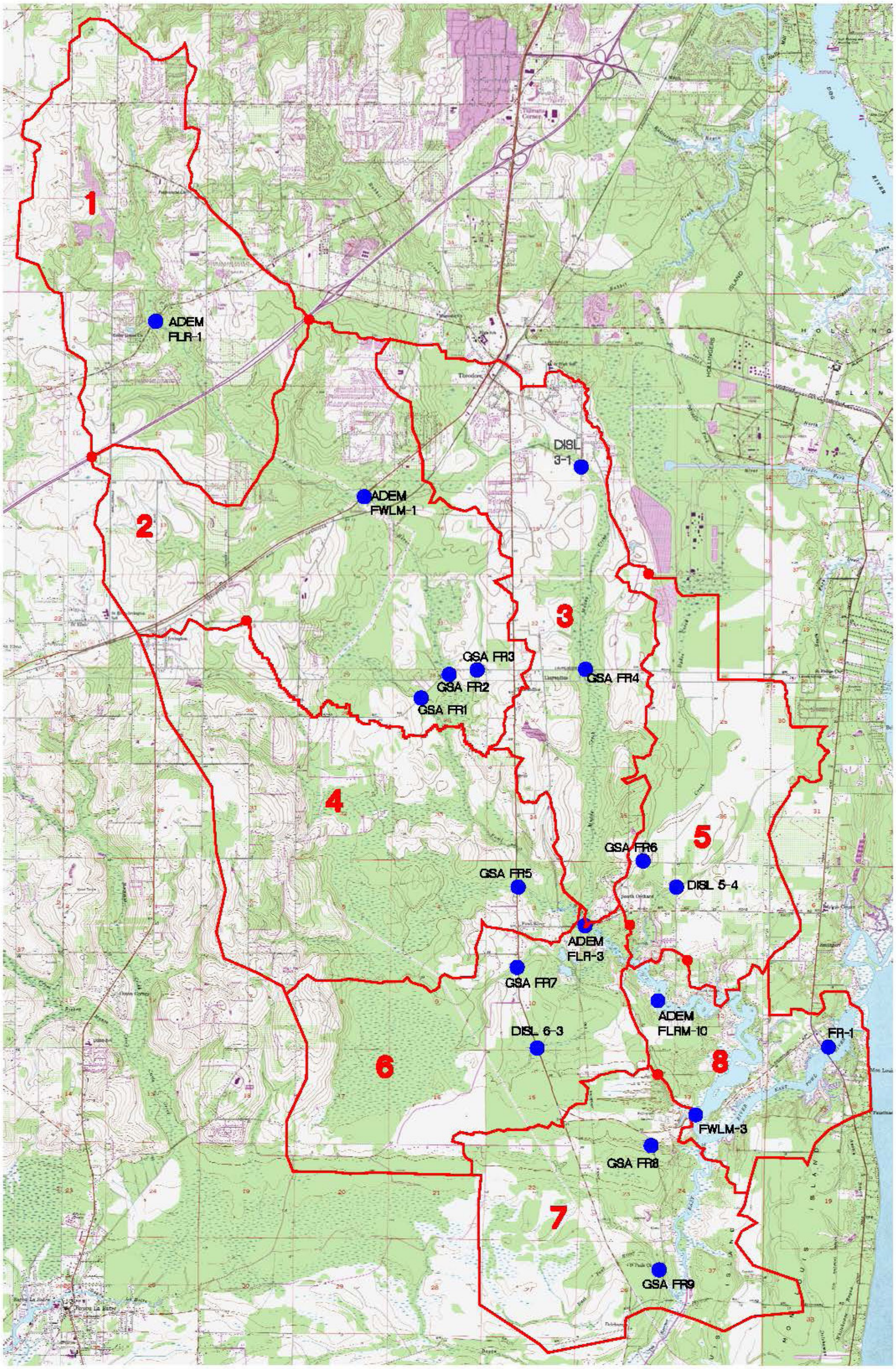
Eighteen priority sample collection locations have been identified (see **Figure 10.1**). These 18 data collection locations were strategically selected because of their geographic location to provide coverage throughout the Watershed, the pre-existing period of record, and the variety of data already available. Therefore, continuing to monitor at these locations will provide the most complete data set. All nine of the data collection stations utilized by the GSA during the 2015 study, along with six ADEM data collection stations and additional monitoring locations are listed in **Table 10.1**. The latitude and longitude coordinates of each site are provided in **Appendix D**.

TABLE 10.1: QUARTERLY SAMPLING LOCATIONS IN THE FOWL RIVER WATERSHED

Sample Location ID	Period of Record	Co-Located with Sample Location
ADEM FLR-1	3/2006	DISL sample location 1-1
ADEM FWLM-1	3/2006 - 10/2006	DISL sample location 2-1
DISL 3-1	2/2015 – 5/2015	
GSA FR-1	2014 - 2015	DISL sample location 2-2
GSA FR-2	2014 - 2015	DISL sample location 2-3
GSA FR-3	2014 - 2015	DISL sample location 2-4
GSA FR-4	2014 - 2015	DISL sample location 3-2
GSA FR-5	2014 - 2015	DISL sample location 4-3
ADEM FLR-3	3/2006	DISL 3-3
GSA FR-7		DISL 6-1
DISL 6-3	2/2015 – 5/2015	
GSA FR-6		DISL 5-2
DISL 5-4	2/2015 – 5/2015	
ADEM FLRM-10	8/1999	
GSA FR-8	2014 - 2015	DISL 7-1
GSA FR-9	2014 - 2015	
ADEM FWLM-3	3/2013 – 10/2013	
ADEM FR-1	10/1985 – 9/2014	

ADEM - Alabama Department of Environmental Management; DISL - Dauphin Island Sea Lab; GSA - Geological Survey of Alabama

FIGURE 10.1: SAMPLE COLLECTION LOCATIONS IN THE FOWL RIVER WATERSHED



10.0 MONITORING AND SAMPLING PLAN

10.4 IMPLEMENTATION SCHEDULE

The implementation schedule for the WMP should be prepared and maintained by the WMTF. The schedule should be modified as needed to address each of the specific management measures contained in Section 6 of the WMP as they are implemented. Each management measure should be listed as a major task in the implementation schedule, with all subtasks being listed to help organize and complete the necessary sampling. The schedule should include the start and projected end dates for each task, and the personnel assigned to each task.

The implementation schedule should be reviewed annually and updated as needed. The status of the implementation schedule should be reported annually to the Mobile County Commission, the City of Mobile, and the MBNEP as part of the annual report. The schedule will serve as an important tool to assess the status of the WMP and to identify where corrective actions are needed to address problems encountered in the implementation of the WMP.

10.5 ANTICIPATED COSTS

The estimated cost for an adequate monitoring program ranges from $150,000 to $175,000 each year. Following approval of this WMP and creation of the WMTF, the specific costs of the monitoring program should be determined by the WMTF by developing more detailed scopes of work for the monitoring program, and soliciting bids for completion of the detailed scope of work. It should be possible to fund the monitoring costs through grants or other funding sources identified in Section 9 of the WMP. The GSA and the U.S. Geological Survey (USGS) have cooperative programs that allow them to share annual costs of collecting environmental data.

SECTION 11.0
References

11

11.0 REFERENCES

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GIS DATASETS AND ONLINE DATABASES

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NRHP Historical Data (https://irma.nps.gov/App/Reference/Profile/2210280/)

National Hydrography Data (https://gdg.sc.egov.usda.gov/GDGOrder.aspx)

1992 National Land Cover Data (http://landcover.usgs.gov/natllandcover.php)

2011 National Land Cover Data (http://www.mrlc.gov/nlcd2011.php)

Land use data (http://www.webgis.com/lulcdata.html)

Historical Shoreline Data

NRCS Soils Data for Mobile County (https://gdg.sc.egov.usda.gov/GDGOrder.aspx)

Wetlands (http://www.fws.gov/wetlands/Data/Data-Download.html)

Historical Sea Level Data

High Res Aerial Photography

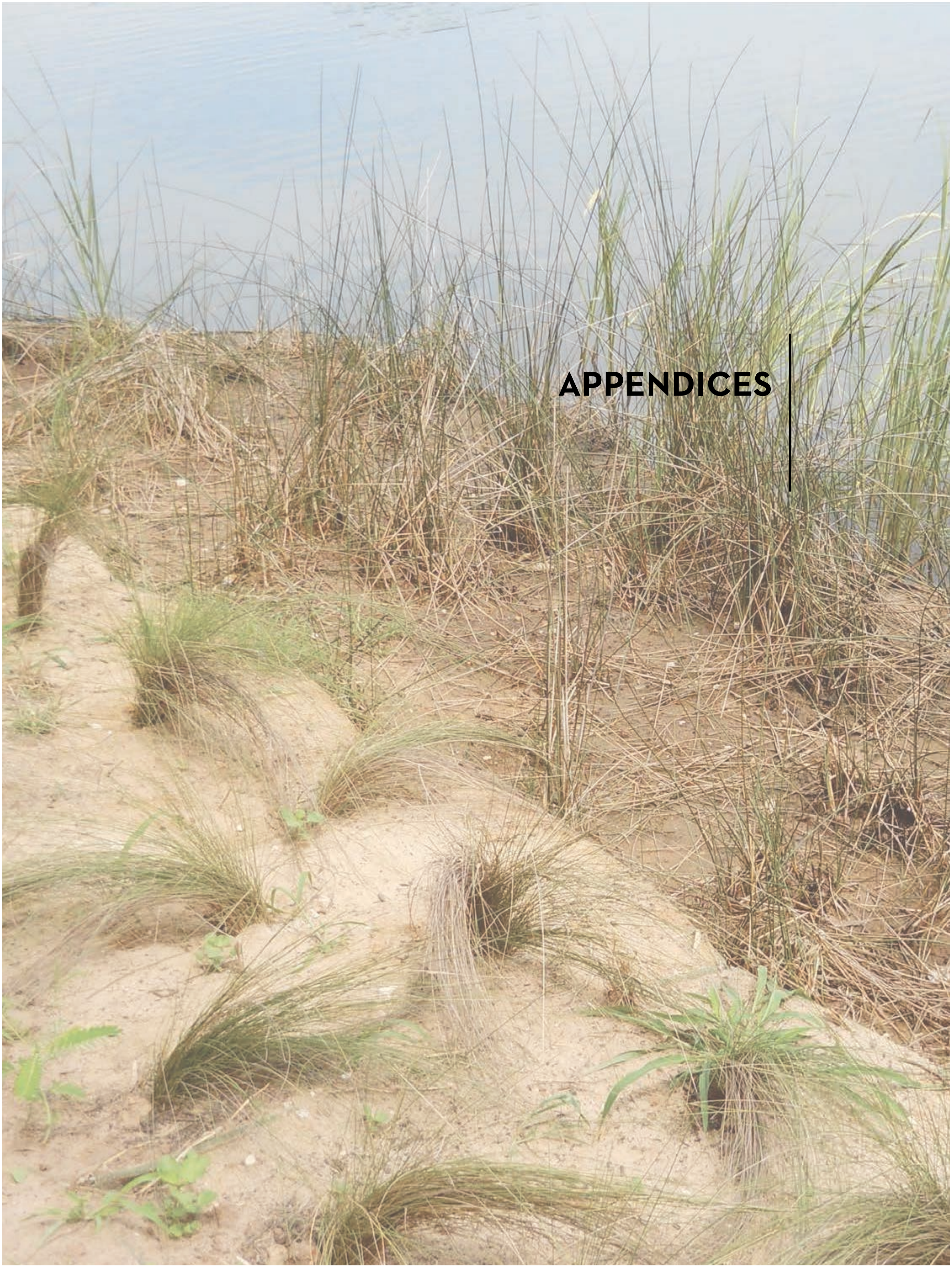
US Census Data

USEPA STORET database (http://www3.epa.gov/storet/)

USGS NWIS online database (http://waterdata.usgs.gov/nwis)

USGS Quads

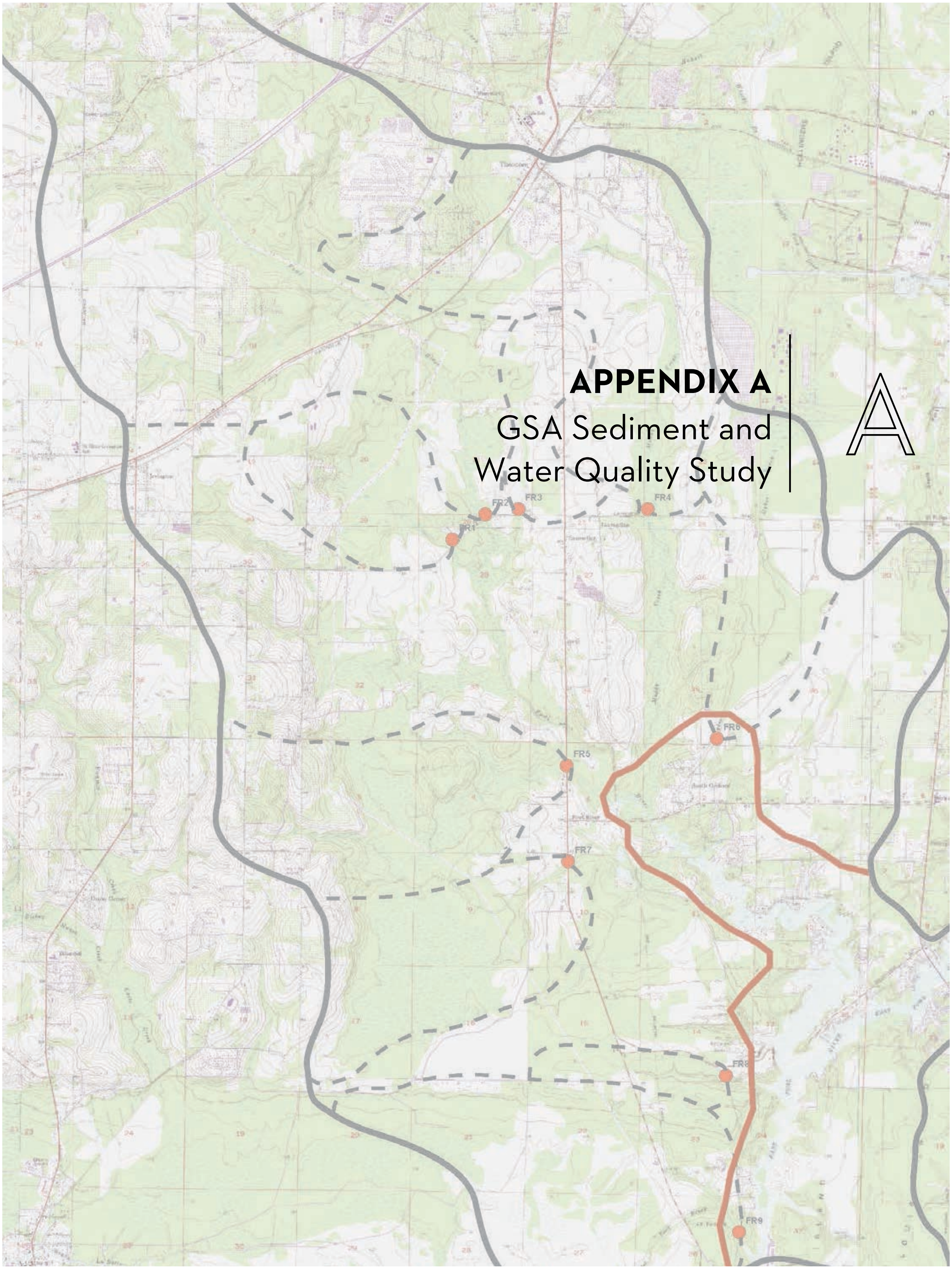
APPENDICES



APPENDIX A

GSA Sediment and Water Quality Study

A



A. GSA SEDIMENT AND WATER QUALITY STUDY

PRE-RESTORATION ANALYSIS OF DISCHARGE, SEDIMENT TRANSPORT RATES, AND WATER QUALITY IN TRIBUTARIES OF FOWL RIVER, MOBILE COUNTY, ALABAMA

A. GSA SEDIMENT AND WATER QUALITY STUDY

GEOLOGICAL SURVEY OF ALABAMA

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PRE-RESTORATION ANALYSIS OF DISCHARGE, SEDIMENT TRANSPORT RATES, AND WATER QUALITY IN TRIBUTARIES OF FOWL RIVER, MOBILE COUNTY, ALABAMA

OPEN FILE REPORT 1511

By

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INTRODUCTION

Commonly, land-use and climate are major contributors to nonpoint source contaminants that impact surface-water quality. In much of Baldwin and Mobile Counties, population growth and economic development are critical issues leading to land-use change. When combined with highly erodible soils and Alabama's coastal climate, characterized by cyclonic storms that produce high intensity rainfall events, deleterious water-quality and biological habitat impacts can be severe. Previous investigations of sediment transport and general water quality performed by the Geological Survey of Alabama (GSA) have shown dramatic increases in sediment loading and loss of biological habitat in streams downstream from areas affected by rapid runoff and resulting erosion. These data are valuable in quantifying negative impacts so that limited remedial resources may be focused where needs are greatest. GSA investigations also identified relatively unimpacted watersheds, such as Yellow River in Covington County and Magnolia River in southwest Baldwin County, where remedial resources may be used to preserve and protect watersheds from threats of future impacts.

The purpose of this investigation is to assess general hydrogeologic and water quality conditions and to estimate sediment loads for Fowl River and all of its major tributaries. These data will be used to quantify water quality impacts and to support development of a watershed management plan that will preserve, protect, and restore the Fowl River watershed.

ACKNOWLEDGMENTS

Ms. Roberta Swann, Director, Mobile Bay National Estuary Program, and Mr. Tom Herder, Watershed Protection Coordinator, Mobile Bay National Estuary Program, provided coordination for the project. Mr. Lee Walters, Regional Vice President, Goodwin, Mills, and Cawood, provided information and guidance in the planning and implementation of the project.

PROJECT AREA

The Fowl River watershed covers 52,782 acres (82.5 square miles (mi^2) (Mobile Bay National Estuary Program (MBNEP), 2015) in southeastern Mobile County and includes monitoring sites on seven tributaries and the main stems of Fowl River and East

A. GSA SEDIMENT AND WATER QUALITY STUDY

Fowl River (fig. 1). Fowl River flows southeast from its headwaters northwest of Theodore to its confluence with East Fowl River near Bellingrath Gardens where it flows along the northern shore of Mon Louis Island and empties into Mobile Bay (fig 1, plate 1). Elevations in the project area vary from more than 180 feet above mean sea level (ft MSL) to sea level (plate 2). The seven monitored tributaries include five unnamed streams, Muddy Creek, and Dykes Creek.

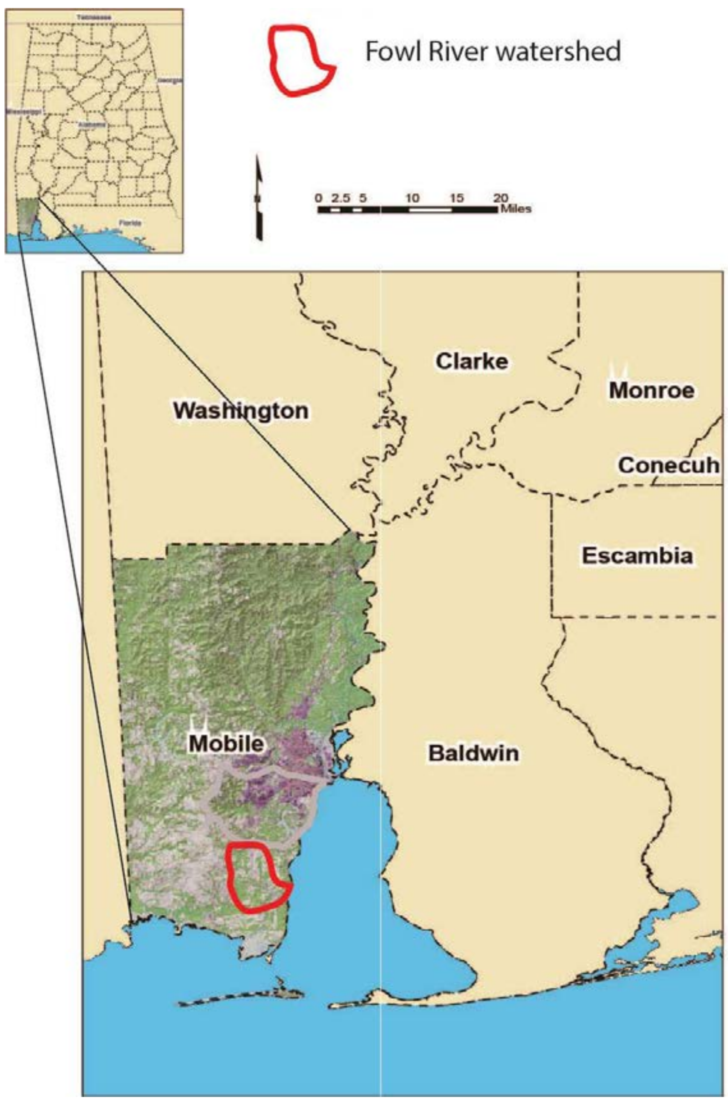

Figure 1.—Fowl River project area.

PROJECT MONITORING STRATEGY AND SITE CONDITIONS

The monitoring strategy employed for the Fowl River project was to collect water samples at each site over a wide range of discharge from base flow to flood for sediment load estimation and collect samples during high and low flow events for comprehensive analyses. A number of factors were considered during selection of monitoring sites, including site accessibility in rural areas, extensive wetlands and tidal influence that constrain stream flow and impact water chemical character, and site locations as far downstream as possible, to include cumulative impacts.

Site FR1 is on an unnamed tributary flowing southeastward in the west-central part of the Fowl River watershed (latitude (lat) 30.49775, longitude (long) -88.18629). The monitored site is at the Half Mile Road crossing, about 2,000 feet (ft) from its confluence with Fowl River. The watershed upstream from site FR1 covers 2.14 mi^2.

Site FR2 is on Fowl River in the central part of the watershed at the Half Mile Road crossing (lat 30.50103, long 88.18144). The watershed upstream from site FR2 covers 15.2 mi^2.

Site FR3 is on an unnamed tributary flowing southward in the central part of the Fowl River watershed (lat 30.50175, long -88.17647). The monitored site is at the Half Mile Road crossing, about 4,500 ft from its confluence with Fowl River. The watershed upstream from site FR3 covers 1.1 mi^2.

Site FR4 is on Muddy Creek at the Laurendine Road crossing (lat 30.50193, long -88.15719). Muddy Creek has its headwaters in the town of Theodore, where it drains the southern part of the urban area. The stream flows southward and eventually discharges into Fowl River, about 2.8 mi downstream from the monitoring site at the Half Mile Road crossing (lat 30.50175, long -88.17647). The watershed upstream from site FR4 covers 5.9 mi^2.

Site FR5 is on an unnamed tributary flowing southeastward in the west-central part of the Fowl River watershed (lat 30.46869, long -88.16890). The monitored site is at the Bellingrath Road crossing, about 2,200 ft from its confluence with Fowl River. The watershed upstream from site FR5 covers 4.0 mi^2.

Site FR6 is on Dykes Creek at the Fowl River Road crossing (lat 30.47238, long -88.14655). Dykes Creek forms the eastern boundary of the Fowl River watershed and flows southward to its confluence with Fowl River about 3,000 ft downstream from site FR6. The watershed upstream from site FR6 covers 4.2 mi^2.

Site FR7 is on an unnamed tributary flowing northeastward in the west-central part of the Fowl River watershed (lat 30.45633, long -88.16855). The monitored site is at the Bellingrath Road crossing, about 1.2 mi from its confluence with Fowl River. The watershed upstream from site FR7 covers 3.2 mi^2.

Site FR8 is on an unnamed tributary flowing eastward in the southwest part of the Fowl River watershed (lat 30.42883, long -88.14466). The monitored site is at the Rebel Road crossing, about 3,000 ft from its confluence with East Fowl River. The watershed upstream from site FR8 covers 0.5 mi^2.

Site FR9 is on East Fowl River at the Rebel Road crossing (lat 30.40863, long -88.14247). The monitored site is about 2.0 mi from its confluence with Fowl River. The watershed upstream from site FR9 covers 5.1 mi^2.

LAND USE AND STREAM FLOW CONDITIONS

Land use is directly correlated with water quality, hydrologic function, ecosystem health, biodiversity, and the integrity of streams and wetlands. Land use classification for the project area was calculated from the U.S. Department of Agriculture (USDA) National Agricultural Statistics Service 2013 Alabama Cropland Data Layer (NASS CDL) raster dataset. The CDL is produced using satellite imagery from the Landsat 5 TM sensor, Landsat 7 ETM+ sensor, the Spanish DEIMOS-1 sensor, the British UK-DMC 2 sensor, and the Indian Remote Sensing RESOURCESAT-1 (IRS-P6) Advanced Wide Field Sensor (AWiFS) collected during recent growing seasons (USDA, 2013). Land use in the project area was subdivided into six classified groups defined as developed, forested, agricultural, grassland/shrub/scrub, wetlands, and open water (fig. 2).

The dominant land use category in the Fowl River project area is herbaceous and woody wetlands (25.6 percent (%) of total land area). Wetlands are important because they provide water quality improvement and management services such as flood abatement, storm water management, water purification, shoreline stabilization, groundwater recharge, and streamflow maintenance. The second largest land use category

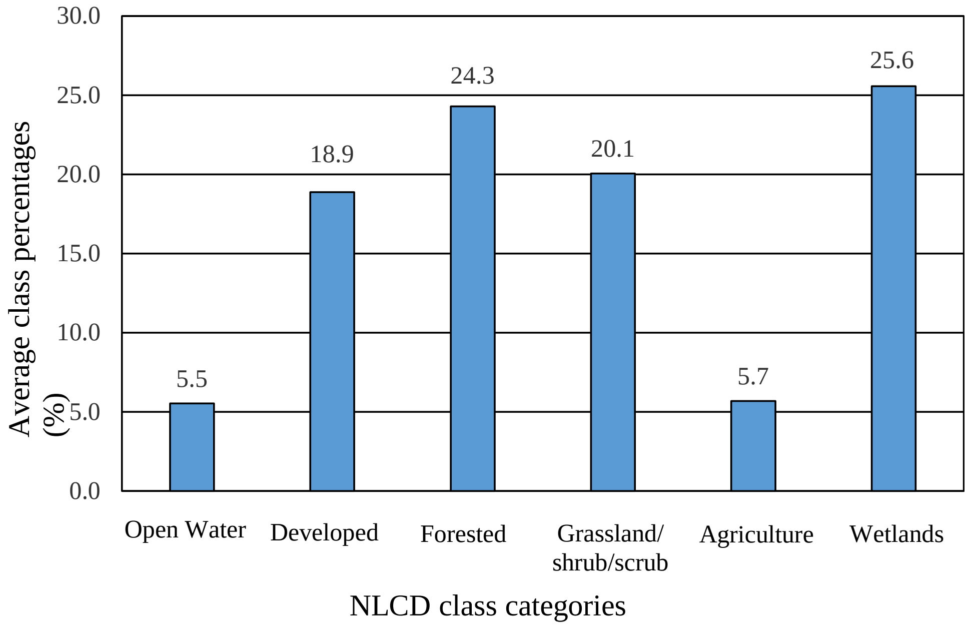

Figure 2.—Land-use classifications for the Fowl River project area.

is evergreen and mixed forest (24.3%). The third most common land use category is grassland/shrub/scrub (20.1%). This category is composed of fallow and idle cropland, grassland and pasture land, hay, and shrubland. The next most abundant category is developed land (18.9%), which includes part of the town of Theodore and the Interstate 10 and U.S. Highway 90 corridors. There are clusters of residential growth in the headwaters of Fowl River as well as a large industrial site along the eastern perimeter of the watershed. Agriculture accounts for 5.7% of the land use in the watershed and consists of peanuts, soybeans, corn, cotton, pecans, winter wheat, and a variety of double crops. Open water covers 5.5% of total land area, consisting of small lakes and ponds, Mobile Bay, East Fowl River, and Fowl River. Land use is shown on plate 3. Land uses for individual tributary watersheds and their impacts are discussed in various following sections of the report.

Unlike streams in Baldwin County, which are extremely flashy due to relatively high topographic relief and land-use change, or streams in the Dog River watershed that are also extremely flashy with relatively high velocities due to channelization and urbanization, the character of stream flows in Fowl River and its tributaries are relatively unimpacted by man and are primarily influenced by relatively low topographic relief, extensive wetlands, vegetation (anastomosing conditions), and tidal effects. The average gradient for streams in the Dog River watershed is 48.0 feet per mile (ft/mi) as compared to the Fowl River watershed, which is 10.3 ft/mi. The average flow velocity for Dog River sites was 2.1 feet per second (ft/s). Relatively small stream gradients for Fowl River streams are reflected in lower stream flow velocities, which averaged 0.7 ft/s (table 1).

A wide range of discharge events is required to adequately evaluate hydrologic conditions in Fowl River. Table 1 shows that sampling occurred in the Fowl River watershed during discharge conditions from base flow to flood. For example, the minimum discharge measured for Fowl River at Half Mile Road (site FR2) was 18 cubic feet per second (cfs) (September 28, 2014) and the maximum was 2,040 cfs, measured during an overbank flood on April 13, 2015. Average daily discharge for each monitored stream is also required to adequately assess constituent loading. Discharge data collected at site FR2 (U.S. Geological Survey (USGS) stream gaging site 02471078, Fowl River at Half Mile Road, near Laurendine, Alabama) was used as a basis for average daily discharge estimation for each monitored stream.

Table 1.--Stream flow characteristics for monitored sites in the Fowl River watershed.

Monitored site	Average discharge (cfs)	Maximum discharge (cfs)	Minimum discharge (cfs)	Average discharge per unit area (cfs/mi)	Average stream flow velocity (ft/s)	Stream gradient (ft/mi)
FR1	48	273	3.5	22.4	0.9	10.0
FR2	314	2,040	18	20.6	n/a	10.3
FR3	22	73	0[1]	19.8	0.4	13.9
FR4	87	604	0[1]	14.8	0.8	7.5
FR5	47	300	4.0	11.8	0.8	13.9
FR6	28	87	TI[2]	10.2	0.6	12.9
FR7	61	130	3.9	18.9	1.0	7.7
FR8	11	30	0[1]	20.4	0.2	12.0
FR9	59	135	TI[2]	11.5	0.6	4.2

[1]0–discharge too low to measure
[2]TI–tidal influence

TURBIDITY

Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms (Eaton and others, 1995). Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted with no change in direction or flux level through the stream (Eaton and others, 1995). Turbidity values measured in nephelometric turbidity units (NTU) from water samples may be utilized to formulate a rough estimate of long-term trends of total suspended solids (TSS) measured in milligrams per liter (mg/L). This relationship of turbidity and TSS is observed in figure 3, where average turbidity and TSS values are plotted. Note that the highest average turbidity and TSS values were measured at sites FR3 and FR6.

Analyses of turbidity and stream discharge provide insights into hydrologic, land-use, and general water-quality characteristics of a watershed. Average measured turbidity and discharge, shown in figure 4, illustrates that, generally, monitored sites with the highest average discharge have the lowest average turbidity, which indicates that the

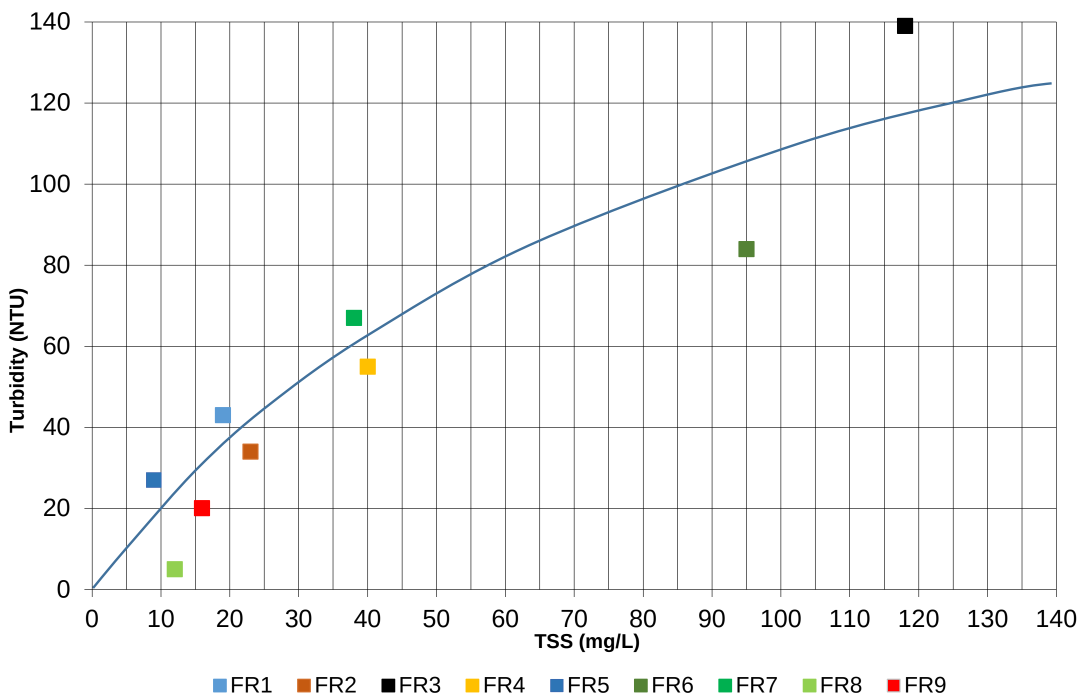

Figure 3.—Regression for average turbidity and TSS for all monitored Fowl River sites.

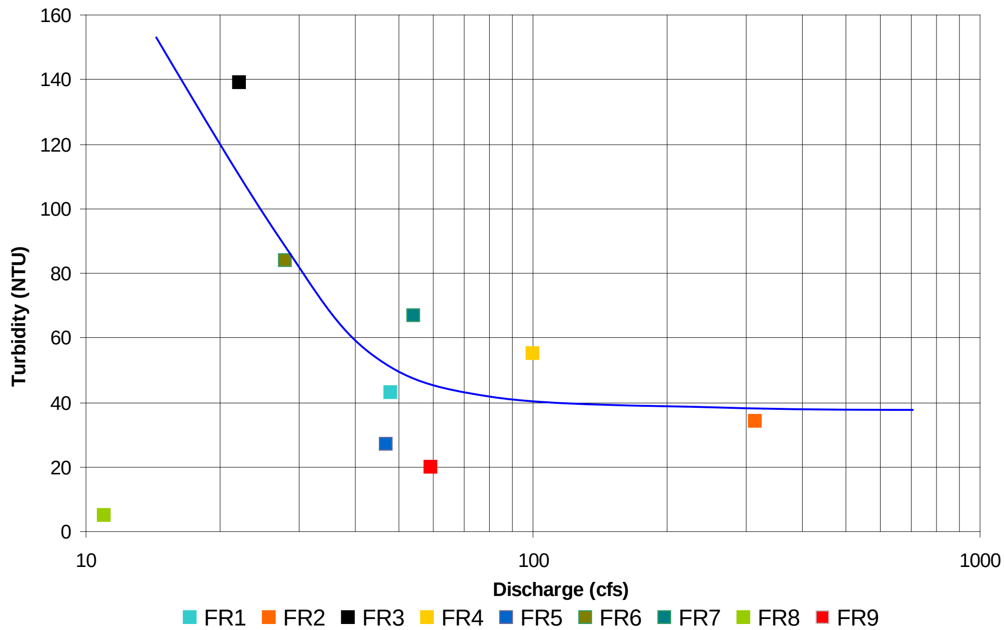

Figure 4.—Regression for average turbidity and discharge for all monitored Fowl River sites.

monitored Fowl River watersheds have limited sources of turbidity so that elevated discharge provides dilution, resulting in relatively low turbidity. Sites FR3 and FR6 have the highest turbidity to discharge ratio (6.3 and 3.0 NTU/cfs, respectively), while site FR2 (Fowl River at Half Mile Road) has the lowest (0.1 NTU/cfs) (fig. 4).

The shape of turbidity and discharge curves are also useful in assessing watershed characteristics that impact water quality and habitats. For example, figure 5 illustrates the most commonly observed curve (positive correlation) of increasing turbidity with increasing discharge. The curve for site FR2 (Fowl River at Half Mile Road) shows rapidly increasing turbidity during the first flush, followed by a slowing of the rate of turbidity increase as discharge continues to increase. Figure 5 shows that turbidity increases at a rate of 50 NTU/100 cfs for the discharge range of 0 to 100 cfs. The second phase shows a rate of 6 NTU/100 cfs for the discharge range of 100 to 500 cfs and a third phase with a rate of 0.7 NTU/100 cfs for the discharge range of 500 to 2,200 cfs. This

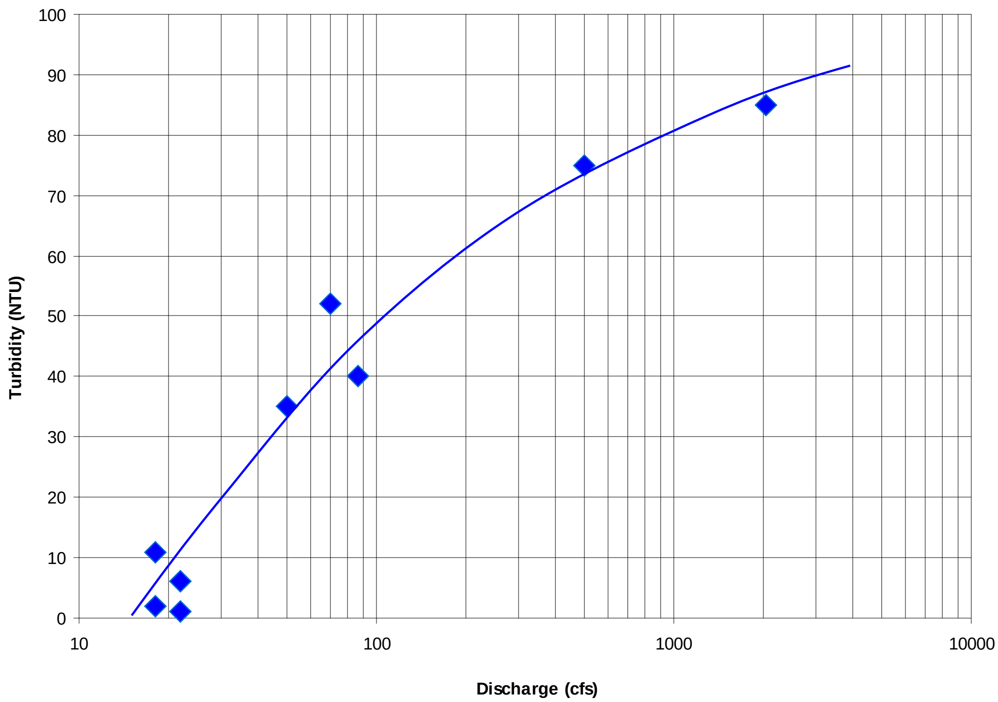

Figure 5.—Regression with positive correlation for measured turbidity and discharge for site FR2 (Fowl River at Half Mile Road).

curve shape indicates local sources of turbidity followed by upstream discharge with limited sources of turbidity, or a limited source of turbidity in the monitored watershed that is diluted with relatively low turbidity runoff as discharge increases.

A second type of curve illustrates rapidly increasing turbidity during the first flush followed by decreasing turbidity as discharge continues to increase (fig. 6). Site FR1 (unnamed tributary to Fowl River at Half Mile Road) has increasing turbidity at a rate of 1.6 NTU/cfs for a discharge range of 0 to 50 cfs followed by decreasing turbidity at a rate of 0.15 NTU/cfs for a discharge range of 50 to 300 cfs (fig. 6). This characterizes a watershed with limited sources for turbidity. Only one large flow event was monitored at site FR1, therefore additional data is needed to confirm the decreasing turbidity limb of the regression curve.

A third type of egression curve illustrates constant turbidity values with increasing discharge. Figure 7 depicts no increase in turbidity for a discharge range of 3

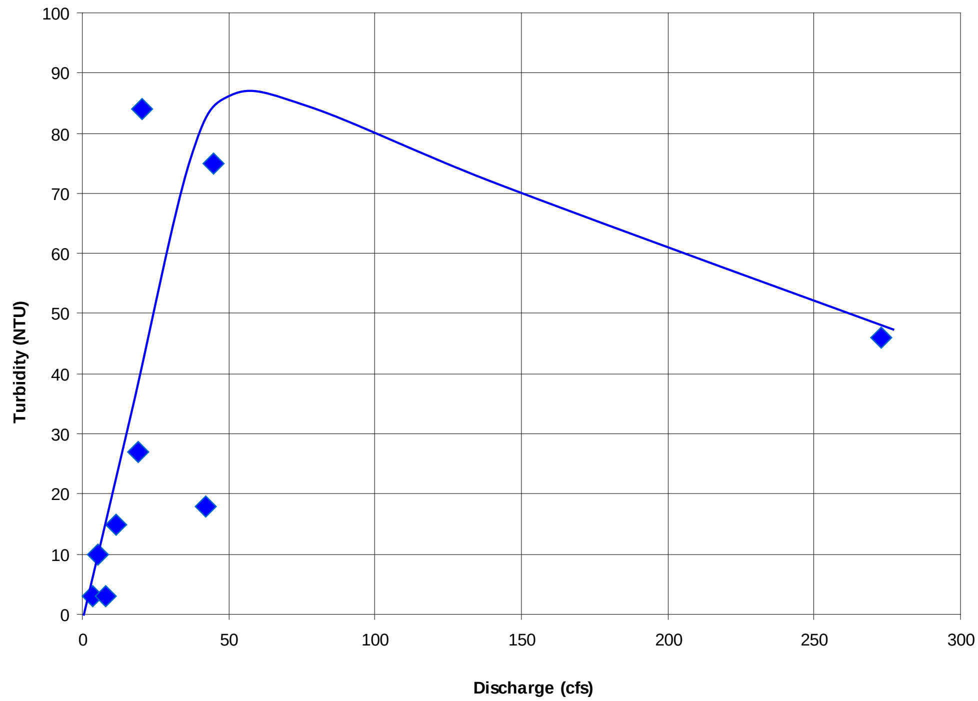

Figure 6.—Regression with positive correlation at low discharge and negative correlation at high discharge for site FR1 (unnamed tributary at Half Mile Road).

to 20 cfs followed by a relatively rapid turbidity increase of 1.5 NTU/cfs for a discharge range of 20 to 30 cfs. This characterizes a watershed with turbidity sources well upstream from the monitoring site or watershed with turbidity sources that require significant discharge to mobilize sediment and other suspended material.

Commonly, excessive turbidity is closely tied to land uses that cause land disturbances that lead to erosion or to land uses that cause excessive runoff. Figures 8 and 9 show correlations between agriculture, wetlands, and turbidity. Figure 8 shows a strong positive correlation between increasing agricultural land percentage and increasing turbidity. Figure 9 shows a strong negative correlation between turbidity and increasing wetland area.

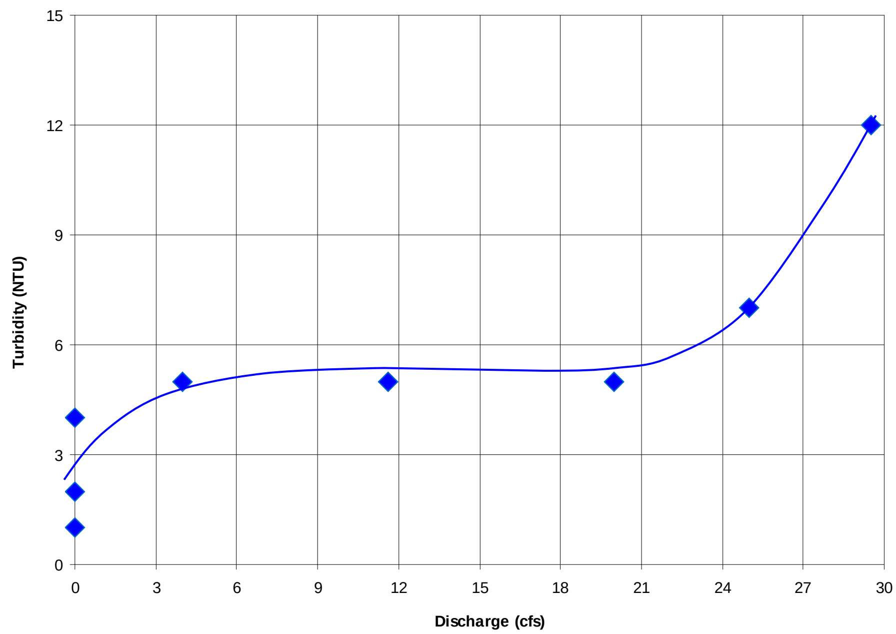

Figure 7.—Regression showing relatively constant turbidity values over the lower 70% of the discharge range and increasing turbidity for the high discharge range for site FR8 (unnamed tributary at Rebel Road).

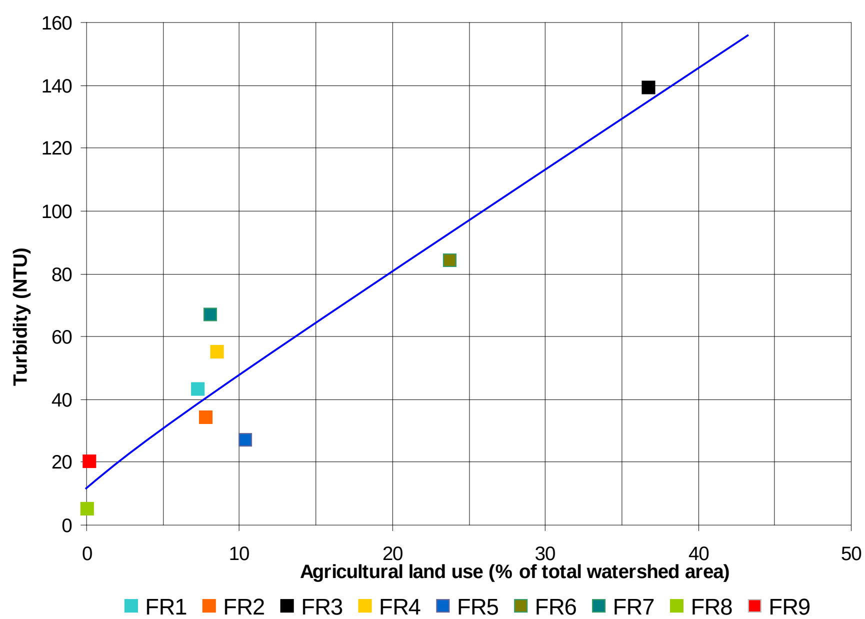

Figure 8.—Average turbidity and agricultural land use for monitored Fowl River sites.

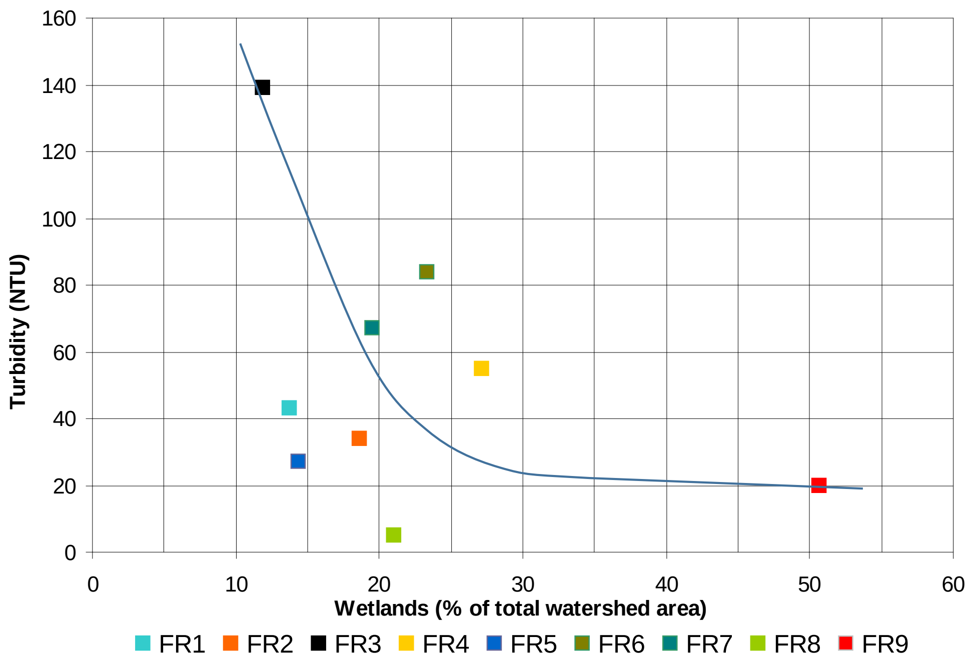

Figure 9.—Average measured turbidity and wetlands at monitored Fowl River sites.

SEDIMENTATION

Sedimentation is a process by which eroded particles of rock are transported primarily by moving water from areas of relatively high elevation to areas of relatively low elevation, where the particles are deposited. Upland sediment transport is primarily accomplished by overland water flow with rill and gully development. Lowland or flood plain transport occurs in streams of varying order, where upland sediment joins sediment eroded from flood plains, stream banks, and stream beds. Erosion rates are accelerated by human activity related to agriculture, construction, timber harvesting, unimproved roadways, or any activity where soils or geologic units are exposed or disturbed. Excessive sedimentation is detrimental to water quality, destroys biological habitat, reduces storage volume of water impoundments, impedes the usability of aquatic recreational areas, and causes damage to structures.

Precipitation, stream gradient, geology and soils, and land use are all important factors that influence sediment transport characteristics of streams. Sediment transport conditions in the Fowl River watershed area are evaluated and quantified by tributary, in order to evaluate factors impacting erosion and sediment transport at a localized scale. In addition to commonly observed factors mentioned above, wetlands, vegetation, and tidal effects also play prominent roles in sediment transport and overall water quality. Estimates of sediment loads for this assessment are based on measured sediment and stream discharge. Therefore, a stream flow dataset composed of values ranging from base flow to flood is desirable. Average observed stream flow conditions are shown in table 1.

Sediment loads in streams are composed of relatively small particles suspended in the water column (suspended solids) and larger particles that move on or periodically near the streambed (bed load). A pre-monitoring assessment of sediment characteristics indicated that relatively little bed sediment was present in the streams at selected Fowl River monitoring sites. Therefore, total sediment loads were assumed to be suspended.

SEDIMENT LOADS TRANSPORTED BY PROJECT STREAMS

The rate of transport of sediment is a complex process controlled by a number of factors related to land use, precipitation runoff, erosion, stream discharge and flow velocity, stream base level, and physical properties of the transported sediment. Highly erodible soils formed from sand, clayey sand, and sandy clay of the undifferentiated Miocene Series, Citronelle Formation, and alluvial, coastal, and low terrace deposits (plate 4), combined with relatively high topographic relief related to the formation of Mobile Bay and land disturbance related to development and agriculture are major contributing factors to high rates of erosion and sedimentation.

Excessive sedimentation causes changes in base level elevation of streams in the watershed and triggers downstream movement of the material as streams reestablish base level equilibrium. Deterrents to excessive erosion and sediment transport include wetlands, forests, vegetative cover and field buffers for croplands, limitations on impervious surfaces, and a number of constructed features to promote infiltration of precipitation and to store and slow runoff. Currently, the East Fowl River and upper Fowl River watersheds maintain a relatively healthy hydrologic environment characterized by a relatively rural setting, minimal row crop agriculture, low topographic relief, abundant wetlands, and anastomosing and natural stream channels.

SUSPENDED SEDIMENT

The basic concept of constituent loads in a river or stream is simple. However, the mathematics of determining a constituent load may be quite complex. The constituent load is the mass or weight of a constituent that passes a cross-section of a stream in a specific amount of time. Loads are expressed in mass units (tons or kilograms) and are measured for time intervals that are relative to the type of pollutant and the watershed area for which the loads are calculated. Loads are calculated from concentrations of constituents obtained from analyses of water samples and stream discharge, which is the volume of water that passes a cross-section of the river in a specific amount of time.

Suspended sediment is defined as that portion of a water sample that is separated from the water by filtering. This solid material may be composed of organic and inorganic particles that include algae, industrial and municipal wastes, urban and agricultural runoff, and eroded material from geologic formations. These materials are transported to stream channels by overland flow related to storm-water runoff and cause varying degrees of turbidity. Figure 3 shows that turbidity and suspended sediment are closely related in the Fowl River watershed. Turbidity, TSS, suspended sediment loads, and discharge values for all monitoring sites are shown in table 2.

Table 2.—Total suspended solids (TSS) and suspended sediment loads measured in monitored streams.

Monitored site	Average measured discharge (cfs)	Average turbidity (NTU)	Maximum turbidity (NTU)	Average TSS (mg/L)	Maximum TSS (mg/L)	Estimated suspended sediment load (t/yr)	Estimated normalized suspended sediment load ($t/mi^2/yr$)
FR1	48	43	84	19	75	251	117
FR2	314	34	85	23	108	795	52
FR3	22	139	740	118	446	336	303
FR4	87	55	182	40	121	414	70
FR5	47	27	56	9	19	256	64
FR6	28	84	255	95	300	1,139	271
FR7	61	67	147	38	134	415	128
FR8	11	5	12	12	42	34	63
FR9	59	20	37	16	55	412	80

A. GSA SEDIMENT AND WATER QUALITY STUDY

Annual suspended sediment loads were estimated for Fowl River monitored streams using the computer regression model Regr_Cntr.xls (*Regression with Centering*) (Richards, 1999). The program is an Excel adaptation of the USGS seven-parameter regression model for load estimation in perennial streams (Cohn and others, 1992). The regression with centering program requires TSS concentrations and average daily stream discharge to estimate annual loads.

Although average daily discharge for project streams was not available from direct measurement for eight of nine Fowl River monitored sites, it was estimated by establishing a ratio between periodic measured discharge in project streams and discharge values for the same times obtained from site FR2, which is also a USGS stream gaging site (02471078, Fowl River at Half Mile Road, near Laurendine, Alabama).

Concentrations of TSS in mg/L were determined by laboratory analysis of periodic water grab samples. These results were used to estimate the mass of TSS for the period of stream flow (May 1, 2014 through April 30, 2015). Sites FR6 (Dykes Creek at Fowl River Road), FR2 (Fowl River at Half Mile Road) and FR7 (unnamed tributary at Bellingrath Road) had the largest suspended sediment loads with 1,139, 795, and 415 tons per year (t/yr), respectively (table 2, fig. 10). For comparison, the largest suspended sediment loads in the Dog River watershed were Eslave Creek, Spencer Branch, and Spring Creek (sites 10, 7, and 2) with 10,803, 5,970, and 5,198 t/yr, respectively (Cook and Moss, 2012). The smallest loads were at sites FR8 (unnamed tributary at Rebel Road), FR5 (unnamed tributary at Bellingrath Road) and FR3 (unnamed tributary at Half Mile Road) with 34, 256, and 336 t/yr, respectively (table 2, fig. 10).

Discharge and watershed area are two of the primary factors that influence sediment transport rates in the Fowl River watershed. Figure 11 depicts average annual daily discharge (calculated from discharge estimates based on average daily discharge measured at the Fowl River at Half Mile Road USGS gage station for the period May 1, 2014 to April 30, 2015) and estimated suspended sediment loads and shows that, generally, increased discharge results in increased suspended sediment loads.

Normalizing suspended sediment loads to unit watershed area permits comparison of monitored watersheds and lessens the influence of drainage area size and discharge on sediment loads. Sites FR3 (unnamed tributary at Half Mile Road), FR6 (Dykes Creek at

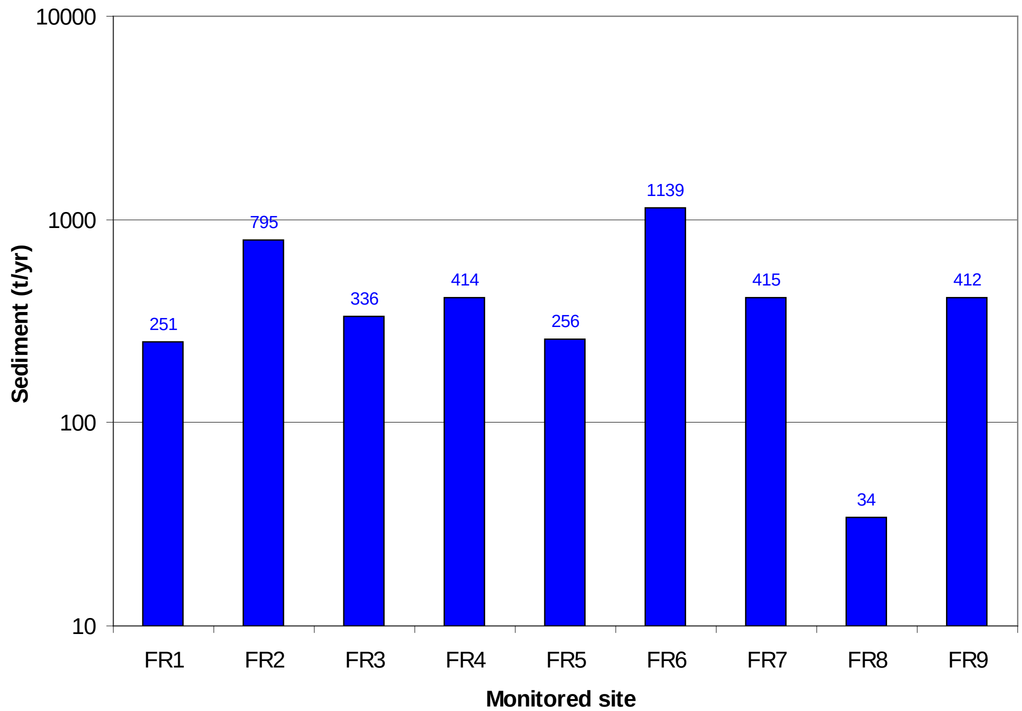

Figure 10.—Estimated suspended sediment loads for monitored Fowl River sites.

Fowl River Road, and FR7 (unnamed tributary at Bellingrath Road) had the largest normalized loads with 303 and 271, and 128 tons per square mile per year (t/mi^2/yr), respectively (table 2). For comparison, the largest normalized suspended sediment loads in the Dog River watershed were Spencer Branch, Spring Creek, and Eslava Creek (sites 2, 7, 10) with 4,332 and 2,985, and 1,662 t/mi^2/yr, respectively (Cook and Moss, 2012). Figure 12 consists of normalized suspended sediment loads and average annual daily discharge and depicts a negative correlation, indicating that when normalized suspended sediment loads are compared to monitored watershed area, then land use and hydrologic characteristics, not area, are the controlling factors that determine sediment load transport in the Fowl River watershed. However, site FR8 does not conform to the regression curve for normalized suspended sediment and discharge (fig. 12). This is most likely due to transport of the vast majority of sediment during a few large discharge events as shown on figure 7 where minimal turbidity was measured except during the largest discharge events.

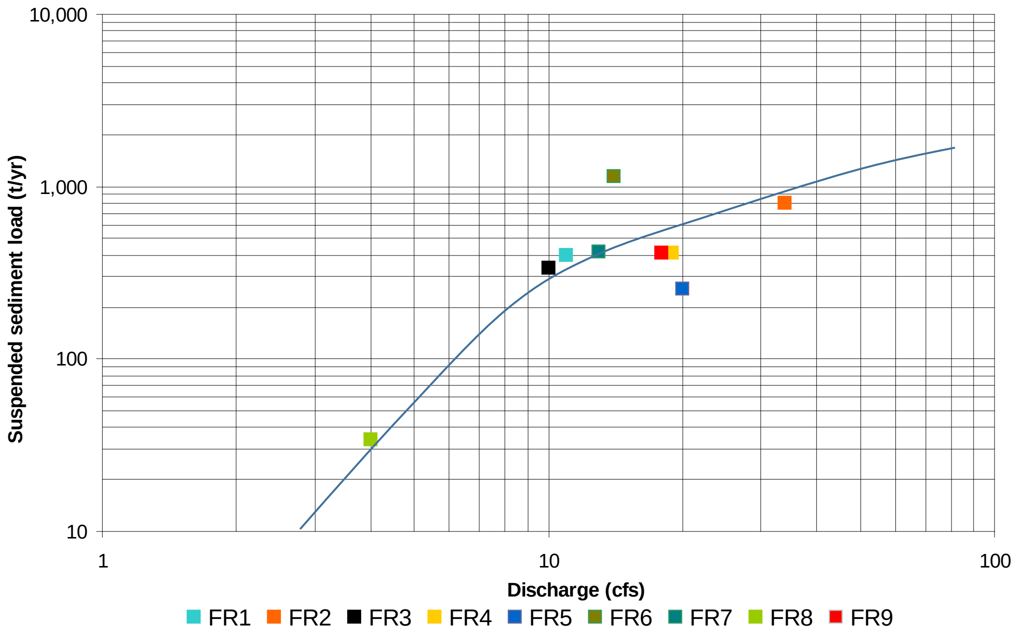

Figure 11.—Average annual daily discharge and suspended sediment loads for monitored Fowl River sites.

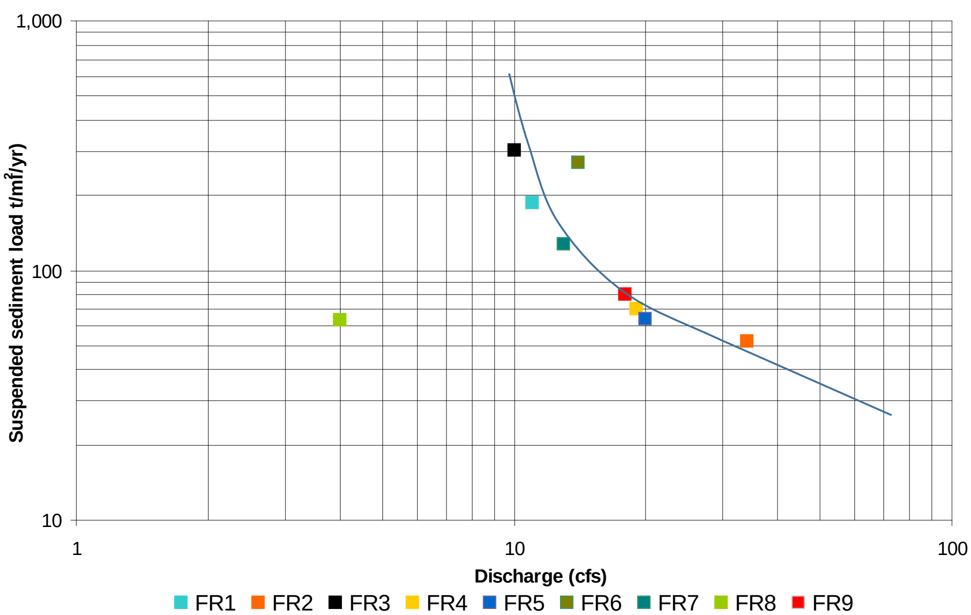

Figure 12.—Average annual daily discharge and normalized suspended sediment loads for monitored Fowl River sites.

A. GSA SEDIMENT AND WATER QUALITY STUDY

BED SEDIMENT

Transport of streambed material is controlled by a number of factors including stream discharge and flow velocity, erosion and sediment supply, stream base level, and physical properties of the streambed material. Most streambeds are in a state of constant flux in order to maintain a stable base level elevation. The energy of flowing water in a stream is constantly changing to supply the required power for erosion or deposition of bed load to maintain equilibrium with the local water table and regional or global sea level. Stream base level may be affected by regional or global events including fluctuations of sea level or tectonic movement. Local factors affecting base level include fluctuations in the water table elevation, changes in the supply of sediment to the stream caused by changing precipitation rates, and/or land use practices that promote excessive erosion in the floodplain or upland areas of the watershed.

Bed load sediment is composed of particles that are too large or too dense to be carried in suspension by stream flow. These particles roll, tumble, or are periodically suspended as they move downstream. Traditionally, bed load sediment has been difficult to quantify due to deficiencies in monitoring methodology or inaccuracies of estimating volumes of sediment being transported along the streambed. This is particularly true in streams that flow at high velocity or in streams with excessive sediment loads.

Due to a number of factors, including relatively small areas of development or land disturbance, limited sources of coarse-grained sediment, relatively low stream gradients and stream flow velocities, and extensive wetlands that slow stream flow velocities and detain sediment, all monitored streams had bed sediment loads that were too small to measure. Therefore, all sediment loads are assumed to be suspended.

TOTAL SEDIMENT LOADS

Without human impact, erosion rates in the watershed, called the geologic erosion rate, would be 64 $t/mi^2/yr$ (Maidment, 1993). Normalized sediment loads for sites FR2 (Fowl River at Half Mile Road), FR8 (unnamed tributary at Rebel Road), and FR5 (unnamed tributary at Bellingrath Road) were at or below the geologic erosion rate. Calculated non-normalized geologic erosion rate loads are compared to total estimated loads in figure 13.

Comparisons of sediment loads from other watersheds are helpful in determining the severity of erosion problems in a watershed of interest. Estimates of total sediment loads from Dog River site 2 (Spencer Branch at Cottage Hill Road in the city of Mobile) (Cook and Moss, 2012), D'Olive Creek site 3 (D'Olive Creek at U.S. Highway 90 in Daphne) (Cook and Moss, 2008), Tiawasee Creek site 7 (Tiawasee Creek upstream from Lake Forest) (Cook and Moss, 2008), in Baldwin County, Joes Branch site 10 (at North Main Street in Daphne) (Cook and Moss, 2008), Magnolia River site 4 (at U.S. Highway 98) (Cook and others, 2009), and Bon Secour River site 3 (County Road 12 in Foley) (Cook and others, 2014) are compared to Fowl River monitored sites in figure 14. GSA has now estimated sediment loads for more than 60 streams in Alabama. Figure 14 compares the total sediment load estimated for Fowl River with loads from other selected streams throughout Alabama and shows that Fowl River sediment loads are among the smallest of any monitored watershed in the state.

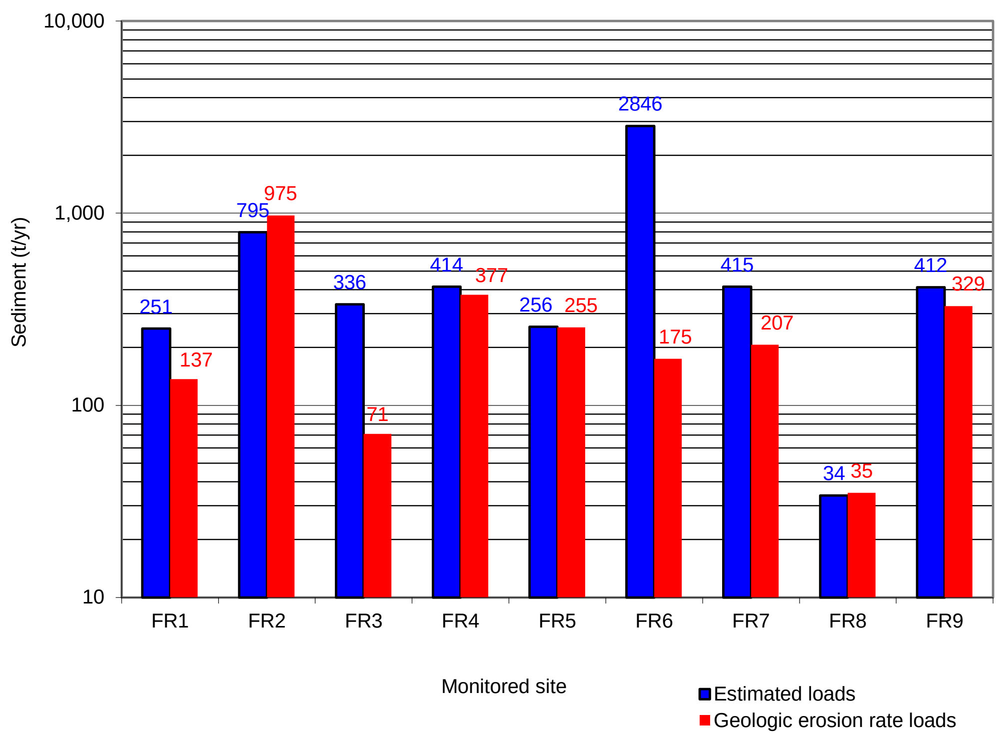

Figure 13.—Estimated sediment loads and calculated geologic erosion rate loads for monitored Fowl River sites.

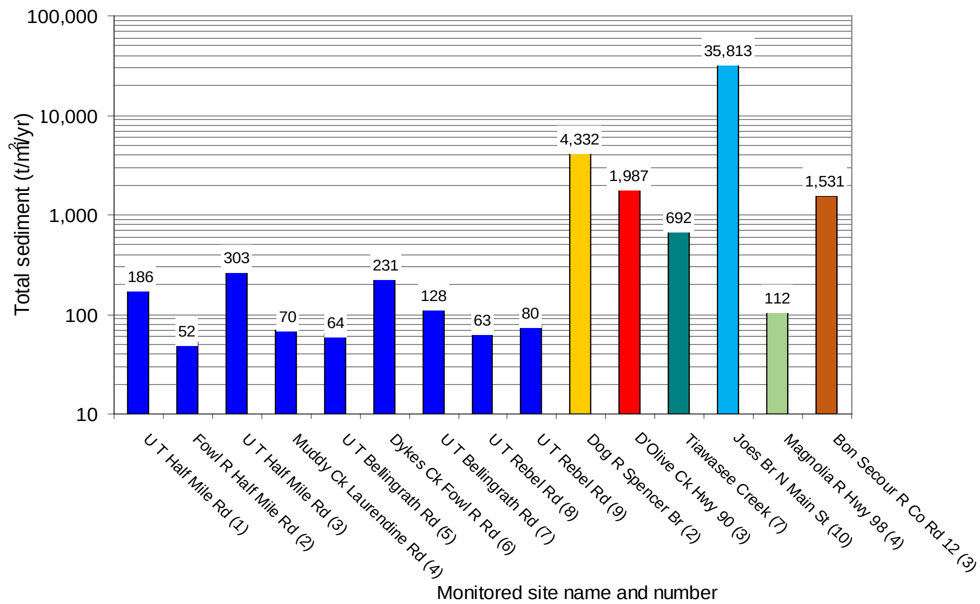

Figure 14.—Comparisons of normalized estimated sediment loads for selected Baldwin and Mobile County and monitored Fowl River sites.

GEOCHEMICAL ASSESSMENT

An assessment of geochemical constituents was performed from grab samples collected during a low flow period (Sept. 28, 2014) and a high flow event (Mar. 10, 2015). Although not comprehensive, this assessment is meant to provide a synoptic view of water quality conditions related to nutrients, metals, and limited organic constituents. A review of the Alabama Department of Environmental Management (ADEM) (Woods, 2006) water quality assessment of Fowl River, Muddy Creek and East Fowl River from October 2004 to September 2006 reveals that five of seven monitored sites were in tidally influenced parts of the watershed. ADEM site FLR1 near the headwaters of Fowl River at Pascagoula Road and FLR2 on Muddy Creek at Laurendine Road (GSA site FR4) were the only monitored sites upstream from tidal influence. The sites were sampled monthly and no discharge was measured, although visual observations by ADEM field personnel and turbidity data indicate that most samples were collected during times of low flow. Therefore, the ADEM data has little utility to supplement or for comparison with GSA data. However, ADEM dissolved oxygen, bacteria, and sediment geochemical analyses may be useful in assessing the biological health and possible industrial impacts on Fowl River.

NUTRIENTS

Excessive nutrient enrichment is a major cause of water-quality impairment. Excessive concentrations of nutrients, primarily nitrogen and phosphorus, in the aquatic environment may lead to increased biological activity, increased algal growth, decreased dissolved oxygen concentrations at times, and decreased numbers of species (Mays, 1996). Nutrient-impaired waters are characterized by numerous problems related to growth of algae, other aquatic vegetation, and associated bacterial strains. Blooms of algae and associated bacteria can cause taste and odor problems in drinking water and decrease oxygen concentrations. Toxins also can be produced during blooms of particular algal species. Nutrient-impaired water can dramatically increase treatment costs required to meet drinking water standards. Nutrients evaluated during this study were nitrate (NO_3-N) and phosphorus (P-total).

NITRATE

The U.S. Environmental Protection Agency (USEPA) Maximum Contaminant Level (MCL) for nitrate in drinking water is 10 mg/L. Typical nitrate (NO_3 as N) concentrations in streams vary from 0.5 to 3.0 mg/L. Concentrations of nitrate in streams without significant nonpoint sources of pollution vary from 0.1 to 0.5 mg/L. Streams fed by shallow groundwater draining agricultural areas may approach 10 mg/L (Maidment, 1993). Nitrate concentrations in streams without significant nonpoint sources of pollution generally do not exceed 0.5 mg/L (Maidment, 1993).

Water samples were collected from low and high flow events for all Fowl River sites during the monitoring period. The critical nitrate concentration in surface water for excessive algae growth is 0.5 mg/L (Maidment, 1993). The 0.5 mg/L nitrate level was exceeded in the low flow samples at sites FR1 (unnamed tributary at Half Mile Road) (0.62 mg/L), FR2 (Fowl River at Half Mile Road) (0.61 mg/L), and FR9 (East Fowl River at Rebel Road) (1.65 mg/L) (fig. 15). The nitrate concentration at site FR2 is expected since it represents the cumulative impact of land uses for the entire Fowl River watershed upstream from the site. However, excessive concentrations at sites FR1 and

FR9 are surprising since the watershed upstream from site FR1 has relatively little agriculture or development and the East Fowl River watershed upstream from site FR9 has the highest percentage of wetlands (50.7) and one of the lowest percentages of agriculture (0.2) of any monitored watershed. The 0.5 mg/L nitrate criterion was not exceeded in any high flow samples (fig. 15). Lower concentrations of nitrate are common during high flows due to dilution.

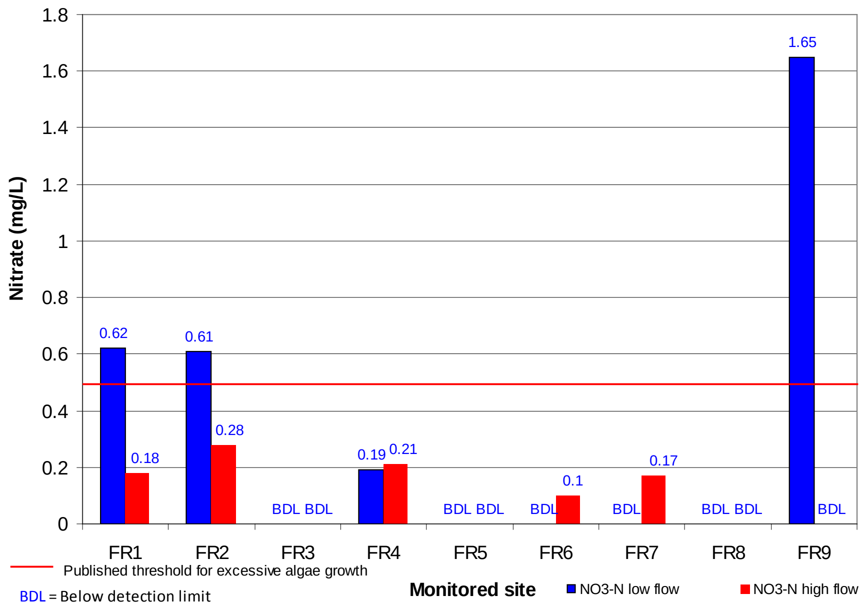

Figure 15.—Measured nitrate concentrations for low and high flow sampled events in monitored Fowl River sites.

PHOSPHORUS

Phosphorus in streams originates from the mineralization of phosphates from soil and rocks or runoff and effluent containing fertilizer or other industrial products. The principal components of the phosphorus cycle involve organic phosphorus and inorganic phosphorus in the form of orthophosphate (PO_4) (Maidment, 1993). Orthophosphate is soluble and is the only biologically available form of phosphorus. Since phosphorus strongly associates with solid particles and is a significant part of organic material, sediments influence water column concentrations and are an important component of the phosphorus cycle in streams.

The natural background concentration of total dissolved phosphorus is approximately 0.025 mg/L. Phosphorus concentrations as low as 0.005 to 0.01 mg/L may cause algae growth, but the critical level of phosphorus necessary for excessive algae is around 0.05 mg/L (Maidment, 1993). Although no official water-quality criterion for phosphorus has been established in the United States, total phosphorus should not exceed 0.05 mg/L in any stream or 0.025 mg/L within a lake or reservoir in order to prevent the development of biological nuisances (Maidment, 1993). In many streams phosphorus is the critical nutrient that influences excessive biological activity. These streams are termed “phosphorus limited.”

The 0.05 mg/L phosphorus criterion was exceeded in the low flow samples at sites FR3 (unnamed tributary at Half Mile Road) (0.314 mg/L), FR4 (Muddy Creek at Laurendine Road) (0.510 mg/L), FR6 (Dykes Creek at Fowl River Road) (0.077 mg/L), and FR7 (unnamed tributary at Bellingrath Road) (0.129 mg/L) (fig. 16). The 0.05 mg/L phosphorus criterion was exceeded in the high flow samples at sites FR3 (unnamed tributary at Half Mile Road) (0.235 mg/L), FR4 (Muddy Creek at Laurendine Road) (0.140 mg/L), FR5 (unnamed tributary and Bellingrath Road) (0.095 mg/L), and FR7 (unnamed tributary at Bellingrath Road) (1.39 mg/L) (fig. 16). Excessive concentrations of phosphorus may be explained by land use, since the watersheds upstream from sites with samples that exceeded the criterion have the largest percentage of land area in agriculture.

METALLIC CONSTITUENTS

The USEPA compiled national recommended water quality criteria for the protection of aquatic life and human health in surface water for approximately 150 pollutants. These criteria are published pursuant to Section 304(a) of the Clean Water Act (CWA) and provide guidance for states and tribes to use in adopting water quality standards (USEPA, 2009). The criteria were developed for acute (short-term exposure) and chronic (long-term exposure) concentrations.

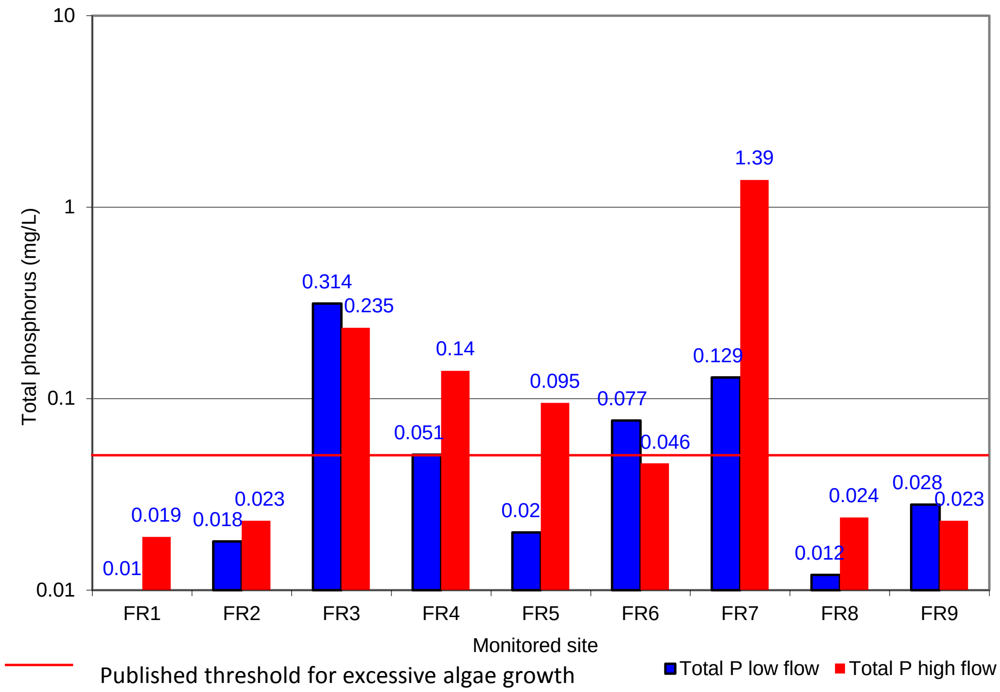

Figure 16.—Measured phosphorus concentrations for low and high flow sampled events in monitored Fowl River sites.

Numerous metals are naturally present in streams in small concentrations. However, toxic metals in Alabama streams, particularly in large concentrations are usually a result of man's activities. Table 3 shows acute and chronic recommended criteria for protection of aquatic life and maximum concentrations measured in analyzed samples collected from monitored sites. Metals detected in water samples are normally a result of the erosion of fine-grained sediments. This is true of relatively large, pervasive concentrations of aluminum and iron observed at all monitored sites (table 3). Generally, the largest concentrations of aluminum occurred during the high flow sampled event, indicating erosion of aluminum-rich clays in sediments in the monitored watersheds. Conversely, the largest iron concentrations occurred during the low flow event, indicating major accumulations of iron hydroxide, the waste product of iron-consuming bacteria present in the monitored streams.

Other metals exceeding the criteria were cadmium at site FR9 and copper and nickel at site FR6. Lead is also pervasive in all monitored watersheds and exceeded the criteria at all sites except FR1 and FR2. Lead is pervasive in streams throughout the

Alabama coastal plain and is thought to originate from atmospheric deposition. However, detection of cadmium and copper are relatively rare and may be from local sources. Although not included in USEPA criteria, barium, manganese, magnesium, and strontium were also detected in most samples. These are common in Alabama streams and are a result of dissolution or erosion of rocks and sediment.

Although not a metallic constituent, pH is included in table 3 due to its importance in the occurrence and solubility of metals. It was consistently low as is common in coastal streams with large organic content, relative to the USEPA criteria in water samples collected in the Fowl River watershed. Another nonmetallic constituent detected in water samples collected at all sites is boron. Although no water quality criteria for boron has been established, concentrations as small as 1 mg/L may be toxic to plant life (Hem, 1985). Boron is naturally associated with igneous rocks and is present in active volcanic areas. In areas without a natural source, it may originate from cleaning wastes and may be present in sewage and industrial wastes (Hem, 1985). Boron was detected in 16 of 18 samples and had a maximum concentration of 1.2 mg/L at site FR9.

ORGANIC CONSTITUENTS

Organic compounds are commonly used in our society today. Frequently, these compounds appear in streams and groundwater aquifers. Many of these compounds are harmful to human health and to the health of the aquatic environment. Selected organic constituents including total organic carbon, phenols, and oil and grease were analyzed from samples collected at Fowl River sites in order to make a general determination of the presence of organic anthropogenic contaminants in the watershed.

Total organic carbon (TOC) analysis is a well-defined and commonly used methodology that measures the carbon content of dissolved and particulate organic matter present in water. Many water utilities monitor TOC to determine raw water quality or to evaluate the effectiveness of processes designed to remove organic carbon. Some wastewater utilities also employ TOC analysis to monitor the efficiency of the treatment process. In addition to these uses for TOC monitoring, measuring changes in TOC concentrations can be an effective surrogate for detecting contamination from organic compounds (e.g., petrochemicals, solvents, pesticides). Thus, while TOC analysis does not give specific information about the nature of the threat, identifying changes in TOC

Table 3.—Metallic constituent concentrations related to USEPA standards for protection of aquatic life.

Metallic constituent	USEPA standards for protection of aquatic life (µg/L[a])		Maximum concentrations (µg/L)			
	Acute	Chronic	FR1	FR2	FR3	FR4
Aluminum	750.0	87.0	482.00	171.00	259.00	304.00
Arsenic	340.0	150.0	1.00	1.10	2.97	1.47
Cadmium	2.0	0.3	<0.1[b]	<0.1	<0.1	<0.1
Chromium (Cr_3)[c]	570.0	74.0	<0.3	<0.3	<0.3	<0.3
Copper	4.7	n/a	<8.0	<8.0	<8.0	<8.0
Cyanide	22.0	0	<0.003	<0.003	<0.003	<0.003
Iron	n/a	176	170.0	311.0	790.0	592.0
Lead	65.0	4.47	2.14	2.29	24.70	4.62
Mercury	1.4	0.8	0.065	0.005	0.008	0.007
Nickel	470.0	52.0	<10.0	<10.0	<10.0	<10.0
Selenium	n/a	5.0	<0.5	<0.5	<0.5	<0.5
Silver	3.2	n/a	<10.0	<10.0	<10.0	<10.0
Zinc	120.0	120.0	31.1	21.9	40.8	31.4
pH range	n/a	6.5-9.0	4.5-6.1	4.9-6.2	5.0-5.7	4.9-5.8

Metallic constituent	USEPA standards for protection of aquatic life (µg/L[a])		Maximum concentrations (µg/L)				
	Acute	Chronic	FR5	FR6	FR7	FR8	FR9
Aluminum	750.0	87.0	552.00	570.00	419.00	217.00	403.00
Arsenic	340.0	150.0	1.27	2.30	1.69	0.35	0.55
Cadmium	2.0	0.3	<0.1	<0.1	0.24	<0.1	1.7
Chromium (Cr_3)	570.0	74.0	2.65	<0.3	<0.3	<0.3	1.12
Copper	4.7	n/a	<8.0	11.0	<8.0	<8.0	<8.0
Cyanide	22.0	n/a	0.06	<0.003	<0.003	<0.003	<0.003
Iron	n/a	176	540.0	1,140.0	286.0	596.0	252.0
Lead	65.0	4.47	5.71	5.85	168.00	10.40	24.40
Mercury	1.4	0.8	0.054	<0.005	<0.005	<0.005	<0.005
Nickel	470.0	52.0	23	118	25	<10.0	20
Selenium	n/a	5.0	<0.5	<0.5	0.80	1.60	<0.5
Silver	3.2	n/a	<10.0	<10.0	10	<10.0	13
Zinc	120.0	120.0	83.9	52.7	36.3	52.9	36.6
pH range	n/a	6.5-9.0	3.9-6.2	4.4-6.5	3.8-6.5	4.2-6.2	4.2-5.9

[a] µg/L = micrograms per liter.

[b] < 0.1= below lower limit of detection.

[c] Chromium reported as total chromium and is assumed to be primarily Cr_3.

can be a good indicator of potential threats to a hydrologic system (USEPA, 2005). Typical TOC values for natural waters vary from 1 to 10 mg/L (Mays, 1996). Concentrations of TOC exceeded 10 mg/L at every site except FR2 and FR8 during high flow conditions and was exceeded at sites FR3, FR5, and FR7 during low flow conditions. The largest concentration (46.4 mg/L) was measured at site FR7, which occurred during low flow conditions (fig. 17). Pervasive, elevated TOC concentrations are normally related to contaminated urban runoff. However, land use in the Fowl River monitored watersheds does not support this conclusion.

Phenols are used in the production of phenolic resins, germicides, herbicides, fungicides, pharmaceuticals, dyes, plastics, and explosives (Bevans and others, 1998). They may occur in domestic and industrial wastewaters, natural waters, and potable water supplies. The USEPA water quality criterion states that phenols should be limited to 10,400 micrograms per liter (µg/L) (10.4 mg/L) in lakes and streams to protect humans from the possible harmful effects of exposure (USEPA, 2009). Phenols cause acute and

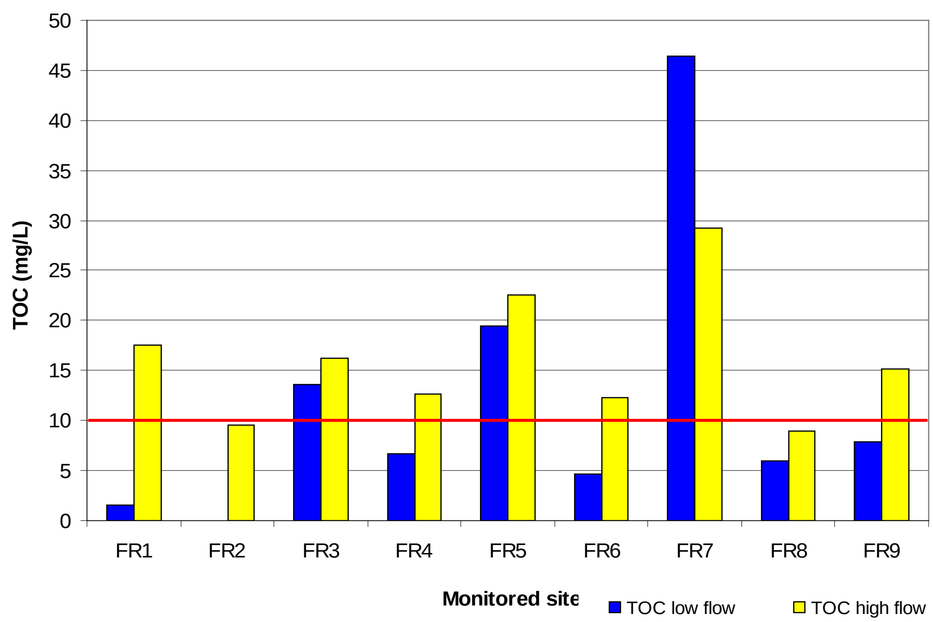

Figure 17.—Concentrations of TOC measured at monitored Fowl River sites for low and high flow events

chronic toxicity to freshwater aquatic life. Phenols were detected in 3 of 18 samples, with the largest concentration (5.2 mg/L) measured at sites FR3 and FR7.

Oil and grease includes fatty matter from animal and vegetable sources and from hydrocarbons of petroleum origin and are normally associated with urban runoff. Oil and grease was not detected in any samples.

SOURCES OF WATER-QUALITY IMPACTS

Evaluations of sediment loads, water-quality analyses, land-use data, and aerial imagery led to conclusions of probable sources of water quality and habitat impairments in the Fowl River watershed. Sites FR3 (unnamed tributary at Half Mile Road) and FR6 (Dykes Creek at Fowl River Road) had the largest sediment loads (303 and 271 t/mi^2/yr, respectively) and the largest percentages of agricultural land use (36.8 and 23.8 %, respectively). Samples collected at these sites in December 2014 and January 2015, had the largest turbidity values measured during the project period (fig. 4). Observations recorded during sampling noted that fields used for row crop agriculture upstream from site FR3 were bare and that rainfall and runoff were intense. Google Earth imagery from January 2015 shows bare fields upstream from site FR3 (fig. 18). Channelized field drainage with no vegetative buffers was also observed on January 2015, Google Earth

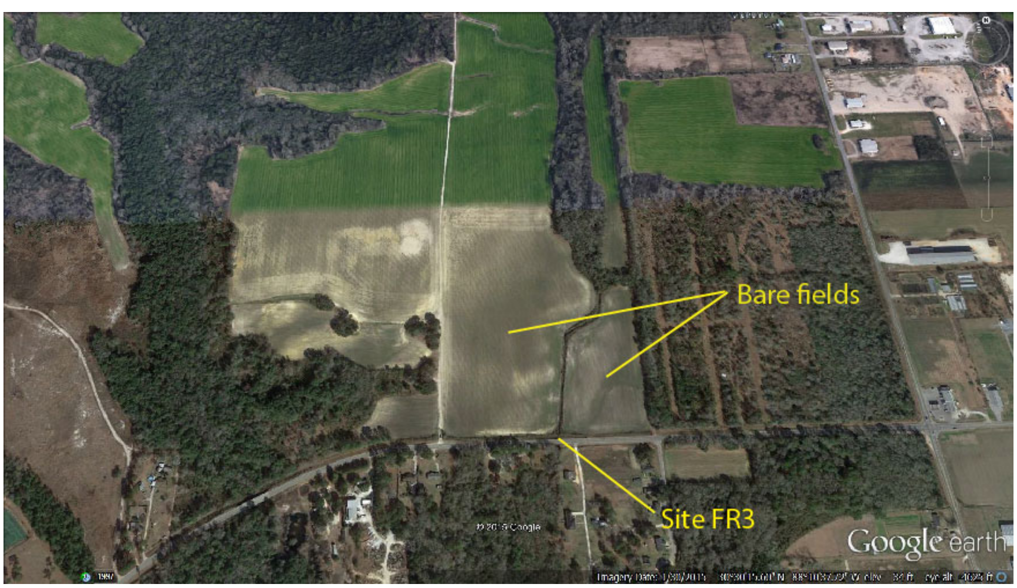

Figure 18.—Google Earth image (January 2015) showing bare fields near Fowl River site FR3.

imagery, along an unnamed tributary along the eastern margin of the Dykes Creek watershed, upstream from site FR6 (fig. 19). Although the largest percentage of land use in the Dykes Creek watershed is classified as forest, an evaluation of January 2015 Google Earth (2015) imagery indicates that much of the forest was recently clear cut, providing additional opportunities for increased runoff and erosion.

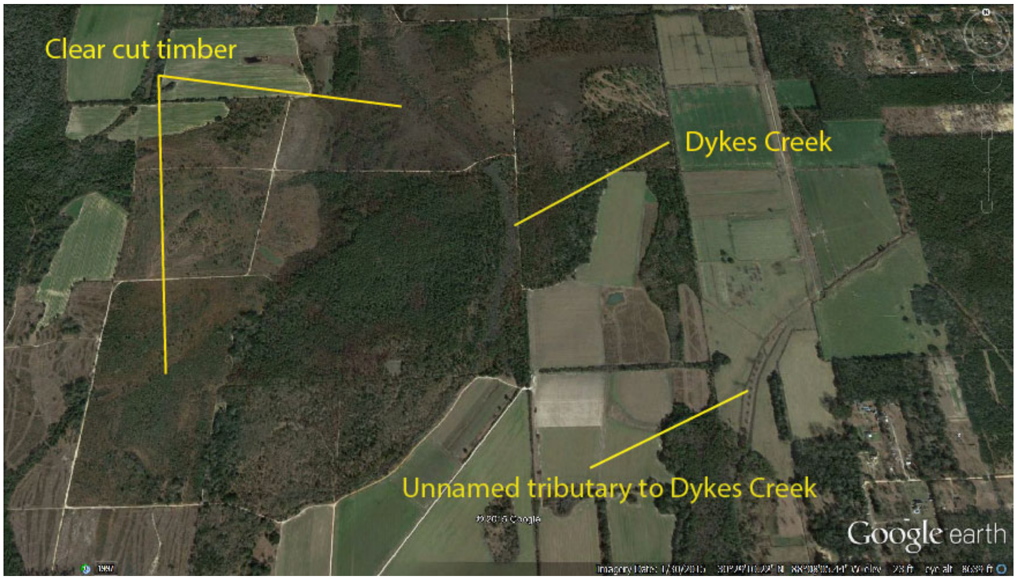

Figure 19.—Google Earth image (January 2015) showing channelized agricultural drainage and clear cut timber land in the Dykes Creek watershed, upstream from Fowl River site FR6.

Figure 15 shows that sites FR1, FR2, and FR9 had nitrate concentrations in excess of the 0.5 mg/L criteria for excessive algae growth. This is expected for site FR2 (Fowl River at Half Mile Road), due to the cumulative volume of nitrate from this relatively large watershed. An evaluation of January 2015 Google Earth imagery indicates that site FR1 (unnamed tributary at Half Mile Road) has a large complex of greenhouses just upstream from the site along with some row crop agriculture and several residential areas (Google Earth, 2015) (fig. 20). Site FR9 (East Fowl River at Rebel Road) has several natural gas processing plants along the southern perimeter of the watershed on Rock Road. Also, there is a large area of clear cut forest in the watershed. A recent study by the

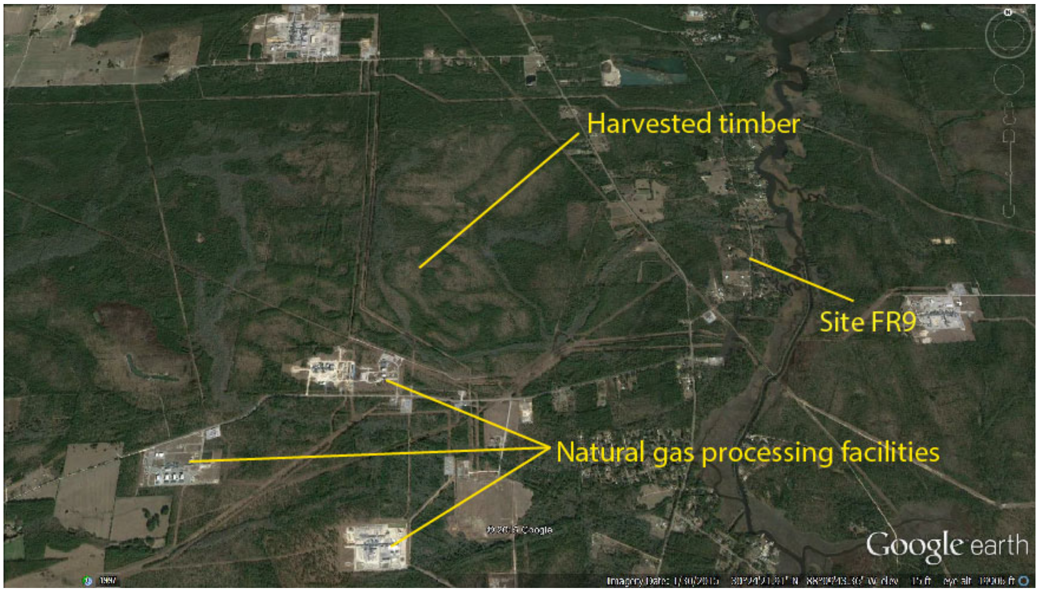

Figure 20.—Google Earth image (January 2015) showing the East Fowl River watershed, Fowl River site FR9, natural gas processing facilities, and areas of harvested timber.

State University of New York found that streams in areas of harvested timber contain significantly more nitrate than streams in non-harvested forests. The source of the nitrate is from shallow groundwater due to a number of factors including increased precipitation infiltration and soil saturation, increased soil temperature, and increased microbial activity (Golden, 2015). This is likely occurring in the monitored Fowl River sites with significant recent timber harvesting, since all excessive nitrate concentrations occurred during base flow conditions where the source of stream flow was from shallow groundwater.

Figures 16 and 17 show that the watershed upstream from site FR7 had the highest phosphorus and TOC concentrations. Although the headwaters are forested, row crop agriculture and a major plant nursery operation dominate land use immediately upstream from the monitoring site (Google Earth, 2015) (fig. 21).

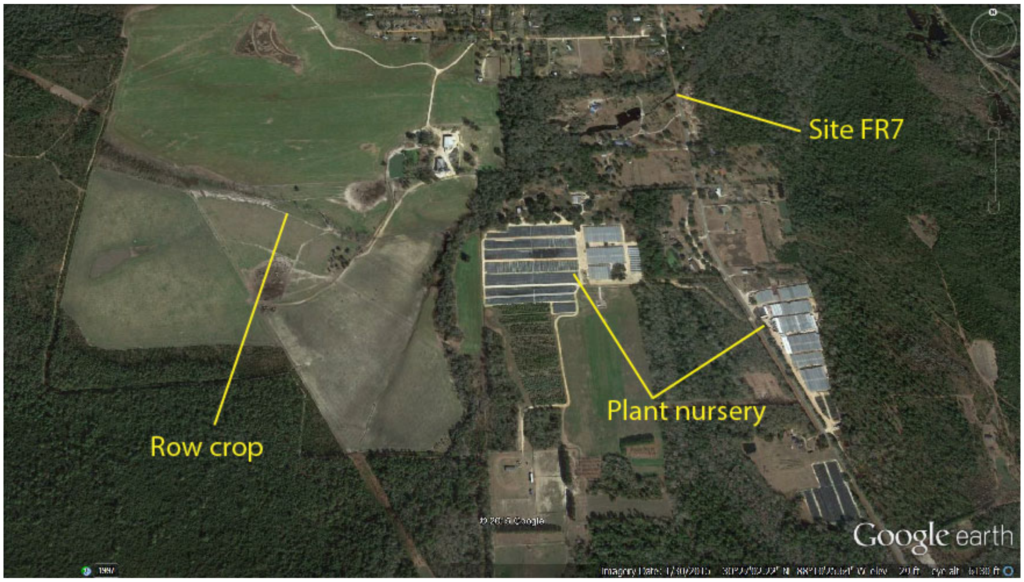

Figure 21.-- Google Earth image (January 2015) showing Fowl River site FR7, plant nursery facilities, and areas of row crop agriculture.

All metals listed on the USEPA list for protection of aquatic life were detected at Fowl River monitoring sites (table 3). A number of these metals are known to be naturally occurring. However, cadmium, chromium, copper, lead, mercury, nickel, selenium, and silver were detected in relatively small concentrations during the GSA assessment and are normally of anthropogenic origin in Alabama streams (table 3). Fowl River is currently on the ADEM 303(d) list for impairment by atmospheric deposition of mercury. Stream sediment samples were collected and analyzed for toxic metals during the ADEM water-quality assessment of Fowl River (Woods, 2006). Results revealed the pervasive nature of these metals with increasing concentrations from upstream to downstream. However, all detected metals were in relatively small concentrations. Regular sampling and analyses of streams in the Fowl River watershed should be conducted to monitor any changes in distribution and concentration.

At least six sand mining operations were identified in the headwaters of Fowl River. No direct impacts were observed in sediment or water-quality data. However, this mining activity should be monitored to determine any negative effects in the future.

CONCLUSIONS AND RECOMMENDATIONS

Comparisons of sediment transport rates and water-quality data in watersheds in Baldwin and Mobile Counties indicate that Fowl River has relatively small sediment loads and good water quality. This is attributed to the relatively rural setting, extensive wetlands and forests, and use of winter cover crops on agricultural fields. However, water quality and habitats could be improved and protected for the future by employing best management practices that prevent destruction of wetlands, prevent erosion and sediment transport from areas of timber harvesting and row crop agriculture, and control runoff from construction sites and areas with significant impervious surfaces.

The GSA assessment indicates that water quality in the Fowl River watershed is relatively good, due primarily to the rural character of the watershed. However, steps should be taken to correct current impairments and to protect the watershed from future negative impacts that are common in streams in Alabama's coastal region.

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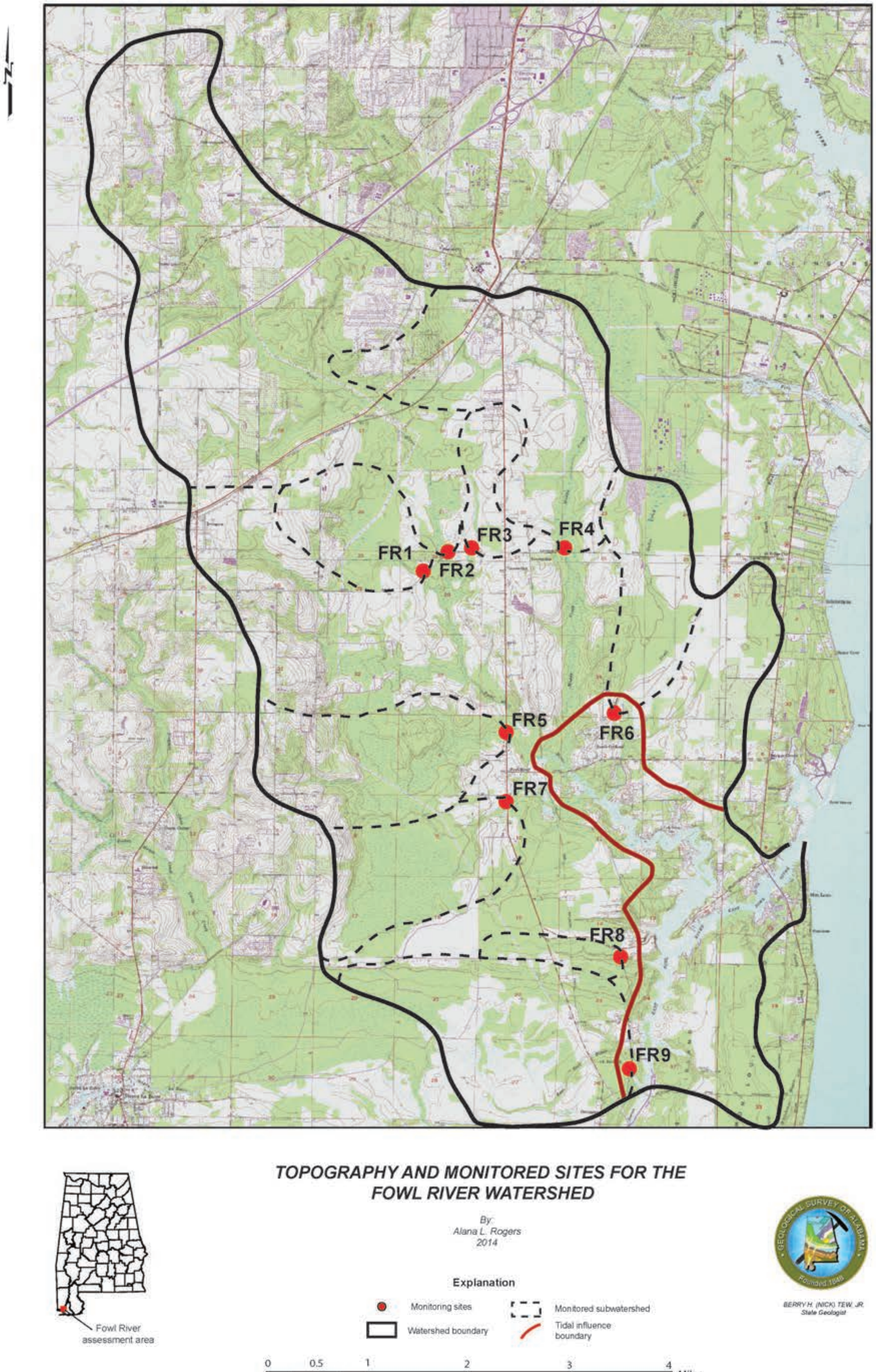
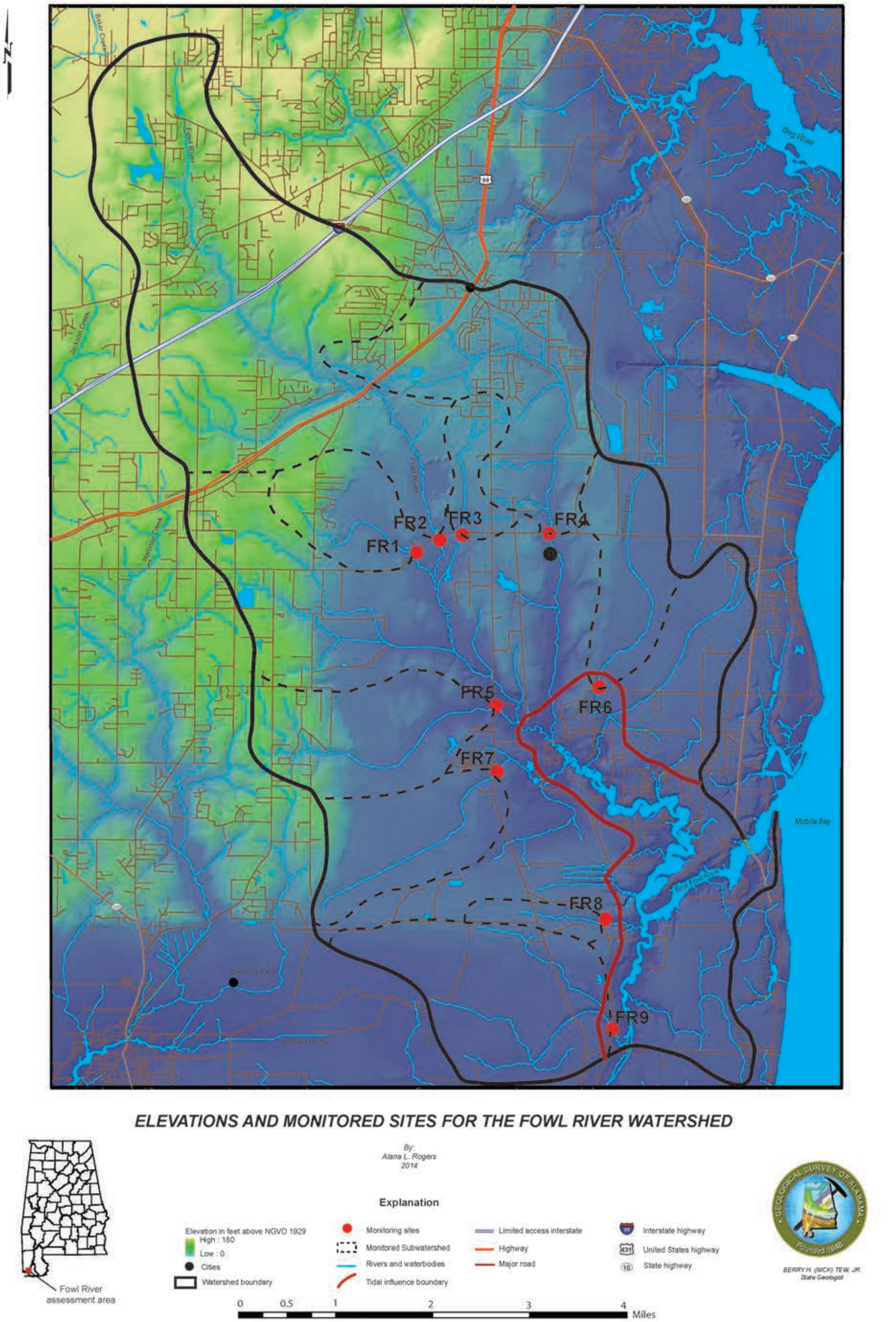
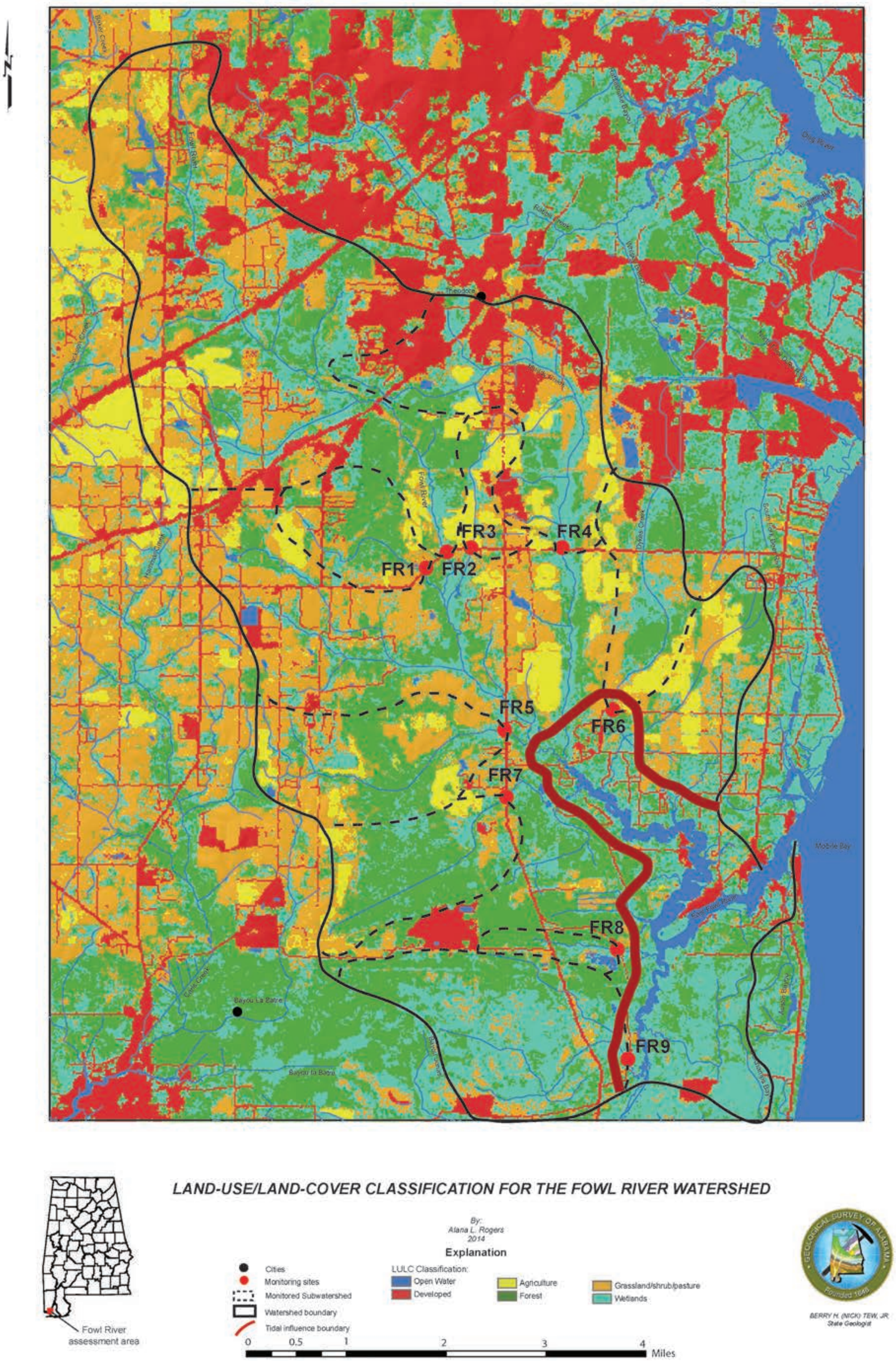
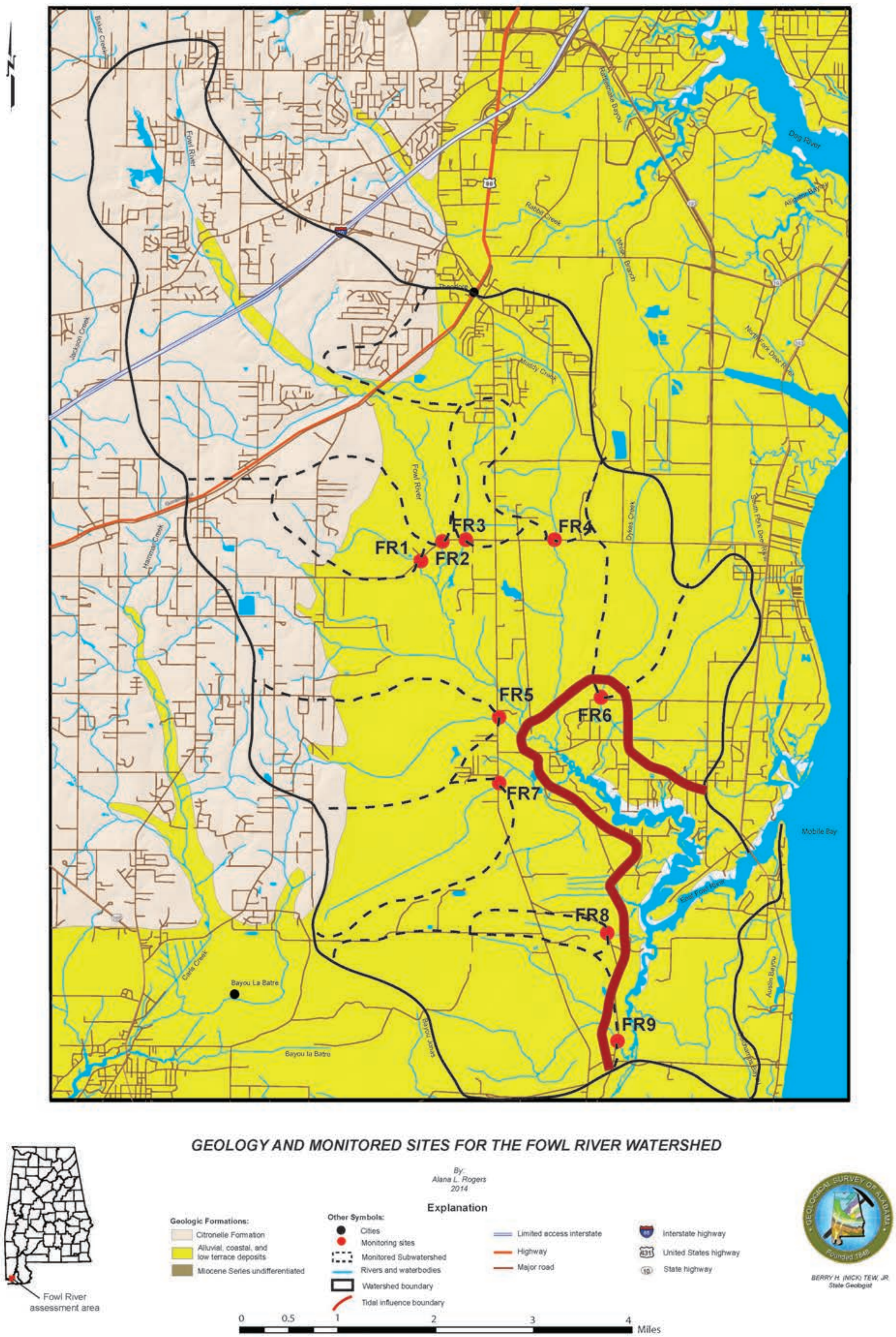
TOPOGRAPHY AND MONITORED SITES FOR THE FOWL RIVER WATERSHED

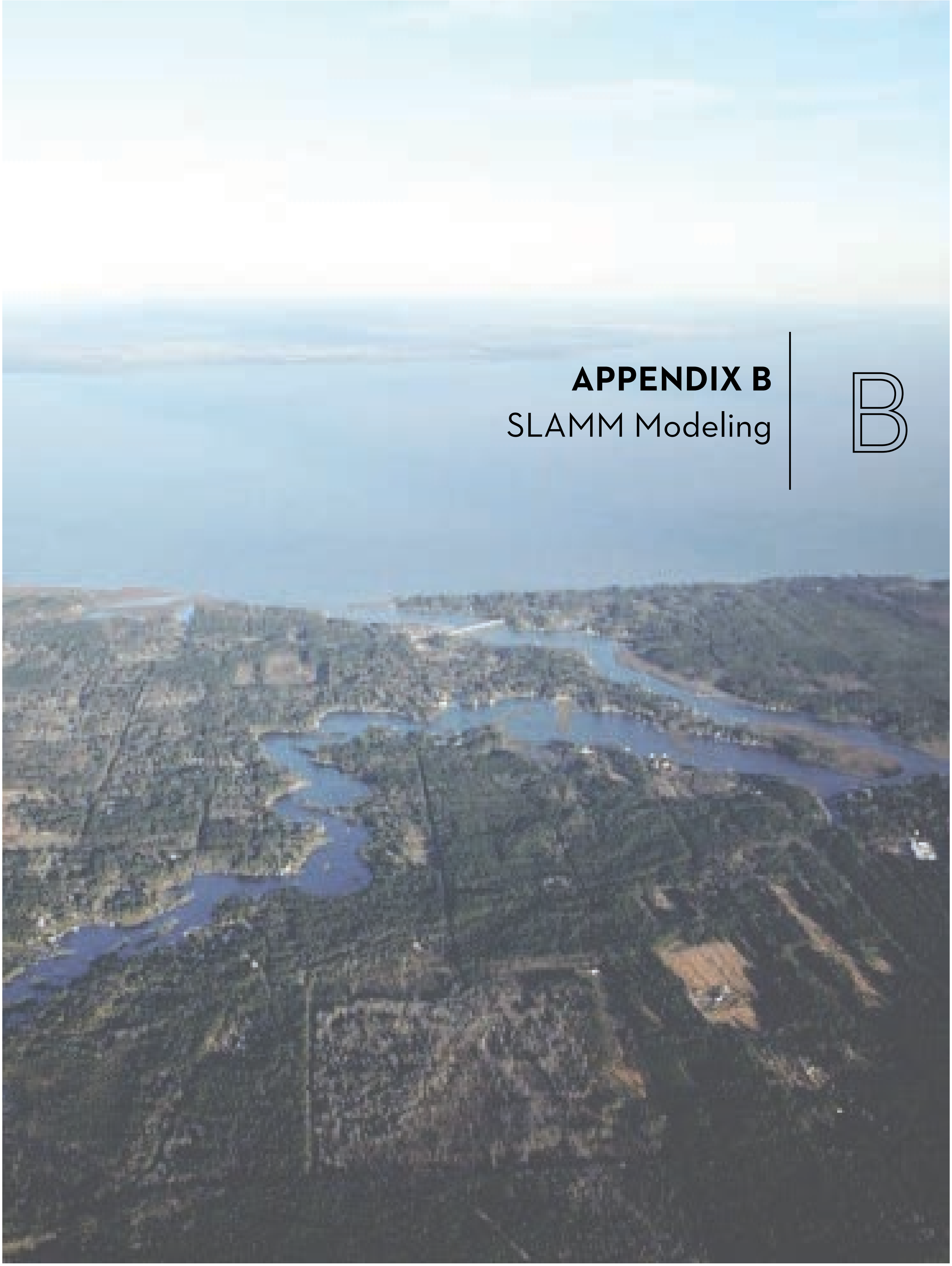



FR1
FR2
FR3
FR4
FR5
FR6
FR7
FR8
FR9
ELEVATIONS AND MONITORED SITES FOR THE FOWL RIVER WATERSHED
By:
Alana L. Rogers
2014
Explanation
Elevation in feet above NGVD 1929
High : 180
Low : 0
Cities
Watershed boundary
Monitoring sites
Monitored Subwatershed
Rivers and waterbodies
Tidal influence boundary
Limited access interstate
Highway
Major road
Interstate highway
United States highway
State highway
Fowl River assessment area
0 0.5 1 2 3 4
Miles
BERRY H. (NICK) TEW, JR.
State Geologist


FR1
FR2
FR3
FR4
FR5
FR6
FR7
FR8
FR9
Mobile Bay
Fowl River
assessment area
LAND-USE/LAND-COVER CLASSIFICATION FOR THE FOWL RIVER WATERSHED
By:
Alana L. Rogers
2014
Explanation
Cities
Monitoring sites
Monitored Subwatershed
Watershed boundary
Tidal influence boundary
LULC Classification:
Open Water
Developed
Agriculture
Forest
Grassland/shrub/pasture
Wetlands
0 0.5 1 2 3 4 Miles
GEOLOGICAL SURVEY OF ALABAMA
Founded 1848
BERRY H. (NICK) TEW, JR.
State Geologist

GEOLOGY AND MONITORED SITES FOR THE FOWL RIVER WATERSHED





APPENDIX B
SLAMM Modeling

B

B. SLAMM MODELING

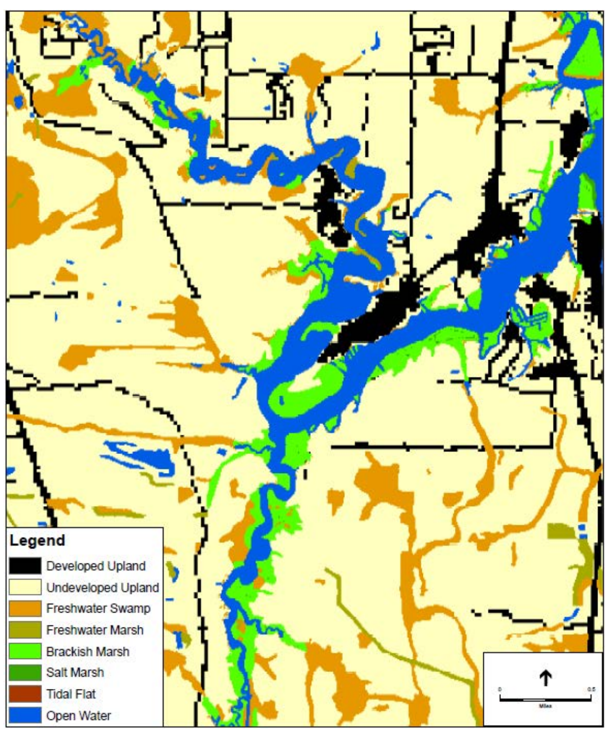
FINAL

FOWL RIVER HABITAT PROJECTION MODELING

Prepared for
GOODWYN | MILLS | CAWOOD

September 2015

ESA



B. SLAMM MODELING

FINAL

FOWL RIVER HABITAT PROJECTION MODELING

Prepared for
GOODWYN | MILLS | CAWOOD

September 2015

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Fowl River Habitat Projection Modeling

1. Fowl River Model Development

SLAMM, the Sea Levels Affecting Marshes Model, was developed by the Environmental Protection Agency (EPA) to evaluate the effects of sea level rise on marsh habitats. The model has been used along the west coast, the gulf coast, and the east coast, since its development in the mid 1980s. The model maps habitat distribution over time in response to sea-level rise, accretion and erosion, and freshwater influence.

SLAMM is based on the conceptual model that Fowl River habitats change over the long-term in response to multiple processes, including tides, accretion, freshwater inflow, ecology, and sea-level rise. These processes are described below and provide the conceptual basis or framework (conceptual model) for the habitat projection model.

1.1 Tides

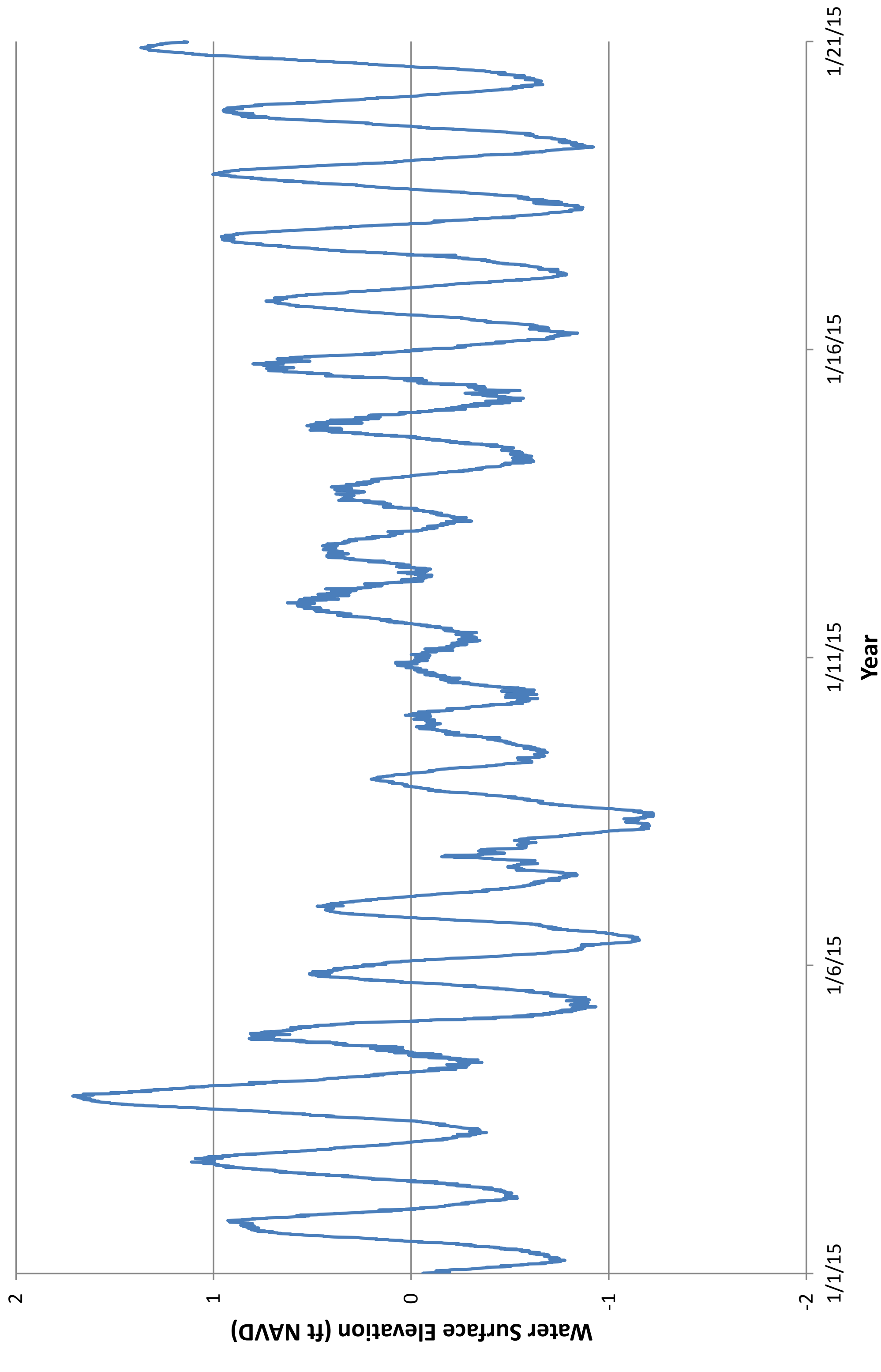
Salt marsh and intertidal habitats establish within zones corresponding to tidal inundation. Tides and tidal inundation within the Fowl River estuary are therefore important processes affecting habitats.

The Alabama coast experiences diurnal tides, with one high and one low tide each day (Figure 1). In addition, the tides exhibit strong spring-neap tide variability; spring tides exhibit the greatest difference between high and low tides while neap tides show a smaller than average range. Wind can also greatly affect tidal ranges in this region. Tidal datums for the Dauphin Island tide gage, which is south of Fowl River and measures the Bay tides (Figure 2), are summarized in Table 1 (NOAA Tides and Currents).

TABLE 1
NOAA TIDAL DATUMS FOR THE DAUPHIN ISLAND TIDE GAGE

Tidal Datum		ft MLLW	ft NAVD
Highest Astronomical Tide	HAT	2.03	1.53
Mean Higher High Water	MHHW	1.20	0.70
Mean High Water	MHW	1.18	0.68
Mean Tide Level	MTL	0.60	0.09
Mean Sea Level	MSL	0.56	0.06
Mean Low Water	MLW	0.01	-0.50
Mean Lower Low Water	MLLW	0.00	-0.51
North American Vertical Datum of 1988	NAVD	0.51	0.00

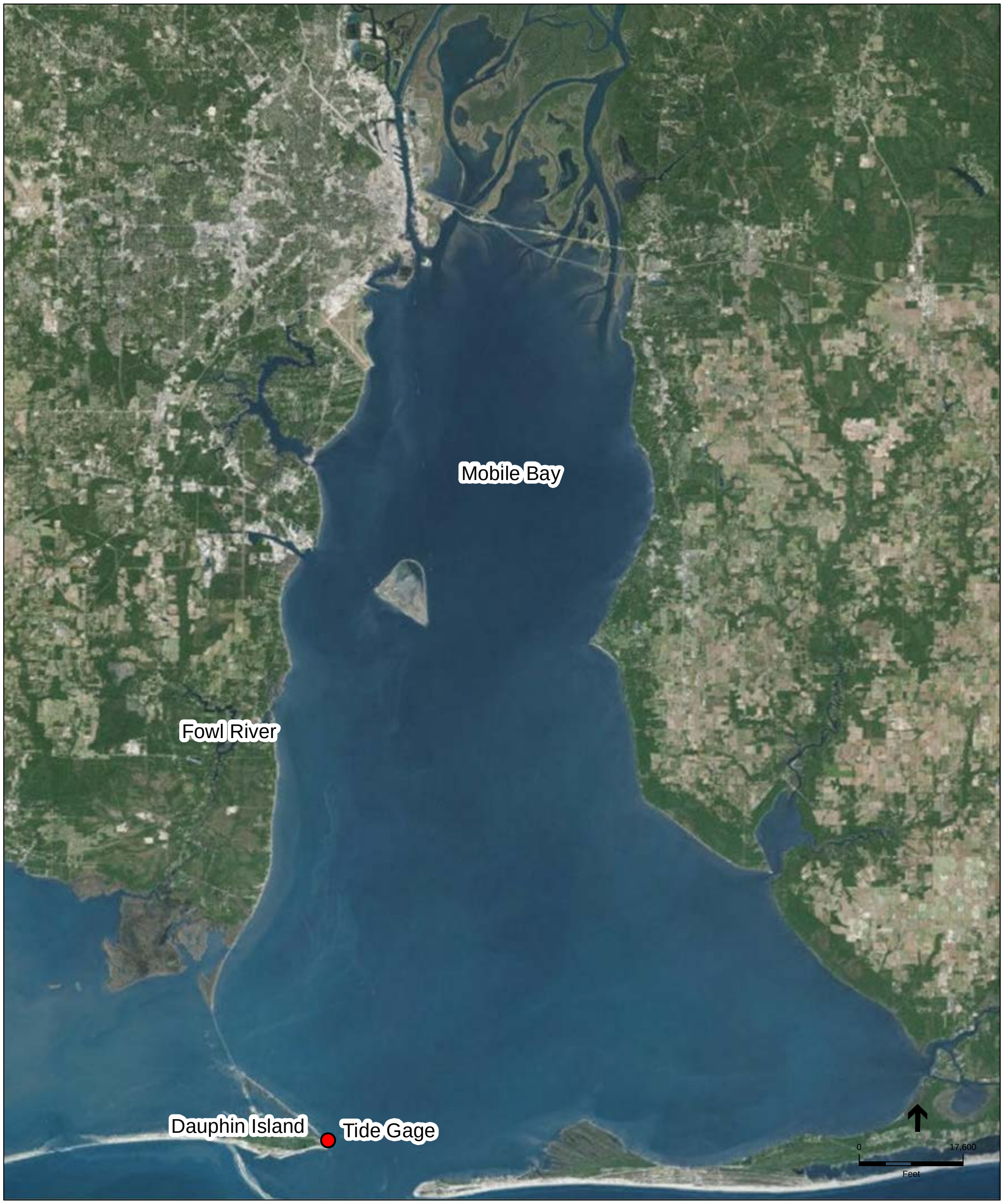
B. SLAMM MODELING



Fowl River Estuary. D140553

Figure 1

Tide Time Series, Jan 1 - Jan 21, 2015



SOURCE: ESRI

Fowl River. D140553

Figure 2

Location of Dauphin Island Tide Gage

1.2 Topography and Accretion

The elevation of an area determines the frequency of tidal inundation and salinity, which then influences the type of vegetation that will establish. If the topography changes due to accretion (or restoration/grading), the habitat types can change in response.

The Fowl River estuary only receives limited sediment from its watershed and tributary creeks due to upstream impoundments. Byrnes et. al. (2013) estimate approximately 15,000 cy/yr is transported from Fowl River to the Bay, compared to the 2.8 million cy/yr from the Mobile-Tensaw River system. Additionally, tidal accretion from the Bay is likely limited to only the river reach before the first bend. The majority of marsh accretion occurs during large storm events (hurricanes), which stir up sediments in the Bay and deposit them in shallower, slow-flowing areas, such as marshes (Smith et. al. 2013). The marshes also receive organic sedimentation from the accumulation of plant biomass over time.

1.3 Freshwater Inflow

Freshwater swamp and marsh habitats form in areas influenced by freshwater inflows. These areas of freshwater influence are either inundated solely by freshwater or are characterized by tidal mixing of ocean water and freshwater inflows, creating brackish salinities. The influence of freshwater determines what type of vegetation can establish in that area. If the extent of freshwater influence increases, the extent of freshwater swamp and marsh habitats will increase. Conversely, if the area of freshwater influence is reduced, the extent of freshwater habitats will be reduced. The area or extent of freshwater influence can be inferred from the extent of existing freshwater habitats, correlated to freshwater inflows, and/or quantified through monitoring and modeling of freshwater inflows and salinity gradients.

Fowl River flow is measured by the USGS at Half-Mile Road near Laurendine (gage #02471078). Table 2 shows the average monthly flow for Fowl River. Flows are fairly even throughout the year, but can become flashy with periodic heavy rains. Unlike other areas in Alabama, Mobile County does not have distinct rainy and dry seasons.

TABLE 2
USGS MONTHLY FLOW DATA FOR FOWL RIVER (CFS)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	39	45	47	34	39	45	35	40	29	30	34

1.4 Habitat Zones

Wetland habitat zones can be defined for different areas based on the elevation of the area relative to tidal datums (i.e., as a surrogate for the frequency of tidal inundation) and whether the area is within the zone of freshwater influence. The model uses an additional datum called the "salt elevation," which is based on the 30-day high tide (1.56 ft NAVD at Dauphine Island).

Figure 3 shows the different elevation-based habitat zones used in SLAMM. Upland species establish at the highest elevations, followed by freshwater swamp and marsh, salt marsh, tidal flat, and lastly, open water habitat.

1.5 Sea-level Rise

Sea-level rise is expected to be a major driver of habitat evolution at Fowl River. Since most vegetation establishes in specific areas based on the local tidal inundation and salinity, habitats will evolve when the tides rise.

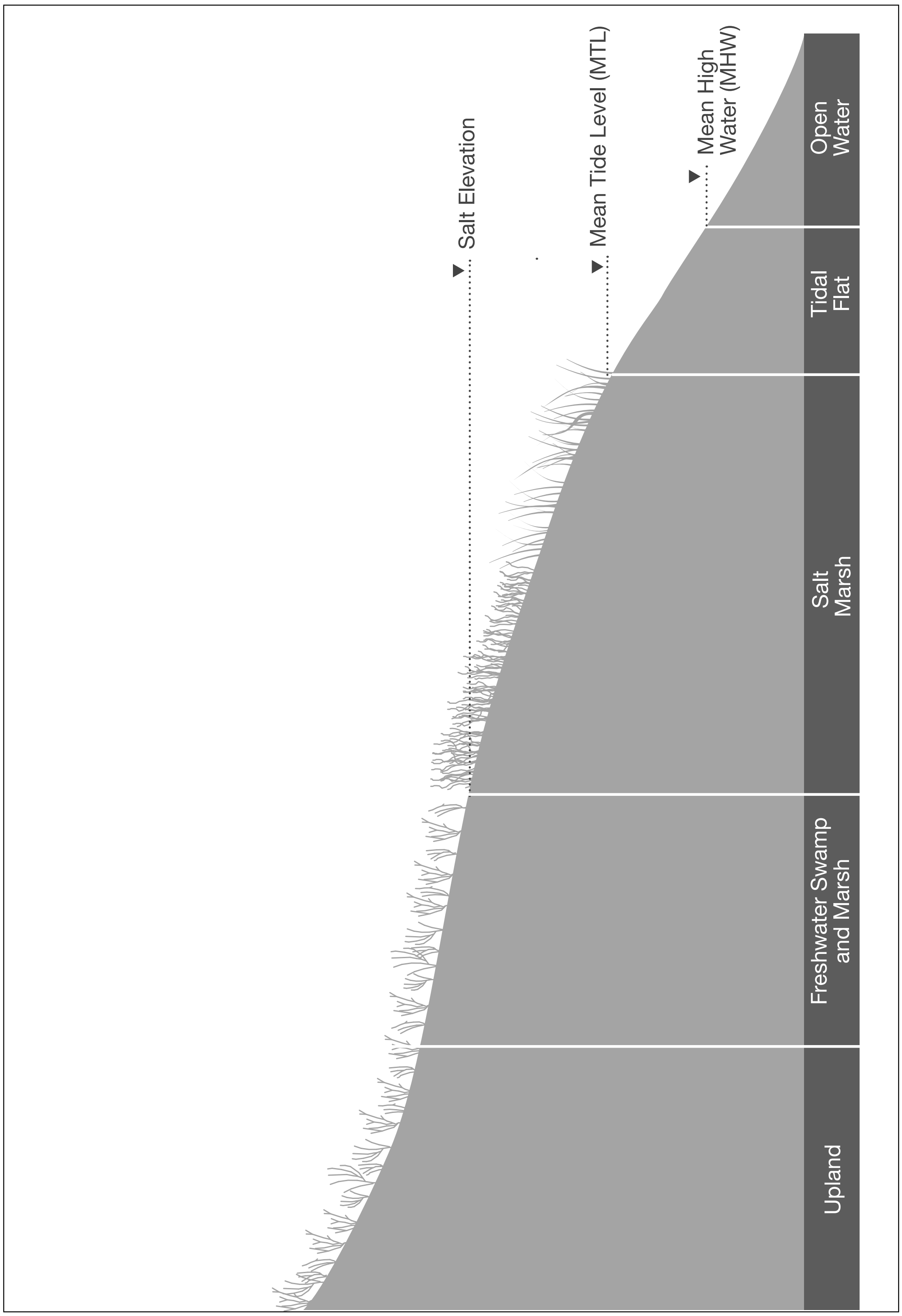
The Intergovernmental Panel on Climate Change (IPCC; 2013) provides guidance for projects in planning for sea-level rise. These predictions for 2100 are:

- Low Emissions: 14 to 28”
- Medium Emissions: 15 to 29”
- High Emissions: 21 to 39”

With climate change, extreme high water levels may change more than mean sea levels due to alterations in the occurrence of strong winds and low pressures. However, this has not been extensively studied for the project area, so it is not included in this conceptual model.

Relative sea level rise is the sum of global sea level rise and the change in vertical land movement. Thus, if sea level rises and the shoreline rises or subsides, the relative rise in sea level could be lesser or greater than the global sea level rise. Vertical land movement can occur due to tectonics (earthquakes, regional subsidence, or uplift), sediment compaction, isostatic readjustment, and groundwater depletion (USACE 2009). While subsidence has been significant in some areas of the Gulf Coast, such as coastal Louisiana, subsidence in Mobile Bay is limited and relative sea level rise is consistent with global sea level rise (Smith et al 2013).

B. SLAMM MODELING



Fowl River . 140553
Figure 3
Conceptual Habitat Elevation Zone Model

2. Model Inputs

SLAMM was run with the following inputs to look at habitat evolution at Fowl River under baseline conditions.

2.1 Topography and Bathymetry

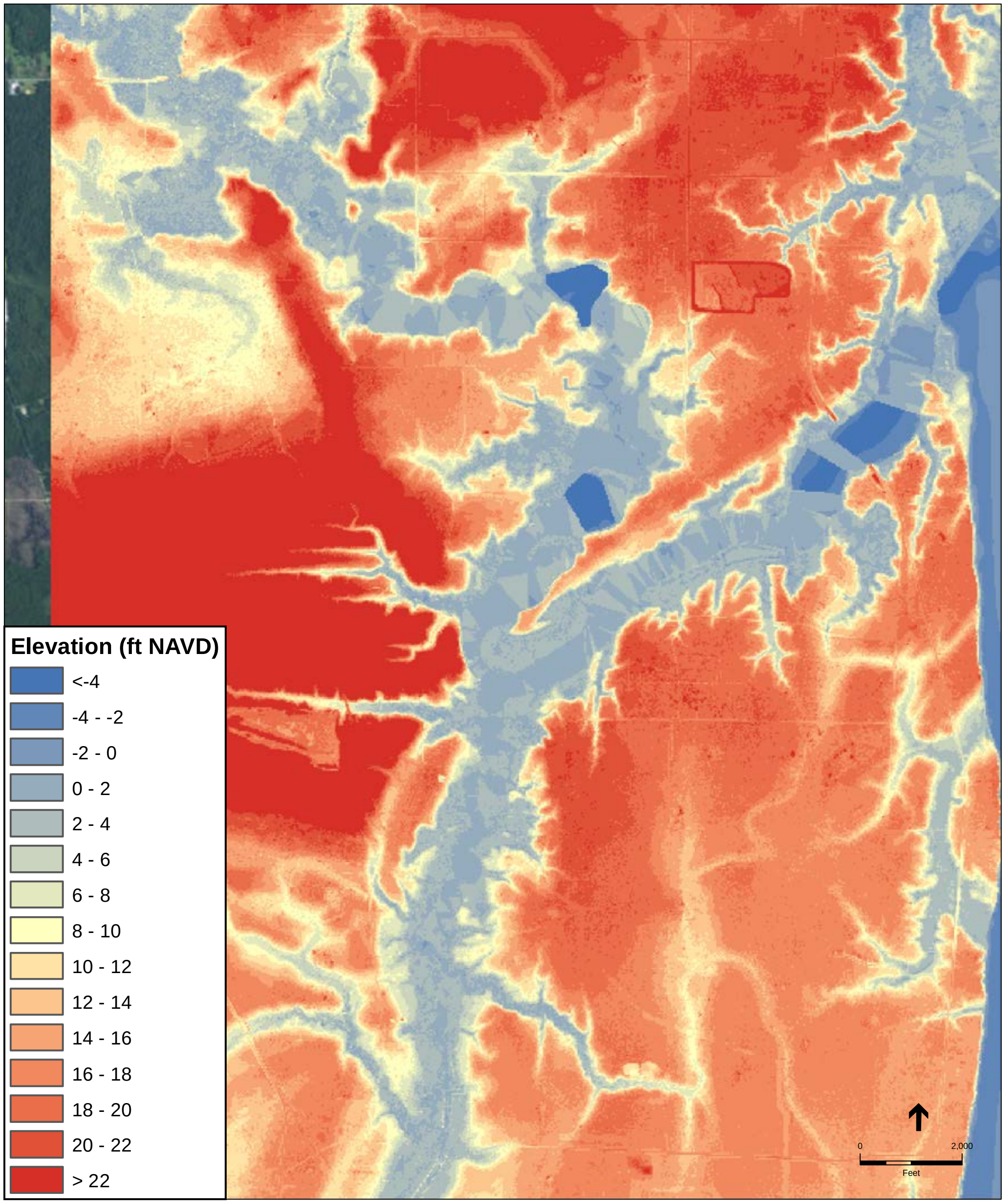
Topography is used in the model as input to the habitat evolution decision tree (see Section 2.2). Figure 4 presents the existing topography of the estuary, which combines the USACE post-Hurricane Katrina LiDAR (2005) with the Mobile County LiDAR (2002).

The resulting topography/bathymetry was converted to 10 m cells to provide a spatial resolution that is consistent with the vegetation mapping (Section 2.2) and maintains reasonable model run times.

2.2 Vegetation Mapping

To evaluate how habitats will evolve over time, existing conditions habitat mapping is needed. A habitat map was created by combining the National Wetlands Inventory (NWI; 2002) data with a map of imperviousness (National Land Cover Database (NLCD) 2011) to delineate between developed and undeveloped upland. The habitat map is shown in Figure 5.

Vegetation was categorized into habitat types according to the SLAMM NWI habitat cross-walk. The SLAMM categories were further simplified to represent the habitat types in the estuary. Of particular concern in the Fowl River is salt marsh habitat which is characterized by herbaceous emergent tidal wetlands dominated by *Spartina alterniflora* and *Juncus roemerianus*.



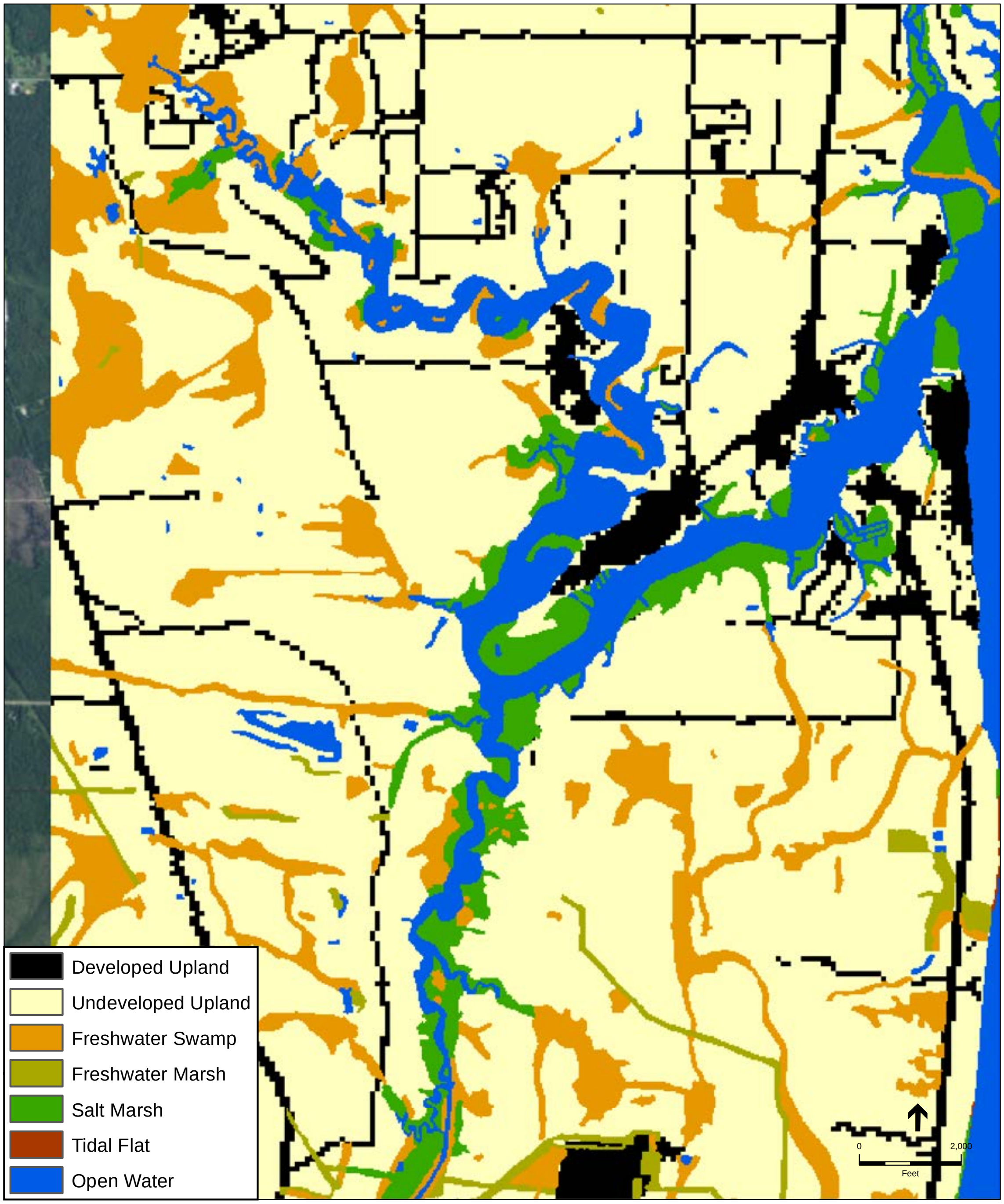
SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553

Figure 4

Topography and Bathymetry

B. SLAMM MODELING



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure 5
Vegetation Map

2.3 Tidal Water Levels

2.3.1 Tidal Datums

Tidal datums are used within the model as an input to the habitat evolution decision tree. For example, MLW is the boundary between open water and tidal flat, because it indicates the elevation at which land is always inundated (during an average day). If land is below MLW, it is assumed to be open water; if land is just above, it is tidal flat.

The model uses tidal datums for Dauphin Island as discussed in Section 1.1. An additional "salt elevation" datum is used to set the limit between freshwater habitats. The salt elevation is set to 1.56 ft NAVD at Fowl River, based on the 30-day high tide elevation (Table 3).

TABLE 3
TIDAL DATUMS USED IN THE MODEL
(values in feet NAVD)

Tidal Datum	Dauphin Island[1]
Salt Elevation	1.56
MHHW	0.70
MHW	0.68
MTL	0.09
MSL	0.06
MLW	-0.50
MLLW	-0.51

1. Data from NOAA Tides and Currents

2.3.2 Sea-Level Rise

In the model, sea-level rise is added to each datum over time. To test the sensitivity of the model to sea-level rise predictions, the model was run with low and high rates of sea-level rise from the IPCC 2013 Report. Table 4 provides the different scenarios.

TABLE 4
SEA-LEVEL RISE SCENARIOS

	Sea Level Rise by 2100 (inches from 2000)
Low Emissions	21
High Emissions	29

2.4 Accretion and Erosion

Smith et al (2013) took sediment cores of marsh sediments in Mobile Bay to estimate sedimentation rates. Near Fowl River, they found sedimentation rates of 0.45 – 0.58 in/yr (11.5 –

14.8 mm/yr) for fringing marshes and 0.11 – 0.13 in/yr (2.9 – 3.3 mm/yr) for interior marshes. To test sensitivity to sedimentation rates, the model was run with marsh accretion rates of 0.12 in/yr (3.1 mm/yr, based off of interior marsh data) and 0.52 in/yr (13.2 mm/yr, based off fringing marsh data).

Byrnes et al (2013) used historic aerials to delineate shorelines over time and to calculate erosion rates in Mobile Bay. For the shoreline north of Fowl River, they calculated 2.7 feet of erosion per year (0.82 m/yr) from 1982 to 2010. For the shoreline south of the river, they estimated 0.9 feet of erosion per year (0.27 m/yr) from 1982 to 2011, with higher rates in the vicinity of Fowl River. The higher erosion rate of 2.7 ft/yr was used in the model as a conservative estimate or worst-case scenario.

2.5 Freshwater Inflow

The model defines the area of year-round freshwater influences based on a freshwater influence polygon. For existing conditions, this polygon was defined by the extent of freshwater marsh in the estuary, which occurred throughout the entire project site. It was assumed that the freshwater influence would remain unchanged in the future.

3. Model Runs

Table 5 presents the scenarios that were run in SLAMM to test the model sensitivity. Low and high rates of sea-level rise were evaluated with low and high accretion rates. The model also evaluates different management scenarios, such as protecting development or "holding the line" versus allowing marsh to migrate into upland areas.

TABLE 5
RUN CATALOG

Run	Sea-Level Rise	Accretion Rates	Protect Development
Run 1	Low (21 in)	Low (0.12 in/yr)	No
Run 2	High (29 in)	Low (0.12 in/yr)	No
Run 3	High (29 in)	High (0.52 in/yr)	No
Run 4	High (29 in)	Low (0.12 in/yr)	Yes

4. Results

The runs in Table 5 allowed for comparisons between different sea-level rise scenarios, accretion rates, and management scenarios. Below, Section 4.1 presents the model "validation" of existing habitat types. Sections 4.2 and 4.3 present the results for sensitivity runs on sea-level rise and accretion rates, and Section 4.4 presents the results for the different management scenarios.

4.1 Model "Validation"

The SLAMM results were compared to existing vegetation to check the model assumptions for the habitat evolution decision tree. Current topography and existing tidal datums were input to the model with no sea-level rise to model the existing conditions (2002) and to validate the model. Table 6 presents habitat acreages from the 2002 mapped vegetation and from the 2002 modeled habitats.

TABLE 6
HABITAT ACREAGES FOR MAPPED VS MODELED

Habitat	2002 Mapped Vegetation[1] (ac)	2002 Modeled Vegetation[1] (ac)	Difference (ac)	Difference %	Notes
Developed Upland	805	805	0	0%	
Undeveloped Upland	6591	6552	-39	-0.6%	The model categorized some upland as freshwater swamp or marsh based on elevations
Freshwater Swamp	1233	1257	23	2%	The model categorized some upland as freshwater swamp or marsh based on elevations
Freshwater Marsh	142	156	15	10%	The model categorized some upland as freshwater swamp or marsh based on elevations
Salt Marsh	436	436	0	0%	
Tidal Flat	3	3	0	-0.7%	
Open Water	1091	1091	0	0%	

1. Results have been rounded

When the mapped vegetation is input to the model, some habitats change, since actual vegetation does not always follow the rules of the model. For example, SLAMM converts upland to freshwater swamp and marsh based on the elevations from the topography.

4.2 Sea-Level Rise

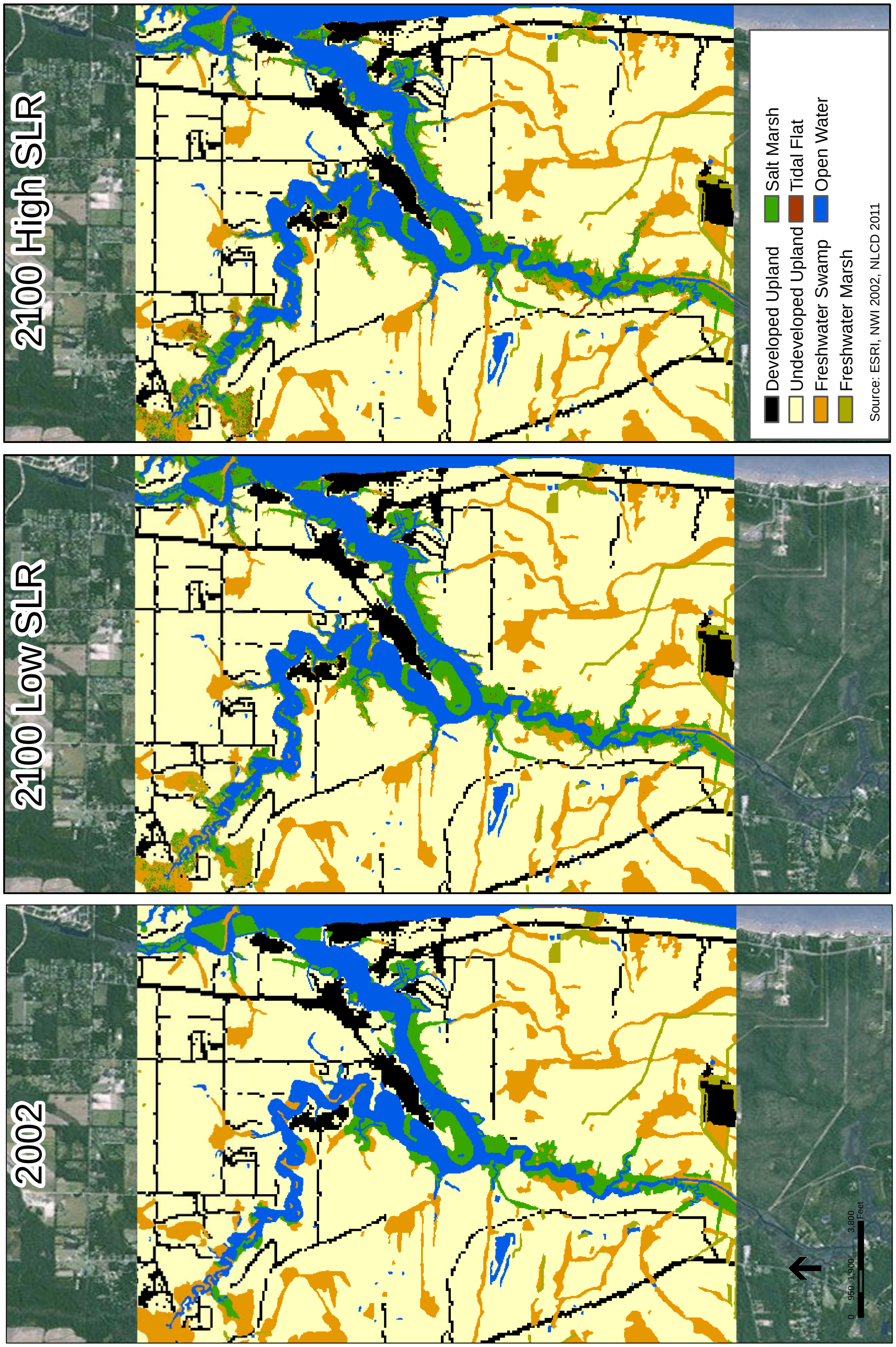
Table 7 presents the habitat acreages for low (run 1) and high (run 2) rates of sea-level rise at 2100, as well as the difference between these habitat acreages and the 2002 modeled habitats (See Appendix A for habitat acreages for 2030, 2050, 2070, and 2100). With higher rates of sea-level rise, higher elevation habitats convert to lower habitat types more quickly. For example, under the high sea-level rise scenario, there is a greater loss of upland and freshwater swamp habitats and a more rapid increase of salt marsh, tidal flat, and open water. Figure 6 shows the 2100 habitat maps for low and high sea-level rise. (See Appendix B for habitat maps at 2030, 2050, 2070, and 2100).

Figure 7 and Figure 8 show the evolution of habitats over time for low and high rates of sea-level rise. Under low sea-level rise, the total amount of freshwater swamp and marsh stays about the same over time. With high sea-level rise, the salt marsh increases at the expense of the freshwater swamp.

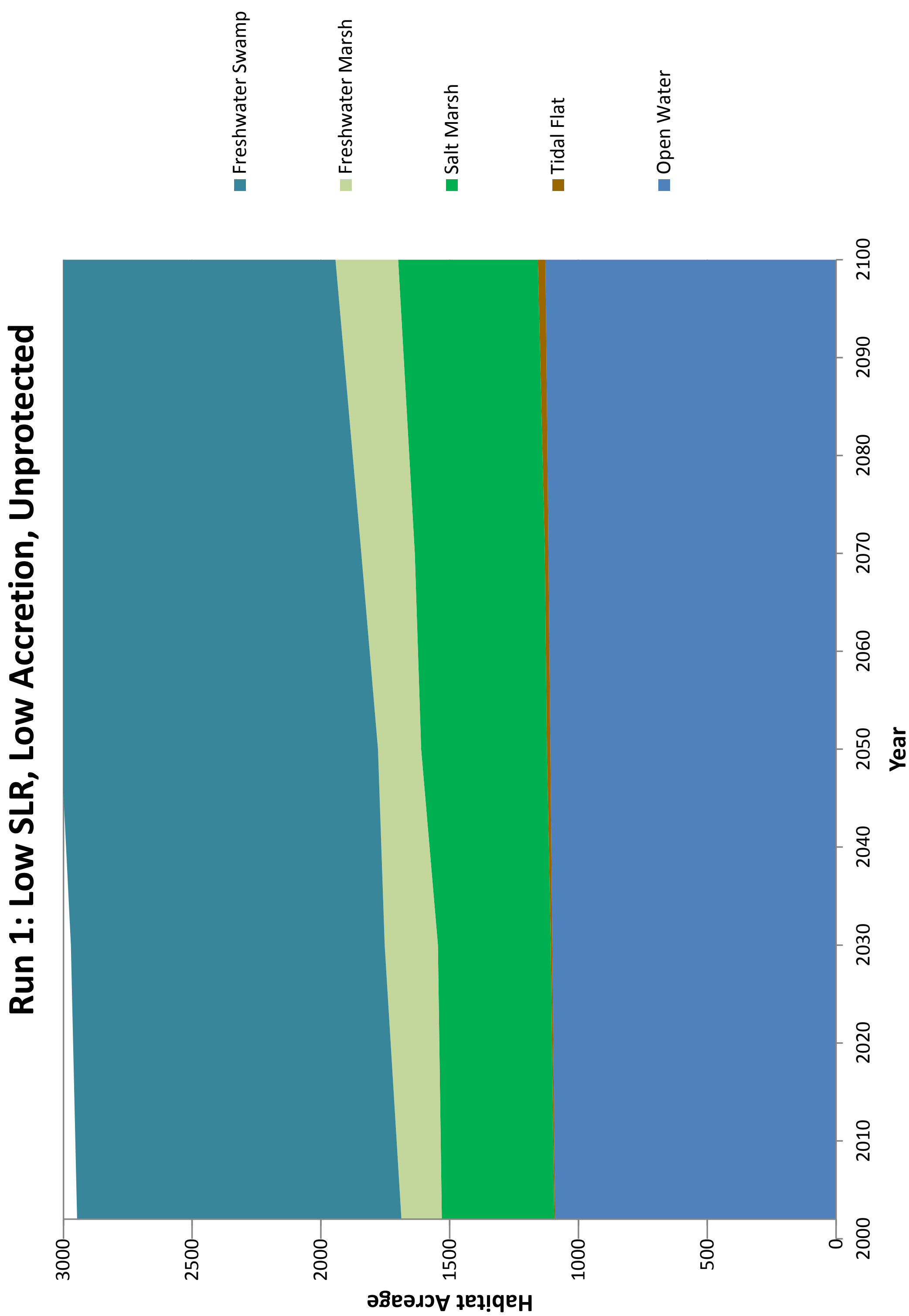
TABLE 7
HABITAT ACREAGES FOR SEA-LEVEL RISE

Habitat	Modeled Acreage in 2002	Acreage in 2100		Acreage difference 2100-2002	
		Low	High	Low	High
Developed Upland	805	788	780	-14	-22
Undeveloped Upland	6552	6380	6327	-172	-225
Freshwater Swamp	1257	1189	1159	-70	-100
Freshwater Marsh	156	243	242	87	86
Salt Marsh	436	543	561	106	125
Tidal Flat	3	29	63	26	60
Open Water	1091	1129	1168	38	77

B. SLAMM MODELING



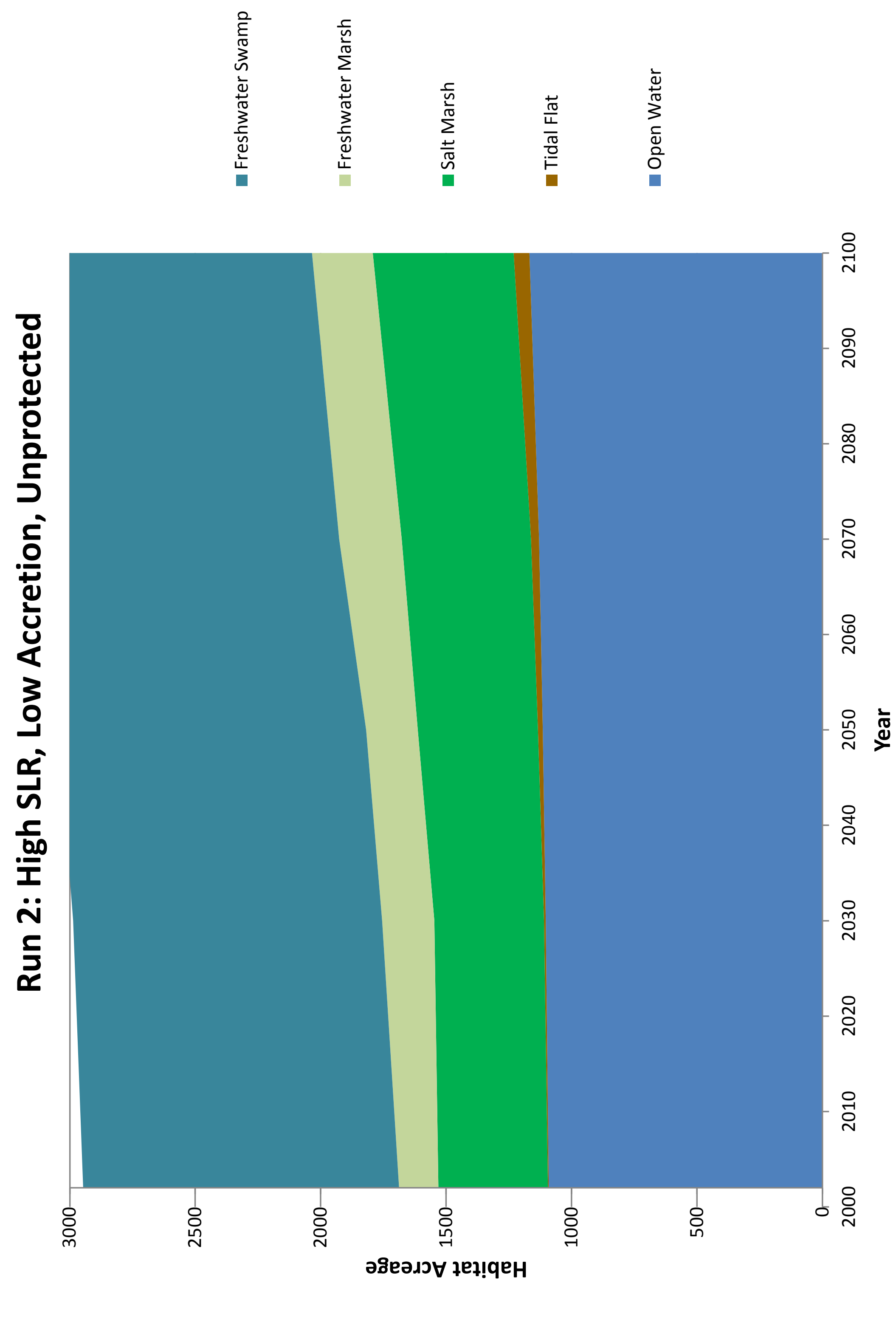
Fowl River, D140553
Figure 6
2002 Modeled Vegetation versus
Low and High Sea-Level Rise



Fowl River Estuary. D140553

Figure 7

Run 1 Habitats Over Time



Fowl River Estuary. D140553

Figure 8

Run 2 Habitats Over Time

4.3 Accretion Rates

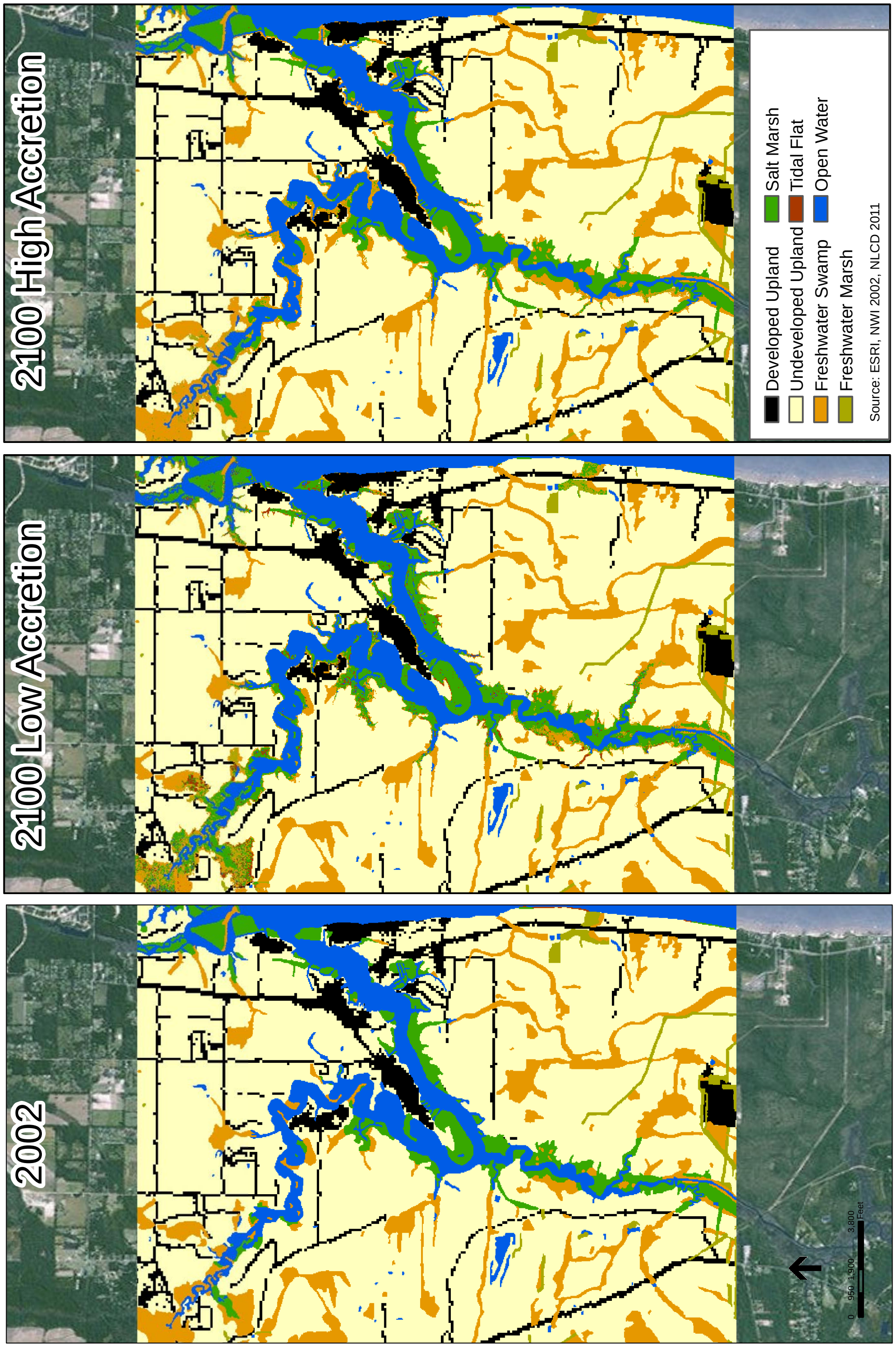
Table 8 compares the habitat acreage at 2100 for the modeled low accretion rate (run 2) and the upper-end high accretion rate (run 3). With less sediment, the habitats convert from freshwater swamp to salt marsh. With the high accretion rates, the freshwater swamp habitat is able to keep up with sea level rise and actually increase in acreage.

Figure 9 shows the 2100 habitat maps with the different accretion rates compared to the 2002 modeled habitats. Figure 10 and Figure 11 show the habitat evolution over time for the run 2 (low accretion) and run 3 (high accretion) respectively.

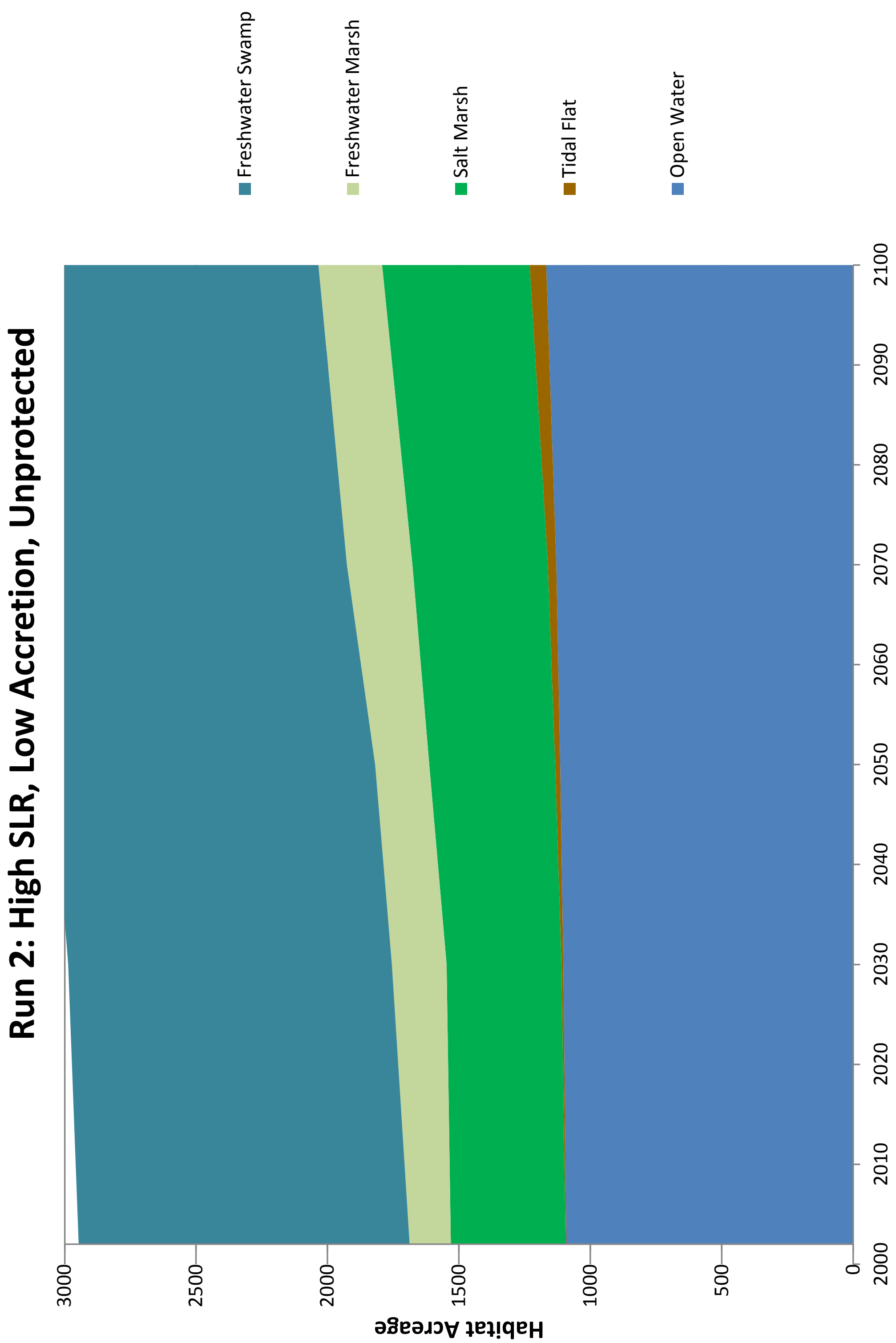
TABLE 8
HABITAT ACREAGES FOR DIFFERENT ACCRETION RATES

		Acreage in 2100		
Habitat	**Modeled Acreage in 2002**	**Run 2 (Low Accretion)**	**Run 3 (High Accretion)**	**Difference (Run 3 –Run 2)**
Developed Upland	805	780	784	4
Undeveloped Upland	6552	6327	6392	65
Freshwater Swamp	1257	1159	1368	209
Freshwater Marsh	156	242	202	-40
Salt Marsh	436	561	453	-108
Tidal Flat	3	63	1	-62
Open Water	1091	1168	1100	-68

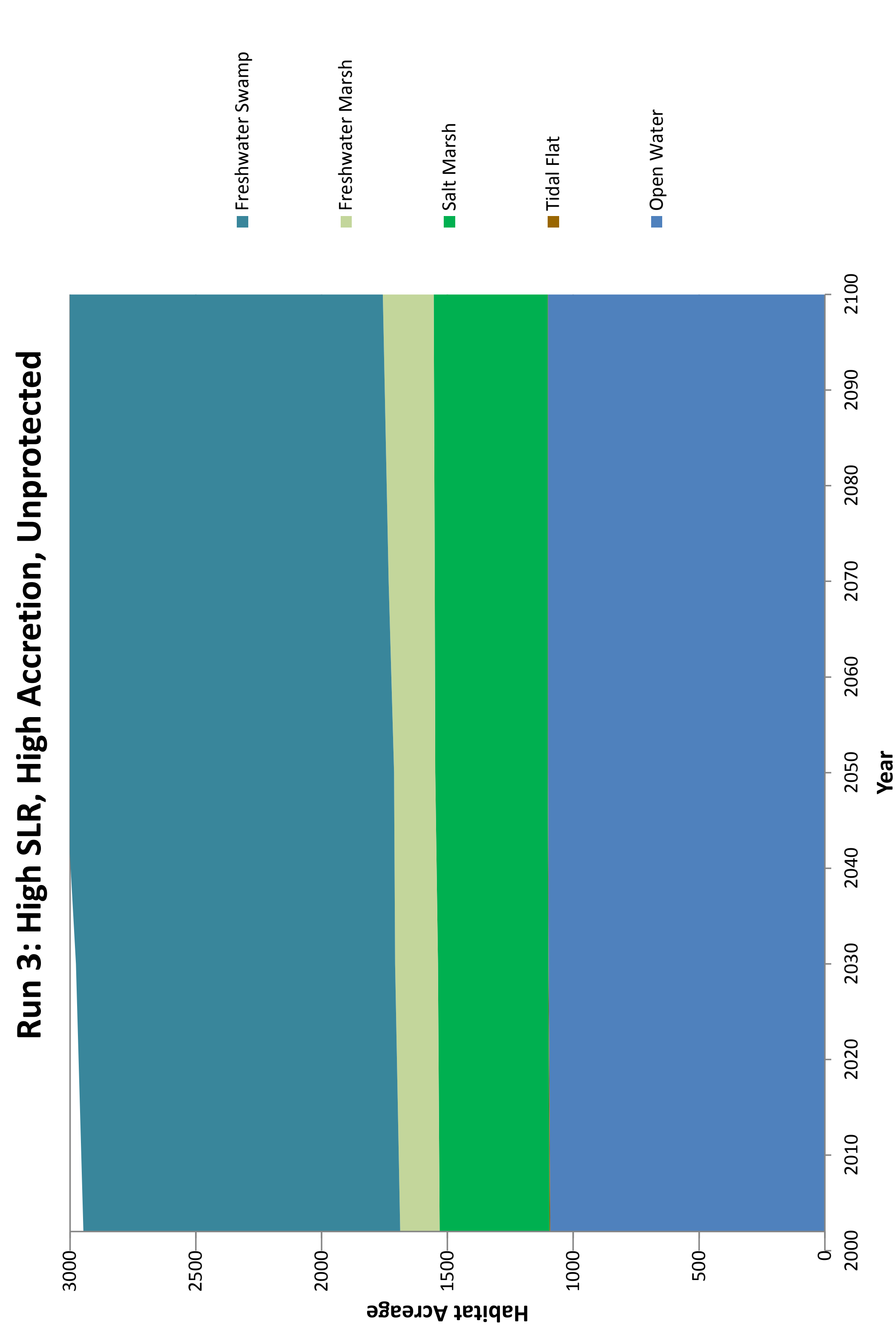
B. SLAMM MODELING



Fowl River, D140553
Figure 9
2002 Modeled Vegetation versus Low and High Accretion Rates



Fowl River Estuary. D140553
Figure 10
Run 2 Habitats Over Time



Fowl River Estuary. D140553

Figure 11

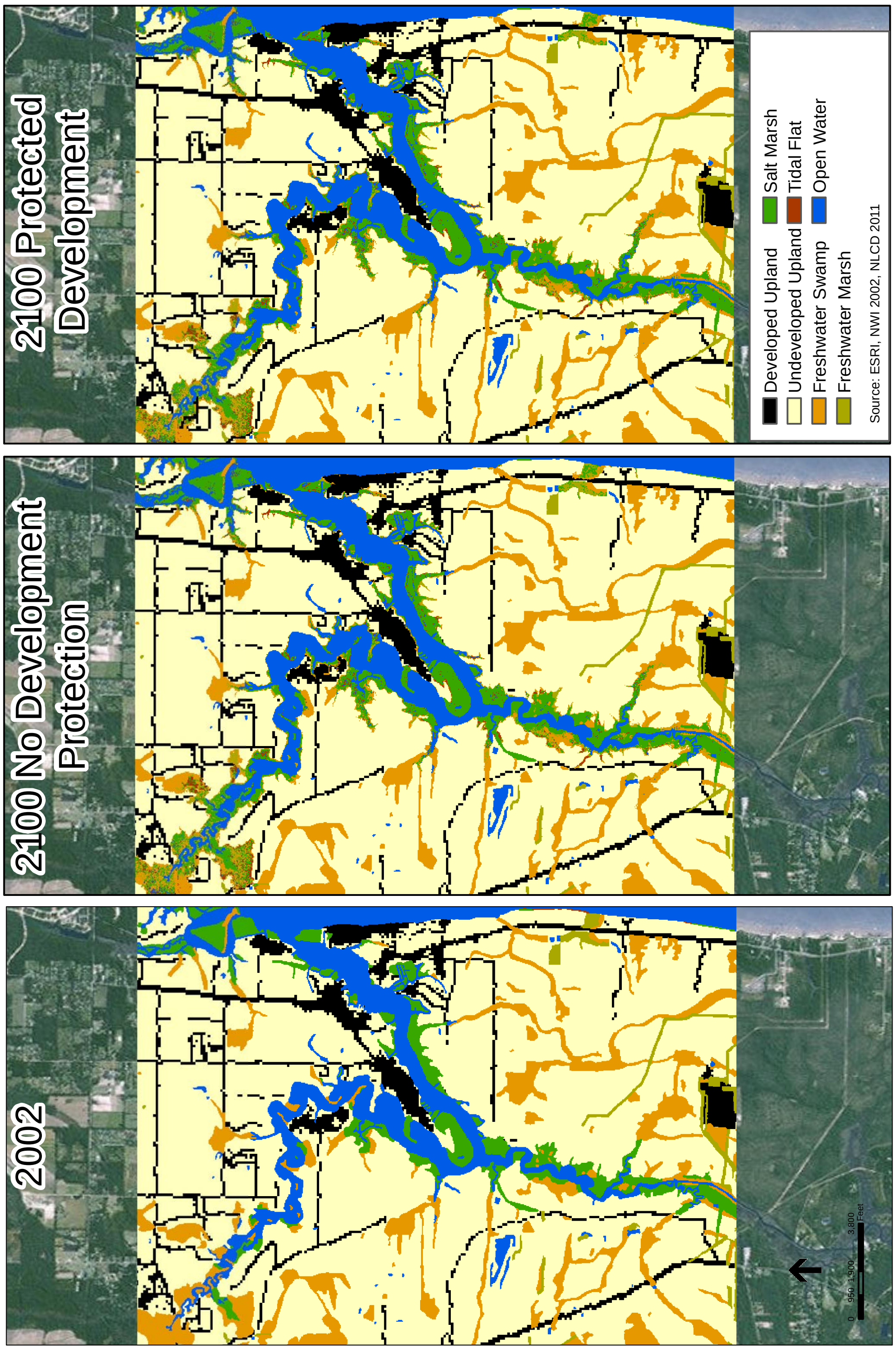
Run 3 Habitats Over Time

4.4 Management Scenarios

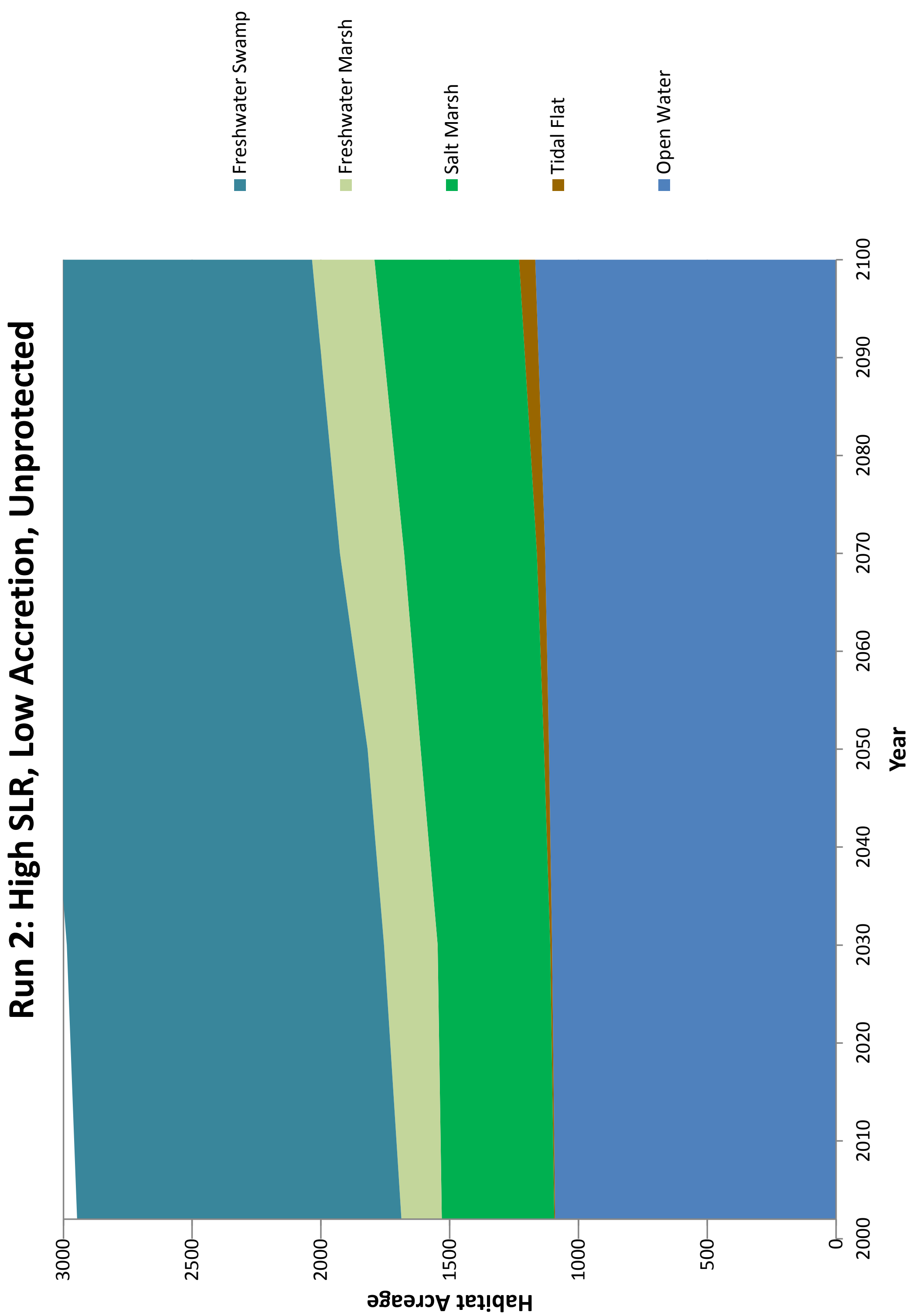
Table 9 provides the habitat acreage for run 2, which allows marsh and freshwater swamp to migrate into developed uplands, and run 4, which protects the developed uplands ("holding the line"). Because the Fowl River estuary is not very developed, the difference in management scenarios is minimal. When the habitats are allowed to migrate into the developed uplands, 24 acres is converted to mostly freshwater swamp, but also freshwater marsh and salt marsh habitat. Figure 12 shows the habitat maps with the different management scenarios.

TABLE 9
HABITAT ACREAGES FOR DIFFERENT MANAGEMENT SCENARIOS

Habitat	Modeled Acreage in 2002	Acreage in 2100		Difference (Protected-Unprotected)
		Unprotected Development	Protected Development	
Developed Upland	805	780	805	24
Undeveloped Upland	6552	6327	6327	0
Freshwater Swamp	1257	1159	1148	-11
Freshwater Marsh	156	242	237	-5
Salt Marsh	436	561	555	-6
Tidal Flat	3	63	62	-1
Open Water	1091	1168	1167	-1



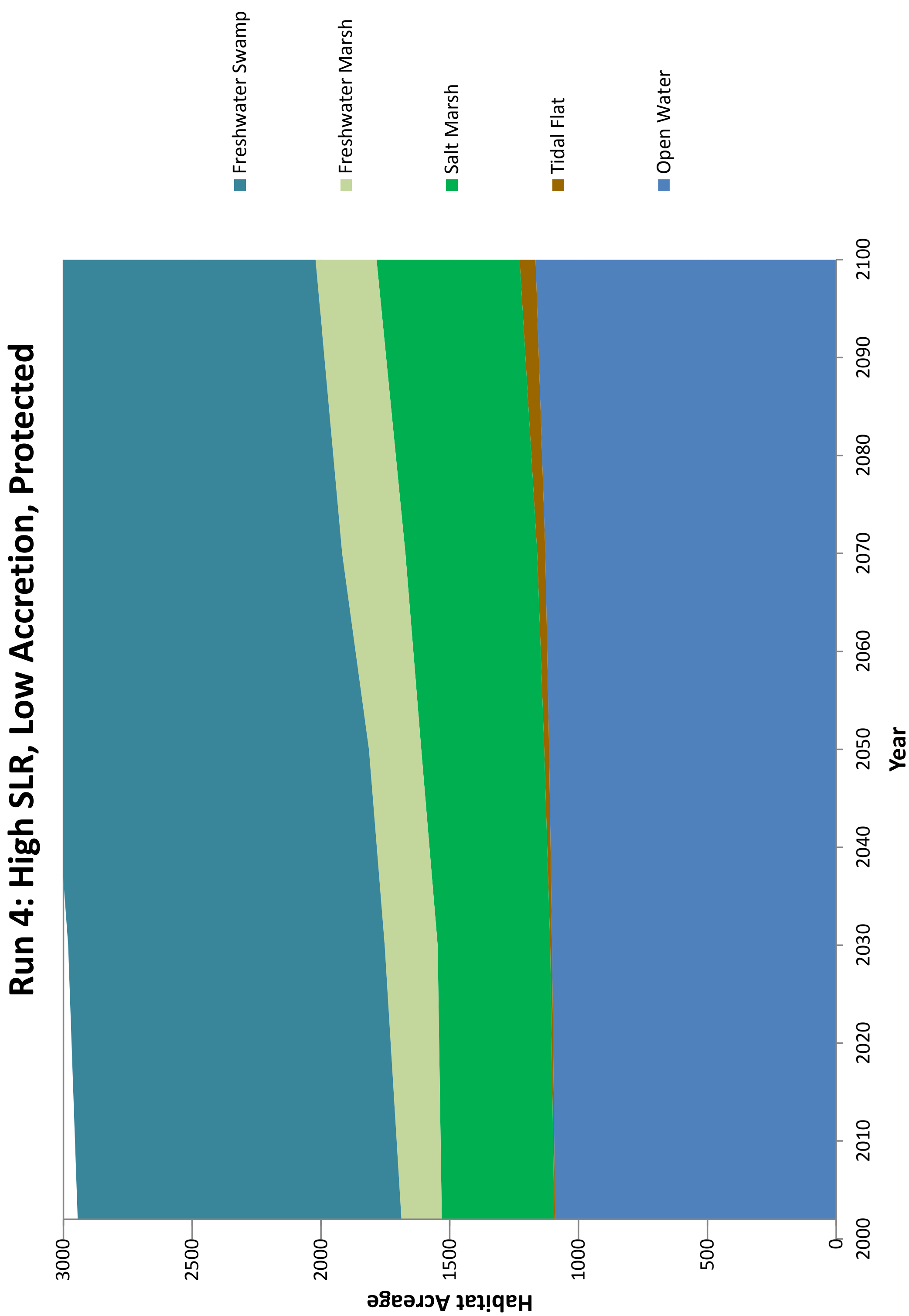
Fowl River, D140553
Figure 12
2002 Modeled Vegetation versus Different Management Scenarios



Fowl River Estuary. D140553

Figure 13

Run 2 Habitats Over Time



Fowl River Estuary. D140553

Figure 14

Run 4 Habitats Over Time

5. Discussion

SLAMM provides graphical and tabular projections of potential future habitat changes in the Fowl River. It can model different levels of sea-level rise, accretion rates, and management scenarios. The results presented here look at the base conditions and predict or project future conditions in the estuary.

5.1 Model Calibration

The current model setup captures the habitat categories very well with less than 1% of the total site changing due to the model assumptions. This indicates the model's elevation/vegetation assumptions are representative of the Fowl River estuary system.

5.2 Sea-Level Rise

As expected, the different rates of sea-level rise provided different results. Under low sea-level rise, salt marsh acreage increases as upland and freshwater swamp habitat fall lower in the tidal frame. Under high sea-level rise, there is a more significant increase in salt marsh. Since rates of sea-level rise still remain uncertain, any future model runs should include multiple scenarios.

5.3 Accretion Rates

The results suggest that the model is most sensitive to accretion rates. Over 100 years, the higher accretion rate would result in 52 inches of accretion on the coastal floodplain. By contrast, the high sea level rise estimate only increases water levels by 29 inches, so there is a net elevation gain of 23 inches by 2100. This scenario (high sea level rise + high accretion) results in a substantial gain in freshwater swamp as the floodplain area increases. Conversely, freshwater swamps decrease under the low accretion scenario. Both freshwater and salt marshes increase in total acreage under both the high and low accretion rates; however, they increase substantially more under the low accretion rate. While counterintuitive, these results indicate that the total acreage of tidal marsh habitat in the Fowl River estuary will better keep pace, and even increase, with sea level rise at low to moderate rates of sedimentation and accretion. It should be noted that the gains in salt marsh acreage occur mostly in freshwater wetland habitats and uplands, and that these gains will be partially offset by losses in existing salt marshes.

The low and high accretion rates provide a bookend of possible future scenarios. Given that the Fowl River SLAMM model was most sensitive to accretion rates compared to other factors, it is recommended that site-specific sedimentation and accretion data be collected in the Fowl River estuary to improve the modeling of habitat conversions resulting from sea level rise within this system.

5.4 Management Scenarios

In the Fowl River estuary, where development is minimal, the difference in protecting development and allowing habitats to migrate into those areas is also minimal. Protecting the upland development, or "holding the line", would result in the maintenance of 24 acres of development, at the expense of potential freshwater swamp and marsh and salt marsh habitat.

6. Conclusions

The Fowl River SLAMM model was used to simulate macro-level habitat conversions in response to sea level rise and related geomorphologic processes. The results of this modeling effort indicate that the total acreage of tidal marsh habitat in the Fowl River estuary will keep pace, and even increase, with projected sea level rise through the year 2100. However, it should be noted that gains in marsh acreage over this time period will take place through the conversion of existing freshwater wetland habitats and uplands, and that these gains will be partially offset by losses in existing salt marshes. The model also indicates that the maintenance and expansion of the overall gross acreage of tidal marsh habitat in the Fowl River estuary would be better supported by lower rates of sedimentation and accretion. At high rates of accretion, sediment deposition in the coastal floodplain will result in net elevation gains that ultimately convert to freshwater swamp, rather than tidal marsh habitat. These findings support recommendations for sediment management in the upper watershed.

Since the lower Fowl River watershed is relatively sparsely developed, the modeling results show that tidal marsh habitats have adequate space to migrate into low lying undeveloped upland areas as sea levels rise. With existing development, the "holding the line" management scenario only impacts 24 acres of potential tidal marsh habitat. Accordingly, it is recommended that the Fowl River Watershed Management Plan identify large undeveloped tracts in the lower Fowl River watershed for potential public acquisition conservation easements or to ensure that there is adequate land area to allow for the upland migration of tidal marsh habitats with future sea level rise.

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8. List of Preparers

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B. SLAMM MODELING

Habitat Acreage Tables

Run 1: Low Sea-Level Rise, Low Accretion, No Development Protection

Year	2002	2030	2050	2070	2100
Developed Dry Land	802	801	798	795	788
Undeveloped Dry Land	6552	6530	6495	6441	6380
Freshwater Swamp	1259	1218	1229	1222	1189
Freshwater Marsh	157	207	168	208	243
Salt Marsh	436	438	488	505	543
Tidal Flat	3	6	14	14	29
Open Water	1091	1102	1109	1117	1129

Run 2: High Sea-Level Rise, Low Accretion, No Development Protection

Year	2002	2030	2050	2070	2100
Developed Dry Land	802	800	796	791	780
Undeveloped Dry Land	6552	6515	6459	6402	6327
Freshwater Swamp	1259	1232	1227	1182	1159
Freshwater Marsh	157	208	206	249	242
Salt Marsh	436	437	479	515	561
Tidal Flat	3	7	19	32	63
Open Water	1091	1103	1115	1130	1168

Run 3: High Sea-Level Rise, High Accretion, No Development Protection

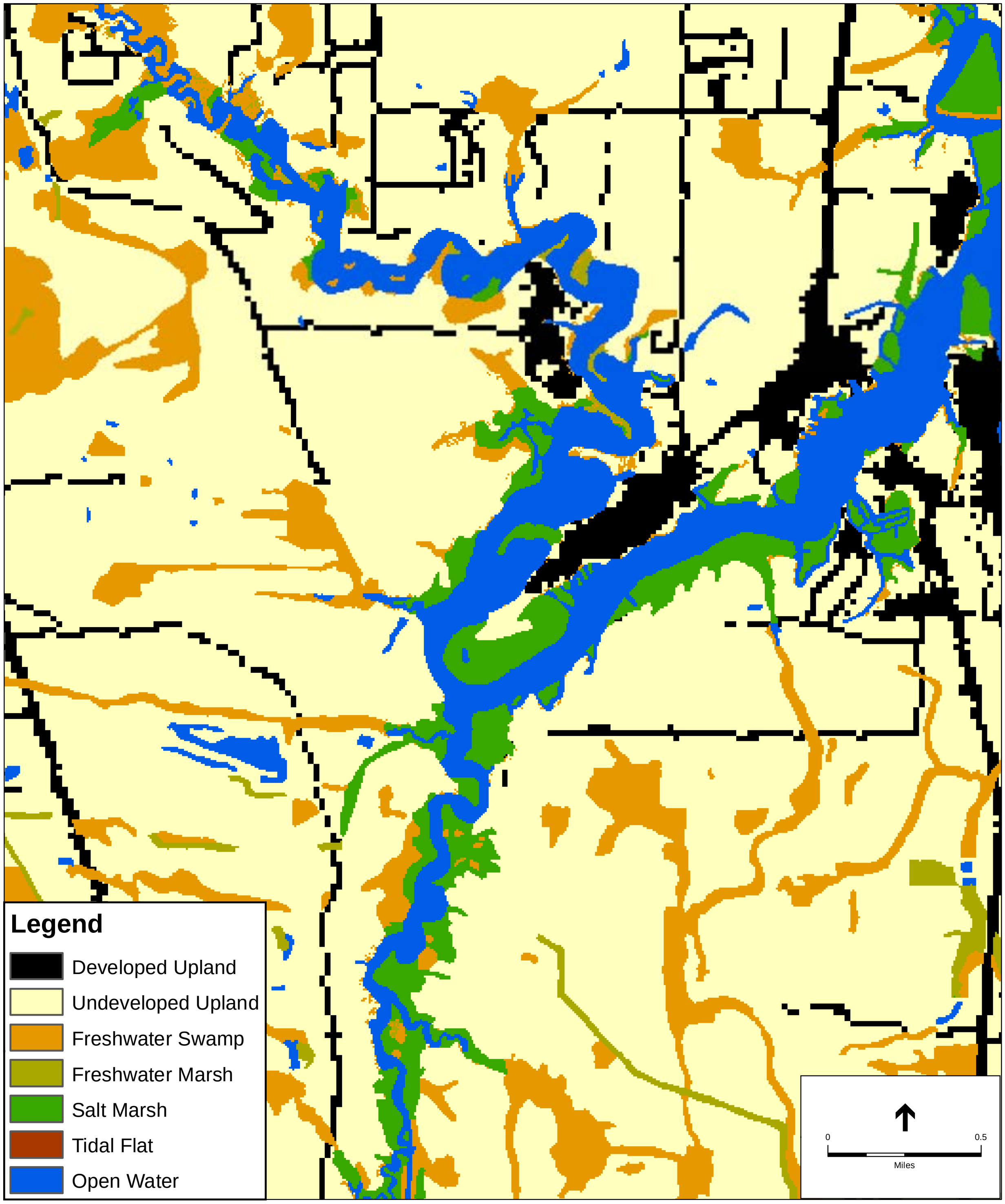
Year	2002	2030	2050	2070	2100
Developed Dry Land	802	800	797	792	784
Undeveloped Dry Land	6552	6525	6486	6444	6392
Freshwater Swamp	1259	1269	1306	1331	1368
Freshwater Marsh	157	170	164	183	202
Salt Marsh	436	439	447	449	453
Tidal Flat	3	1	1	1	1
Open Water	1091	1098	1100	1100	1100

Run 4: High Sea-Level Rise, Low Accretion, Protect Development

Year	2002	2030	2050	2070	2100
Developed Dry Land	805	805	805	805	805
Undeveloped Dry Land	6552	6515	6459	6402	6327
Freshwater Swamp	1257	1229	1223	1177	1148
Freshwater Marsh	157	206	203	246	237
Salt Marsh	436	437	477	512	555
Tidal Flat	3	7	19	31	62
Open Water	1091	1103	1114	1129	1167

B. SLAMM MODELING

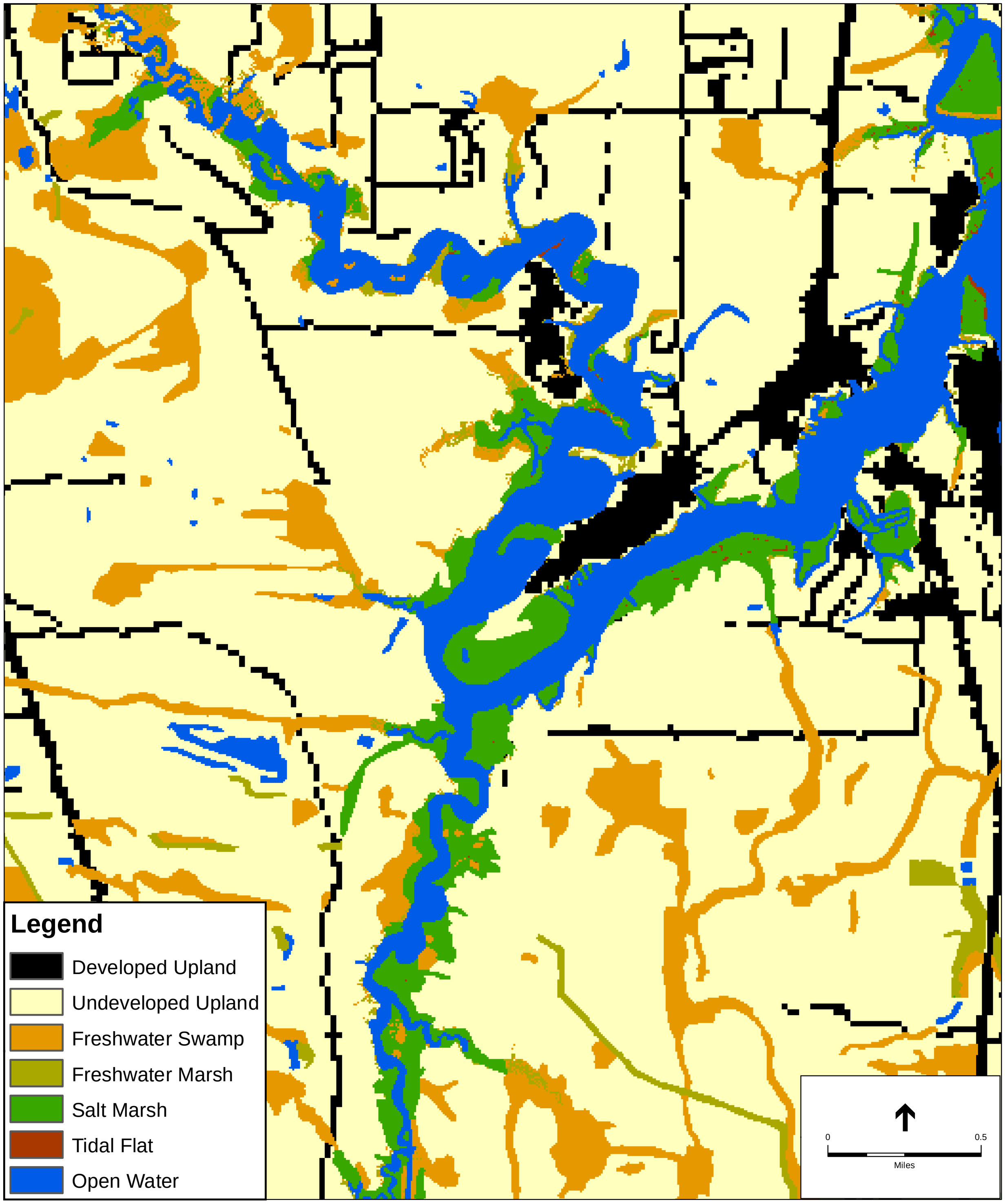
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-1
Run 1, 2002

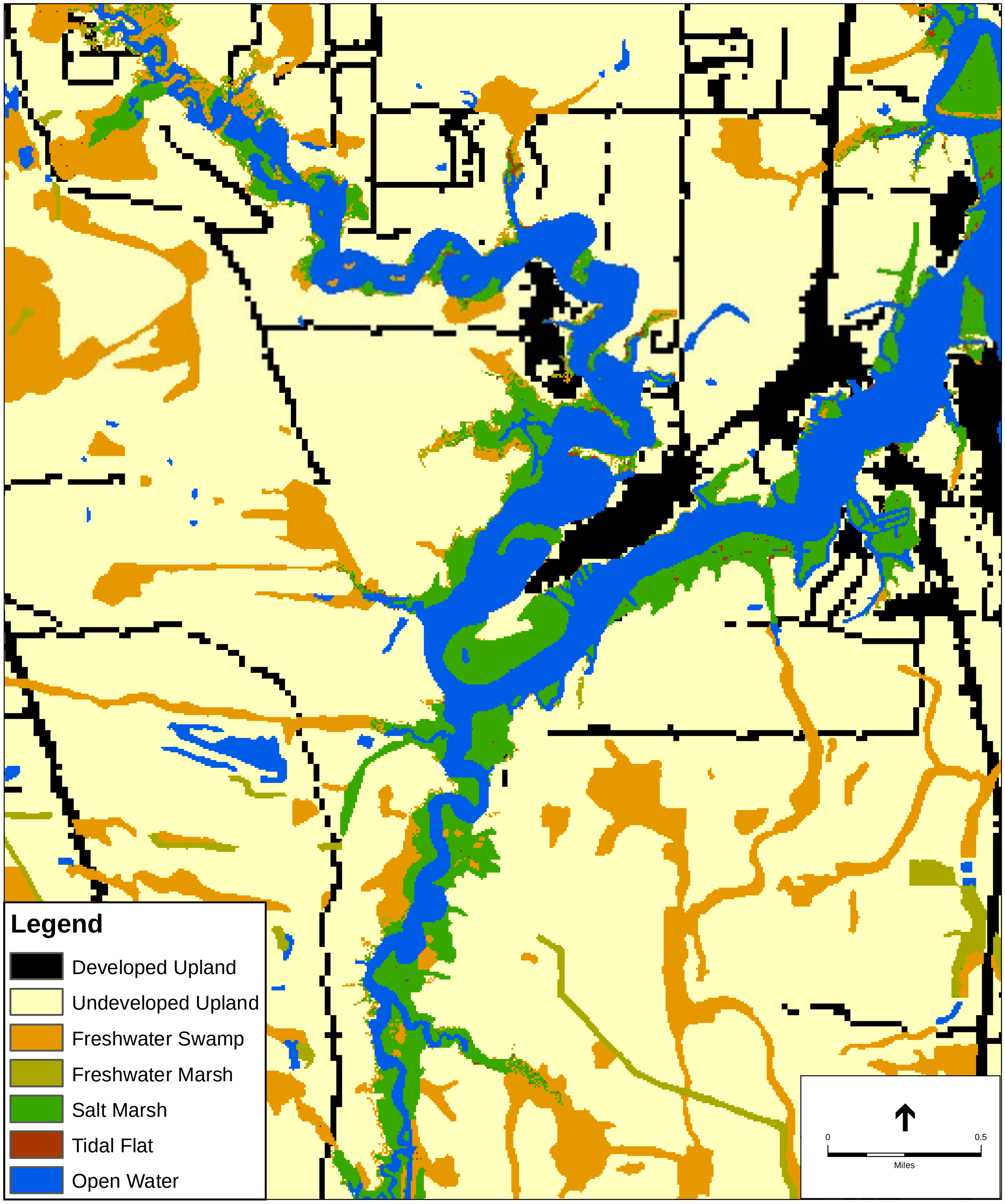
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-2
Run 1, 2030

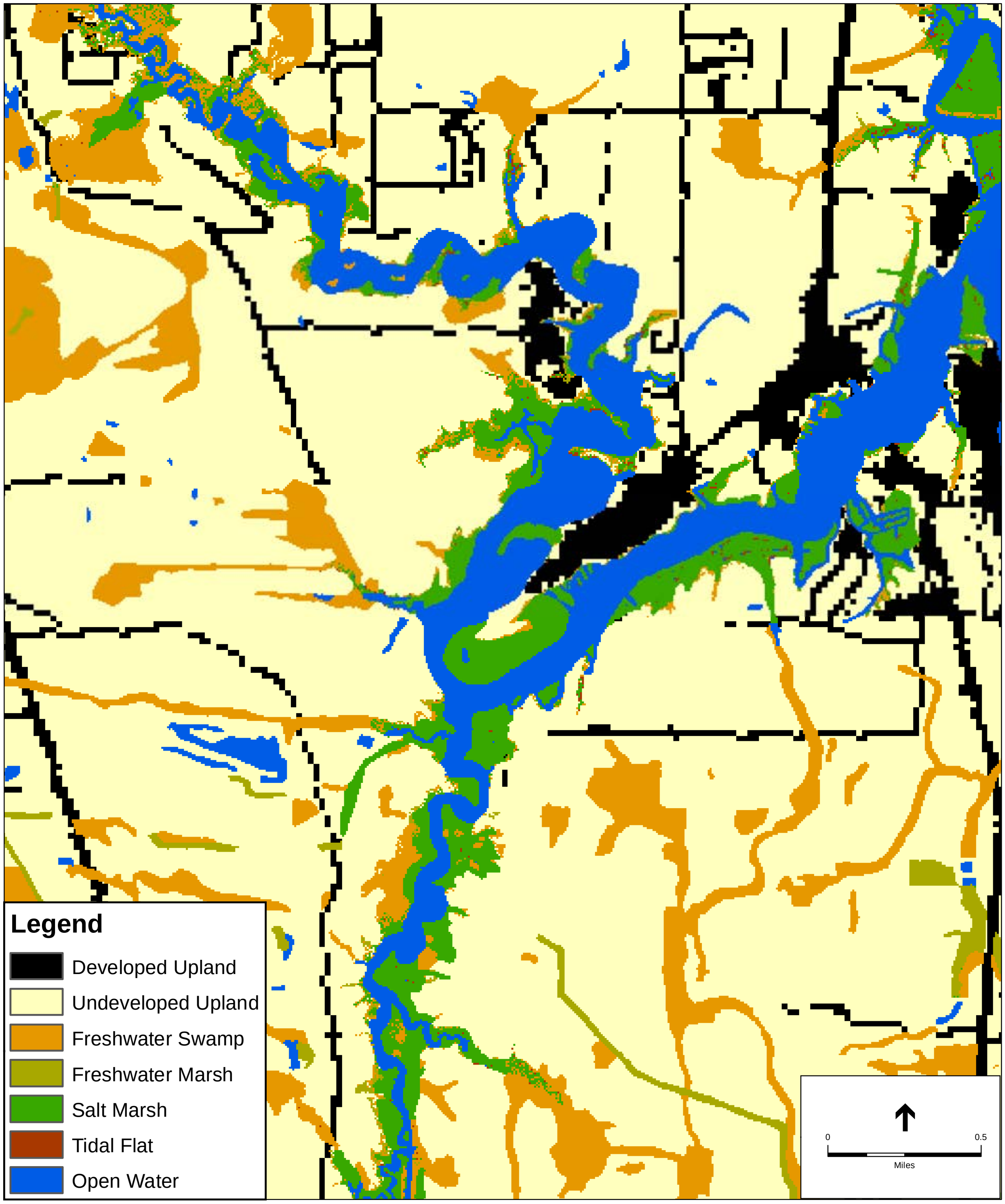
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-3
Run 1, 2050

Habitat Maps



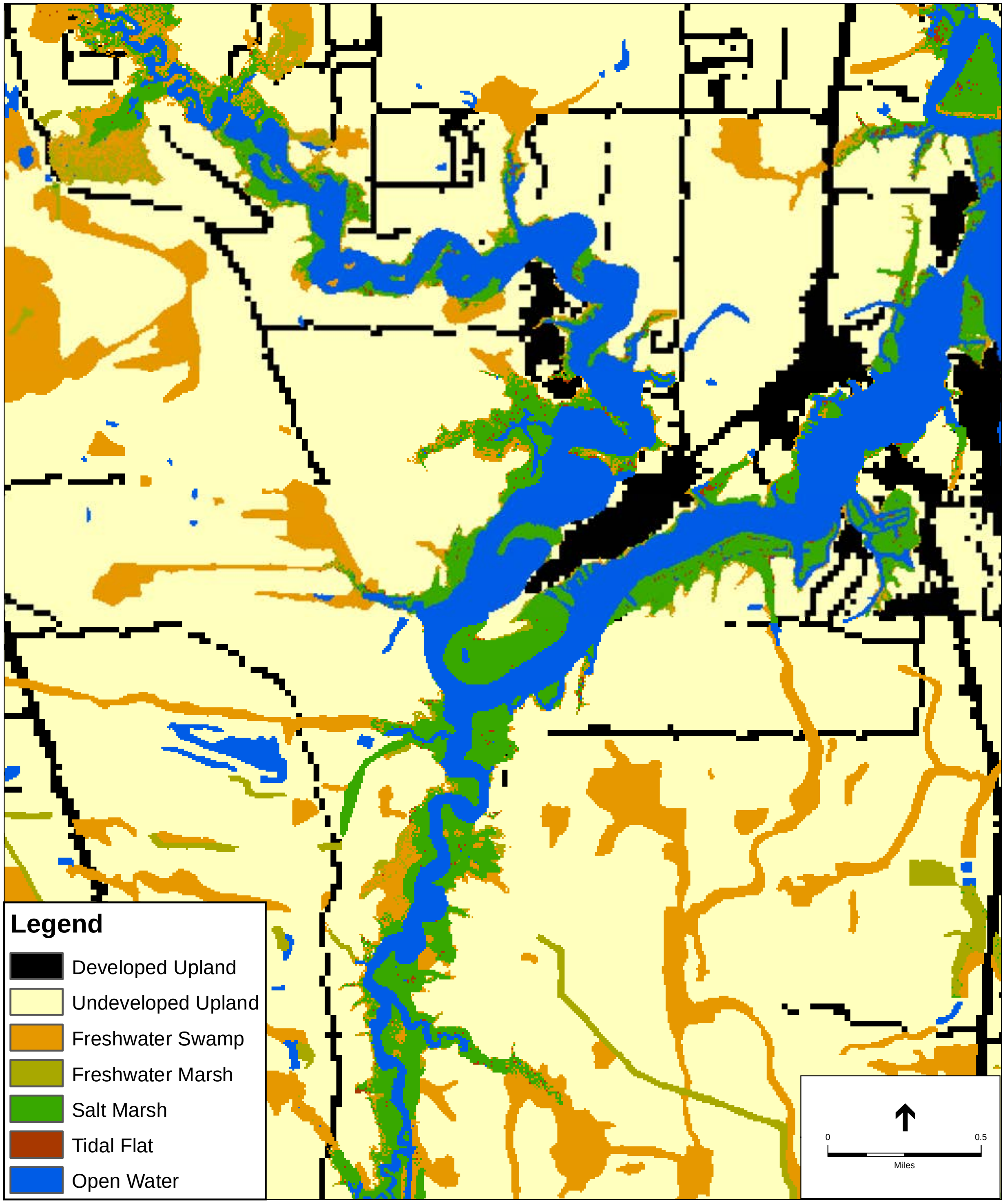
SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553

Figure B-4

Run 1, 2070

Habitat Maps



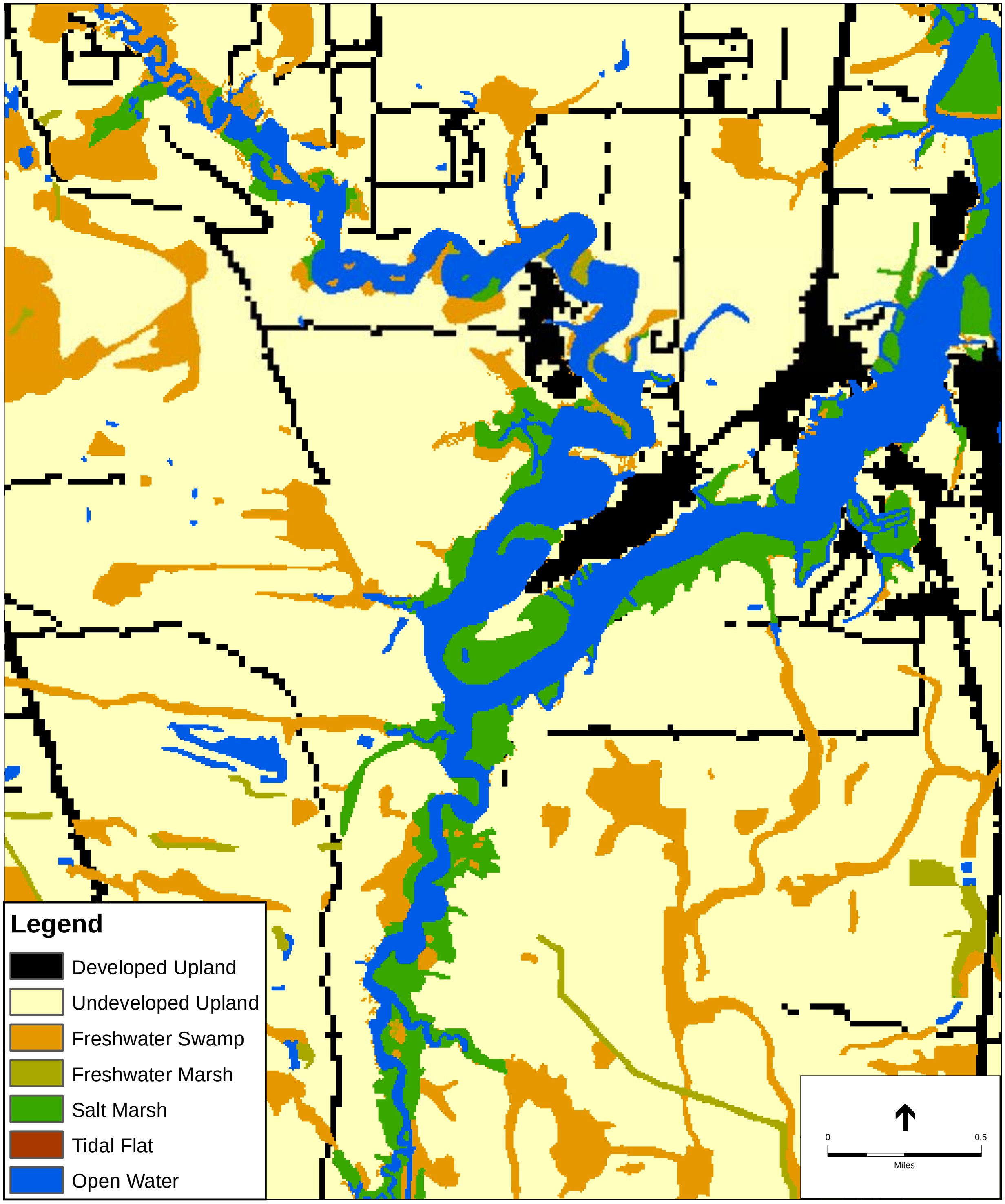
SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553

Figure B-5

Run 1, 2100

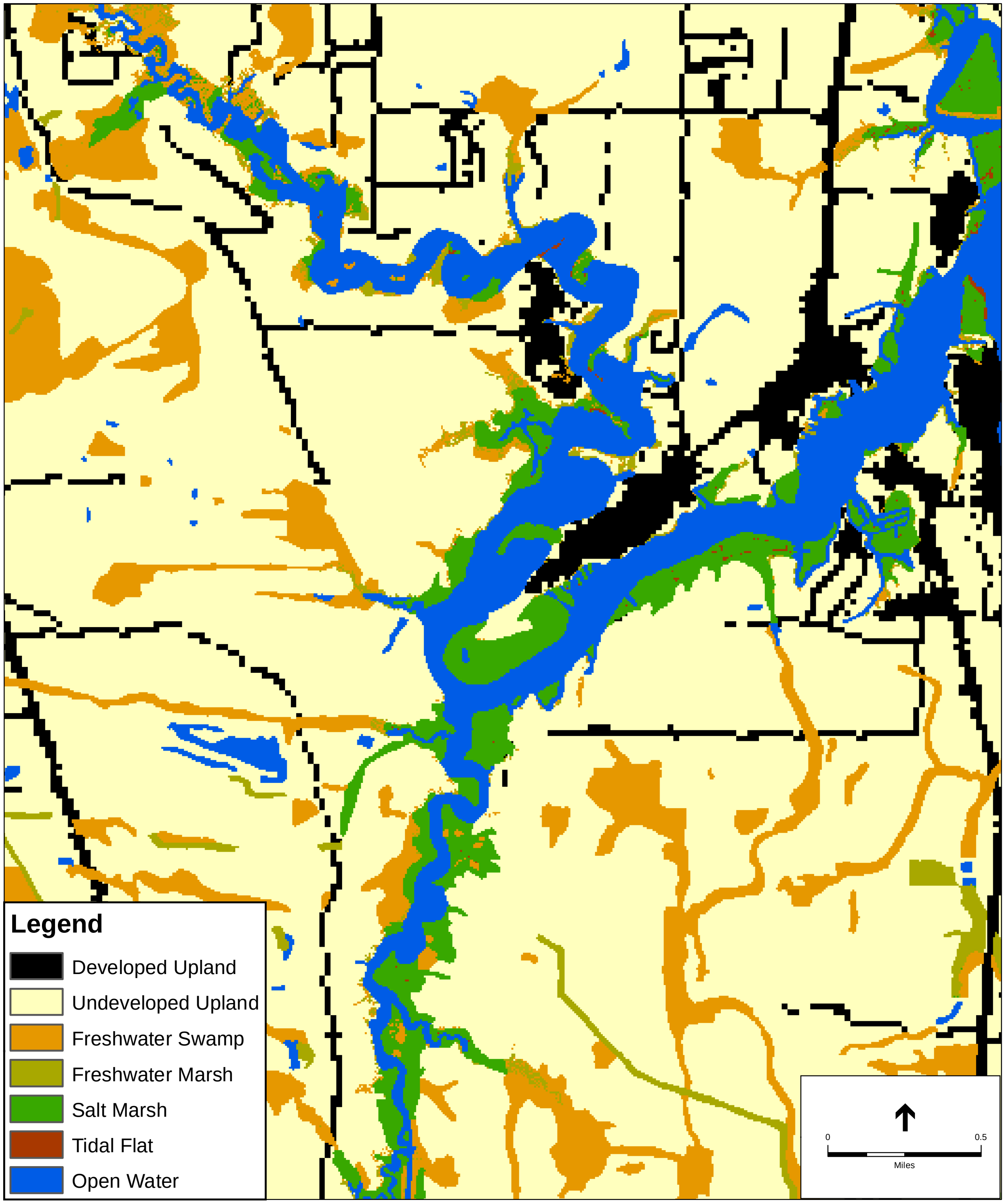
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-6
Run 2, 2002

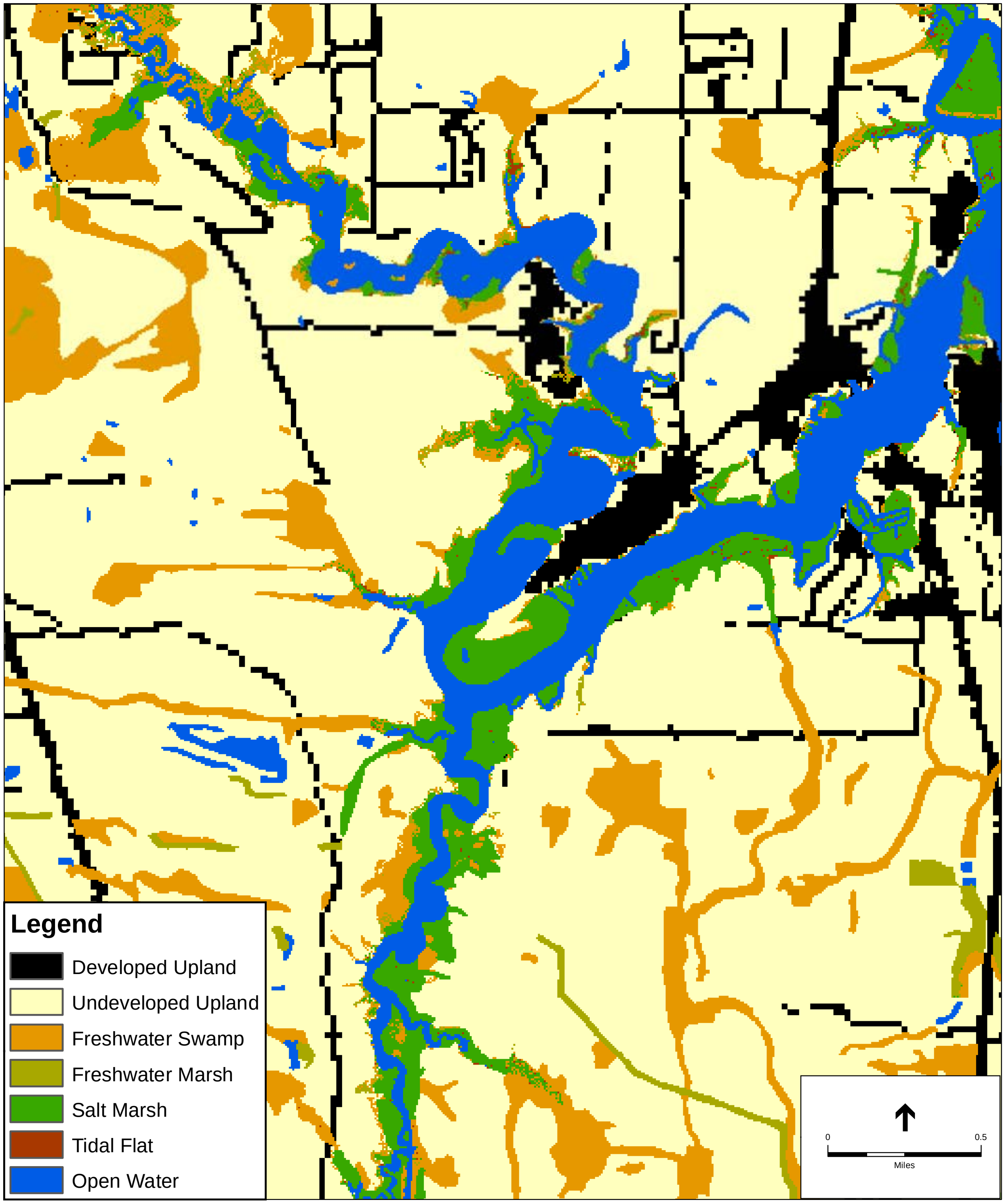
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-7
Run 2, 2030

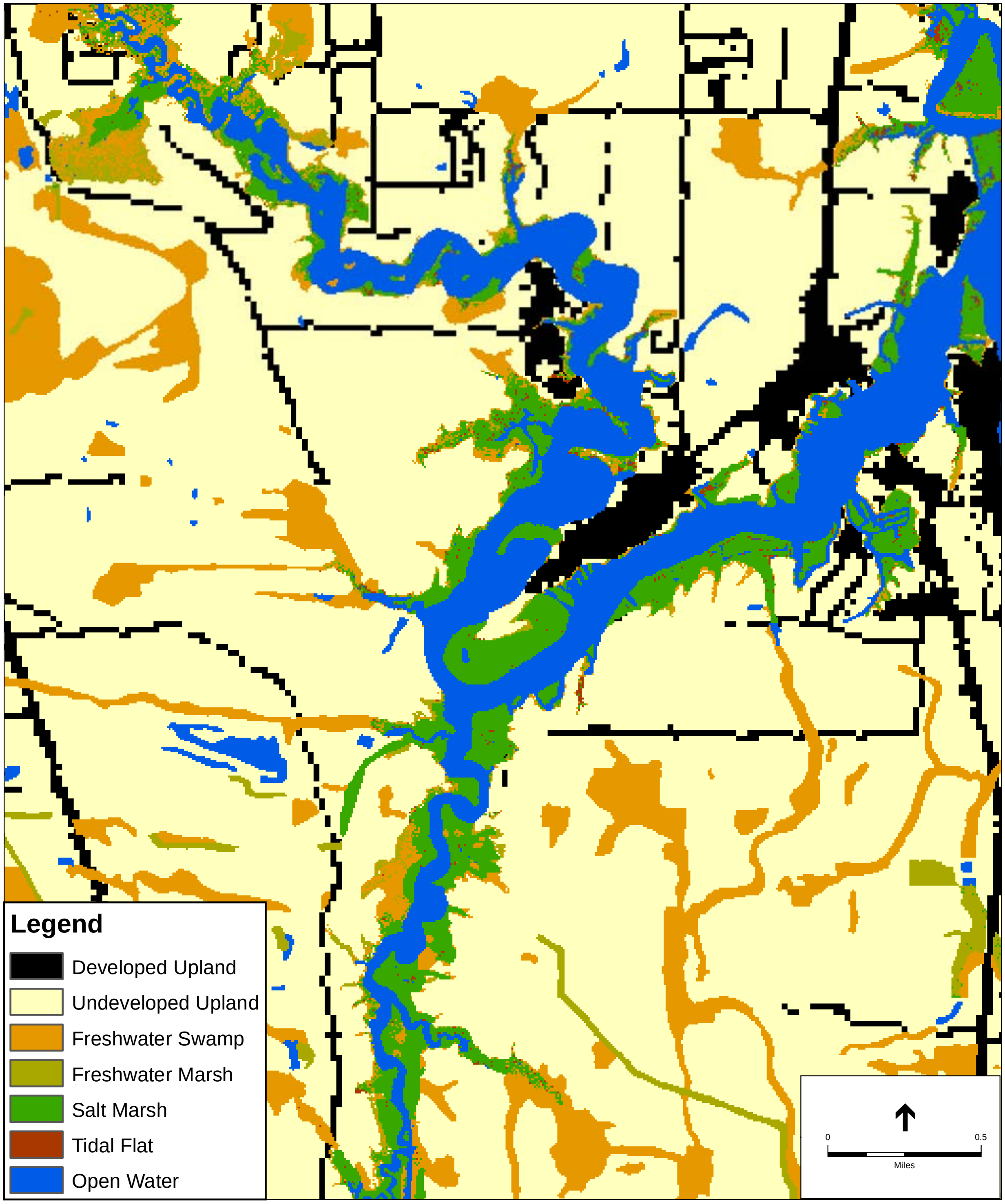
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-8
Run 2, 2050

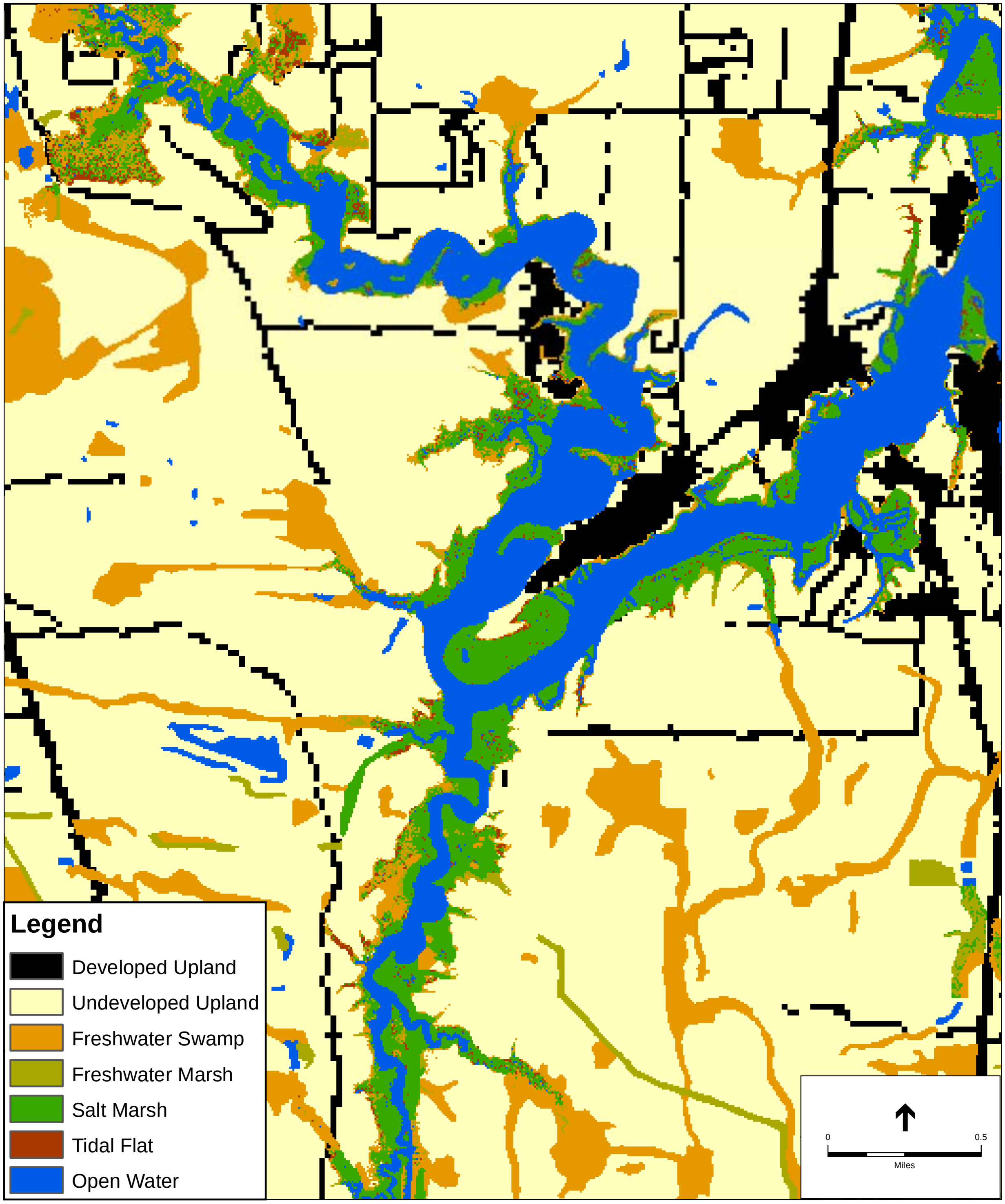
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-9
Run 2, 2070

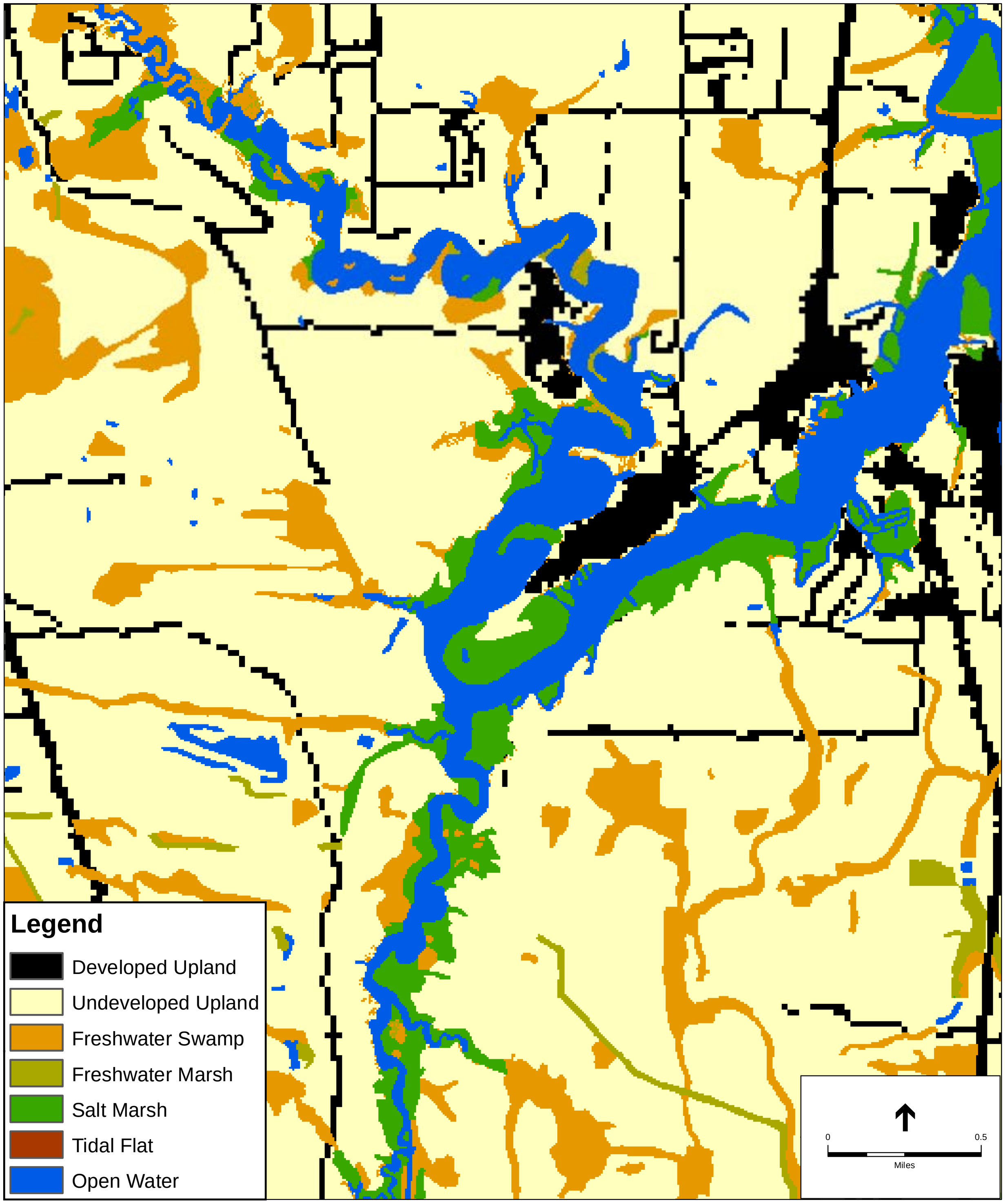
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-10
Run 2, 2100

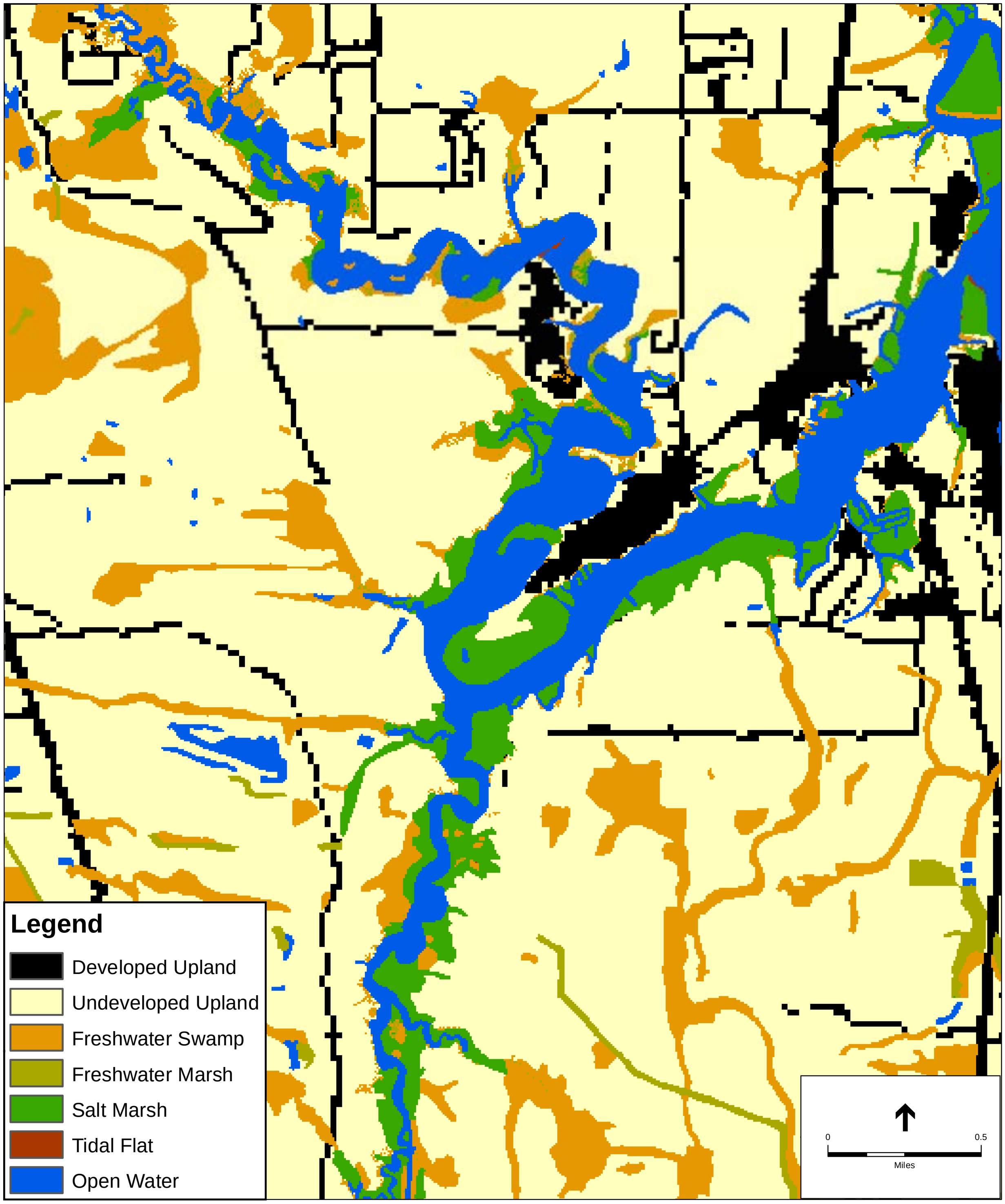
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-11
Run 3, 2002

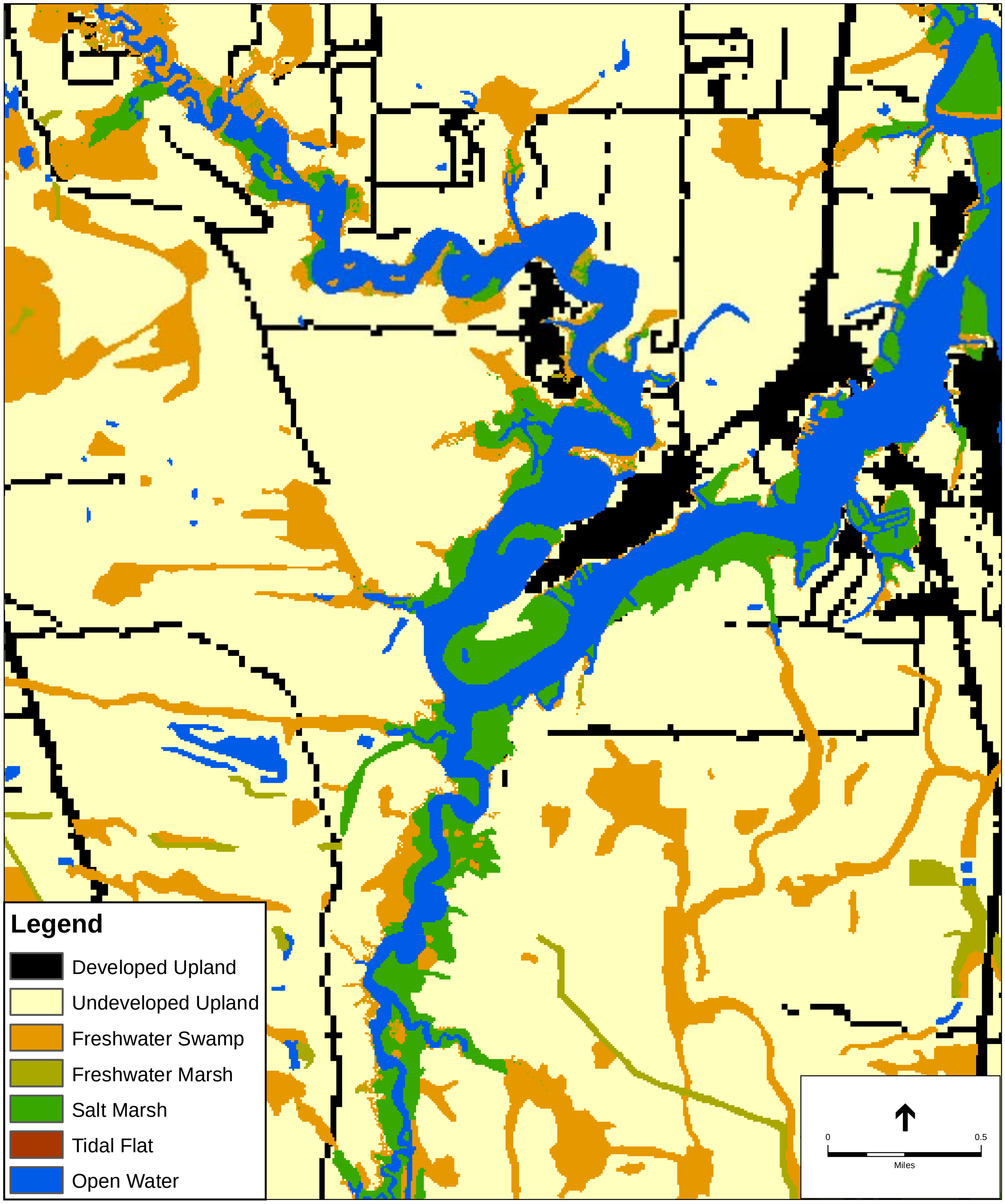
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-12
Run 3, 2030

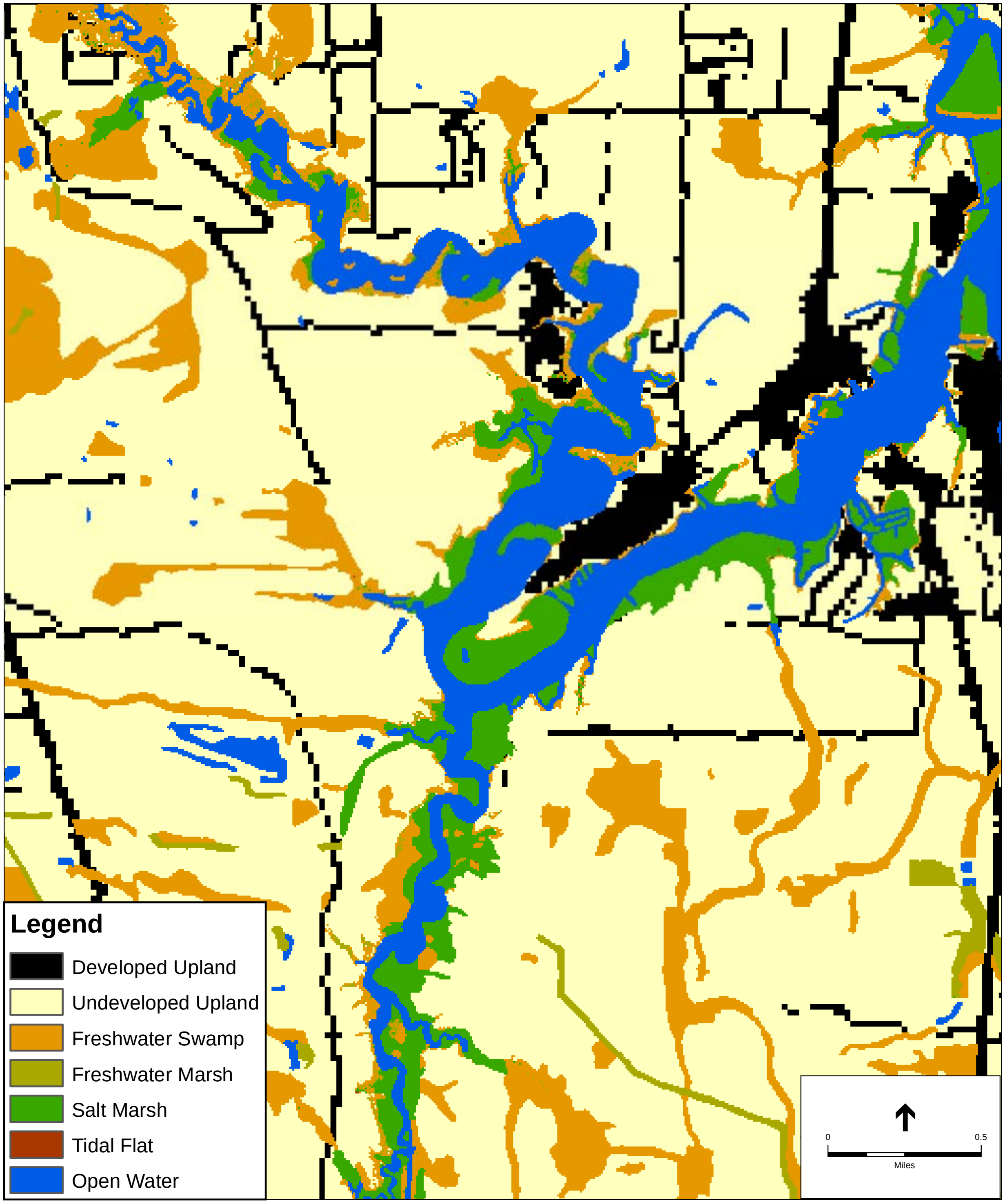
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-13
Run 3, 2050

Habitat Maps



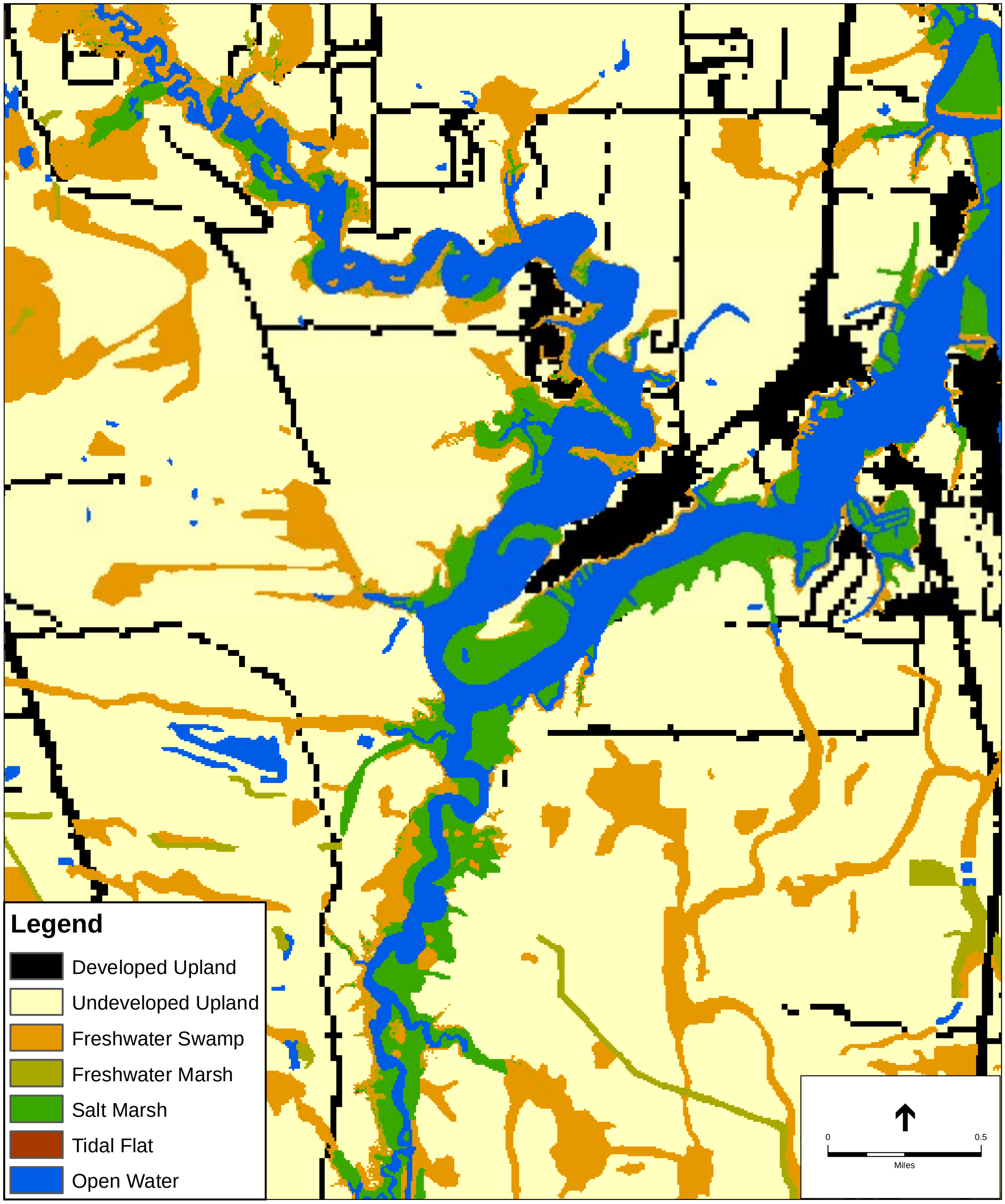
SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553

Figure B-14

Run 3, 2070

Habitat Maps



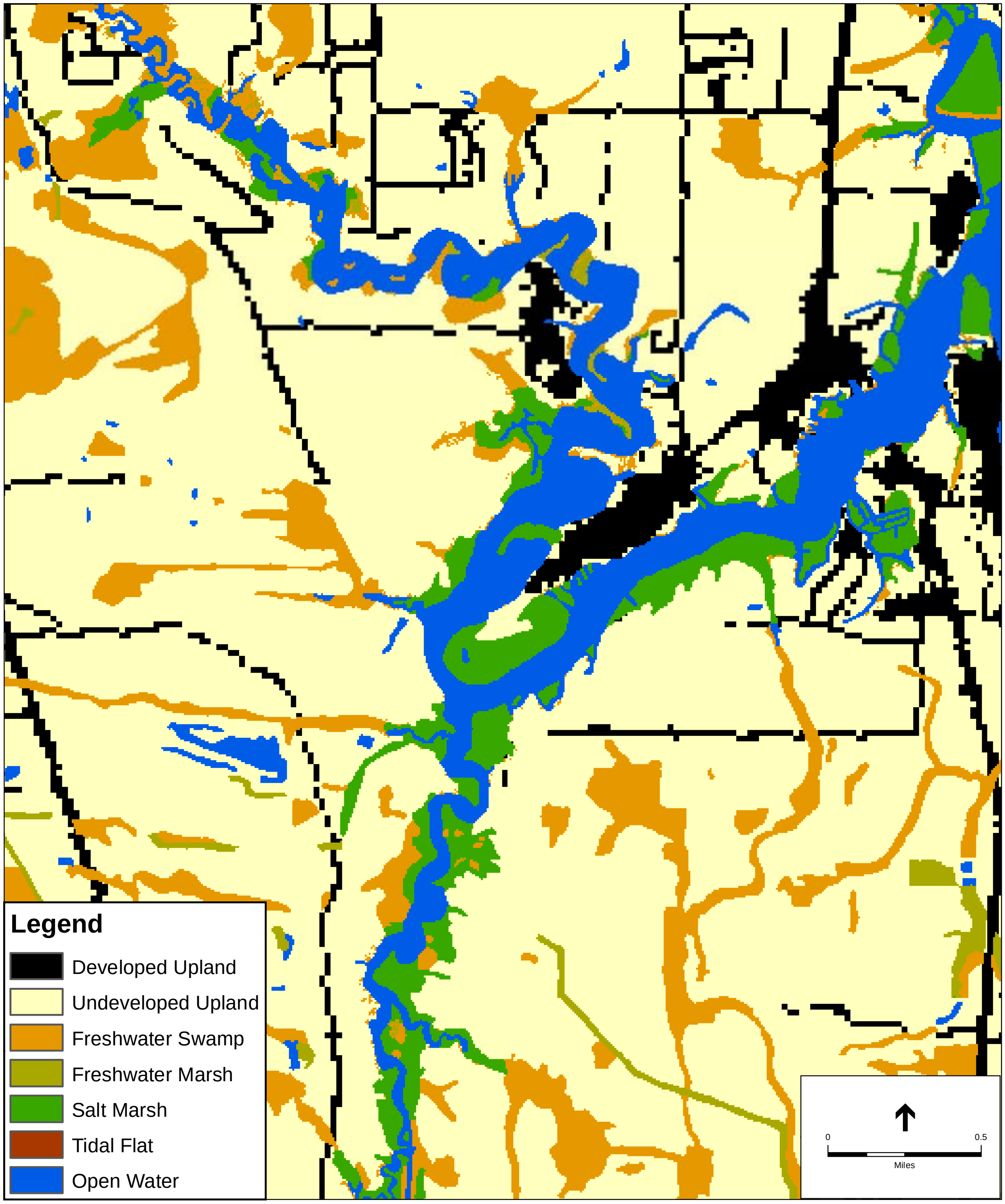
SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553

Figure B-15

Run 3, 2100

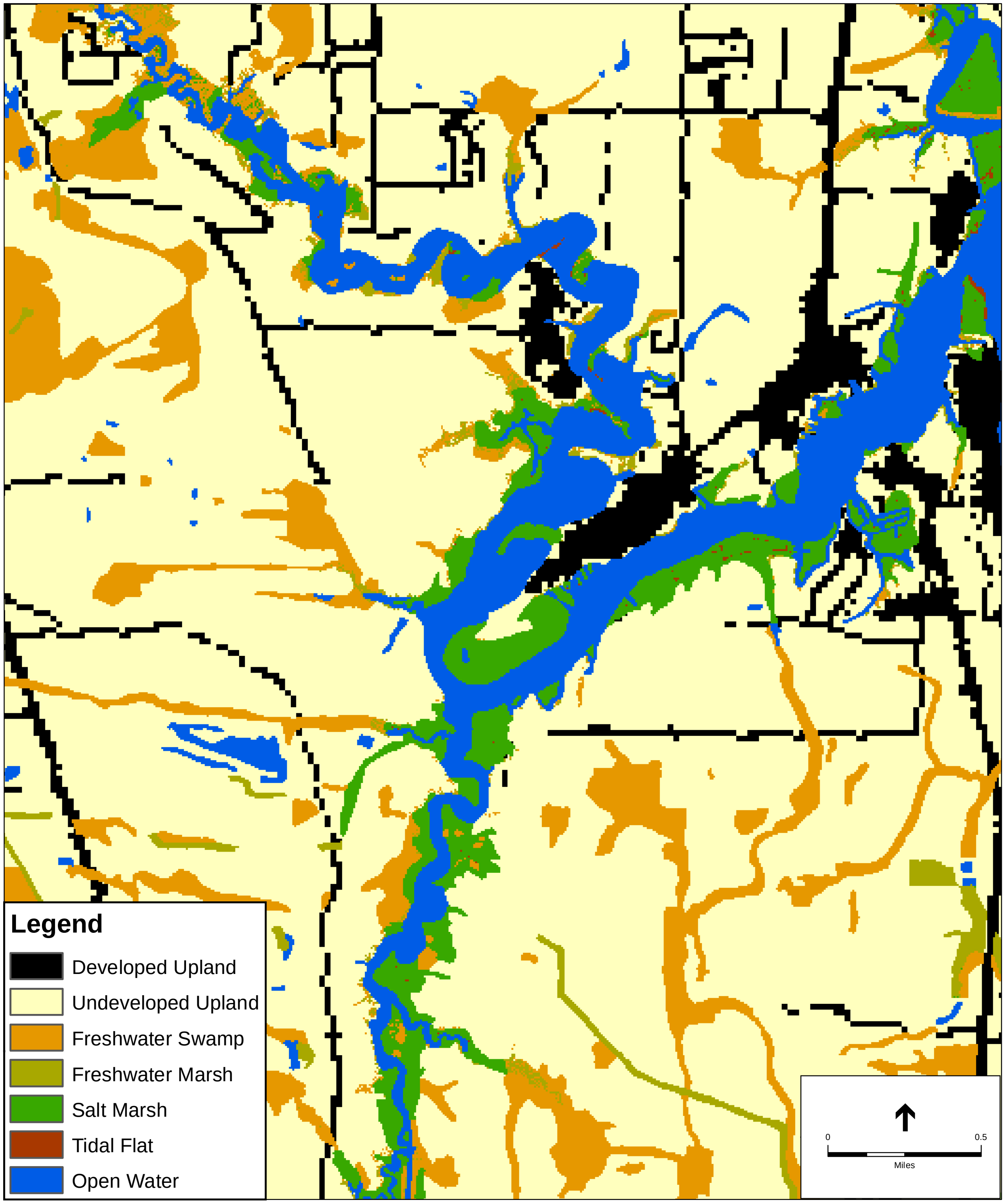
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-16
Run 4, 2002

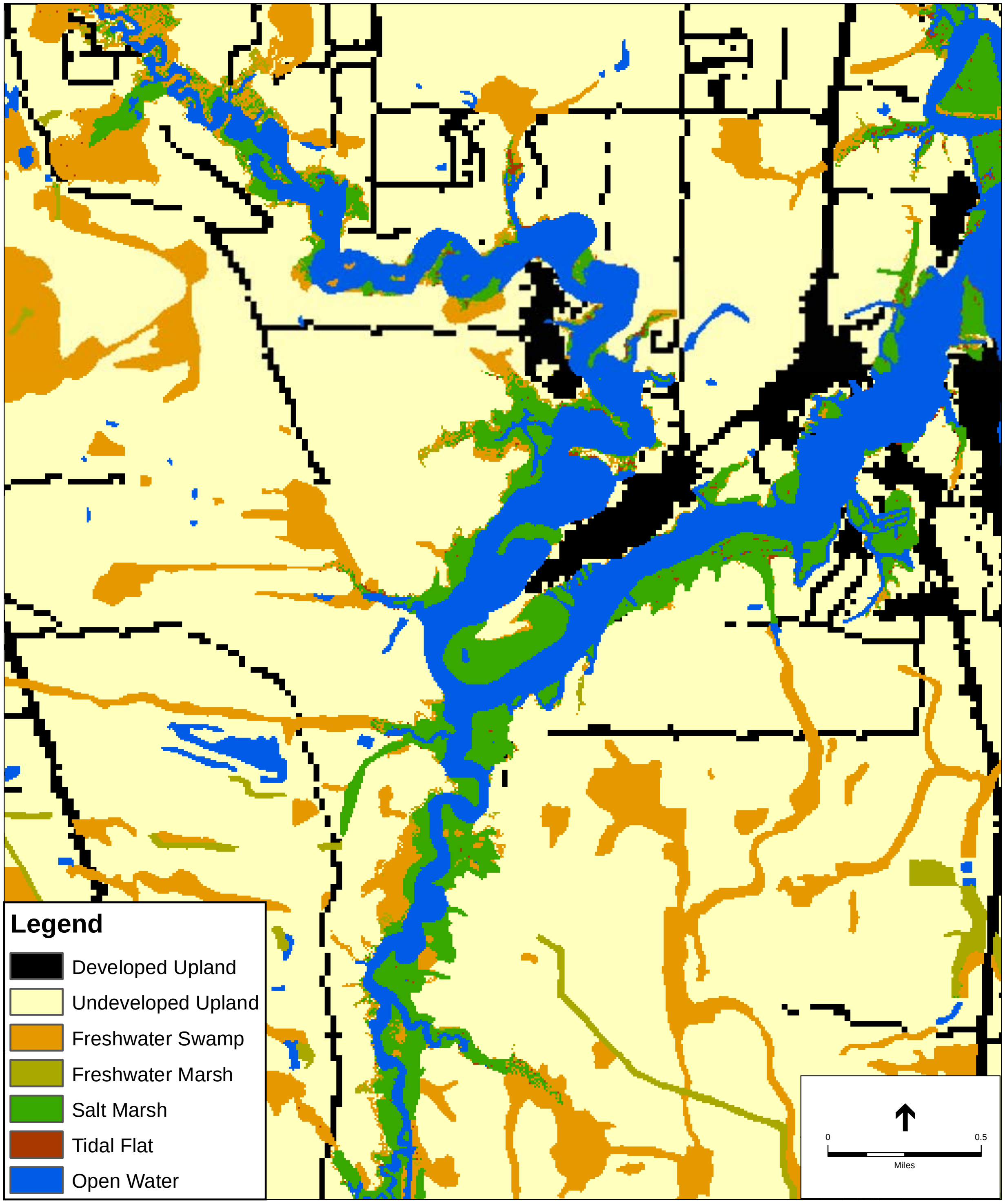
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-17
Run 4, 2030

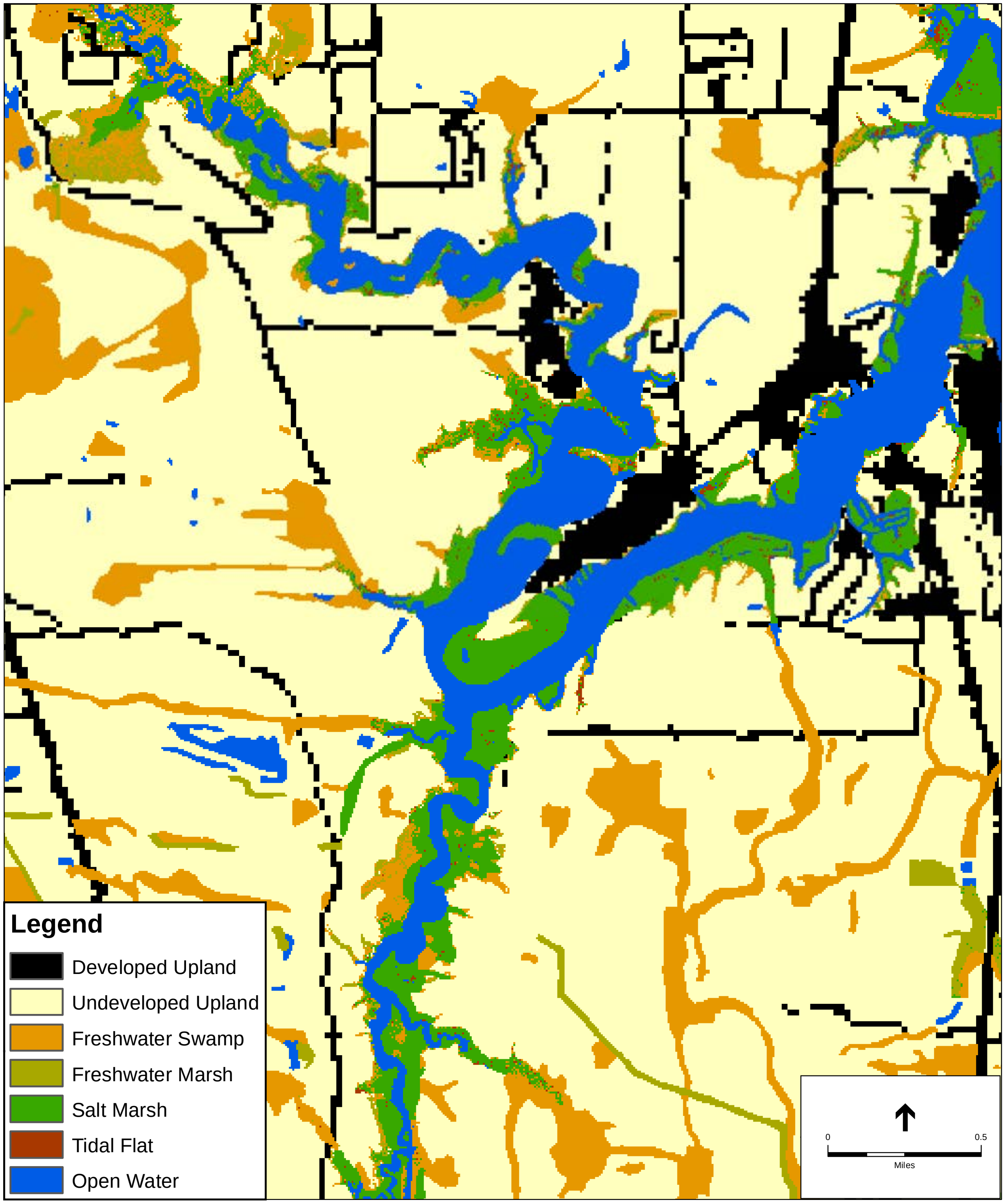
Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-18
Run 4, 2050

Habitat Maps



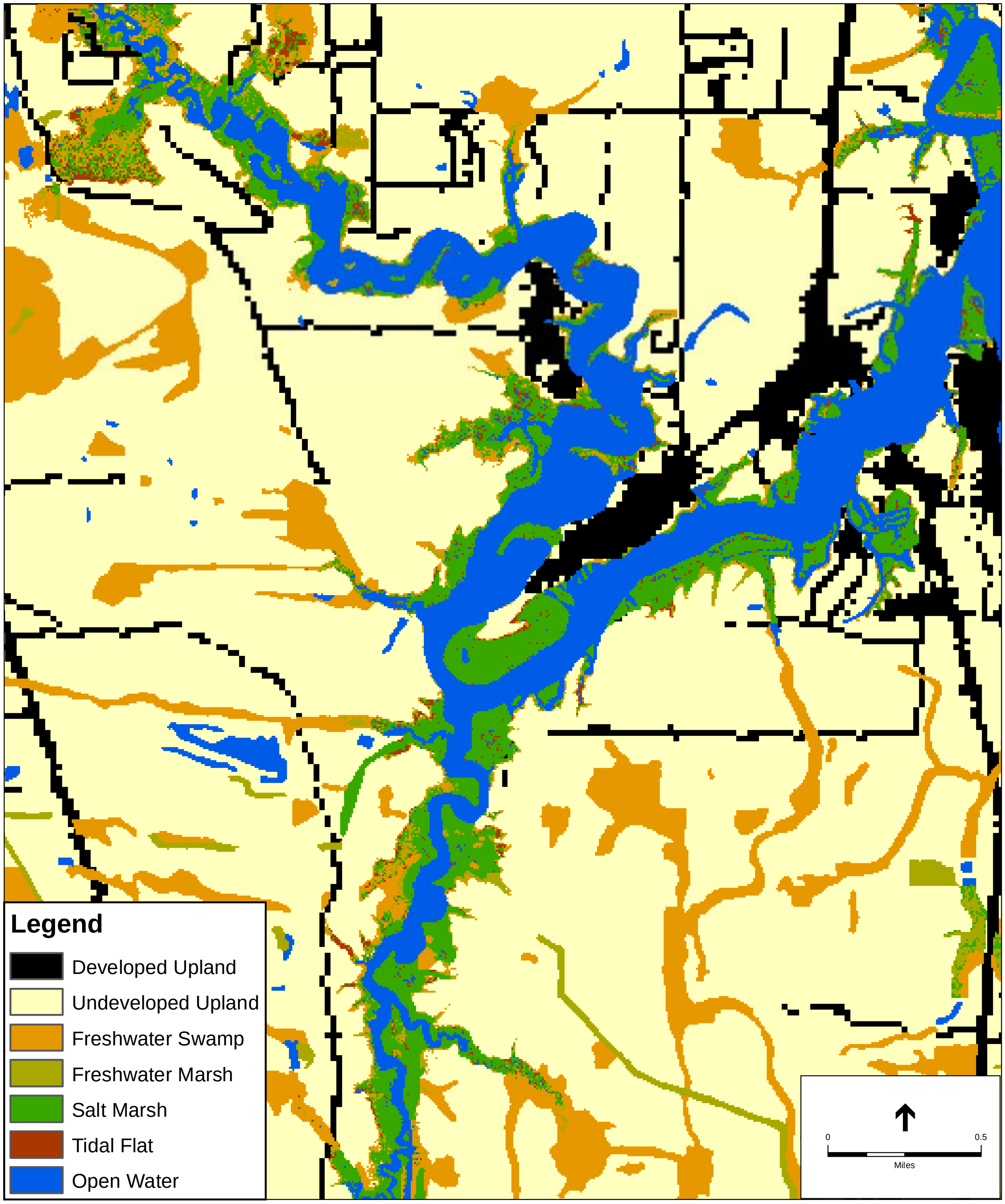
SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553

Figure B-19

Run 4, 2070

Habitat Maps



SOURCE: USACE 2005, Mobile County 2002

Fowl River. D140553
Figure B-20
Run 4, 2100

APPENDIX C
PLOAD Modeling

C. PLOAD MODELING

C.1 WATERSHED MODELING

Watershed and water quality models are essential planning tools for evaluating potential future conditions and the impact of management alternatives in a watershed. There exists a wide range of models based on their complexity, modeled processes and constituents, and spatial and temporal detail. The evaluation tool chosen for use in the assessment area is the Pollutant Loading (PLOAD) model which was run using the BASINS environmental analysis interface developed by the U.S. Environmental Protection Agency (EPA 2013). This interface accesses national environmental data and can incorporate local site-specific data, as well as user-defined inputs. The tool is a simple, screening-level model that can provide estimates of nonpoint source pollutant loading on an annual average basis. This tool will allow for an evaluation of the relative magnitude of change in pollutant loading associated with future land use scenarios. In addition, results can be used to target management measures to those areas with the highest existing and/or future pollutant loading.

C.1.1 Model Description

The PLOAD tool allows for analysis based on one of two empirical approaches: the Simple Method (Schueler, 1987) or export coefficient method. The former method, chosen for the present study, estimates pollutant load as a product of annual runoff volume and pollutant concentration in aggregate for a given watershed area. Runoff volume is calculated from annual rainfall and runoff coefficients based on its relationship to watershed imperviousness. Pollutant concentrations are typically estimated from local and regional data.

As with all modeling approaches, there are limitations that should be considered when evaluating results from the PLOAD model analysis. Its purpose is to provide a general planning estimate of likely pollutant export from delineated regions of a watershed. This model is appropriate for assessing and comparing the changes in relative stormflow pollutant loads from various land use scenarios. The error associated with predicting actual pollutant loads and concentrations using the tool is unknown and could be considerable. Additional limitations of the PLOAD model and the Simple Method are provided below:

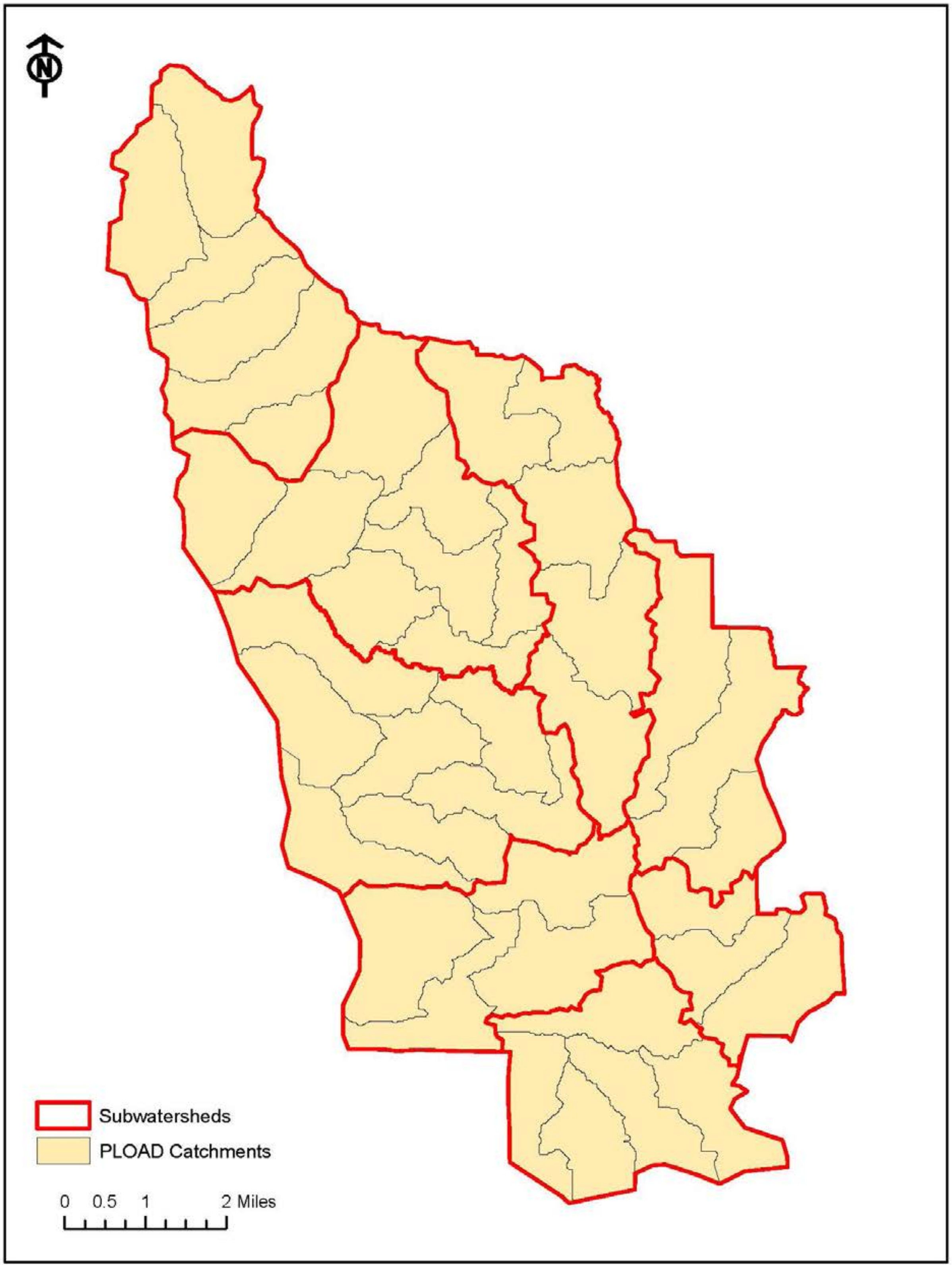
- Baseflow contributions to pollutant loading are not considered.
- Instream transport and transformations are not incorporated.
- The model cannot predict loading on short time intervals.
- As a screening tool, the model is not formally calibrated to local, observed data.

C.1.2 Model Setup

Since the Simple Method was developed for application to small drainage areas of approximately one square mile, the assessment area was segmented into 41 catchments with an average size of 1.5 square miles. The catchments form the basis on which the model is applied and results are given (see **Figure C.1**).

The model uses a value of average annual precipitation based on the 29 years of record at the Mobile Regional Airport (55.15 inches) and the Mobile Downtown Airport (65.28) weather stations. The average of the two sites, 65.715 inches, was used for the model). No point sources were included in the model as there are no facilities in the Watershed that are currently permitted to discharge wastewater. Additional parameters and input data developed include land use, impervious factors, and event mean concentrations (EMC). Development of these data inputs is described in the following sections.

FIGURE C.1: FOWL RIVER SUB-WATERSHEDS AND PLOAD CATCHMENTS



C.1.3 Land Use Land Cover

Land use and land cover (LULC) is an important aspect of a watershed assessment as it can be used to determine areas that may have impaired watershed function and where preservation may be useful. Two LULC scenarios were used to investigate existing pollutant loads and the effects of future land use development on pollutant loads in the Watershed.

Existing Land Use/Land Cover

The National Land Cover Database (NLCD) 2011 was used to represent existing LULC in the Watershed. This database is the most recent national land cover dataset created by the Multi-Resolution Land Characteristics Consortium (MRLC). This dataset uses several pre-defined developed and undeveloped LULC types **(Table C.1).** Undeveloped LULC types within the Watershed include: open water; barren land; deciduous, evergreen and mixed forest; scrub/shrub; grassland; pasture/hay; cropland; and woody and emergent wetlands. Developed LULC types include developed open space and low-, medium-, and high-density development.

TABLE C.1: NLCD LAND COVER CATEGORIES

Land Cover Category	Description
Open Water	Areas of open water
Developed, open space	Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Examples include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
Developed, low intensity	Areas with a mixture of constructed materials and vegetation. These areas usually include single-family housing units.
Developed, medium intensity	Areas with a mixture of constructed materials and vegetation. These areas usually include single-family housing units.
Developed, high intensity	Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial.
Barren land	Areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover
Deciduous forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simulta-neously in response to seasonal change.
Evergreen forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cov-er. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
Shrub/scrub	Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Herbaceous	Areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Hay/pasture	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
Cultivated crops	Areas used for the production of annual crops, such as corn, soybeans, vegeta-bles, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
Woody wetlands	Areas where forest or shrubland vegetation accounts for greater than 20% of vege-tative cover and the soil or substrate is periodically saturated with or covered with water.
Emergent herbaceous wetland	Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water

C. PLOAD MODELING

Class\ Value	Classification Description
Water	
11	**Open Water** - areas of open water, generally with less than 25% cover of vegetation or soil.
12	**Perennial Ice/Snow** - areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
Developed	
21	**Developed, Open Space** - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22	**Developed, Low Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
23	**Developed, Medium Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
24	**Developed High Intensity** -highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
Barren	
31	**Barren Land (Rock/Sand/Clay)** - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
Forest	
41	**Deciduous Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
42	**Evergreen Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
43	**Mixed Forest** - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
Shrubland	
52	**Shrub/Scrub** - areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Herbaceous	
71	**Grassland/Herbaceous** - areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Planted/ Cultivated	
81	**Pasture/Hay** – areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
82	**Cultivated Crops** – areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
Wetlands	
90	**Woody Wetlands** - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
95	**Emergent Herbaceous Wetlands** - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

C. PLOAD MODELING

Future Land Use/Land Cover

Future LULC datasets were developed previously for the Mobile Bay Watershed (Estes et al. 2009, Estes, 2012). Researchers used the Prescott Spatial Growth Model (PSGM), an Arc GIS compatible application, to develop a future LULC scenario based on observed trends in socio-economic data. The model allocates growth to available (undeveloped) land based on user-defined parameters. Estes et al. utilized the 2001 NLCD layer as a base and growth projections to quantify the demand for undeveloped land uses to produce a future LULC scenario for 2030 for the Mobile Bay Watershed.

The 2030 future LULC layer was updated for the Fowl River Watershed for use in the PLOAD model. Updates were based on the more recent 2011 NLCD used for the existing condition model. Land that appeared as developed in the 2030 future layer was added to the 2011 NLCD layer if it appeared as undeveloped. If it was already developed in the 2011 NLCD layer, the category was not changed. In those instances, it was assumed that the existing developed land use would remain instead of being redeveloped. In a rural watershed, growth on undeveloped land is more likely than re-development. Re-development often occurs in more urban areas where undeveloped land is scarce.

C.1.4 Impervious Cover Factors and Runoff Coefficients

The method used to calculate pollutant loading in PLOAD requires specification of assumed impervious factors for each land use. The impervious factor is subsequently used to calculate a runoff coefficient (see Equation 1), which when applied to a rainfall volume yields a corresponding runoff volume (see Equation 2). The impervious factors for each land use category used in the model are presented in **Table C.2.**

Equation 1: $Rv = 0.05 + 0.9\ Ia$

Equation 2: $R = P * Pj * Rv$

R = annual runoff (in)
P = annual rainfall (in)
Pj = Fraction of annual rainfall events that produce runoff
Rv = Runoff coefficient
Ia = Impervious fraction

Impervious factors were selected based on the 2011 NLCD literature which contains a range for each of the developed categories. The remaining land cover categories were given an average impervious cover level of zero percent.

TABLE C.2: IMPERVIOUS COVER FACTORS USED TO CALCULATE RUNOFF COEFFICIENTS IN PLOAD

	Range of Percent Impervious*	Average Percent Impervious Cover
Land Use Category		
Developed, open space	<20%	10
Developed, low intensity	20-49%	35
Developed, medium intensity	50-79%	60
Developed, high intensity	80-100%	90

C. PLOAD MODELING

C.1.5 Event Mean Concentrations

The PLOAD model calculates annual pollutant loads based on runoff and pollutant EMC for each land use. EMCs represent the average concentration of a pollutant in stormwater runoff and is usually reported in mass per unit volume (mg/l). Many factors may affect EMC values including land use, annual rainfall, percent imperviousness, season, watershed size, and storm event size. Appropriate selection of EMC values is an important step in development of the model application.

Regional differences in EMCs are largely determined by the amount and frequency of rainfall. Pitt et al. (2005) reporting on findings from the National Stormwater Quality Database (NSQD) found that residential areas located in the wettest parts of the country such as the Southeast appear to have lower EMCs for many stormwater pollutants. The result most likely stems from the reduced time between rainfall events allowing for less accumulation of pollutants on impervious surfaces which then become available for washoff during the next storm event. Regression analyses by Driver (1988) and Maestre and Pitt (2005) have supported similar conclusions. Driver (1988) found that annual rainfall depth was the best overall predictor of stormwater EMCs.

The relative impact of land use and imperviousness is less clear. The National Urban Runoff Program (NURP) findings showed no significant differences in urban runoff concentrations as a function of common urban land uses (USEPA, 1983). Maestre and Pitt (2005) conducted a statistical analysis of data from the NSQD. The NSQD includes data from around the country, however sufficient data for the study were only found within EPA Rain Zone 2 which includes North Carolina, Viriginia, Maryland, Tennessee, Kentucky, and West Virginia. They found that only nitrate-nitrite exhibited a significant regression relationship (negative) with percent imperviousness in residential land use categories. A lack of data in the study prevented a full analysis for commercial and industrial land uses.

EMCs selected for the present study are derived based on a number of literature sources **(see Tables 3 through 6)**. Climate and physiographic characteristics contribute to high variability in nutrient export from both urban and agricultural watersheds (Beaulac and Reckhow, 1982). In undeveloped watersheds of the southeast, background concentrations of nitrogen (0.5 to 1.0 mg/l) are controlled predominately by atmospheric deposition, whereas phosphorus concentrations (0.014 to 0.037 mg/l) appear to be controlled by rates of organic decomposition and mineral weathering (Clark et al., 2000).

EMC values for nitrogen and phosphorus by land use are presented in **Tables E.6 and E.7.** Studies focus on states in the southern United Stated although a few national studies are included due to a lack of readily available data.

Nitrogen values for residential land uses fell between 1.2 and 3.2 mg/l, while phosphorus EMCs ranged from 0.2 to 0.7 mg/l. Nonresidential development fell in about the same range. Final selection was based on an average of the values. The lowest selected values were for forested land use: 0.2 mg/l TP and 1.3 mg/L TN. Barren, pasture land, and row crop agriculture had the highest nutrient concentrations. Values selected for these rural land uses were based on compressing the range of average values.

Literature estimates of EMCs for (TSS) exhibit a higher level of variability than do nutrients **(Table E.8)**. Using only regional values and excluding the high values from Driver (1988) and CDM (1993) compresses the range considerably. Therefore the selected values for the residential and office/light industrial land uses are based on the average of the regional values excluding Driver (1988) and CDM (1993). A further reduction was used for the other land uses in order to compress the range slightly.

TABLE C.3: LITERATURE REVIEW OF TOTAL NITROGEN EMC VALUES (MG/L)

Source	Location	Low Density Res	Medium Density Res	High Density Res	Office & Light Industrial	Commercial & Heavy Industrial	Road	Forest	Pasture	Row Crop	Managed Open Space
NURP (1983)	US	2.64	2.64	2.64		1.75		1.51			
Smullen and Cave (1998)	US	2.00	2.00	2.00		2.00		2.00			
Schueler (1987)	US	2.20	2.20	2.20		2.25	3.00	0.78			
Pitt et al. (2004)	US			2.00	2.04	2.20	2.28				1.33
Driscoll et al. (1990)	US						2.14				
Driver (1988)	Region 3	2.15	2.15	2.15							
CDM (1993)	GA	3.05	2.06	1.93	2.25	3.15		0.71			
Baird et al. (1996)	TX	1.82	1.82	1.82	1.26	1.34	1.86	1.50		4.40	
Harper (1994)	FL	1.77	2.29	2.42		1.93	2.08	1.60	2.48	2.68	1.25
Pitt et al. (2004)	EPA Rain Zone 3	1.60	1.60	1.60	1.24	1.55					
Pitt et al. (2004)	EPA Zone 2	1.97	1.97	1.97	1.95	2.18					2.19
Wu et al. (1998)	NC						1.14				
Line et al. (2002)	NC		1.97			1.30		1.47	3.61		
Hunt and Lucas (2003) [1]	NC	1.65	2.02	1.61	2.02	2.09		1.05			
Tetra Tech (2005) [2]	NC-Neuse					3.48	3.48	1.45	2.59	2.59	6.23
Tetra Tech (2004) [2]	NC-Cary	3.00	2.30	2.00	2.10	3.50		1.50			
Bales et al. (1999)	NC- Meckleburg		2.10		1.10	1.60					
CH2M HILL (2000) [3]	NC	1.20	1.70	2.70	2.40	3.10	3.30	1.10	1.10	1.10	1.10

All values are medians unless otherwise noted. 1 - Mean value 2 - Literature review 3 - Regression analysis

TABLE C.4: LITERATURE REVIEW OF TOTAL PHOSPHORUS EMC VALUES (MG/L)

Source	Location	Low Density Res	Medium Density Res	High Density Res	Office & Light Industrial	Commercial & Heavy Industrial	Road	Forest	Pasture	Row Crop	Managed Open Space
NURP (1983)	US	0.38	0.38	0.38		0.20		0.12			
Smullen and Cave (1998)	US	0.26	0.26	0.26		0.26	0.26				
Schueler (1987)	US	0.40	0.40	0.40		0.30	0.50	0.15			
Pitt et al. (2004)	US			0.30	0.22	0.22	0.25				0.31
Driscoll et al. (1990)	US						0.29				
Driver (1988)	Region 3	0.31	0.31	0.31							
CDM (1993)	GA	0.67	0.47	0.19	0.17	0.45					
Baird et al. (1996)	TX	0.57	0.57	0.57	0.28	0.32	0.22	0.12		1.3	
Harper (1994)	FL	0.18	0.30	0.49		0.33	0.34	0.19	0.48	0.56	0.05
Pitt et al. (2004)	EPA Rain Zone 3	0.18	0.18	0.18	0.16	0.11					
Pitt et al. (2004)	EPA Zone 2	0.29	0.29	0.29	0.21	0.22					0.15
Wu et al. (1998)	NC						0.37				
Line et al. (2002)	NC		0.40			0.23		0.25	1.56		
Hunt and Lucas (2003) [1]	NC	0.26	0.37	0.24	0.32	0.33		0.17			
Tetra Tech (2005) [2]	NC-Neuse					0.49	0.49	0.25	0.4	0.4	1.13
Tetra Tech (2004) [2]	NC-Cary	0.50	0.40	0.30	0.17	0.50		0.25			
Bales et al. (1999)	NC- Meckleburg		0.29		0.20	0.26					
CH2M HILL (2000) [3]	NC	0.20	0.30	0.40	0.30	0.40	0.40	0.2	0.2	0.2	0.2

All values are medians unless otherwise noted. 1 - Mean value 2 - Literature review 3 - Regression analysis

TABLE C.5: LITERATURE REVIEW OF TOTAL SUSPENDED SOLIDS (TSS) EMC VALUES (MG/L)

Source	Location	Low Density Res	Medium Density Res	High Density Res	Office & Light Industrial	Commercial & Heavy Industrial	Road	Forest	Pasture	Row Crop	Managed Open Space
NURP (1983)	US	101	101	101		69		70			
Smullen and Cave (1998	US	55	55	55		55		55			
Schueler (1987)	US	100	100	100		98	150				
Driscoll et al. (1990)	US						93				
Pitt et al. (2004)	US			49		42	99				11
Driver (1988) [1]	Region III	120	120	120							
CDM (1993)	GA	280	140	109	93	243		216			
Baird et al. (1969)	TX	41	41	41	61	56	74	70		107	
Harper (1994)	FL	19	27	72		90	50	10	94	55	11
Pitt et al. (2004)	EPA Rain Zone 3	41	41	41	66	34					49
Pitt et al. (2004)	EPA Rain Zone 2	43	43	43	37	39					
Wu et al. (1998)	NC						88				
Line et al. (2002)	NC		42		48	170		113	84		150
Hunt and Lucas (2003) [1]	NC										
Tetra Tech (2005) [2]	NC-Neuse					70	70	49	400	400	25
Tetra Tech (2004) [2]	NC-Cary	25	42	75		69		50			
CH2M HILL (2000) [3]	NC	22	52	48	42	54	58	20	19	19	20

All values are medians unless otherwise noted. 1 - Mean value 2 - Literature review 3 - Regression analysis

TABLE C.6: SELECTED EMC VALUES FOR MODEL LAND USE CATEGORIES

Land Use Category	TN (mg/L)	TP (mg/L)	TSS (mg/L)
Open Water	0.50	0.20	10.0
Developed, open space	2.00	0.40	32.0
Developed, low intensity	2.00	0.30	53.0
Developed, medium intensity	2.00	0.30	53.0
Developed, high intensity	2.30	0.30	60.0
Barren land	2.70	0.60	100.0
Deciduous forest	1.30	0.20	40.0
Evergreen forest	1.30	0.20	40.0
Mixed forest	1.30	0.20	40.0
Shrub/scrub	1.30	0.20	40.0
Herbaceous	1.30	0.20	40.0
Hay/pasture	2.70	0.70	80.0
Cultivated crops	2.70	0.60	100.0
Woody wetlands	1.30	0.20	40.0
Emergent herbaceous wetland	1.30	0.20	40.0

C.1.6 Results

The results of the PLOAD model are summarized in **Figures C.2 - C.4**. These bar charts show the pollutant loads associated with existing land use conditions as well as the future land use conditions. Model results predict an increase in pollutant loads over the whole Watershed of 30 percent for TN, 28 percent for TP, and 22 percent for TSS between existing and future.

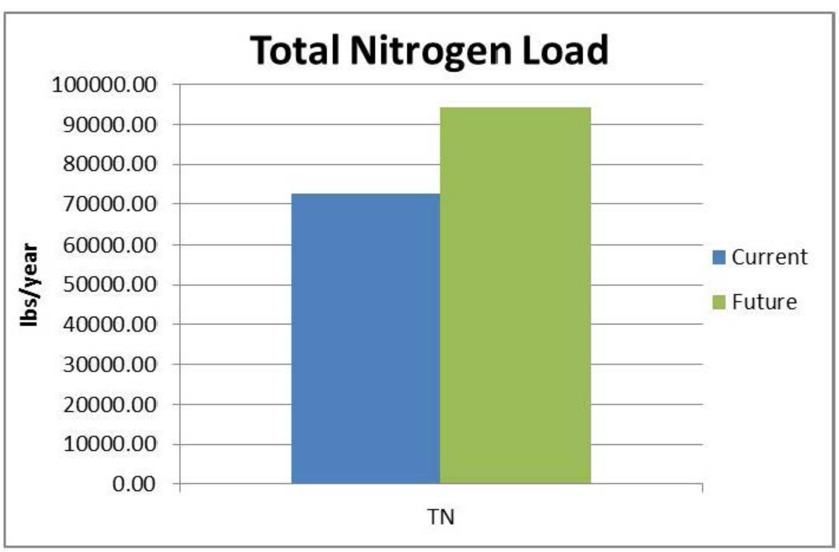


Figure C.2: Annual average current & future loadings of nitrogen totaled over assessment area

C. PLOAD MODELING

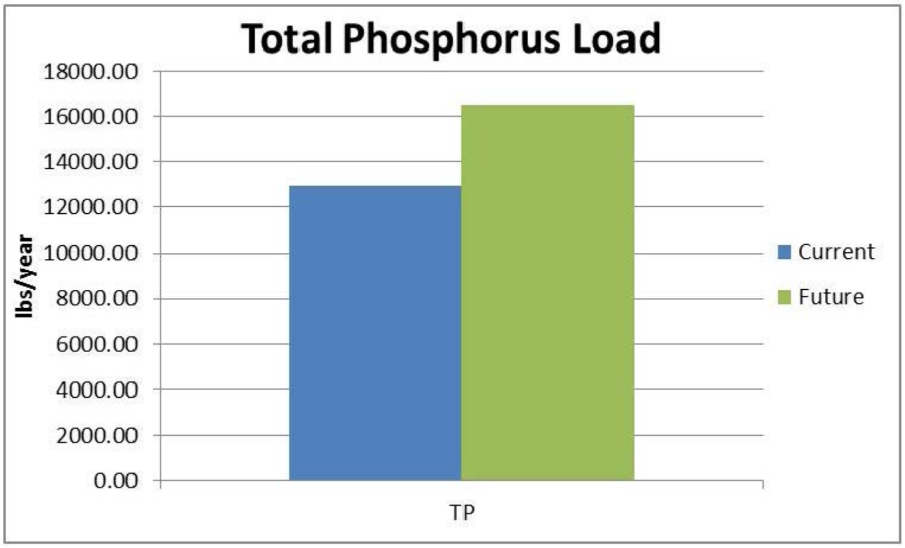


Figure C.3: Annual average current and future loadings of phosphorus totaled over the assessment area

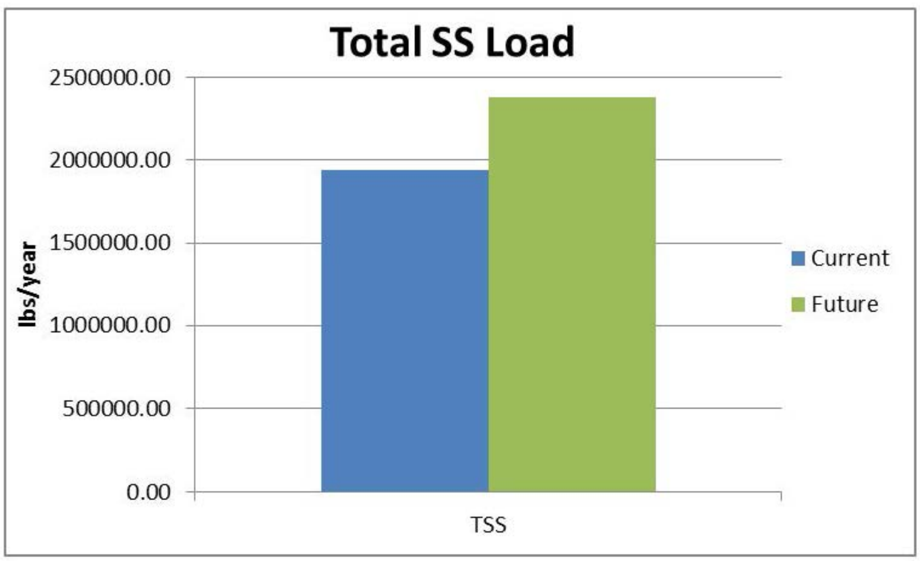


Figure C.4: Annual average current and future loadings of total suspended solids totaled over the assessment area

C. PLOAD MODELING

In addition to looking at the Watershed as a whole, PLOAD breaks down the existing and future condition results by catchment. As described in the model setup, 41 catchments were created within the Fowl River Watershed.

Mapping the PLOAD model results by catchment indicate which catchments currently have high pollutant loads, where pollutant loads increase in the future, and where loads are low and conditions will stay relatively the same (see **Figures C.5 - C.10**). This information combined with results from other data collected during the course of this watershed assessment can help inform where preservation and restoration activities should occur. It can also be used to help prioritize watershed projects.

The community of Theodore, located in the northeastern portion of the Watershed has the highest loading rates (catchments 15 and 16) in the existing condition that remain the highest in the future as well. This area is characterized by residential neighborhoods as well as institutional and commercial land use. While the catchments in Thoedore continue to have the highest loading rates in the future, the increase is minor compared to the growth experienced in other catchments. This is likely a result of existing high density development

The northern portion of the Watershed had somewhat high loading rates in the existing condition (catchments 1, 4, 5, and 7) as well as areas along of Laurendine Road/Half Mile Road (catchments 13 and 21) where residential neighborhoods are located. The northern portion of the Watershed is predicted to experience new development which will lead to even higher loading rates in the future condition. Other areas in the northern portion had moderate loading rates in the existing condition and are predicted to experience sufficient development to have high loading rates in the future condition. (catchments 2, 3, 8, and 9).

The areas along Laurendine Road are predicted to experience some development which will lead to an increase in loading rate in more areas than identified in the existing condition (13 and 21 plus 20 in the future).

Pollutant loads in the existing and future condition are relatively low in almost all of the catchments south of Laurendine Road/Half Mile Road and along the mainstem of Fowl River south of US Highway 90 (23 of the 41 catchments).

One exception, in the southern portion of the Watershed, only one catchment has a somewhat high loading rate in the existing condition (32). This single catchment is predicted to continue to see an increase in development and have a high future condition loading rate.

In addition, an increase in development in the eastern edge of the Watershed along the main stem of Fowl River will lead to an increase in loading rates from low in the existing condition to high in the future (catchments 28, 29, 40 and 41).

In conclusion, the areas with high existing condition loading rates are generally located north of Laurendine Road/Half Mile Road while areas with low loading rates are found to the south. This loading pattern generally continues in the future condition as most of the development and additional loading occurs in the north with the exception of new growth in the northeast.

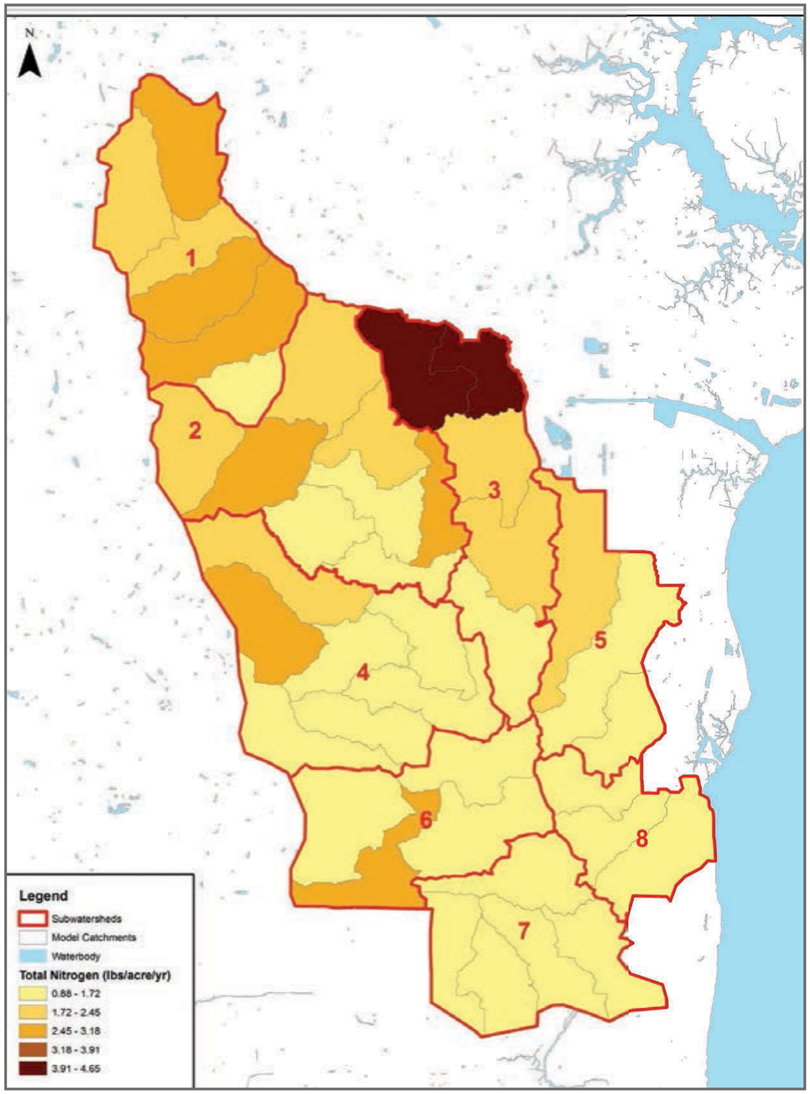


Figure C.5: Total Nitrogen Loading Rate - Existing Condition

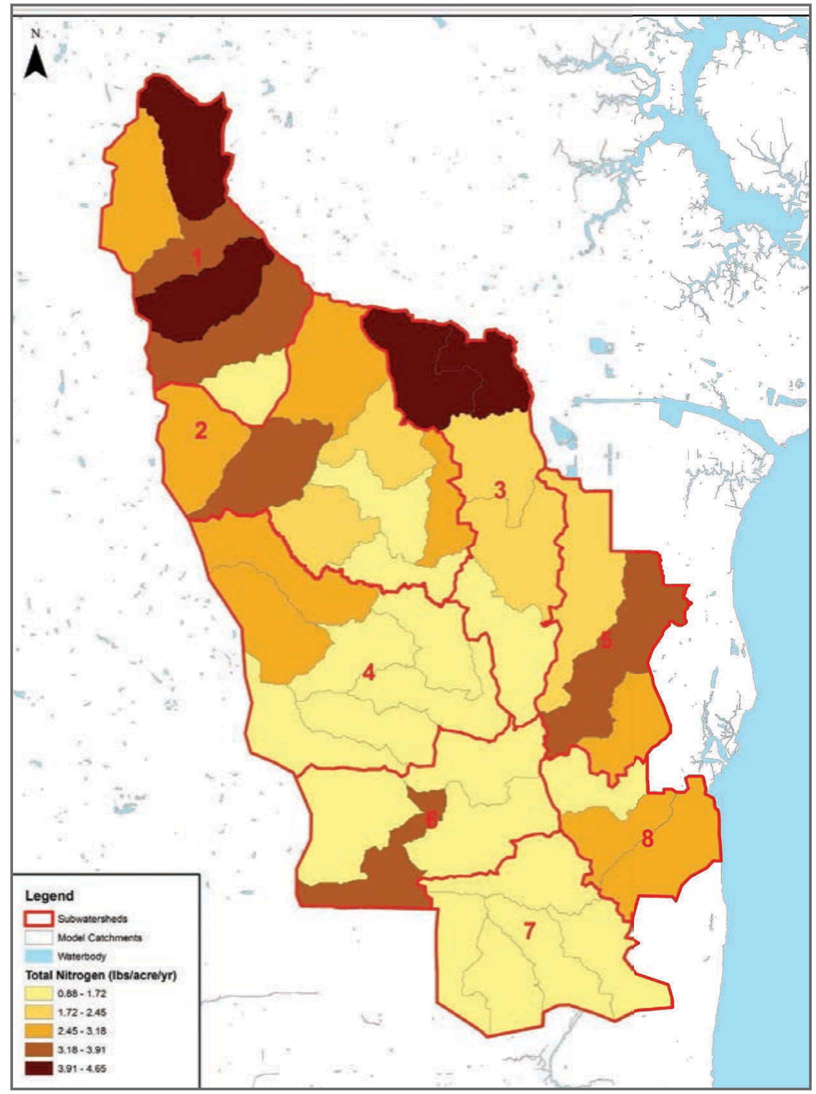


Figure C.6: Total Nitrogen Loading Rate - Future Condition

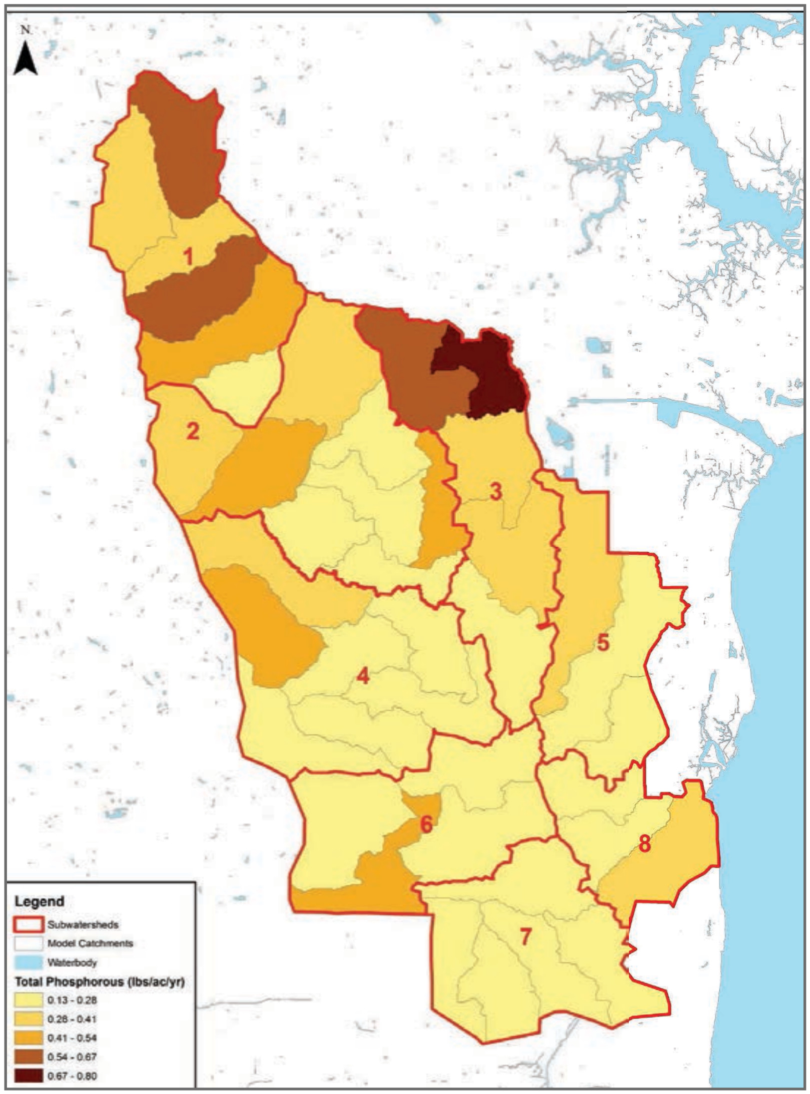


Figure C.7: Total Phosphorous Loading Rate - Existing Condition

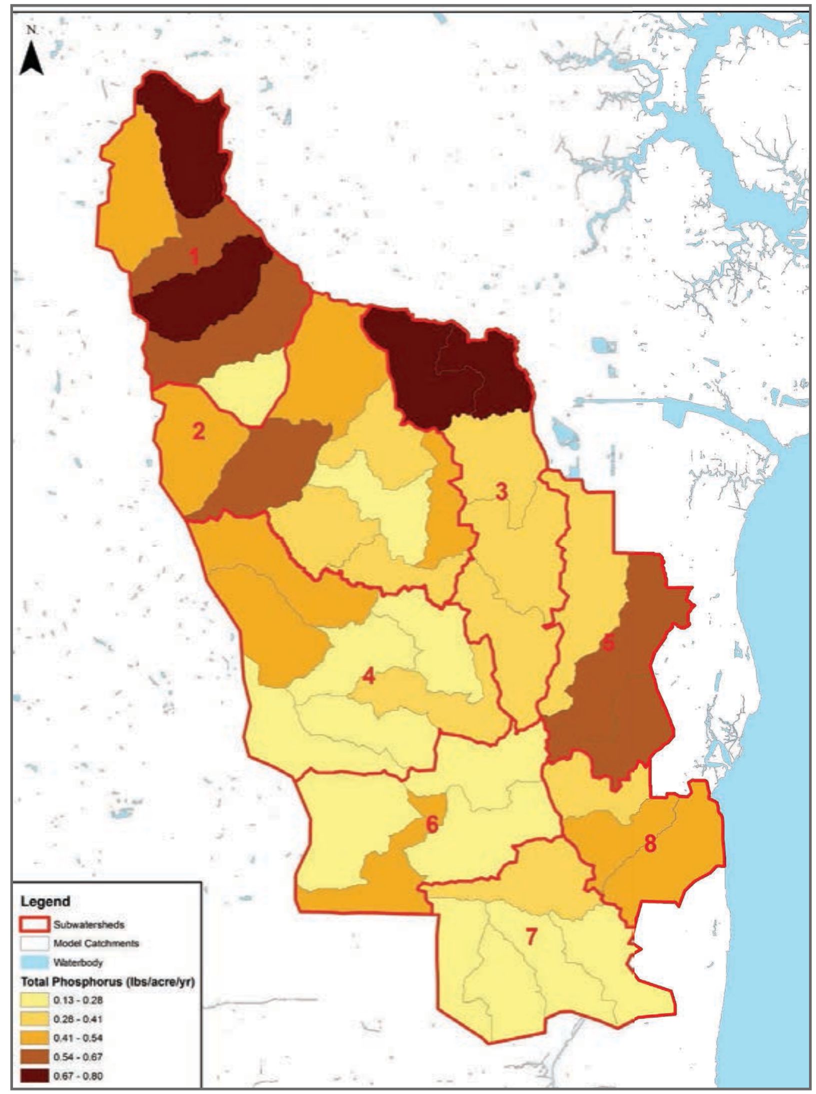


Figure C.8: Total Phosphorous Loading Rate - Future Condition

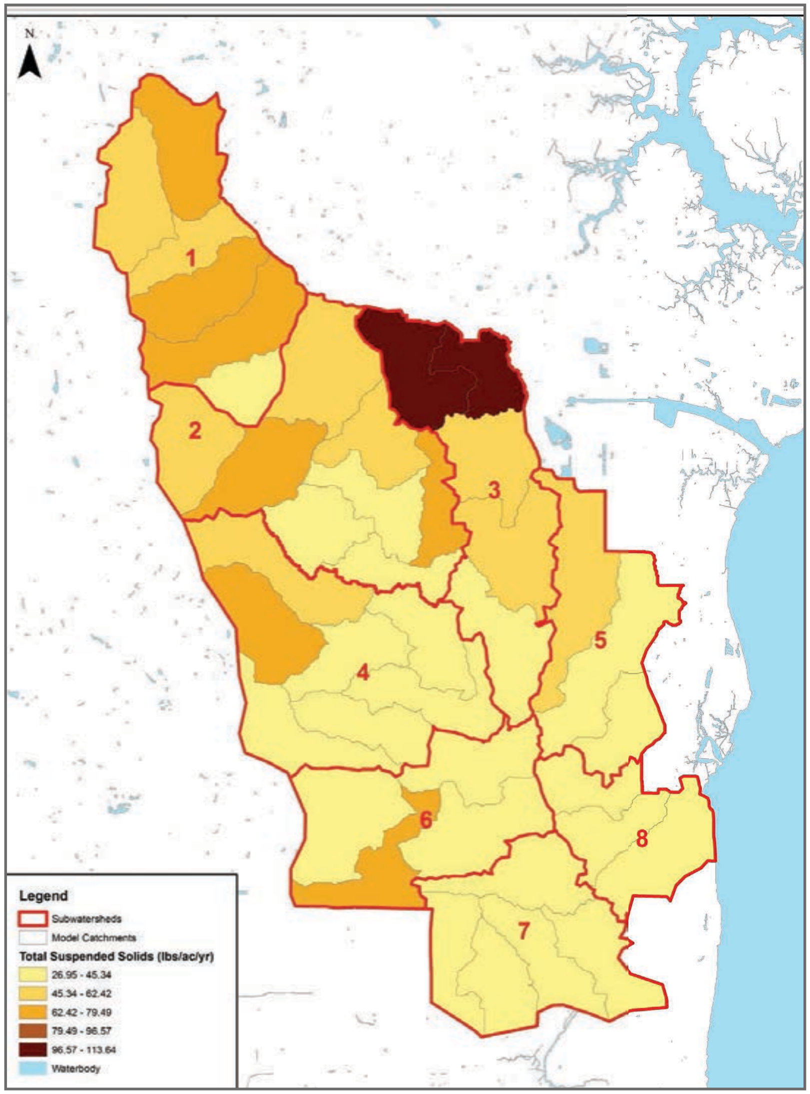


Figure C.9: Total Suspended Solids Loading Rate – Existing Condition

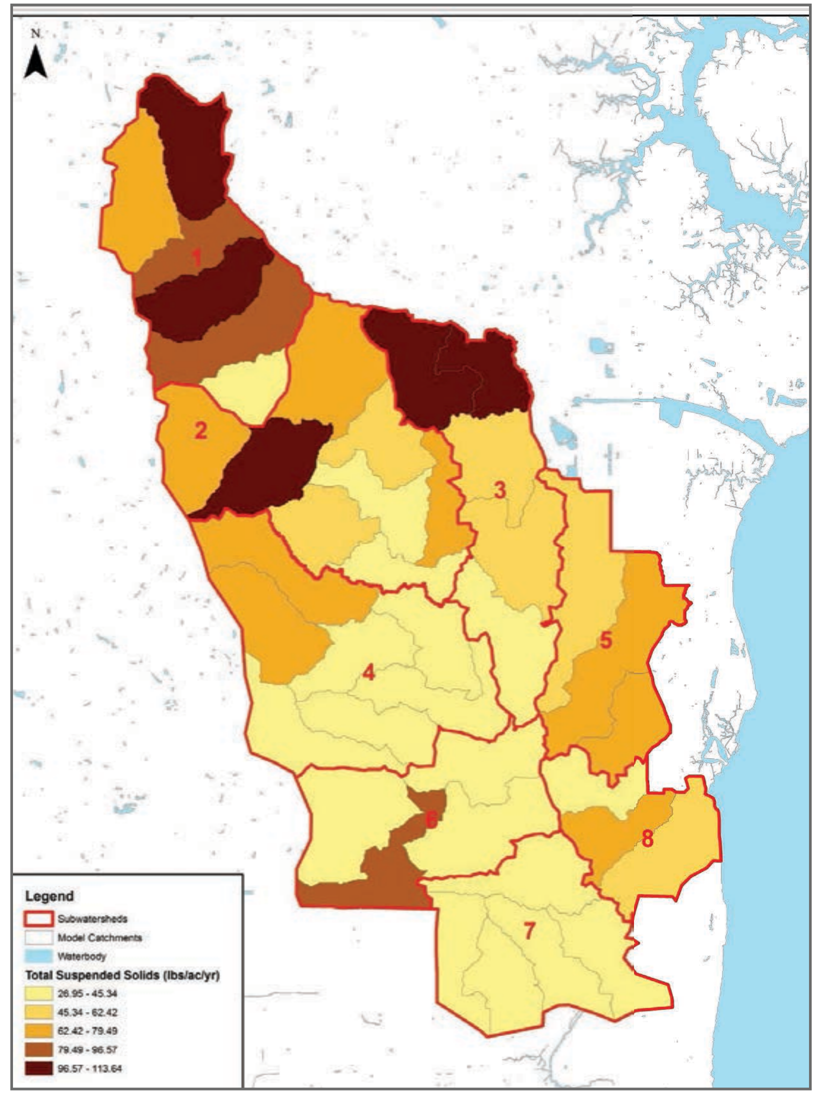


Figure C.10: Total Suspended Solids Loading Rate -Future Condition

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APPENDIX D
Raw Data

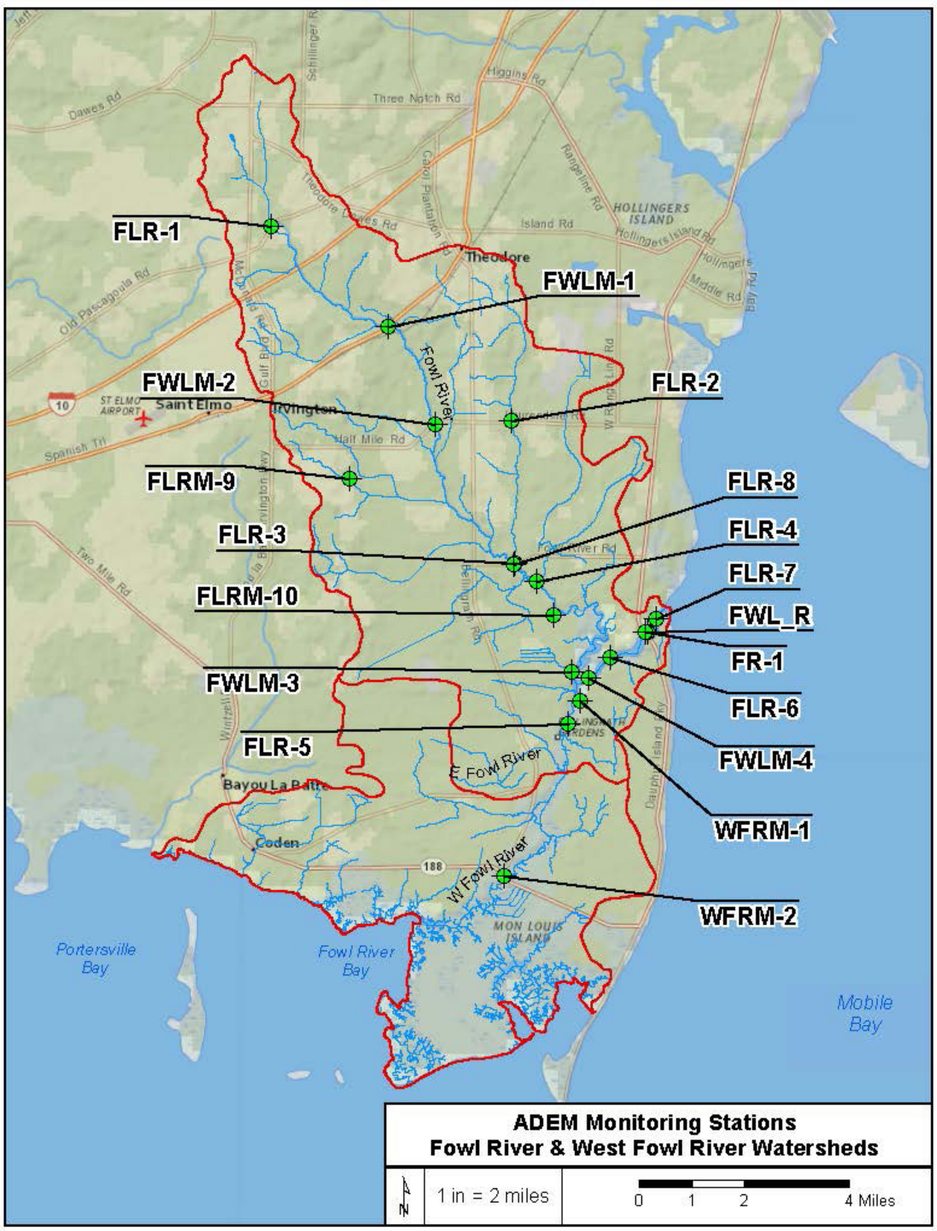
D. RAW DATA

INTRODUCTION

As part of the development of the Fowl River Watershed Management Plan (WMP), a review of existing federal, state, and local data was conducted. In addition, extensive data collection was performed by the Watershed Management Team. Selected raw data and summary plots for state and Watershed Management Team data are also included in this Appendix.

D.1 ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT (ADEM)

The Alabama Department of Environmental Management (ADEM) has been collecting water quality and sediment data in the Fowl River Watershed for approximately 30 years. Figure D.1 shows ADEM data collection stations, and Table D.1 lists the stations where ADEM data was used to help characterize the water quality of the Fowl River Watershed. Because of the number of data collection stations, and the time over which data has been collected, selected data for the stations with the greatest period-of-record are illustrated below.

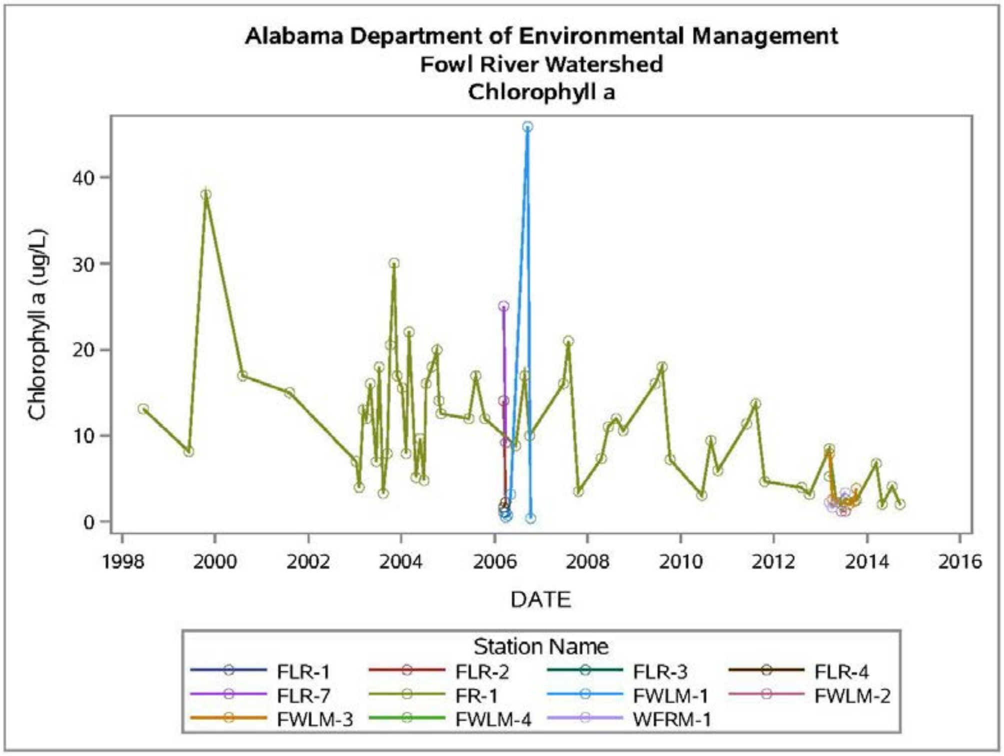


D. RAW DATA

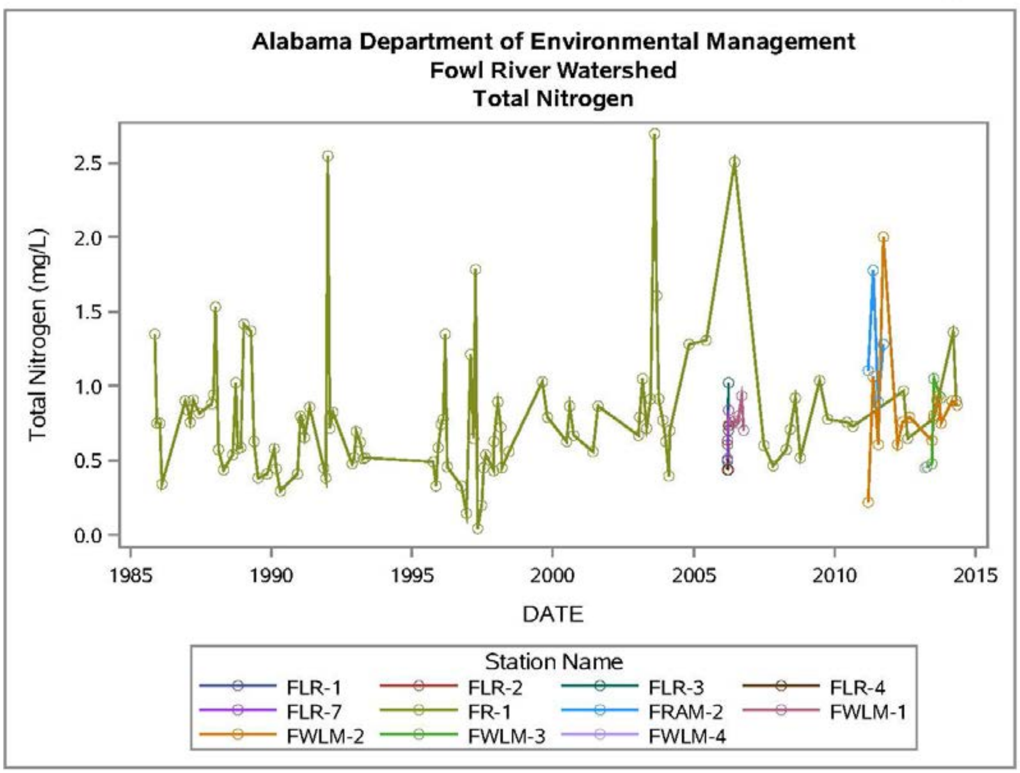
SAMPLING SUMMARY

Station Name	FLR_1	FLR_2	FLR_3	FLR_4	FLR_7	FR_1	FRAM_2	FWLM_1	FWLM_2	FWLM_3	FWLM_4	WFRM_1	FLRM_10
Source	ADEM	ADEM	ADEM	ADEM	ADEM	ADEM	ADEM	ADEM	ADEM	ADEM	ADEM	ADEM	ADEM
Station Name	FLR-1	FLR-2	FLR-3	FLR-4	FLR-7	FR-1	FRAM-2	FWLM-1	FWLM-2	FWLM-3	FWLM-4	WFRM-1	FLRM-10
First Sampling Date	16-Mar-06	16-Mar-06	15-Mar-06	15-Mar-06	15-Mar-06	17-Oct-85	14-Mar-11	28-Mar-06	15-Mar-11	12-Mar-13	12-Mar-13	12-Mar-13	30-Aug-99
Last Sampling Date	29-Mar-06	29-Mar-06	28-Mar-06	28-Mar-06	28-Mar-06	22-Sep-14	28-Sep-11	10-Oct-06	5-May-15	8-Oct-13	12-Mar-13	8-Oct-13	30-Aug-99
Number of Samples	2	2	2	2	2	198	4	8	29	8	1	8	1
Chlorophyll a	4	4	4	4	4	140	8	16	39	14	2	14	-
Dissolved Aluminum	-	-	-	-	-	13	-	3	11	3	-	3	-
Dissolved Arsenic	-	-	-	-	-	5	-	-	5	2	-	2	-
Dissolved Cadmium	-	-	-	-	-	13	-	3	10	3	-	3	-
Dissolved Chromium	-	-	-	-	-	13	-	3	11	3	-	3	-
Dissolved Copper	-	-	-	-	-	13	-	3	11	3	-	3	-
Dissolved Iron	-	-	-	-	-	13	-	3	11	3	-	3	-
Dissolved Lead	-	-	-	-	-	13	-	3	10	3	-	3	-
Dissolved Manganese	-	-	-	-	-	13	-	3	11	3	-	3	-
Dissolved Mercury	-	-	-	-	-	9	-	3	5	-	-	-	-
Dissolved Nickel	-	-	-	-	-	13	-	3	11	3	-	2	-
Dissolved Silver	-	-	-	-	-	13	-	3	10	3	-	3	-
Dissolved Thallium	-	-	-	-	-	13	-	3	10	3	-	3	-
Dissolved Zinc	-	-	-	-	-	5	-	-	5	3	-	3	-
Enterococcus	-	-	-	-	-	43	-	-	25	6	1	5	-
Escherichia coli	-	-	-	-	-	-	4	-	-	-	-	-	-
Fecal Coliform	2	2	2	2	2	162		6	-	-	-	-	1
Inorganic nitrogen (nitrate and nitrite) as N	2	2	2	2	2	196	4	8	16	6	1	-	1
Kjeldahl nitrogen	2	2	2	2	2	192	4	8	16	6	1	-	-
Orthophosphate as P	2	2	2	2	2	42	4	8	16	6	1	-	-
Total Aluminum	-	-	-	-	-	12		3	11	3		3	-
Total Ammonia-nitrogen as N	2	2	2	2	2	106	4	8	16	6	1	-	-
Total Cadmium	-	-	-	-	-	5	-	-	1	-	-	-	-
Total Calcium	-	-	-	-	-	1	-	-	2	-	-	-	-
Total Chloride	-	-	-	-	-	186	-	8	17	6	1	6	1
Total Chromium	-	-	-	-	-	5	-	-	-	-	-	-	-
Total Copper	-	-	-	-	-	5	-	-	-	-	-	-	-
Total Iron	-	-	-	-	-	13	-	3	11	3		3	
Total Lead	-	-	-	-	-	5	-	-	1	-	-	-	-
Total Magnesium	-	-	-	-	-	1	-	-	2	-	-	-	-
Total Manganese	-	-	-	-	-	13	-	3	11	3		3	
Total Mercury	-	-	-	-	-	4	-	-	-	-	-	-	-
Total Nickel	-	-	-	-	-	4	-	-	-	-	-	-	-
Total Phosphorus	2	2	2	2	2	199	4	8	16	6	1		1
Total Silver	-	-	-	-	-	4	-	-	1	-	-	-	-
Total Thallium	-	-	-	-	-	4	-	-	1	-	-	-	-
Zinc	-	-	-	-	-	12	-	3	6	-	-	-	-

D. RAW DATA

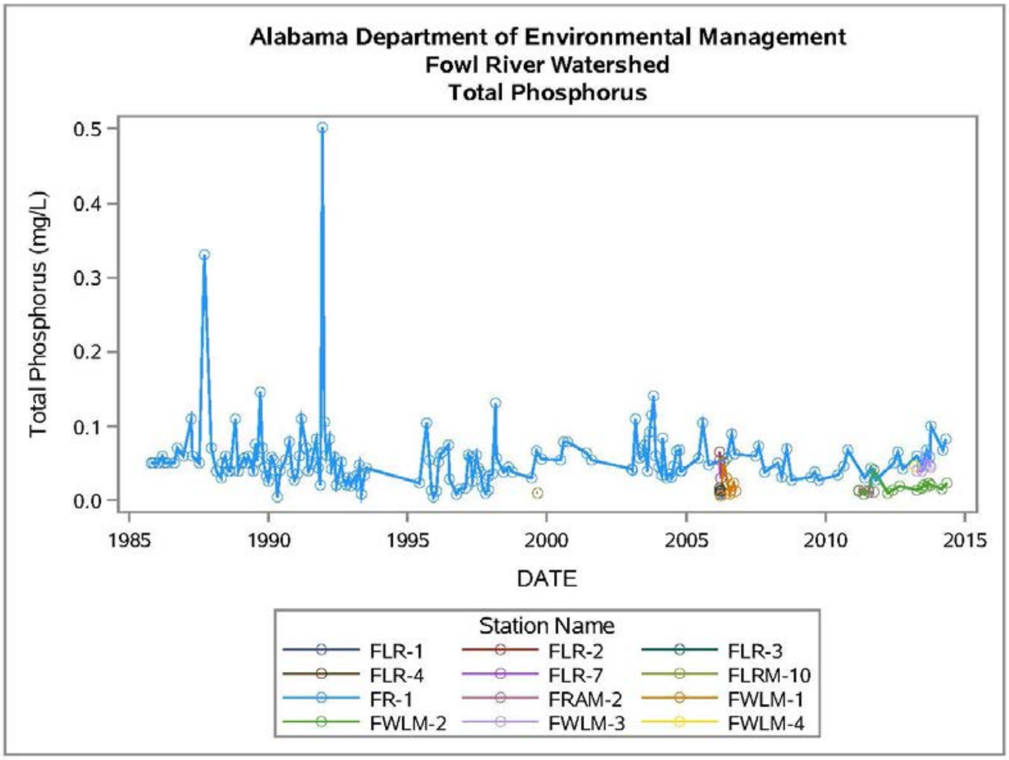


Alabama Department of Environmental Management
Fowl River Watershed
Chlorophyll a
Chlorophyll a (ug/L)
0
10
20
30
40
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
DATE
Station Name
FLR-1
FLR-2
FLR-3
FLR-4
FLR-7
FR-1
FWLM-1
FWLM-2
FWLM-3
FWLM-4
WFRM-1

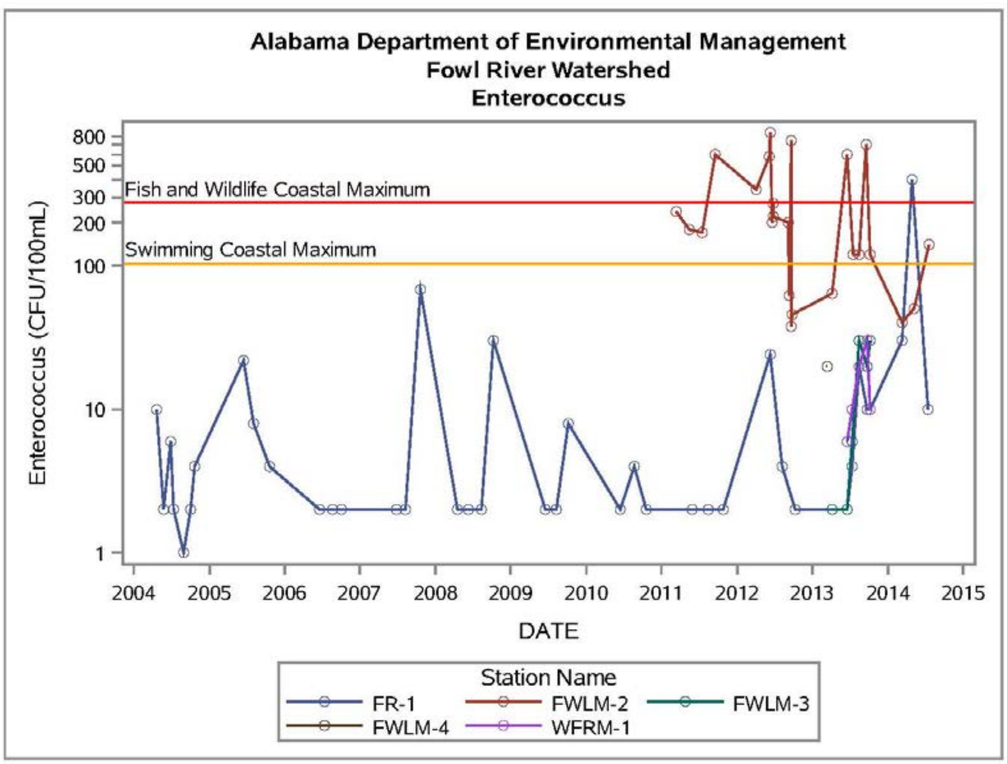


Alabama Department of Environmental Management
Fowl River Watershed
Total Nitrogen
Total Nitrogen (mg/L)
0.0
0.5
1.0
1.5
2.0
2.5
1985
1990
1995
2000
2005
2010
2015
DATE
Station Name
FLR-1
FLR-2
FLR-3
FLR-4
FLR-7
FR-1
FRAM-2
FWLM-1
FWLM-2
FWLM-3
FWLM-4

D. RAW DATA

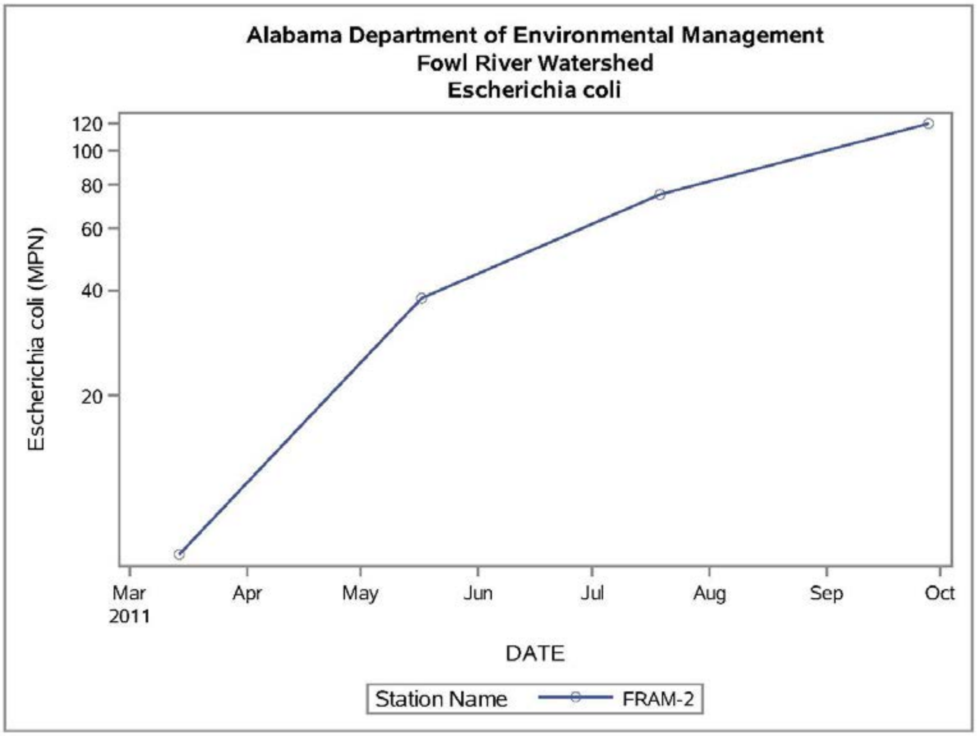


Alabama Department of Environmental Management
Fowl River Watershed
Total Phosphorus
Total Phosphorus (mg/L)
0.5
0.4
0.3
0.2
0.1
0.0
1985
1990
1995
2000
2005
2010
2015
DATE
Station Name
FLR-1
FLR-2
FLR-3
FLR-4
FLR-7
FLRM-10
FR-1
FRAM-2
FWLM-1
FWLM-2
FWLM-3
FWLM-4

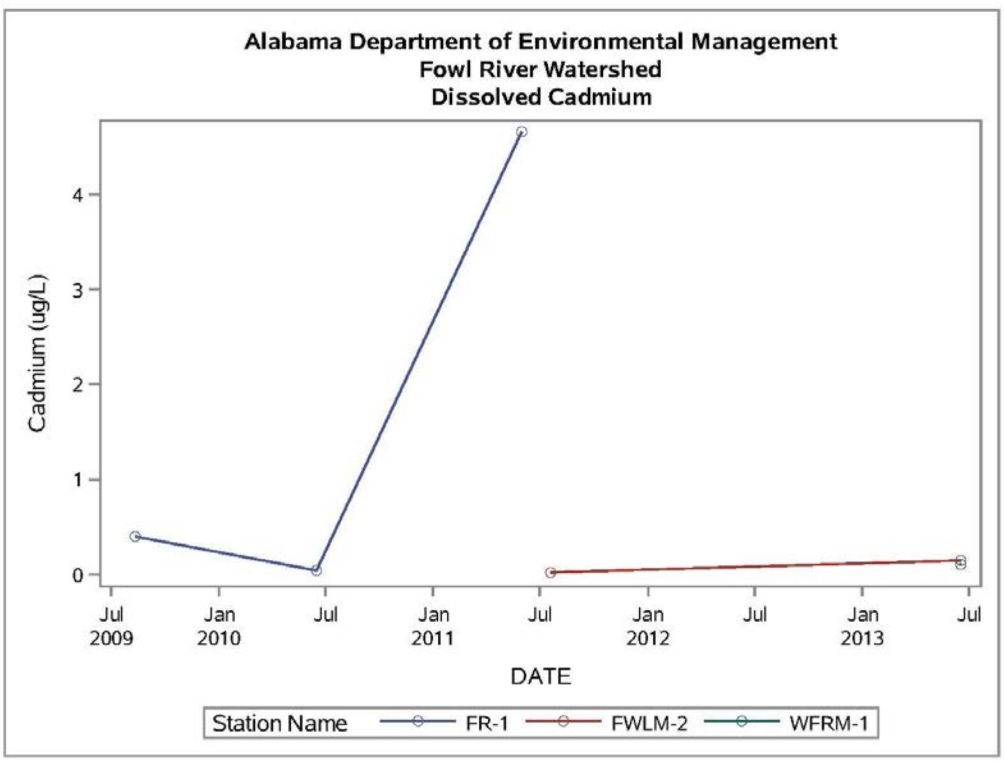


Alabama Department of Environmental Management
Fowl River Watershed
Enterococcus
Enterococcus (CFU/100mL)
800
500
300
200
100
10
1
Fish and Wildlife Coastal Maximum
Swimming Coastal Maximum
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
DATE
Station Name
FR-1
FWLM-2
FWLM-3
FWLM-4
WFRM-1

D. RAW DATA

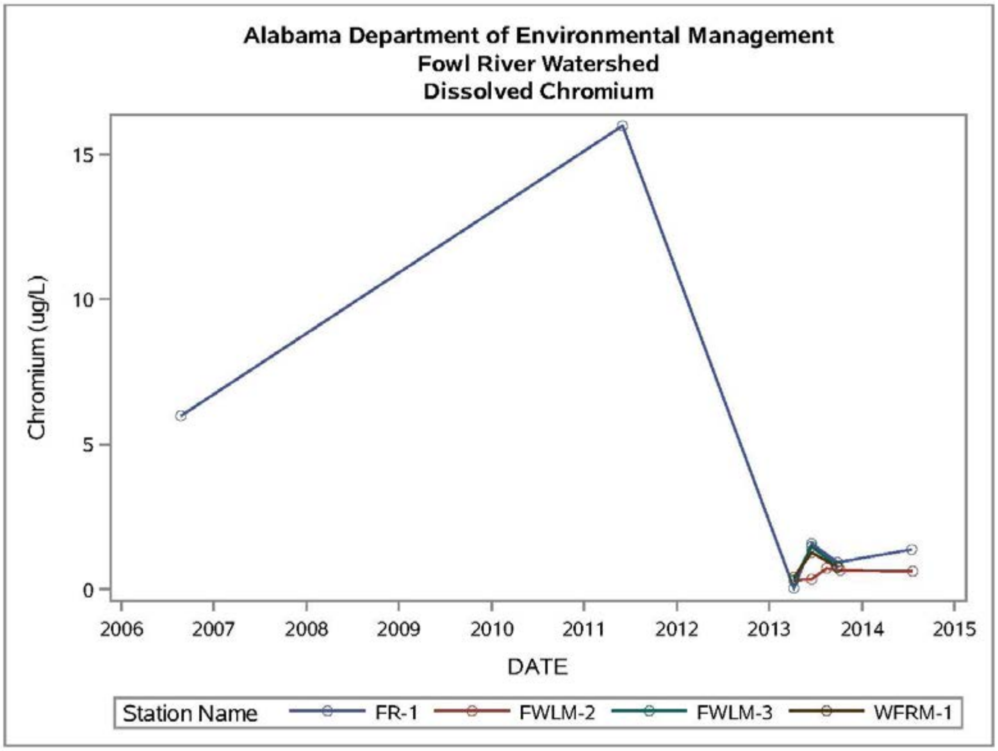


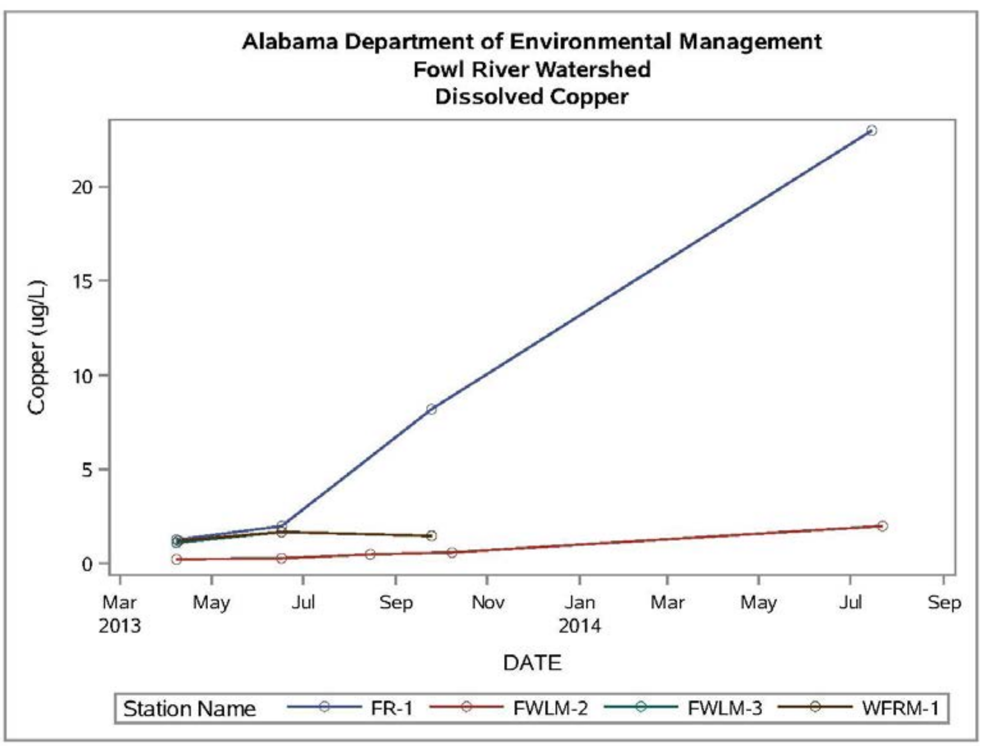
Alabama Department of Environmental Management
Fowl River Watershed
Escherichia coli
Escherichia coli (MPN)
120
100
80
60
40
20
Mar 2011
Apr
May
Jun
Jul
Aug
Sep
Oct
DATE
Station Name
FRAM-2



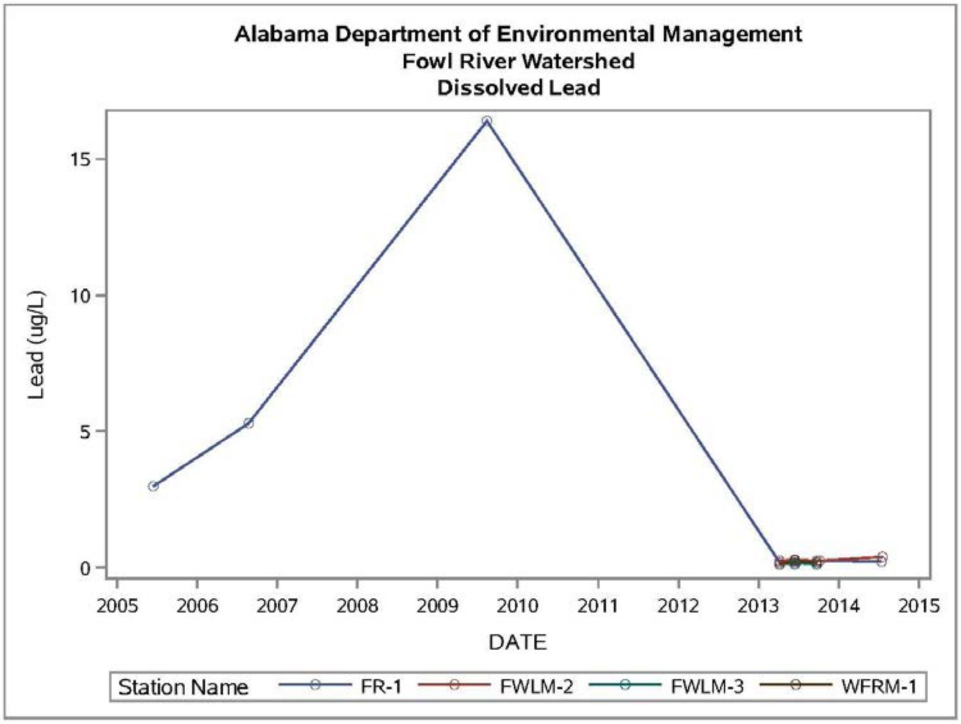
Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Cadmium
Cadmium (ug/L)
4
3
2
1
0
Jul 2009
Jan 2010
Jul
Jan 2011
Jul
Jan 2012
Jul
Jan 2013
Jul
DATE
Station Name
FR-1
FWLM-2
WFRM-1

D. RAW DATA

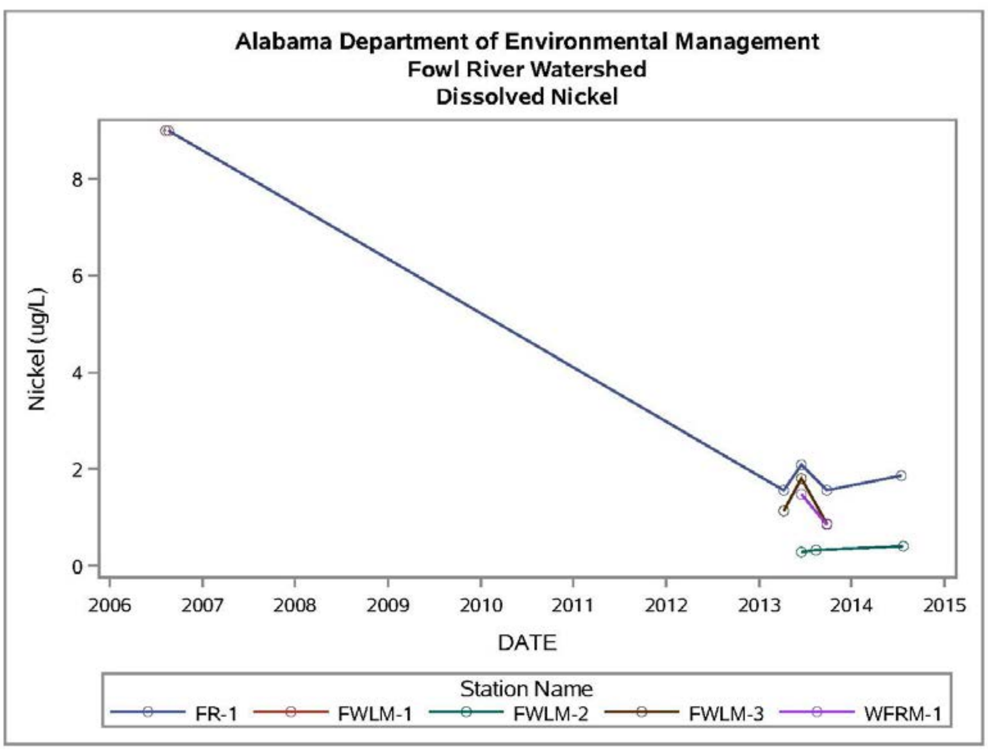

Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Chromium
Chromium (ug/L)
0
5
10
15
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
DATE
Station Name
FR-1
FWLM-2
FWLM-3
WFRM-1


Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Copper
Copper (ug/L)
0
5
10
15
20
Mar 2013
May
Jul
Sep
Nov
Jan 2014
Mar
May
Jul
Sep
DATE
Station Name
FR-1
FWLM-2
FWLM-3
WFRM-1

D. RAW DATA

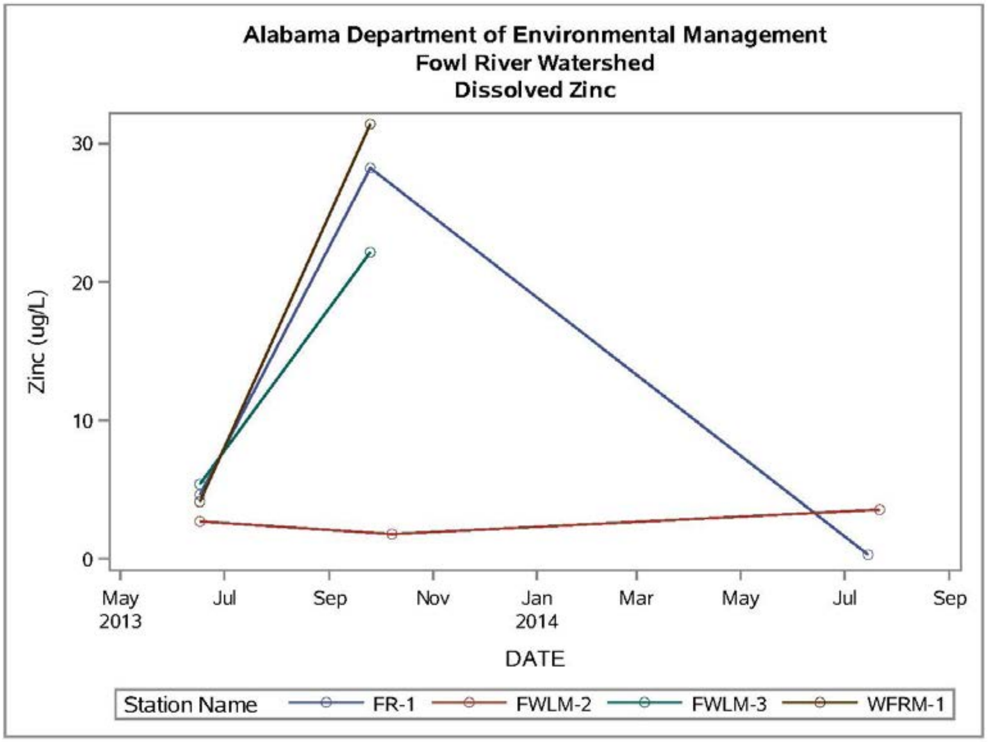


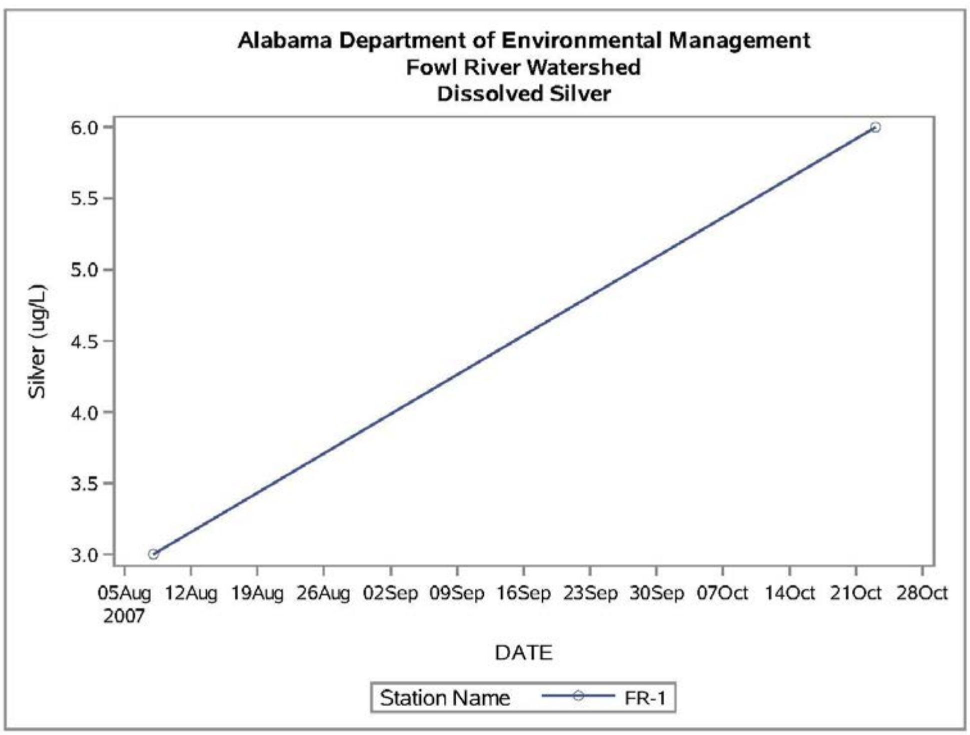
Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Lead
Lead (ug/L)
0
5
10
15
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
DATE
Station Name
FR-1
FWLM-2
FWLM-3
WFRM-1



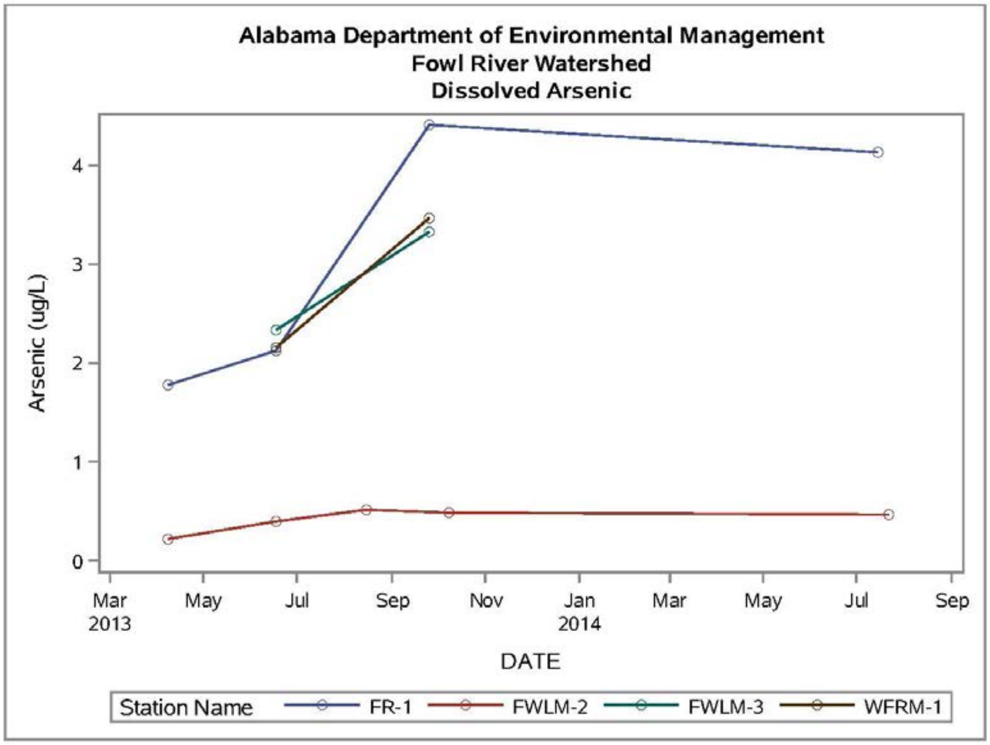
Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Nickel
Nickel (ug/L)
0
2
4
6
8
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
DATE
Station Name
FR-1
FWLM-1
FWLM-2
FWLM-3
WFRM-1

D. RAW DATA

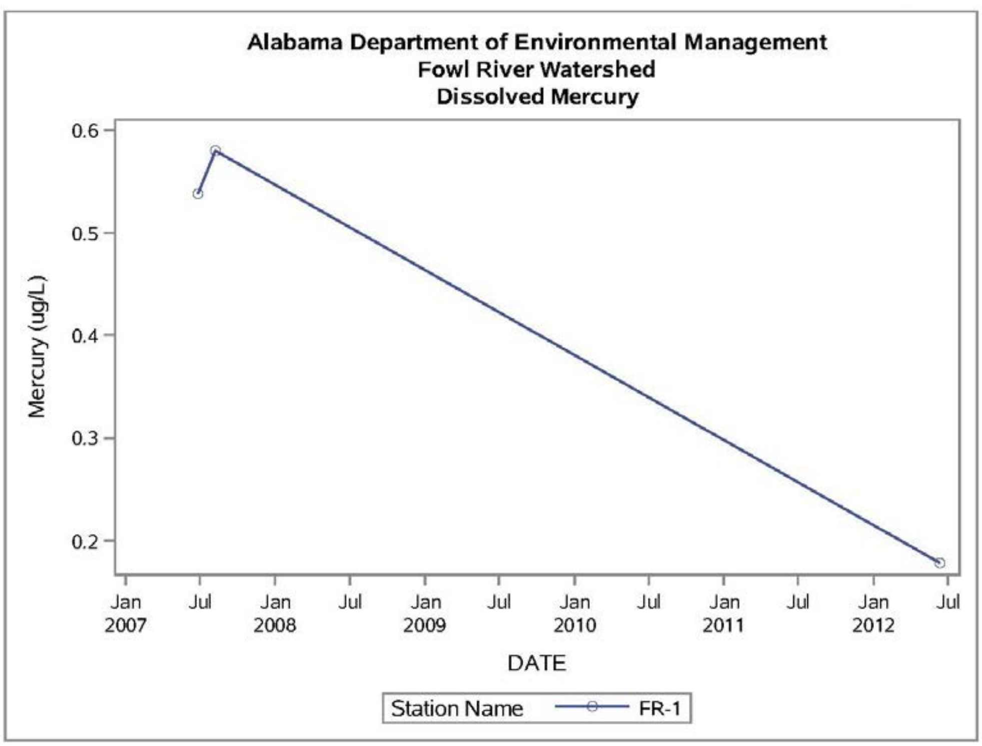

Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Zinc
Zinc (ug/L)
30
20
10
0
May 2013
Jul
Sep
Nov
Jan 2014
Mar
May
Jul
Sep
DATE
Station Name
FR-1
FWLM-2
FWLM-3
WFRM-1


Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Silver
Silver (ug/L)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
05Aug 2007
12Aug
19Aug
26Aug
02Sep
09Sep
16Sep
23Sep
30Sep
07Oct
14Oct
21Oct
28Oct
DATE
Station Name
FR-1

D. RAW DATA

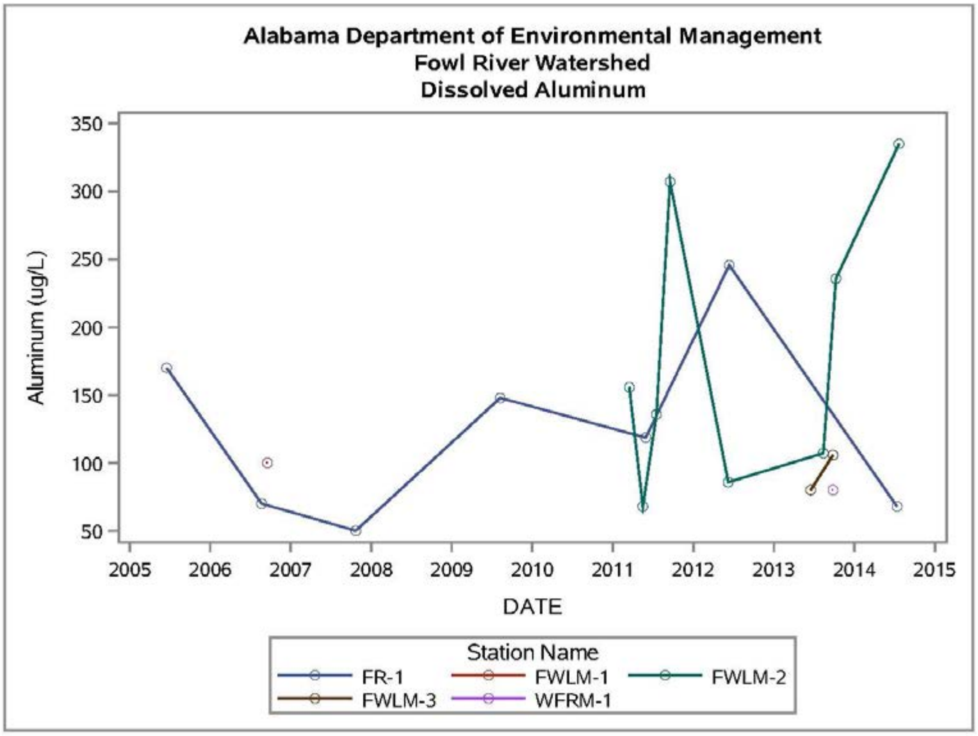


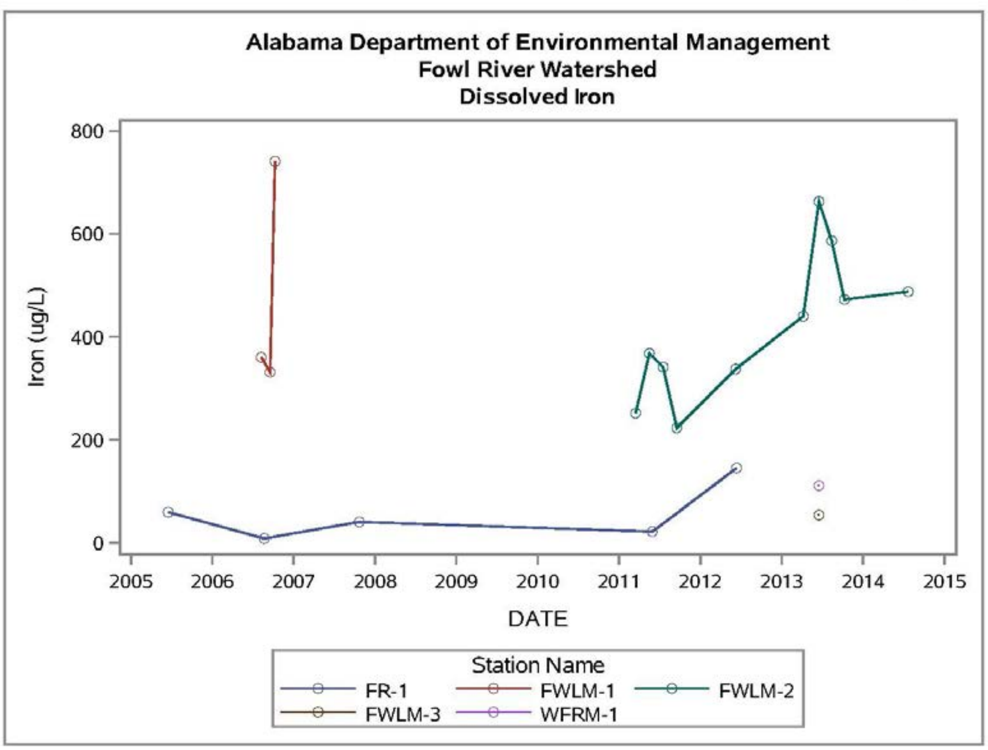
Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Arsenic
Arsenic (ug/L)
0
1
2
3
4
Mar 2013
May
Jul
Sep
Nov
Jan 2014
Mar
May
Jul
Sep
DATE
Station Name
FR-1
FWLM-2
FWLM-3
WFRM-1



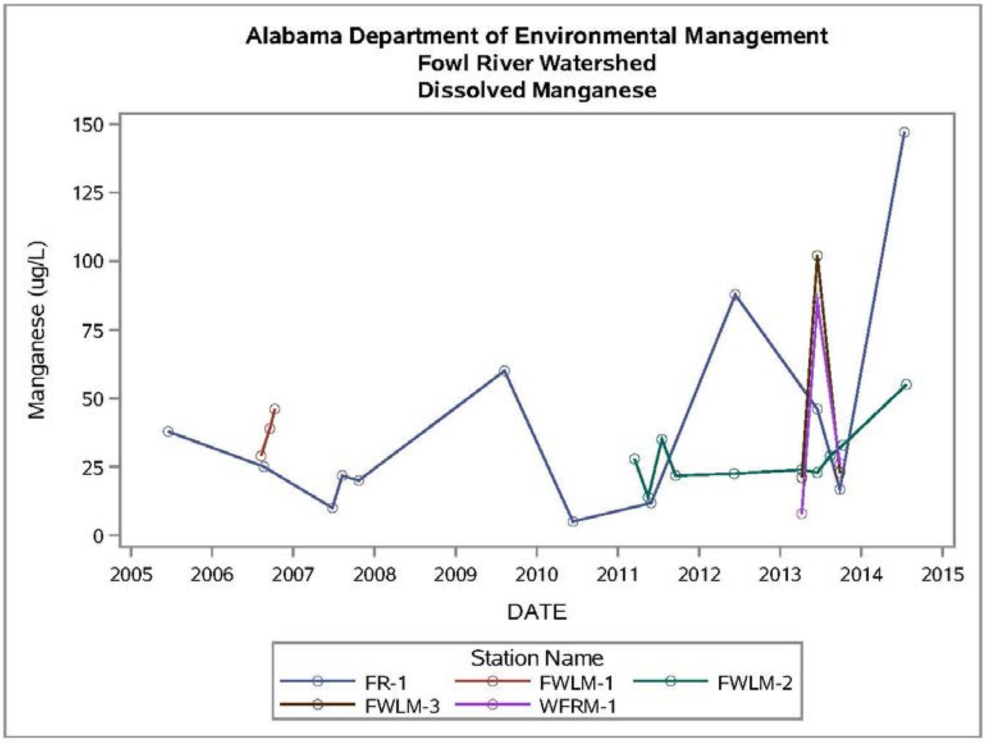
Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Mercury
Mercury (ug/L)
0.2
0.3
0.4
0.5
0.6
Jan 2007
Jul
Jan 2008
Jul
Jan 2009
Jul
Jan 2010
Jul
Jan 2011
Jul
Jan 2012
Jul
DATE
Station Name
FR-1

D. RAW DATA

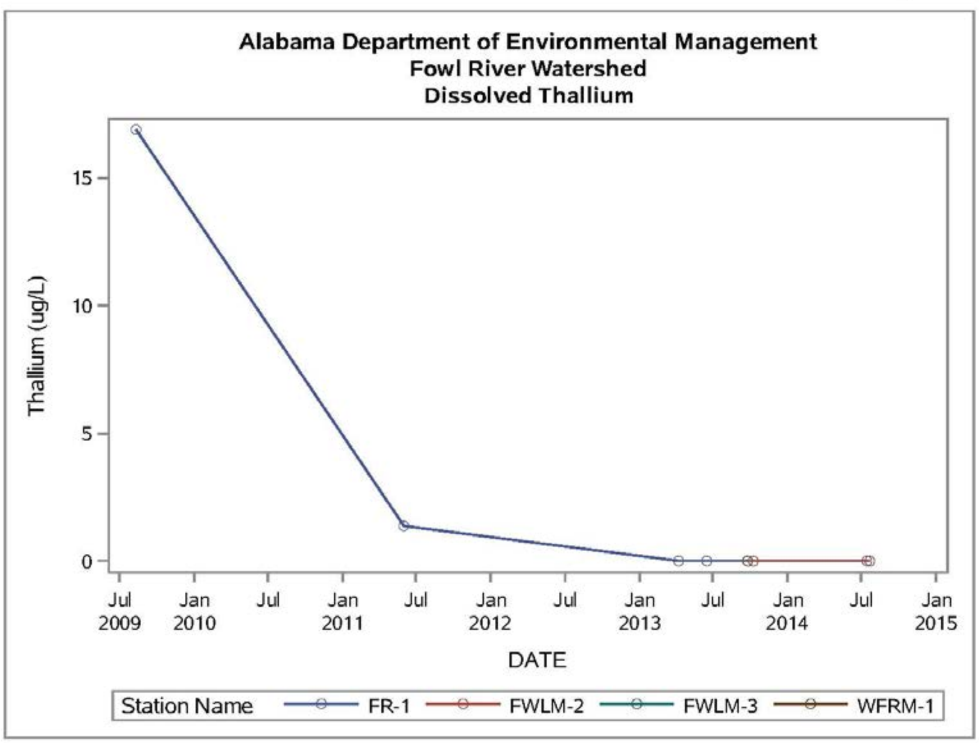

Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Aluminum
Aluminum (ug/L)
350
300
250
200
150
100
50
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
DATE
Station Name
FR-1
FWLM-1
FWLM-2
FWLM-3
WFRM-1


Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Iron
Iron (ug/L)
800
600
400
200
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
DATE
Station Name
FR-1
FWLM-1
FWLM-2
FWLM-3
WFRM-1

D. RAW DATA

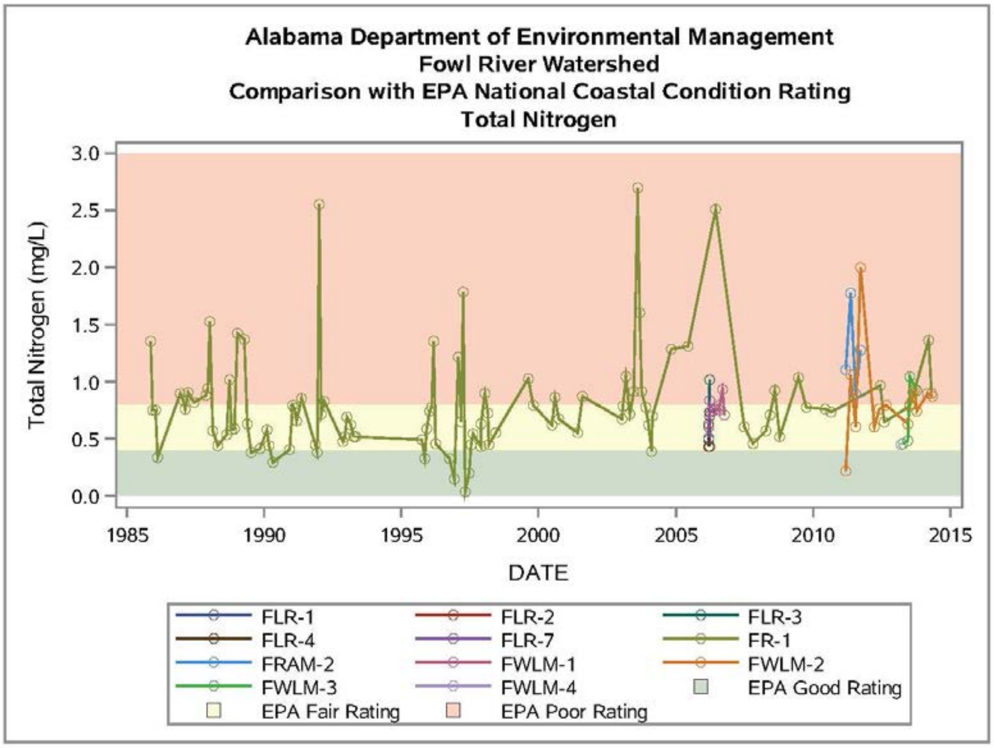


Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Manganese
Manganese (ug/L)
150
125
100
75
50
25
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
DATE
Station Name
FR-1
FWLM-1
FWLM-2
FWLM-3
WFRM-1

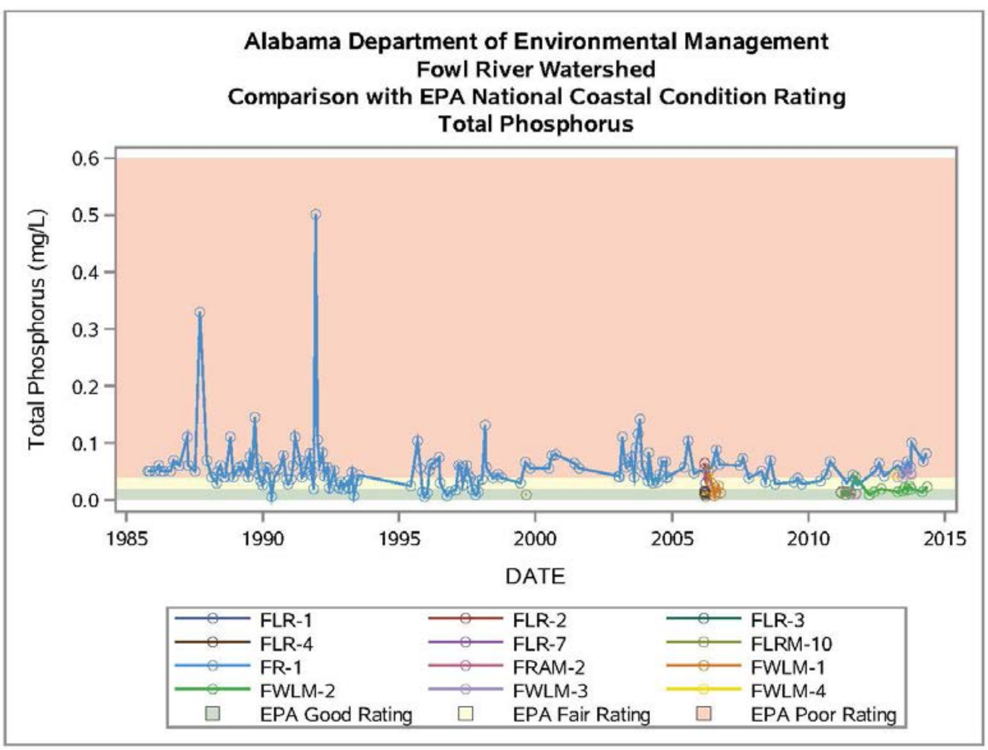


Alabama Department of Environmental Management
Fowl River Watershed
Dissolved Thallium
Thallium (ug/L)
15
10
5
0
Jul 2009
Jan 2010
Jul
Jan 2011
Jul
Jan 2012
Jul
Jan 2013
Jul
Jan 2014
Jul
Jan 2015
DATE
Station Name
FR-1
FWLM-2
FWLM-3
WFRM-1

D. RAW DATA

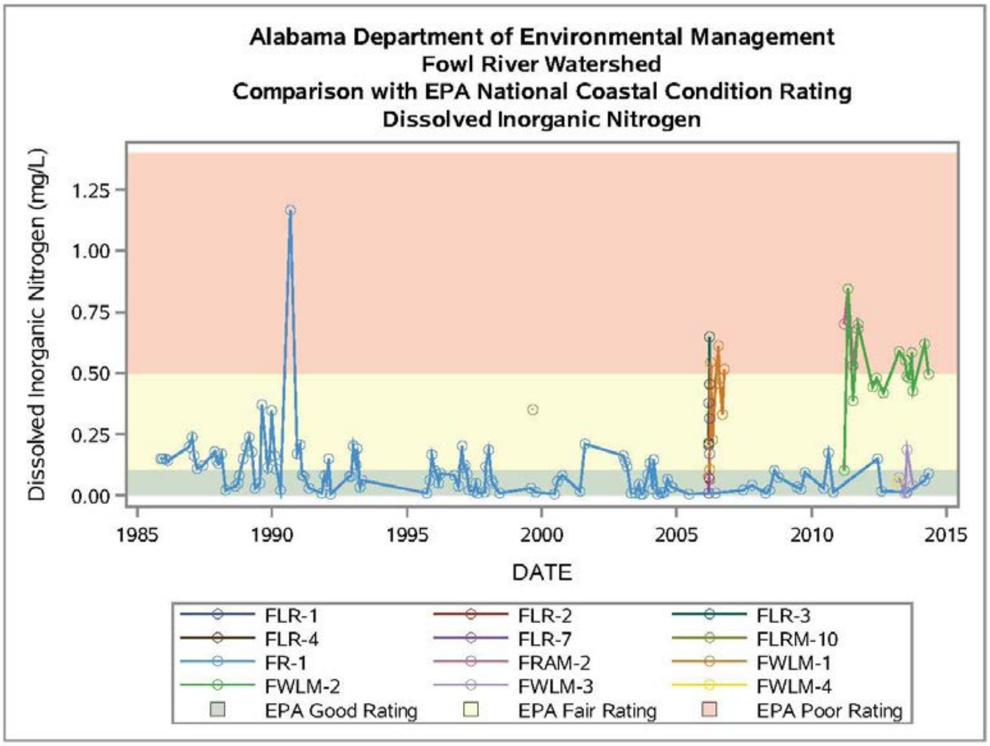


Alabama Department of Environmental Management
Fowl River Watershed
Comparison with EPA National Coastal Condition Rating
Total Nitrogen
Total Nitrogen (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1985
1990
1995
2000
2005
2010
2015
DATE
FLR-1
FLR-2
FLR-3
FLR-4
FLR-7
FR-1
FRAM-2
FWLM-1
FWLM-2
FWLM-3
FWLM-4
EPA Good Rating
EPA Fair Rating
EPA Poor Rating

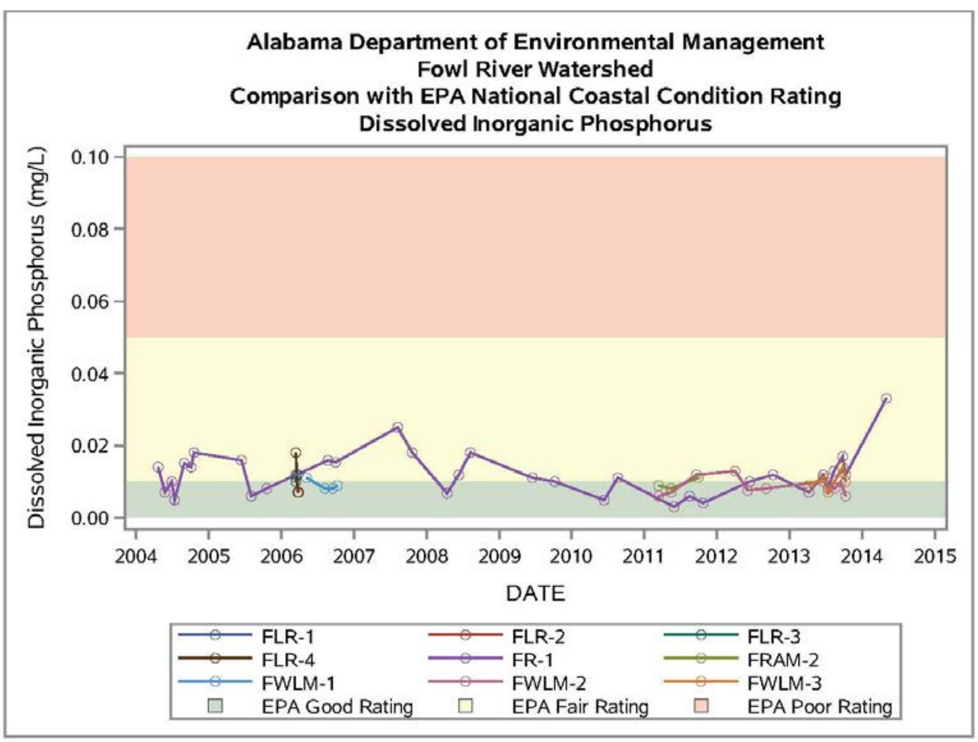


Alabama Department of Environmental Management
Fowl River Watershed
Comparison with EPA National Coastal Condition Rating
Total Phosphorus
Total Phosphorus (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1985
1990
1995
2000
2005
2010
2015
DATE
FLR-1
FLR-2
FLR-3
FLR-4
FLR-7
FLRM-10
FR-1
FRAM-2
FWLM-1
FWLM-2
FWLM-3
FWLM-4
EPA Good Rating
EPA Fair Rating
EPA Poor Rating

D. RAW DATA

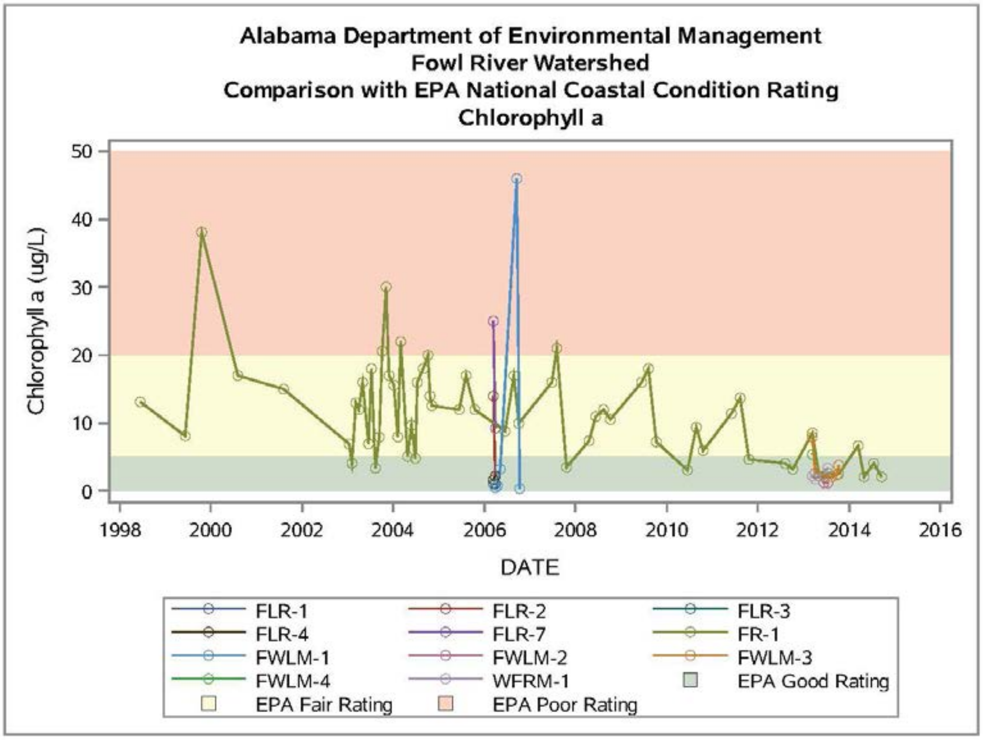


Alabama Department of Environmental Management
Fowl River Watershed
Comparison with EPA National Coastal Condition Rating
Dissolved Inorganic Nitrogen
Dissolved Inorganic Nitrogen (mg/L)
1.25
1.00
0.75
0.50
0.25
0.00
1985
1990
1995
2000
2005
2010
2015
DATE
FLR-1
FLR-2
FLR-3
FLR-4
FLR-7
FLRM-10
FR-1
FRAM-2
FWLM-1
FWLM-2
FWLM-3
FWLM-4
EPA Good Rating
EPA Fair Rating
EPA Poor Rating



Alabama Department of Environmental Management
Fowl River Watershed
Comparison with EPA National Coastal Condition Rating
Dissolved Inorganic Phosphorus
Dissolved Inorganic Phosphorus (mg/L)
0.10
0.08
0.06
0.04
0.02
0.00
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
DATE
FLR-1
FLR-2
FLR-3
FLR-4
FR-1
FRAM-2
FWLM-1
FWLM-2
FWLM-3
EPA Good Rating
EPA Fair Rating
EPA Poor Rating

D. RAW DATA



Alabama Department of Environmental Management
Fowl River Watershed
Comparison with EPA National Coastal Condition Rating
Chlorophyll a
Chlorophyll a (ug/L)
0
10
20
30
40
50
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
DATE
FLR-1
FLR-2
FLR-3
FLR-4
FLR-7
FR-1
FWLM-1
FWLM-2
FWLM-3
FWLM-4
WFRM-1
EPA Good Rating
EPA Fair Rating
EPA Poor Rating

D.2 U.S. GEOLOGICAL SURVEY (USGS)

The U.S. Geological Survey (USGS) maintains a discharge measuring station on Fowl River at Half Mile Road. The period-of-record for that station includes March 3, 1995 to the present (2015). The data collected, and the time over which that data was collected are shown in **Table D.2**.

DESCRIPTION:
Latitude 30°30'02", Longitude 88°10'53" NAD27
Mobile County, Alabama, Hydrologic Unit 03160205
Drainage area: 16.5 square miles
Contributing drainage area: 16.5 square miles,
Datum of gage: 16.96 feet above NGVD29.

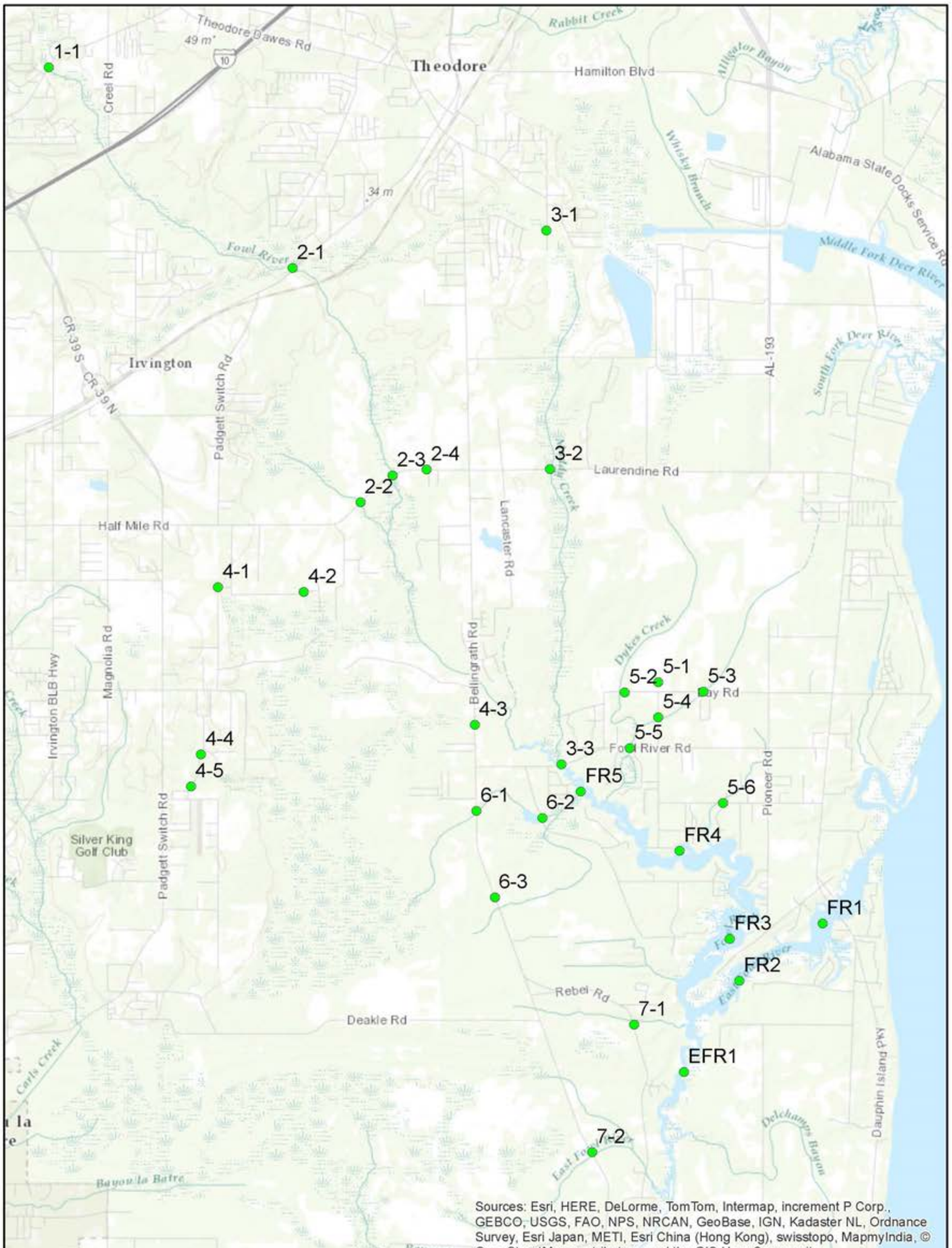
AVAILABLE DATA:

Data Type	Begin Date	End Date	Count
Current / Historical Observations (availability statement)	2007-10-01	2015-11-11	
Daily Data			
Discharge, cubic feet per second	1995-03-09	2015-11-10	7552
Gage height, feet	1995-03-10	2015-11-10	7490
Daily Statistics			
Discharge, cubic feet per second	1995-03-09	2014-12-11	7218
Gage height, feet	1995-03-10	2014-12-11	7156
Monthly Statistics			
Discharge, cubic feet per second	1995-03	2014-12	
Gage height, feet	1995-03	2014-12	
Annual Statistics			
Discharge, cubic feet per second	1995	2015	
Gage height, feet	1995	2015	
Peak streamflow	1995-04-11	2014-04-30	20
Field measurements	1995-04-27	2015-10-29	130
Field/Lab water-quality samples	1966-10-05	2005-09-21	58
Water-Year Summary	2006	2014	9
Additional Data Sources	**Begin Date**	**End Date**	**Count**
Instantaneous-Data Archive **offsite**	1995-03-10	2007-09-30	184875

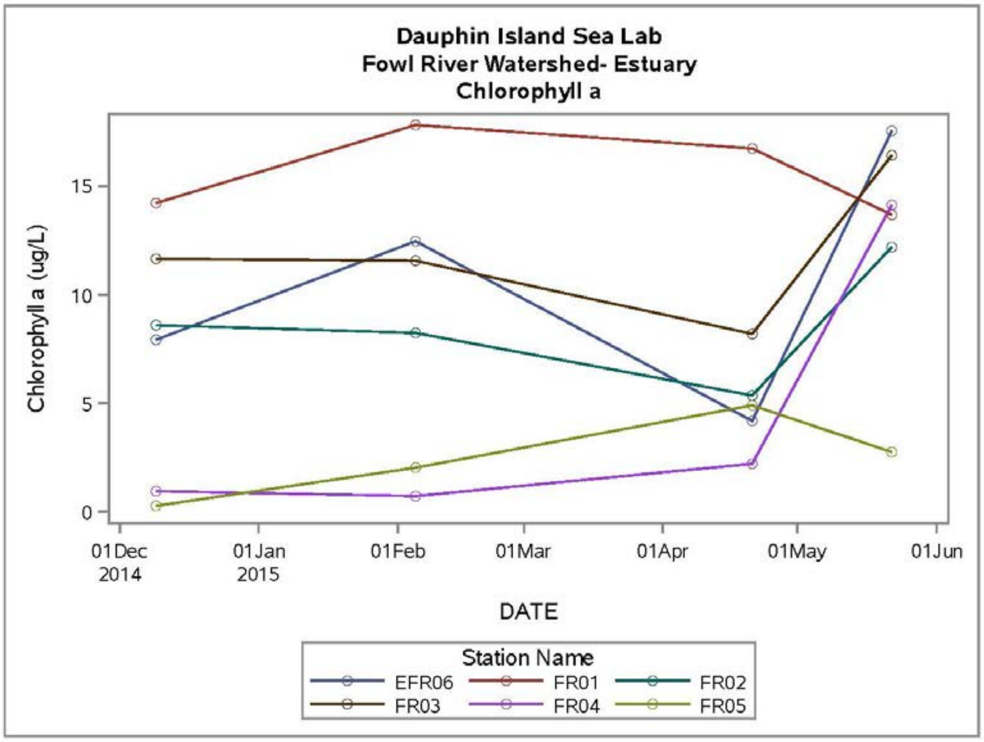
D. RAW DATA

D.3 DAUPHIN ISLAND SEA LAB (DISL)

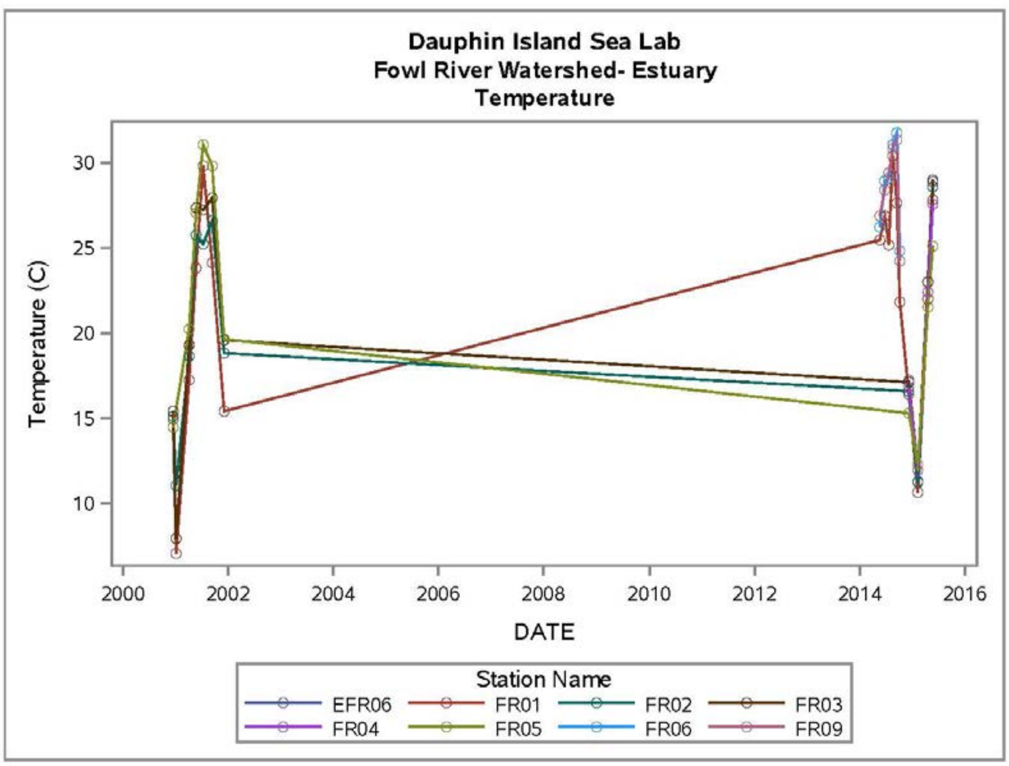
The Dauphin Island Sea Lab (DISL) was part of the Watershed Management Team and provided invaluable service by collecting and analyzing water quality samples. Data collection stations are illustrated in Figure D.3, and data summary plots are included as well.



D. RAW DATA

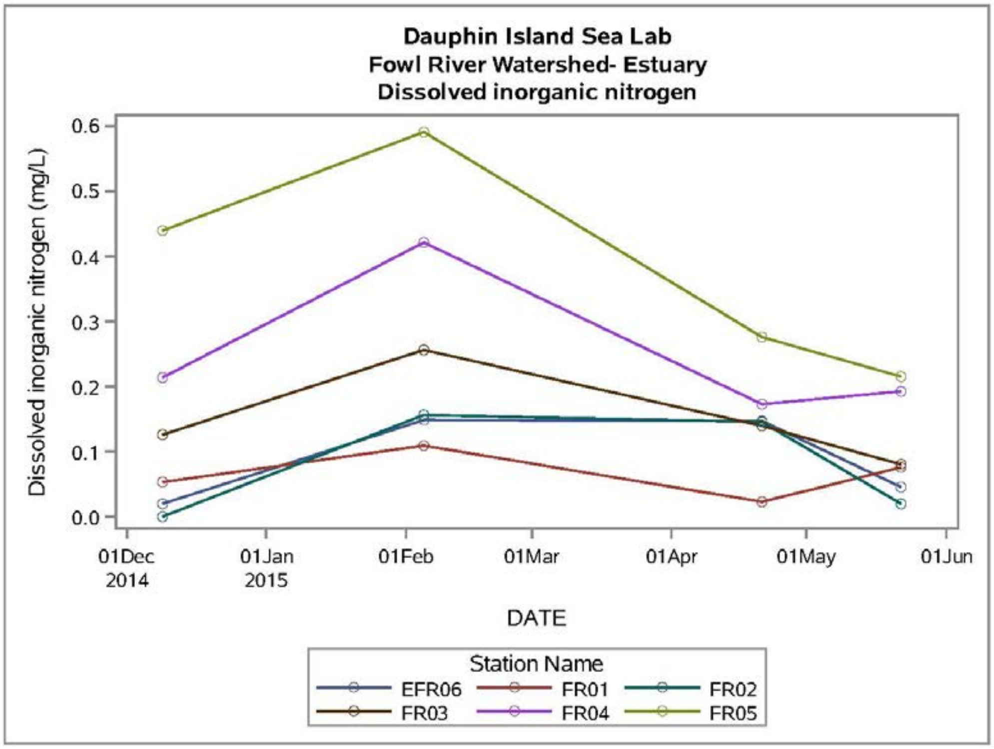


Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Chlorophyll a
Chlorophyll a (ug/L)
0
5
10
15
01Dec 2014
01Jan 2015
01Feb
01Mar
01Apr
01May
01Jun
DATE
Station Name
EFR06
FR01
FR02
FR03
FR04
FR05

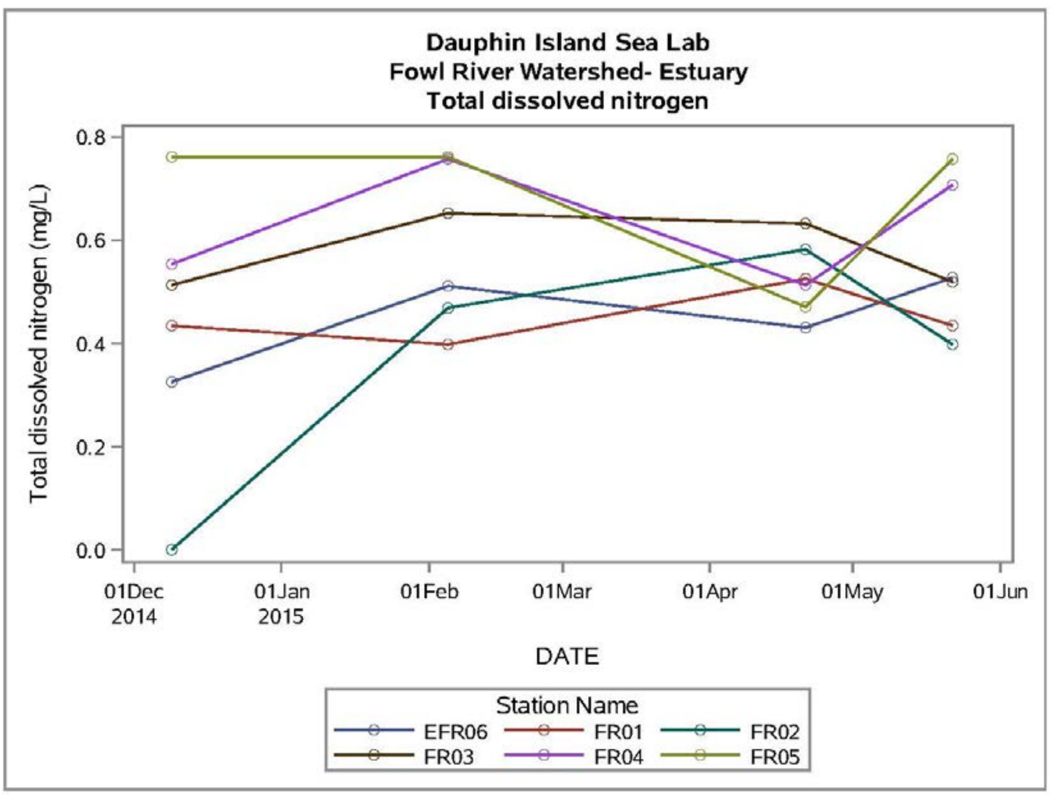


Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Temperature
Temperature (C)
10
15
20
25
30
2000
2002
2004
2006
2008
2010
2012
2014
2016
DATE
Station Name
EFR06
FR01
FR02
FR03
FR04
FR05
FR06
FR09

D. RAW DATA

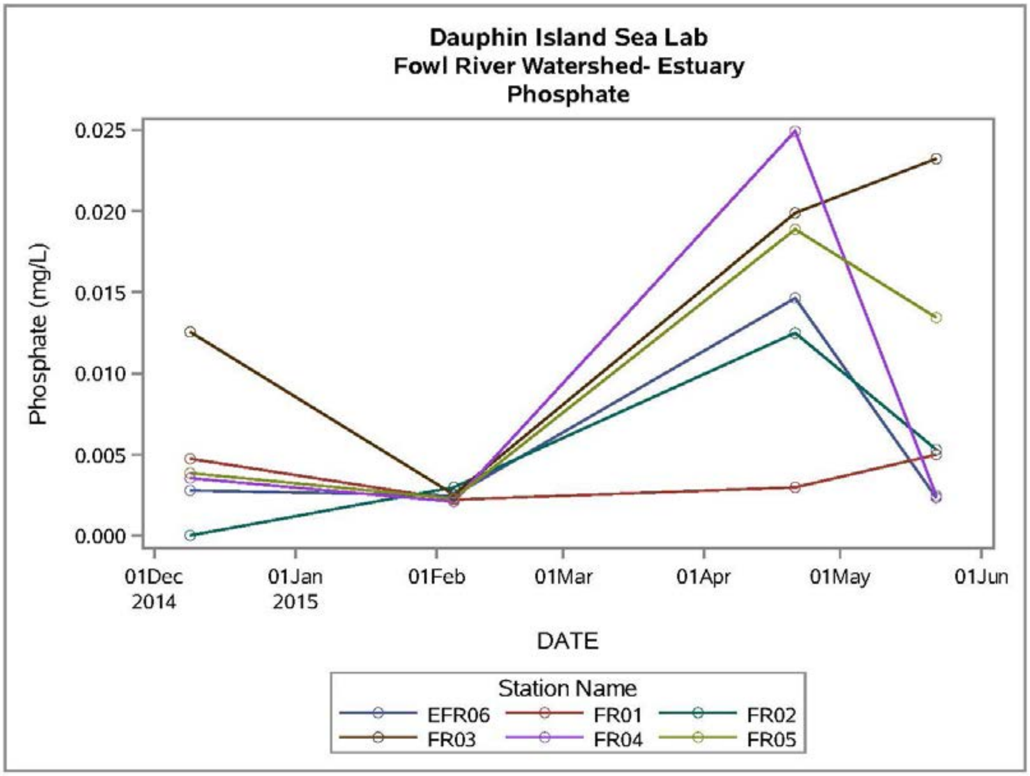


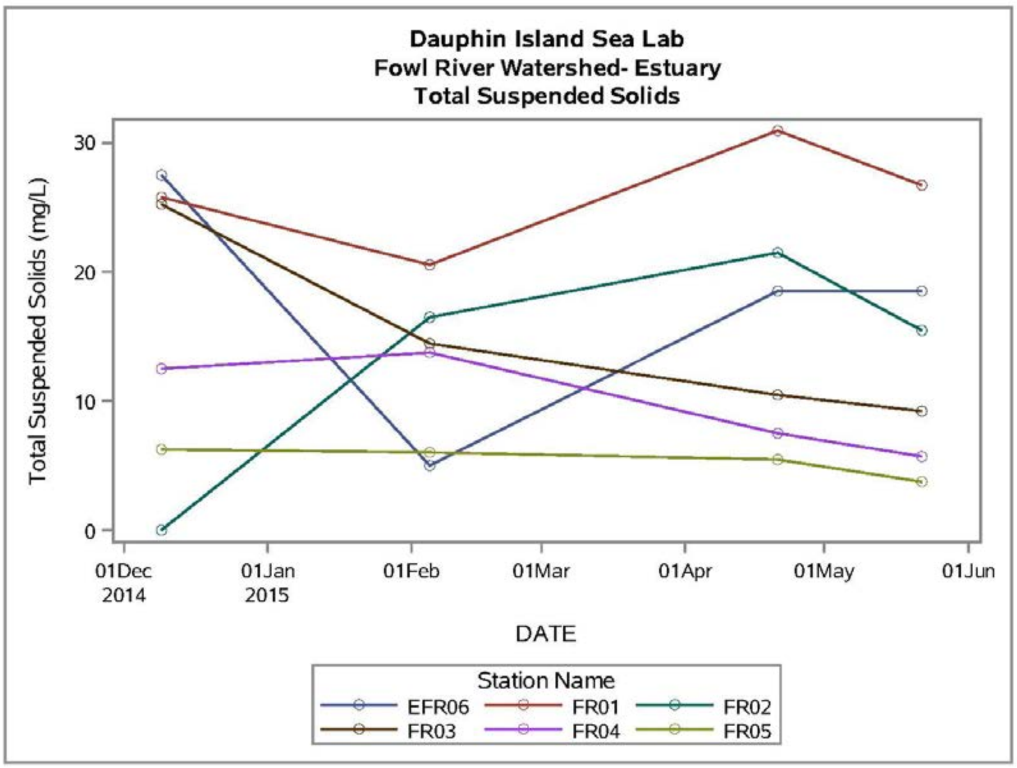
Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Dissolved inorganic nitrogen
Dissolved inorganic nitrogen (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
01Dec 2014
01Jan 2015
01Feb
01Mar
01Apr
01May
01Jun
DATE
Station Name
EFR06
FR01
FR02
FR03
FR04
FR05



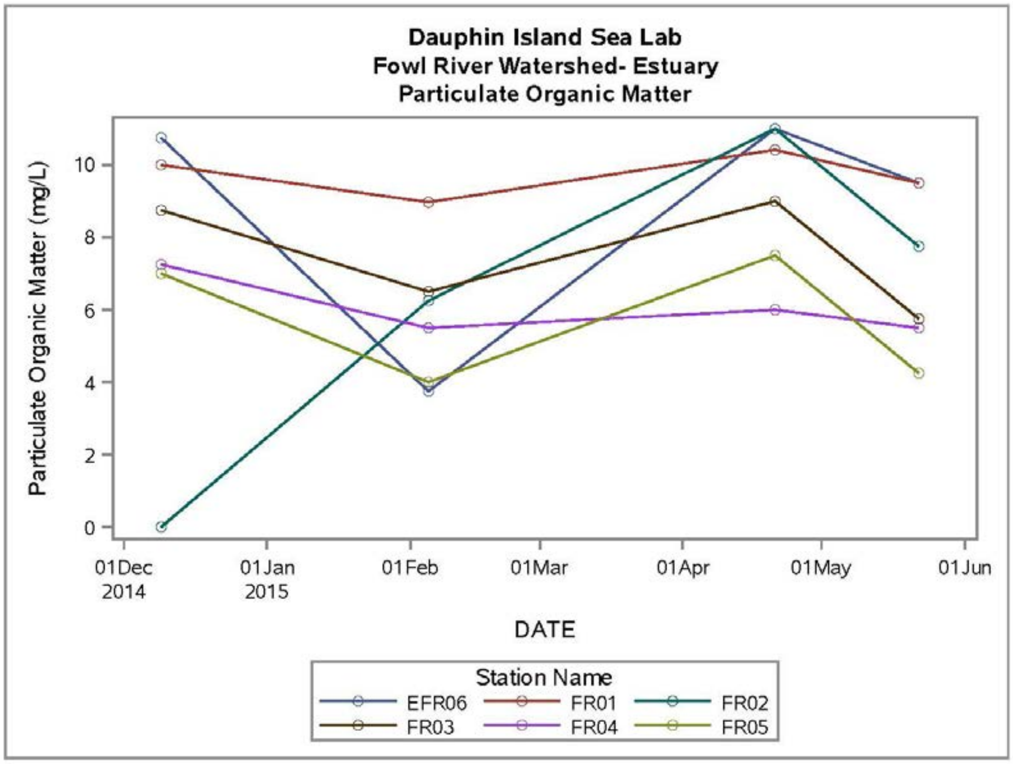
Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Total dissolved nitrogen
Total dissolved nitrogen (mg/L)
0.8
0.6
0.4
0.2
0.0
01Dec 2014
01Jan 2015
01Feb
01Mar
01Apr
01May
01Jun
DATE
Station Name
EFR06
FR01
FR02
FR03
FR04
FR05

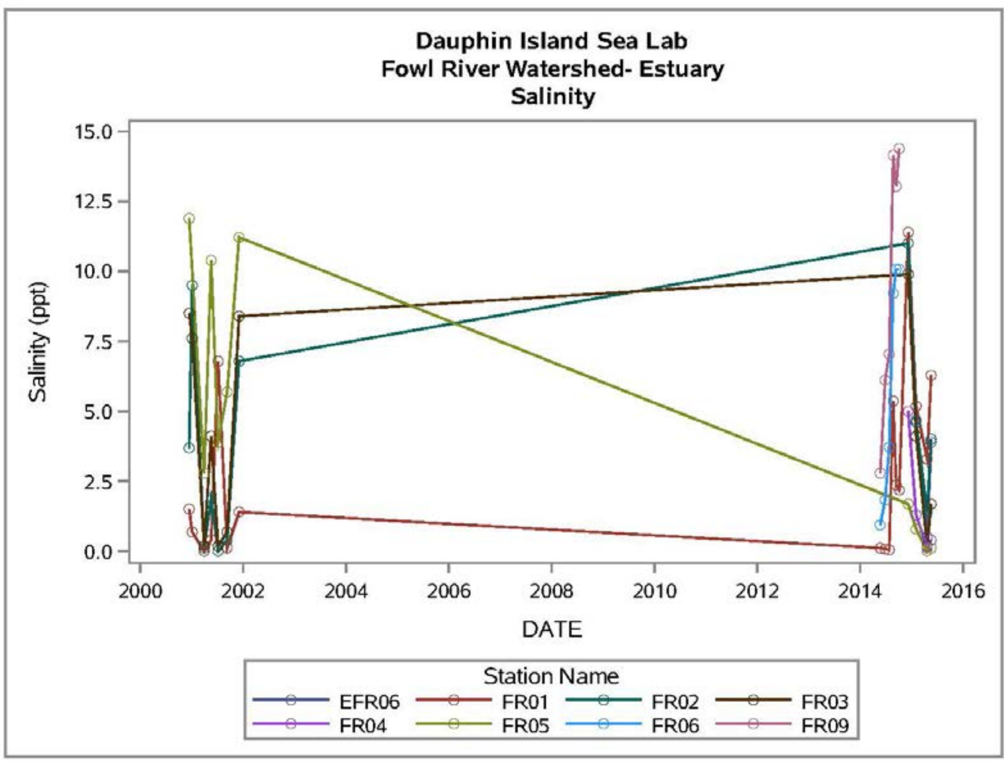
D. RAW DATA


Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Phosphate
Phosphate (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
01Dec 2014
01Jan 2015
01Feb
01Mar
01Apr
01May
01Jun
DATE
Station Name
EFR06
FR01
FR02
FR03
FR04
FR05

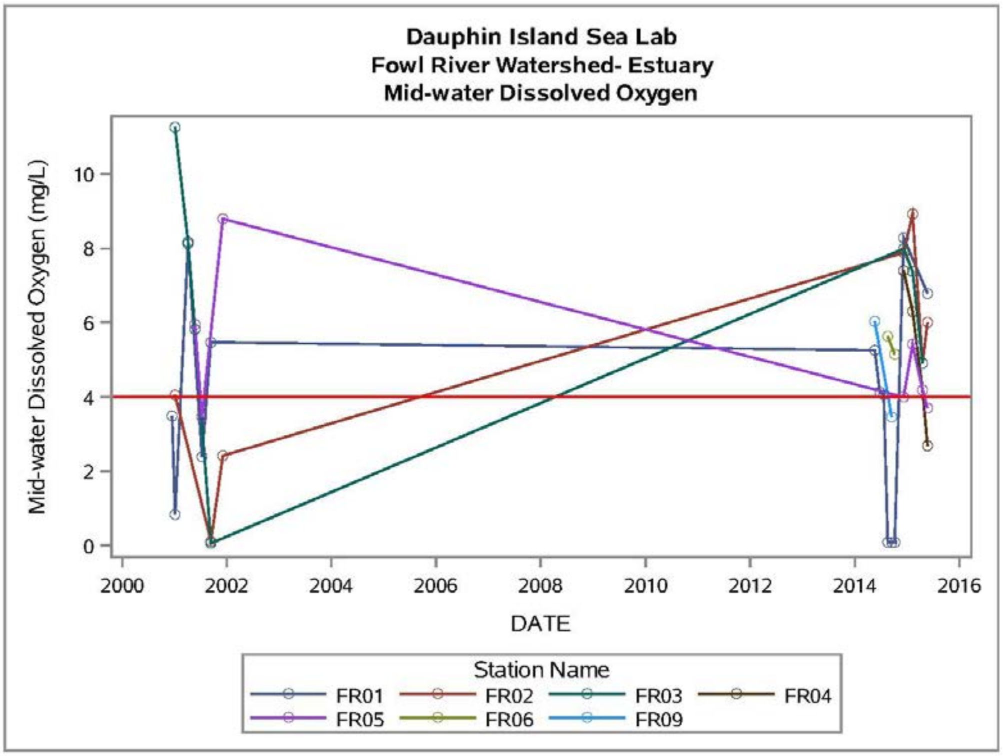

Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Total Suspended Solids
Total Suspended Solids (mg/L)
30
20
10
0
01Dec 2014
01Jan 2015
01Feb
01Mar
01Apr
01May
01Jun
DATE
Station Name
EFR06
FR01
FR02
FR03
FR04
FR05

D. RAW DATA

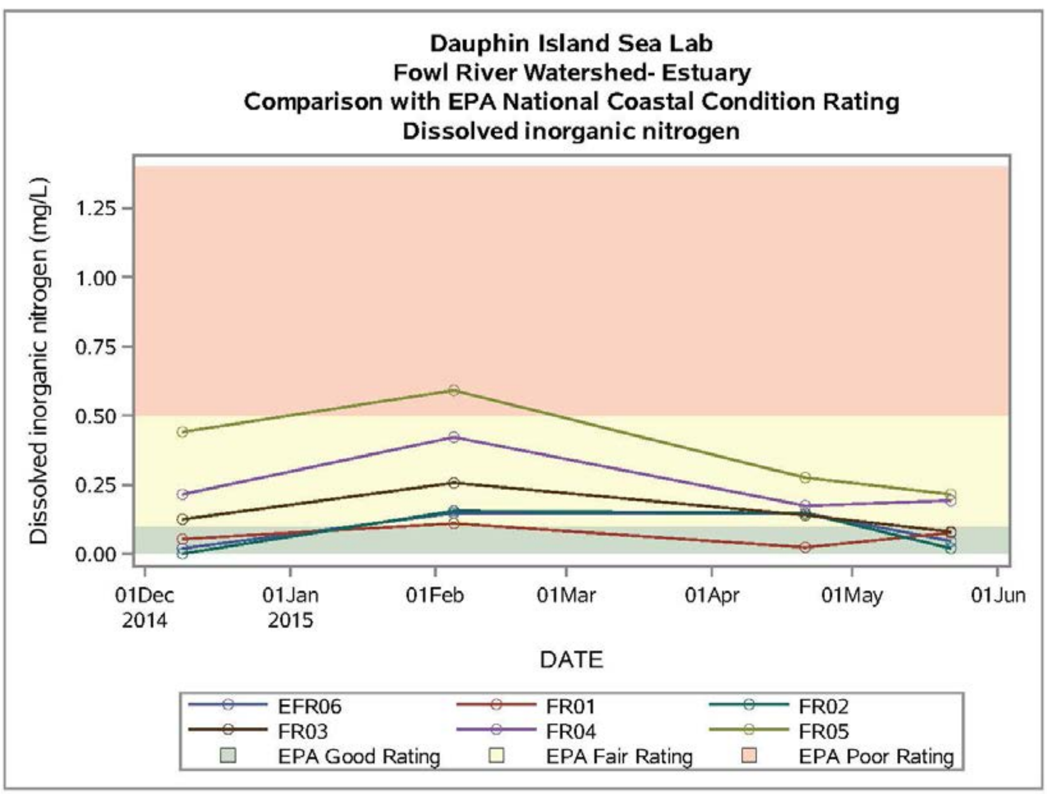

Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Particulate Organic Matter
Particulate Organic Matter (mg/L)
0
2
4
6
8
10
01Dec 2014
01Jan 2015
01Feb
01Mar
01Apr
01May
01Jun
DATE
Station Name
EFR06
FR01
FR02
FR03
FR04
FR05


Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Salinity
Salinity (ppt)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
2000
2002
2004
2006
2008
2010
2012
2014
2016
DATE
Station Name
EFR06
FR01
FR02
FR03
FR04
FR05
FR06
FR09

D. RAW DATA

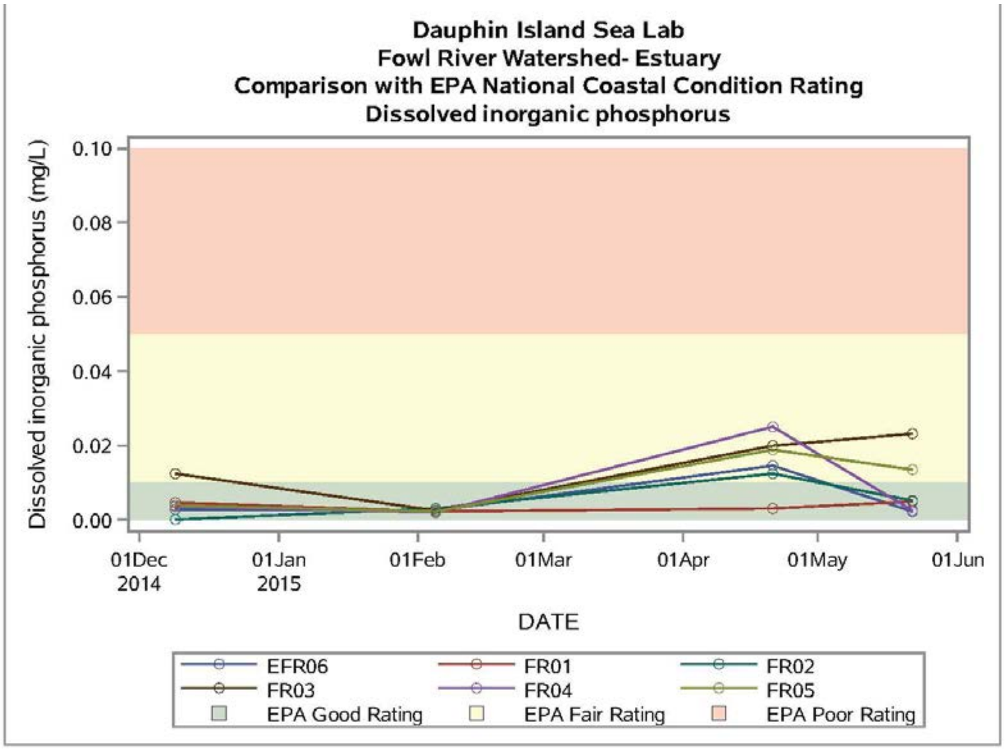


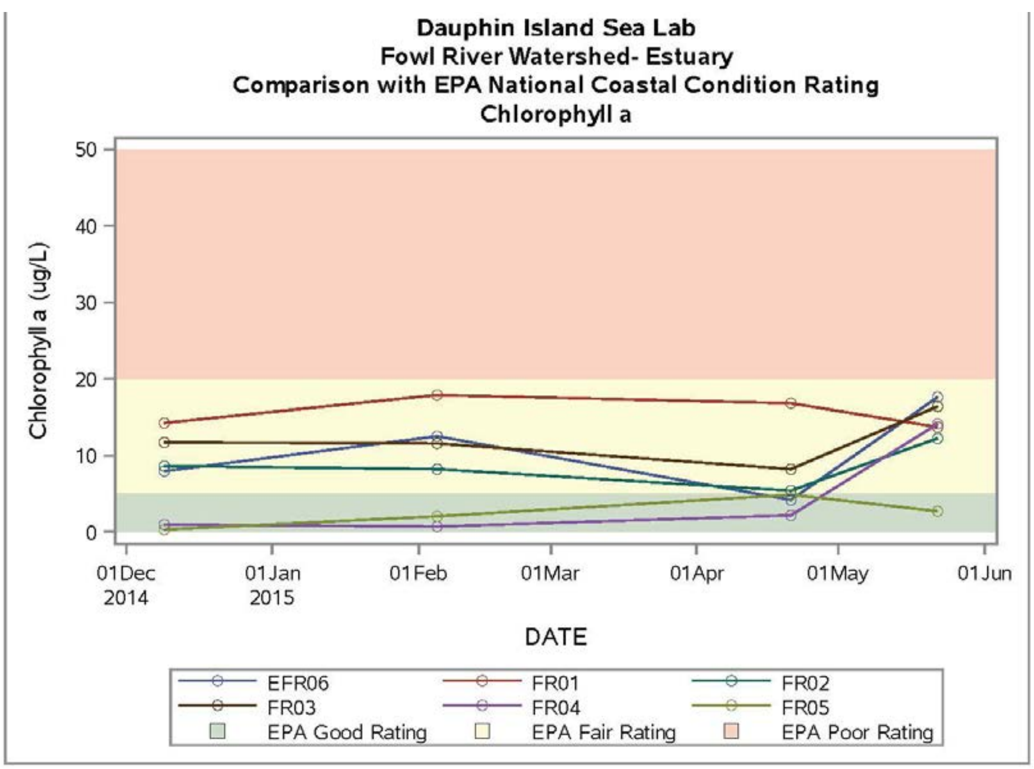
Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Mid-water Dissolved Oxygen
Mid-water Dissolved Oxygen (mg/L)
0
2
4
6
8
10
2000
2002
2004
2006
2008
2010
2012
2014
2016
DATE
Station Name
FR01
FR02
FR03
FR04
FR05
FR06
FR09



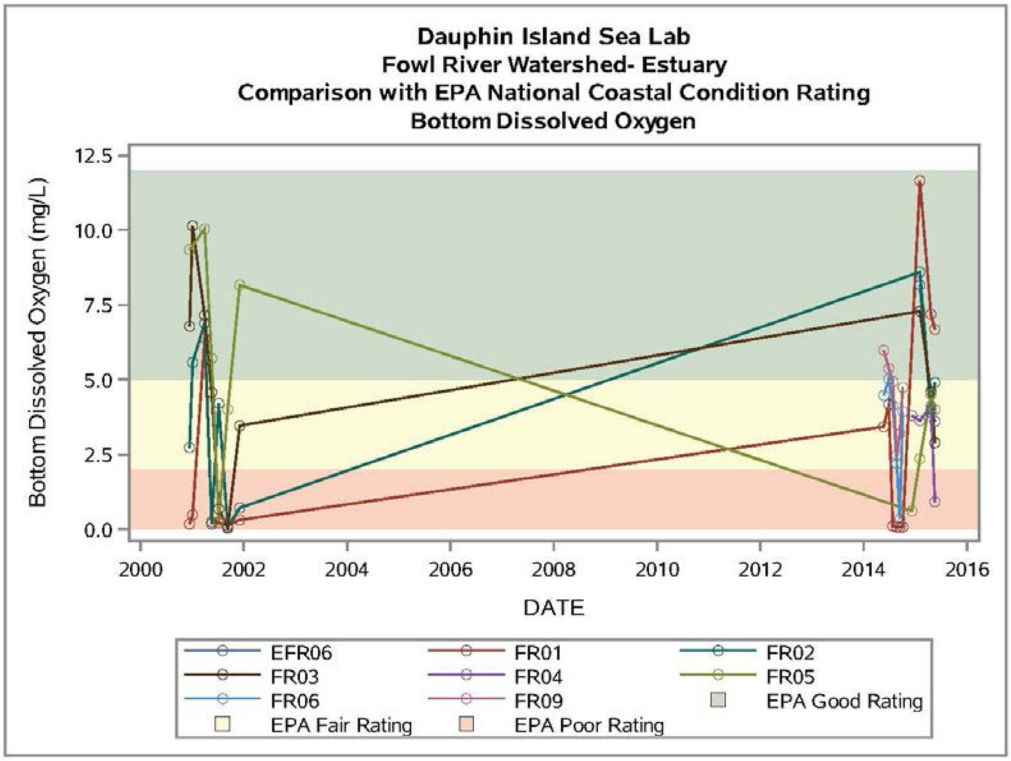
Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Comparison with EPA National Coastal Condition Rating
Dissolved inorganic nitrogen
Dissolved inorganic nitrogen (mg/L)
0.00
0.25
0.50
0.75
1.00
1.25
01Dec 2014
01Jan 2015
01Feb
01Mar
01Apr
01May
01Jun
DATE
EFR06
FR01
FR02
FR03
FR04
FR05
EPA Good Rating
EPA Fair Rating
EPA Poor Rating

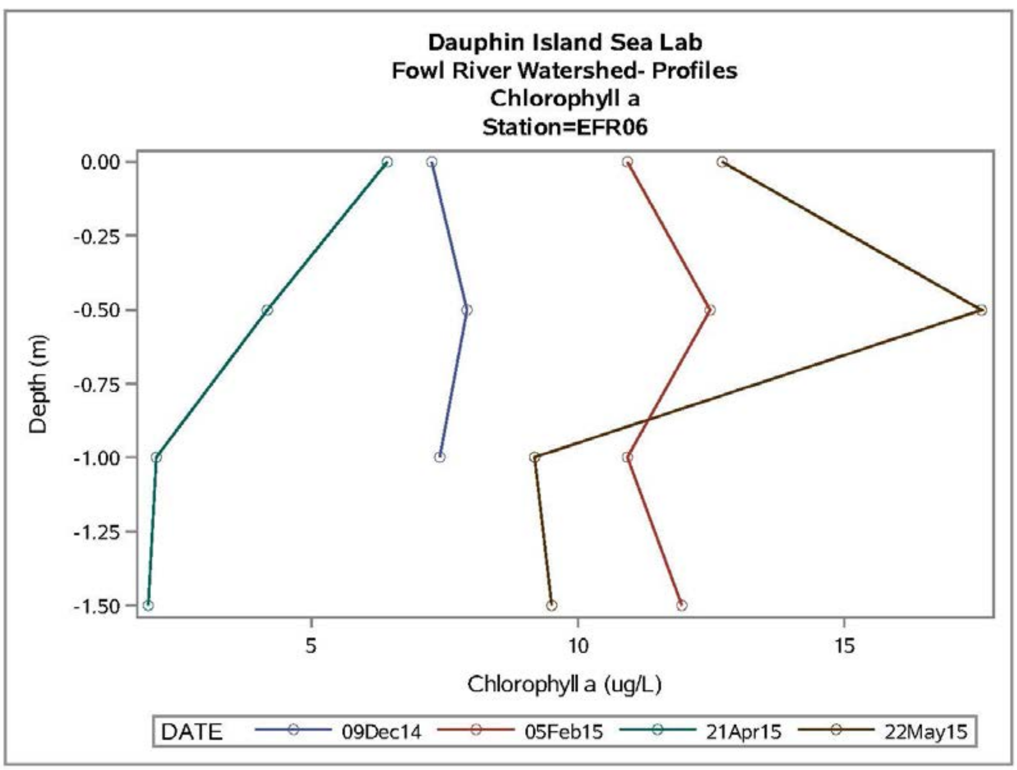
D. RAW DATA


Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Comparison with EPA National Coastal Condition Rating
Dissolved inorganic phosphorus
Dissolved inorganic phosphorus (mg/L)
0.10
0.08
0.06
0.04
0.02
0.00
01Dec 2014
01Jan 2015
01Feb
01Mar
01Apr
01May
01Jun
DATE
EFR06
FR01
FR02
FR03
FR04
FR05
EPA Good Rating
EPA Fair Rating
EPA Poor Rating

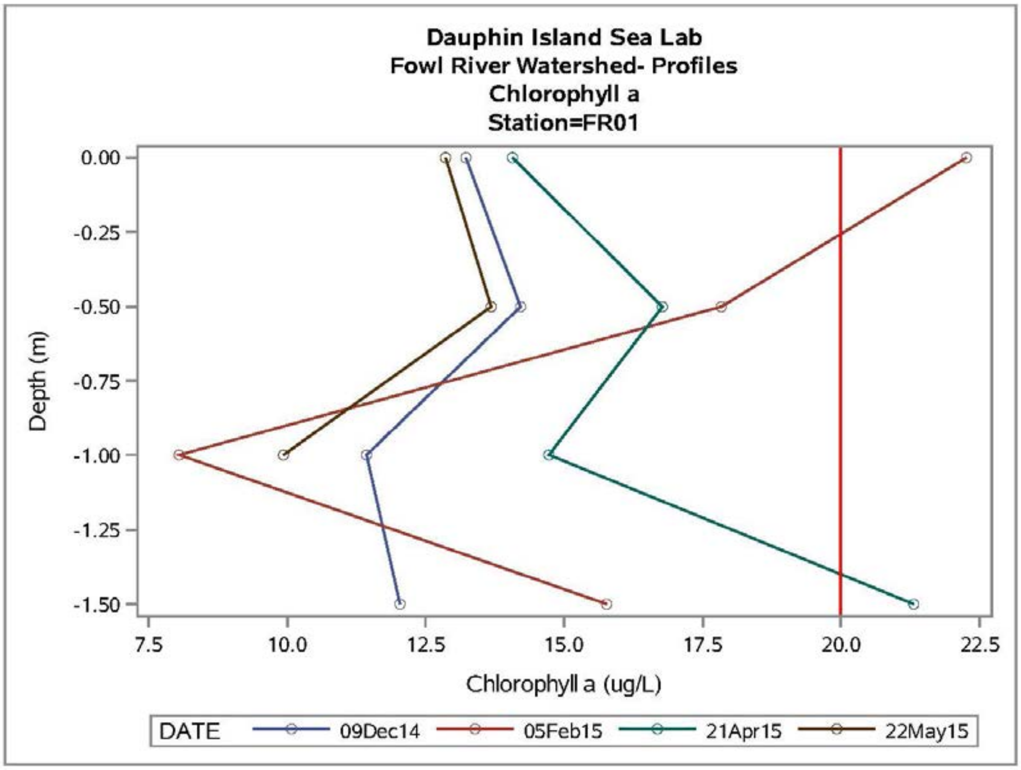

Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Comparison with EPA National Coastal Condition Rating
Chlorophyll a
Chlorophyll a (ug/L)
50
40
30
20
10
0
01Dec 2014
01Jan 2015
01Feb
01Mar
01Apr
01May
01Jun
DATE
EFR06
FR01
FR02
FR03
FR04
FR05
EPA Good Rating
EPA Fair Rating
EPA Poor Rating

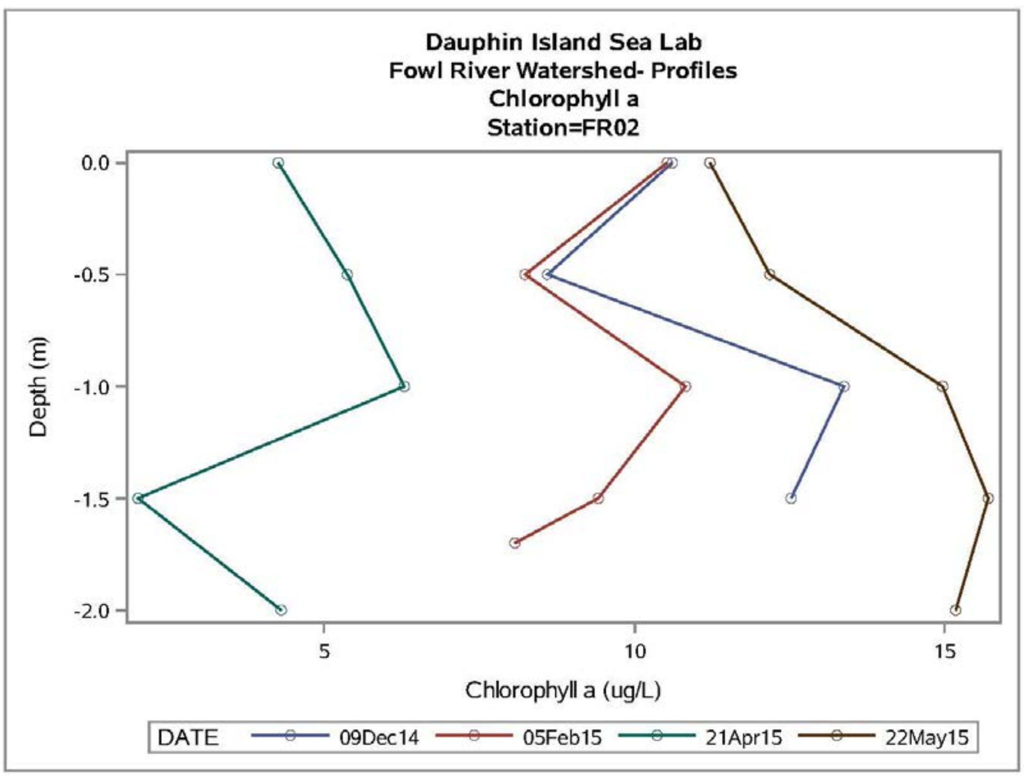
D. RAW DATA


Dauphin Island Sea Lab
Fowl River Watershed- Estuary
Comparison with EPA National Coastal Condition Rating
Bottom Dissolved Oxygen
Bottom Dissolved Oxygen (mg/L)
12.5
10.0
7.5
5.0
2.5
0.0
2000
2002
2004
2006
2008
2010
2012
2014
2016
DATE
EFR06
FR01
FR02
FR03
FR04
FR05
FR06
FR09
EPA Good Rating
EPA Fair Rating
EPA Poor Rating

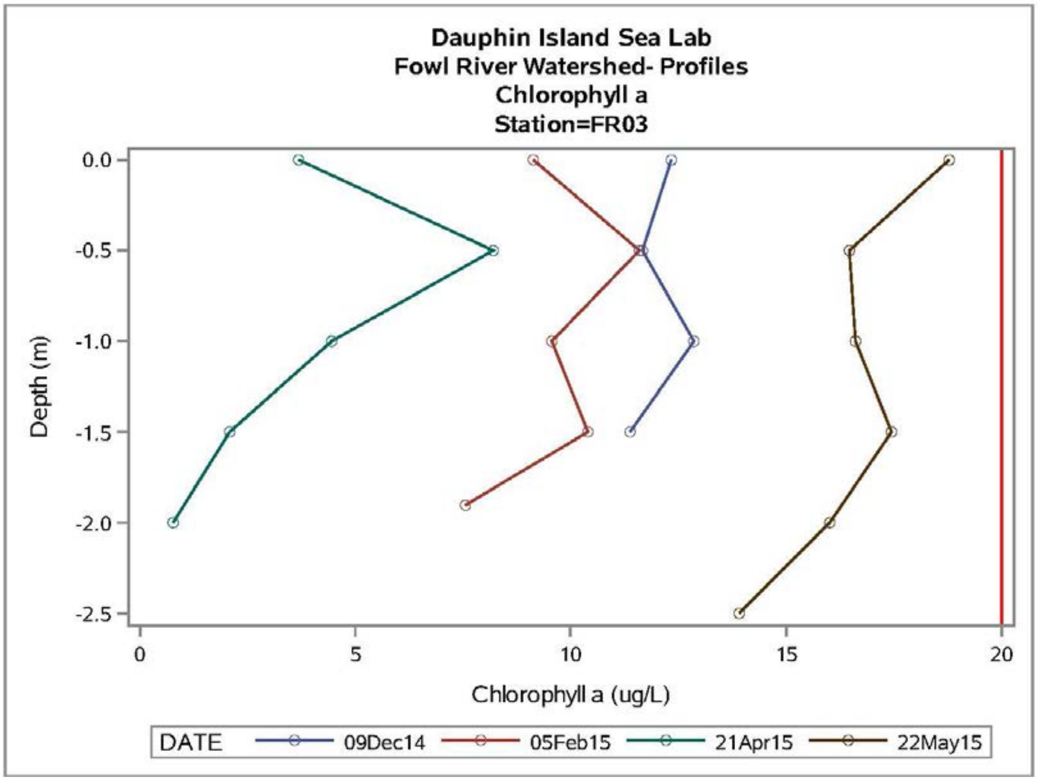

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Chlorophyll a
Station=EFR06
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
5
10
15
Chlorophyll a (ug/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

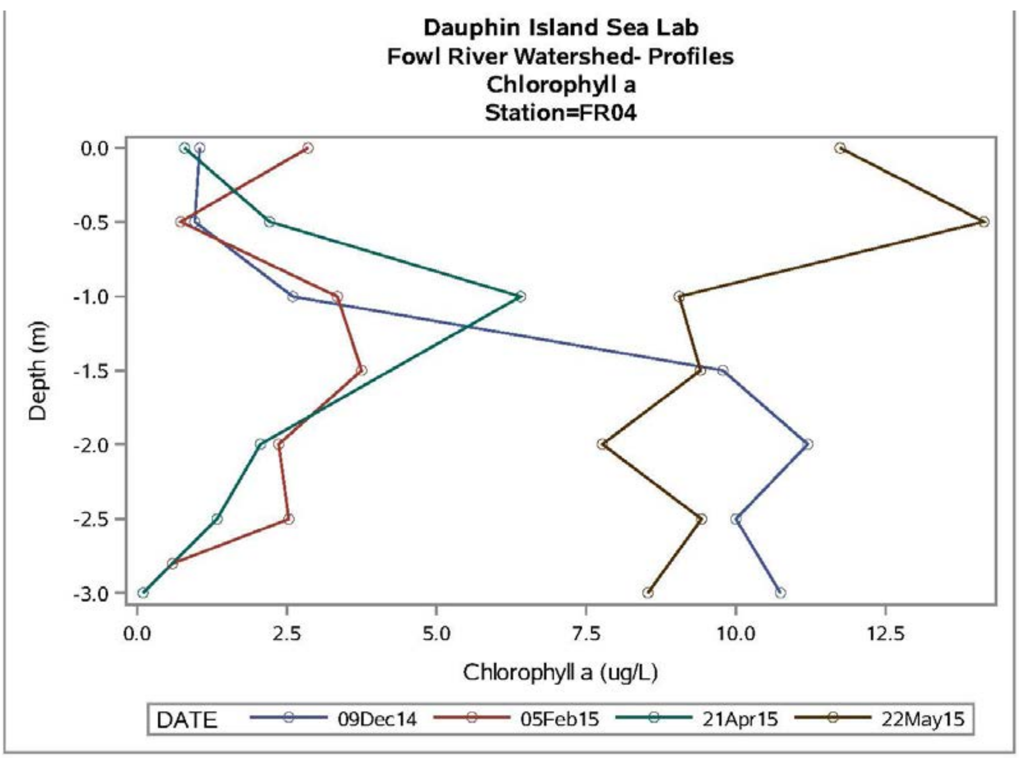

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Chlorophyll a
Station=FR01
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
Depth (m)
7.5
10.0
12.5
15.0
17.5
20.0
22.5
Chlorophyll a (ug/L)
DATE
09Dec14
05Feb15
21Apr15
22May15


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Chlorophyll a
Station=FR02
0.0
-0.5
-1.0
-1.5
-2.0
Depth (m)
5
10
15
Chlorophyll a (ug/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

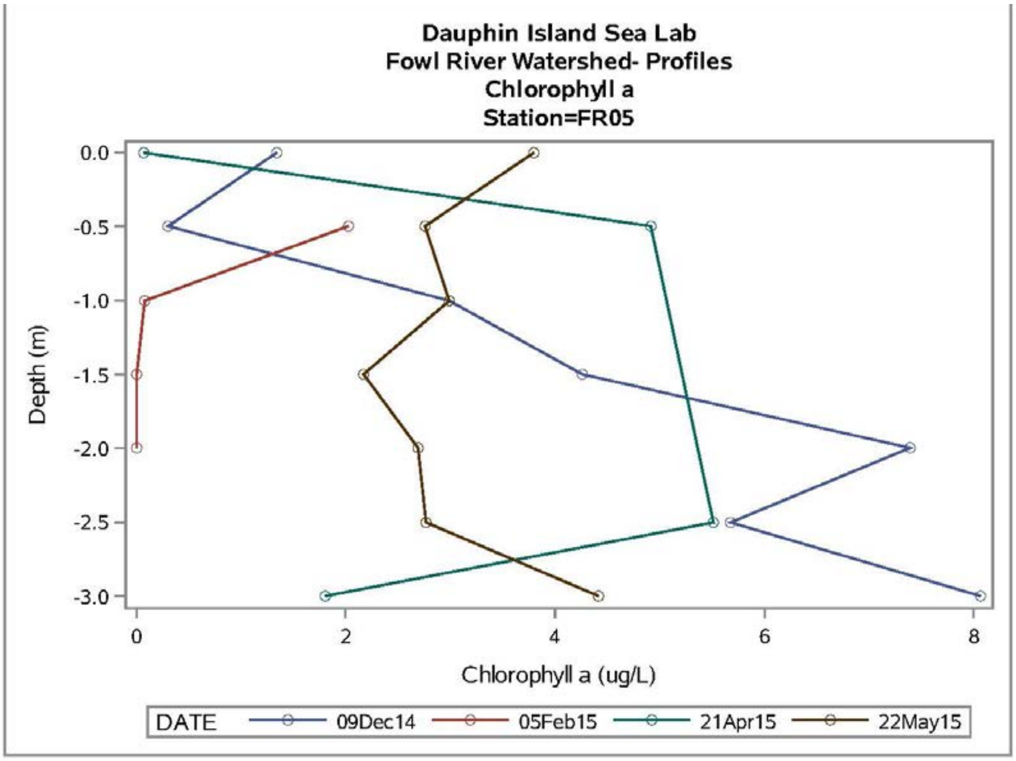


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Chlorophyll a
Station=FR03
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
0
5
10
15
20
Chlorophyll a (ug/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

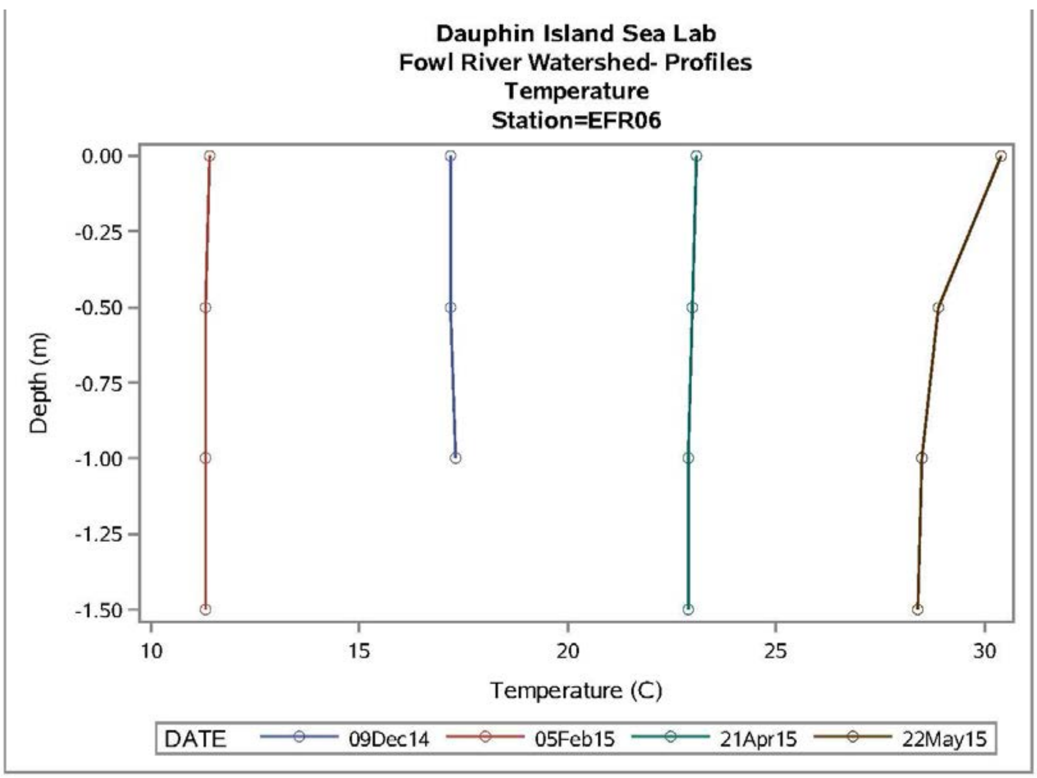


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Chlorophyll a
Station=FR04
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0.0
2.5
5.0
7.5
10.0
12.5
Chlorophyll a (ug/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

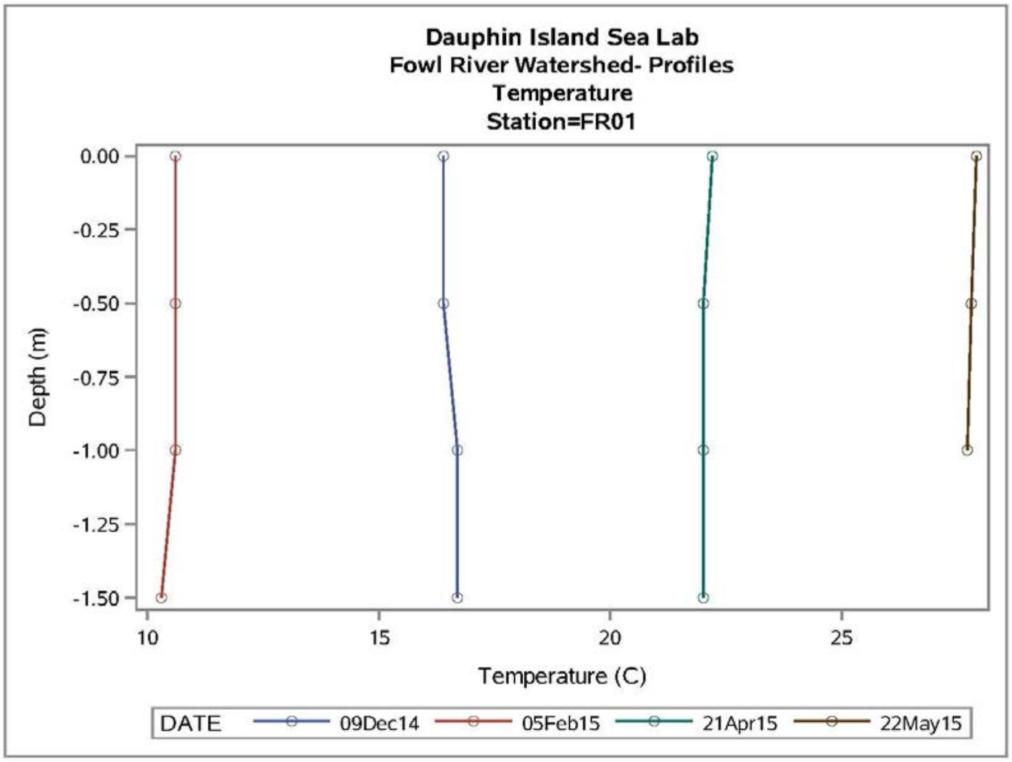


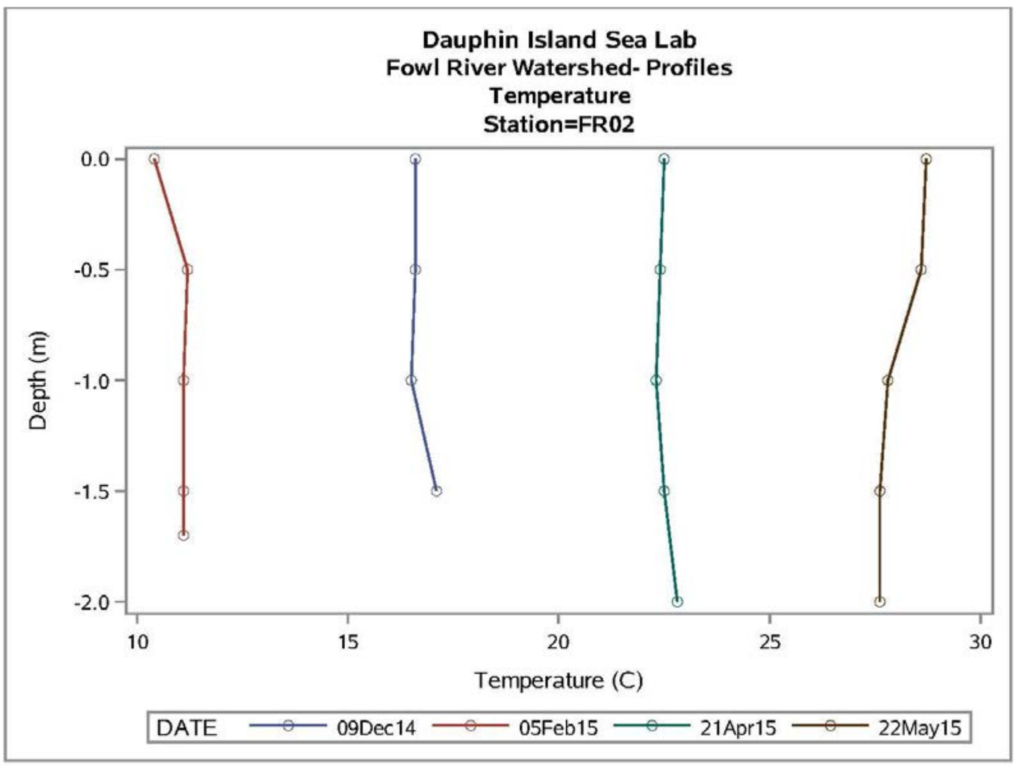
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Chlorophyll a
Station=FR05
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0
2
4
6
8
Chlorophyll a (ug/L)
DATE
09Dec14
05Feb15
21Apr15
22May15



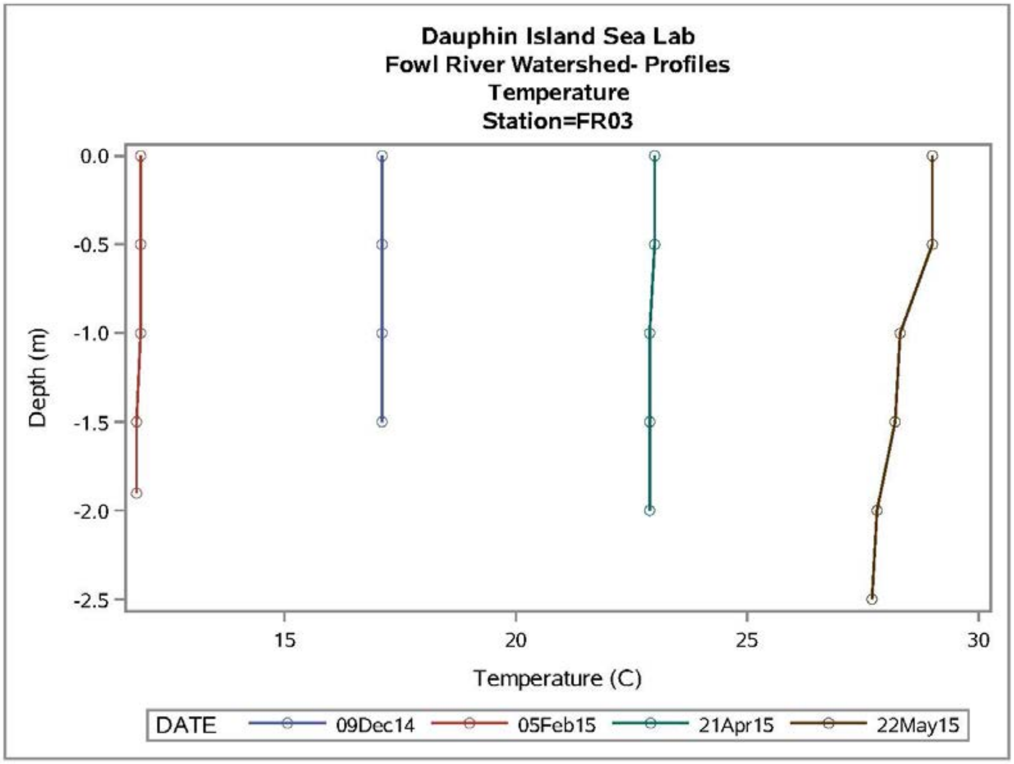
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Temperature
Station=EFR06
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
10
15
20
25
30
Temperature (C)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

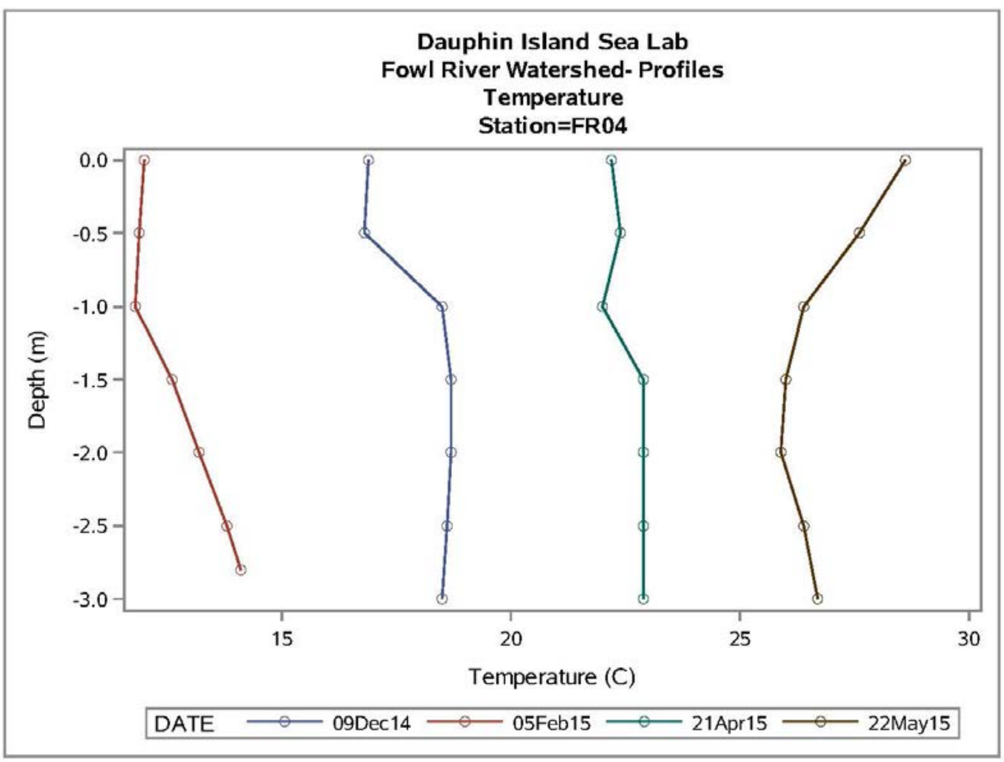

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Temperature
Station=FR01
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
10
15
20
25
Temperature (C)
DATE
09Dec14
05Feb15
21Apr15
22May15


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Temperature
Station=FR02
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
10
15
20
25
30
Temperature (C)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

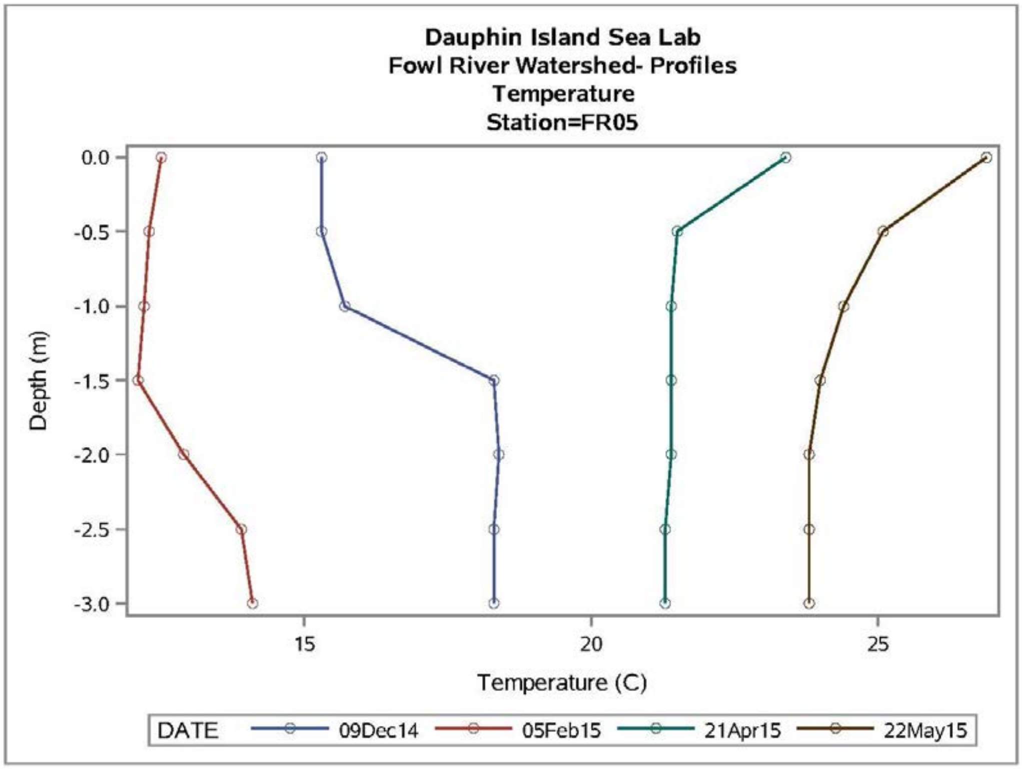


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Temperature
Station=FR03
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
Depth (m)
15
20
25
30
Temperature (C)
DATE
09Dec14
05Feb15
21Apr15
22May15

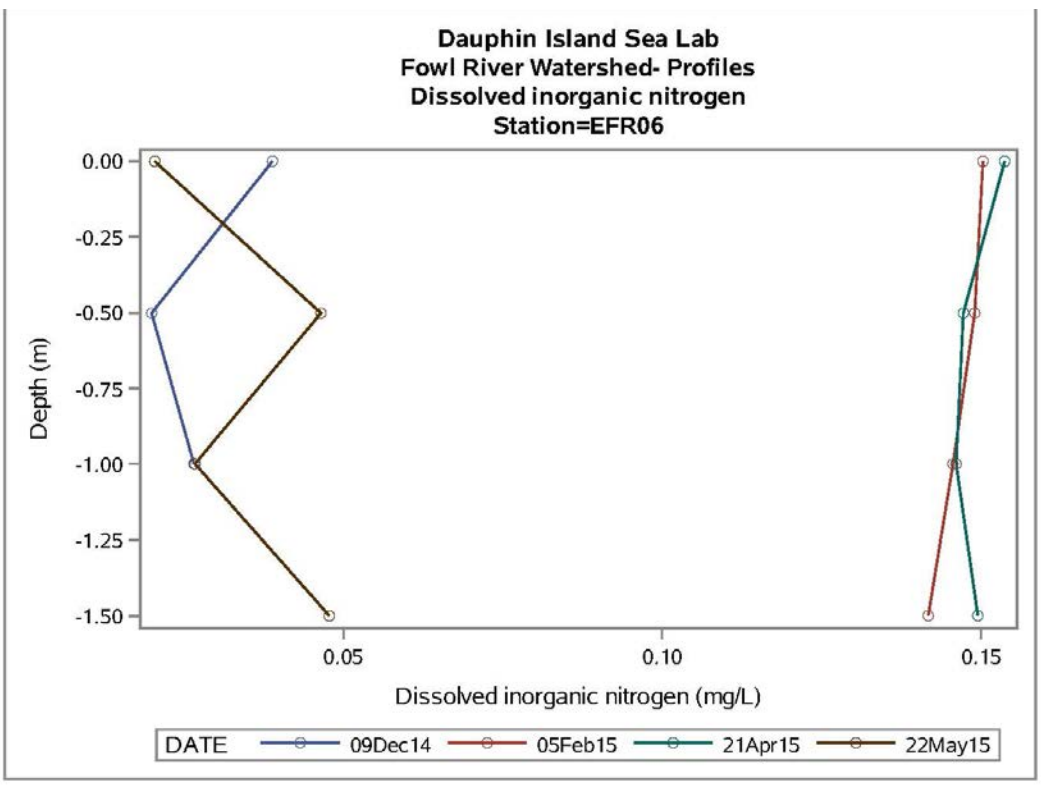


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Temperature
Station=FR04
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
Depth (m)
15
20
25
30
Temperature (C)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

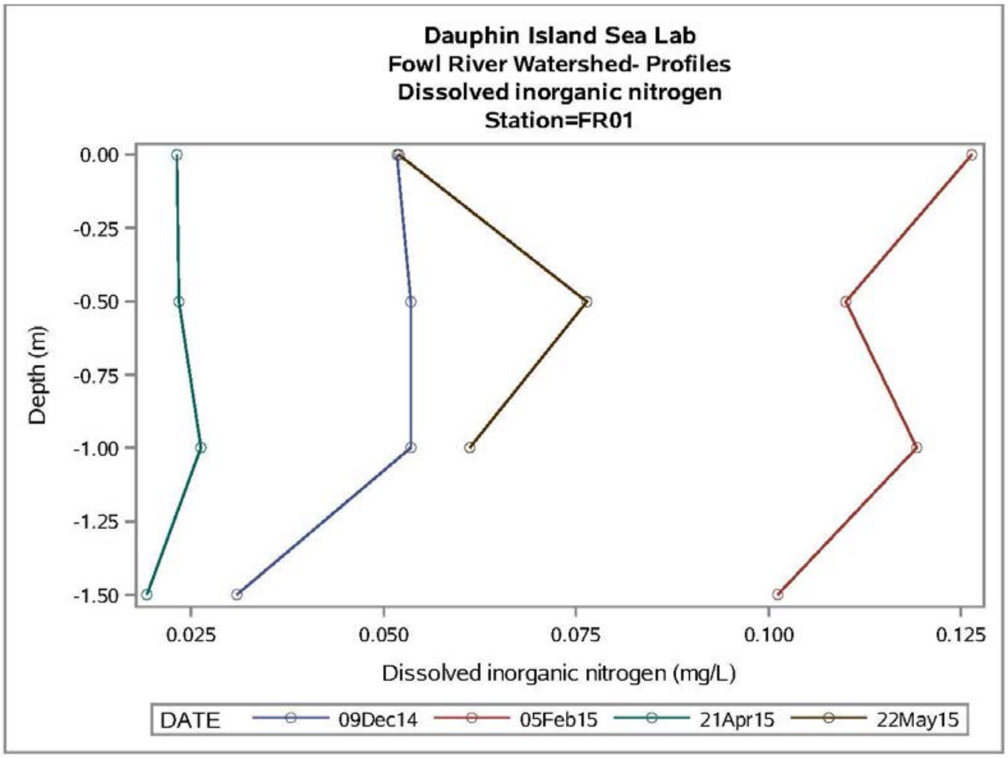


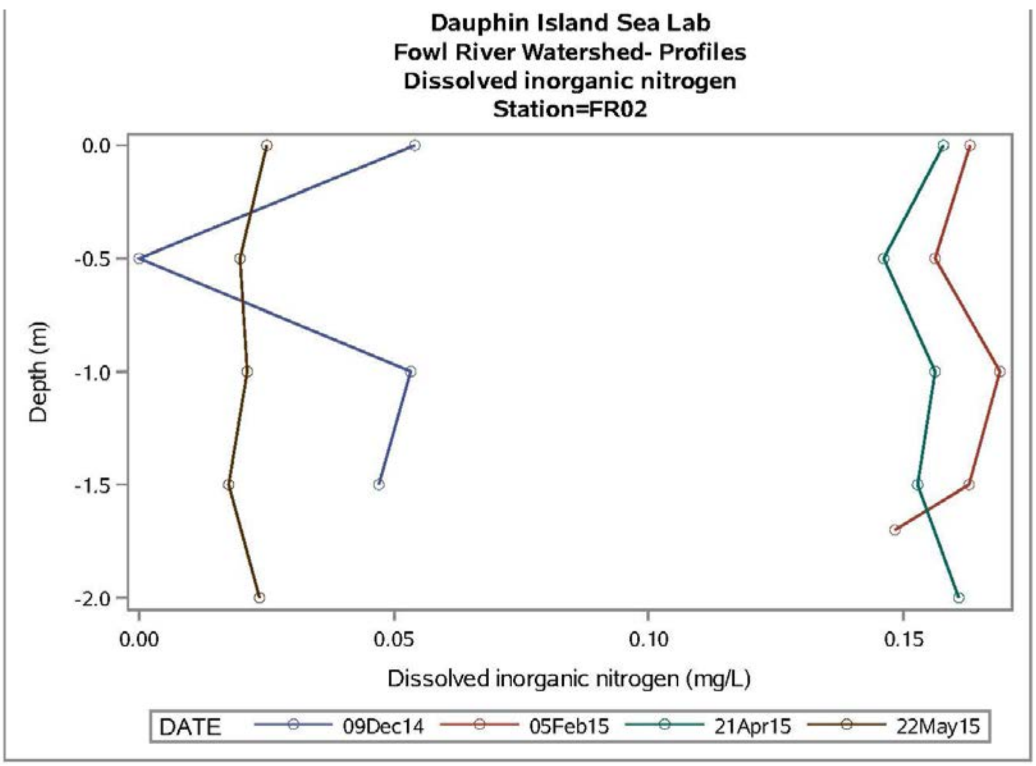
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Temperature
Station=FR05
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
15
20
25
Temperature (C)
DATE
09Dec14
05Feb15
21Apr15
22May15



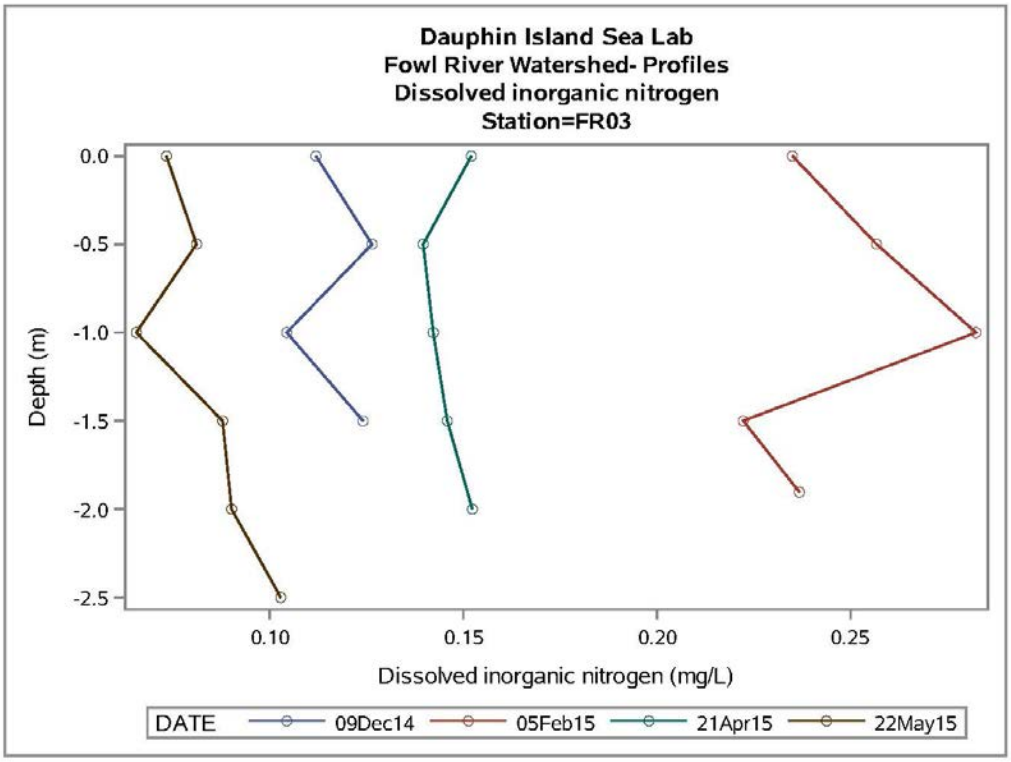
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved inorganic nitrogen
Station=EFR06
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
0.05
0.10
0.15
Dissolved inorganic nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

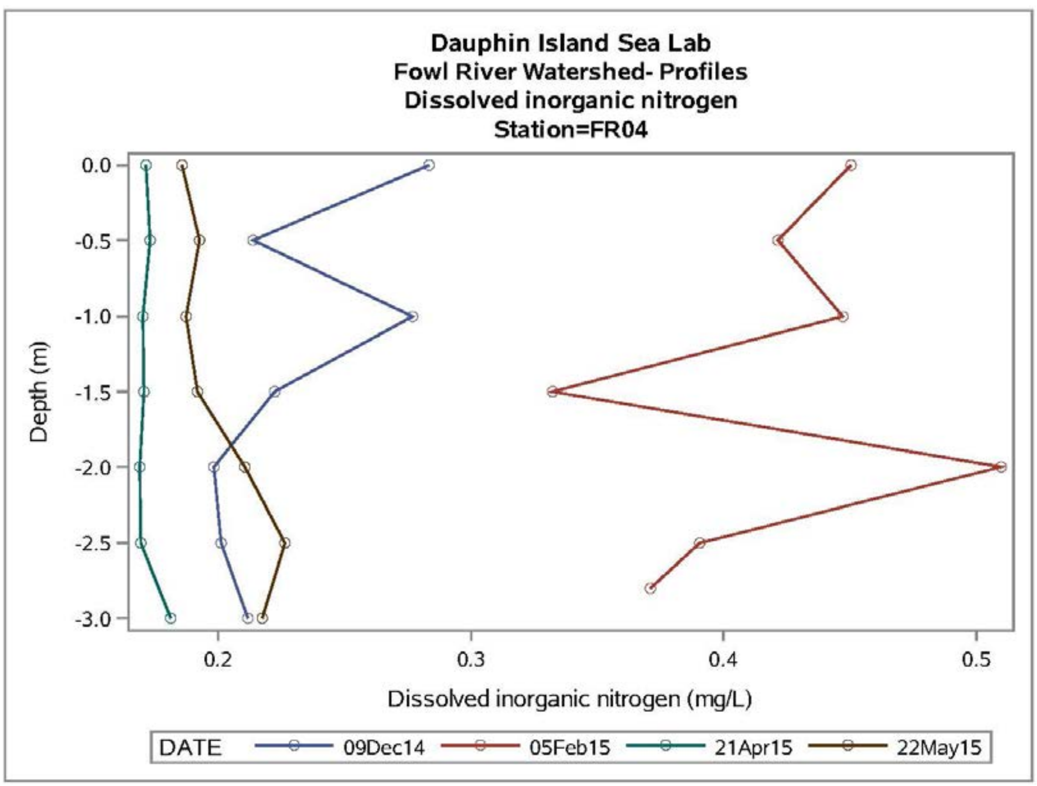

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved inorganic nitrogen
Station=FR01
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
Depth (m)
0.025
0.050
0.075
0.100
0.125
Dissolved inorganic nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved inorganic nitrogen
Station=FR02
0.0
-0.5
-1.0
-1.5
-2.0
Depth (m)
0.00
0.05
0.10
0.15
Dissolved inorganic nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

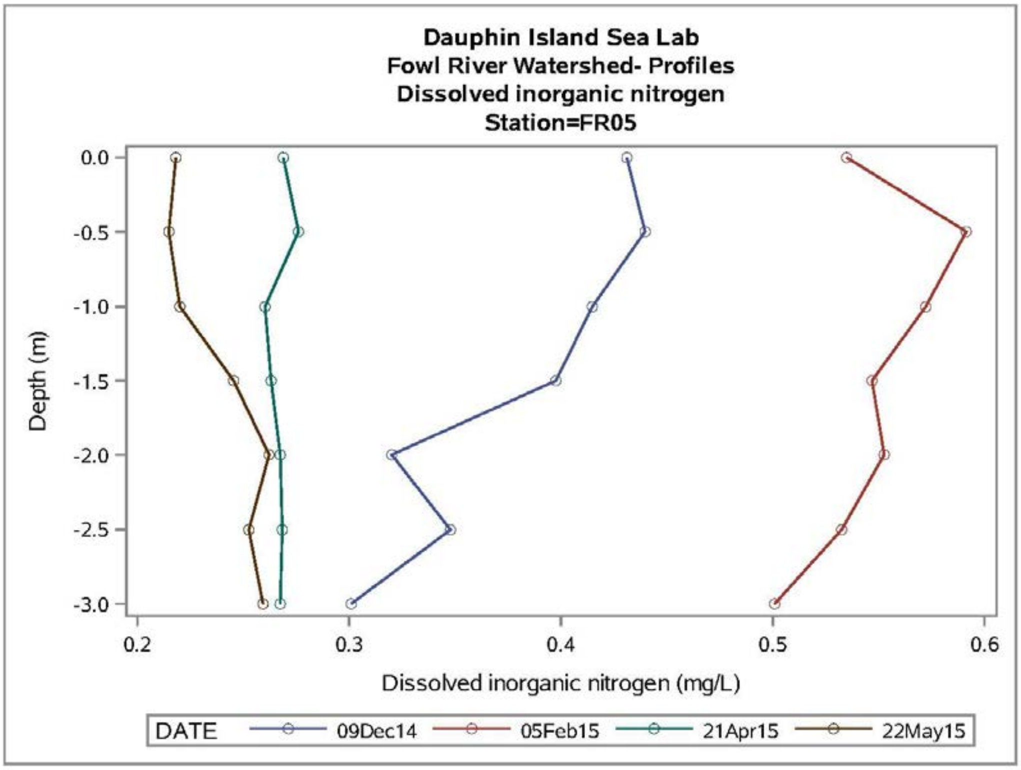


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved inorganic nitrogen
Station=FR03
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
0.10
0.15
0.20
0.25
Dissolved inorganic nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

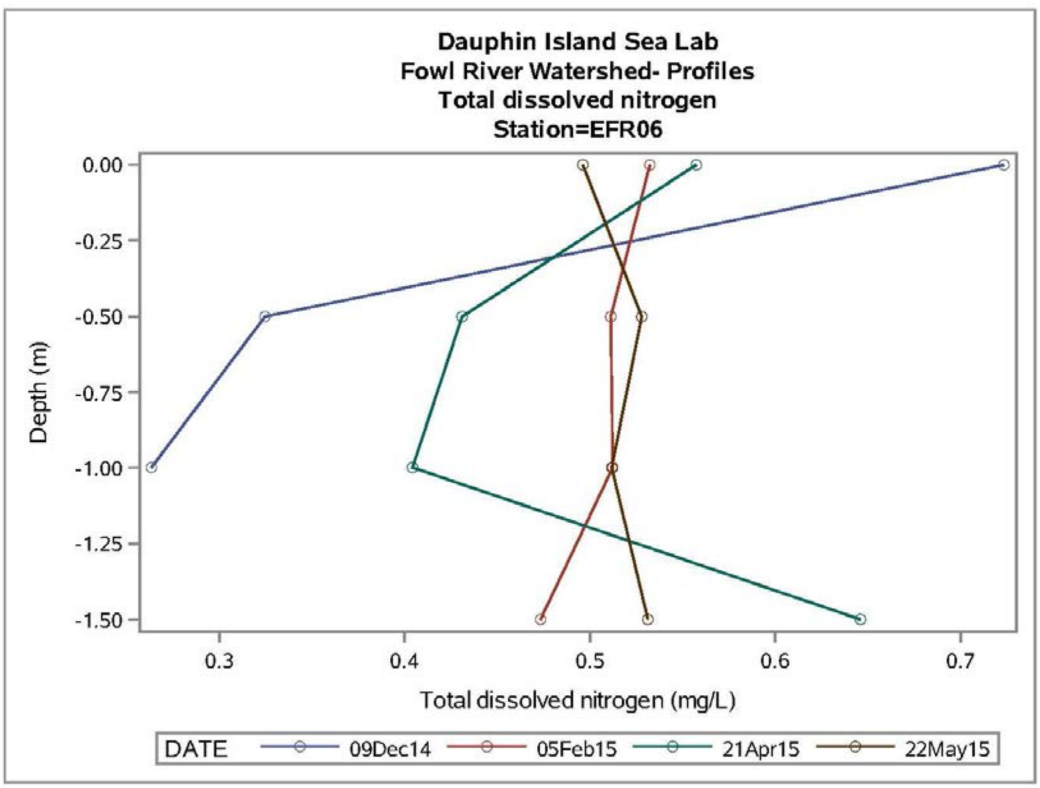


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved inorganic nitrogen
Station=FR04
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0.2
0.3
0.4
0.5
Dissolved inorganic nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

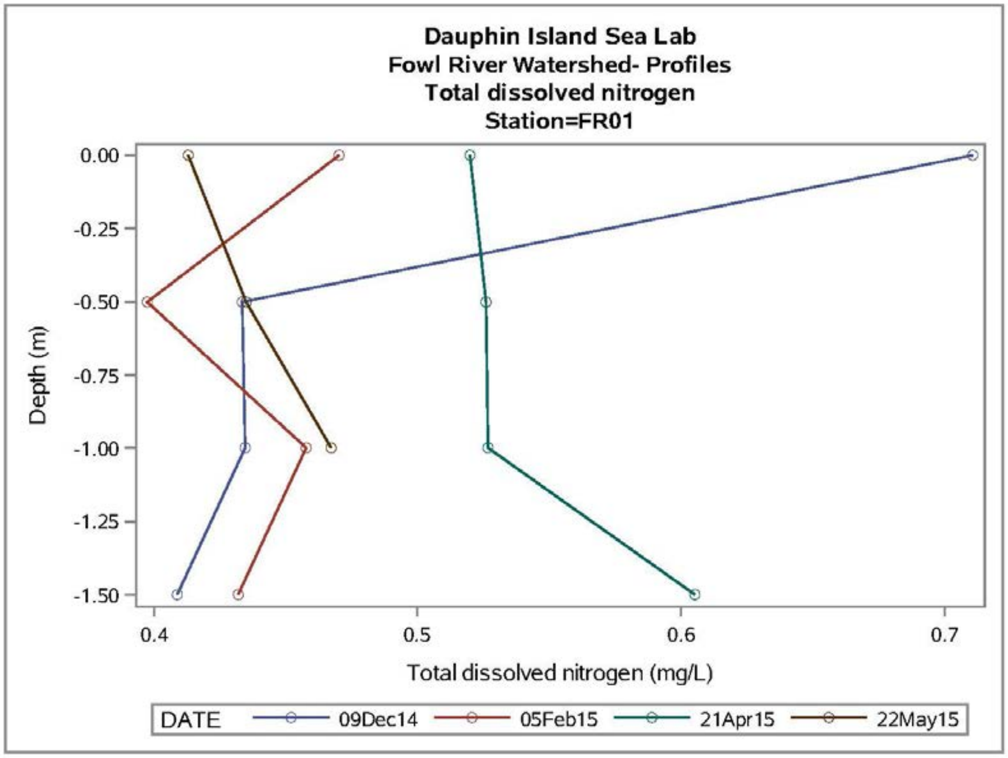


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved inorganic nitrogen
Station=FR05
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0.2
0.3
0.4
0.5
0.6
Dissolved inorganic nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

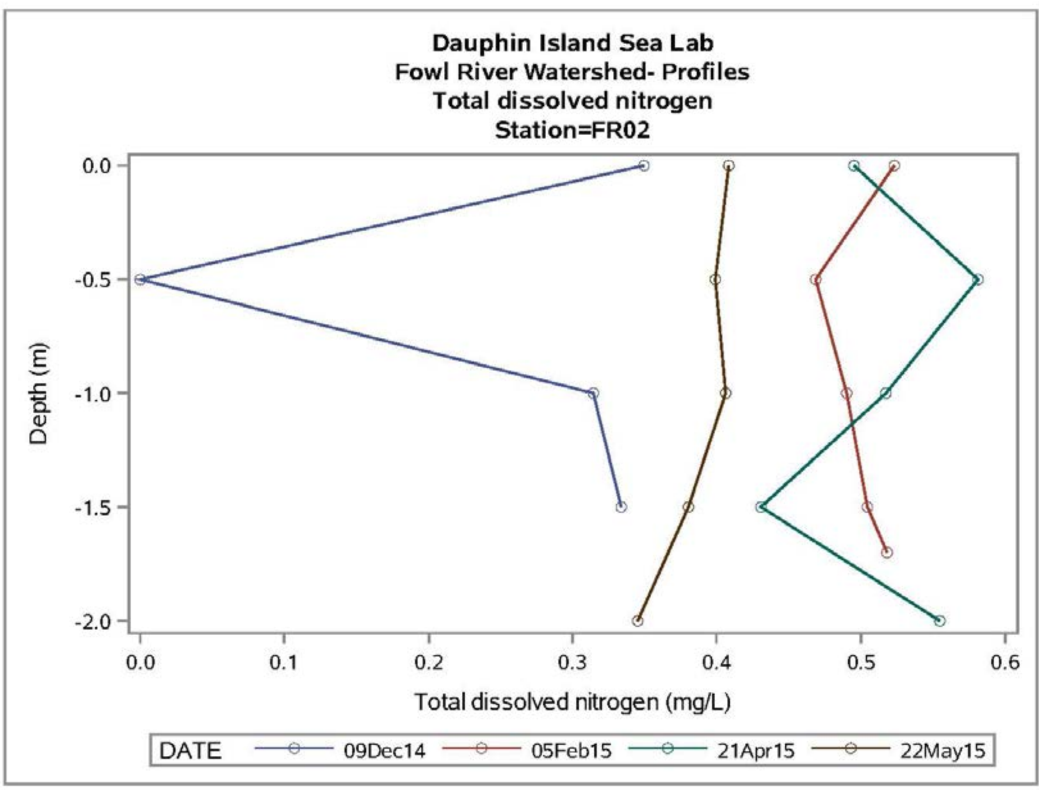


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total dissolved nitrogen
Station=EFR06
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
0.3
0.4
0.5
0.6
0.7
Total dissolved nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

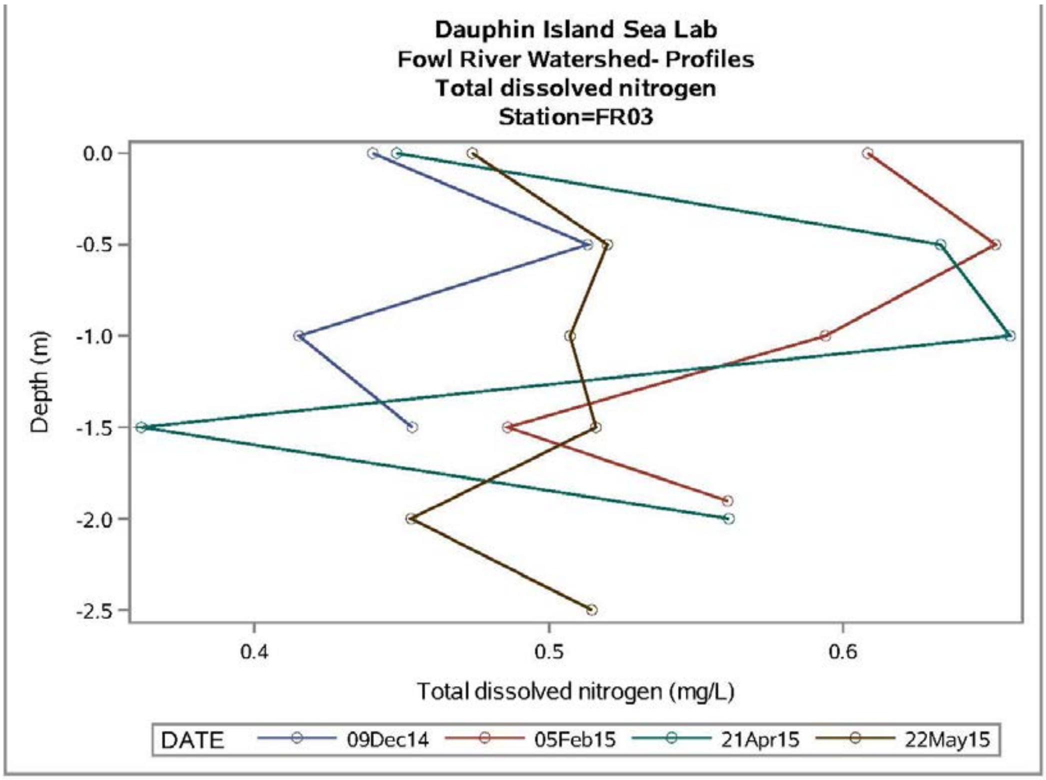


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total dissolved nitrogen
Station=FR01
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
0.4
0.5
0.6
0.7
Total dissolved nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

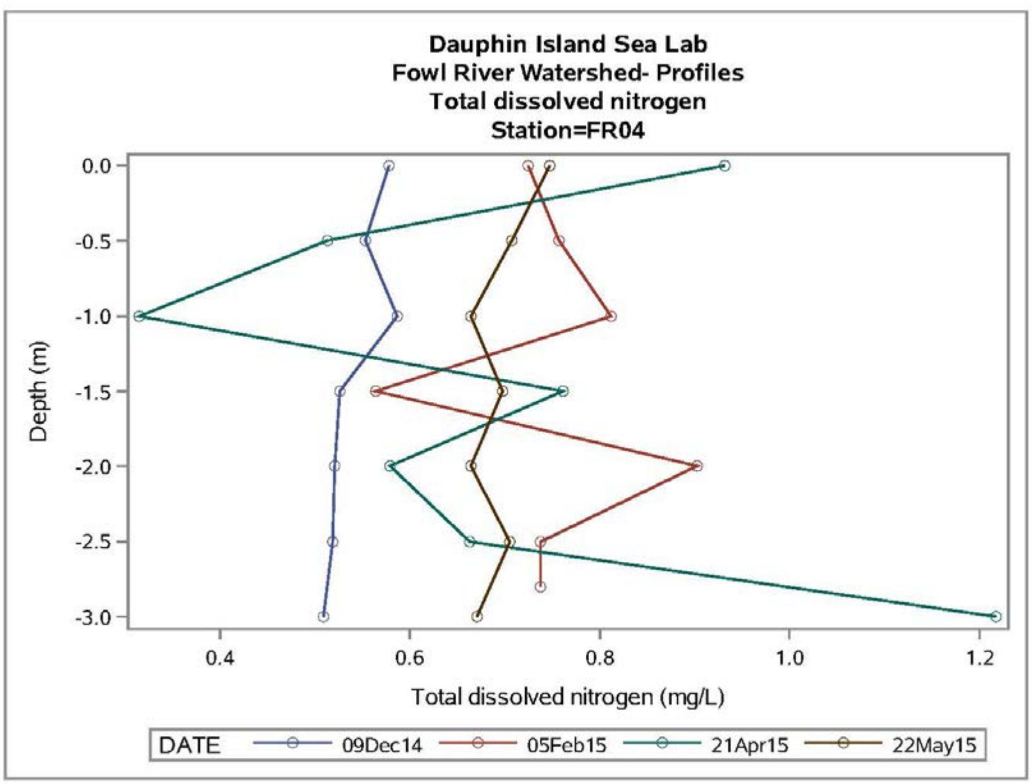


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total dissolved nitrogen
Station=FR02
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Total dissolved nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

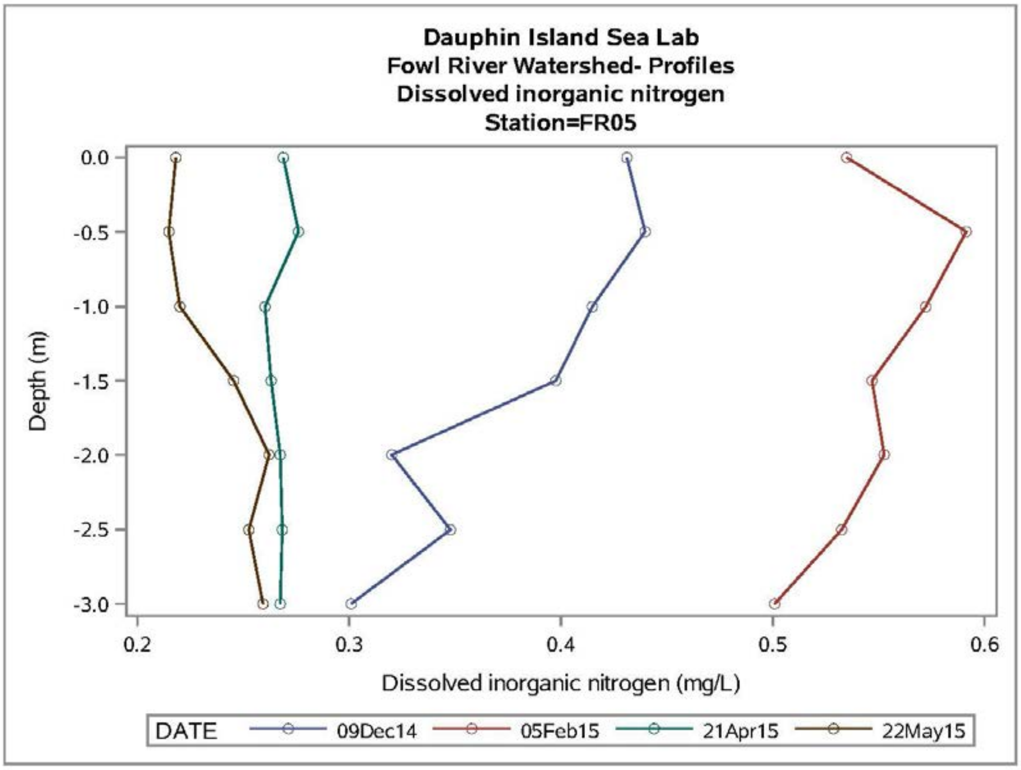


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total dissolved nitrogen
Station=FR03
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
0.4
0.5
0.6
Total dissolved nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

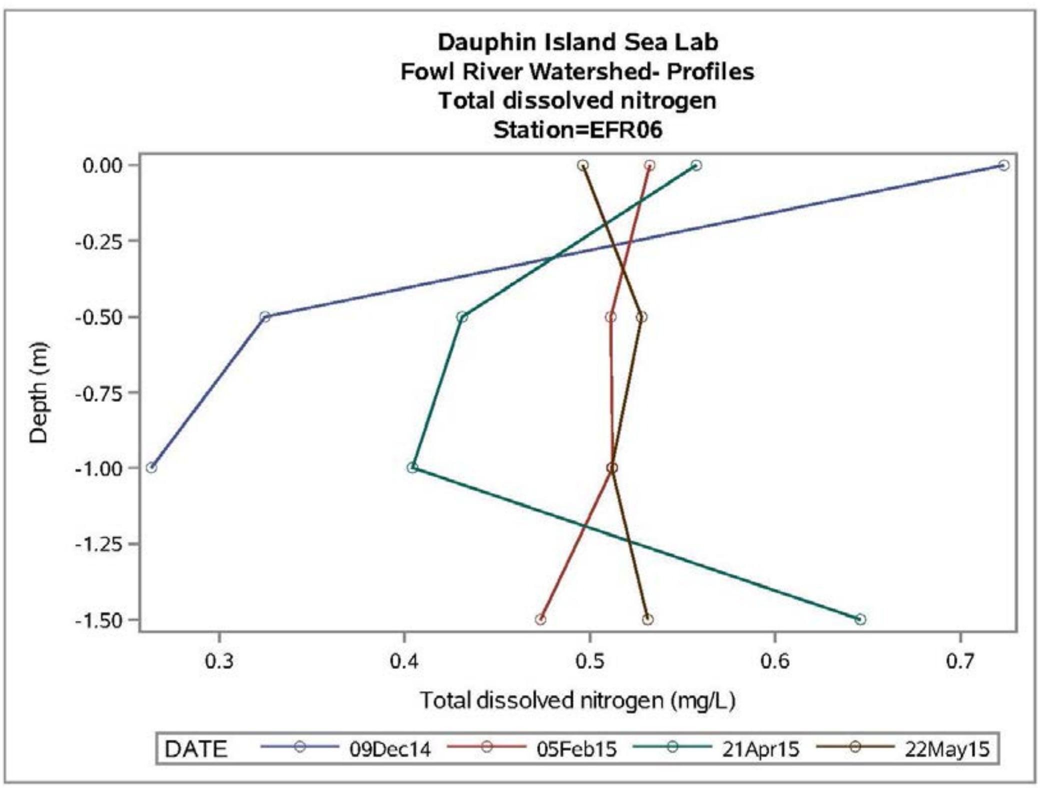


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total dissolved nitrogen
Station=FR04
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0.4
0.6
0.8
1.0
1.2
Total dissolved nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

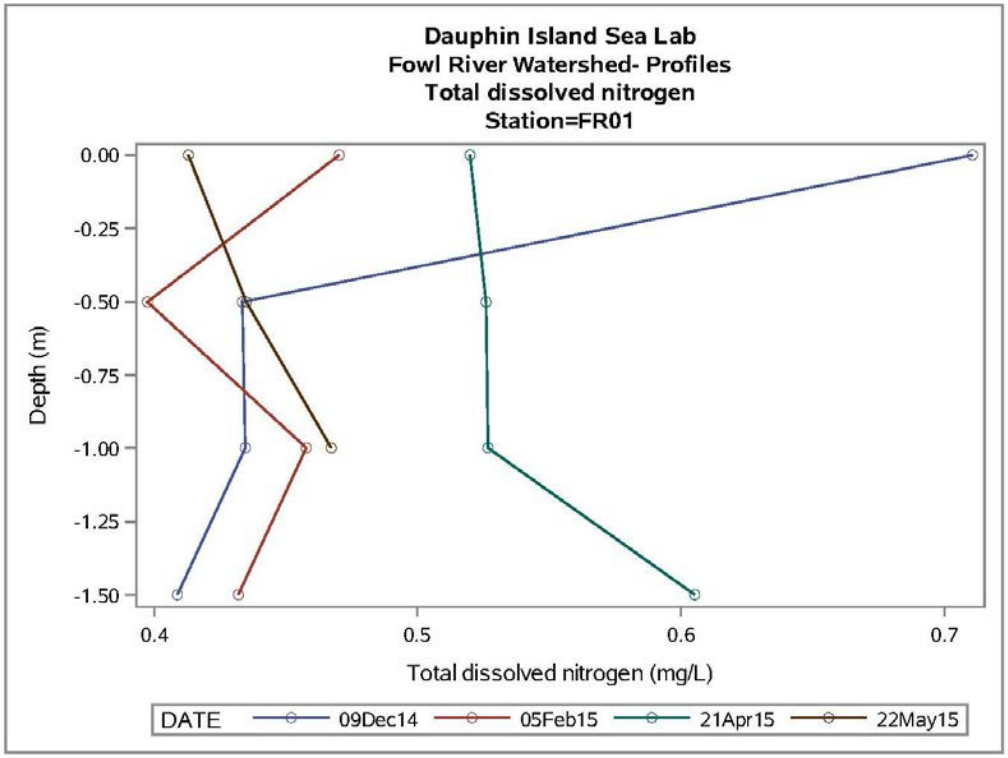


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved inorganic nitrogen
Station=FR05
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0.2
0.3
0.4
0.5
0.6
Dissolved inorganic nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

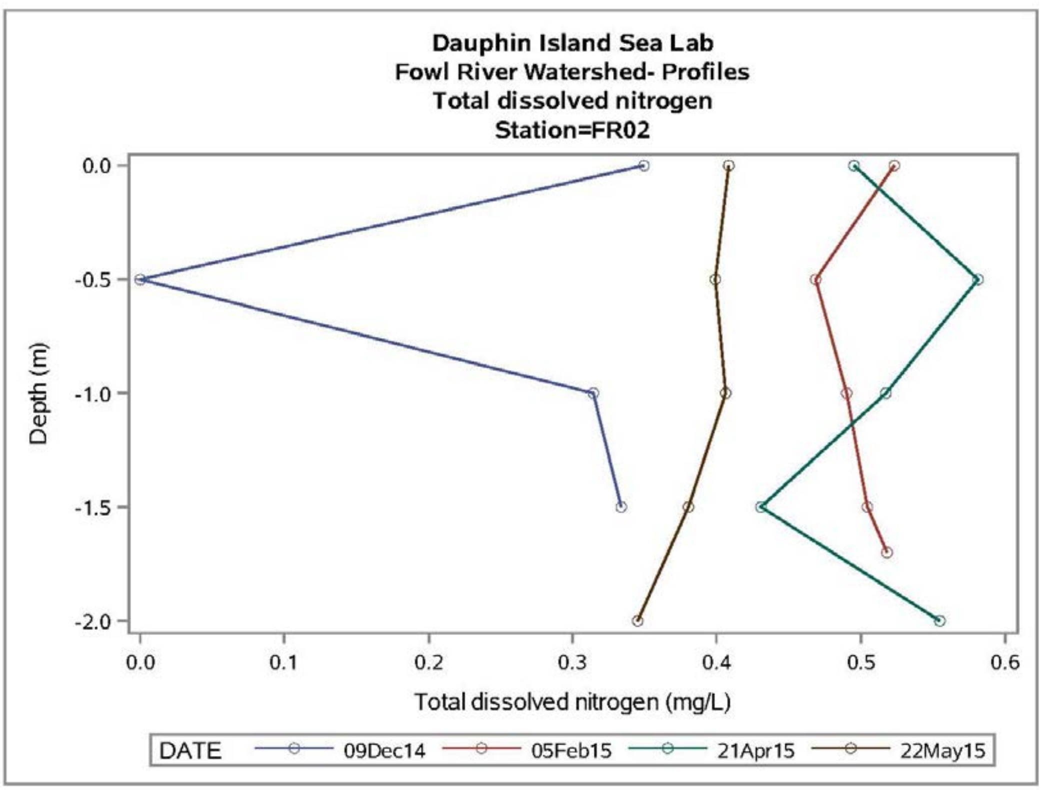


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total dissolved nitrogen
Station=EFR06
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
0.3
0.4
0.5
0.6
0.7
Total dissolved nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

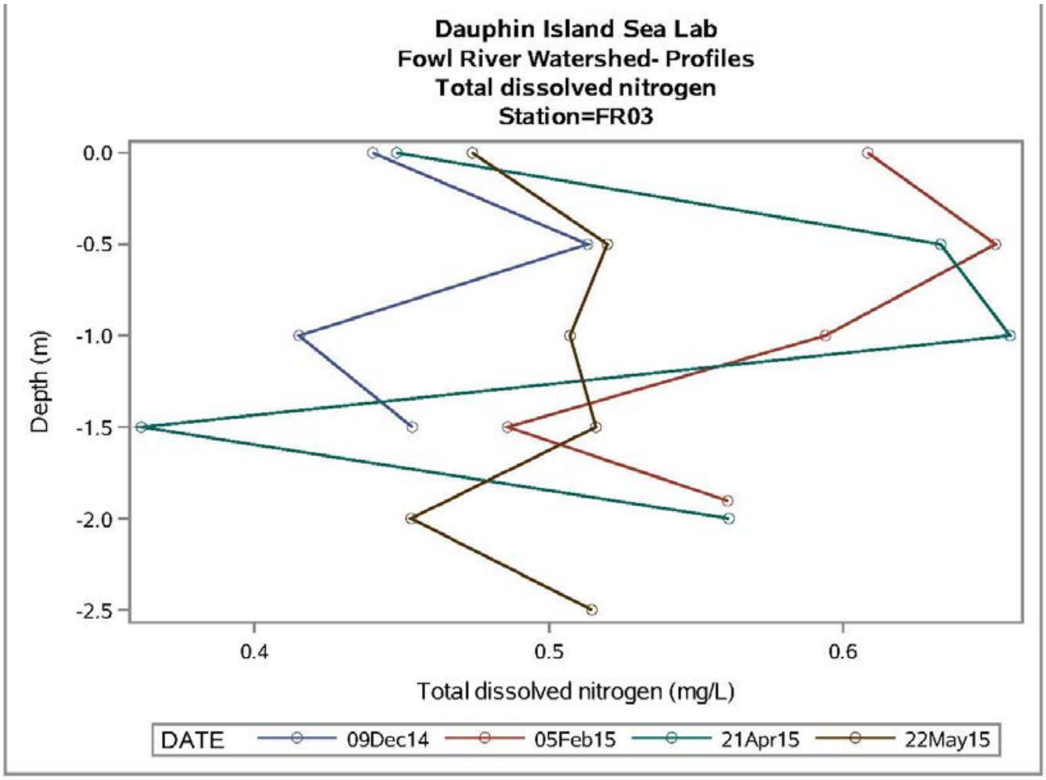


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total dissolved nitrogen
Station=FR01
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
0.4
0.5
0.6
0.7
Total dissolved nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

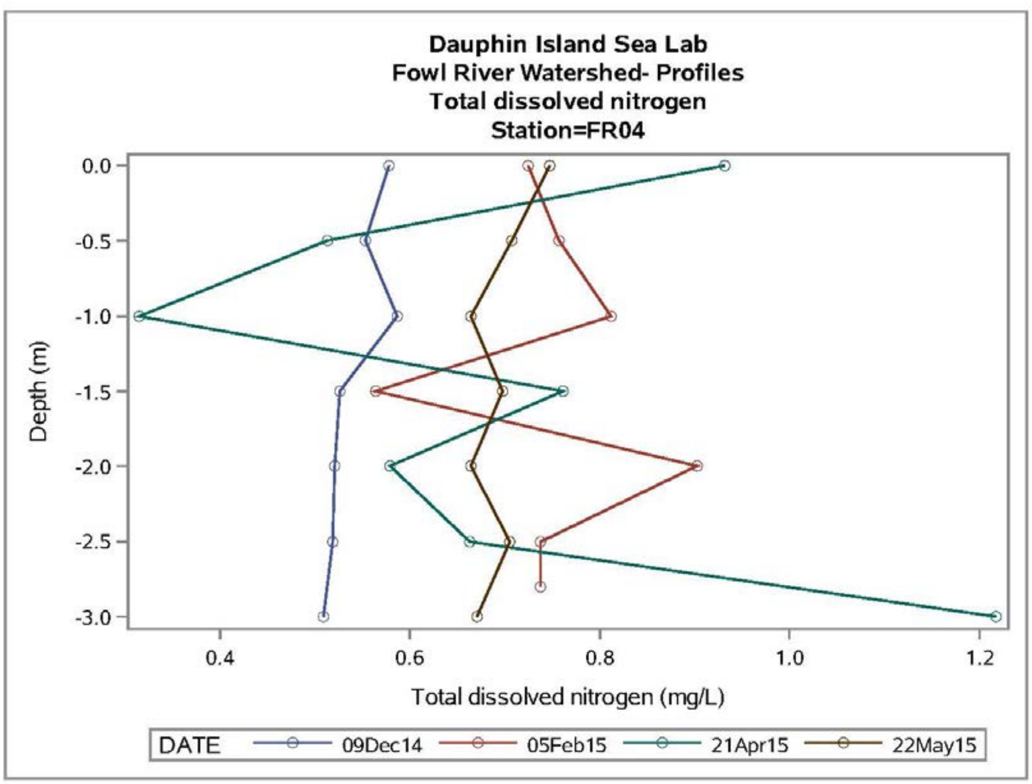


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total dissolved nitrogen
Station=FR02
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Total dissolved nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

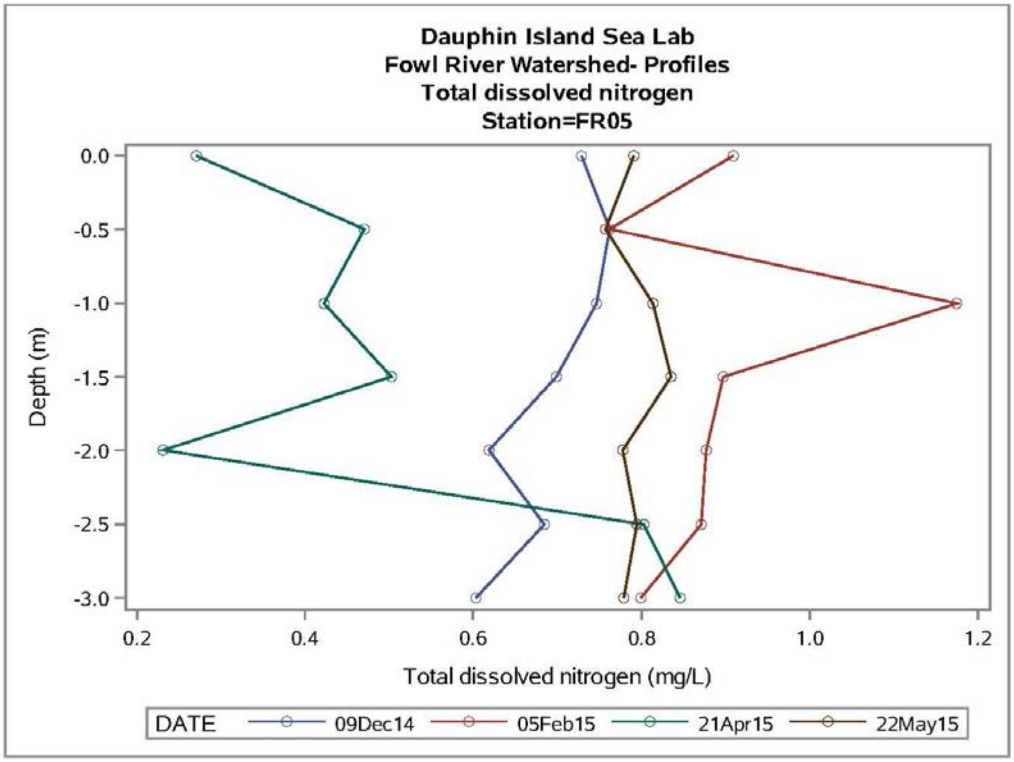


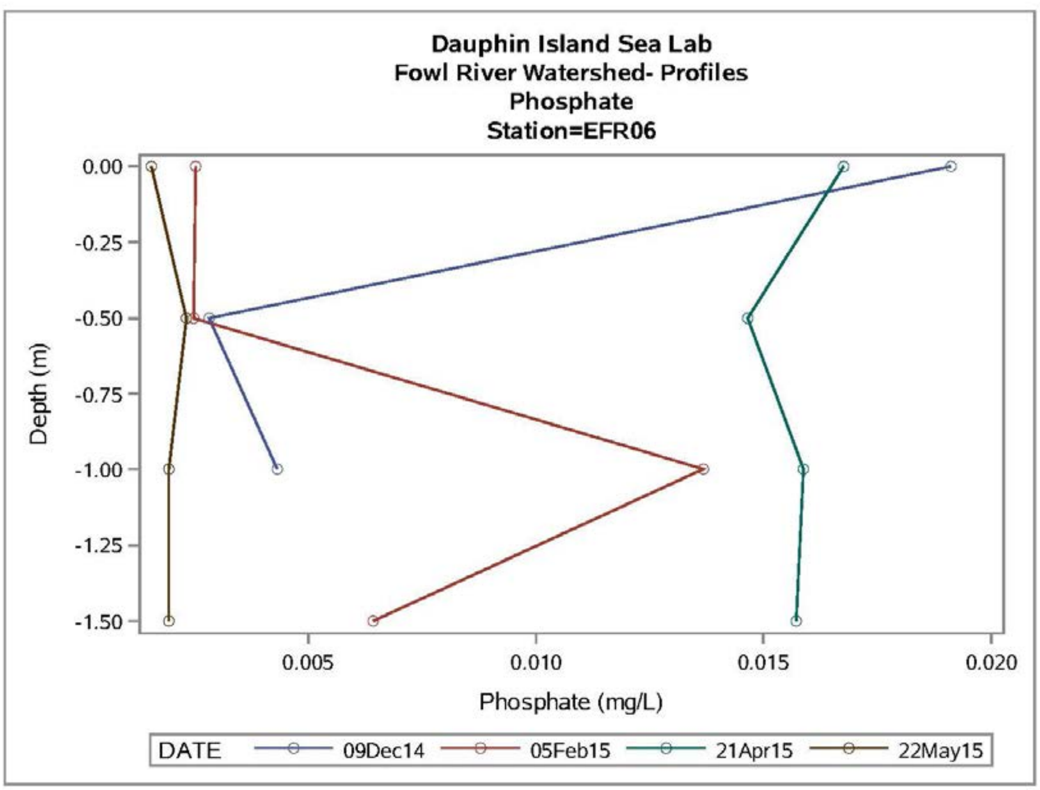
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total dissolved nitrogen
Station=FR03
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
Depth (m)
0.4
0.5
0.6
Total dissolved nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15



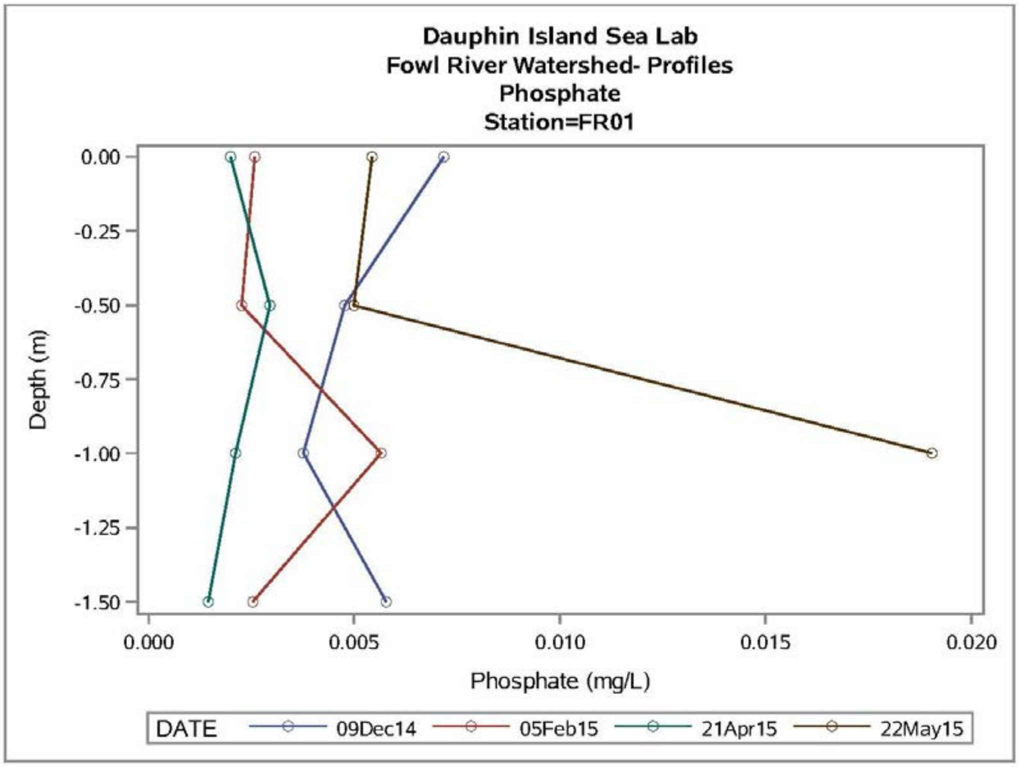
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total dissolved nitrogen
Station=FR04
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
Depth (m)
0.4
0.6
0.8
1.0
1.2
Total dissolved nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

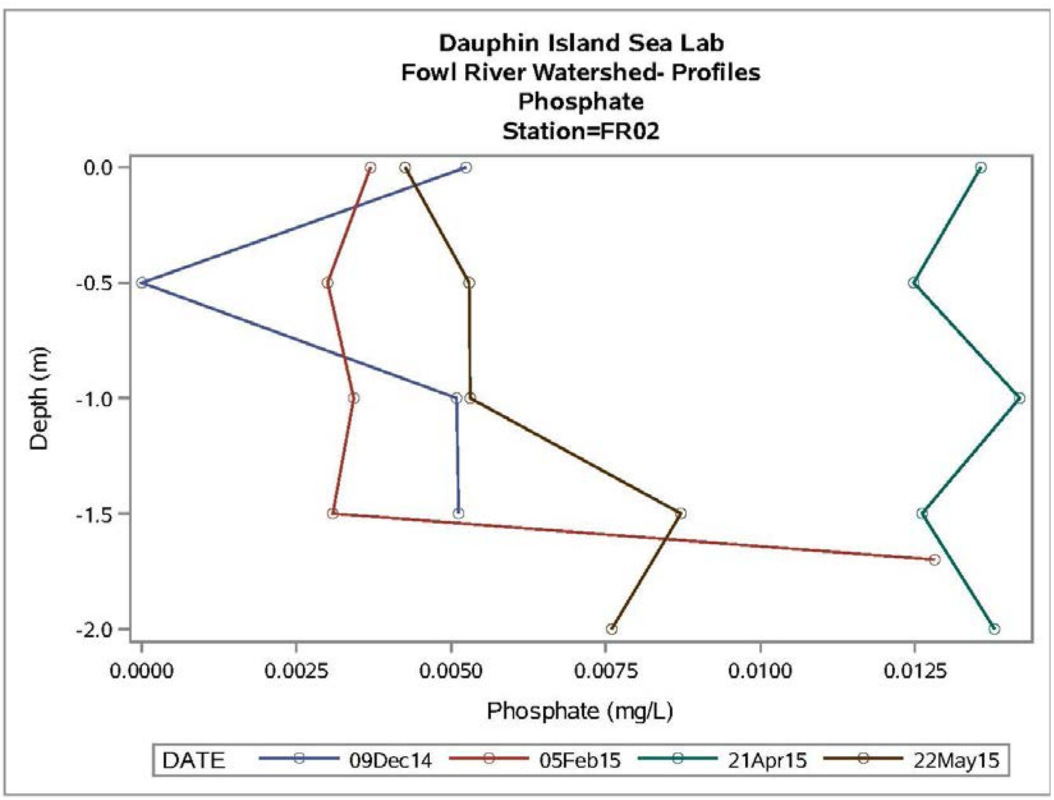
D. RAW DATA


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total dissolved nitrogen
Station=FR05
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
Depth (m)
0.2
0.4
0.6
0.8
1.0
1.2
Total dissolved nitrogen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

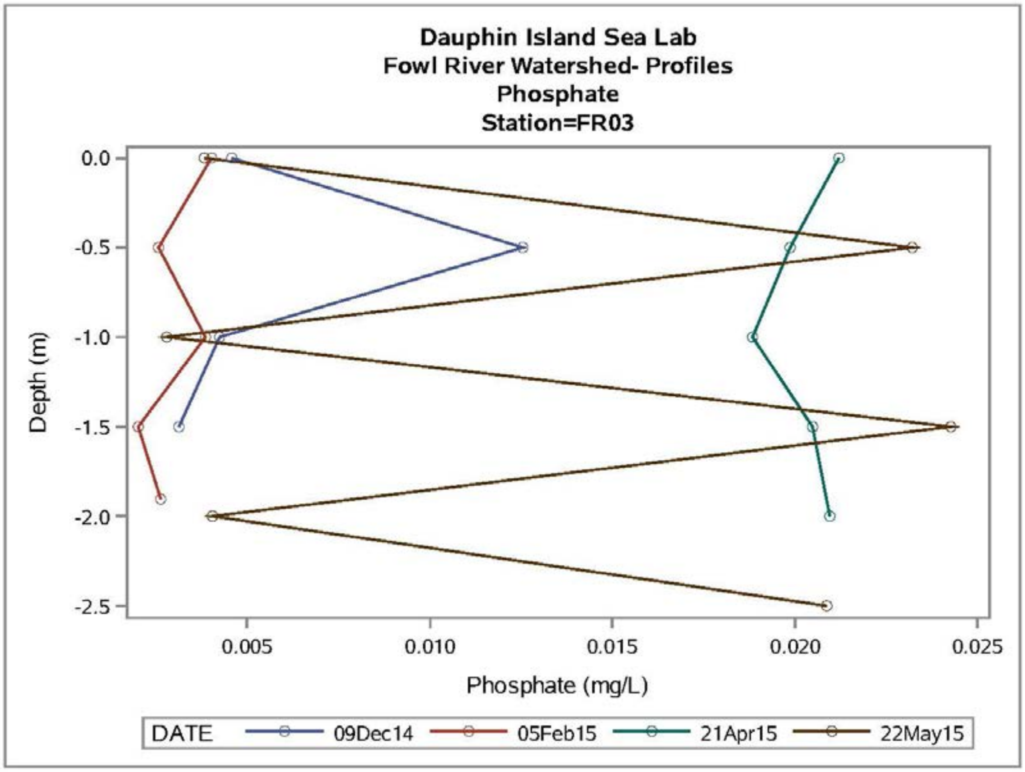

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Phosphate
Station=EFR06
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
Depth (m)
0.005
0.010
0.015
0.020
Phosphate (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

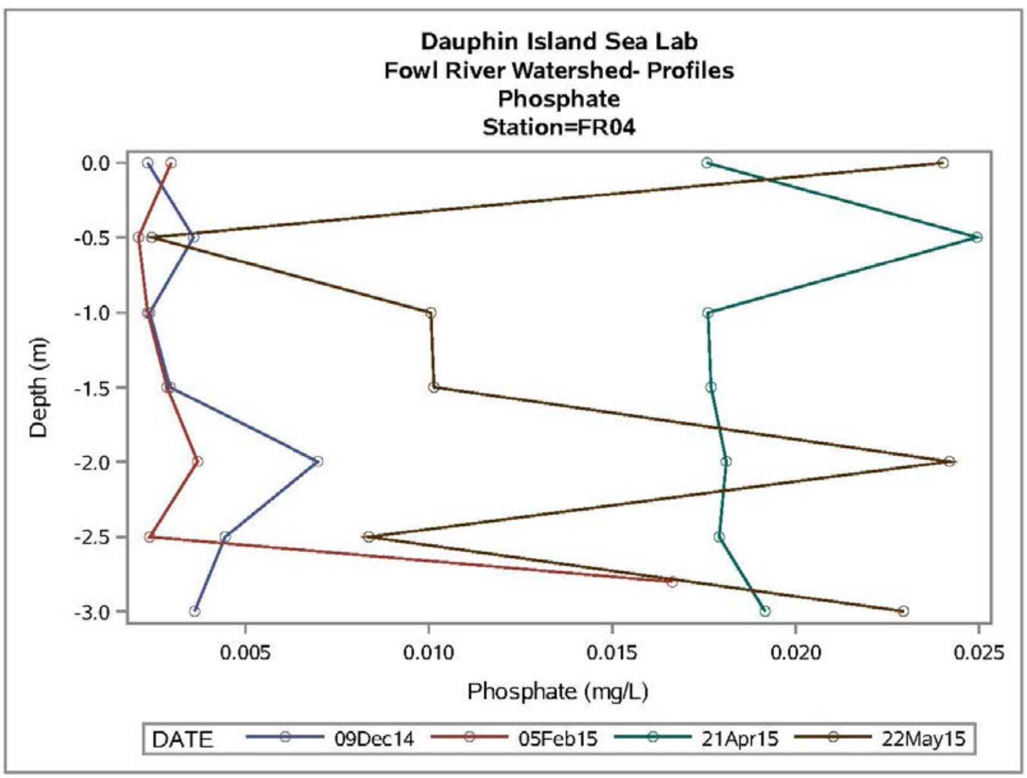
D. RAW DATA


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Phosphate
Station=FR01
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
0.000
0.005
0.010
0.015
0.020
Phosphate (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

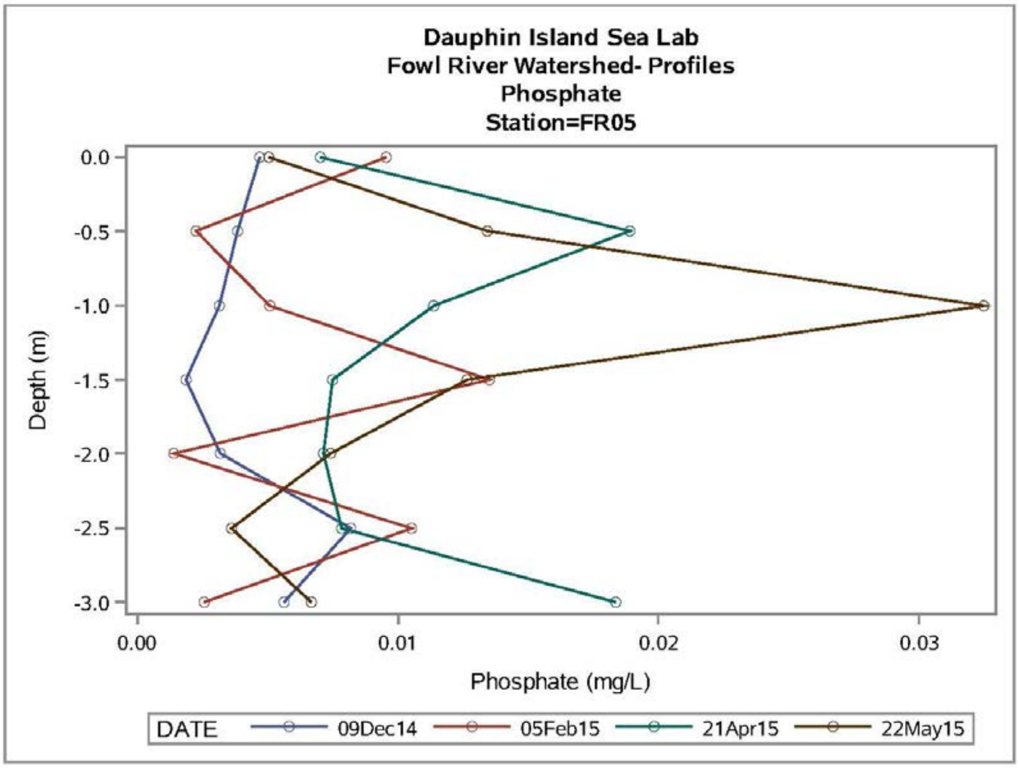

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Phosphate
Station=FR02
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
0.0000
0.0025
0.0050
0.0075
0.0100
0.0125
Phosphate (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

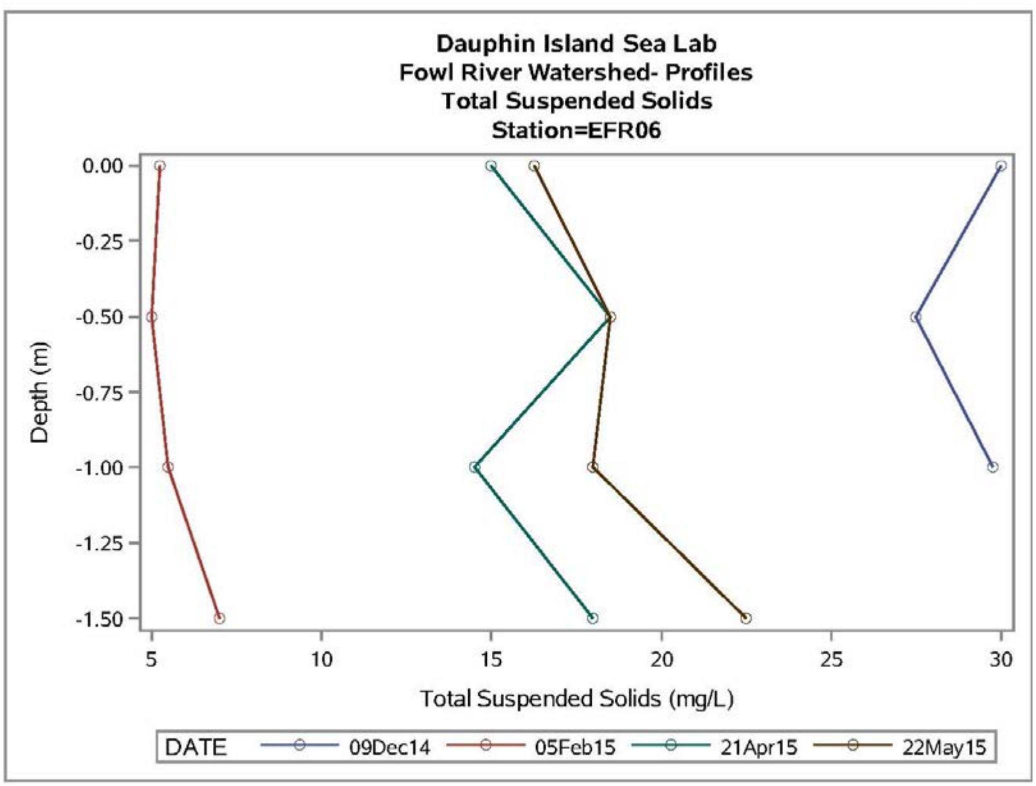

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Phosphate
Station=FR03
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
0.005
0.010
0.015
0.020
0.025
Phosphate (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Phosphate
Station=FR04
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0.005
0.010
0.015
0.020
0.025
Phosphate (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

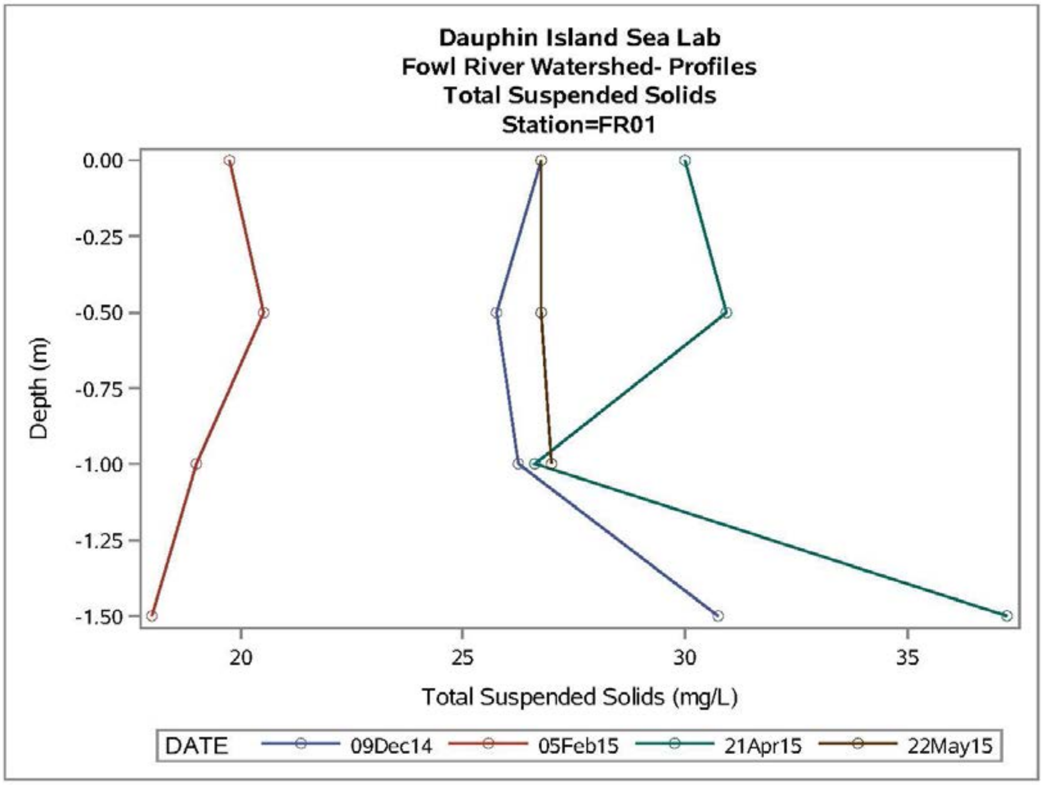


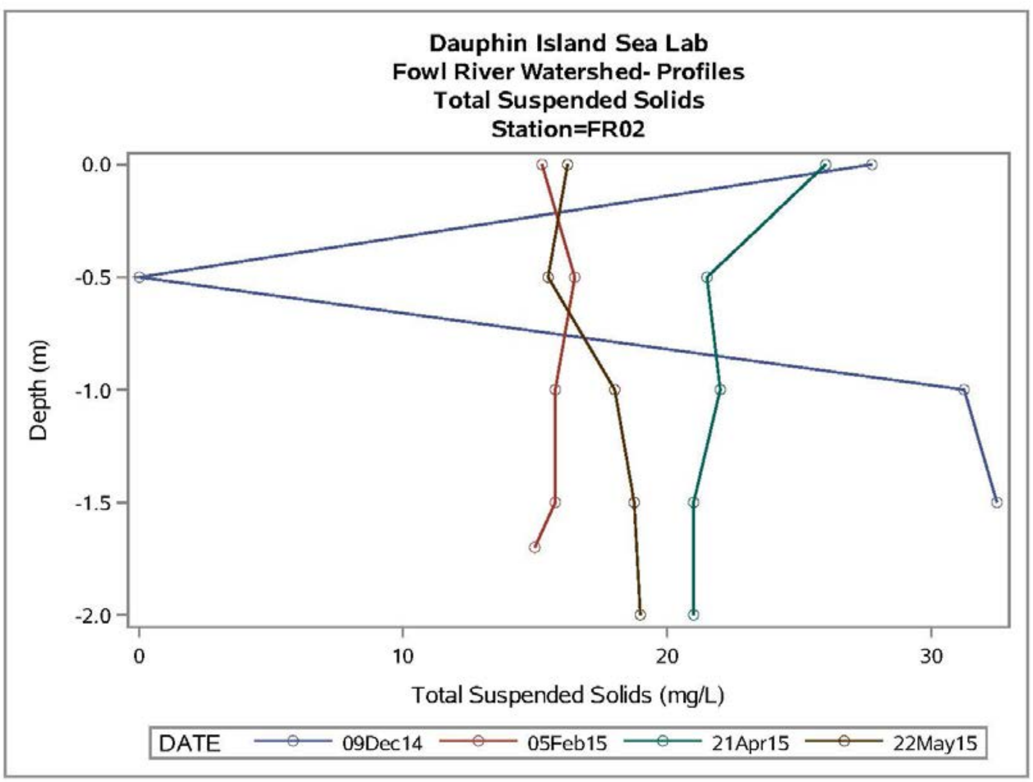
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Phosphate
Station=FR05
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0.00
0.01
0.02
0.03
Phosphate (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15



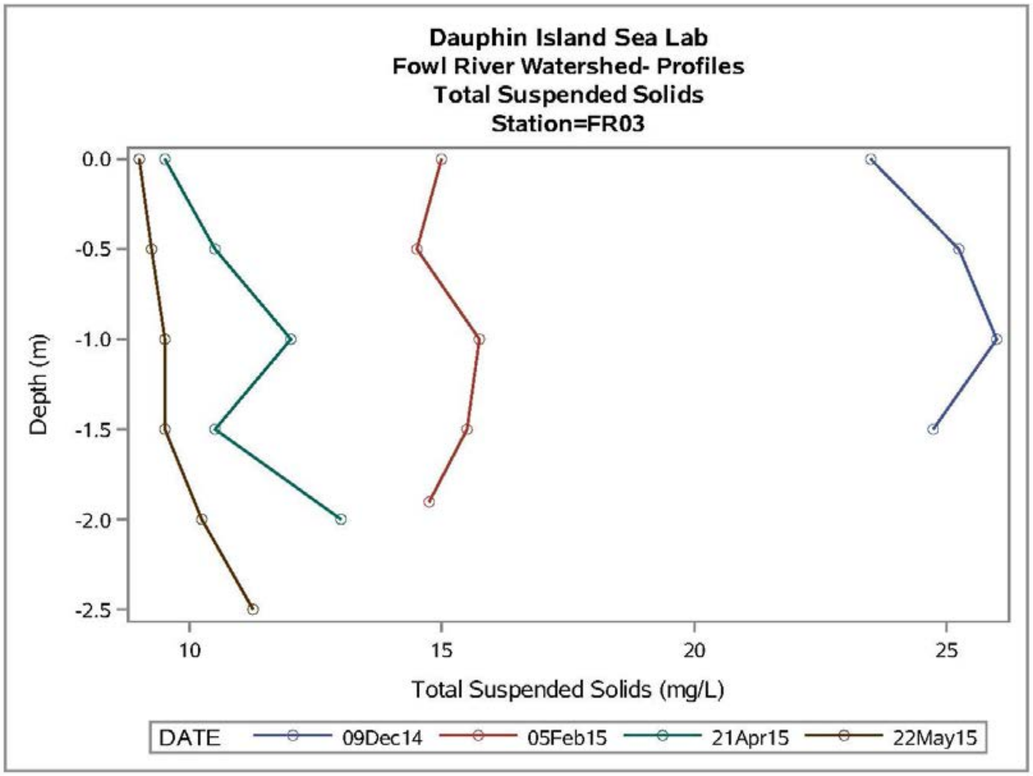
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total Suspended Solids
Station=EFR06
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
5
10
15
20
25
30
Total Suspended Solids (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

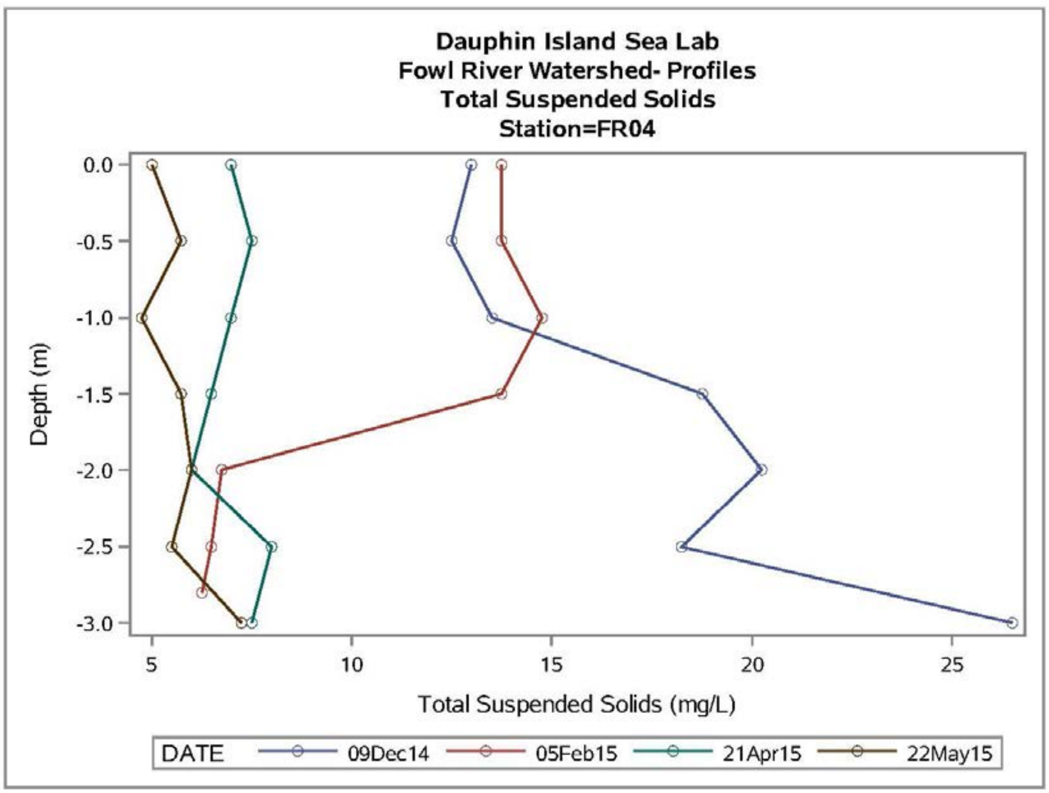

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total Suspended Solids
Station=FR01
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
20
25
30
35
Total Suspended Solids (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total Suspended Solids
Station=FR02
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
0
10
20
30
Total Suspended Solids (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

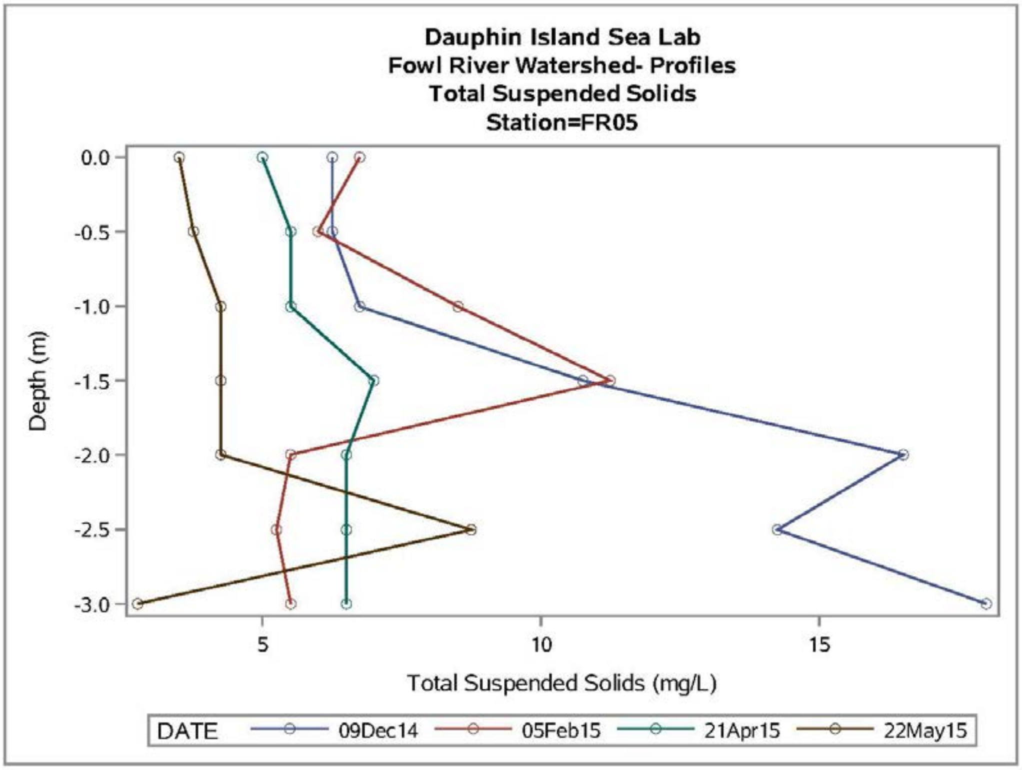


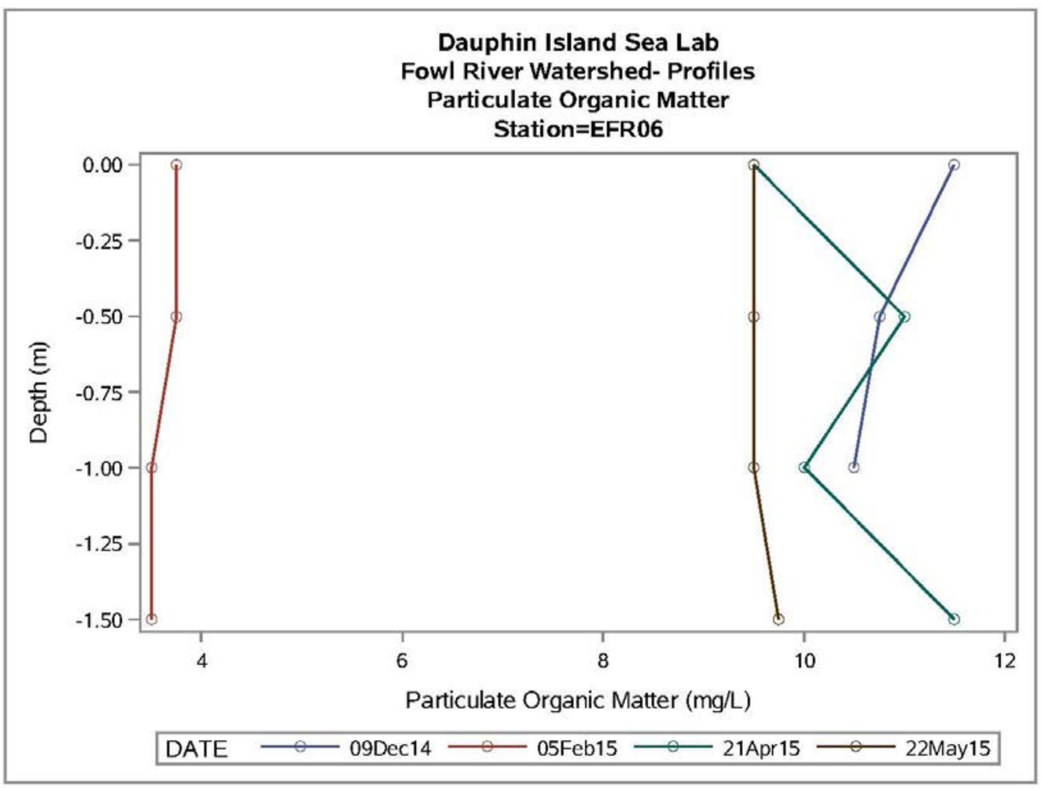
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total Suspended Solids
Station=FR03
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
10
15
20
25
Total Suspended Solids (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15



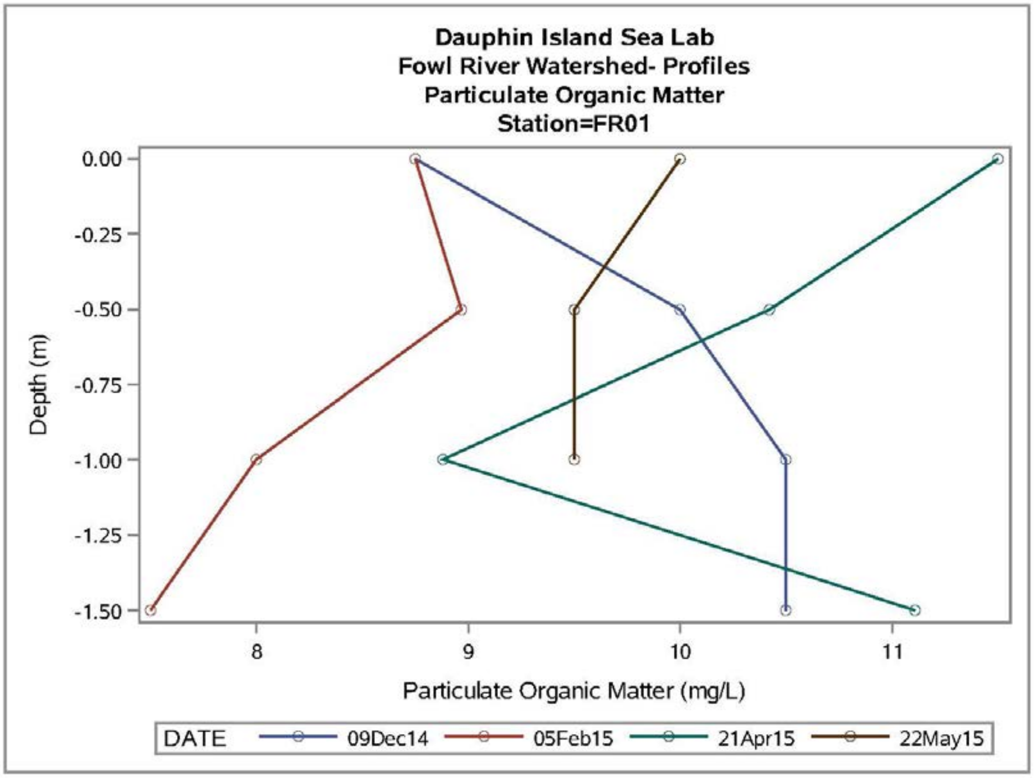
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total Suspended Solids
Station=FR04
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
5
10
15
20
25
Total Suspended Solids (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

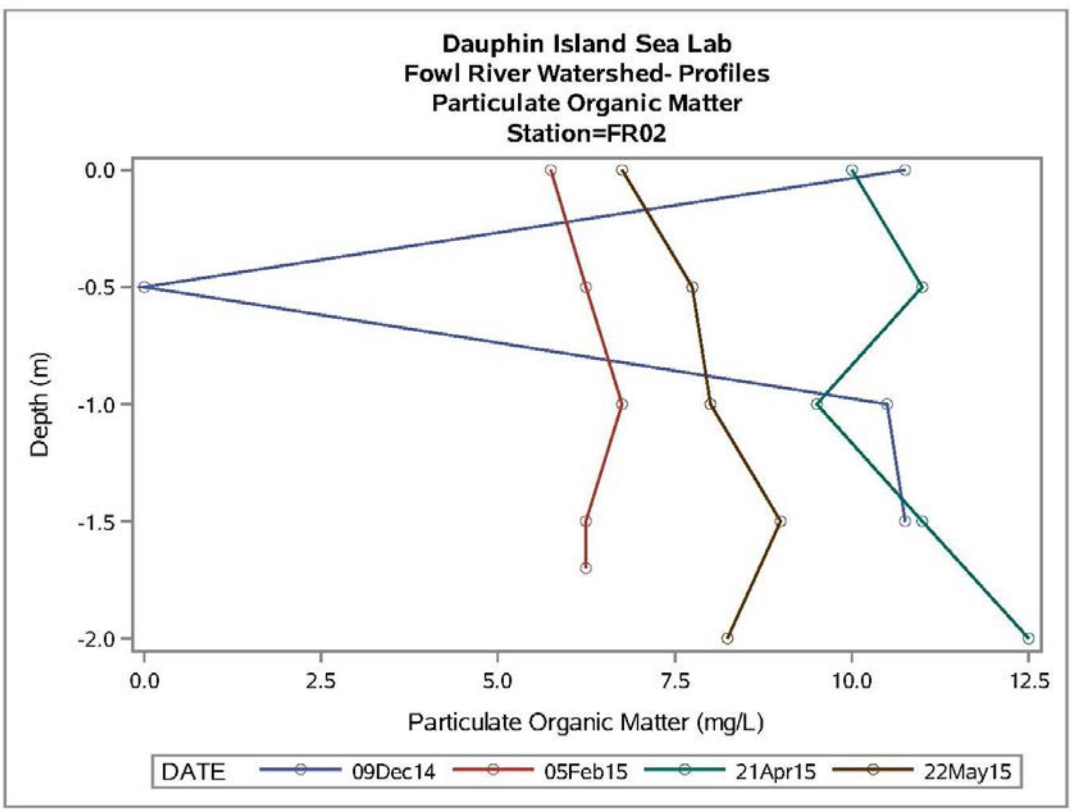
D. RAW DATA


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Total Suspended Solids
Station=FR05
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
Depth (m)
5
10
15
Total Suspended Solids (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

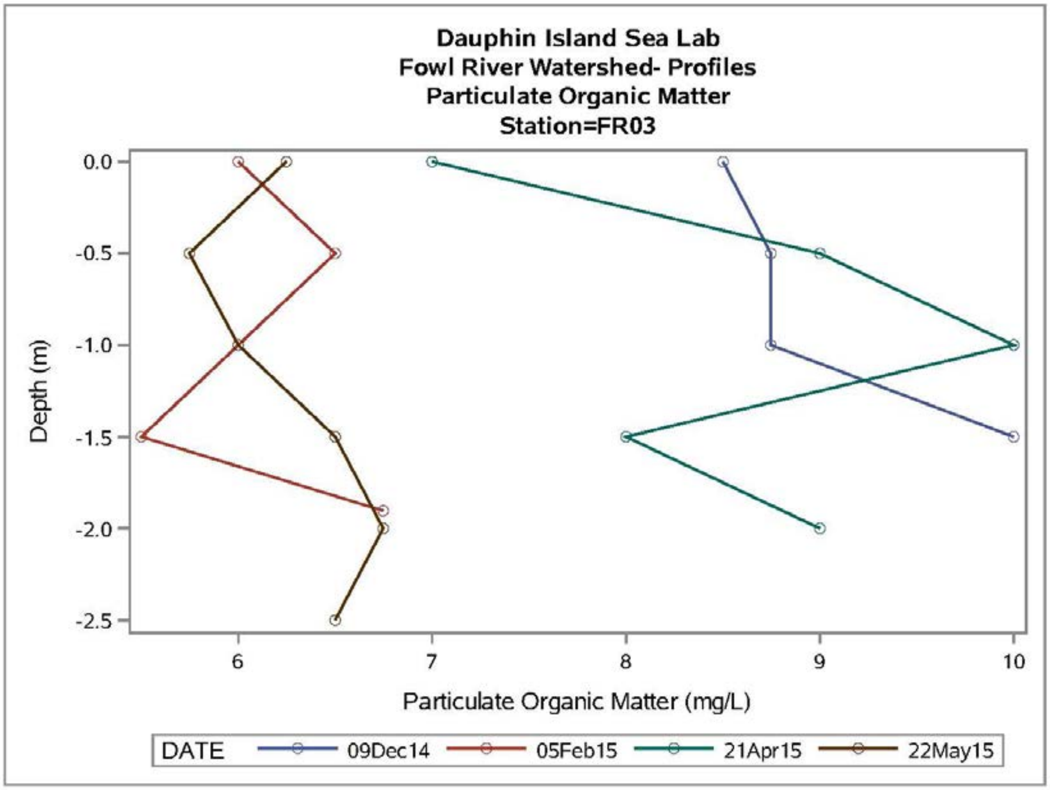

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Particulate Organic Matter
Station=EFR06
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
Depth (m)
4
6
8
10
12
Particulate Organic Matter (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

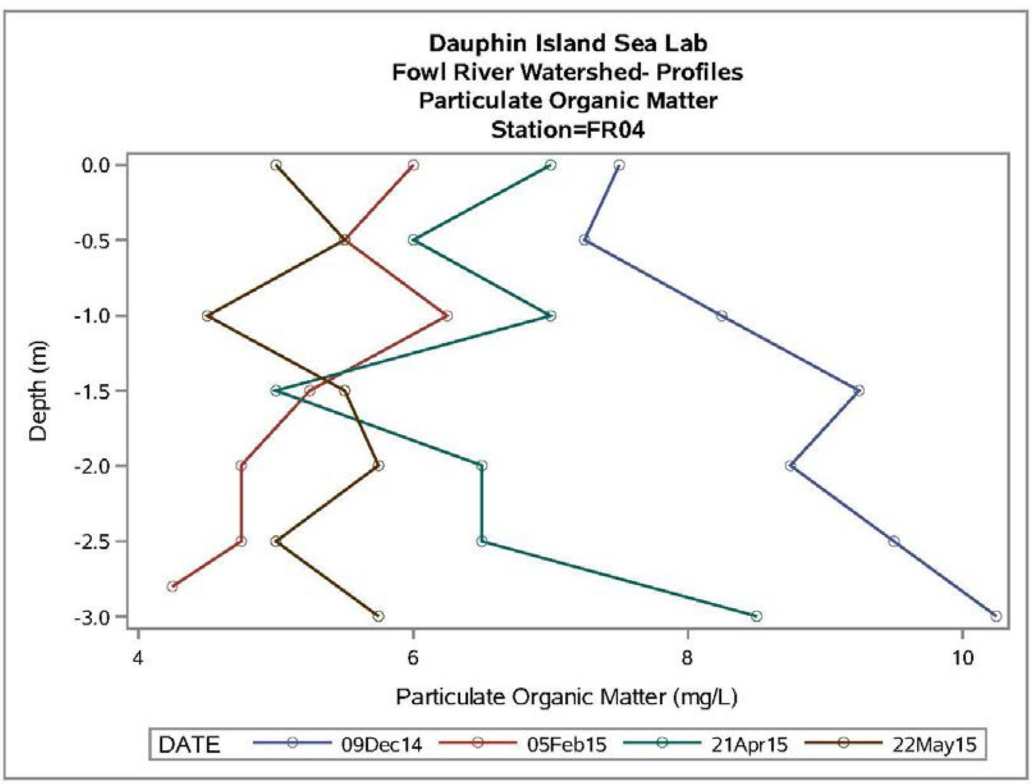

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Particulate Organic Matter
Station=FR01
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
8
9
10
11
Particulate Organic Matter (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Particulate Organic Matter
Station=FR02
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
0.0
2.5
5.0
7.5
10.0
12.5
Particulate Organic Matter (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

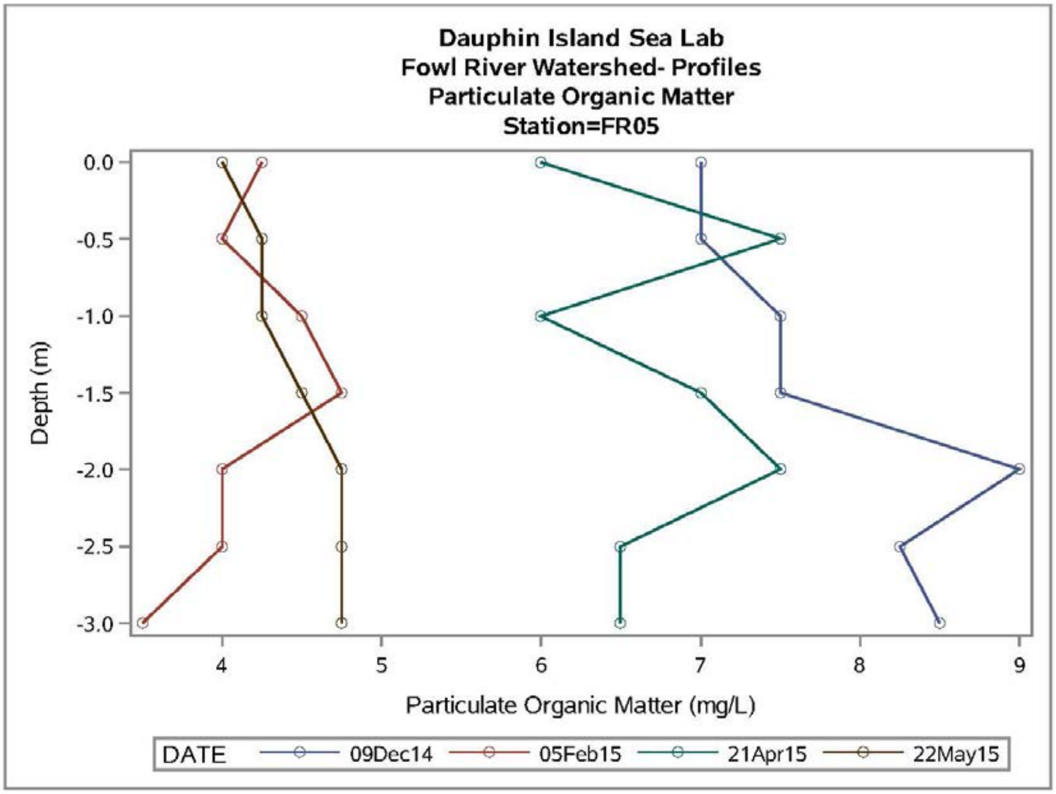


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Particulate Organic Matter
Station=FR03
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
6
7
8
9
10
Particulate Organic Matter (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

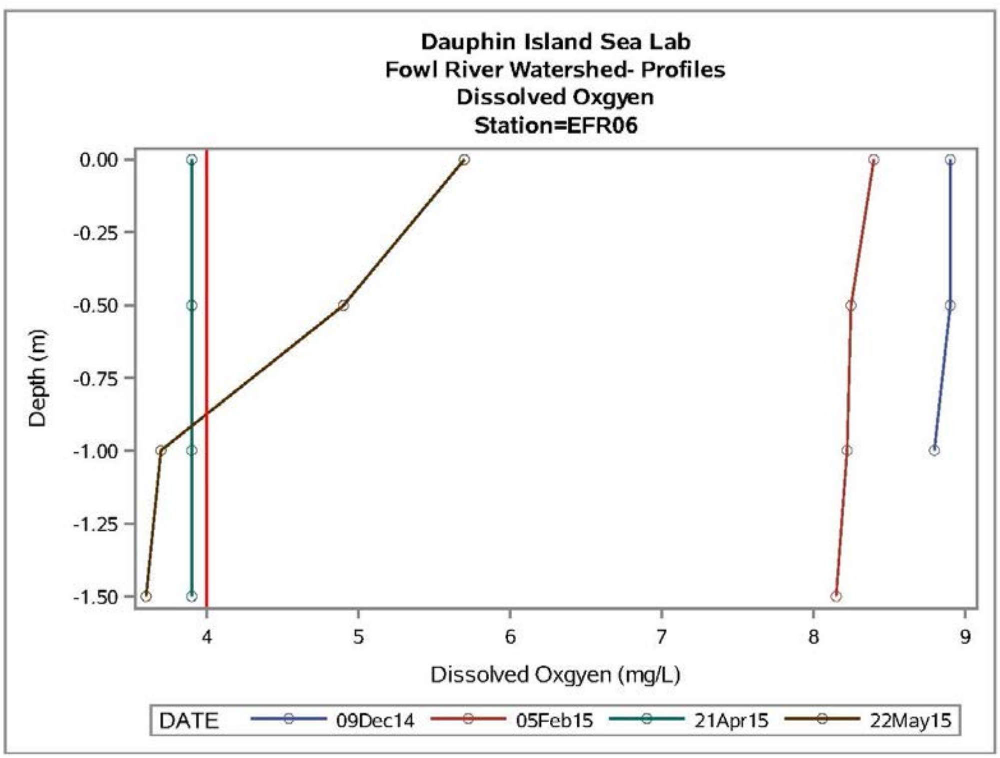


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Particulate Organic Matter
Station=FR04
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
4
6
8
10
Particulate Organic Matter (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

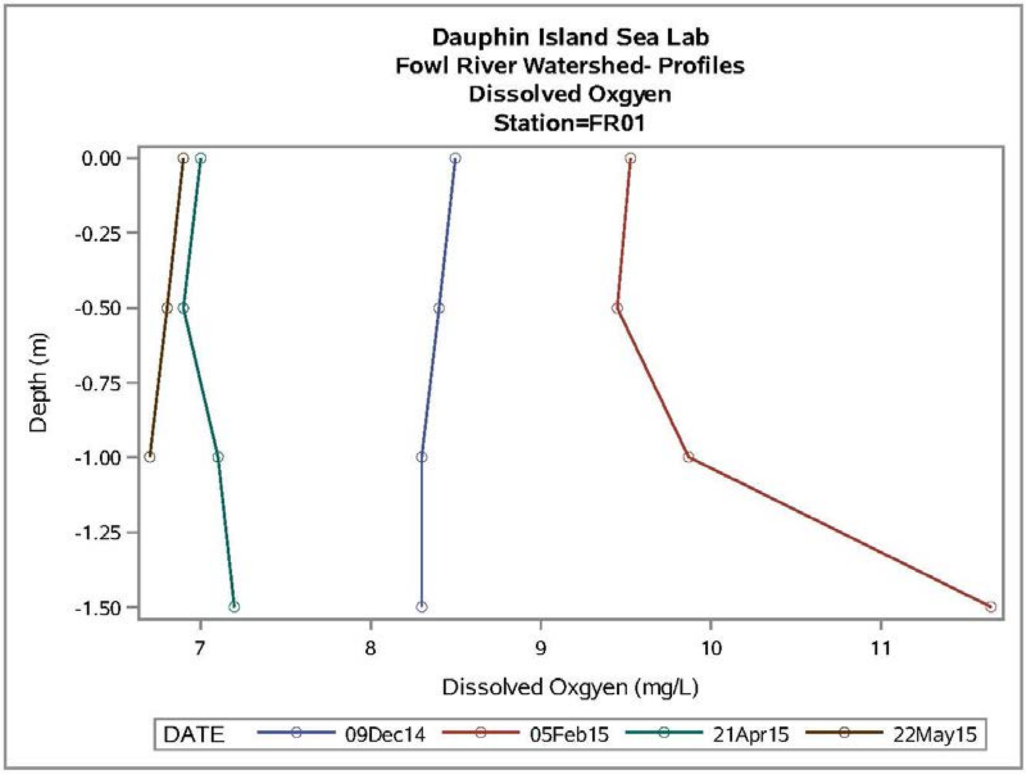


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Particulate Organic Matter
Station=FR05
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
4
5
6
7
8
9
Particulate Organic Matter (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

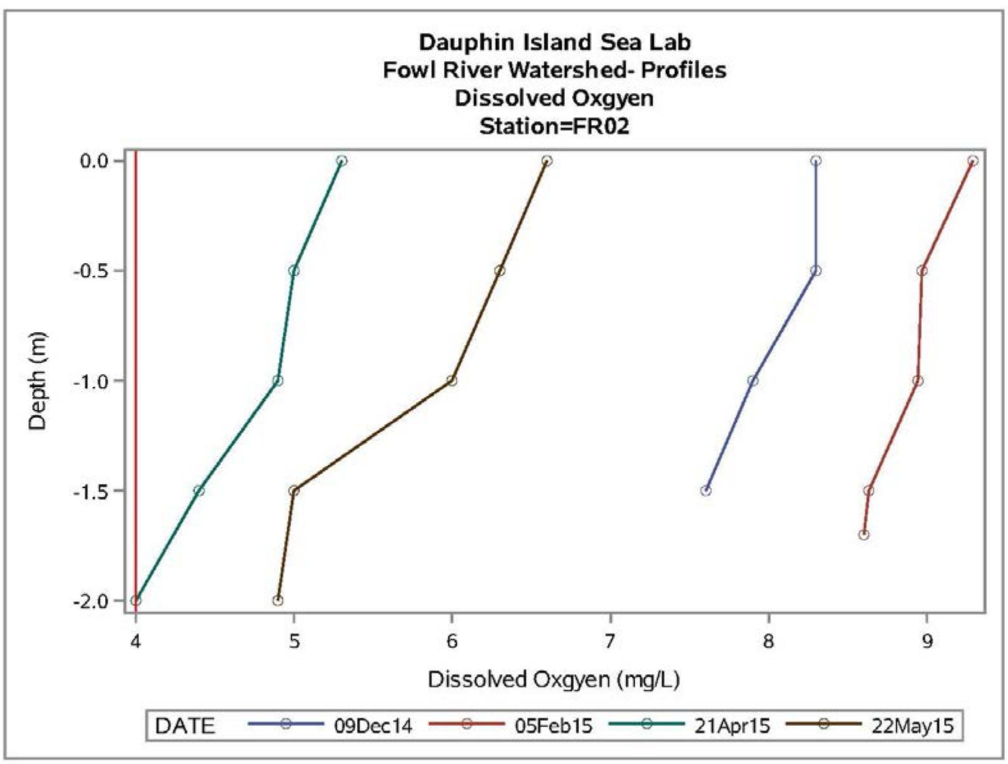


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved Oxgyen
Station=EFR06
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
4
5
6
7
8
9
Dissolved Oxgyen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

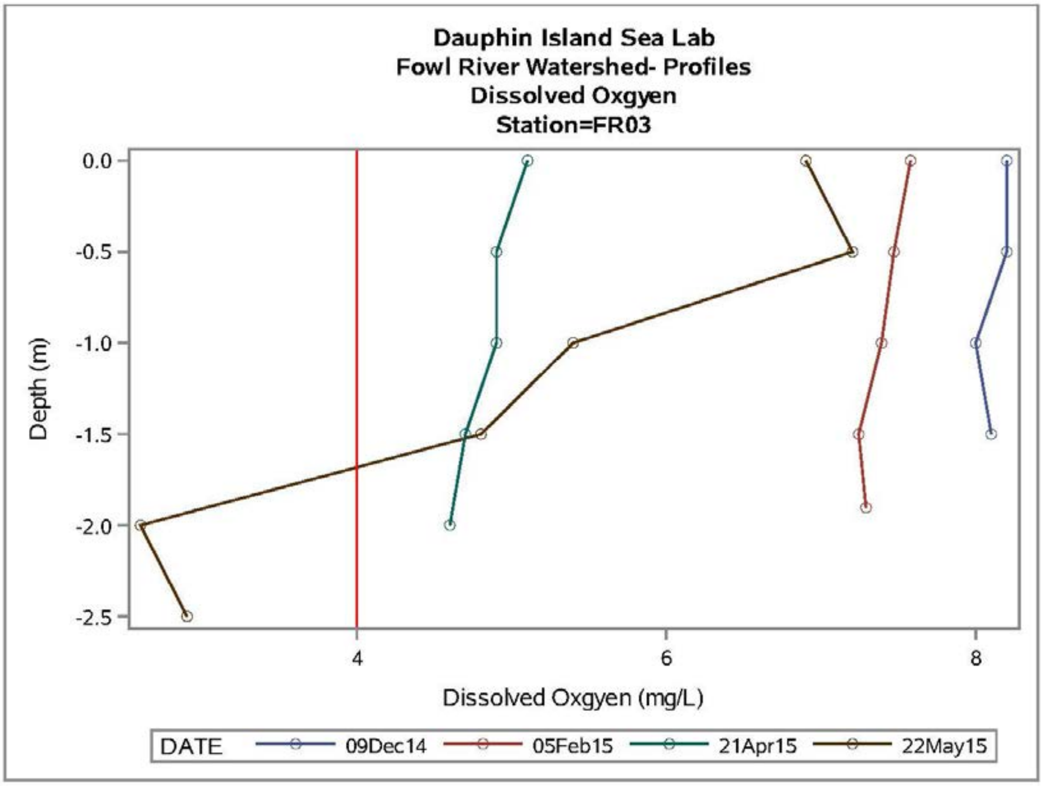


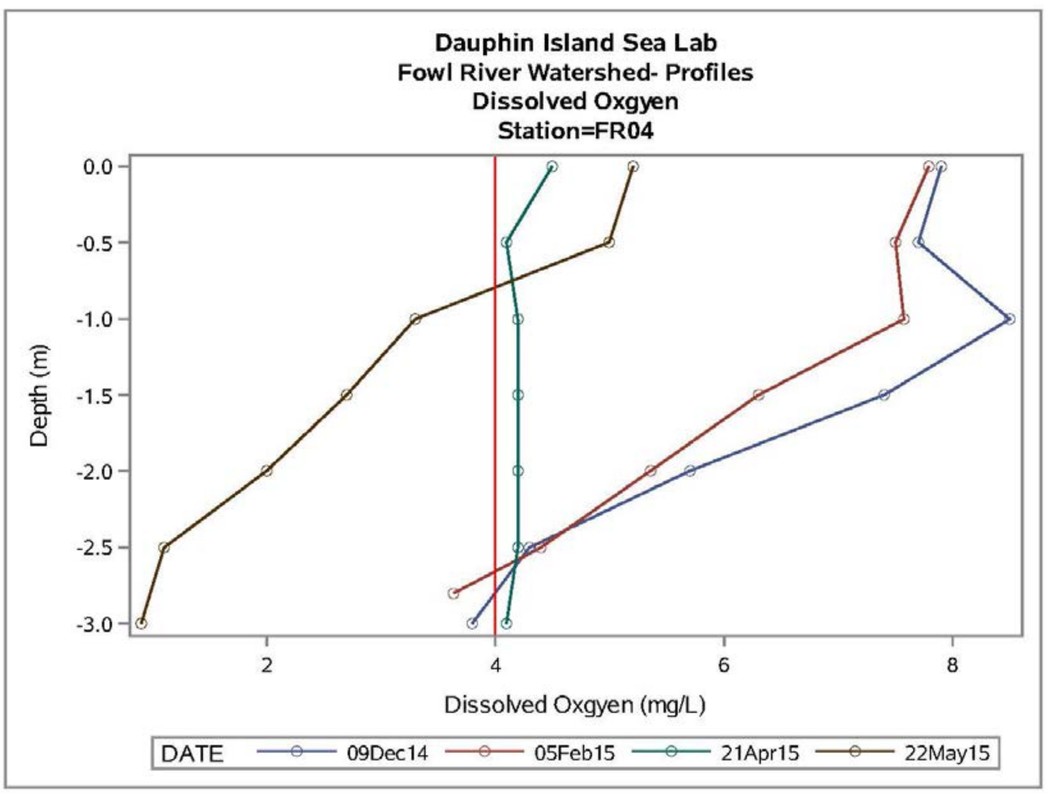
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved Oxgyen
Station=FR01
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
7
8
9
10
11
Dissolved Oxgyen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15



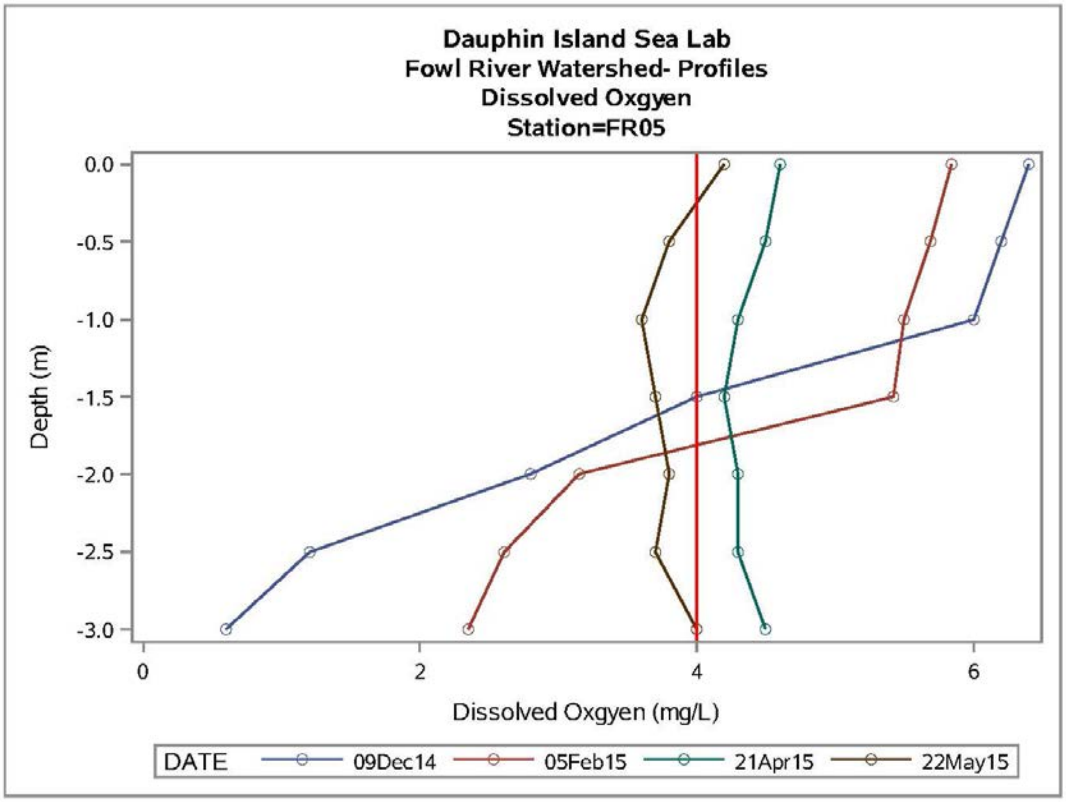
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved Oxgyen
Station=FR02
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
4
5
6
7
8
9
Dissolved Oxgyen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

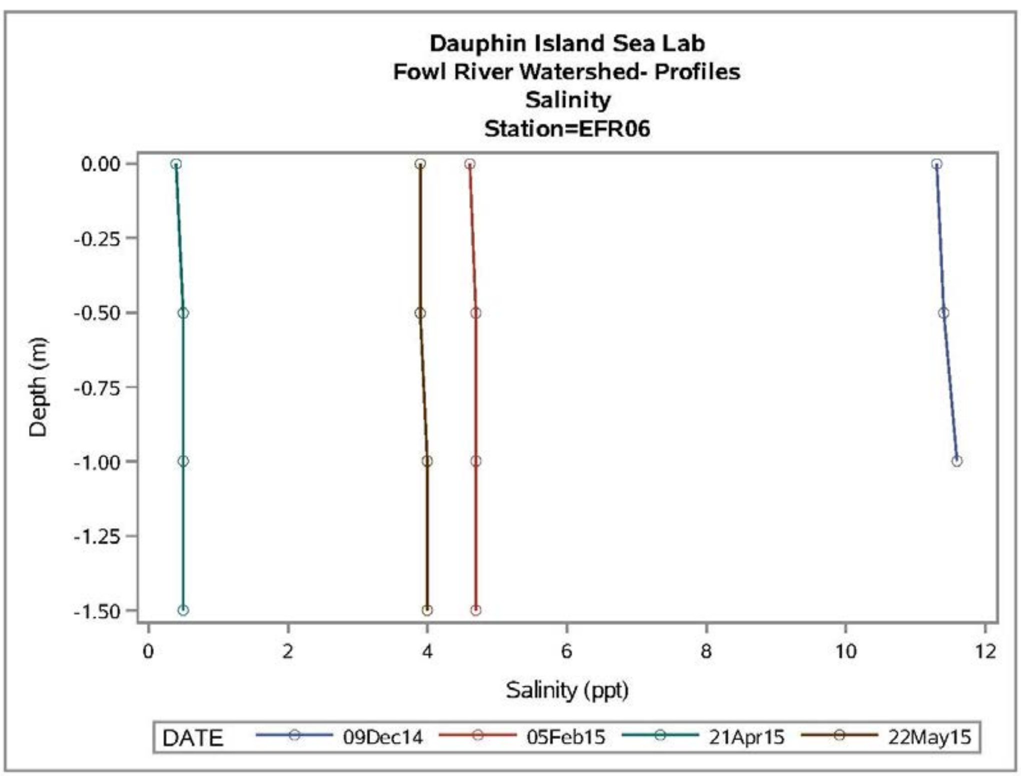
D. RAW DATA


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved Oxgyen
Station=FR03
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
4
6
8
Dissolved Oxgyen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

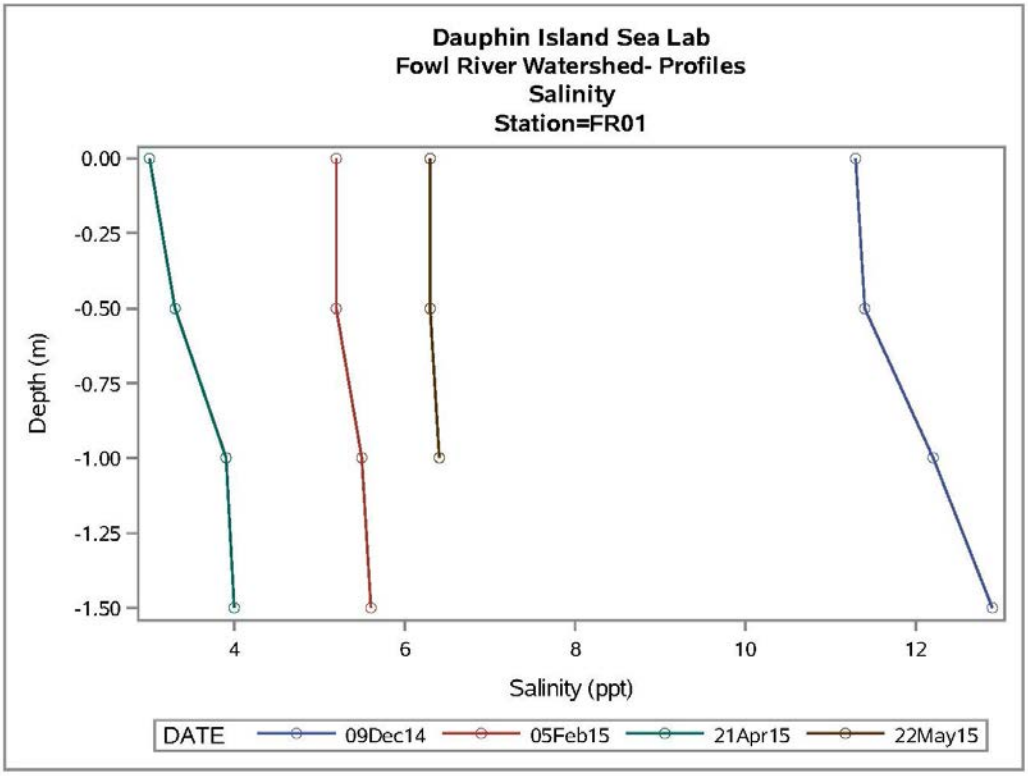

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved Oxgyen
Station=FR04
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
2
4
6
8
Dissolved Oxgyen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

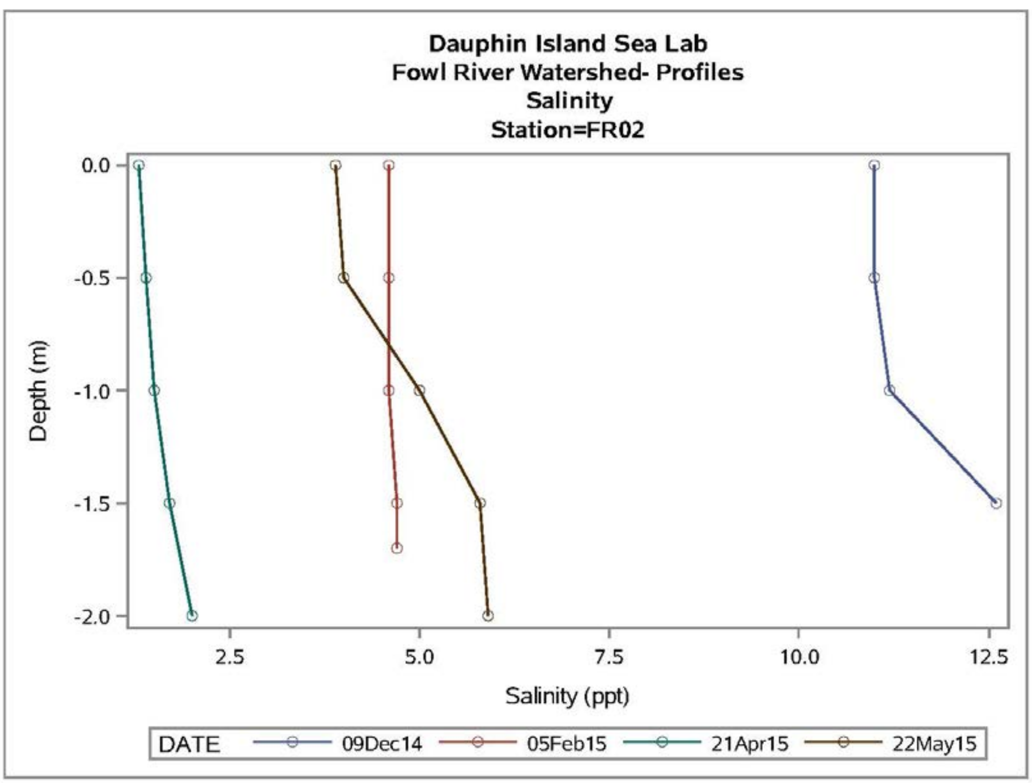

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Dissolved Oxgyen
Station=FR05
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0
2
4
6
Dissolved Oxgyen (mg/L)
DATE
09Dec14
05Feb15
21Apr15
22May15


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Salinity
Station=EFR06
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
0
2
4
6
8
10
12
Salinity (ppt)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

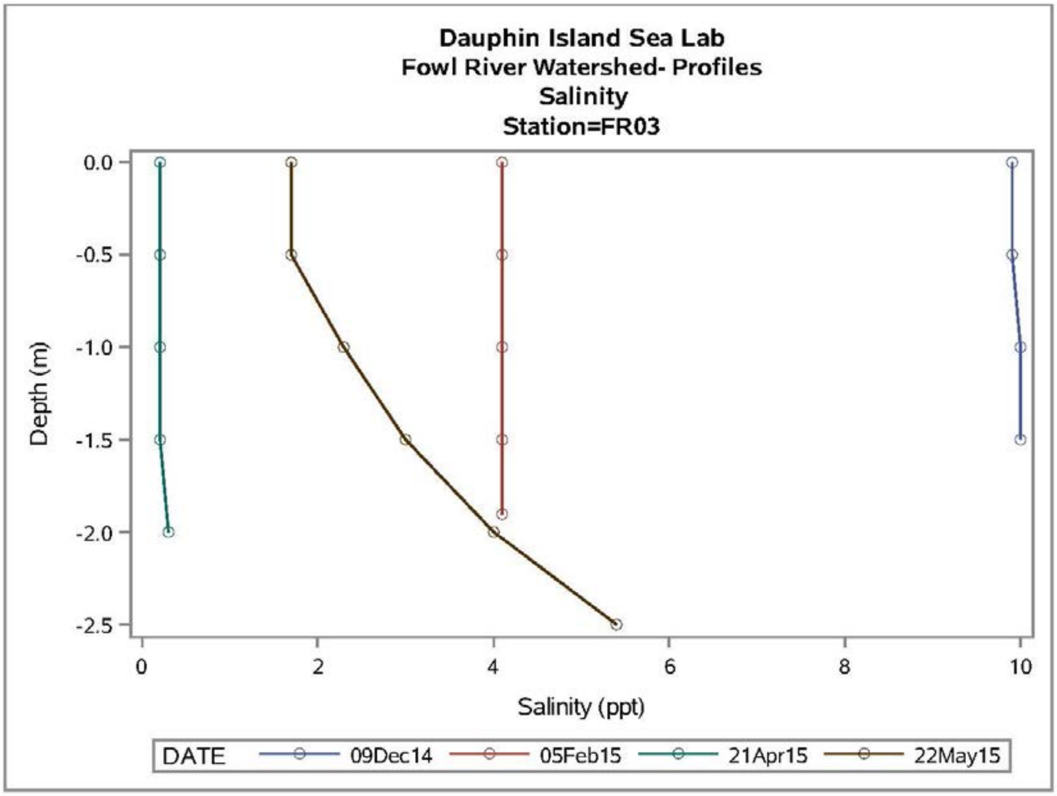


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Salinity
Station=FR01
Depth (m)
0.00
-0.25
-0.50
-0.75
-1.00
-1.25
-1.50
4
6
8
10
12
Salinity (ppt)
DATE
09Dec14
05Feb15
21Apr15
22May15

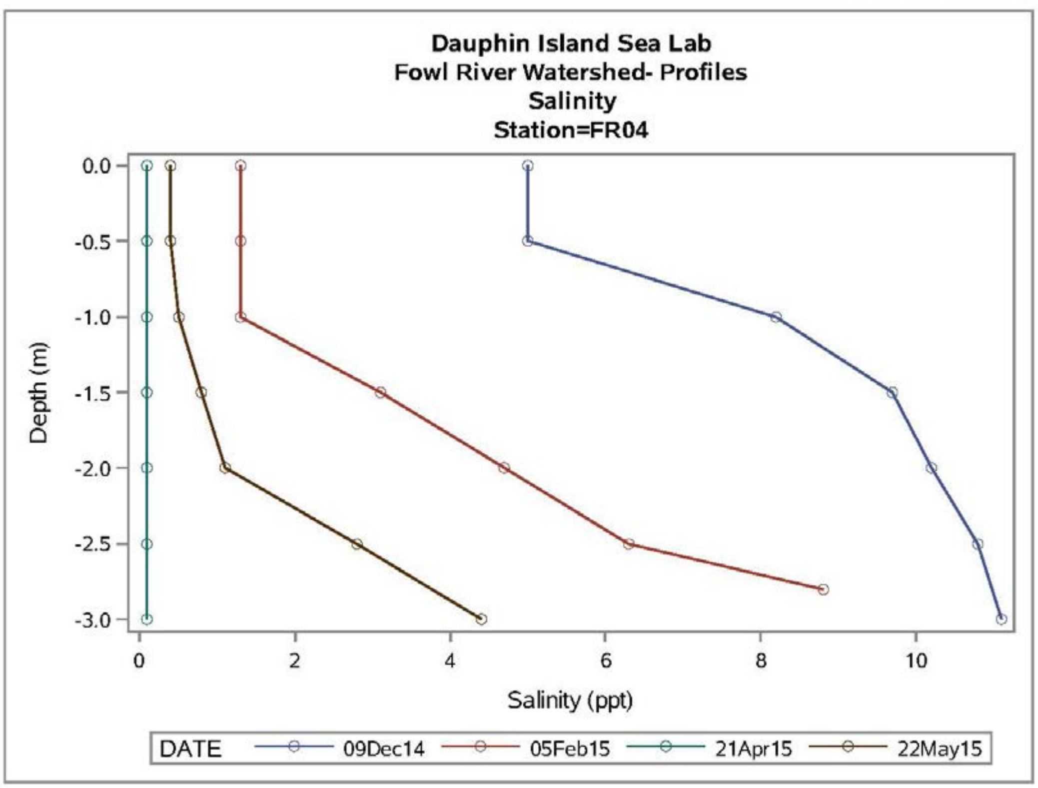


Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Salinity
Station=FR02
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
2.5
5.0
7.5
10.0
12.5
Salinity (ppt)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

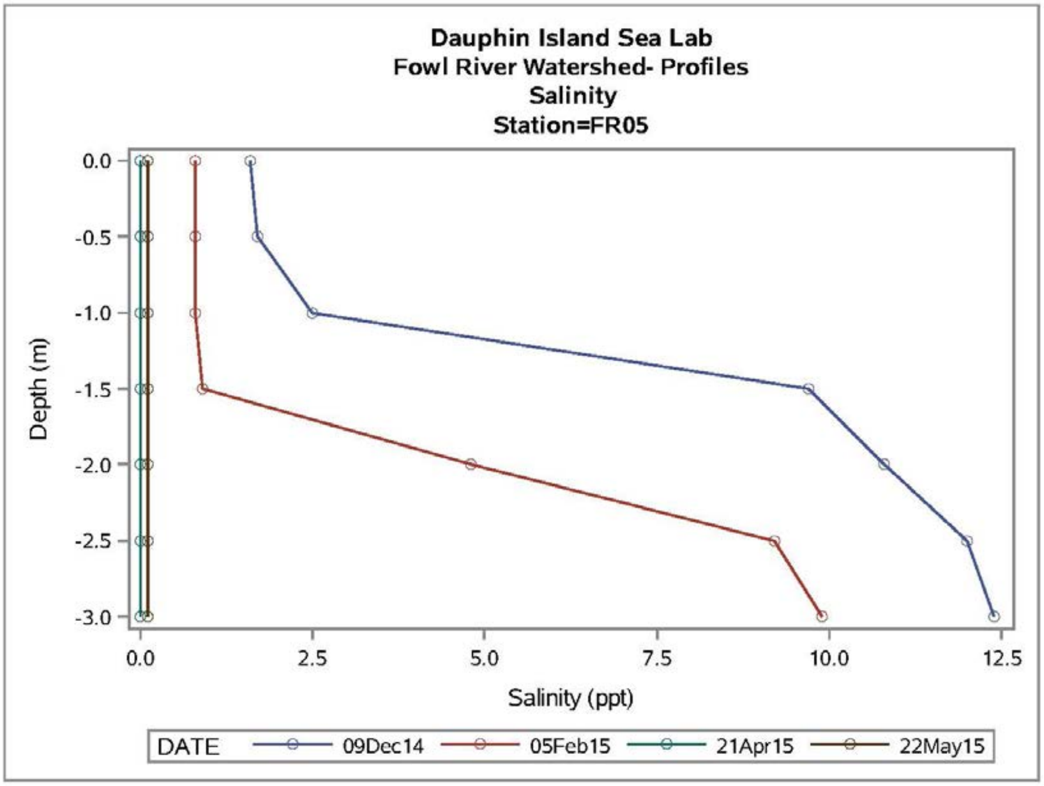


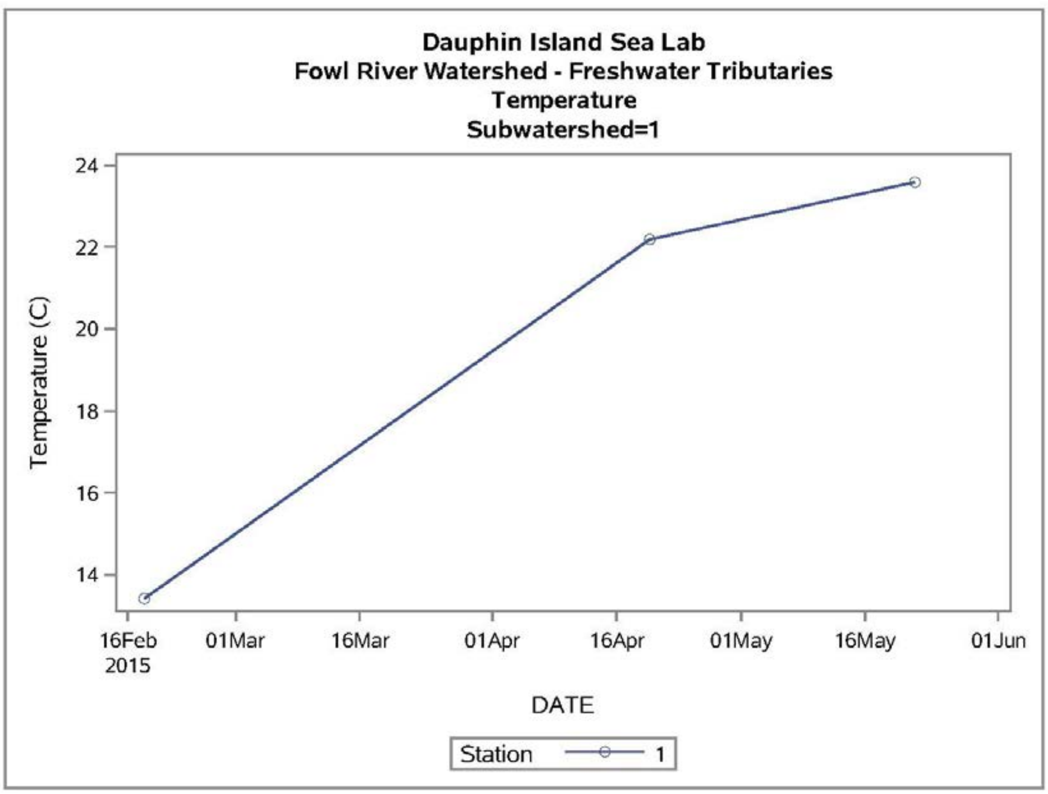
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Salinity
Station=FR03
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
0
2
4
6
8
10
Salinity (ppt)
DATE
09Dec14
05Feb15
21Apr15
22May15



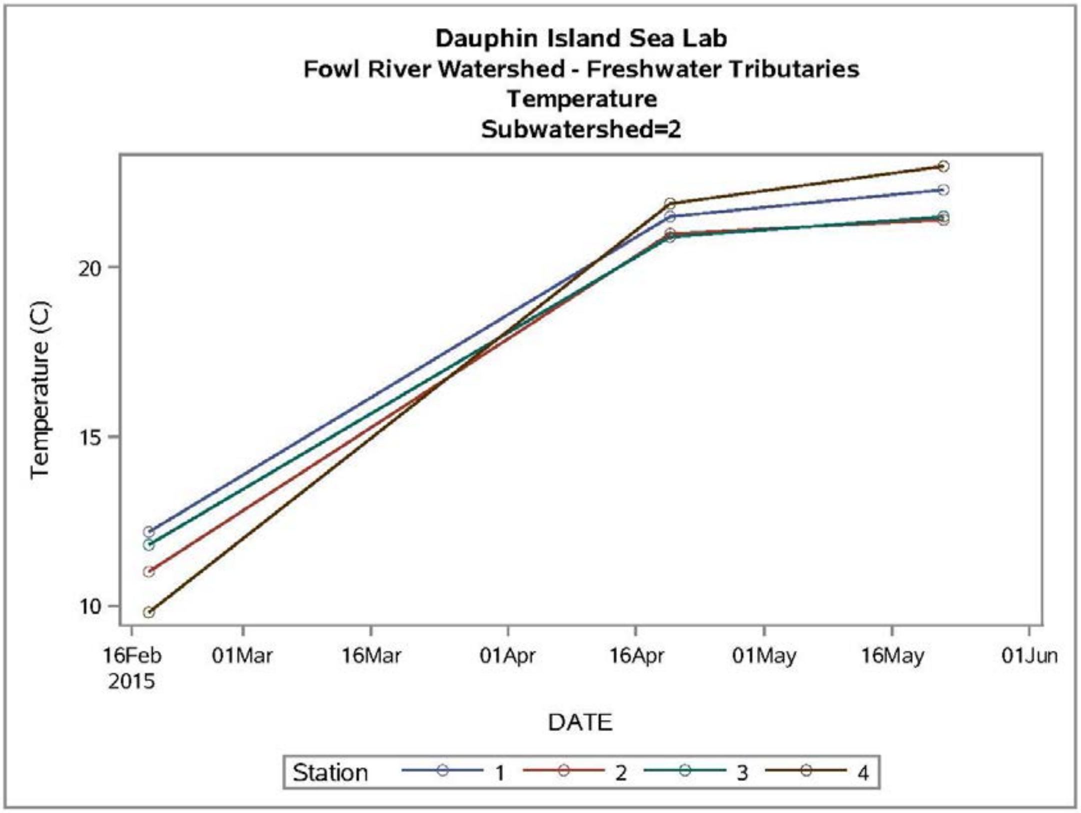
Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Salinity
Station=FR04
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0
2
4
6
8
10
Salinity (ppt)
DATE
09Dec14
05Feb15
21Apr15
22May15

D. RAW DATA

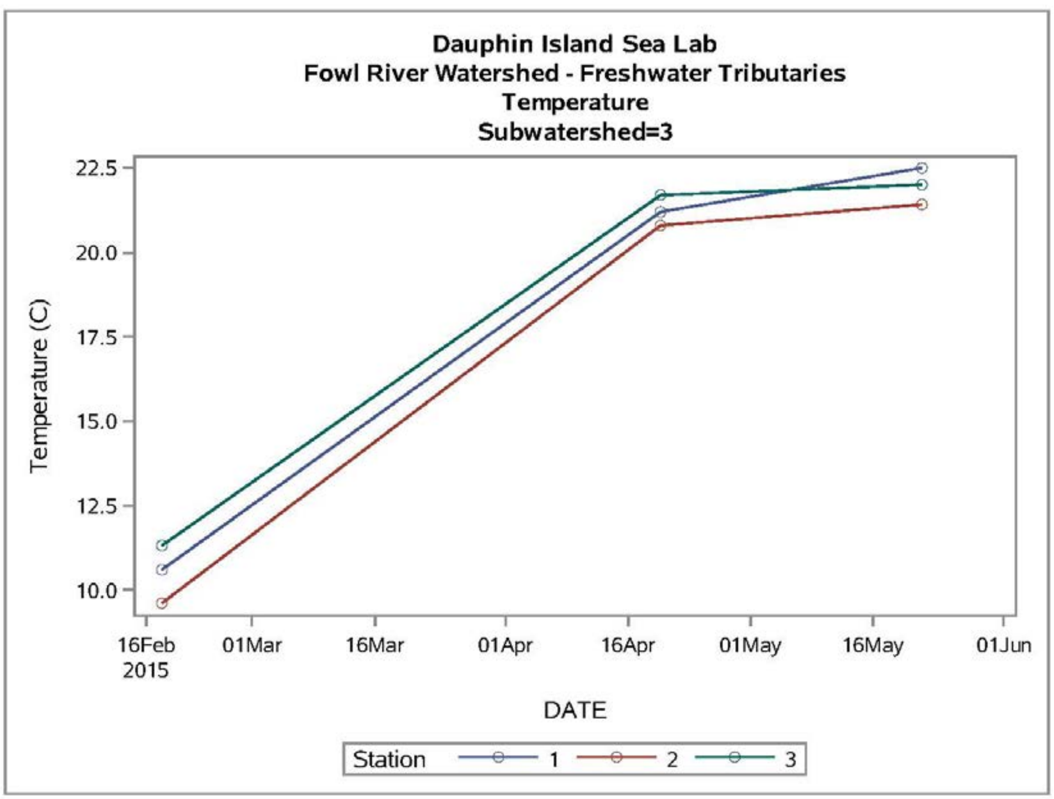

Dauphin Island Sea Lab
Fowl River Watershed- Profiles
Salinity
Station=FR05
Depth (m)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0.0
2.5
5.0
7.5
10.0
12.5
Salinity (ppt)
DATE
09Dec14
05Feb15
21Apr15
22May15


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Temperature
Subwatershed=1
Temperature (C)
24
22
20
18
16
14
16Feb
2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1

D. RAW DATA

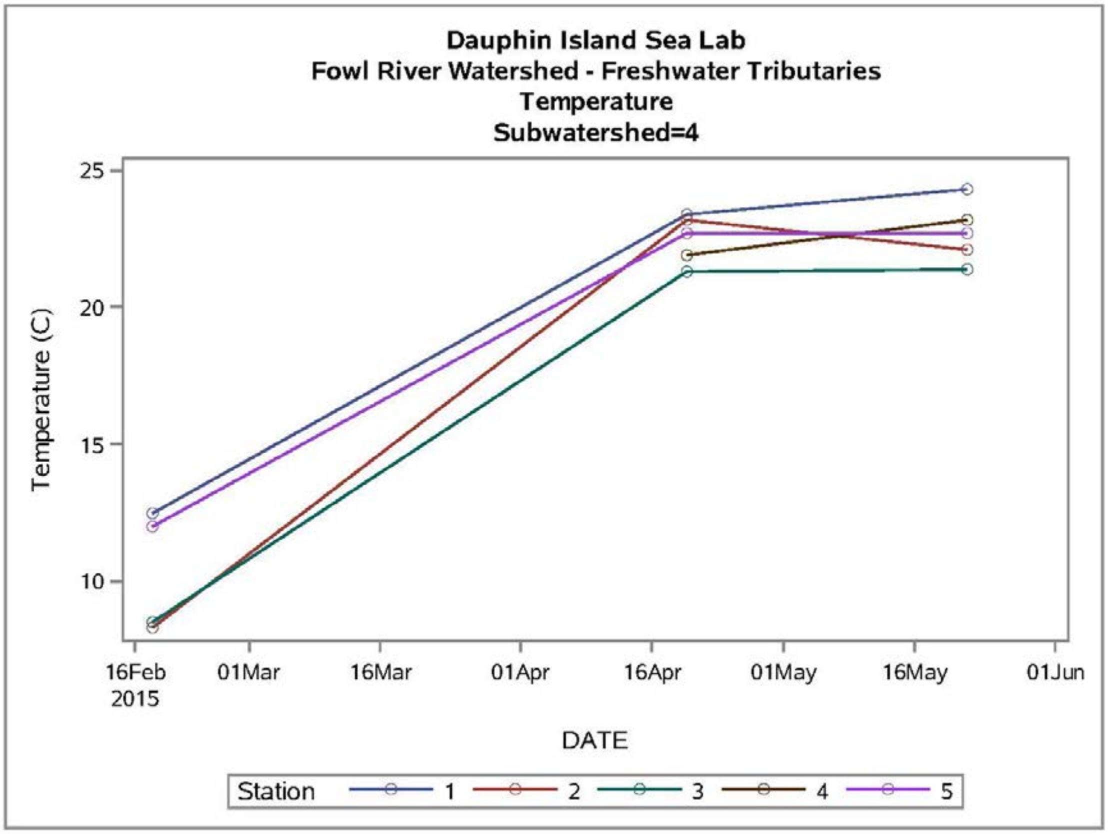


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Temperature
Subwatershed=2
Temperature (C)
20
15
10
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4

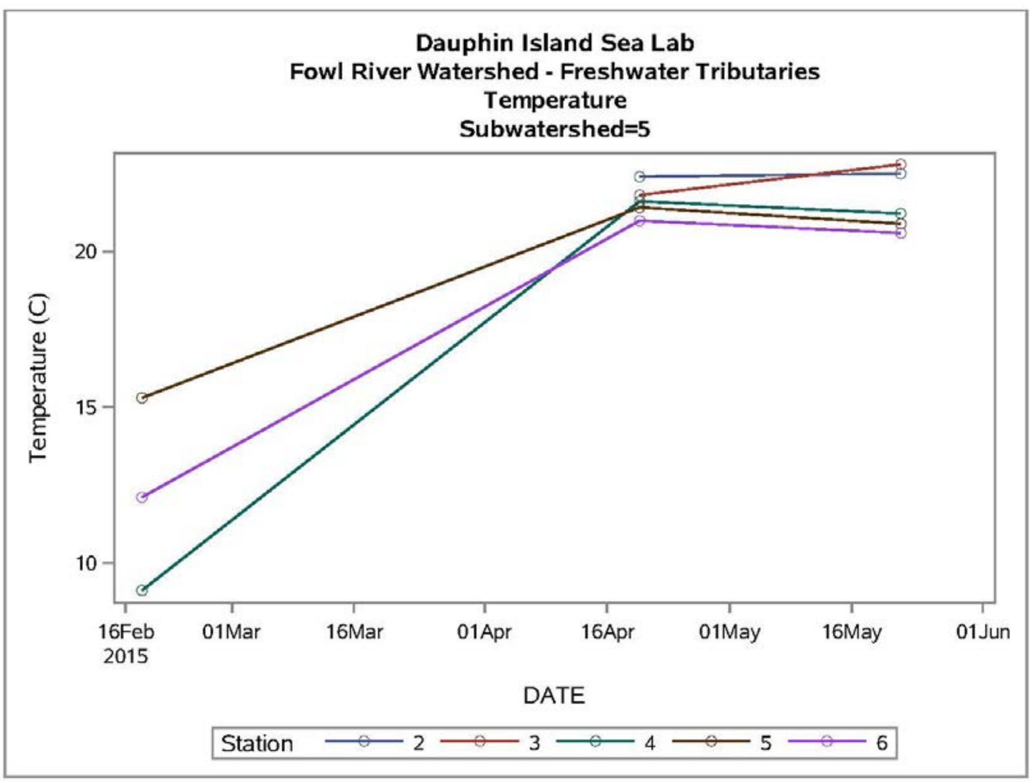


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Temperature
Subwatershed=3
Temperature (C)
22.5
20.0
17.5
15.0
12.5
10.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

D. RAW DATA

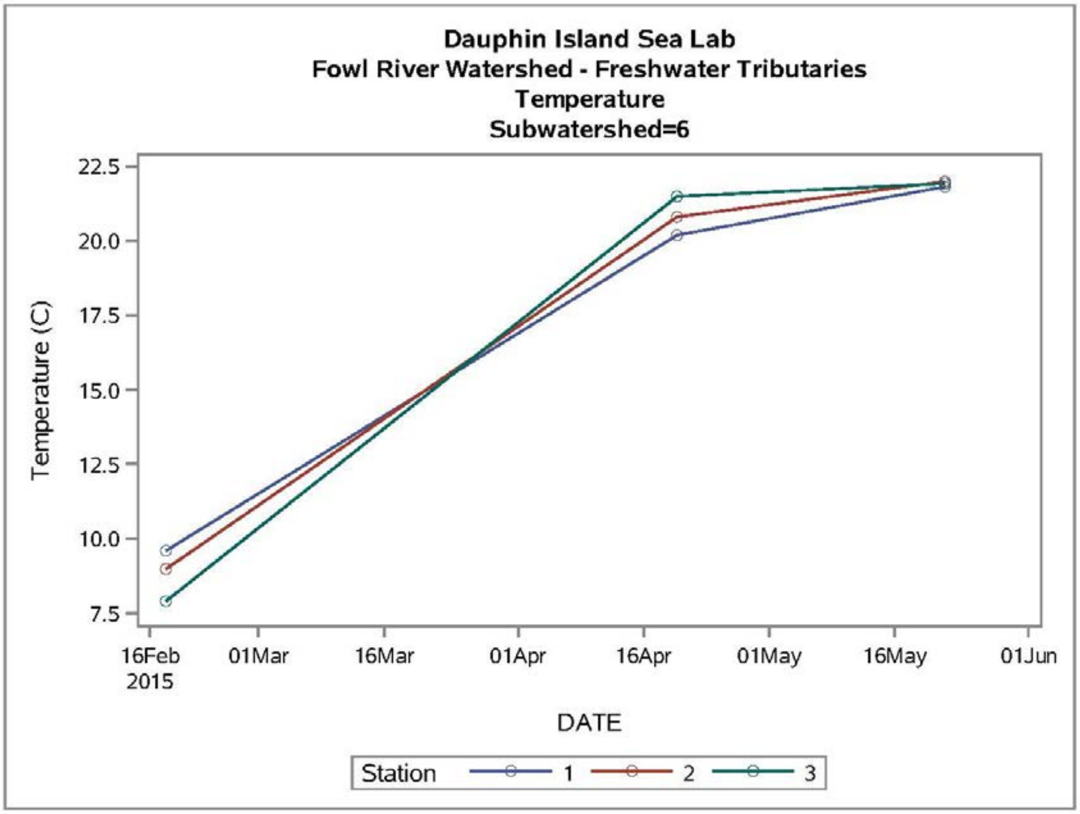


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Temperature
Subwatershed=4
Temperature (C)
25
20
15
10
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4 5

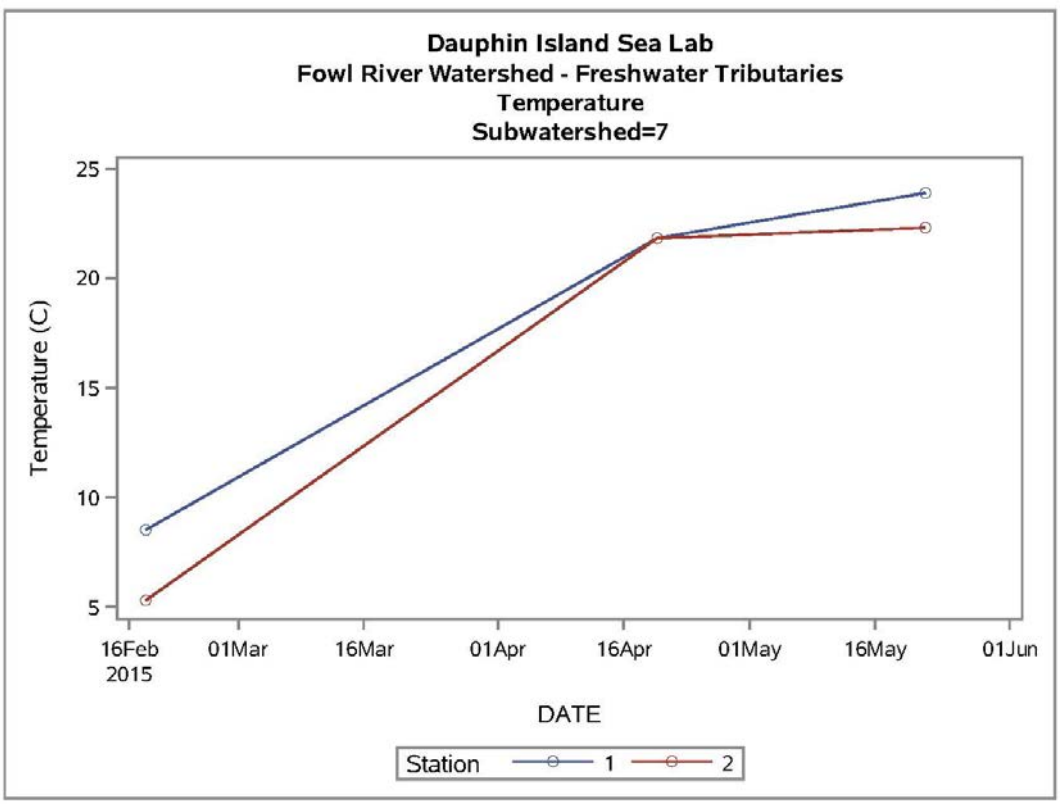


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Temperature
Subwatershed=5
Temperature (C)
20
15
10
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 2 3 4 5 6

D. RAW DATA

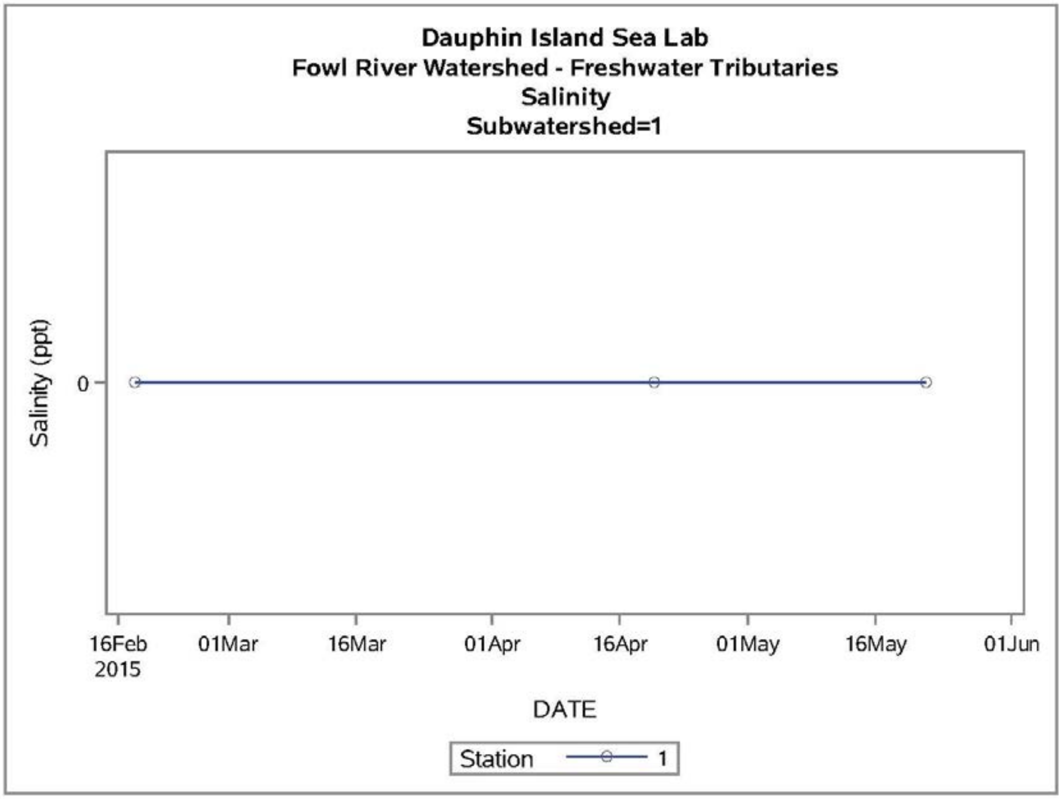


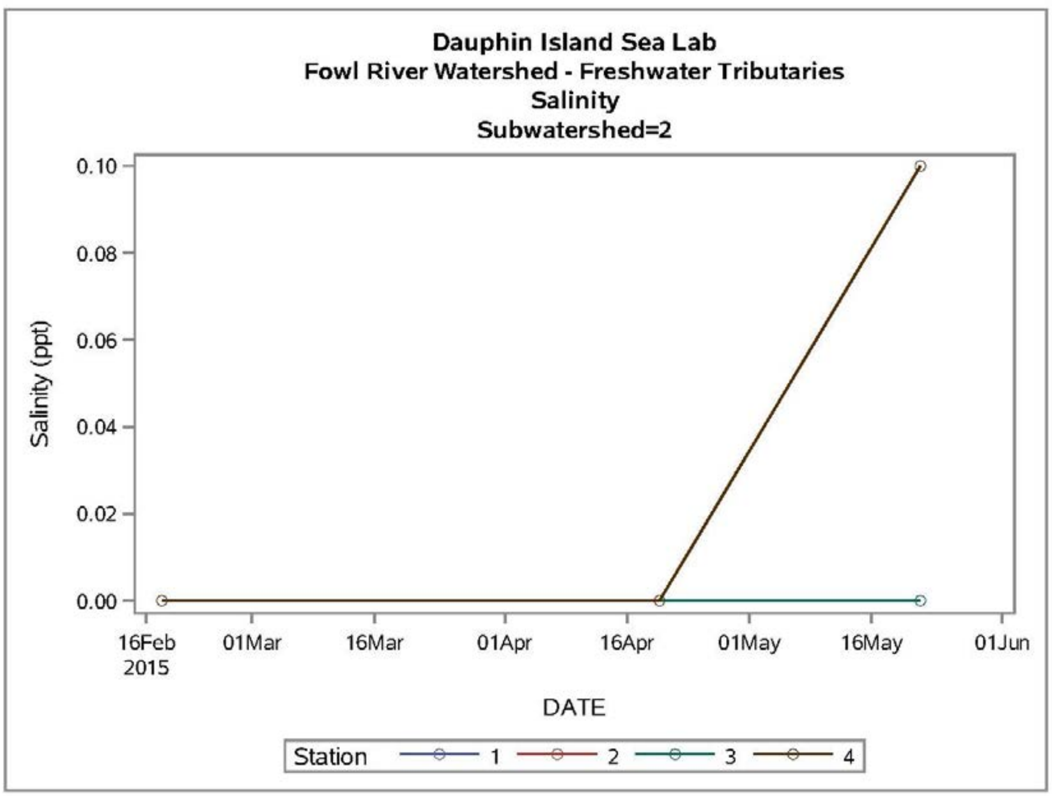
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Temperature
Subwatershed=6
Temperature (C)
22.5
20.0
17.5
15.0
12.5
10.0
7.5
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3



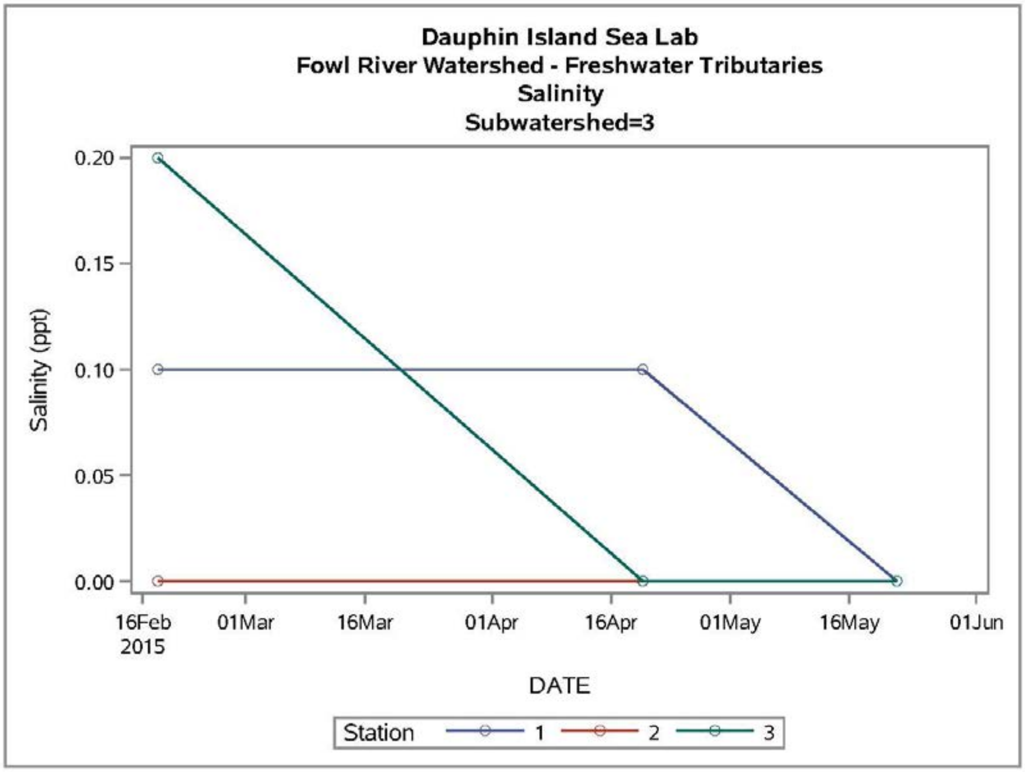
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Temperature
Subwatershed=7
Temperature (C)
25
20
15
10
5
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2

D. RAW DATA

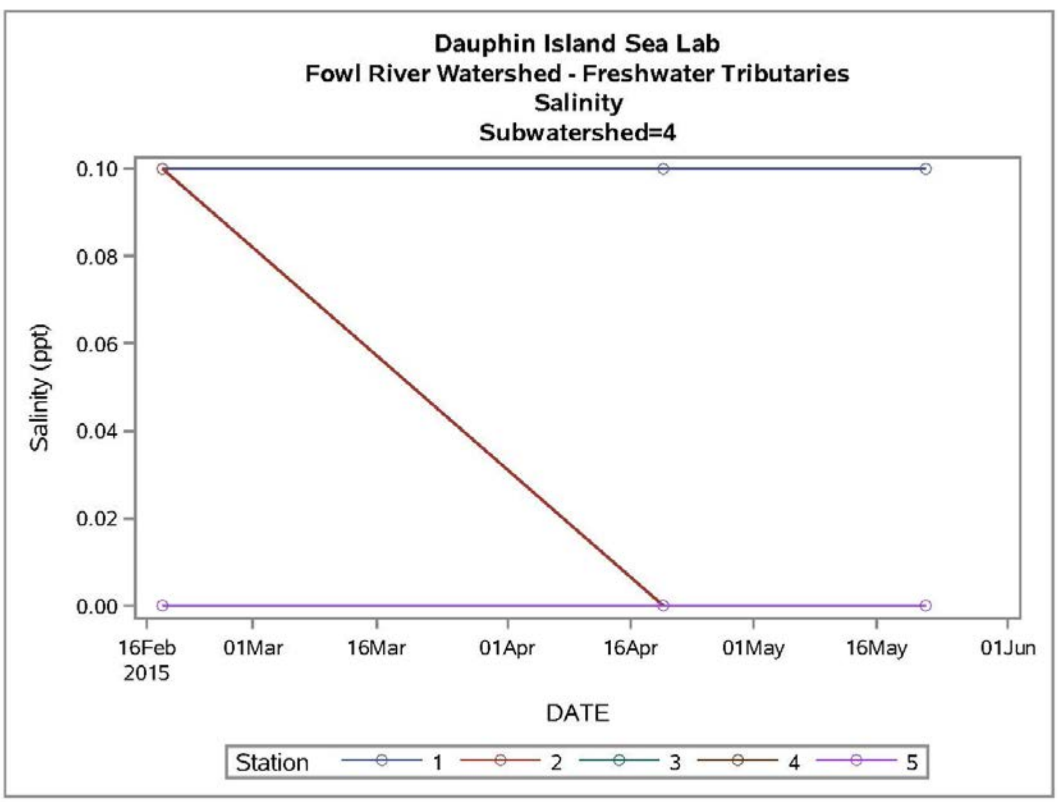

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Salinity
Subwatershed=1
Salinity (ppt)
0
16Feb
2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Salinity
Subwatershed=2
Salinity (ppt)
0.10
0.08
0.06
0.04
0.02
0.00
16Feb
2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3
4

D. RAW DATA

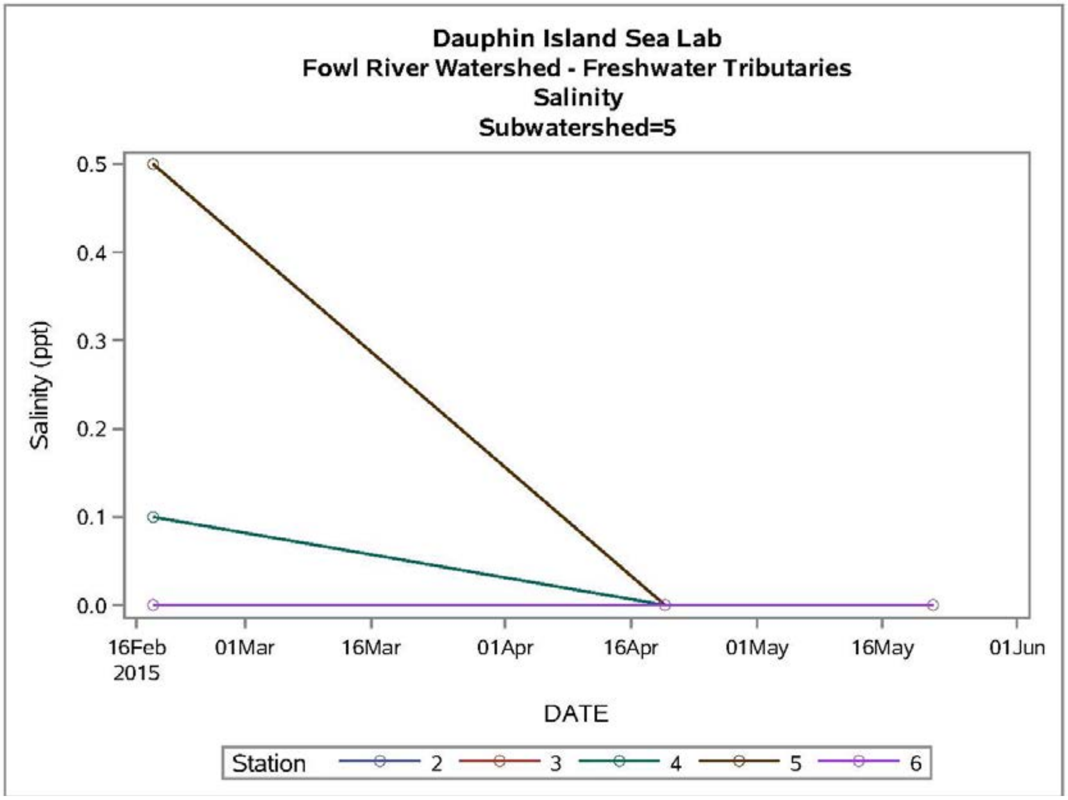


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Salinity
Subwatershed=3
Salinity (ppt)
0.20
0.15
0.10
0.05
0.00
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

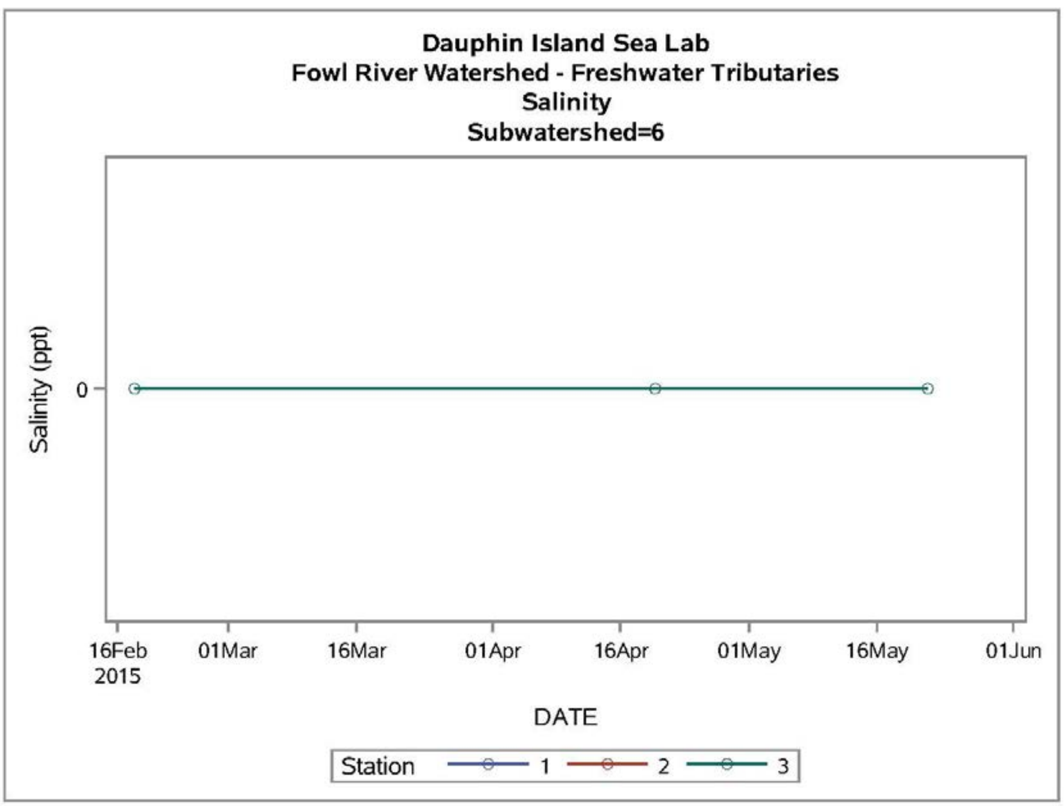


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Salinity
Subwatershed=4
Salinity (ppt)
0.10
0.08
0.06
0.04
0.02
0.00
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4 5

D. RAW DATA

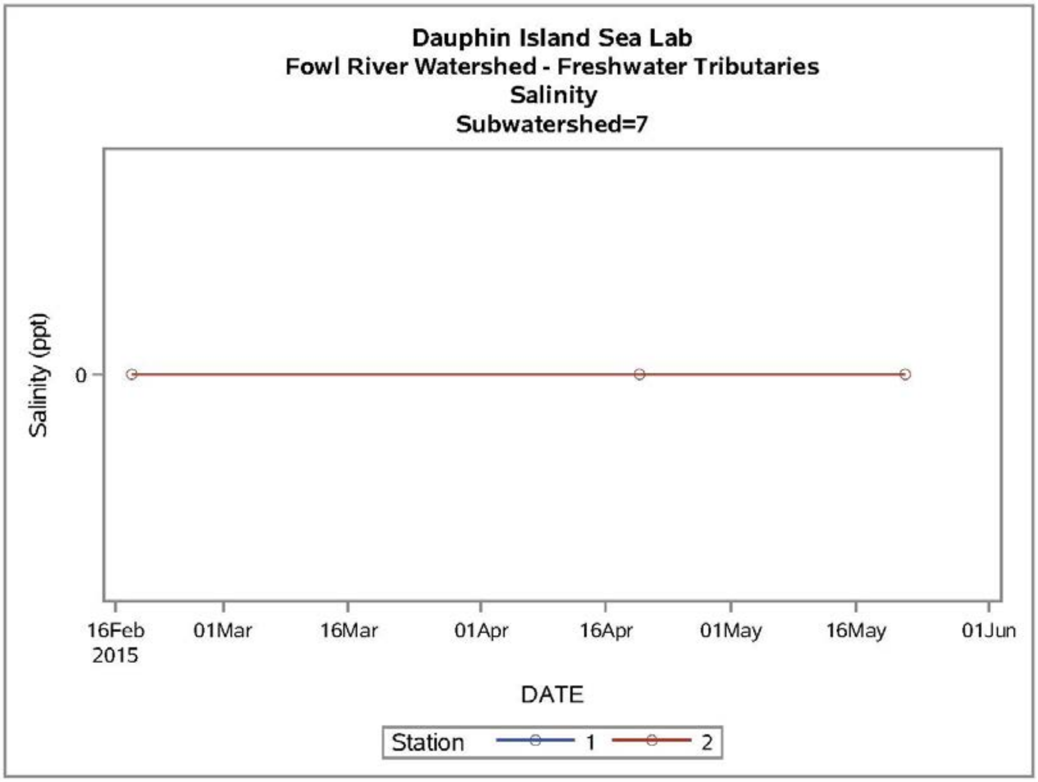


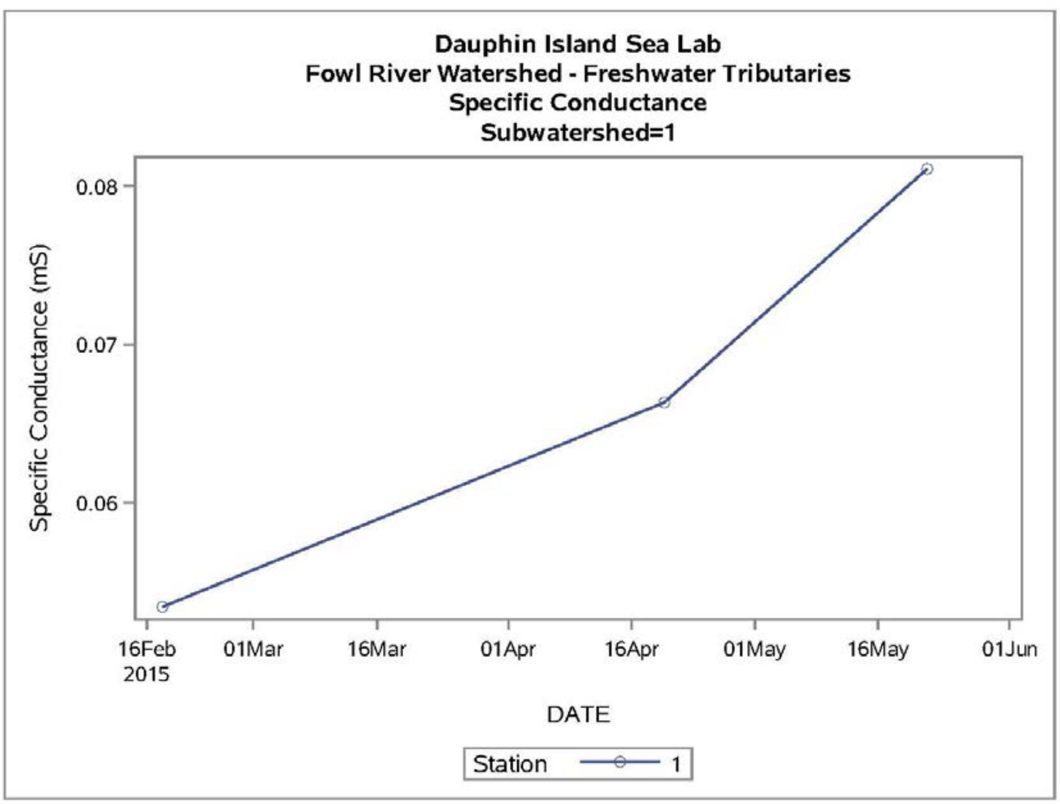
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Salinity
Subwatershed=5
Salinity (ppt)
0.5
0.4
0.3
0.2
0.1
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
2
3
4
5
6



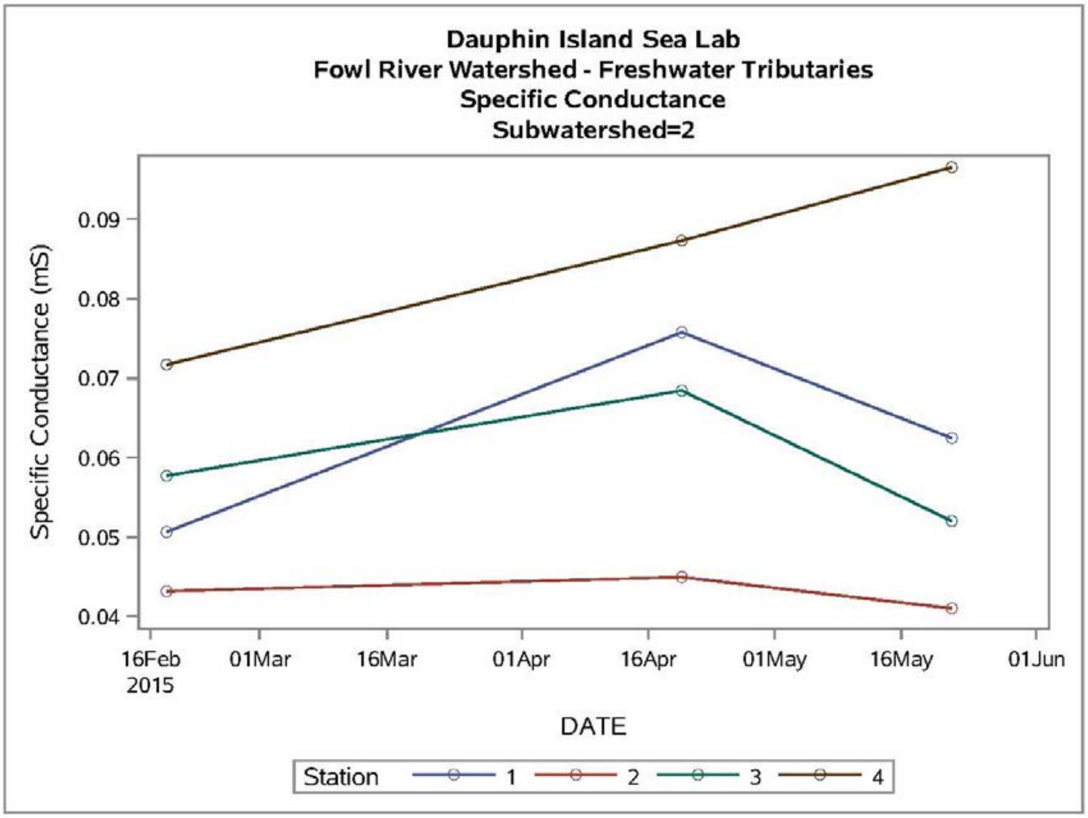
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Salinity
Subwatershed=6
Salinity (ppt)
0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3

D. RAW DATA

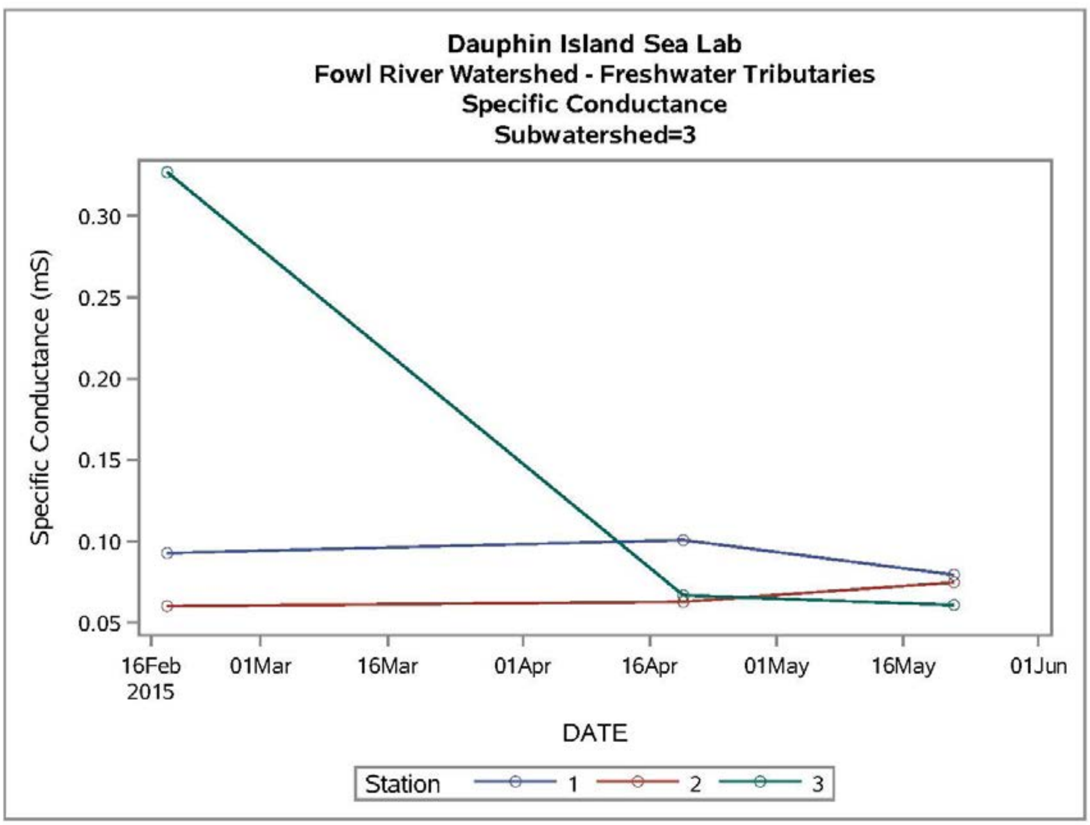

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Salinity
Subwatershed=7
Salinity (ppt)
0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Specific Conductance
Subwatershed=1
Specific Conductance (mS)
0.08
0.07
0.06
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1

D. RAW DATA

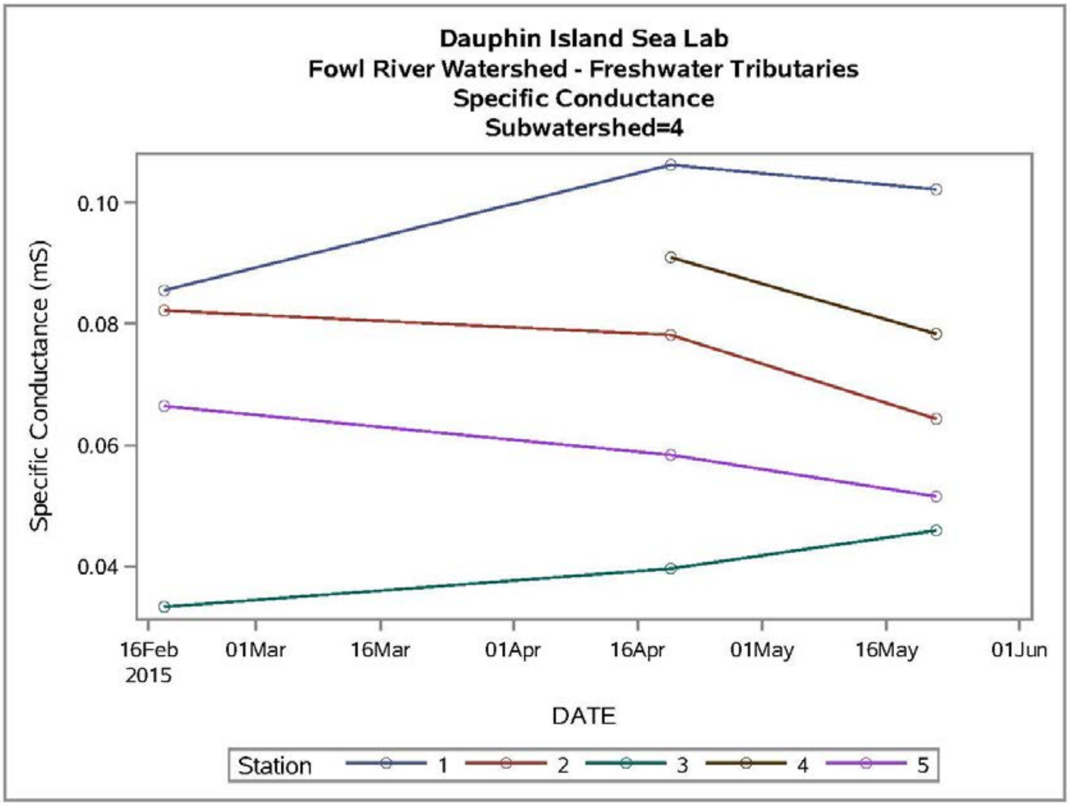


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Specific Conductance
Subwatershed=2
Specific Conductance (mS)
0.09
0.08
0.07
0.06
0.05
0.04
16Feb
2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3
4

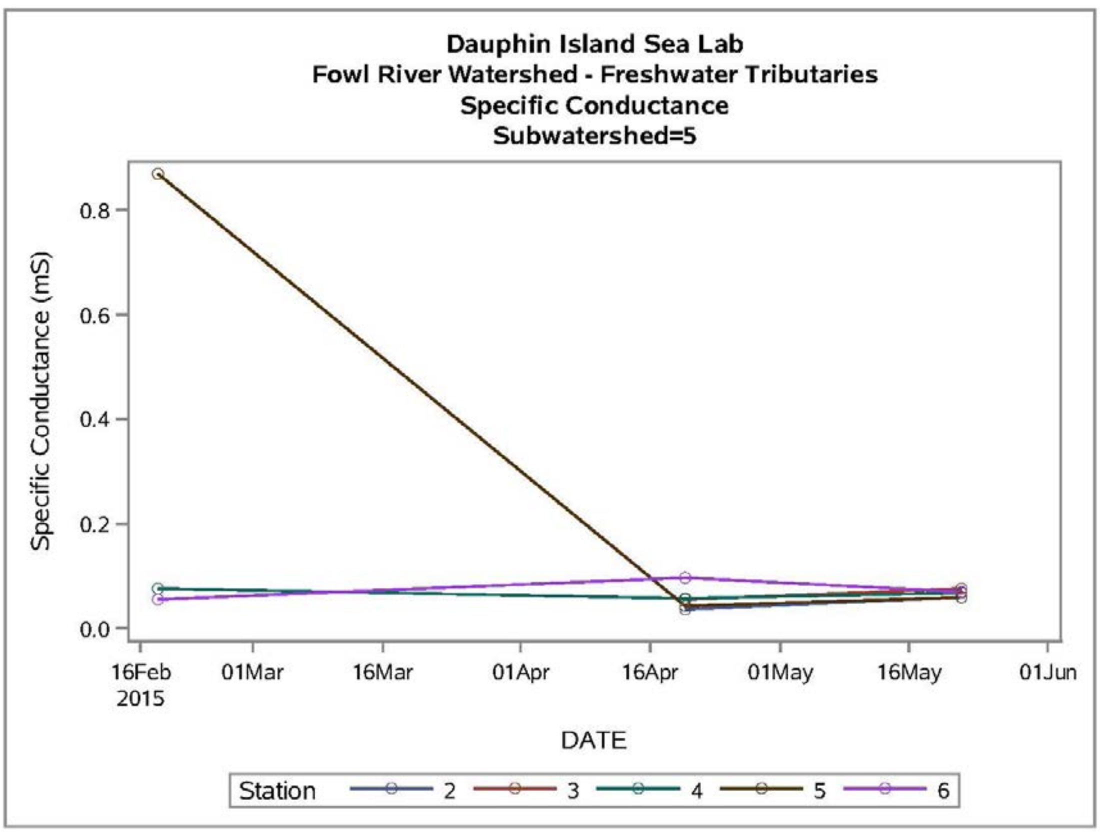


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Specific Conductance
Subwatershed=3
Specific Conductance (mS)
0.30
0.25
0.20
0.15
0.10
0.05
16Feb
2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3

D. RAW DATA

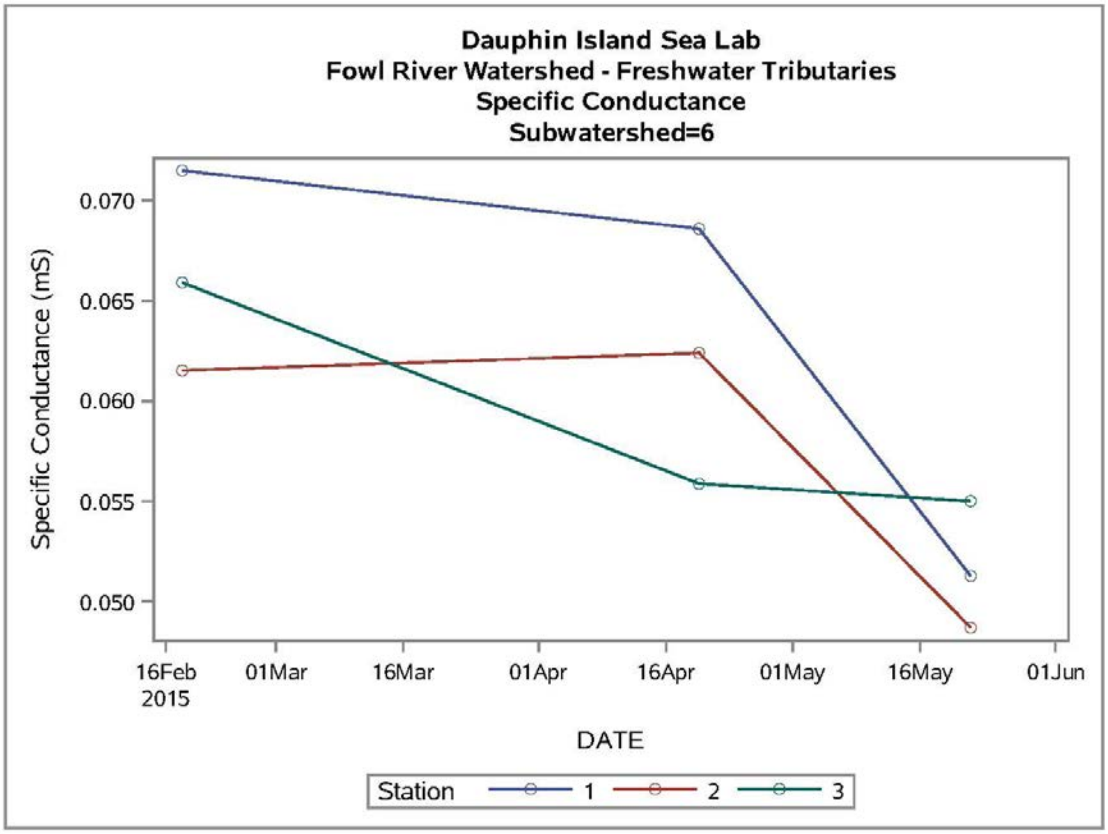


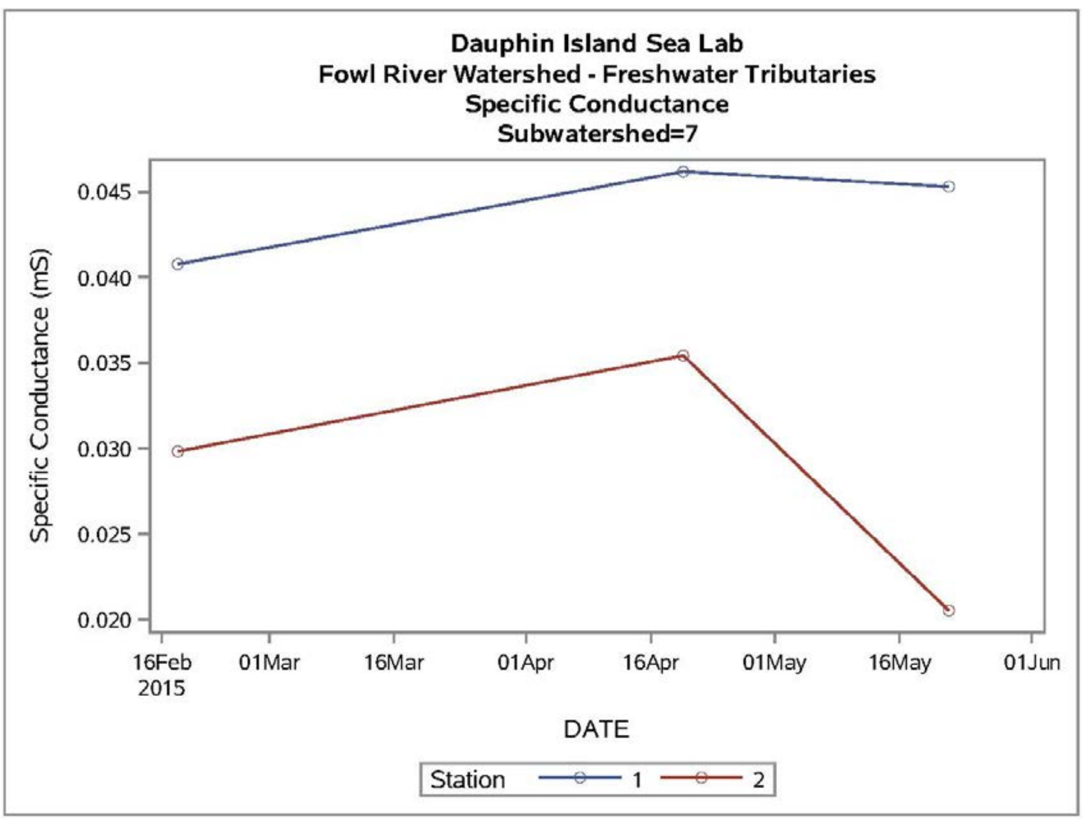
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Specific Conductance
Subwatershed=4
Specific Conductance (mS)
0.10
0.08
0.06
0.04
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4 5



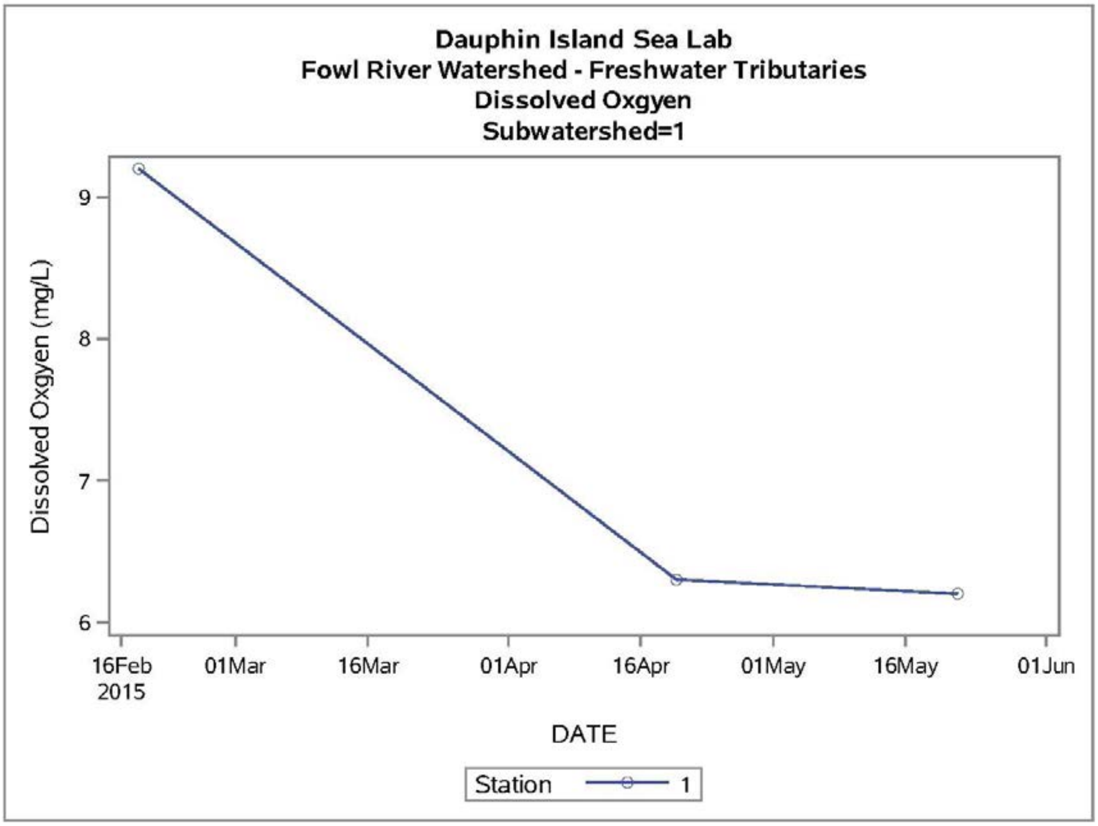
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Specific Conductance
Subwatershed=5
Specific Conductance (mS)
0.8
0.6
0.4
0.2
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 2 3 4 5 6

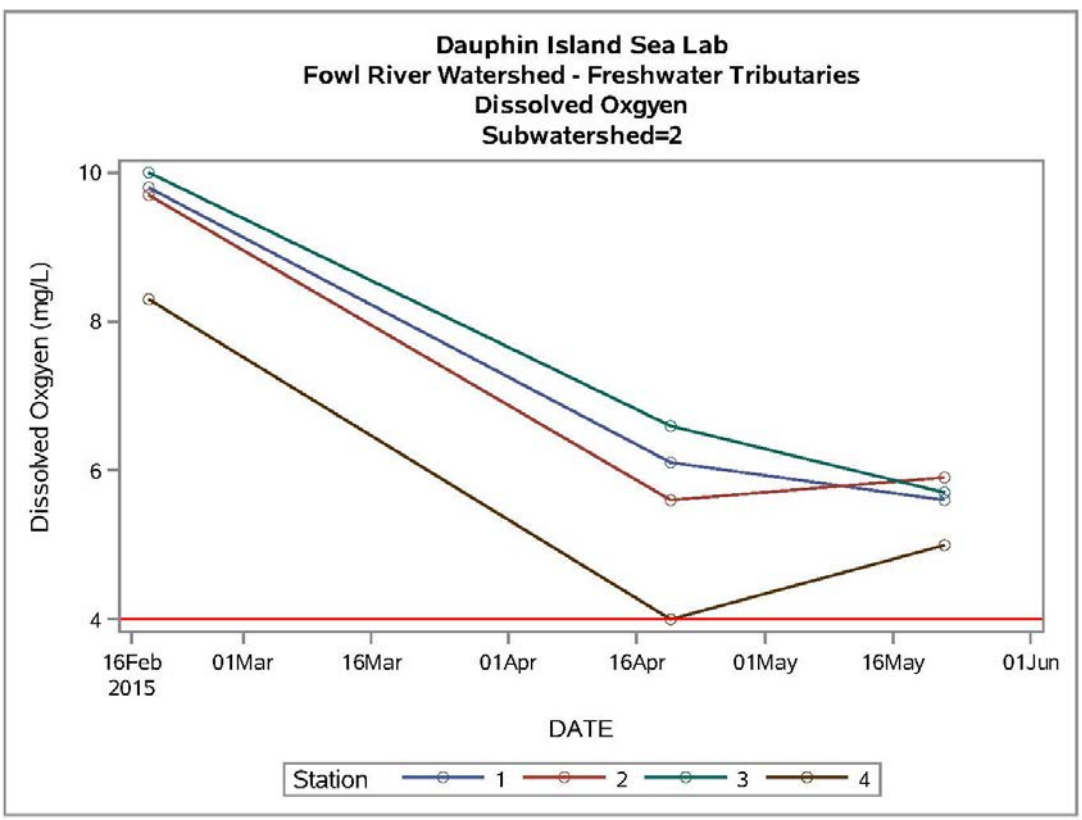
D. RAW DATA


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Specific Conductance
Subwatershed=6
Specific Conductance (mS)
0.070
0.065
0.060
0.055
0.050
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

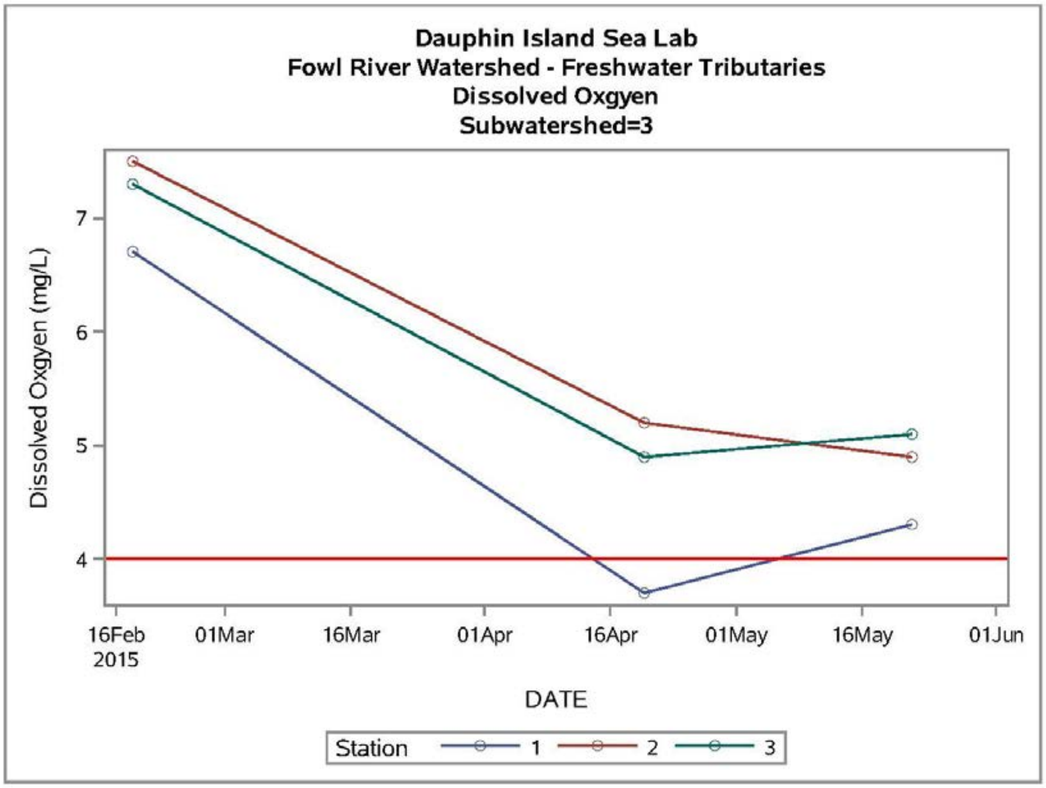

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Specific Conductance
Subwatershed=7
Specific Conductance (mS)
0.045
0.040
0.035
0.030
0.025
0.020
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2

D. RAW DATA

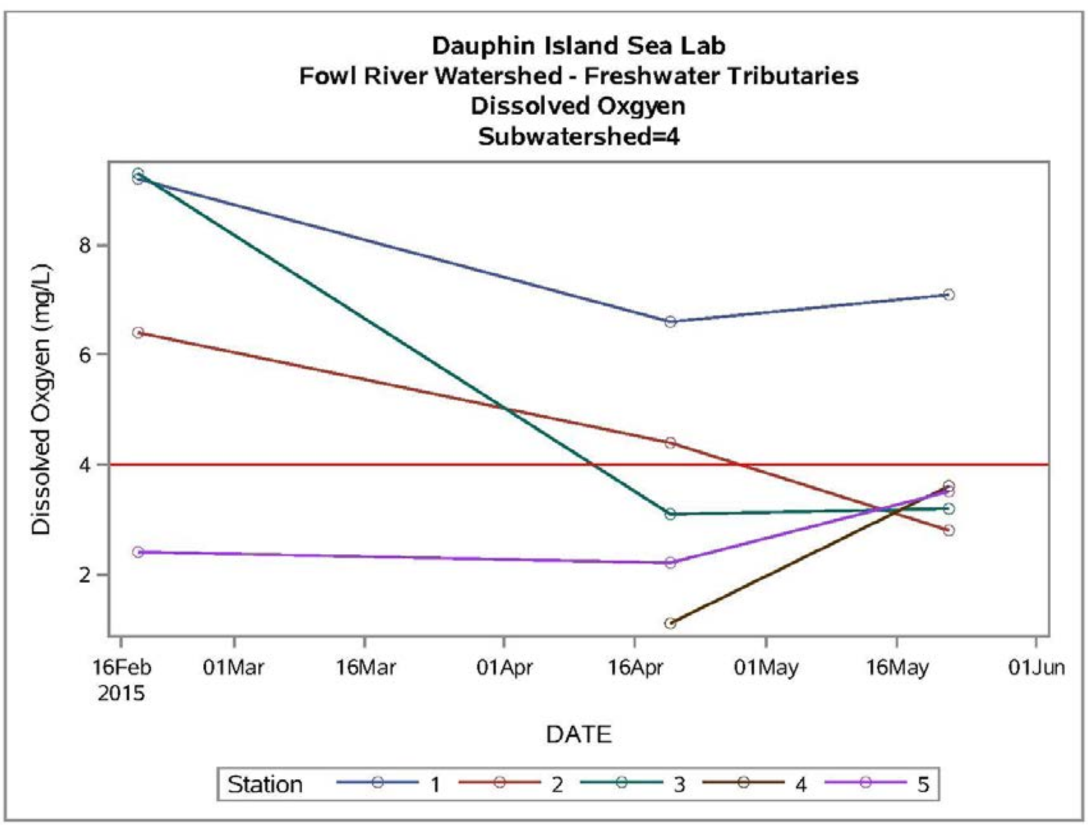

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved Oxgyen
Subwatershed=1
Dissolved Oxgyen (mg/L)
9
8
7
6
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved Oxgyen
Subwatershed=2
Dissolved Oxgyen (mg/L)
10
8
6
4
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3
4

D. RAW DATA

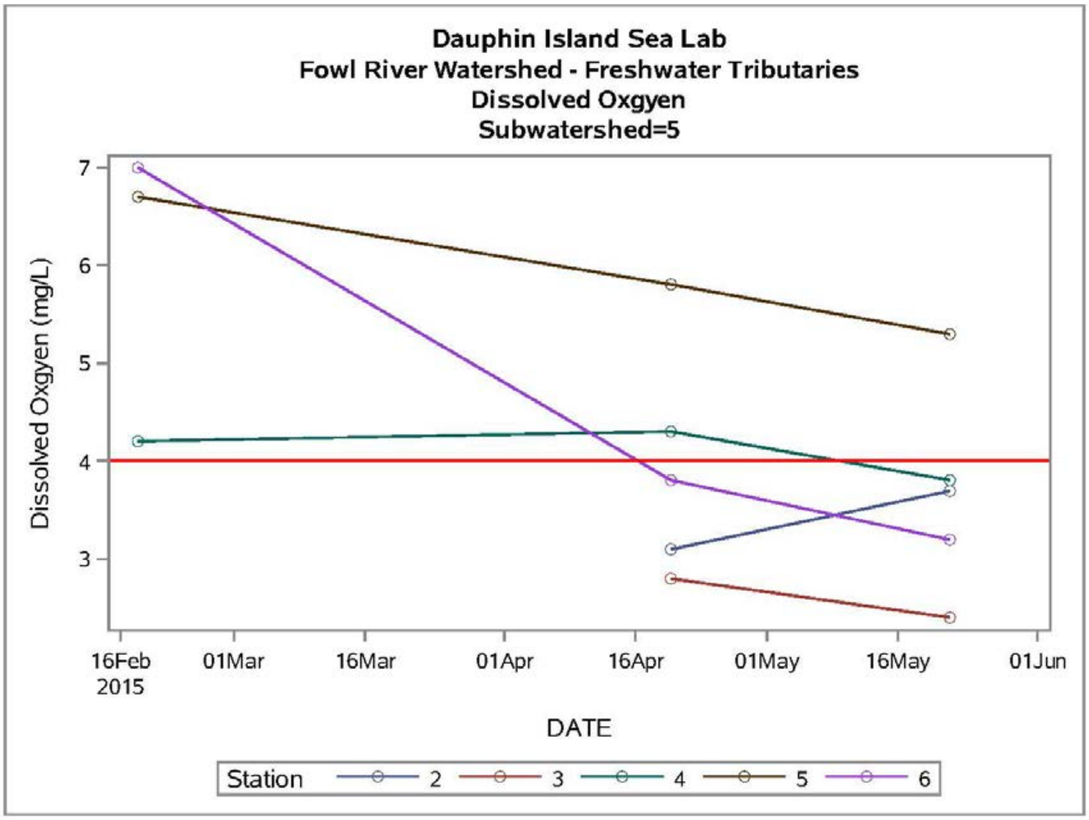


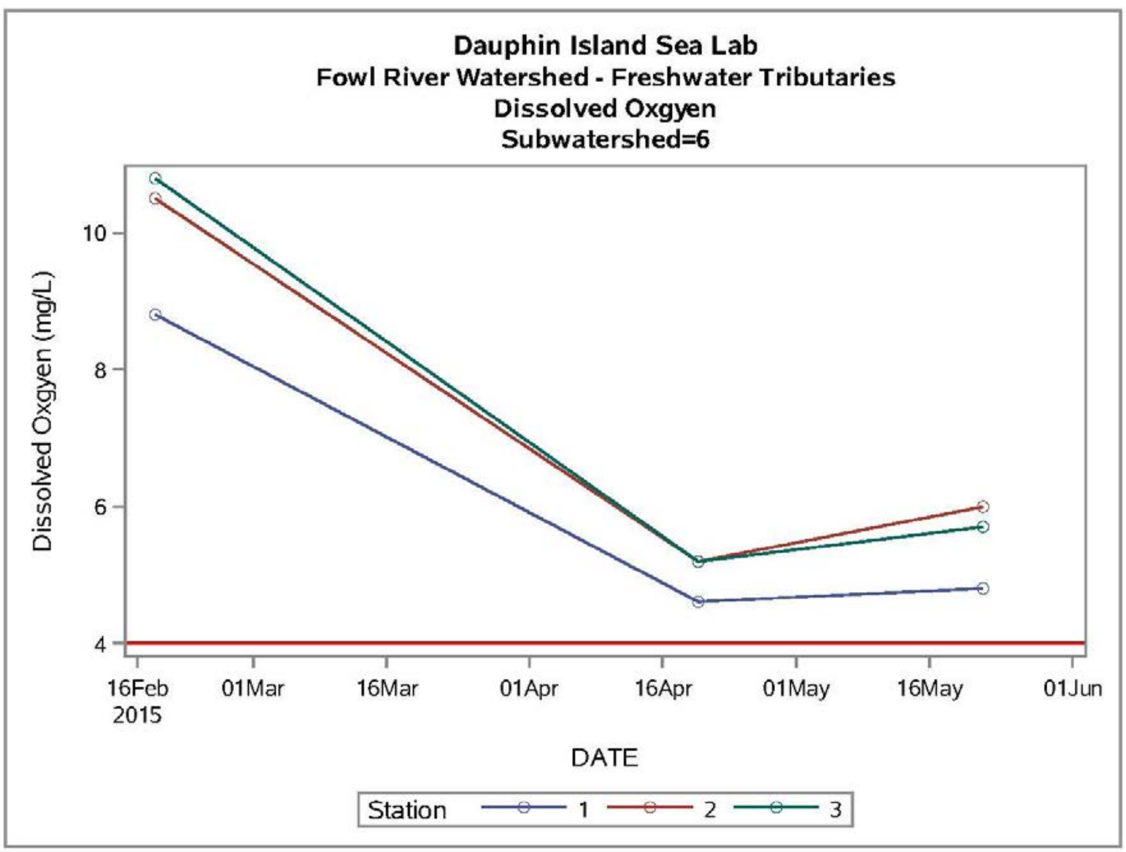
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved Oxgyen
Subwatershed=3
Dissolved Oxgyen (mg/L)
7
6
5
4
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3



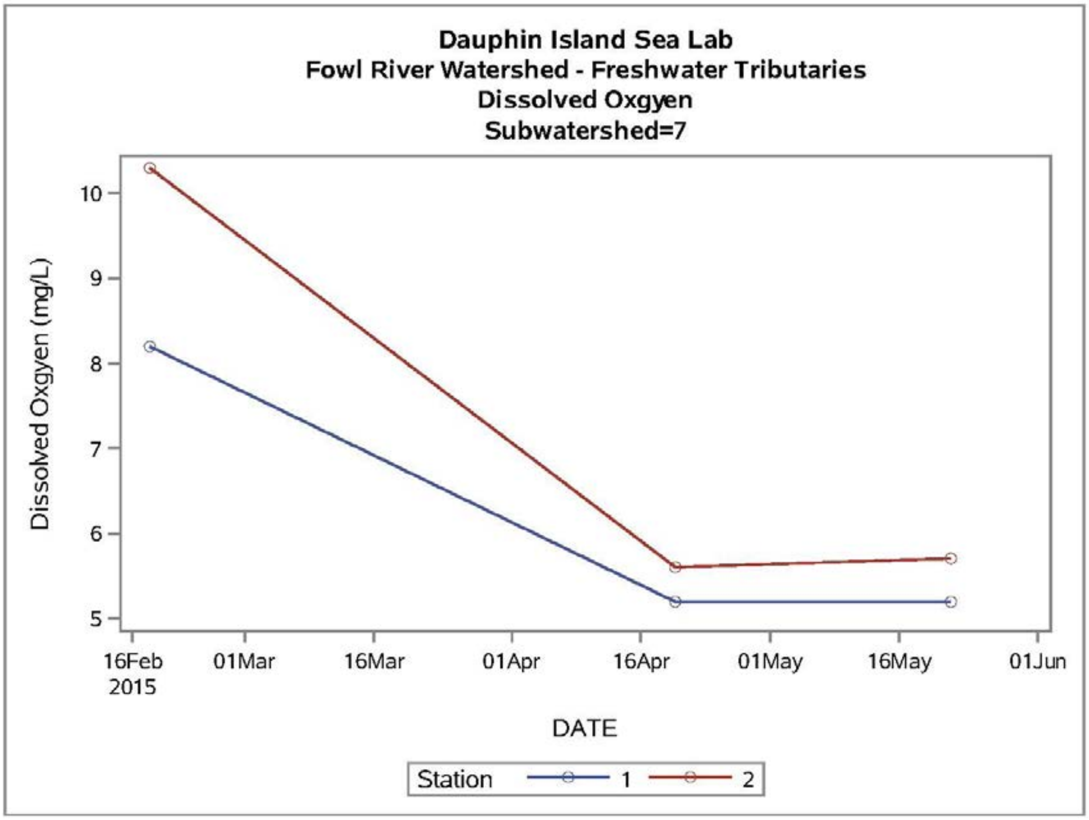
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved Oxgyen
Subwatershed=4
Dissolved Oxgyen (mg/L)
8
6
4
2
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4 5

D. RAW DATA

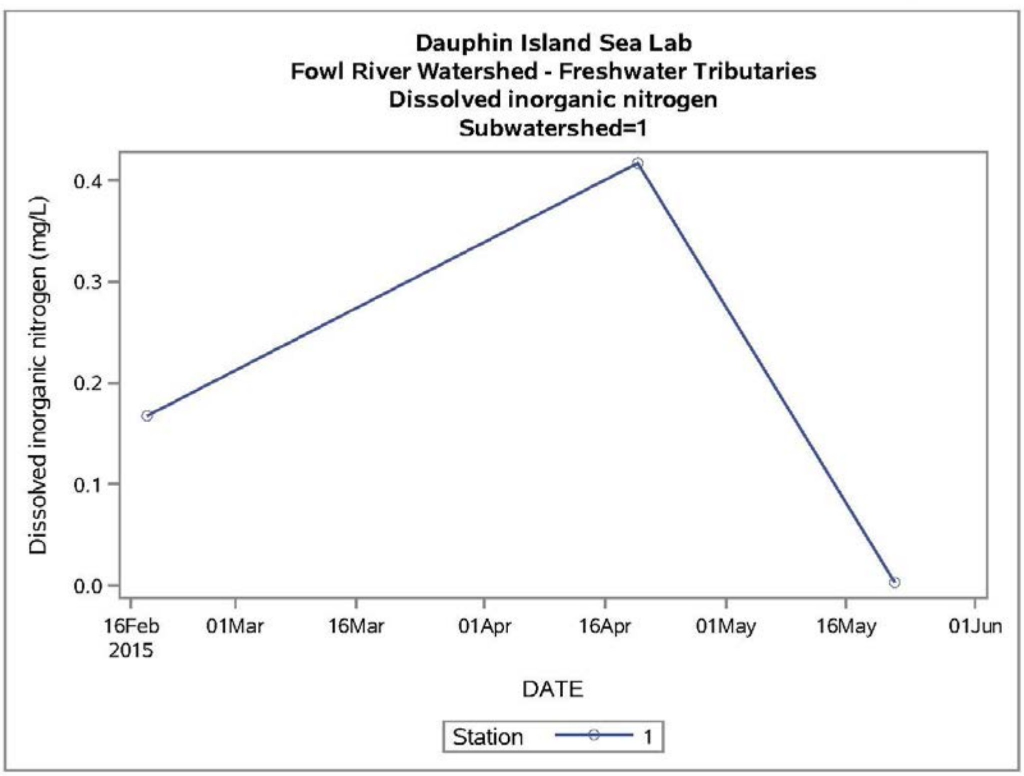

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved Oxgyen
Subwatershed=5
Dissolved Oxgyen (mg/L)
7
6
5
4
3
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 2 3 4 5 6


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved Oxgyen
Subwatershed=6
Dissolved Oxgyen (mg/L)
10
8
6
4
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

D. RAW DATA

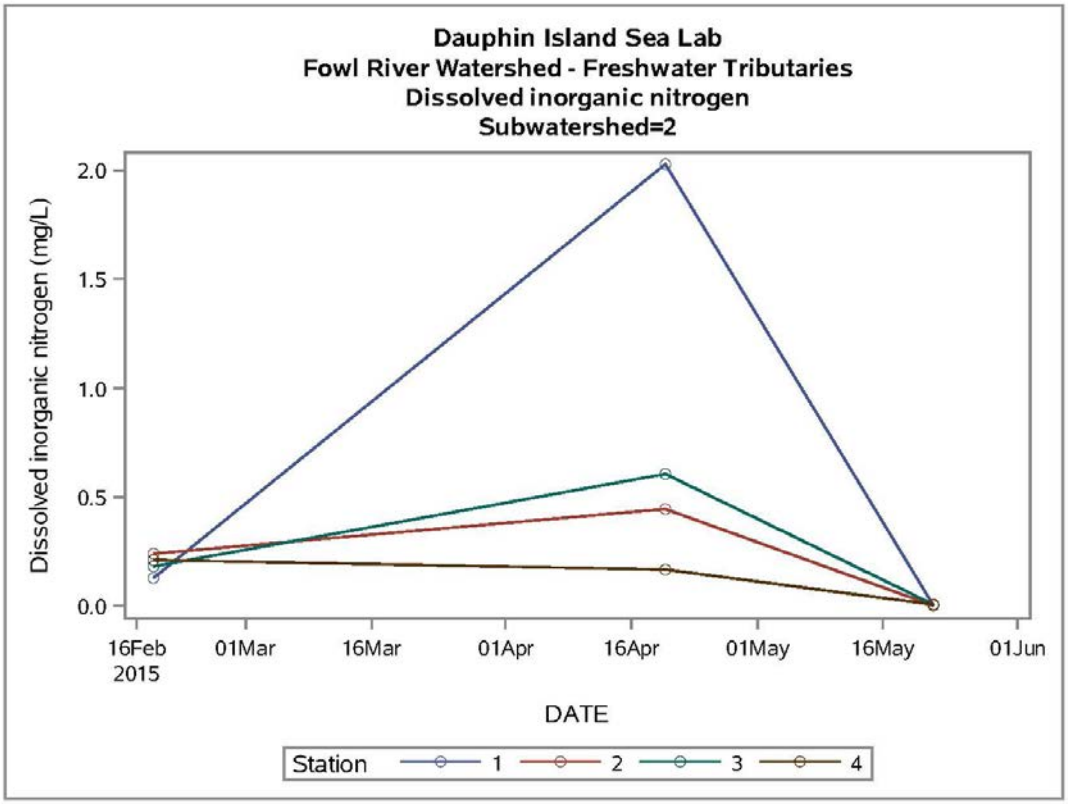


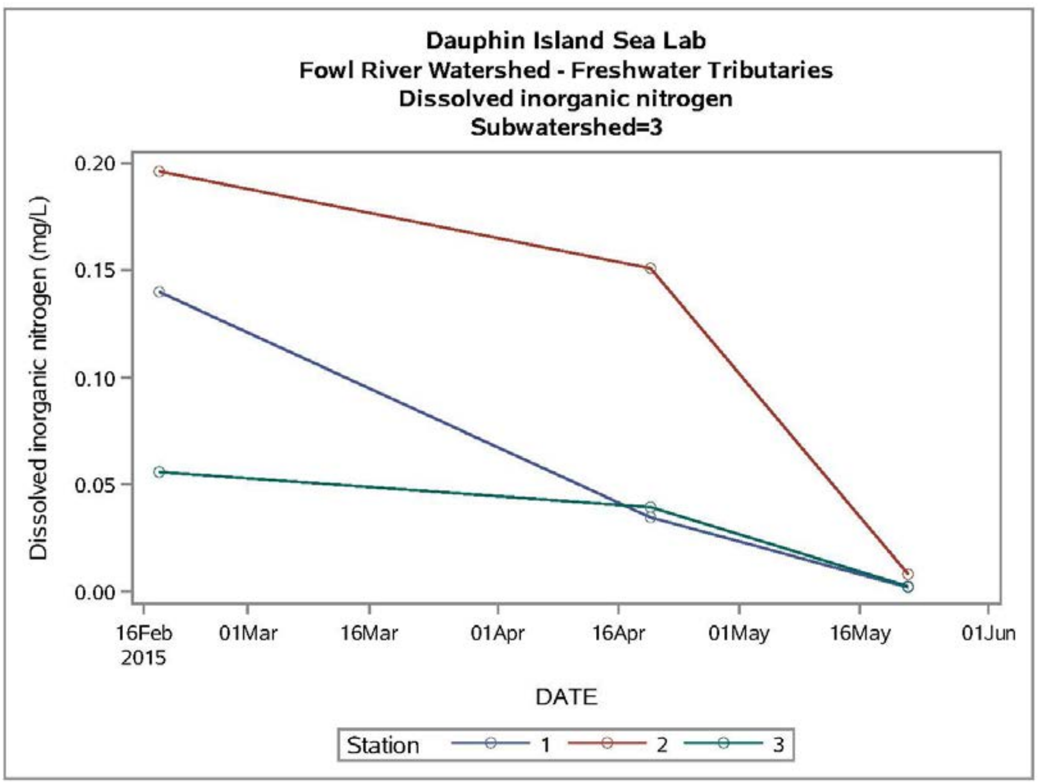
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved Oxgyen
Subwatershed=7
Dissolved Oxgyen (mg/L)
10
9
8
7
6
5
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2



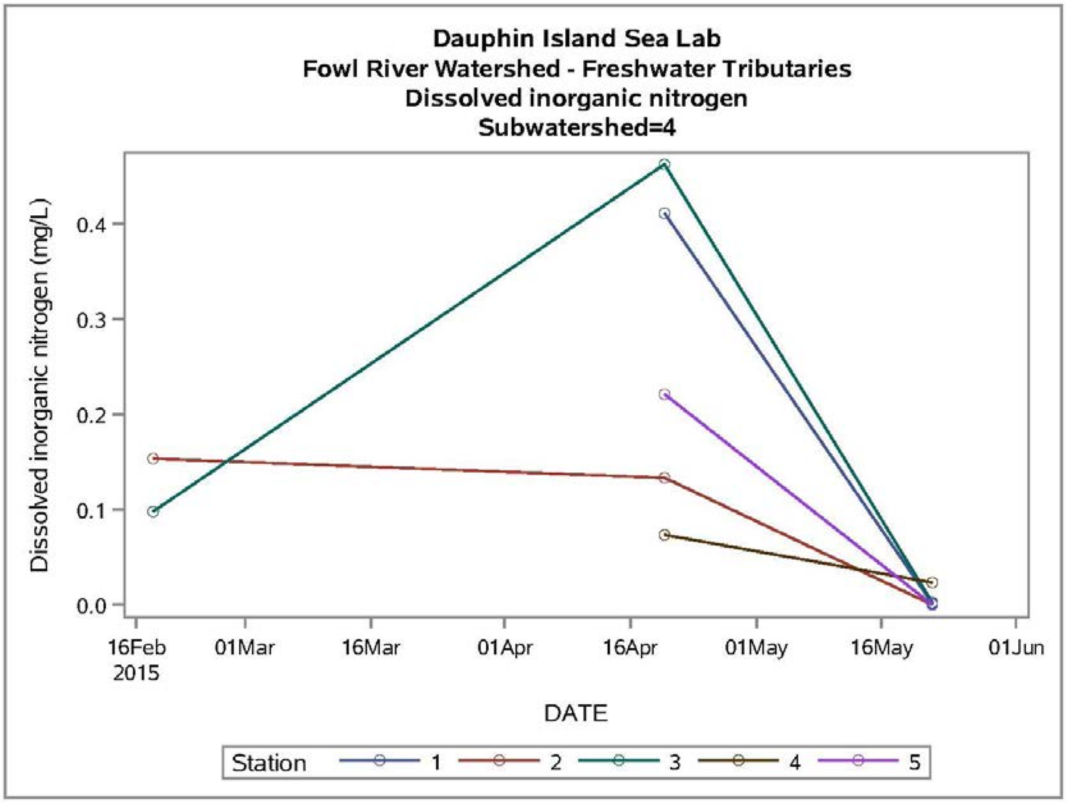
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved inorganic nitrogen
Subwatershed=1
Dissolved inorganic nitrogen (mg/L)
0.4
0.3
0.2
0.1
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1

D. RAW DATA

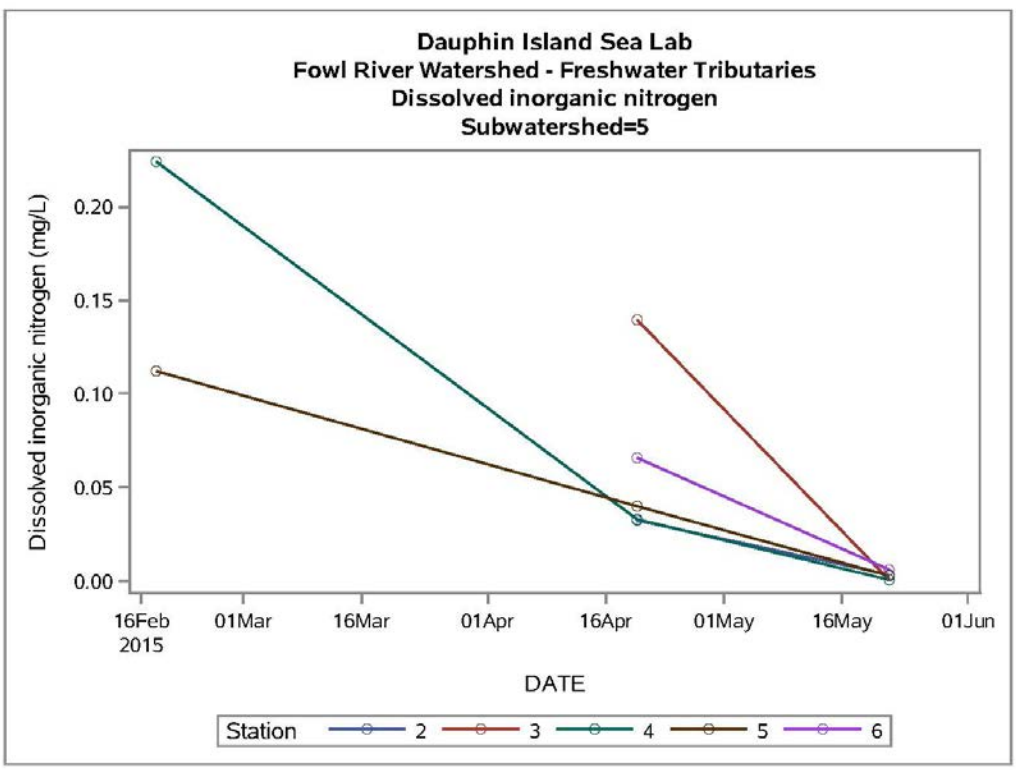

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved inorganic nitrogen
Subwatershed=2
Dissolved inorganic nitrogen (mg/L)
2.0
1.5
1.0
0.5
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved inorganic nitrogen
Subwatershed=3
Dissolved inorganic nitrogen (mg/L)
0.20
0.15
0.10
0.05
0.00
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

D. RAW DATA

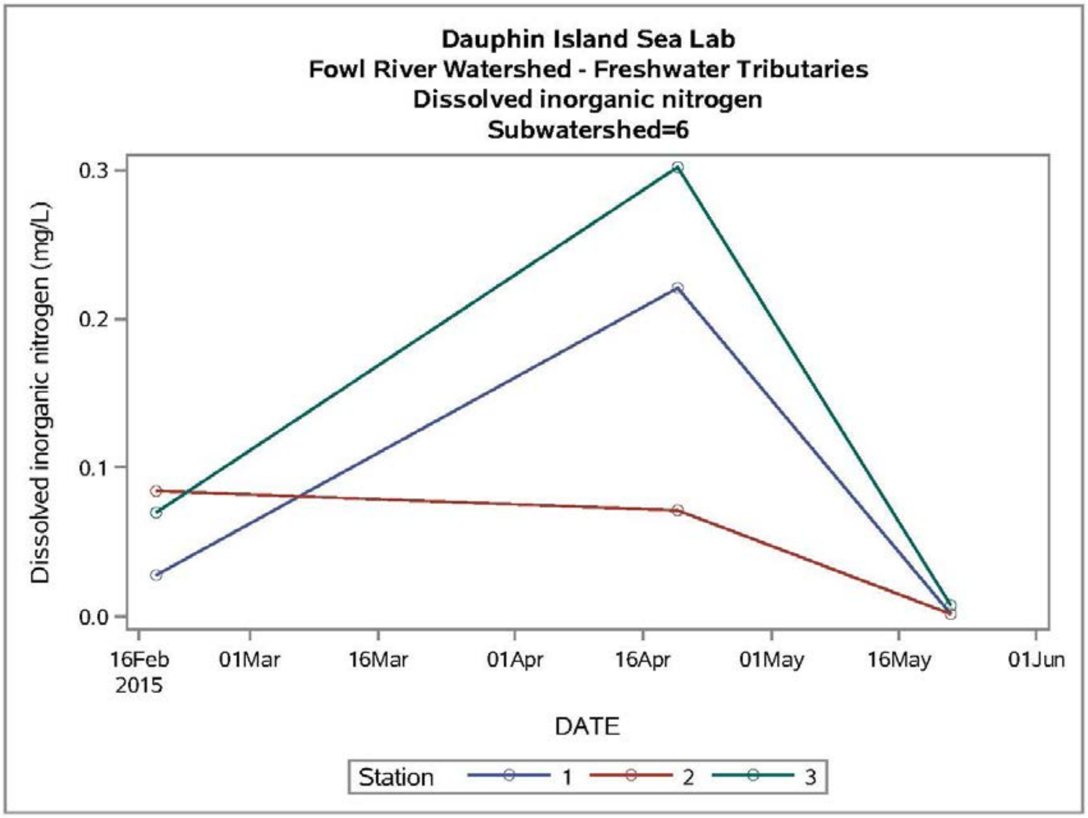


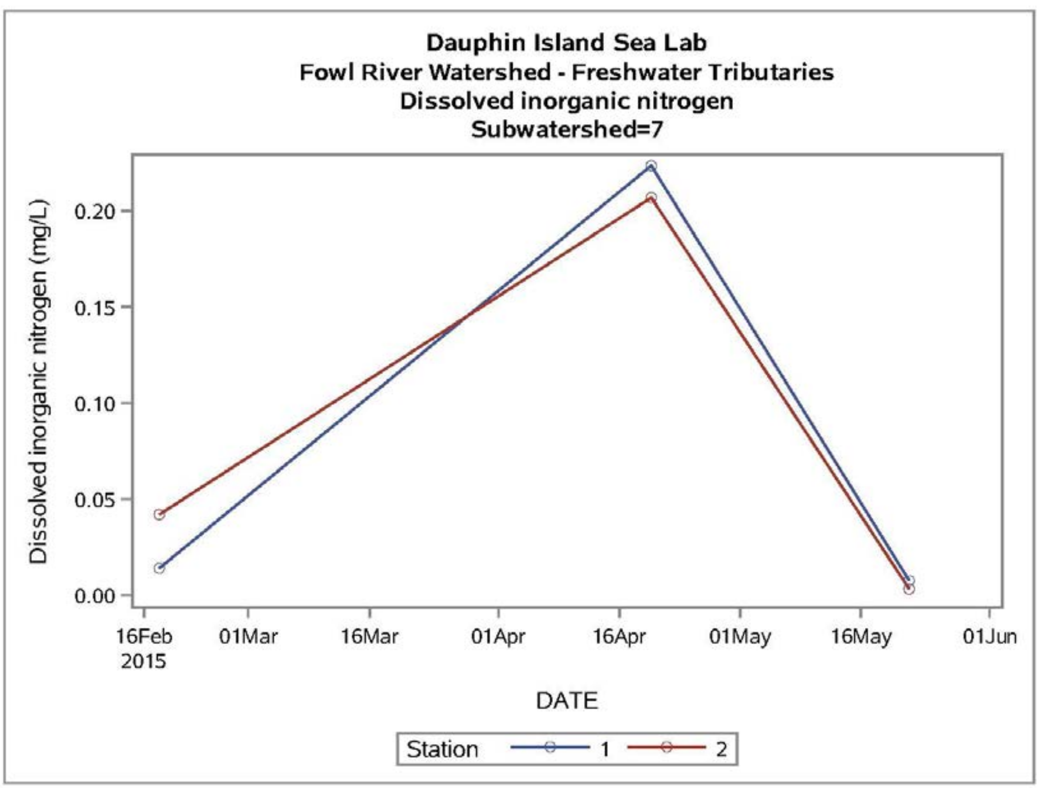
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved inorganic nitrogen
Subwatershed=4
Dissolved inorganic nitrogen (mg/L)
0.0
0.1
0.2
0.3
0.4
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4 5



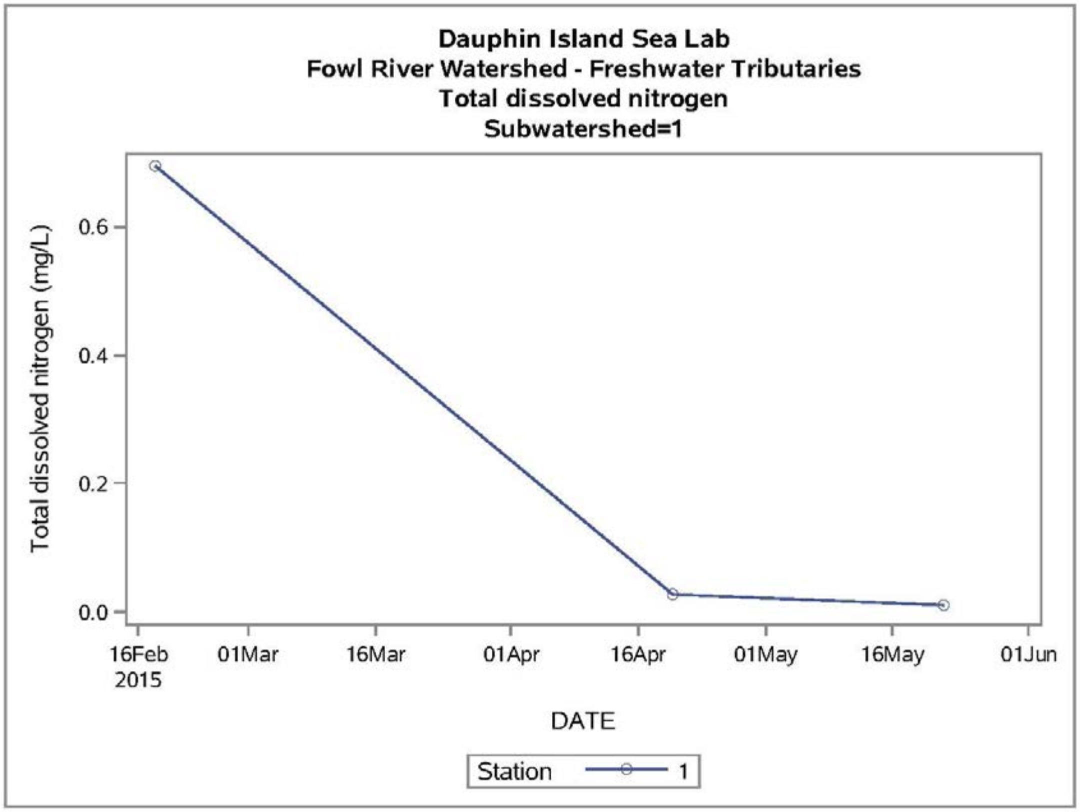
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved inorganic nitrogen
Subwatershed=5
Dissolved inorganic nitrogen (mg/L)
0.00
0.05
0.10
0.15
0.20
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 2 3 4 5 6

D. RAW DATA

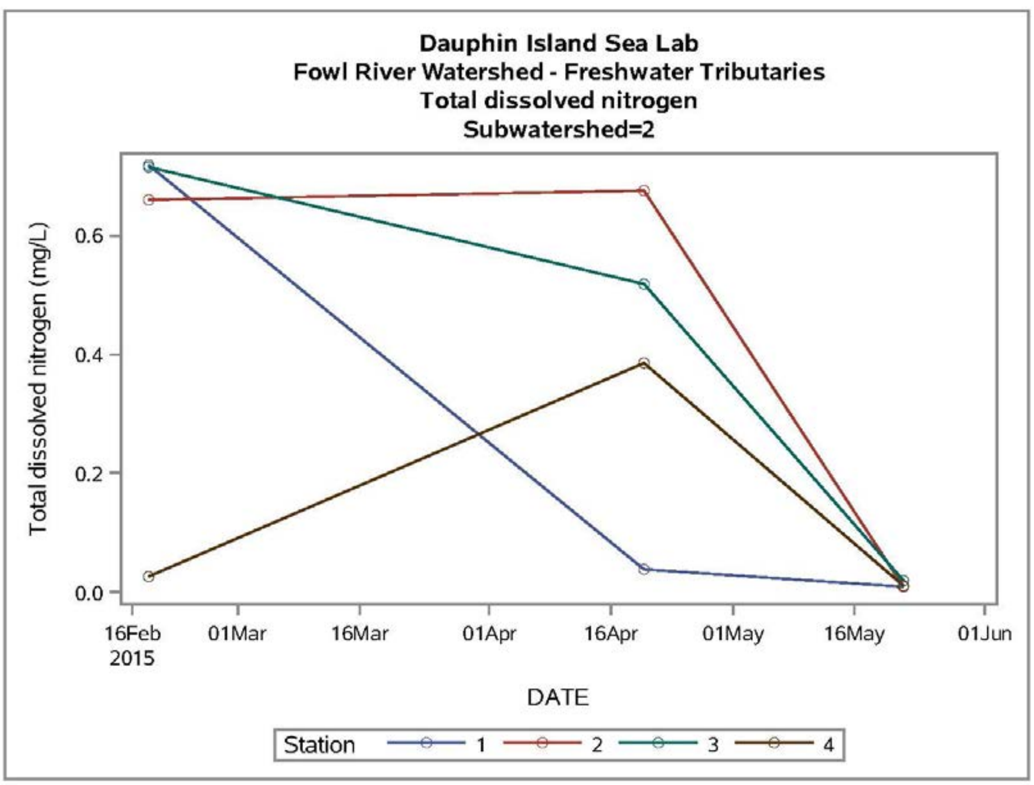

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved inorganic nitrogen
Subwatershed=6
Dissolved inorganic nitrogen (mg/L)
0.3
0.2
0.1
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Dissolved inorganic nitrogen
Subwatershed=7
Dissolved inorganic nitrogen (mg/L)
0.20
0.15
0.10
0.05
0.00
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2

D. RAW DATA

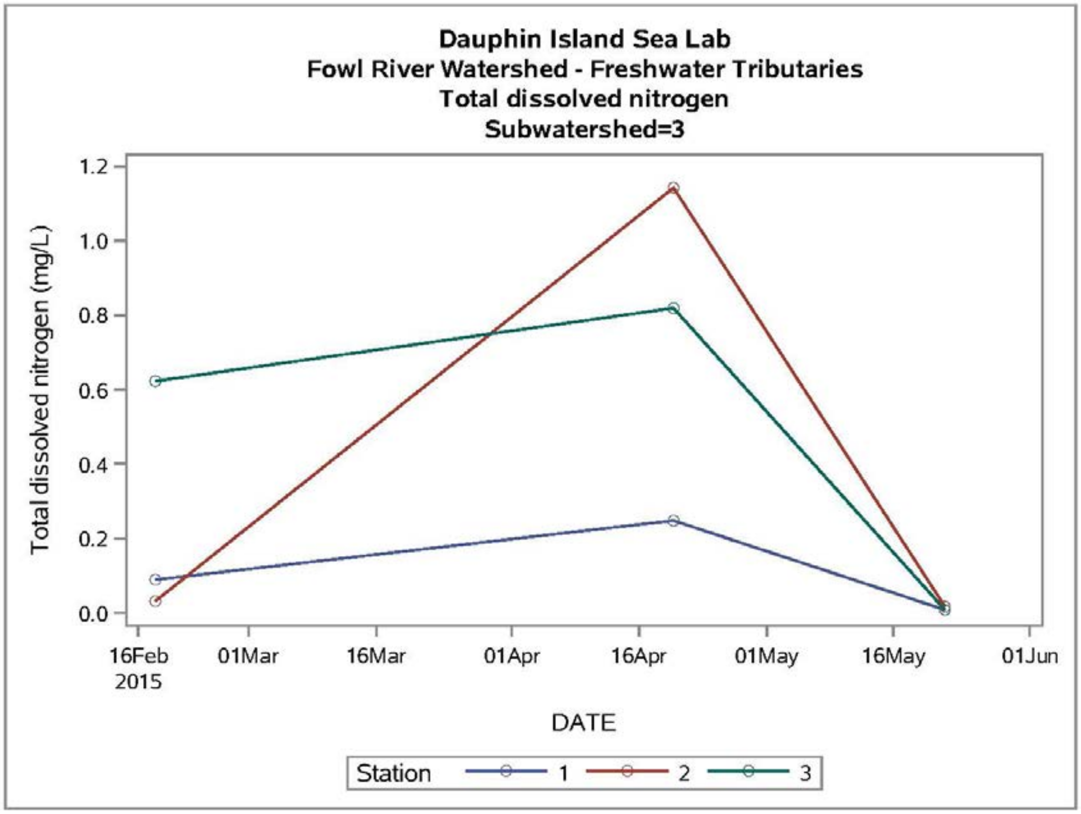


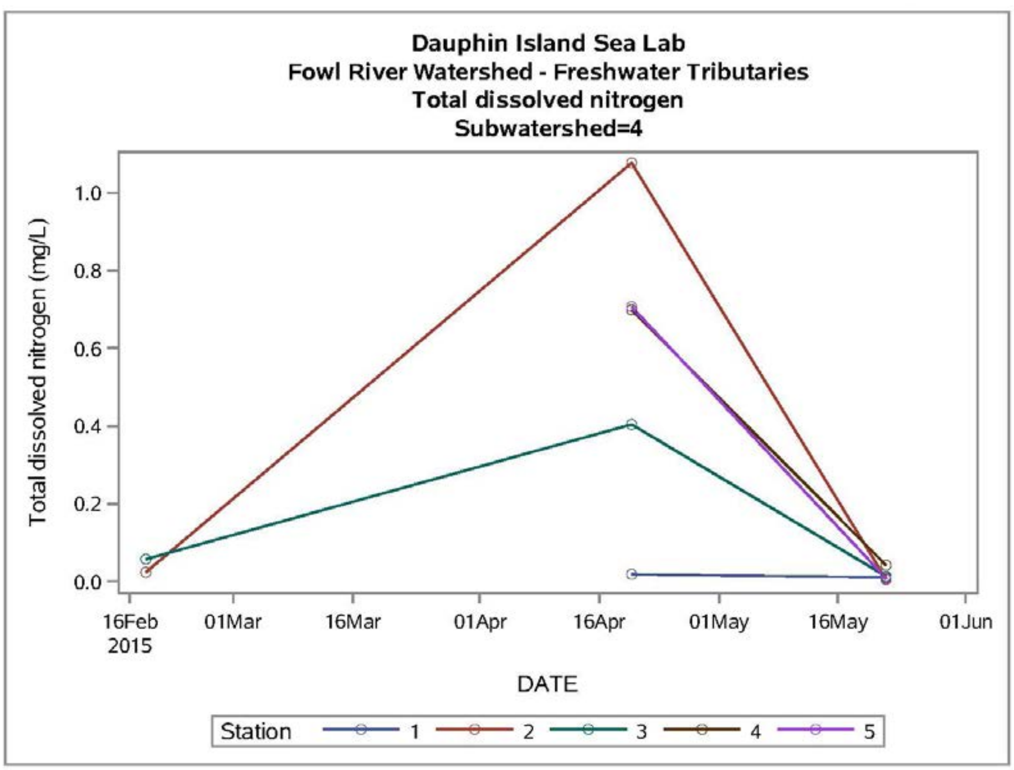
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total dissolved nitrogen
Subwatershed=1
Total dissolved nitrogen (mg/L)
0.0
0.2
0.4
0.6
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1



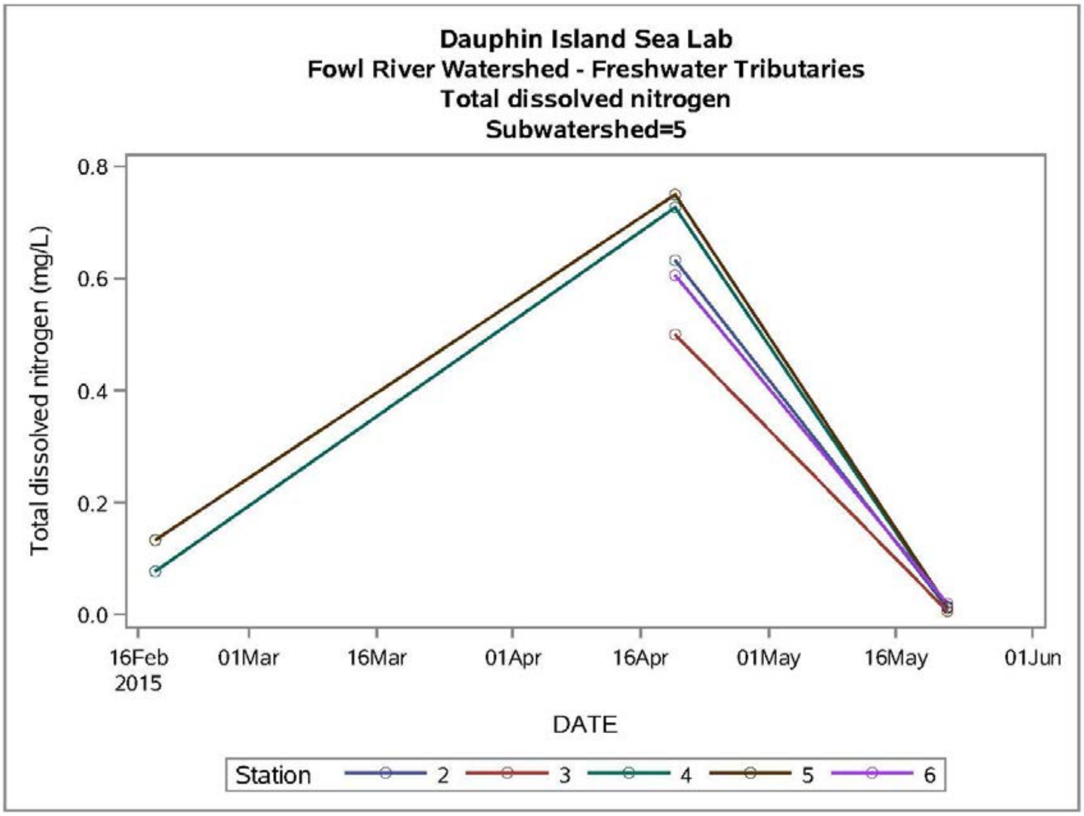
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total dissolved nitrogen
Subwatershed=2
Total dissolved nitrogen (mg/L)
0.0
0.2
0.4
0.6
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3
4

D. RAW DATA

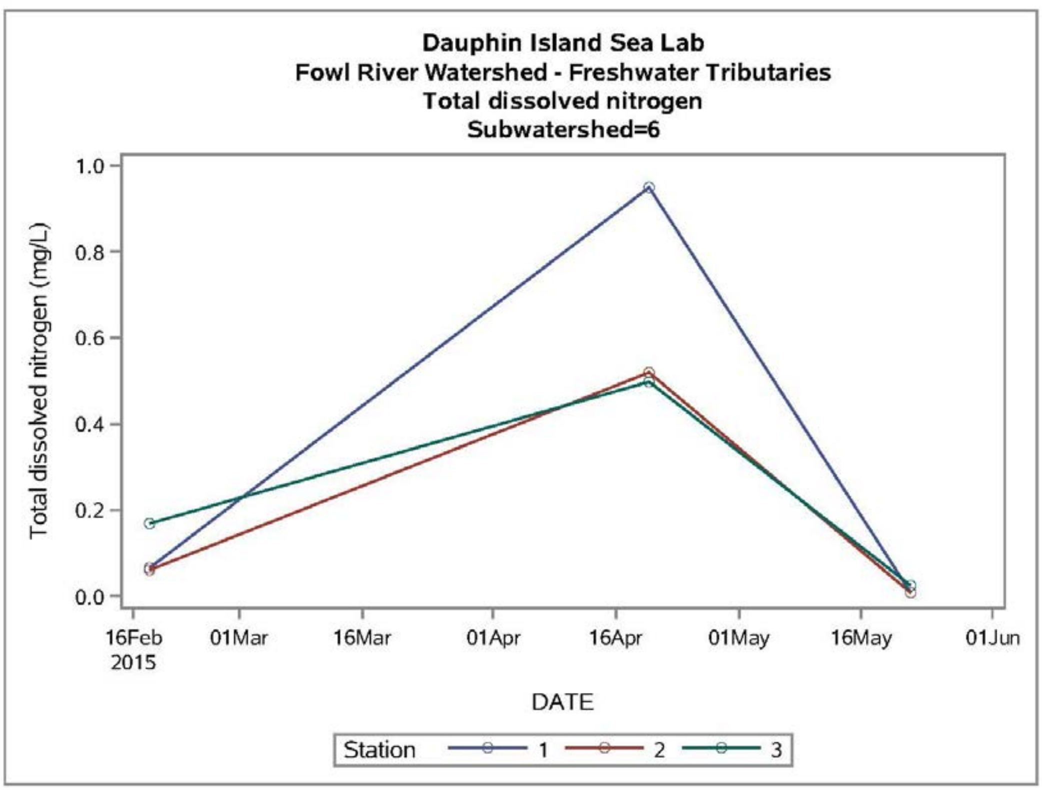

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total dissolved nitrogen
Subwatershed=3
Total dissolved nitrogen (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total dissolved nitrogen
Subwatershed=4
Total dissolved nitrogen (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4 5

D. RAW DATA

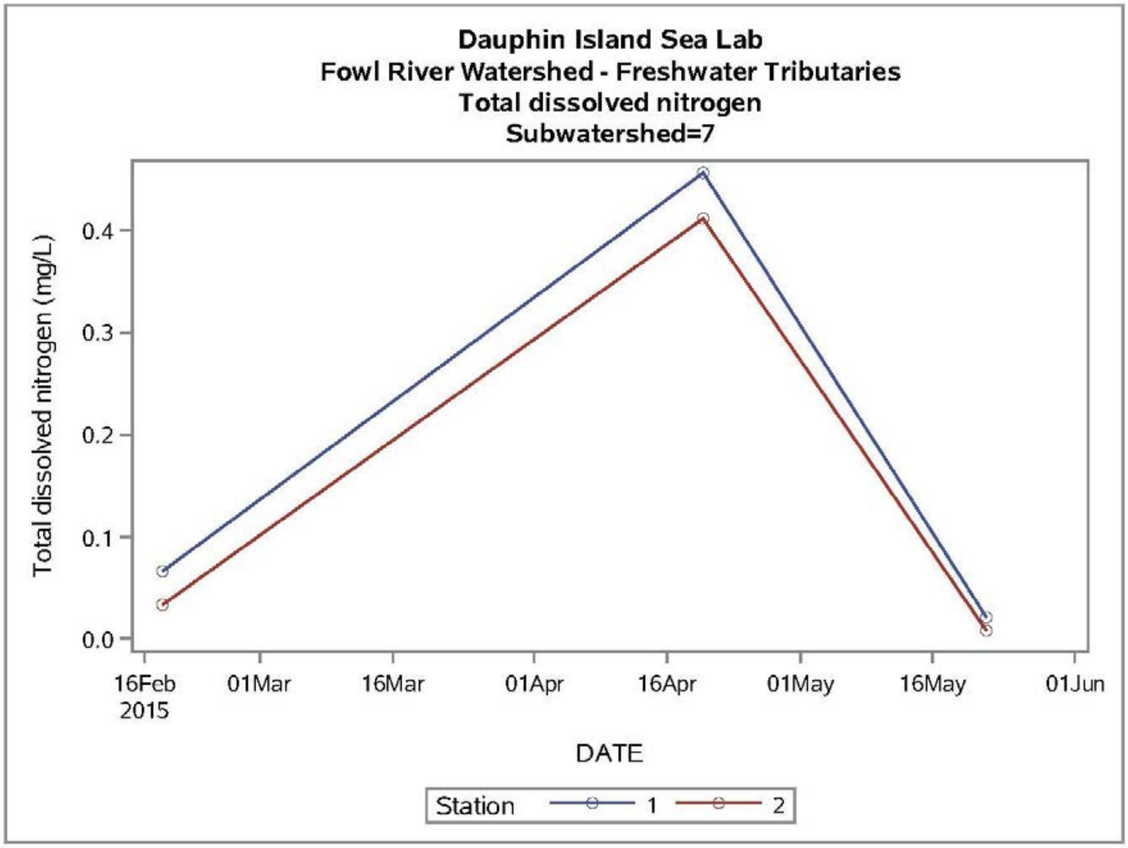


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total dissolved nitrogen
Subwatershed=5
Total dissolved nitrogen (mg/L)
0.8
0.6
0.4
0.2
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 2 3 4 5 6

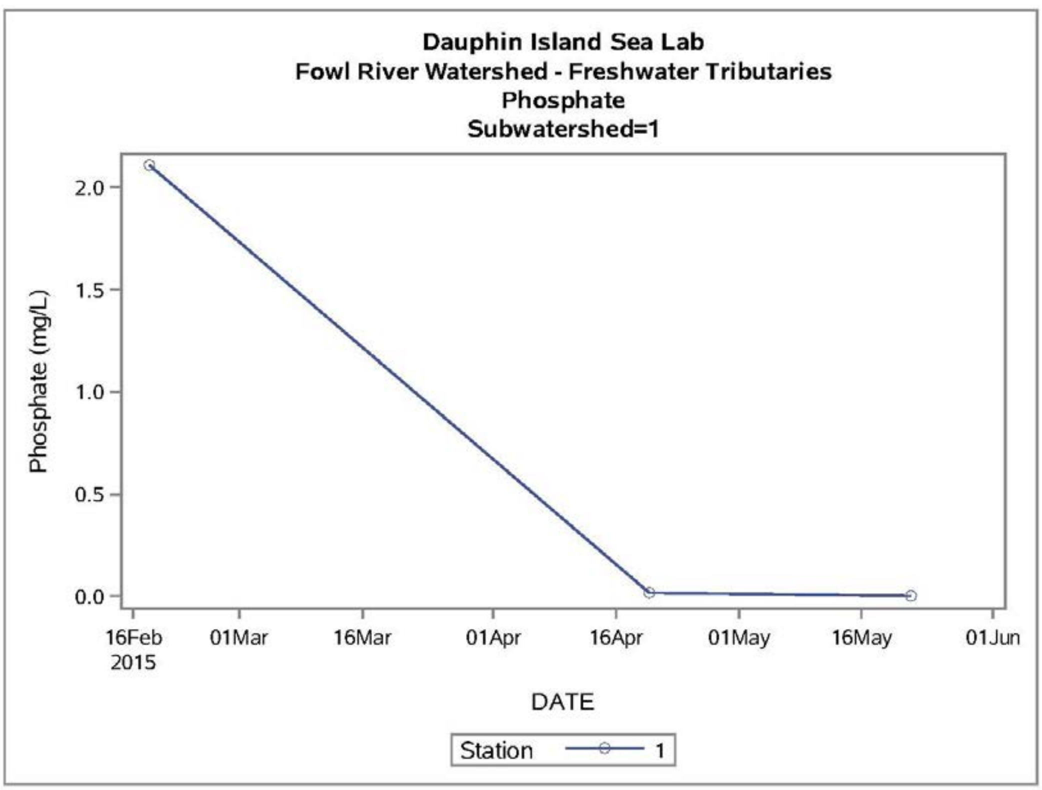


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total dissolved nitrogen
Subwatershed=6
Total dissolved nitrogen (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

D. RAW DATA

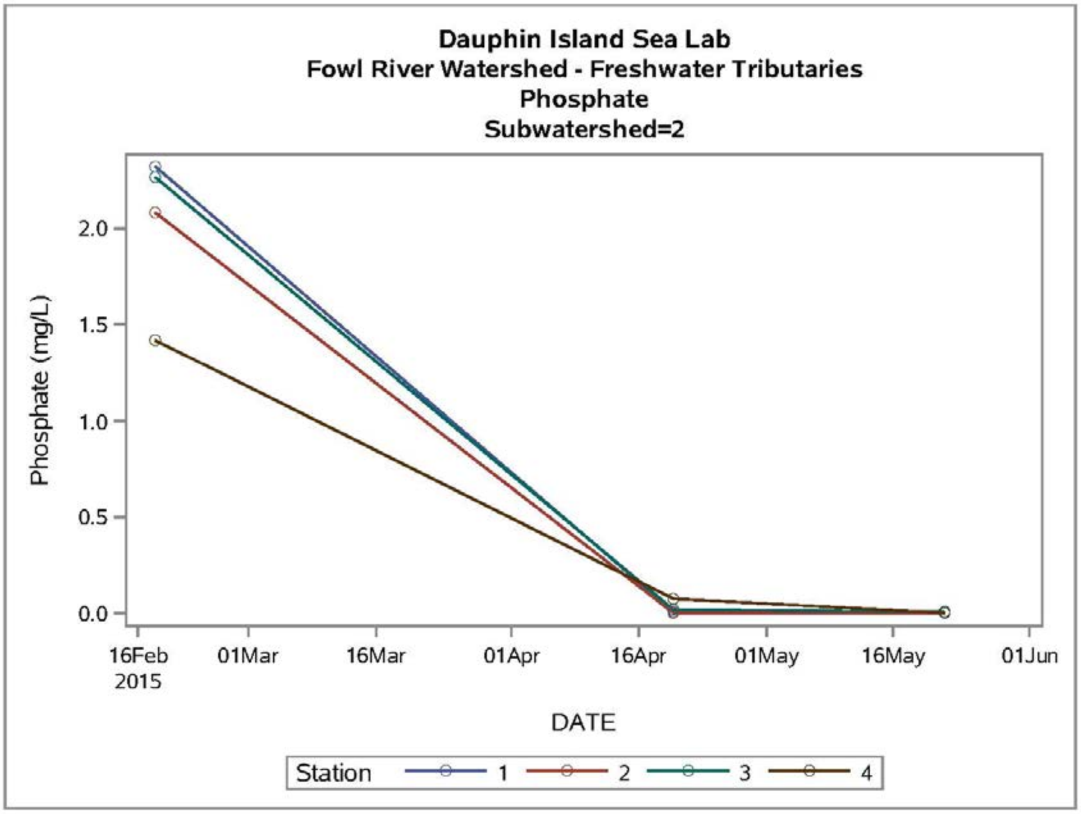


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total dissolved nitrogen
Subwatershed=7
Total dissolved nitrogen (mg/L)
0.0
0.1
0.2
0.3
0.4
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2

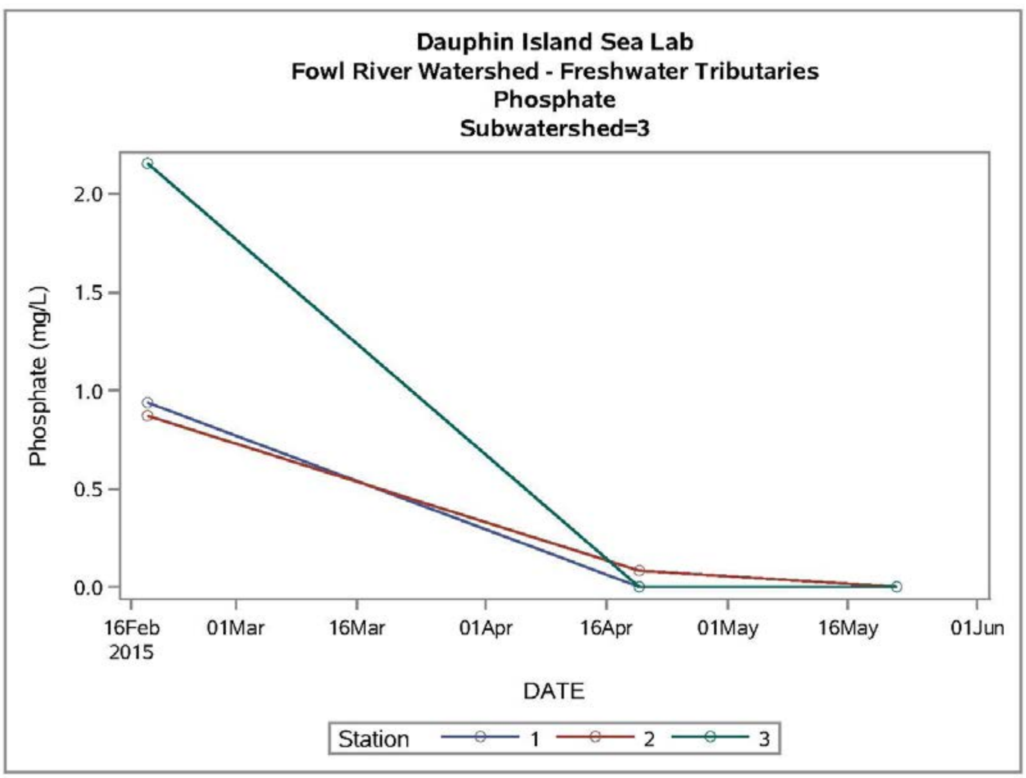


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Phosphate
Subwatershed=1
Phosphate (mg/L)
0.0
0.5
1.0
1.5
2.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1

D. RAW DATA

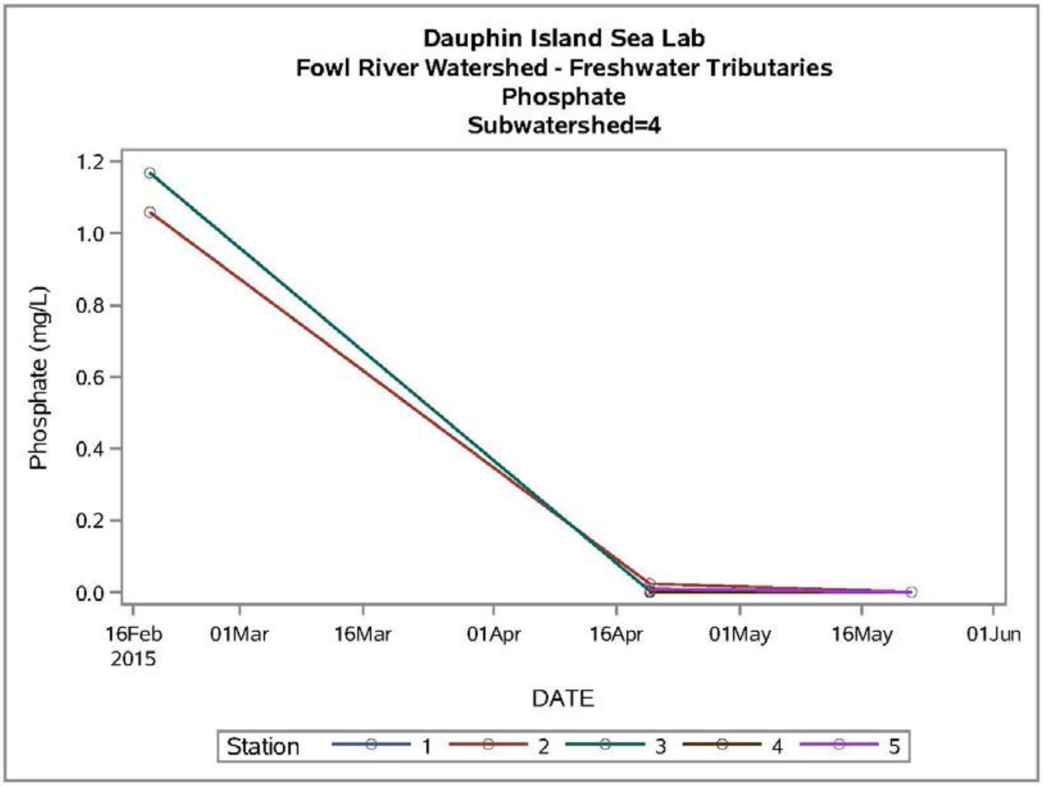


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Phosphate
Subwatershed=2
Phosphate (mg/L)
0.0
0.5
1.0
1.5
2.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4

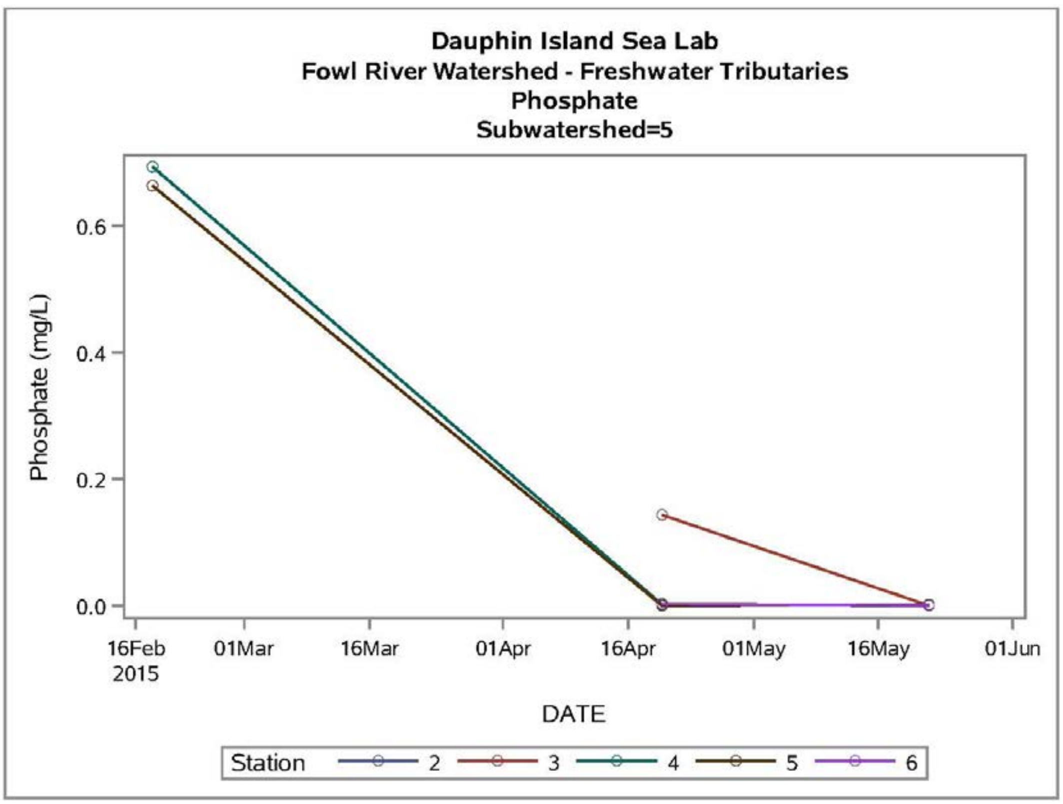


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Phosphate
Subwatershed=3
Phosphate (mg/L)
0.0
0.5
1.0
1.5
2.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

D. RAW DATA

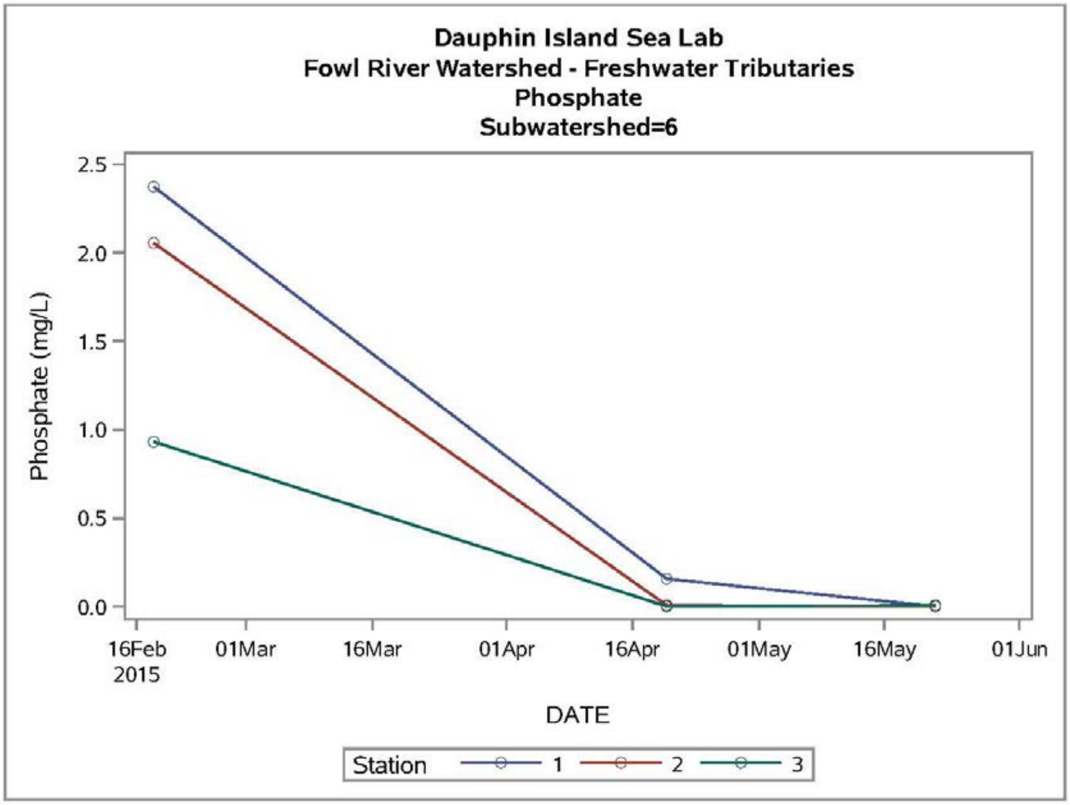


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Phosphate
Subwatershed=4
Phosphate (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4 5

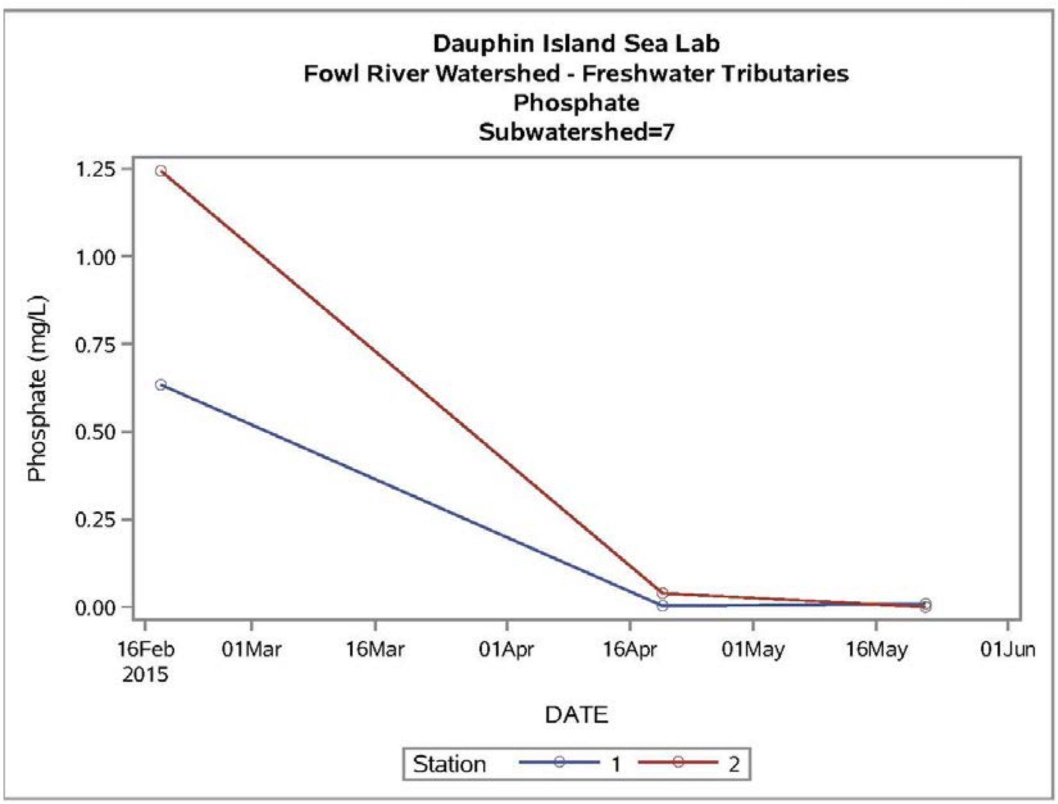


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Phosphate
Subwatershed=5
Phosphate (mg/L)
0.6
0.4
0.2
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 2 3 4 5 6

D. RAW DATA

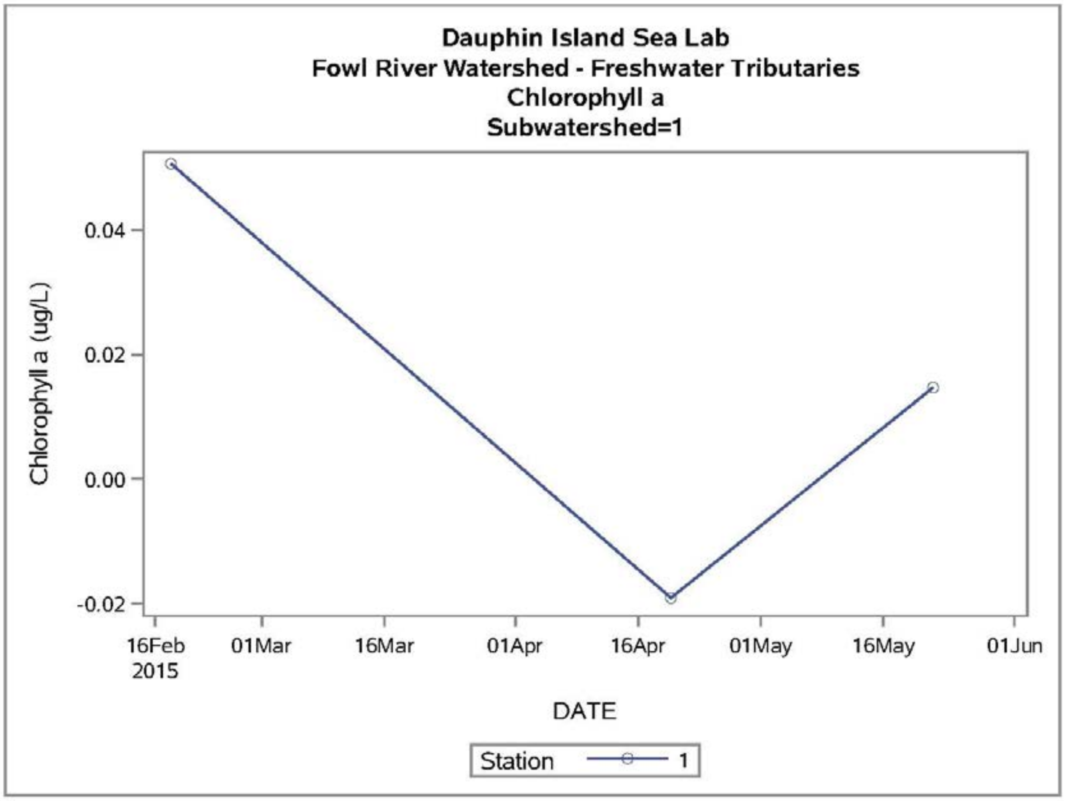


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Phosphate
Subwatershed=6
Phosphate (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

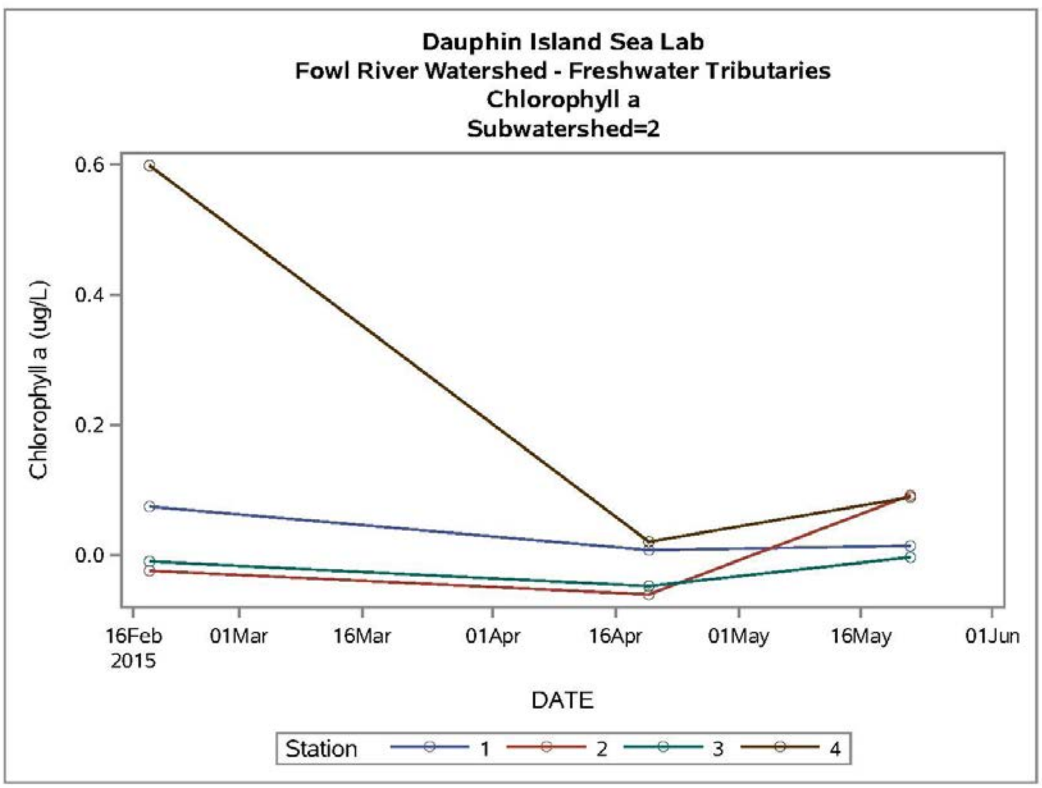


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Phosphate
Subwatershed=7
Phosphate (mg/L)
1.25
1.00
0.75
0.50
0.25
0.00
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2

D. RAW DATA

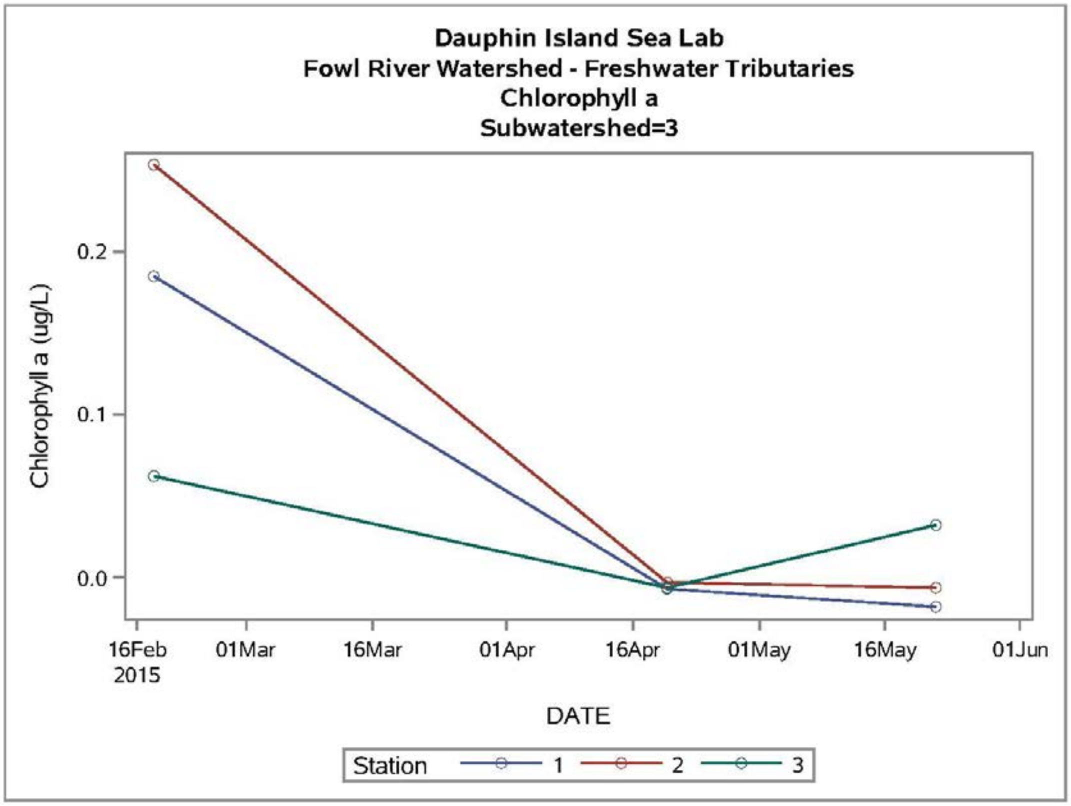


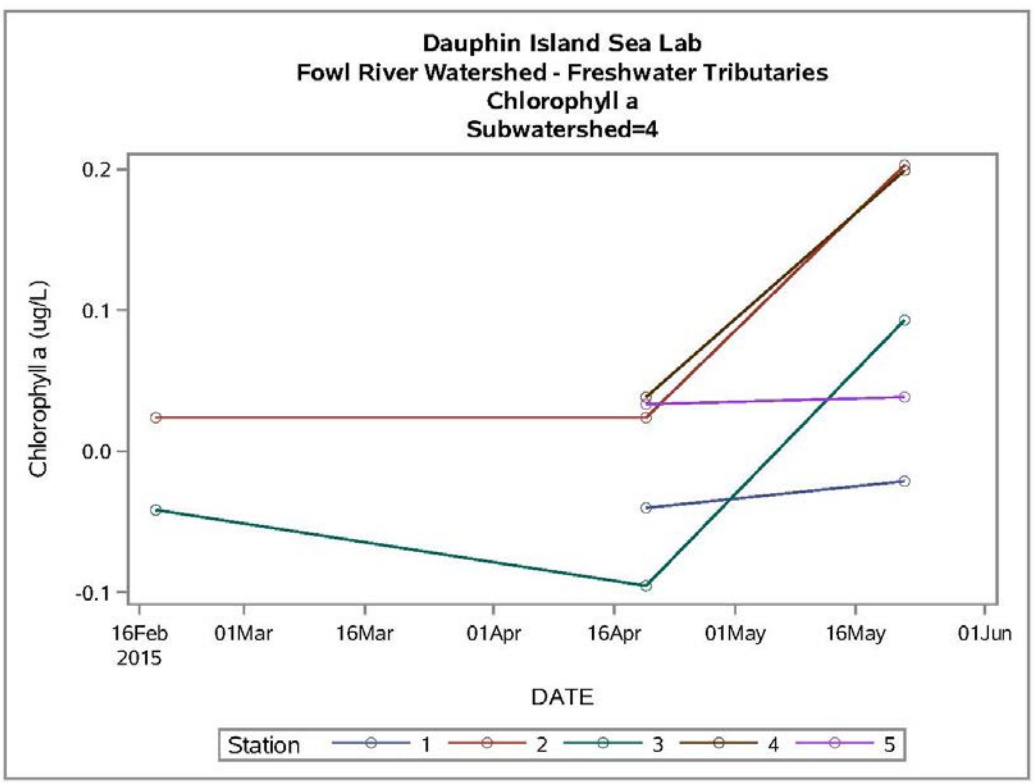
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Chlorophyll a
Subwatershed=1
Chlorophyll a (ug/L)
0.04
0.02
0.00
-0.02
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1



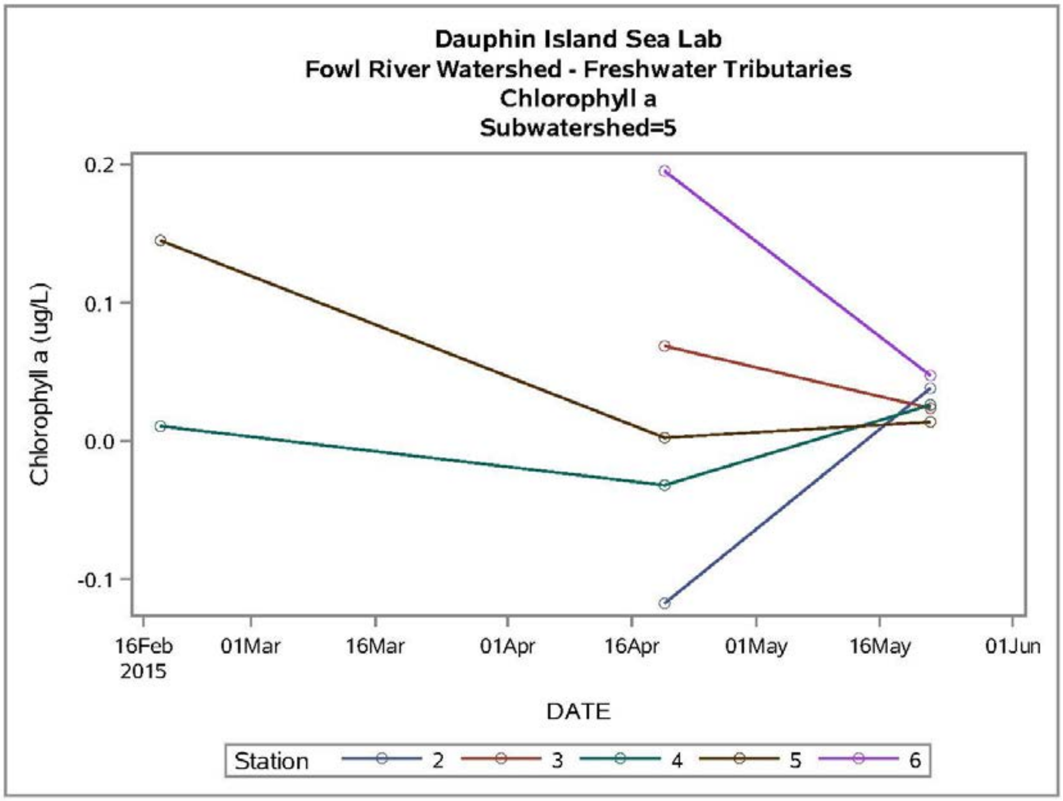
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Chlorophyll a
Subwatershed=2
Chlorophyll a (ug/L)
0.6
0.4
0.2
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3
4

D. RAW DATA

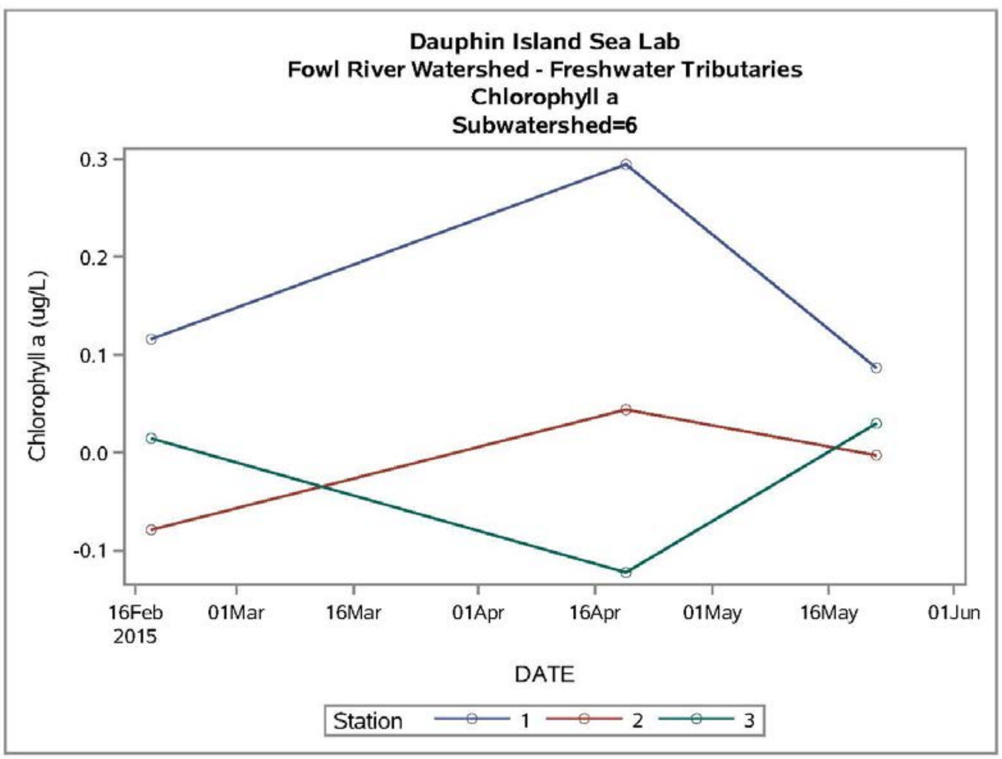

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Chlorophyll a
Subwatershed=3
Chlorophyll a (ug/L)
0.2
0.1
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Chlorophyll a
Subwatershed=4
Chlorophyll a (ug/L)
0.2
0.1
0.0
-0.1
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4 5

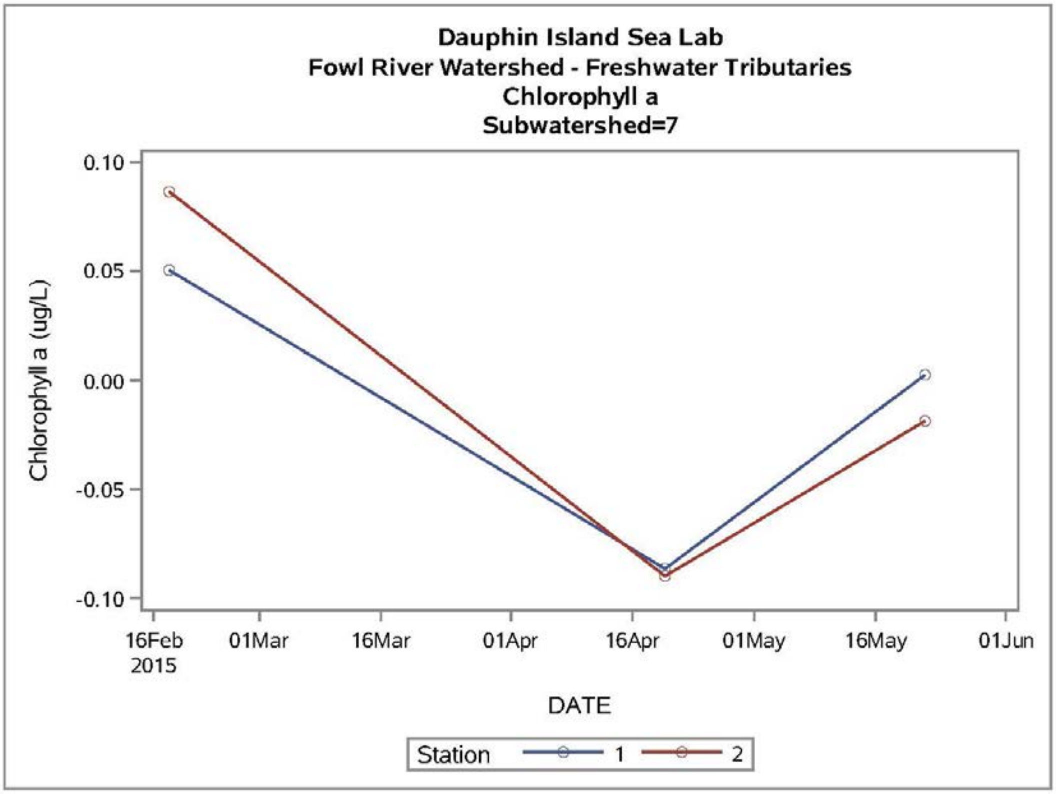
D. RAW DATA



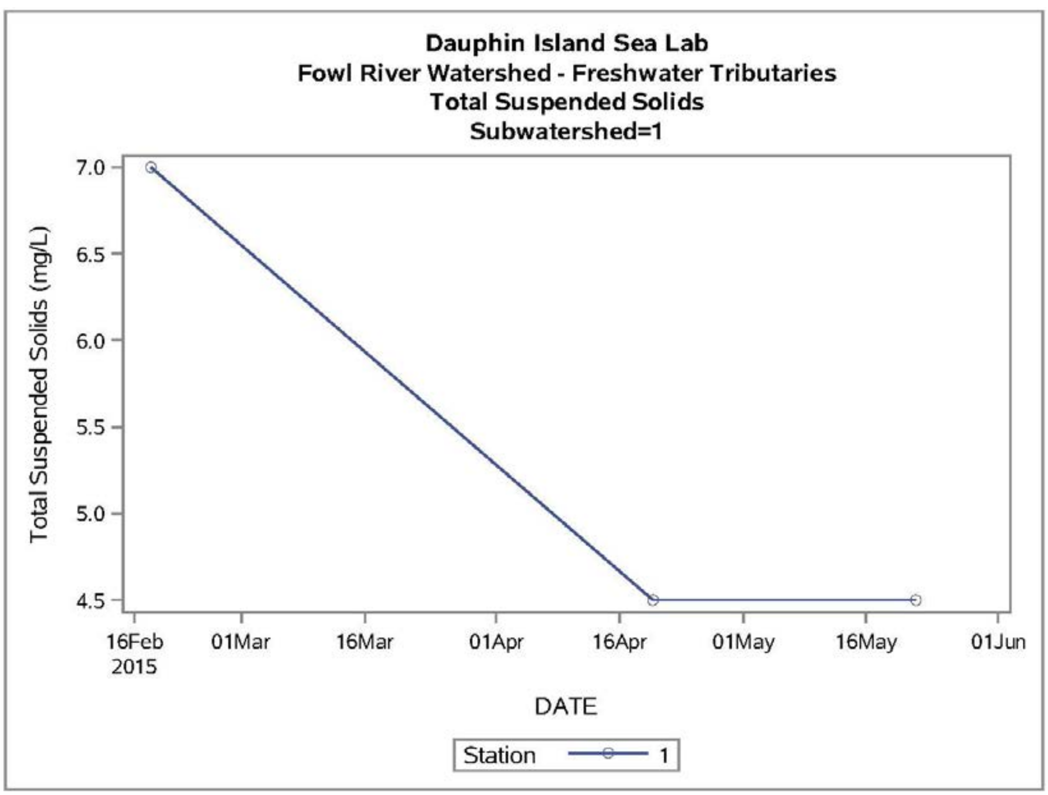
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Chlorophyll a
Subwatershed=5
Chlorophyll a (ug/L)
0.2
0.1
0.0
-0.1
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 2 3 4 5 6



Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Chlorophyll a
Subwatershed=6
Chlorophyll a (ug/L)
0.3
0.2
0.1
0.0
-0.1
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

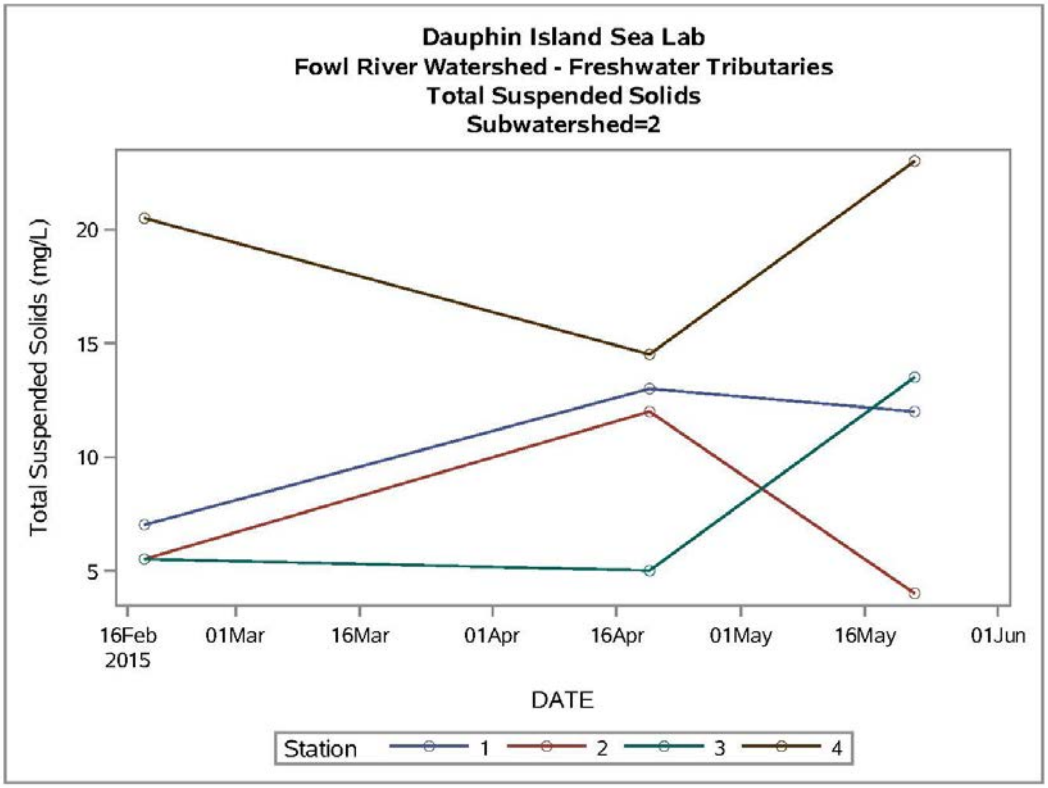


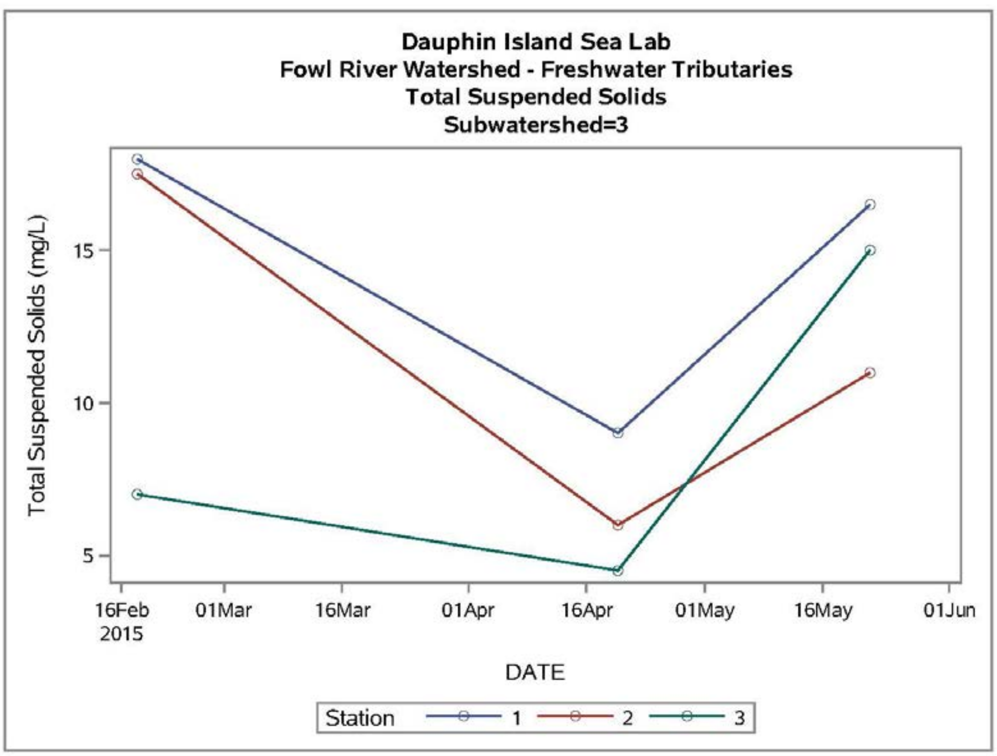
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Chlorophyll a
Subwatershed=7
Chlorophyll a (ug/L)
0.10
0.05
0.00
-0.05
-0.10
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2



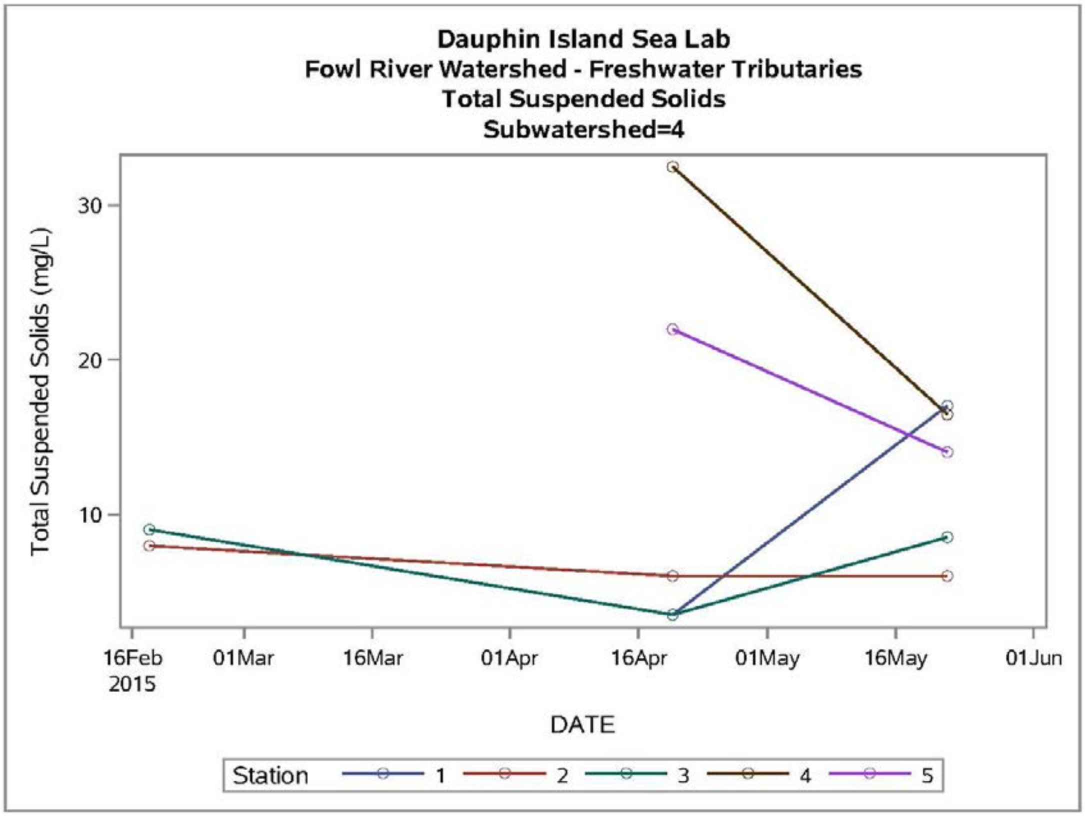
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total Suspended Solids
Subwatershed=1
Total Suspended Solids (mg/L)
7.0
6.5
6.0
5.5
5.0
4.5
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1

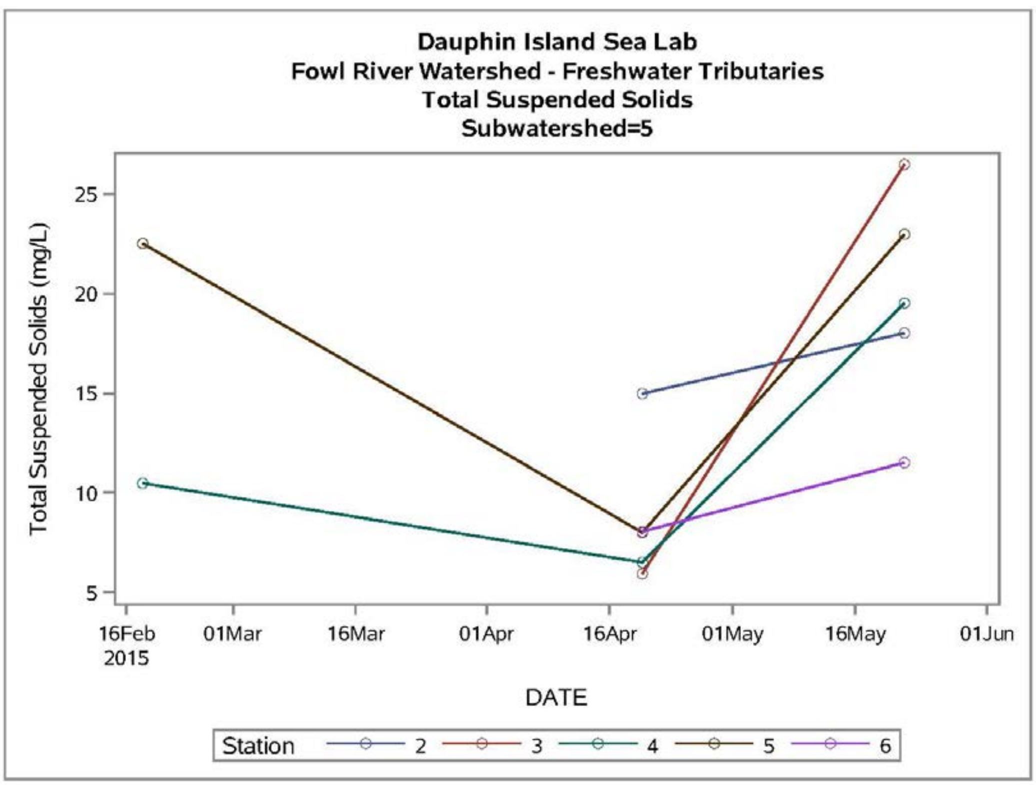
D. RAW DATA


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total Suspended Solids
Subwatershed=2
Total Suspended Solids (mg/L)
20
15
10
5
16Feb
2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3
4

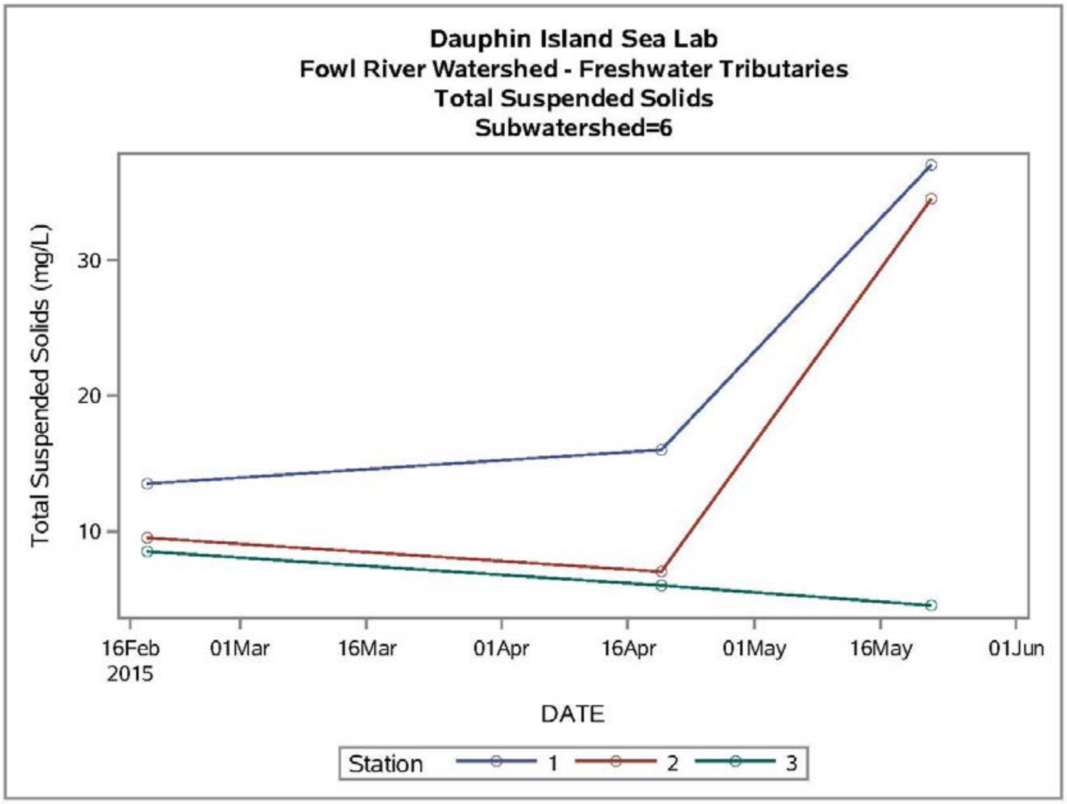

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total Suspended Solids
Subwatershed=3
Total Suspended Solids (mg/L)
15
10
5
16Feb
2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3

D. RAW DATA

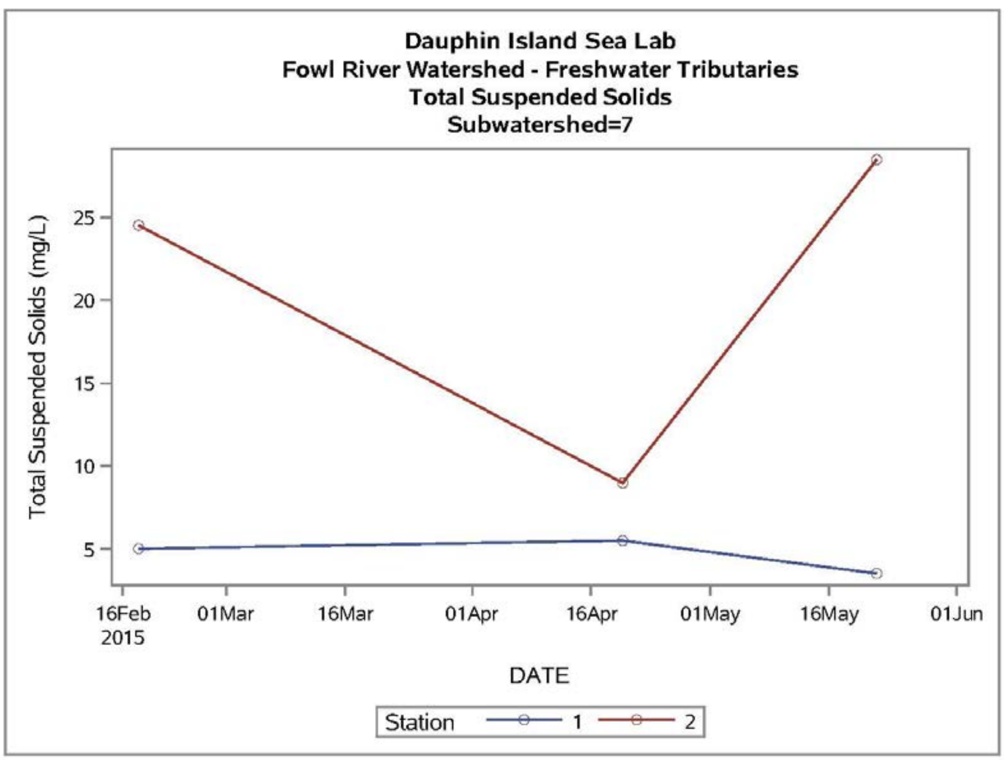

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total Suspended Solids
Subwatershed=4
Total Suspended Solids (mg/L)
30
20
10
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4 5


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total Suspended Solids
Subwatershed=5
Total Suspended Solids (mg/L)
25
20
15
10
5
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 2 3 4 5 6

D. RAW DATA

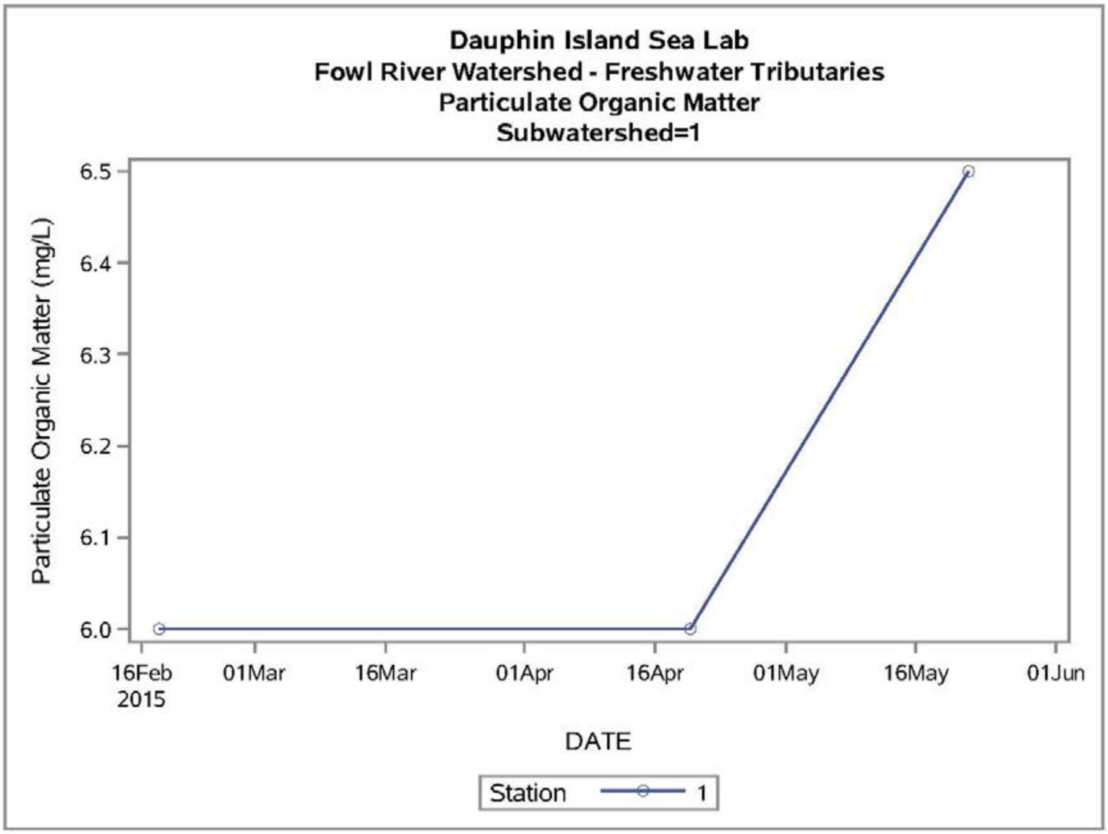


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total Suspended Solids
Subwatershed=6
Total Suspended Solids (mg/L)
30
20
10
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

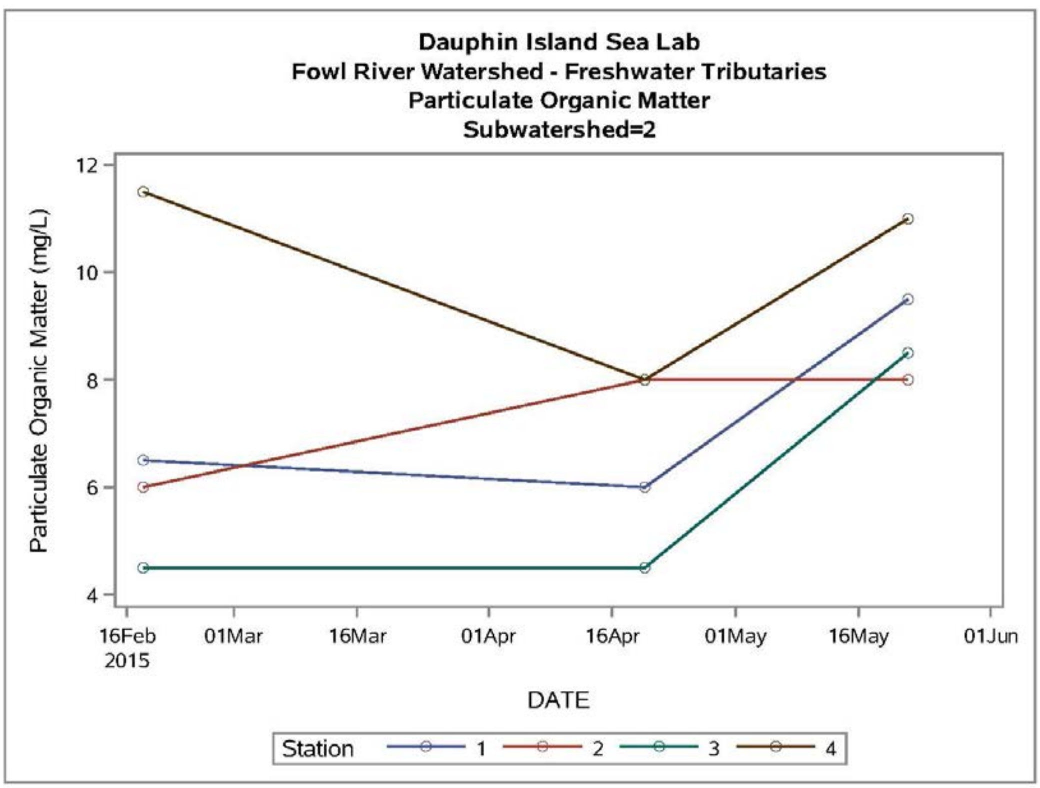


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Total Suspended Solids
Subwatershed=7
Total Suspended Solids (mg/L)
25
20
15
10
5
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2

D. RAW DATA

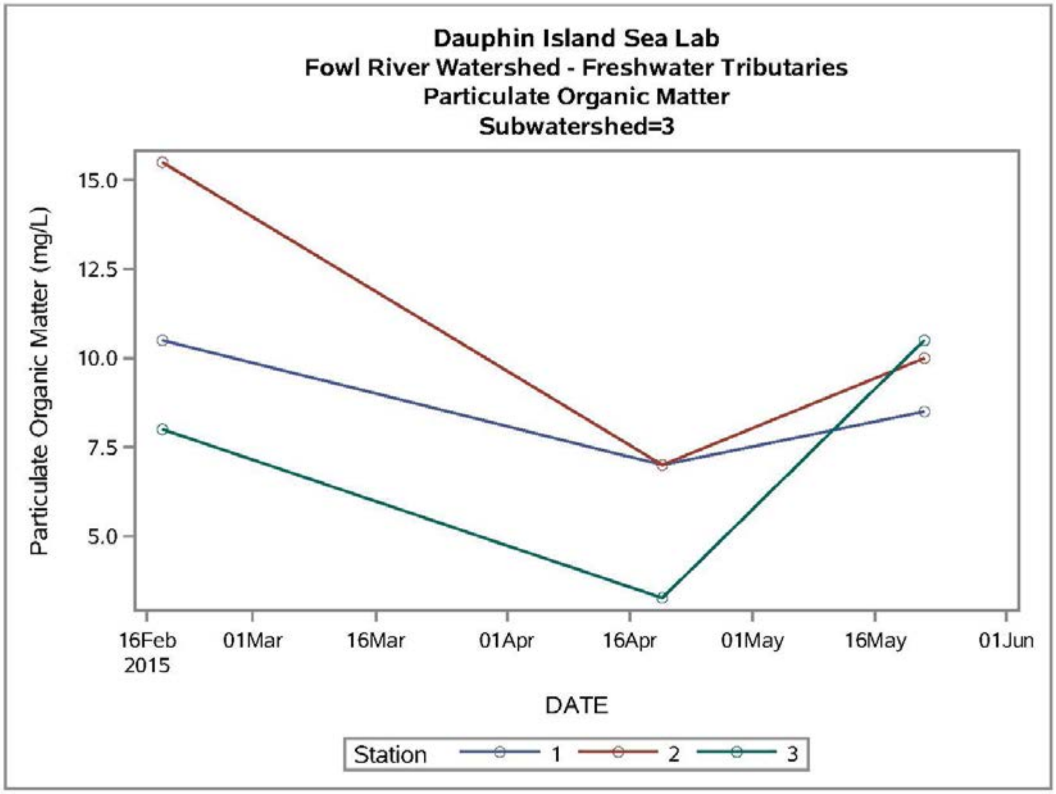


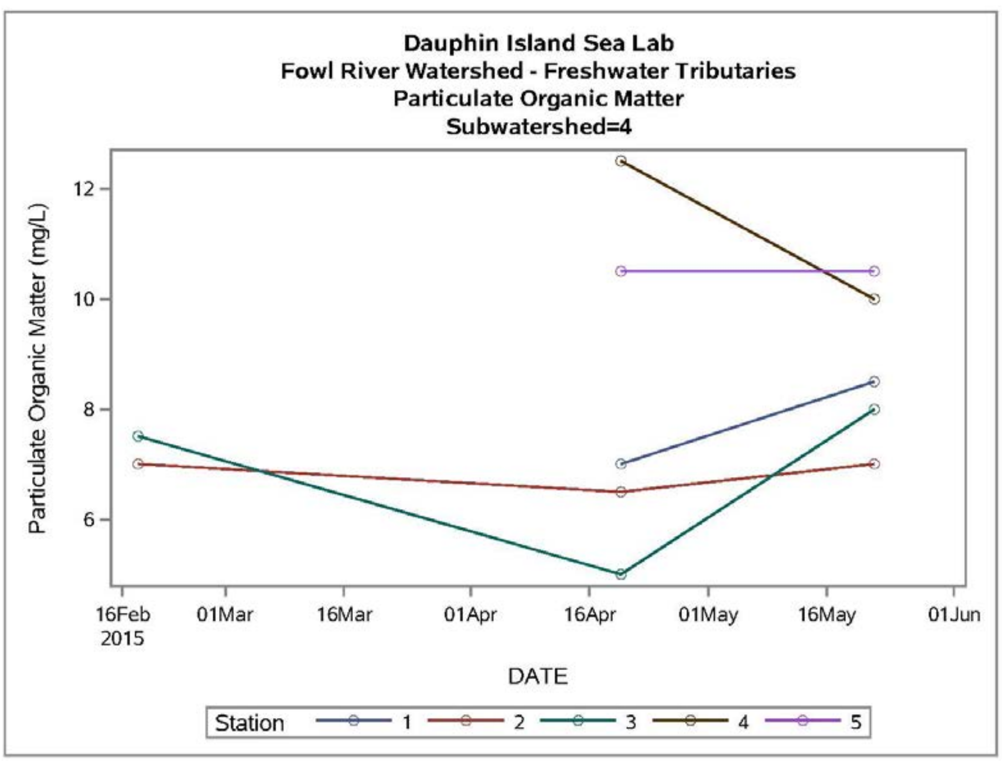
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Particulate Organic Matter
Subwatershed=1
Particulate Organic Matter (mg/L)
6.5
6.4
6.3
6.2
6.1
6.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1



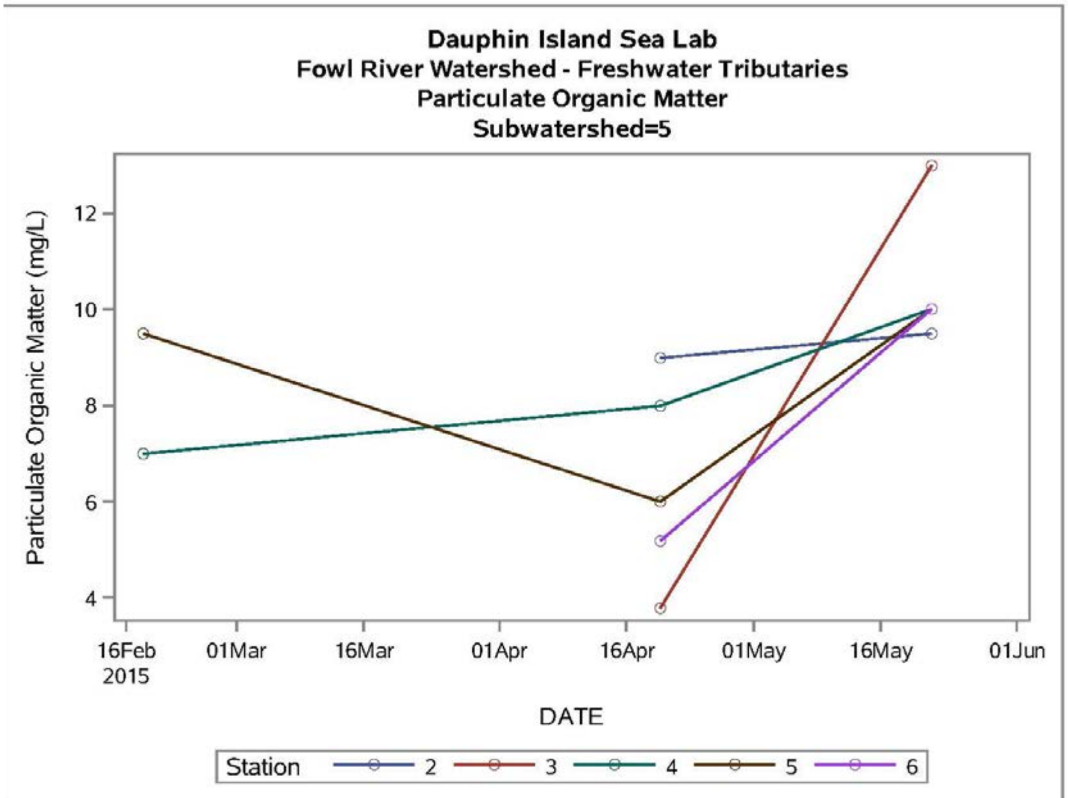
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Particulate Organic Matter
Subwatershed=2
Particulate Organic Matter (mg/L)
12
10
8
6
4
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3
4

D. RAW DATA

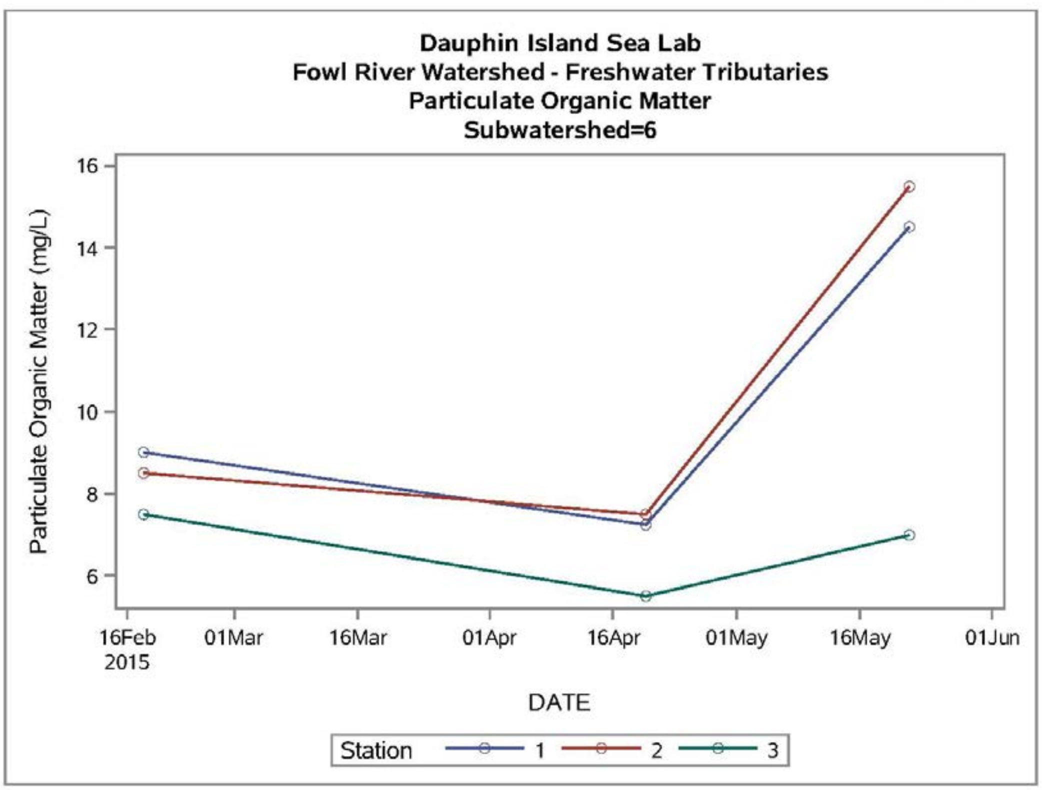

Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Particulate Organic Matter
Subwatershed=3
Particulate Organic Matter (mg/L)
15.0
12.5
10.0
7.5
5.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Particulate Organic Matter
Subwatershed=4
Particulate Organic Matter (mg/L)
12
10
8
6
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4 5

D. RAW DATA

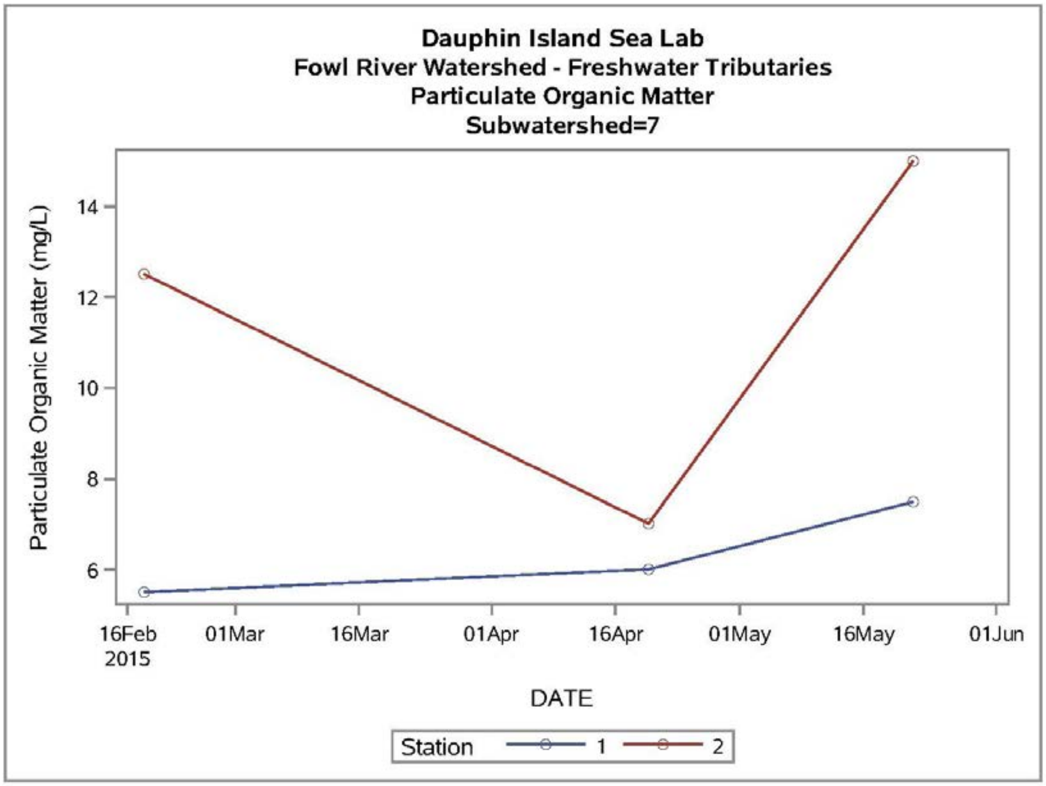


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Particulate Organic Matter
Subwatershed=5
Particulate Organic Matter (mg/L)
4
6
8
10
12
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 2 3 4 5 6

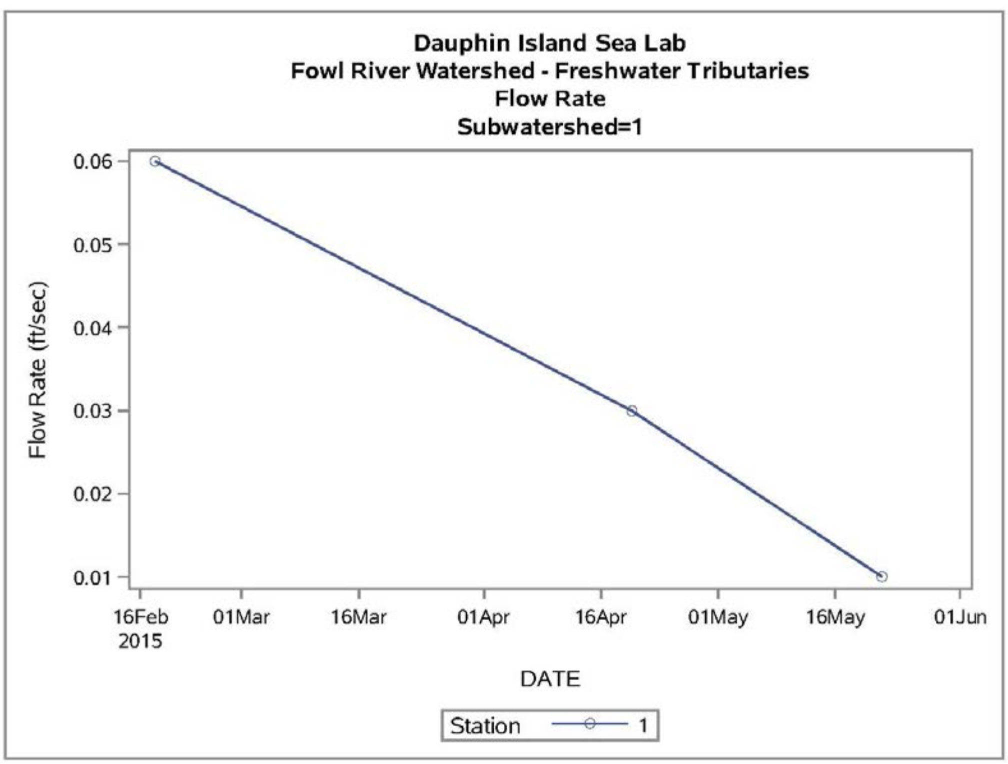


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Particulate Organic Matter
Subwatershed=6
Particulate Organic Matter (mg/L)
6
8
10
12
14
16
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

D. RAW DATA

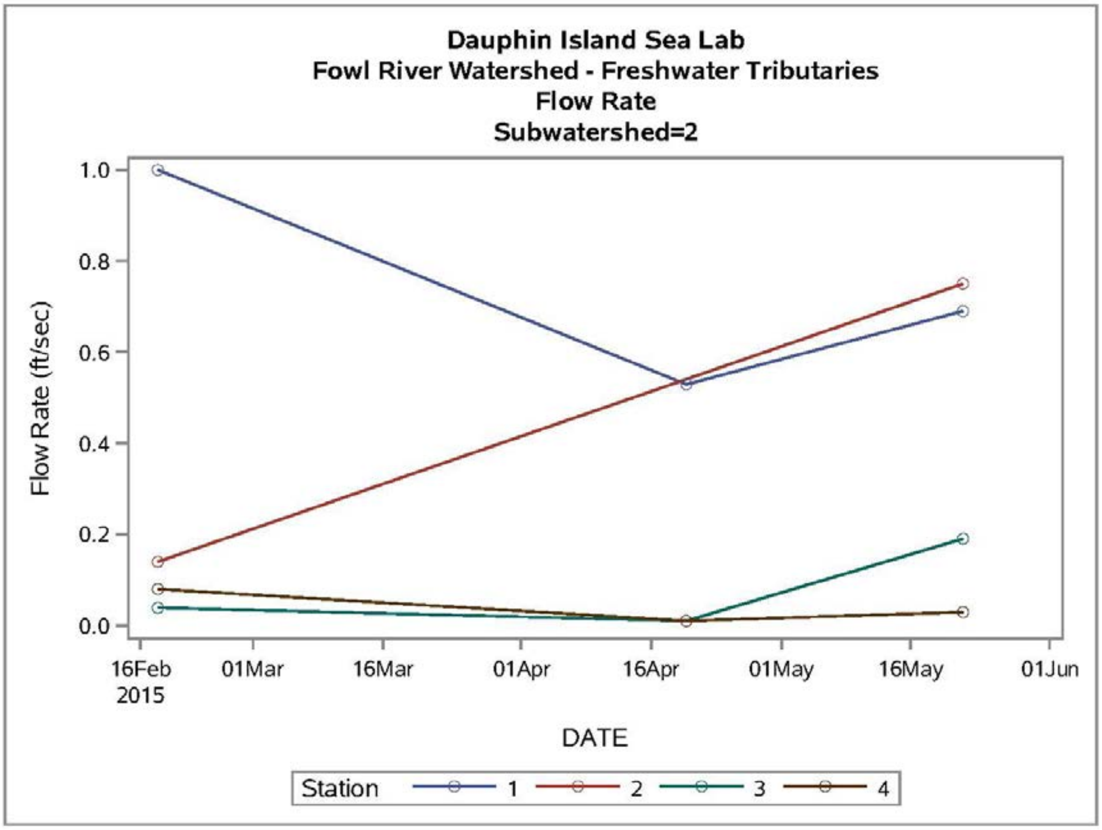


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Particulate Organic Matter
Subwatershed=7
Particulate Organic Matter (mg/L)
14
12
10
8
6
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2

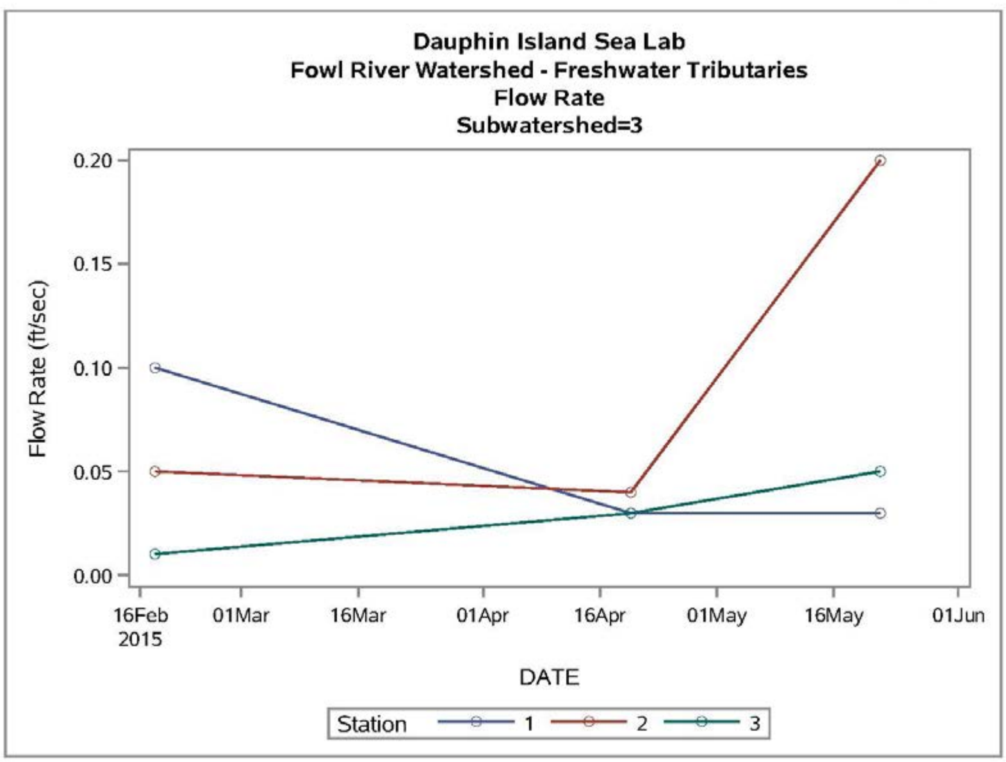


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Flow Rate
Subwatershed=1
Flow Rate (ft/sec)
0.06
0.05
0.04
0.03
0.02
0.01
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1

D. RAW DATA

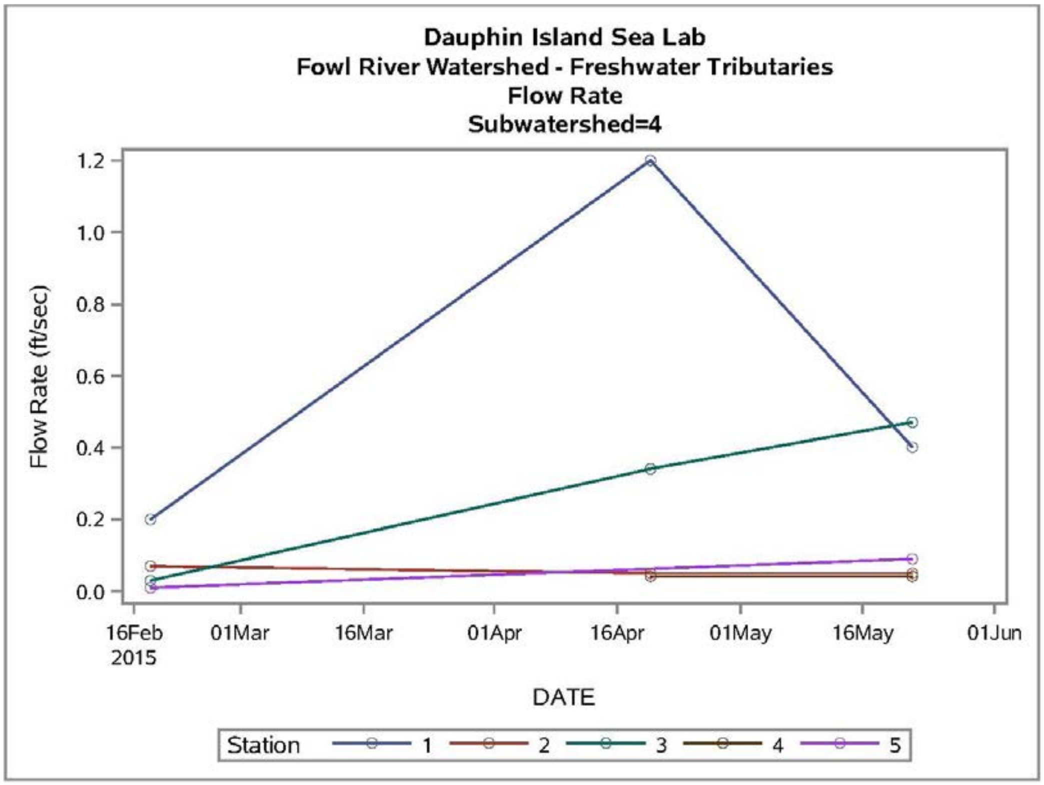


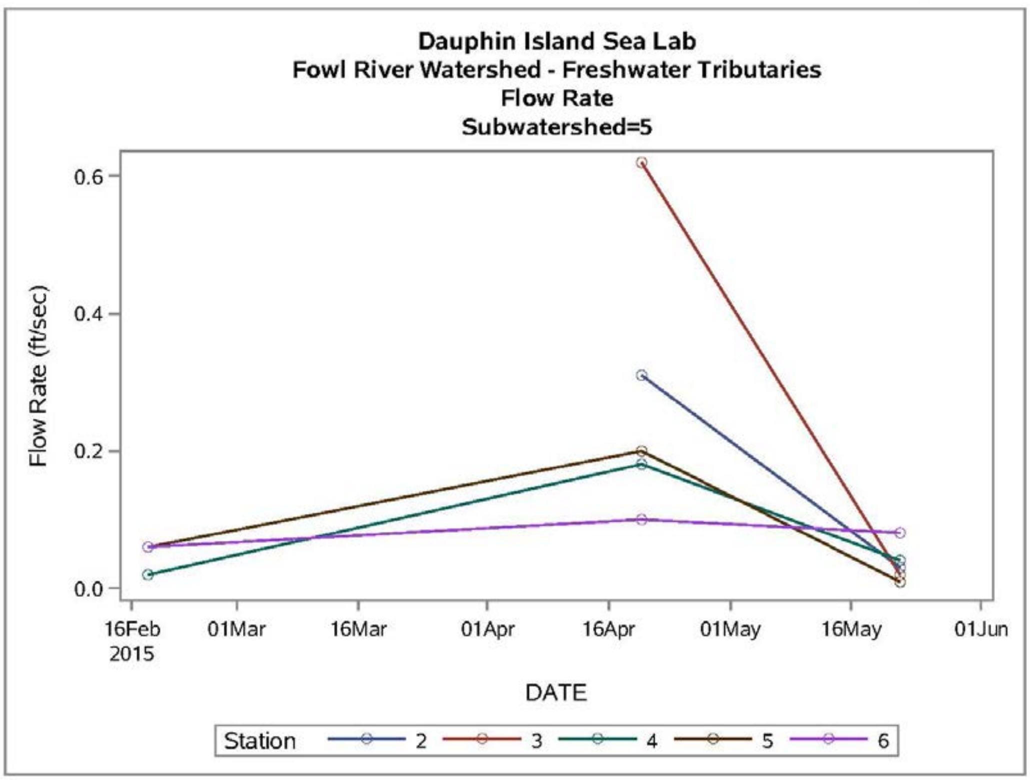
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Flow Rate
Subwatershed=2
Flow Rate (ft/sec)
1.0
0.8
0.6
0.4
0.2
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3 4



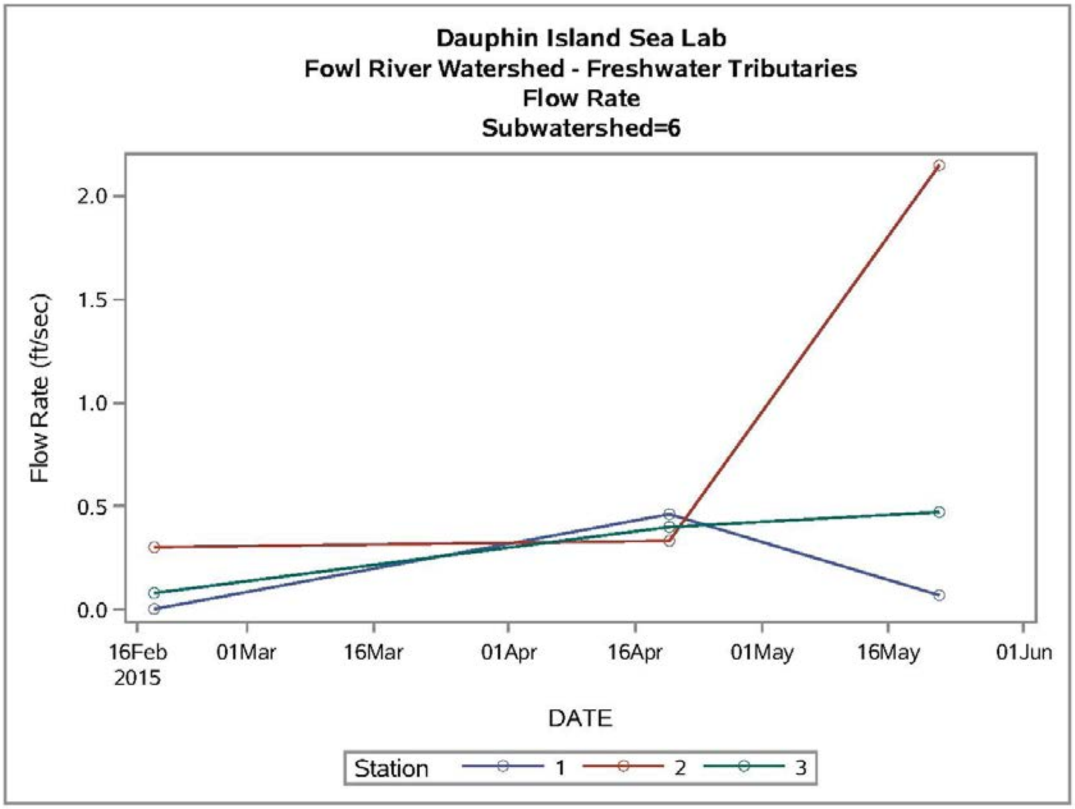
Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Flow Rate
Subwatershed=3
Flow Rate (ft/sec)
0.20
0.15
0.10
0.05
0.00
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station 1 2 3

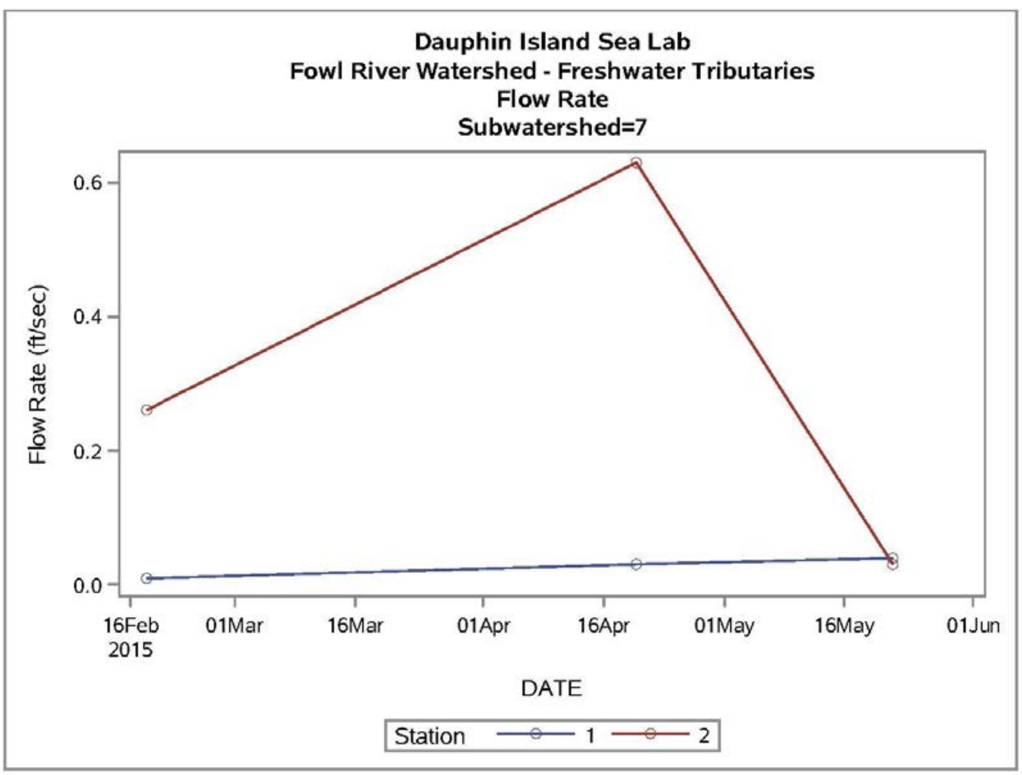
D. RAW DATA


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Flow Rate
Subwatershed=4
Flow Rate (ft/sec)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3
4
5


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Flow Rate
Subwatershed=5
Flow Rate (ft/sec)
0.6
0.4
0.2
0.0
16Feb 2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
2
3
4
5
6

D. RAW DATA


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Flow Rate
Subwatershed=6
Flow Rate (ft/sec)
2.0
1.5
1.0
0.5
0.0
16Feb
2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2
3


Dauphin Island Sea Lab
Fowl River Watershed - Freshwater Tributaries
Flow Rate
Subwatershed=7
Flow Rate (ft/sec)
0.6
0.4
0.2
0.0
16Feb
2015
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
DATE
Station
1
2

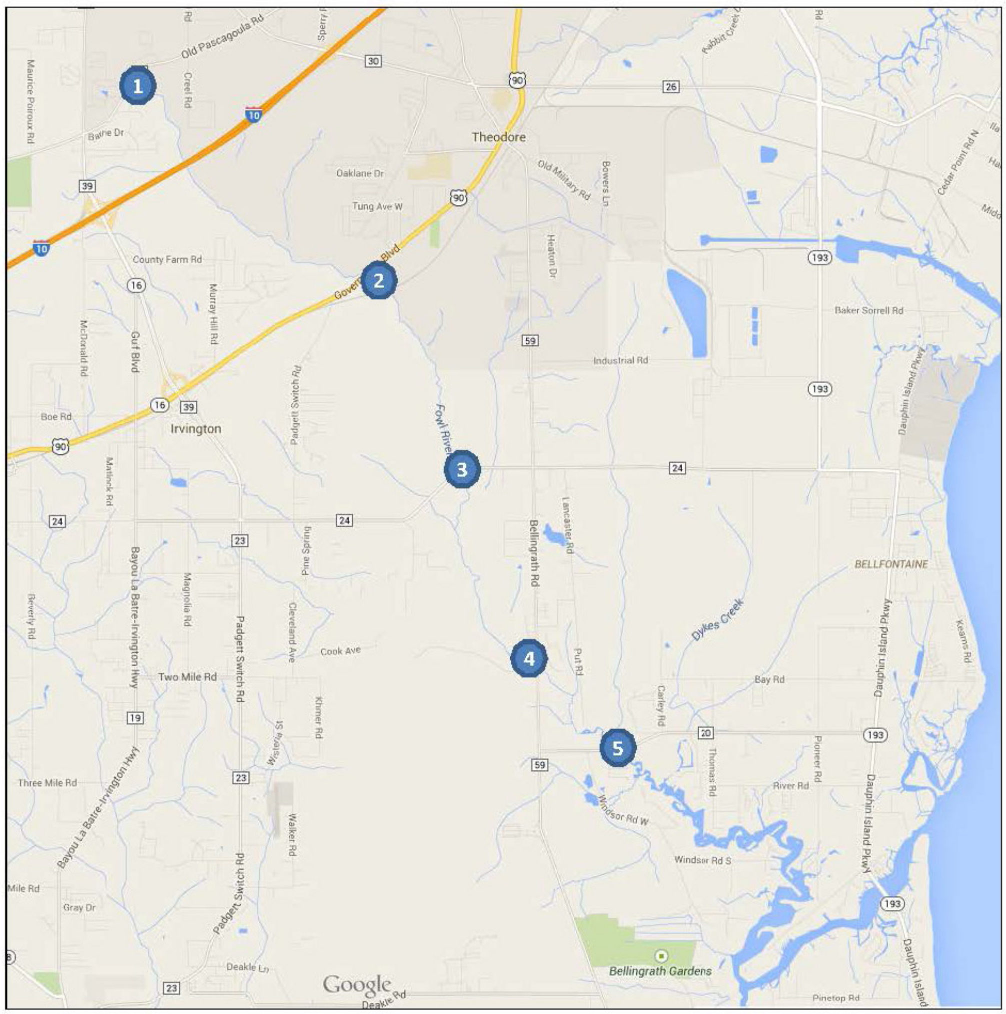
D. RAW DATA

D.4 MICROBIAL SOURCE TRACKING DATA

The Watershed Management Team collected water samples from Fowl River to determine the source of fecal coliform bacteria in the water that has been detected by the ADEM sample collection and analyses for many years. Watershed Management Team data collection stations are shown in Figure D.4, and the results of analyses follow.

Fowl River Bacteriological Sampling Stations

1. Fowl River @ Old Pascagoula Rd.
2. Fowl River @ SR-90
3. Fowl River @ Half Mile Rd.
4. Fowl River @ Bellingrath Rd.
5. Fowl River @ Fowl River Rd.



D. RAW DATA

Source Molecular

Leader in Microbial Source Tracking

4985 SW 74th Court, Miami, FL 33155 USA
Tel: (1) 786-220-0379, Fax: (1) 786-513-2733, Email: info@sourcemolecular.com

Preliminary Interpretation of Human Fecal Pollution ID™ Results

Detection and quantification of the fecal Human gene biomarker for Human fecal contamination by real-time quantitative Polymerase Chain Reaction (qPCR) DNA analytical technology

Submitter: ESA
Date Received: December 11, 2014
Date Reported: December 31, 2014

SM #	Client #	Approximate Contribution of Human Fecal Pollution in Water Sample	Comment
SM-4L11013	Station #1	Negative	Negative for 2 human fecal biomarkers
SM-4L11014	Station #2	Negative	Negative for 2 human fecal biomarkers
SM-4L11015	Station #3	Negative	Negative for 2 human fecal biomarkers
SM-4L11016	Station #4	Negative	Negative for 2 human fecal biomarkers
SM-4L11017	Station #5	Negative	Negative for 2 human fecal biomarkers
SM-4L11018	Station #1	Negative	Negative for 2 human fecal biomarkers
SM-4L11019	Station #2	Negative	Negative for 2 human fecal biomarkers
SM-4L11020	Station #3	Negative	Negative for 2 human fecal biomarkers
SM-4L11021	Station #4	Negative	Negative for 2 human fecal biomarkers
SM-4L11022	Station #5	Negative	Negative for 2 human fecal biomarkers

D. RAW DATA

Source Molecular

Leader in Microbial Source Tracking

4985 SW 74th Court, Miami, FL 33155 USA
Tel: (1) 786-220-0379, Fax: (1) 786-513-2733, Email: info@sourcemolecular.com

Human Fecal Pollution ID™ Quantification

Detection and quantification of the fecal Human gene biomarker for Human fecal contamination by real-time quantitative Polymerase Chain Reaction (qPCR) DNA analytical technology

Submitter: ESA
Date Received: December 11, 2014
Date Reported: December 31, 2014

SM #	Client #	Analysis Requested	Species	General Marker Quantified*	Human Specific Marker Quantified*	DNA Analytical Results
SM-4L11013	Station #1	Human Bacteroidetes ID 1	Dorei	1.29E+04	ND**	Absent
SM-4L11014	Station #2	Human Bacteroidetes ID 1	Dorei	1.40E+04	ND**	Absent
SM-4L11015	Station #3	Human Bacteroidetes ID 1	Dorei	1.69E+04	ND**	Absent
SM-4L11016	Station #4	Human Bacteroidetes ID 1	Dorei	5.70E+03	ND**	Absent
SM-4L11017	Station #5	Human Bacteroidetes ID 1	Dorei	5.35E+03	ND**	Absent
SM-4L11018	Station #1	Human Bacteroidetes ID 2	EPA	1.29E+04	ND**	Absent
SM-4L11019	Station #2	Human Bacteroidetes ID 2	EPA	1.40E+04	ND**	Absent
SM-4L11020	Station #3	Human Bacteroidetes ID 2	EPA	1.69E+04	ND**	Absent
SM-4L11021	Station #4	Human Bacteroidetes ID 2	EPA	5.70E+03	ND**	Absent
SM-4L11022	Station #5	Human Bacteroidetes ID 2	EPA	5.35E+03	ND**	Absent

*Numbers reported as copy numbers per 100 mL of water
**Non-detect

Laboratory Comments

Submitter: ESA

Report Date: December 31, 2014

Negative Results

In sample(s) classified as negative, the human-associated Bacteroidetes gene biomarker(s) was either not detected in test replicates, one replicate was detected at a cycle threshold greater than 35 and the other was not, or one replicate was detected at a cycle threshold less than 35 and the other was not after repeated analysis. It is important to note that a negative result does not mean that the sample does not definitely have human fecal contamination. Only repeated sampling (both during wet and dry sampling events) will enable you to draw more definitive conclusions as to the contributor(s) of fecal pollution.

In order to strengthen the result, a negative sample should be analyzed further for human fecal contamination with other DNA analytical tests. A list of human fecal ID tests can be found at **www.sourcemolecular.com/human**.

Human Fecal Reference Samples

The client is encouraged to submit samples from the surrounding wastewater facilities and/or septic systems in order to gain a better understanding of the concentration of the human-associated fecal Bacteroidetes genetic marker as well as the concentration of the general fecal Bacteroidetes genetic marker in the geographic region of interest. A more precise interpretation would be available to the client with the submittal of such baseline samples.

Result Interpretations

Quantitative results are reported along with interpretations. Interpretations are given as "negative", "trace", "minor contributor", "important contributor", or "major contributor" based on the concentration and proportion of the genetic markers found in the water samples.

Additional Testing

A portion of all samples has been frozen and will be archived for 3 months. The client is encouraged to perform additional tests on the sample(s) for other hosts suspected of contributing to the fecal contamination. A list of available tests can be found at **www.sourcemolecular.com/tests**

DNA Analytical Method Explanation

All reagents, chemicals and apparatuses were verified and inspected beforehand to ensure that no false negatives or positives could be generated. In that regard, positive and negative controls were run to attest the integrity of the analysis. All inspections and controls tested negative for possible extraneous contaminates, including PCR inhibitors.

Each submitted water sample was filtered through 0.45 micron membrane filters. Each filter was placed in a separate, sterile 2ml disposable tube containing a unique mix of beads and lysis buffer. The sample was homogenized for 1min and the DNA extracted using the Generite DNA-EZ ST1 extraction kit (GeneRite, NJ), as per manufacturer's protocol.

Amplifications were run on an Applied Biosystems StepOnePlus real-time thermal cycler (Applied Biosystems, Foster City, CA) in a final reaction volume of 20ul containing sample extract, forward primer, reverse primer, probe and an optimized buffer. The following thermal cycling parameters were used: 50°C for 2 min, 95°C for 10 min and 40 cycles of 95°C for 15 s and 60°C for 1 min. All assays were run in duplicate. Absolute quantification was achieved by extrapolating genome copy numbers from standard curves generated from serial dilutions of Human specific and generic genomic DNA.

For quality control purposes, a positive control consisting of appropriate genomic DNA and a negative control consisting of PCR-grade water were run alongside the sample(s) to ensure a properly functioning reaction and reveal any false negatives or false positives.

Human Bacteroidetes ID™ Species: *B. dorei*

The **Human Bacteroidetes ID™ Species: *B. dorei*** service targets the species *Bacteroides dorei*. *B. dorei* is an anaerobe that is frequently shed from the gastrointestinal tract and isolated from human feces worldwide. It is a newly discovered species that is widely distributed in the USA.[1,2] The human-associated marker DNA sequence is located on the 16S rRNA gene of *B. dorei*.[3] The marker is the microbial source tracking (MST) marker of choice for detecting human fecal pollution due to its exceptional sensitivity and specificity. Internal validations have been conducted on hundreds of sewage, septage, human and animal host fecal samples collected from throughout the U.S and archived in the Source Molecular fecal bank. The marker has also been evaluated in both inland and coastal waters. A recent, comprehensive, multi-laboratory MST method evaluation study, exploring the performance of current MST methods, concluded the *B. dorei* qPCR assay to be the top performing human-associated assay amongst those tested. The success and consistency of this marker in numerous studies around the world[1,3,4] makes the **Human Bacteroidetes ID™ Species: *B. dorei*** service the primary service for identifying human fecal pollution at Source Molecular.

Fecal *Bacteroidetes* are considered for several reasons an interesting alternative to more traditional indicator organisms such as *E. coli* and *Enterococci*.[5] Since they are strict anaerobes, they are indicative of recent fecal contamination when found in water systems. This is a particularly strong reference point when trying to determine recent outbreaks in fecal pollution. They are also more abundant in feces of warm-blooded animals than *E. coli* and *Enterococci*.

The Human Bacteroidetes ID™ service is designed around the principle that fecal *Bacteroidetes* are found in large quantities in feces of warm-blooded animals.[3,5,6,7,8] Furthermore, certain strains of *Bacteroidetes* have been found to be associated with humans.[3,6] As such, these bacterial strains can be used as indicators of human fecal contamination.

Accuracy of the results is possible because the method amplifies DNA into a large number of small copies of the gene biomarker of interest. This is accomplished with small pieces of DNA called primers that are complementary and specific to the unique *B. dorei* DNA sequence. Through a heating process called thermal cycling, the double stranded DNA is denatured, hybridized to the complementary primers and amplified to create many copies of the DNA fragment desired. If the primers are successful in finding a site on the DNA fragment that is specific to the *B. dorei* DNA sequence, then billions of copies of the DNA fragment will be available and detected in real-time. The accumulation of DNA product is plotted as an amplification curve by the qPCR software. The absence of an amplification curve indicates that the *B. dorei* gene biomarker is not detected in the water sample because it is either not present or present at concentrations below the analytical detection limit.

To strengthen the validity of the results, additional tests targeting other high-ranking, human-associated *Bacteroidetes* species should be performed, such as
Human Bacteroidetes ID™ Species: *B. stercoris*,
Human Bacteroidetes ID™ Species: *B. fragilis*, and
Human Bacteroidetes ID™ Species: *B. thetaiotaomicron*.

[1]Boehm, A., Fuhrman, J., Mrse, R., Grant, S. **Tiered approach for identification of a human fecal pollution source at a recreational beach: case study at Avalon Bay, Catalina Island, California**. Environ Sci Technol. 2003 37: 673–680.
[2]Bakir, M., Sakamoto, M., Kitahara, M., Matsumoto, M., Benno, Y. **Bacteroides dorei sp. nov., isolated from human faeces**. Int. J. Syst. Evol. Microbiol. 2006 56: 1639–1641.
[3] Bernhard, A., Field, K. **A PCR assay to discriminate human and ruminant feces on the basis of host differences in Bacteroides-Prevotella genes encoding 16S rRNA.** Appl. Environ. Microbiol. 2000b 66: 4571-4574.
[4]Ahmed, w., Masters, N., Toze, S. **Consistency in the host specificity and host sensitivity of the Bacteroides HF183 marker for sewage pollution tracking. Lett. Appl. Microbiol. 2012 55: 283-289.**
[5] Scott, T., Rose, J., Jenkins, T., Farrah, S., Lukasik, J. **Microbial Source Tracking: Current Methodology and Future Directions.** Appl. Environ. Microbiol. 2002 68: 5796-5803.
[6] Bernhard, A., Field, K. **Identification of nonpoint sources of fecal pollution in coastal waters by using host-specific 16S ribosomal DNA genetic markers from fecal anaerobes.** Appl. Environ. Microbiol. 2000a 66: 1587-1594.
[7] Fogarty, L., Voytek, M. **A Comparison of Bacteroides-Prevotella 16S rRNA Genetic Markers for Fecal Samples from Different Animal Species.** Appl. Environ. Microbiol. 2005 71: 5999-6007.
[8] Dick, L., Bernhard, A., Brodeur, T., Santo Domingo, J., *et al.* **Host Distributions of Uncultivated Fecal Bacteroidales Bacteria Reveal Genetic**

General Bacteroidetes ID™

The **General Bacteroidetes ID™** service is designed around the principle that general fecal *Bacteroidetes* are commonly found in the gastrointestinal tract and feces of Humans and warm-blooded animals worldwide.[1,2,3,4] Fecal *Bacteroidetes* are considered for several reasons an interesting alternative to more traditional indicator organisms such as *E. coli* and *Enterococci*. Since they are strict anaerobes, they are unlikely to persist for extended periods of time in oxygenated environments. Their presence in water systems is therefore indicative of recent fecal contamination.[1,2] This is a particularly strong reference point when trying to determine recent outbreaks in fecal pollution. They are also more abundant in feces of warm-blooded animals than *E. coli* and *Enterococci*. [1,2] In addition, a strong positive correlation has been observed between qPCR-measured *Bacteroidetes* and swimming-associated gastrointestinal illness rates (GIIR).[5] As such, testing for general *Bacteroidetes* can supplement routine *E. coli* and *Enterococci* membrane filtration culture methods and enhance water quality testing results.

The **General Bacteroidetes ID™** service adapts the qPCR assay from the U.S. EPA Method B for the detection and quantification of the16S ribosomal RNA (16S rRNA) target gene from all known Bacteroidales in water.[6]

Accuracy of the results is possible because the method amplifies DNA into a large number of small copies of the gene biomarker of interest. This is accomplished with small pieces of DNA called primers that are complementary and specific to the general *Bacteroidetes* 16S rRNA DNA sequence. Through a heating process called thermal cycling, the double stranded DNA is denatured, hybridized to the complementary primers and amplified to create many copies of the DNA fragment desired. If the primers are successful in finding a site on the DNA fragment that is specific to the *Bacteroidetes* DNA sequence, then billions of copies of the DNA fragment will be available and detected in real-time. The accumulation of DNA product is plotted as an amplification curve by the qPCR software. The absence of an amplification curve indicates that the *Bacteroidetes* gene biomarker is not detected in the water sample because it is either not present or present at concentrations below the analytical detection limit. Once general *Bacteroidetes* is found to be present in the water sample, additional tests may be used to determine the specific sources of the fecal pollution. Please call **(786) 220-0379** or visit **www.sourcemolecular.com** for a list of available tests.

[1] Scott, T., Rose, J., Jenkins, T., Farrah, S., Lukasik, J. **Microbial Source Tracking: Current Methodology and Future Directions.** Appl. Environ. Microbiol. 2002 68: 5796-5803.
[2]Dick, L. K., Field, K. G. **Rapid Estimation of Numbers of Fecal *Bacteroidetes* by Use of a Quantitative PCR Assay for 16S rRNA Genes.** Appl. Environ. Microbiol. 2004 70: 5695-5697.
[3] Bernhard, A., Field, K. **A PCR assay to discriminate human and ruminant feces on the basis of host differences in Bacteroides-Prevotella genes encoding 16S rRNA.** Appl. Environ. Microbiol. 2000b 66: 4571-4574.
[4]Dick, L., Bernhard, A., Brodeur, T., Santo Domingo, J., *et al.* **Host Distributions of Uncultivated Fecal Bacteroidales Bacteria Reveal Genetic Markers for Fecal Source Identification.** Appl. Environ. Microbiol. 2005 71: 3184-3191.
[5]Siefring, S., Varma, M., Atikovic, E., Wymer, L., Haugland, R. A. **Improved real-time PCR assays for the detection of fecal indicator bacteria in surface waters with different instrument and reagent systems.** J. of Water And Health. 2008 06.2 225-237.
[6]United States Environmental Protection Agency. **Method B: Bacteroidales in Water by Quantitative Polymerase Chain Reaction (qPCR) Assay.** 2010

D. RAW DATA

NPDES Permit Name	Status	Location	Owner City	Owner
5744-Grocery Store & Gas Stati	Active	7360 Theodore Dawes Rd	Theodore	Bradford Building Company Inc
Adams Homes - Dawes Oak	Active	Dawes Oak Drive	Theodore	Adams Homes, LLC
Alabama Power Company	Active	IRVINGTON CREW HQ 404 PARK BLVD	Birmingham	Alabama Power Company
ALDOT ACIM-IM-IO10327	Active	County Road 39	Mobile	ALDOT
ALDOT STPAA-HSIP-0016 509 PS11	In-Active	SR-16	Mobile	ALDOT
American Aero Crane	In-Active	9500 BELLINGRATH RD THEODORE	Unknown	American Aero Crane
Angela Law - RV Park	Active	Intersection of Three Notch Rd & Dawes Lane	Mobile	Angela Law
Baker Dev LLC Team Holdings Mc	Active	McDonald Rd	Irvington	Baker Development LLC
Baldwin Mining Co	Active	8093 Padgett Switch Rd	Irvington	Baldwin Mining Company
Bay Concrete	Active	8631 Boe Rd	Irvington	Bay Enterprises Inc.
Bay Enterprises Inc	Active	BAY CONCRETE 8631 BOC RD IRVINGTON	Mobile	Bay Enterprises Inc
Benchmark Homes Dawes Oak	Active	Dawes Lane Ext	Theodore	Benchmark Homes, Inc.
Benchmark Homes Woodside	In-Active	Nan Gray Davis Rd at Woodside Drive North	Theodore	Benchmark Homes, Inc
Breland Homes LLC Hunters Cove	In-Active	S. to Theodore Dawes; Right for 1 mile	Theodore	Breland Homes LLC
C&H Const Services LLC	Active	9466 Bellingrath Raod	Theodore	C&H Construction Services, LLC
Creel Excavation	Active	7800 County Farm Road	Irvington	Creel Excavation
Crown Oil Co	In-Active	0912 BELINGRATH	Theodore	Crown Oil Co
Delta Industries Inc	In-Active	GULF STATES 7191 I10 SERVICE RD THEODORE	Jackson	Delta Industries Inc
Dixie Pipe Sales Inc	In-Active	7555 Half Mile Road	Irvington	Dixie Pipe Sales, Inc.
DR Horton - Hunters Cove	Active	Theodroe Dawes Rd at Hunter's Cove Blvd	Theodore	DR Horton, Inc
Ed Bridgman - Homestead RV Com	Active	Intersection of Bay Rd and Pioneer Rd	Theodore	Ed Bridgman
Elite Dev LLC Hunters Cove	Active	Theodore Dawes Rd to Hunters Cove Blvd	Theodore	Elite Development, LLC
Emerald Coast Dirt Pit	Active	5260 McDonald Road	Theodore	Emerald Coast Dirt, L.L.C.
Endurance Equipment LLC	Active	7501 Half Mile Road	Irvington	Endurance Equipment LLC
Esfeller Const Gibson Road Pit	Active	8230 Padgett Switch Road	Coden	Esfeller Construction Co., Inc
Esfeller Const Walker Rd Pit	In-Active	South End of Walker Road	Coden	Esfeller Construction Co., Inc.
Express Auto Sales	Active	7491 Theodore Dawes Road	Theodore	Express Auto Sales LLC
FedEx Mobile	Active	Trippel Road	Theodore	Satterfield and Pontikes Construction, Inc.
G And V Industrial Contractors	In-Active	5370 FOWL RIVER RD THEODORE	Unknown	G And V Industrial Contractors Inc
Gateway Pipeline Company	In-Active	MOBILE COUNTY	Countywide	Gateway Pipeline Company
Great Southern Wood Pres Irvin	Active	7940 Park Boulevard	Irvington	Great Southern Wood Preserving Inc
Great Southern Wood Preserving	In-Active	PO Drawer 458	Abbeville	Great Southern Wood Preserving Inc
Gulf Pallet Co Inc	Active	8325 Padgett Switch Rd	Irvington	Gulf Pallet Co Inc
Gulf South Pipe Tpl 880 30-In	Active	111 Park Place, Suite 100	Covington	Gulf South Pipeline Co Lp
Gulf South Pipeline-Theodore	Active	4.5 miles southwest of theodore	Countywide	Gulf South Pipeline Company LP
Gulf States Ready Mix theodore	Active	7191 Interstate-10 Service Road	Theodore	Delta Industries Inc
HO Weaver - Trippel Rd Ext	Active	end of Tripple Road	Theodore	Hosea O Weaver & Sons, Inc
JDS Const LLC McDonald Road P	Pending	5460 McDonald Road	Theodore	JDS Construction LLC
Jeremy Hunt Ent Gold Mine Road	In-Active	4657 Gold Mine Road East	Mobile	Jeremy Hunt Enterprise General Contractors, LLC
Jeremy Hunt Gold Mine Road Pit	Active	4657 Gold Mine Road East	Mobile	Jeremy Hunt Enterprise General Contractors, LLC
Labrador Ltd Labrador Run	In-Active	Off Belmont Park Drive	Theodore	Labrador, LLC
Late Model Auto Parts Inc	In-Active	6251 HWY 90 W MOBILE	Unknown	Late Model Auto Parts Inc
Matthew Ray Southern Sand	Active	Bellingrath Road	Mobile	Matthew Ray
Mobile Cnty Comm MCP-311-09	In-Active	Shasta Way	Theodore	Mobile County Commission
Mobile Co Comm - MCR-2008-001	In-Active	Theodore Dawes Rd - Schillinger Rd S (from old Pasagoula Rd	Mobile	Mobile County Commission
Mobile Co Comm McDonald Rd	In-Active	McDonald Road from old Pascagoula Road to Three Notch Rd	Mobile	Mobile County Commission
Mobile Co Comm MCP-003-08 HSIP	In-Active	Three Notch Rd @ Dawes Lane & Dawes Lane Extension	Mobile	Mobile County Commission
Mobile Co Comm MCP-098-98B Sw	Active	Swedentown Rd Phase 2	Mobile	Mobile County Commission
Mobile Co Comm MCP-098-98B Sw	Pending	Swedentown Rd Phase 2	Mobile	Mobile County Commission
Mobile Co Comm MCR 4996 308B	In-Active	Pine Springs Road, Cecil Drive, Taylor Avenue	Mobile	Mobile County Commission
Mobile Co PSS - Padgett Switch	Active	8771 Padgett Switch Rd	Irvington	Mobile County Public School System
Mobile Co WSF Joe Carl Rd Old	In-Active	Joe Carl Rd, Old Military Road ALbert Carl Rd, Wazner Rd & R	Theodore	Mobile County Water, Sewer & Fire Protection Authority
Mobile County C Mcp-212-03	Active	205 Government Street	Mobile	Mobile County Commission
Mobile County C Theodore Dawes	Active	205 Government Street, 6th Floor South	Mobile	Mobile County Commission
Mobile Import Salvage Co	Active	7471-B Theodore Dawes Road	Theodore	Mobile Import Salvage Co
Mobile Industri Theodore AL W	In-Active	Trippel Road, behind Pilot Truck Stop	Theodore	Mobile Industrial Properties LLC
Mobile Industri Theodore AL W	Active	NW Corner of Theodore-Dawes exit on I-10	Theodore	Mobile Industrial Properties LLC
Mobile Water & Sewer Ext Fowl	Active	Sand Island Rd. west to Pioneer Rd., and south to River Rd.	Mobile	Mobile Area Water & Sewer System
Nicholson Pit	In-Active	8230 Padgett Switch Road	Coden	Esfeller Construction Company, Inc.
Nicholson Pit	Active	Barnswood Drive	Theodore	Esfeller Construction Company, Inc.
Padgett Switch Road Pit	In-Active	8230 Padgett Switch Road	Irvington	Esfeller Construction Company, Inc.
Padgett Switch Road Pit	Active	8230 Padgett Switch Road	Irvington	Esfeller Construction Company, Inc.
Phi Inc	Active	6000 Deakle Road, Lot 2	Theodore	PHI Inc
Pit Development Corp Pit 4	Active	Padget Switch Road	Mobile	Pit Development Corporation
Psi Sales Inc	In-Active	7501 HALF MILE RD IRVINGTON	Theodore	Psi Sales Inc
Ray Matthew Southern Sand	In-Active	Bellingrath Road	Mobile	Ray, Matthew
Research Solns Grp - Irvington	Active	8100 Padgett Switch Road	Irvington	Research Solutions Group, Inc.
Research Solvents And Chemical	In-Active	8100 PADGETT SWITCH RD	Irvington	Research Solvents And Chemicals
Sabel Industries Inc	In-Active	6051 HWY 90 W THEODORE	Unknown	Sabel Industries Inc
Serenity Funeral Home	Active	8691 Old Pascagoula Rd	Theodore	Serenity Funeral Home
SESH LLC Natural Gas Pepeline	In-Active	From MS border SSE to Coden	Coden	Southeast Supply Header, LLC
SESH LLC Natural Gas Piepeline	Active	Irvington SSE to Coden	Coden	Southeast Supply Header, LLC
Steel Processors Inc	Active	8639 BELLINGRATH RD THEODORE	Theodore	Steel Processors Inc
Theodore Mitigation Site	Active	End of Baywoods Road	Coden	Alabama Power Company
Walker Road Pit	Active	South End of Walker Road	Coden	Esfeller Construction Co., Inc.
Woodside LLC Unit 9 Phase 1 an	Active	W of W end of Woodside Dr. N, S of S end of Destinee Nicole	Theodore	Woodside, LLC

D. RAW DATA

SAMPLING LOCATIONS IN THE FOWL RIVER WATERSHED

Organization Name	Station Name	Station Latitude	Station Longitude	Data Station Location
ADEM	FLR-1	30.55528	-88.23472	Fowl River @ Old Pascagoula Road
ADEM	FLR-2	30.50222	-88.15722	Muddy Creek north of Laurendine Road
ADEM	FLR-3	30.46306	-88.15556	Muddy Creek upstream of concluence with Fowl River
ADEM	FLR-4	30.45778	-88.14861	Fowl River downstream of confluence with Dykes Creek
ADEM	FLR-7	30.44778	-88.11028	Fowl River near DIP and Mobile Bay
ADEM	FR-1	30.444166	-88.113056	Fowl River near DIP and Mobile Bay
ADEM	FWLM-1	30.52817	-88.19708	Fowl River @ State Road 90
ADEM	FWLM-2	30.5011	-88.1814	Fowl River @ Laurendine Road
ADEM	FWLM-3	30.433077	-88.137131	Fowl River @ Bellingrath Gardens
ADEM	FWLM-4	30.431301	-88.131809	Fowl River between Riverview Drive and Pinetop Road
ADEM	WFRM-1	30.42501	-88.134298	Fowl River south of Pinetop Road
ADEM	FLRM-10	30.4487	-88.143	Fowl River north of Windsor Road South
WMT BACTERIA	1	30.55528	-88.23472	Fowl River @ Old Pascagoula Road
WMT BACTERIA	2	30.52817	-88.19708	Fowl River @ State Road 90
WMT BACTERIA	3	30.50103	-88.18144	Fowl River @ Half Mile Road
WMT BACTERIA	4	30.474601	-88.16938	Fowl River @ Bellingrath Road
WMT BACTERIA	5	30.463449	-88.156021	Fowl River @ Fowl River Road
GSA	FR1	30.49775	-88.18629	Unnamed tributary @ Half Mile Road
GSA	FR2	30.50103	-88.18144	Fowl River @ Half Mile Road
GSA	FR3	30.50175	-88.17647	Unnamed tributary @ Half Mile Road
GSA	FR4	30.50193	-88.15719	Muddy Creek at Laurendine Road
GSA	FR5	30.46869	-88.1689	Unnamed tributary @ Bellingrath Road
GSA	FR6	30.47238	-88.14655	Dykes Creek at Fowl River Road
GSA	FR7	30.45633	-88.16855	Unnamed tributary @ Bellingrath Road
GSA	FR8	30.42883	-88.14466	Unnamed tributary @ Rebel Road
GSA	FR9	30.40863	-88.14247	Fowl River @ Rebel Road
DISL	EFR01	30.4219245	-88.13677428	Fowl River just upstream of Palmetto Point East
DISL	FR01	30.44163773	-88.11542891	Fowl River near DIP and Mobile Bay
DISL	FR02	30.43405392	-88.12822465	Fowl River at the end of Riverview Drive
DISL	FR03	30.43959376	-88.12970201	Fowl River between Old Windsor Road and Baumhauer Road
DISL	FR04	30.45128718	-88.1374237	Fowl River at the end of Wacker Drive
DISL	FR05	30.45916107	-88.15263025	Fowl River below Bass Drive
DISL	FR06			co-located with FR03 (Jarvis and Lehrter)
DISL	FR09			co-located with FR01 (Jarvis and Lehrter)
DISL	1.1	30.5552564	-88.23456466	Fowl River @ Old Pascagoula Road
DISL	2.1	30.52859869	-88.19701121	Fowl River @ Hwy 90
DISL	2.2	30.49752159	-88.18656302	Unnamed tributary @ Half-Mile Road
DISL	2.3	30.50106542	-88.18159045	Fowl River @ Half-Mile Road
DISL	2.4	30.50184788	-88.17637653	Unnamed tributary @ Half-Mile Road
DISL	3.1	30.53359773	-88.15794557	Muddy Creek @ Bowers Lane
DISL	3.2	30.50190589	-88.1573976	Muddy Creek @ Laurendine Road
DISL	3.3	30.46280842	-88.15562462	Fowl River @ Fowl River Road
DISL	4.1	30.48623706	-88.20851776	Unnamed tributary @ Cleveland Avenue
DISL	4.2	30.48563304	-88.19531211	Unnamed tributary @ Taylor Avenue
DISL	4.3	30.46803902	-88.16897774	Unnamed tributary @ Bellingrath Road
DISL	4.4	30.46409039	-88.21112732	Unnamed tributary @ Highgate Drive east
DISL	4.5	30.45986239	-88.21267153	Unnamed tributary @ Wisteria Street
DISL	5.1	30.4737147	-88.14069802	Unnamed drainage feature @ Bay Road
DISL	5.2	30.47235618	-88.14588445	Dykes Creek @ Bay Road
DISL	5.3	30.47246216	-88.13375853	Unnamed tributary @ Bay Road
DISL	5.4	30.46902937	-88.1407123	Unnamed tributary @ Thomas Road
DISL	5.5	30.46496247	-88.14507444	Unnamed tributary @ Fowl River road
DISL	5.6	30.45767228	-88.13074879	Unnamed tributary @ River Road
DISL	6.1	30.45659788	-88.16868266	Unnamed tributary @ Bellingrath Road
DISL	6.3	30.44509694	-88.16586306	Unnamed tributary @ Bellingrath Road
DISL	6.3	30.44509694	-88.16586306	Unnamed tributary @ Bellingrath Road
DISL	7.1	30.42823411	-88.14440686	Unnamed tributary @ Rebel Road
DISL	7.2	30.41125689	-88.15085384	East Fowl River @ Bellingrath Road
ADEM: Alabama Department of Environmental Management; WMT: Watershed Management Team; GSA: Geological Survey of Alabama; DISL: Dauphin Island Sea Lab				

D. RAW DATA

SUMMARY OF FOWL RIVER WATER QUALITY DATA COMPARED TO WATER QUALITY STANDARDS		
Criteria or Water Quality Parameter	**Standard***	**Fowl River**
	Swimming and Whole Body Contact	**Range in Measured Values**
pH	6.0 - 8.5 su	5.7 - 6.8 su average (ADEM 2008)
Temperature	<= 90°F	65.3 - 70.5 average (ADEM 2008)
Dissolved Oxygen	>= 5.0 mg/L	5.3 - 8 average (ADEM 2008)
Turbidity	<= 50 ntu above background	6 - 14 average (ADEM 2008)
Fecal Coliform Bacteria	<= 200 colonies/100 ml (geometric mean)	149 - 3,429 average (ADEM 2008)
	<= 100 colonies/100 ml (geometric mean) coastal	
Enterococcus	104 /100 ml single sample Coastal max**	1 - 800 (ADEM Data Stations)
	Fish and Wildlife	
pH	6.0 - 8.5 su	5.7 - 6.8 su average (ADEM 2008)
Temperature	<= 90°F	65.3 - 70.5 average (ADEM 2008)
Dissolved Oxygen	>= 5.0 mg/L	5.3 - 8 average (ADEM 2008)
Turbidity	<= 50 ntu above background	6 - 14 average (ADEM 2008)
Fecal Coliform Bacteria	<= 200 colonies/100 ml (geometric mean June - Sept)	149 - 3,429 average (ADEM 2008)
	<= 1000 colonies/100 ml (geometric mean Oct - May)	
	<= 2000 colonies/100 ml (single sample max)	
Fecal Coliform Bacteria Coastal	<= 100 colonies/100 ml (geometric mean June - Sept)	149 - 3,429 average (ADEM 2008)
	<= 1000 colonies/100 ml (geometric mean Oct - May)	
	<= 2000 colonies/100 ml (single sample max)	
Enterococcus	275 cfu/100 ml single sample coastal max**	1 - 800 (ADEM data stations)
**ADEM 335-6-10-.09; **EPA*		
	Organic Enrichment	
Chlorophyll a	< 5 good water quality conditions	0 - 45 (ADEM data stations)
Nitrate	0.5 mg/L threshold for excessive algae growth	BDL - 1.65 (GSA 2015)
Total Nitrogen	0.4 mg/L good water quality conditions	0.01 - 2.6 (ADEM data stations)
Total Phosphorus	0.05 mg/L threshold for excessive algae growth	0.01 - 1.39 (GSA 2015)
Total Organic Carbon	1 - 10 mg/L natural range	1 - 46.4 (GSA 2015)
	EPA Protection of Aquatic Life Chronic (ug/L)	from GSA 2015
	Metals in Sediment	**Range in Maximum Measured**
Aluminum	87	171 - 570
Arsenic	150	1 - 2.97
Cadmium	0.3	<0.1 - 1.7
Chromium	74	<0.3 - 1.12
Copper	n/a	<8.0
Cyanide	0	<0.003
Iron	176	170 - 1,140
Lead	4.47	2.14 - 168
Mercury	0.8	0.005 - 0.065
Nickel	52	<10.0 - 118
Selenium	5	<0.5 - 1.6
Silver	n/a	<10 - 13
Zinc	120	21.9 - 83.9

Note: Bacterial concentrations in surface waters can be notoriously sporadic and variable, with occasional spikes associated with large rains events.

APPENDIX E
Flora and Fauna

E

RARE, THREATENED & ENDANGERED SPECIES AND NATURAL COMMUNITIES DOCUMENTED IN MOBILE COUNTY, ALABAMA

Scientific Name	Common Name	Global	State	Federal	State	State
		Rank	Rank	Status	Status	Priority1
Amphibians						
Ambystoma bishopi	Reticulated Flatwoods Salamander4	G2	S1	LE	SP	P1
Amphiuma means	Two-toed Amphiuma	G5	S3			
Amphiuma pholeter	One-toed Amphiuma	G3	S1		SP	P2
Desmognathus auriculatus	Southern Dusky Salamander	G5	S2		SP	P1
Lithobates heckscheri	River Frog5	G5	S1		SP	P3
Lithobates sevosa	Mississippi Gopher Frog6	G1	SH	LE	SP	P1
Birds						
Ammodramus henslowii	Henslow's Sparrow	G4	S2N		SP	P1
Ammodramus leconteii	Le Conte's Sparrow	G4	S3N		SP	
Ammodramus maritimus	Seaside Sparrow	G4	S2		SP	P2
Ammodramus nelsoni	Nelson's Sparrow	G5	S3N		SP	P2
Anas fulvigula	Mottled Duck	G4	S2N,S3B		SP	
Asio flammeus	Short-eared Owl	G5	S2N		SP	P2
Athene cunicularia	Burrowing Owl	G4	S2N		SP	
Charadrius melodus	Piping Plover	G3	S1N	LE, LT7	SP	P1
Charadrius nivosus	Snowy Plover	G3	S1B,S2N		SP	P1
Charadrius wilsonia	Wilson's Plover	G5	S1		SP	P1
Circus cyaneus	Northern Harrier	G5	S3N		SP	P2
Cistothorus palustris	Marsh Wren	G5	S2B,S4N		SP	
Columbina passerina	Common Ground-dove	G5	S3		SP	
Coturnicops noveboracensis	Yellow Rail	G4	S2N		SP	P2
Crotophaga sulcirostris	Groove-billed Ani	G5	S2N		SP	
Egretta rufescens	Reddish Egret	G4	S1B,S3N		SP	P2
Elanoides forficatus	Swallow-tailed Kite	G5	S2		SP	P2
Eudocimus albus	White Ibis	G5	S2B,S3N		SP	
Gelochelidon nilotica	Gull-billed Tern	G5	S2B,S4N		SP	
Haematopus palliatus	American Oystercatcher	G5	S1		SP	P1
Hydroprogne caspia	Caspian Tern	G5	S2B,S4N		SP	
Ixobrychus exilis	Least Bittern	G5	S2N,S4B		SP	P2
Mycteria americana	Wood Stork	G4	S2N	LE,PT8	SP	P2
Numenius americanus	Long-billed Curlew	G5	S2N		SP	
Passerina ciris	Painted Bunting	G5	S2B		SP	
Peucaea aestivalis	Bachman's Sparrow	G3	S3		SP	P2
Plegadis falcinellus	Glossy Ibis	G5	S1B,S3N		SP	
Porphyrio martinicus	Purple Gallinule	G5	S3B		GB	
Rallus elegans	King Rail	G4	S2S3B,S4N	SC	GB	
Rallus longirostris	Clapper Rail	G5	S2	SC	GB	
Rynchops niger	Black Skimmer	G5	S2B,S4N		SP	
Scolopax minor	American Woodcock	G5	S3B,S5N		GB	P2
Sterna forsteri	Forster's Tern	G5	S1B,S5N		SP	
Sterna hirundo	Common Tern	G5	S1B,S4N		SP	
Sternula antillarum	Least Tern	G4	S2B,S4N		SP	
Thalasseus maximus	Royal Tern	G5	S2B, S5N		SP	
Thalasseus sandvicensis	Sandwich Tern	G5	S1B,S5N		SP	
Tringa semipalmata	Willet	G5	S2B,S5N		SP	
Tyrannus dominicensis	Gray Kingbird	G5	S2B		SP	
Tyrannus forficatus	Scissor-tailed Flycatcher	G5	S2		SP	
Caddisflies						
Brachycentrus chelatus	Caddisfly	G4	S1			
Ceraclea resurgens	Caddisfly	G5	S1			
Chimarra falculata	Caddisfly	G4	S1			
Hydroptila parastrepha	Caddisfly	G2G3	S1			
Hydroptila scheiringi	A Caddisfly	G1G2	S1			
Neotrichia mobilensis	Caddisfly	G1G2	S1S2			
Nyctiophylax morsei	Caddisfly	G2	S1			
Oxyethira anabola	Caddisfly	G4G5	S1			
Oxyethira sininsigne	Caddisfly	G3G4	S1			
Polycentropus clinei	A Caddisfly	G5	SNR			
Crayfishes						
Cambarellus diminutus	Least Crayfish	G3	S3			P2
Cambarellus shufeldtii	Cajun Dwarf Crayfish	G5	S2			
Cambarus lesliei	Angular Dwarf Crayfish5	G3	S3			P2
Fallicambarus danielae	Speckled Burrowing Crayfish	G2	S1			P2
Fallicambarus oryktes	Flatwoods Digger5	G4	S1			P2
Procambarus bivittatus	Ribbon Crayfish5	G5	S3S4			
Procambarus clemmeri	Cockscomb Crayfish	G5	S2			
Procambarus evermanni	Panhandle Crayfish	G4	S3			
Procambarus lecontei	Mobile Crayfish	G3G4	S3			
Procambarus penni	Pearl Blackwater Crayfish5	G3	S2			
Procambarus shermani	Gulf Crayfish	G4	S2			
Ferns and relatives						
Botrychium jenmanii	Alabama Grapefern	G3G4	S1			

Fishes						
Acipenser oxyrinchus desotoi	Gulf Sturgeon	G3T2	S1	LT	SP	P2
Alosa alabamae	Alabama Shad5	G2G3	S2	SC9	SP	P2
Ammocrypta vivax	Scaly Sand Darter	G5	S1			
Atractosteus spatula	Alligator Gar	G3G4	S2		CNGF	
Cycleptus meridionalis	Southeastern Blue Sucker	G3G4	S3		CNGF	
Enneacanthus gloriosus	Bluespotted Sunfish	G5	S3		GF	
Etheostoma fusiforme	Swamp Darter	G5	S3			
Etheostoma lynceum	Brighteye Darter	G5	S1		SP	P1
Fundulus blaire	Western Starhead Topminnow	G4	S3			
Fundulus chrysotus	Golden Topminnow	G5	S3			
Fundulus cingulatus	Banded Topminnow	G4	S2			
Fundulus dispar	Starhead Topminnow	G4	S2			
Fundulus jenkinsi	Saltmarsh Topminnow	G3	S1	SC9		
Fundulus pulvereus	Bayou Killifish	G5	S2			
Heterandria formosa	Least Killish	G5	S3			
Hiodon tergisus	Mooneye	G5	S3S4			
Lucania parva	Rainwater Killifish	G5	S3			
Lythrurus roseipinnis	Cherryfin Shiner	G5	S2			
Notropis chalybaeus	Ironcolor Shiner5	G4	SH			P1
Notropis maculatus	Taillight Shiner	G5	S3			
Notropis petersoni	Coastal Shiner	G5	S2			
Noturus mocturnus	Freckled Madtom	G5	S3		CNGF	
Perca flavescens	Yellow Perch	G5	S3		GF	
Poecilia latipinna	Sailfin Molly	G5	S2			
Polyodon spathula	Paddlefish	G4	S3		SP, CNGF10	
Pteronotropis signipinnis	Flagfin Shiner	G5	S3			
Flowering Plants						
Agalinis aphylla	Leafless False-foxglove	G3G4	S2			
Agalinis filicaulis	Thin-stemmed False-foxglove	G3G4	S2			
Agalinis linifolia	Flax-leaf False-foxglove	G4?	S2			
Agrimonia incisa	Incised Groovebur	G3	S2			
Andropogon virginicus var. glaucus	Beardgrass	G5T4T5	S2			
Calopogon barbatus	Bearded Grass-pink	G4?	S1			
Calopogon multiflorus	Many-flowered Grass-pink	G2G3	S1			
Canna flaccida	Bandana-of-the-everglades	G4?	S1			
Carex striata	Walter's Sedge	G4G5	S1			
Chasmanthium nitidum	Shiny Spikegrass	G3G4	S1			
Cirsium lecontei	Le Conte's Thistle	G2G3	S1			
Cirsium nuttallii	Nuttall's Thistle	G5	S1			
Cladium mariscoides	Twig Rush	G5	S1			
Coreopsis gladiata	Southeastern Tickseed	G4G5	S2			
Coreopsis nudata	Georgia Tickseed	G3?	S1			
Eleocharis olivacea	Capitate Spikerush	G5	S1			
Eleocharis robbinsii	Robbins' Spikerush	G4G5	S1			
Eleocharis rostellata	Beaked Spikerush	G5	S1			
Epidendrum magnoliae	Green-fly Orchid	G4	S2			
Eriocaulon texense	Texas Pipewort	G4	S2			
Eurybia chapmanii	Chapman Aster	G2G3	SH			
Gordonia lasianthus	Loblolly Bay	G5	S1			
Helianthemum arenicola	Coastal-sand Frostweed	G3	S1			
Hibiscus coccineus	Brilliant Hibiscus	G4?	S1			
Hypericum reductum	Atlantic St. John's-wort	G5	S2			
Ilex amelanchier	Serviceberry Holly	G4	S2			
Juncus gymnocarpus	Naked-fruited Rush	G4	S2			
Kosteletzkya smilacifolia	Southern Seashore Mallow	G1G3Q	S1?			
Lachnocaulon digynum	Pineland Bogbutton	G3	S2			
Lepuropetalon spathulatum	Southern Lepuropetalon5	G4G5	SH			
Lilaeopsis carolinensis	Carolina Lilaeopsis	G3G5	S1			
Lindera subcoriacea	Bog Spicebush	G2G3	S1			
Linum macrocarpum	Flax	G2	S1			
Ludwigia arcuata	Pond Seedbox	G4G5	S1			
Ludwigia spathulata	Spathulate Seedbox	G2	S1S2			
Lycium carolinianum	Christmas Berry	G4	S1S2			
Macranthera flammea	Flame Flower	G3	S2			
Myriophyllum laxum	Loose Water-milfoil	G3	S2			
Nuphar lutea ssp. ulvacea	West Florida Cowlily	G5T2	S1			
Orbexilum simplex	Single-stemmed Scurf-pea	G4G5	SH			
Panicum nudicaule	Naked-stemmed Panic Grass	G3Q	S2			
Peltandra sagittifolia	Spoon-flower	G3G4	S2			
Pieris phillyreifolia	Climbing Fetter-bush	G3	S2			
Pinguicula planifolia	Chapman's Butterwort	G3?	S1S2			

Platanthera blephariglottis var. conspicua	Large White Fringed Orchid	G4G5T3T4	S1S2			
Platanthera integra	Yellow Fringeless Orchid	G3G4	S2			
Platanthera nivea	Snowy Orchis	G5	S2			
Polygala crenata	Crenate Milkwort	G4?	S1			
Pteroglossaspis ecristata	Crestless Eulophia	G2	S1			
Ptilimnium costatum	Eastern Bishop-weed	G4	S1			
Quercus similis	Bottomland-post Oak	G4	S1			
Rhynchospora crinipes	Hairy-peduncled Beakrush	G2	S1			
Rhynchospora macra	Southern White Beak Rush	G3	S1			
Rhynchospora stenophylla	Chapman Beakrush	G4	S2			
Rhynchospora tracyi	Tracy's Beak Rush	G4	S1			
Ruellia noctiflora	Night-flowering Wild-petunia	G2	S1			
Sageretia minutiflora	Tiny-leaved Buckthorn	G4	S1			
Sarracenia leucophylla	Whitetop Pitcher-plant	G3	S3			
Sarracenia rubra ssp. wherryi	Wherry's Sweet Pitcher-plant	G4T3	S3			
Schizachyrium maritimum	Gulf Bluestem	G3G4Q	S1			
Schizachyrium scoparium ssp. divergens	Eastern Little Bluestem	G5T5	SH			
Schwalbea americana	Chaffseed5	G2G3	S1	LE		
Spiranthes longilabris	Giant Spiral Ladies'-tresses	G3	S1			
Utricularia floridana	Florida Bladderwort	G3G5	S1S2			
Xyris chapmanii	Chapman's Yellow-eyed Grass	G3	S1			
Xyris drummondii	Drummond's Yellow-eyed Grass	G3	S3			
Xyris scabrifolia	Harper's Yellow-eyed Grass	G3	S1S2			
Freshwater Mussels						
Glebula rotundata	Round Pearlshell	G4G5	S2		PS	
Ligumia subrostrata	Pondmussel	G5	S3		PS	
Freshwater Snails						
Ferrissia mcneili	Hood Ancylid 2	G2G3	S2			
Mammals						
Lasiurus intermedius	Northern Yellow Bat	G4G5	S1			P2
Trichechus manatus	West Indian Manatee	G2	S1	LE	SP	P1
Trichechus manatus	West Indian Manatee	G2G3	S1	LE	SP	P1
Ursus americanus	Black Bear	G5T2	S2		GANOS	P1
Natural Communities						
Aristida beyrichiana - Rhynchospora oligantha - Panicum nudicaule - (Eurybia eryngiifolia) Herbaceous Vegetation	East Gulf Coastal Plain Seepage Bog (upper Terrace Type)	G2	S2			
Ceratiola ericoides - (Chrysoma pauciflosculosa) / Polygonella polygama / Cladonia leporina Shrubland	Coastal Rosemary - Woody-goldenrod Scrub	G2?	SNR			
Juncus roemerianus - Herbaceous Vegetation	Needlerush High Marsh	G5	S2S3			
Nyssa biflora/Ilex myrtifolia/Carex glaucescens - Eriocaulon compressum Forest	East Gulf Coastal Plain Blackgum Dome Swamp	G2G3	SNR			
Pinus palustris - (Pinus elliottii var. elliottii)/Ctenium aromaticum - Carphephorus pseudoliatris - (Sarracenia alata) Woodland	East Gulf Coastal Plain Wet Longleaf Pine Savanna	G3?	S2			
Quercus laurifolia - Magnolia virginiana - Nyssa biflora / Chasmanthium ornithorhynchum Forest	East Gulf Coastal Plain Blackgum Bayhead Forest (clayey Type)	G2?	S2			
Quercus virginiana - (Juniperus virginiana) - Zanthoxylum clava-herculis / Sideroxylon lanuginosum Woodland	Gulf Coast Shell Midden Woodland	G2G3	SNR			
Sarcocornia perennis - (Batis maritima, Distichlis spicata) Dwarf-shrubland	Salt Flat (woody Glasswort Type)	G4	S1			
Spartina alterniflora - Juncus roemerianus - Distichlis spicata Louisianian Zone Salt Tidal Herbaceous Vegetation	Gulf Coast Cordgrass Salt Marsh	G5	S2S3			
Spartina patens - Schizachyrium maritimum - Solidago sempervirens Herbaceous Vegetation	East Gulf Coastal Plain Cordgrass Dune Grassland	G3?	SNR			
Spartina patens - Schoenoplectus (americanus, pungens) - (Distichlis spicata) Herbaceous Vegetation	Saltmeadow Cordgrass - (chairmaker's Bulrush, Threesquare) - (saltgrass) Herbaceous Vegetation	G4?	SNR			
Spartina spartinae - Sporobolus virginicus Tidal Herbaceous Vegetation	Gulf Coast Irregularly Flooded Tidal Marsh	G4G5	SNR			
Taxodium ascendens - Ilex myrtifolia - Hypericum myrtifolium - Lobelia floridana - Polygala cymosa Woodland	Pond-cypress Dome Swamp	G3	S1			
Reptiles						
Crotalus adamanteus	Eastern Diamond-backed Rattlesnake	G4	S3			P2
Drymarchon couperi	Eastern Indigo Snake	G3	S1	LT	SP	P1, possibly extirpated
Farancia erytrogramma	Rainbow Snake	G4	S3		SP	P2
Lampropeltis calligaster rhombomaculata	Mole Kingsnake	G5T5	S3			
Lampropeltis getula getula	Eastern Kingsnake	G5T5	S4		SP	P2
Lampropeltis getula holbrooki	Speckled Kingsnake	G5T5	S4		SP	P2
Masticophis flagellum	Coachwhip	G5	S3		SP	
Micrurus fulvius	Eastern Coralsnake	G5	S3		SP	P2
Nerodia clarkii clarkii	Gulf Saltmarsh Watersnake	G4T4	S2		SP	
Nerodia cyclopion	Green Watersnake	G5	S1S2			
Ophisaurus mimicus	Mimic Glass Lizard11	G3	S2		SP	P2
Pituophis melanoleucus lodingi	Black Pinesnake	G4T2T3	S2	C	SP	P1
Plestiodon anthracinus	Coal Skink12	G5	S3		SP	P2
Plestiodon inexpectatus	Southeastern Five-lined Skink	G5	S3		SP	P2
Rhadinaea flavilata	Pine Woods Littersnake	G4	S2			

E. FLORA AND FAUNA

Turtles						
Apalone ferox	Florida Softshell	G5	S2		RT	
Caretta caretta	Loggerhead Sea Turtle	G3	S1	LT	SP	P1
Chelonia mydas	Green Sea Turtle13	G3	S1	LE, LT14	SP	P1
Deirochelys reticularia	Chicken Turtle	G5	S3			
Dermochelys coriacea	Leatherback Sea Turtle15	G2	SNA	LE	SP	P1
Gopherus polyphemus	Gopher Tortoise	G3	S3	LT16	SP	P2
Graptemys nigrinoda delticola	Delta Map Turtle2	G3T2Q	S2		SP	
Graptemys pulchra	Alabama Map Turtle	G4	S3		SP	
Lepidochelys kempii	Kemp's Ridley Sea Turtle17	G1	S1	LE	SP	P1
Macrochelys temminckii	Alligator Snapping Turtle	G3G4	S3		SP	P2
Malaclemys terrapin pileata	Mississippi Diamondback Terrapin	G4T3Q	S2		SP	P1
Pseudemys alabamensis	Alabama Redbelly Turtle	G1	S1	LE	SP	P1
Sternotherus carinatus	Razorback Musk Turtle	G5	S1			
1 Priority as identified in the State Wildlife Action Plan and its list of Species of Greatest Conservation Concern (for more information on SWAP, see http://www.outdooralabama.com/research-mgmt/swcs/).						
2 Alabama endemic.						
4 Historic occurrence, not documented in Alabama since 1981.						
5 Historic occurrence.						
6 Historic occurrence, possibly extirpated in Alabama.						
7 Listed by USFWS as Endangered in Great Lakes watersheds of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin; Listed as Threatened elsewhere, including Alabama.						
8 Listed by USFWS as Endangered in Alabama, Florida, Georgia, North Carolina, and South Carolina; not listed elsewhere. The USFWS proposed reclassifying the continental U.S. breeding population from endangered to threatened on 26 December, 2012.						
9 Listed as a species of concern by the National Marine Fisheries Service (Federal Register 69(73):19975-19979, available at).						
10 Polyodon spathula is not included in the list of protected species of the Nongame Species Regulation (Regulation 220-2-.92), but is protected by Regulations 220-2-.94 Prohibition of Taking or Possessing Paddlefish (Spoonbill) and 220-2-.43 Unlawful to Willfully Waste Paddlefish.						
11 Historic occurrence						
12 Historic Occurrence						
13 Possible occurrence						
14 Listed as Threatened throughout most of its range, including Alabama, except in Florida and Mexico where it is listed as Endangered.						
15 Occasional visitor but not known to nest in state.						
16 Listed by USFWS as Threatened west of the Mobile and Tombigbee rivers in Alabama (Choctaw, Mobile, and Washington counties), Mississippi, and Louisiana. Eastern populations were elevated to a candidate for protection under the federal Endangered Species Act 27 July 2011.						
17 Possible Occurrence.						
USFWS Designated Critical Habitat in Mobile County, Alabama						
Scientific Name	**Common Name**	**Global**	**State**	**Federal**	**State**	**State**
		Rank	**Rank**	**Status**	**Status**	**Priority**
Birds						
Charadrius melodus	Piping Plover	G3	S1N	LE, LT	SP	P1
Location: Coastal islands.						

APPENDIX F
Public Comments

F. PUBLIC COMMENTS

From:	Lehrter, John
To:	James Robinson
Cc:	Just Cebrian; Lee Walters
Subject:	Comments-Fowl River WMP
Date:	Monday, February 08, 2016 2:10:36 PM
Attachments:	Lehrter 2008 (Eutrophication susceptibility in oligohaline regions).pdf Comments on Draft-Fowl River WMP (Lehrter).docx

Hi James,

Just Cebrian forwarded me the announcement about the draft plan. I was reading through it and thought I'd go ahead and submit some comments for consideration. Overall I think it is pretty good with lots of interesting data. It's great to see all of these data presented in one place Please see the attached Word document for comments and an attached manuscript that has some additional Fowl River data that could be referenced in the report. My main suggestion is to revise some of the statements about hypoxia and chla in the Fowl River estuary. Based on my review of the data, I consider the low O2 values to be a pretty serious issue that are likely linked to elevated phytoplankton biomass (Chlorophyll-a) as stimulated by nutrients. In the current draft, though, the text seems to discount chlorophyll-a as an issue, which leave the low O2 being explained away as a 'natural' phenomenon. I think the report should be careful on this topic. If needed, I'll be happy to have a more detailed discussion about the issues I highlight.

Cheers,
John

Comments:

Page 132: It would be helpful to include a map to show where these stations are located in the estuary

Page 135: Be careful about suggesting an improving trend with these Chla data. It's more likely that the pattern is driven by inter-annual high/low rainfall patterns. As shown in Lehrter (2008) Chla is very sensitive to changes in discharge. For example during drought years you may see increased chla in the upper estuary due to slower hydrologic flushing (i.e. greater residence times). The converse is also true with lower chla observed in the upper estuary during high discharge periods. See Lehrter 2008, Table 3, which shows the negative relationship between discharge and Chla. Also, the long-term data seem to indicate a "fair" rating, i.e. most of the data fall in the 5-20 mg/L range. See the time-series of chla presented in Lehrter (2008, Fig 9b) for additional data.

Page 136: Revise the last two sentences on this page. As commented on above, chla is actually pretty high in this system, so this sentence should be revised or omitted.

Page 137: Again, I think it is incorrect to say Fowl River has "low chlorophyll-a concentration". In estuaries, a chla > 10 mg/L is considered to indicate an algal bloom. The chla data presented on pg. 406 of the appendix and in Fig 9b in Lehrter (2008) indicate that bloom conditions are frequently encountered.

Page 252: Again, need a map. Here it says that station FR1 is an estuarine sampling station, but elsewhere the report refers to FR1 as a site off of half-mile road, which is up in the watershed. The map on pg. 311 in the appendix also shows FR1 as being a watershed site.

F. PUBLIC COMMENTS

From: Doug Taylor
To: James Robinson
Subject: Fowl River Watershed Plan Draft
Date: Tuesday, January 26, 2016 4:20:57 PM

Dear Mr Robinson:

As you are aware, the private individual resident "Stakeholders" referred to in the draft plan, which does not include non-residential property owners for some reason, consists of a very diverse group. That being said, I have a couple of questions concerning the implementation and regulation of the proposed plan. First: Who and/or what persons, entities, agencies, or organizations make up the MBNEP Project Implementation Committee? Second: By what means will the proposed Watershed Management Task Force(WMTF) be selected? Thank you.

Sincerely,
Doug Taylor

From: Ollie Stuardi
To: James Robinson
Cc: sam@cbroker.com
Subject: Comments-Fowl River WMP
Date: Wednesday, February 17, 2016 5:28:50 PM

Mr. Robinson:

As a lifelong resident of Fowl River I would like to go on record as opposing the Public Access portion of the draft plan (specifically Section 8.8) as it relates to the East Fowl River (upper) section.

With the exception of a few properties east of the Dauphin Island Parkway bridge (near the mouth) and Memories in the extreme upper reaches of the river, the entire river consists of single family, residential properties. Placing public access ramps in residential neighborhoods is an extremely poor idea as it will increase vehicular traffic, compromise safety and decrease property values.

Additionally, the plan states one benefit of additional public access is to DECREASE boat traffic. This is probably the most convoluted logic I have ever heard. The current public access is self limiting in that only so many boats can be launched in a given period of time. Additional ramps will simply increase the number of boats that can be launched. The result will be INCREASED traffic on an already congested river at peak times.

Again, please register my opposition to the Public Access portion of the draft plan.

Respectfully,

Oliver Stuardi

F. PUBLIC COMMENTS

From:	jmshps
To:	James Robinson
Subject:	Fowl River Watershed Mgmt Draft Plan Comments
Date:	Thursday, February 18, 2016 10:06:29 AM
Attachments:	Comments Regarding Proposed Public Ramp on Murray Road.docx

Mr. Robinson,

Attached are my comments relative to page 232 of the draft proposing construction of a public landing at the end of Murray Road.

Julius Sitterlee

From:	Ray Mayhall
To:	James Robinson
Subject:	Fowl River Watershed Comments from Julius Sitterlee
Date:	Sunday, February 21, 2016 1:34:52 PM
Attachments:	Sitterlee Fowl River Comments.pdf

James, please add these comments to the plan.

Thanks

Ray

Comments on Proposed Public Access Facility on Murray Road – Fowl River

Re: Fowl River Watershed Management Plan Draft – February 2016

Adverse Environmental Impact on River

Storm Water – Murray Road Improvements

Murray Road is essentially a one lane road bordered by heavy vegetation, serving approximately eight (8) residences. The vegetation limits the quantity, quality and velocity of storm water entering the river by significantly absorbing and filtering rainfall runoff.

In order to provide public access, Murray Road would have to be widened and improved to accommodate a huge increase in traffic. A wider road would require additional gravel or paving, as well as ditches to drain the road of rainfall runoff. Ditches would put raw runoff water directly into the river with no check of nature on the quantity and quality of runoff. This means mud and silt in our river as well as turbulence, and probably trash, at runoff entry points.

Storm Water at Access Site

The access site on the river is presently covered in vegetation. There is, at present, virtually no runoff at the site. Public access will require that the site be cleared, and a parking area (gravel or paving) created. Storm water, previously contained will then have to go, full force, into the river.

Boat Wake Impact

Certainly, public access will create a significant increase in boat traffic in this area of the river. This means more erosion from wake turbulence battering our shorelines in this area of the river. There is an area of wetlands (approximately 5 acres) immediately to the west of the proposed site that is suffering greatly just due to the existing wake traffic.

Issues to be Ensured for the Preservation of Human Health and Safety

- Construction and Maintenance of Restroom and Septic Facilities at Site
- Site Trash Disposal Containers and Collection
- Site Lighting
- Site Security
- Site Parking Area Maintenance
- Murray Road Maintenance

Julius Sitterlee - **(2/16/2016)**

F. PUBLIC COMMENTS

From: Sam St. John
To: James Robinson
Subject: Fowl River Watershed Plan
Date: Thursday, February 18, 2016 10:37:23 AM

I am a resident of Fowl River. I am writing to comment on the Public Access portion of the draft plan(Section 8.8). I am definitely opposed to placing a public access ramp at the end of Murray Road.

The plan describes a positive of adding public access to reduce boat traffic. While being on the river will certainly make you appreciate the wonderful environment of the river, creating boat ramps will certainly not reduce boat traffic. The river currently experiences overload conditions with the number of boats on the river during the Spring and Summer seasons. The increased boat traffic created by additional public access ramps will certainly accelerate the shoreline erosion problem that is described in the plan.

The Murray Road location recommended is accessed by a dirt road. The location is surrounded by single family residential homes. Placing a public access ramp in a residential neighborhood is a flawed idea for a number of reasons. It will increase vehicular traffic, compromise safety as well as decrease property values. Additionally, placing an access ramp at the end of a dirt road will cause water runoff that will cause erosion to flow directly into the pristine waters of our river. We should never do projects that potentially take away from our quality of the waters in our river.

The Public Access portion of the draft plan presents more negatives than positives for the river and the residents of the river. Please record this letter as opposition to the Public Access section of the draft plan.

I will be happy to assist in the proper placement of low impact public assess.

Thank you,

Sam St John
President
Logical Computer Solutions, Inc.
(251) 661-3111
sam@logicalus.com

F. PUBLIC COMMENTS

From: Cooper Thurber (8264)
To: James Robinson
Subject: Comments-Fowl River WMP
Date: Thursday, February 18, 2016 1:06:21 PM

I have lived on Fowl River for 18 years. There is already adequate access for such a narrow river. It can't support the present traffic. I would limit a public ram to the mouth of the river so as to have access to the river and Mobile Bay, Certainly not on Murray road.

Cooper C. Thurber
Phelps Dunbar LLP

From: Dell
To: James Robinson
Cc: Sam St. John; Ray Mayhall
Subject: Fowl River Watershed Management Plan - Please Confirm Receipt
Date: Thursday, February 18, 2016 11:11:34 AM
Attachments: Fowl River Watershed Management Plan ASG Letter 02-18-2016.pdf
Fowl River Watershed Manatement Plan DWG Letter 02-18-2016.pdf

Mr. Robinson,

It has recently been brought to my husband's and my attention that a section of the Fowl River Watershed Management Plan (specifically Section 8.8 as it relates to the East Fowl River (upper) section) will be a detriment to our beloved river and we go on record as **vehemently opposing this**!

"The Plan," which I am sure has taken a great deal of time and effort on the part of many, whose overall intent is to protect our watersheds in fact contains a section that undermines the very purpose of the protection.

Our letters of opposition are attached; the courtesy of an acknowledgement of receipt would be greatly appreciated.

Dell

Adele S. Gwatkin
Secretary/Treasurer
D. W. Gwatkin Construction Company, Inc.

F. PUBLIC COMMENTS

Mr. Robinson,

It has recently been brought to my attention that a section of the Fowl River Watershed Management Plan (specifically Section 8.8 as it relates to the East Fowl River (upper) section) will be a detriment to our beloved river and I go on record as **vehemently opposing this**!

My association with Fowl River goes back three generations...my grandfather owned property here, my parents had a permanent residence here for over forty-four years and prior to that had a summer home for eighteen years, I have two brothers who live here now, and my husband and I have been permanent residents since 2003. We all have worked very hard to improve our properties and take pride in the fact that this is such a beautiful place to live.

Over my lifetime I have seen the river islands and shores eroded by boat traffic. During the summer months I do not even like sitting on my wharf because of the traffic from those not residing here running recklessly up and down the river. Trying to take a boat ride on Saturdays and Sundays is relegated to late afternoons after the "townies," with boats filled with passengers (some even "camping out" all day anchored in coves), leave and go back to wherever they live.

Even though we have tried to protect our property's shoreline, it is a constant battle and tremendous expense keeping the seawall in tact due to the wave action (in some cases three/four feet wakes) which undulates against our shoreline. Erosion is a tremendous problem and concern for all property owners here.

And now, through this "PLAN," more access is to be granted to our beloved river for **PUBLIC ACESS**...this is absolute **INSANITY**.

I trust you will register this letter of opposition with the proper authorities and will acknowledge receipt of same.

Thank you!

Adele Stuardi Gwatkin

Secretary/Treasurer
D. W. Gwatkin Construction Company, Inc.
251-973-9212 (Office)
251-973-9382 (Fax)
gwatkind@bellsouth.net

F. PUBLIC COMMENTS

Mr. Robinson,

As a property owner on Fowl River, I am most worried about river priorities.

A public boat ramp at the end of Murray Road via the Fowl River Watershed Management Plan would accelerate river damage:

1. Increase in boat traffic
2. Safety – speed/blind corners
3. Erosion – wakes
4. Litter – trash off boats
5. Quality of life – consternation/noise

I cannot stress enough my opposition to the Public Access portion of the draft plan (specifically Section 8.8) as it relates to the East Fowl River (upper) section. This opens the flood gate to the demise of our wonderful river!

I go on record in OPPOSITION to the Public Access portion of this plan.

David W. Gwatkin

President
D. W. Gwatkin Construction Company, Inc.
251-973-9212 (Office)
251-973-9382 (Fax)
gwatkind@bellsouth.net

F. PUBLIC COMMENTS

From:	Don Rowell
To:	James Robinson
Subject:	Comments-Fowl River WMP
Date:	Thursday, February 18, 2016 6:14:12 PM

RE Increasing Public Access: Murray Road. I believe that purchasing a property in this residential neighborhood to convert to a public access boat ramp would be detrimental to the character and safety of the residential neighborhood. Bad idea.
Don Rowell

From:	Candace Eiland
To:	James Robinson
Subject:	Comments-Fowl River WMP
Date:	Thursday, February 18, 2016 8:08:11 PM
Importance:	High

On page 231/232 of the Fowl River WMP it mentions Murray Rd as a possible location for a public boat ramp. I live on Murray Rd and do not want to see a boat ramp at the end of the road. Murray Rd is a one lane dirt road. Two cars cannot pass at the same time. There does not need to be more traffic on this road. It is hard enough at times for the people who live on the road to navigate it without having to wait for oncoming traffic. I can just see vehicles pulling boats coming up and down the road at all hours of the day. The road also gets dusty when it is dry and more traffic is going to create more dust. When it rains, water covers most of the road in two or three places. The County would have to constantly maintain the road if it has more traffic.

Property is very expensive on the river and those of us who has invested in this area do not want to see anything that will hurt our property values. I believe having a public boat ramp on Murray Road would hurt our property value. Most of us moved to the river for the peace and tranquility and don't want more traffic on our road.

I don't believe Fowl River needs anymore boat traffic. Fowl River has enough boats speeding up and down the river causing erosion of the banks and islands in the river. I have lived on the river for over 11 years and most of the islands that were in the river when I moved here are now gone because of boat wakes. Fowl River is a very short river with many sharp curves and more boat traffic would be hazardous. People who don't know the river speed around curves and I've seen many boats hit stumps that are under the water where the islands once were. Many of us who live on the river love to fish and it is already difficult to fish because of the boat traffic.

I have talked with several of my neighbors who were on this committee and all of them say another boat ramp was never mentioned in any of the meetings. They are as upset as I am about this recommendation as I am.

I would love to discuss this with you.

Thaank you.

Kenneth Eiland

F. PUBLIC COMMENTS

From: Tom Wolf
To: James Robinson
Cc: Tom Wolf; gwwolf111@yahoo.com; smbwilbur@comcast.net
Subject: Fowl River Access
Date: Thursday, February 18, 2016 10:01:35 PM

Dear Mr. Robinson,

My name is Thomas Wolf. I live at I am writing you today to submit my comment on the creation of a public access point at the end of Murray road. I am fully against this plan for several reasons. One reason is a traffic concern. Another reason I am opposed to this plan is due to concerns of trash in the river. Last but not least is my opposition of making a very private neighborhood open to the public.

On the traffic issue, I can give you some insight. The small road is not capable of handling any more traffic than there currently is at this point. I go out to work everyday and sometimes have to pull over and wait for neighbors either coming in or going out. It's not a big deal right now, but if you add a line of trucks pulling boat trailers, going in and out, well you get the point. We as a neighborhood do *NOT* want to make this any worse than it already is. Also before you answer back with a proposition of widening the road, in mine and my neighbors opinions, (whom I have discussed this with) we are strictly opposed to this approach as well. It will do nothing for our sense of a small tight-knit neighborhood. We also have small children here and do not want to feel that we can't trust our kids to be outside alone in our own yard for fear of wandering off and into traffic.

In your presentation on this matter it is made clear that there is a need to reduce boat traffic and pollution. If I understand the reasoning behind this plan, it is stated in the report that, it will reduce travel in the river by adding access closer to the destination. Where is the research to back this claim? Those I have discussed this with think that to be totally false. What it *would* do is add more parking, and therefore, more boats that could be in the river at a given time. Just how does it make any sense at all to reduce traffic or pollution by adding access? That's the same as reducing traffic and emissions on the Interstate by adding more on ramps. I do believe there are some good ideas in the Fowl River Watershed Management Plan. I just really do not think this proposed access point is a good idea at all. It will create another point for garbage to be discarded, and be washed into the river. Just look at Dog River for an example of this. At every "access" area there is trash everywhere.

We as a neighborhood want to stay private. We do not want strangers next door at all hours of the day and possibly the night. Please consider those of us who live here and would have to deal with the traffic, trash, and most importantly turning a private neighborhood into a public place! We choose to live here for many reasons. The main one being that we are free to let our children play outside without the fear of whom they will come into contact with. It has the potential to totally disrupt the way we go about our daily lives at our homes. I don't think anyone anywhere would be for something that would make their family less safe.

In closing, we as a neighborhood are totally against this plan and would have spoken out before now if given the chance. No one has made any effort whatsoever to let me or my neighbors know about this plan until just recently. (that I am aware of) Will there be any future meetings on this that I may be able to attend? Please respond to this email so that I know you received it and I am looking forward to having an open and honest dialogue with you in the future.

Thanks,

Tom Wolf

F. PUBLIC COMMENTS

From: Lance Estrada
To: James Robinson
Subject: Comments-Fowl River WMP
Date: Friday, February 19, 2016 6:35:13 AM

Dear Mr. Robinson,

As a resident on fowl river directly across from the proposed new public access boat ramp, I would like to go on record as opposing this section of the plan. The addition of another ramp in the middle of a residential neighborhood would increase boat traffic and compromise safety for the families that live in this area. Such congestion, noise and pollution would only serve to decrease our property values and increase the chances of an accident. Nearly all of the homes near the proposed site have young children which swim in the river and I fear that a public ramp would be dangerous in that location. Thank you for your consideration.

Lance Estrada,

From: paul@mancill.com
To: James Robinson
Cc: sam@cbroker.com
Subject: Fowl River Plan
Date: Friday, February 19, 2016 11:06:50 AM

Mr. Robinson,

My name is Paul Mancill and I grew up on Fowl River on Thomas Road. I now own a vacation home on the river at a private road that pulls off of Pioneer Road. I have some concerns about a public boat launch at the end of Murray Rd. (Section 8.8 of the plan) which would be very close to our property. How would the boat launch be managed? Would there be an attendant and a fee charged to launch?

In general, I am not in favor of this part of the plan. This is a very beautiful, peaceful and well maintained section of the river and I feel that this would make it considerably more noisy and dangerous in the summer months. There is already a lot, and I do mean a lot, of skiing, tubing, jet skis, etc. using this rather wide section of the river. Having this public access would only increase this activity.

I will say that I am supportive of all your conservation efforts on behalf of the wetlands and environment in the plan.

Thank you for your consideration.

Yours Truly,

Paul Mancill

F. PUBLIC COMMENTS

From: Greg Gaudin
To: James Robinson
Subject: Fowl River Watershed Plan
Date: Friday, February 19, 2016 3:10:32 PM

Mr" Robinson,

I am a resident of the Fowl River Community and I would like to add an opposition to "The Plan". After reviewing the plan, I see no reason to place a boat launch at the end of Murray Road. This area is surrounded by A-1 residential properties and see no need for an additional launch on this river! During the summer months, the river is crowded with a few "to many boats" and this would only add to an already heavy boat traffic on a not so easy navigable waterway!

In the plan, it states this river is heavily navigated and by adding another boat launch would add more congestion to this river!

Please register my vote as "NO" to take this boat launch out of Fowl River Watershed "the plan"!

Sincerely,

Greg Gaudin

F. PUBLIC COMMENTS

From: Glinda Lathan
To: James Robinson
Subject: Comments-Fowl River WMP
Date: Saturday, February 20, 2016 8:25:35 PM

Dear James,

We are residents of Fowl River and live on the cove where the public boat ramp is proposed at the end of Murray Road. There are over 25 waterfront homes within close proximity. In general, this is a high density single family residential location. We are opposed to putting a public boat ramp at this location for the following reasons:

1. Homeowner Impact
   - o Significant damage to property values
   - o Increased car and boat traffic creating noise and light pollution
   - o Disrupting wildlife habits and homeowners' enjoyment

2. Environmental Impact

o Additional truck, trailer and boat traffic on Murray Rd and launching at this point in Fowl River can result in further damage to the river. This would be due to land erosion which would increase sediment and nearby marshes could be damaged that are a priority for protection and restoration.

o Increasing the demand on Murray Rd and establishing a parking and boat launch facility will increase run-off of sediment, trash and pollutants such as oil, gas and other chemicals directly into the river.

o The proposed location will launch boats into close proximity to both a submerged island and a peninsula of marsh grass and trees. Navigation through that narrow channel will create further erosion of both the island and peninsula.

o This is a prime location for osprey nesting, pelican and heron fishing as well as recreational fishing. This will all be negatively impacted by increased river traffic due to a public boat launch.

3. Safety

o After launching and exiting the short, narrow channel described above, boaters will quickly enter a pinch point on the river where north and south boat and skier traffic is heavy. This will create hazards to both boaters and skiers.

o It is common for children and adults to swim off the docks of homeowners and the additional boat congestion will be a major threat to the safety of homeowners and their guests.

o The river channel snakes through the cove in a general north to south direction. Introducing traffic from a boat launch will create a choke point where fast and slow boat speeds will be in conflict in an area where visibility is already limited due to the shoreline topography.

We've lived here for over ten years and love Fowl River. We support the Fowl River Watershed Management program. However, we respectively oppose the installation of a public boat ramp at the proposed site at the end of Murray Road.

Thank you for allowing us the opportunity to provide our comments.

Sincerely,
Ted and Glinda Lathan

F. PUBLIC COMMENTS

From:	Johnson, Michael
To:	James Robinson
Subject:	Fowl River Watershed Management Plan Section 8.8
Date:	Sunday, February 21, 2016 7:07:49 AM

Mr. Robinson,

The purpose of this e-mail is to express our opposition to the current draft of Section 8.8 of the Fowl River Watershed Management Plan. As residents of Fowl River for over a decade, we love the area and this beautiful river.

Through your efforts, and the efforts of many others, the "Plan" will help ensure a long term best practices and quality broad view of a small but important river in our state. However, the basis of sandwiching the creation of a public boat ramp in an already existing neighborhood is flawed. Please consider the following points:

- The existing two ramps located at the mouth of the river, Pelican Reef, are underutilized today. The vast majority of home owners on the river have boat lifts adjoining their homes and rarely have the need for trailering their boats (storms or boat maintenance being the exception).
- These existing ramps are in the perfect location, near the mouth of the river with easy access to all three stems of the river as well as Mobile Bay.
- The ecosystem of the river includes a vibrant marsh that is constantly tested by large wakes from boats. IF we keep the new ramp concept out of the Plan, there will be less boat traffic.
- Upriver areas are more fragile and more narrow, not to mention more dangerous for boaters unfamiliar with the depths and navigational hazards.
- A neighborhood launch will devalue surrounding residential properties.
- Today boats are trailered on Dauphin Island Parkway but any boats hauled in a neighborhood is far less safe for residents of the area.

Fowl River is beautiful. The Plan will help insure its existence for future generations of Alabamians, including our lineal descendants. The proposed boat ramp embedded in Section 8.8 is totally counterintuitive to the intentions of the Fowl River Watershed Management Plan. We strongly request that you and the reviewing members have the vision to remove it from the Plan.

Thank you for your consideration,
Mike and Leah Johnson

From: Richard Craig
To: James Robinson
Subject: Fowl River Watershed Plan Feedback
Date: Sunday, February 21, 2016 7:42:38 AM

Good morning, and thanks for the opportunity to share some feedback.

Personal Background: I was born in Mobile, and was first exposed to Fowl River in the 50's. Our family routinely took 2 week vacations on the the river by renting homes. I moved away from Mobile with my career, but never doubted where I would retire. We purchased a home on the river in 2002, and have lived there since then.

Feedback:

Overall plan is excellent from my perspective. A couple of items to consider for emphasis......

1) My favorite fishing islands in the 50's don't exist anymore. And the deterioration is unquestionably boat wakes for those particular islands. I've lost a mature Cypress tree that is up in a small slough (50 ft from the main river) in the last few years. I think it is clear that the most immediate environmental issue is bank erosion due to boat wakes. And I would suggest it is accelerating ! That would suggest a high priority boat traffic plan with no wake in sensitive zones. (I have a boat; and, yes, that would create an inconvenience for many of us) Last night, I could not find the no wake plan that I remember reviewing in Dec. I know there is a significant NIMBY mentality on the river - I would suggest a local river active plan, prior to telling property owners 10 miles away how they should manage there individual properties.

2) The armoring design for river points is by far the best I have seen suggested.

3) Adding boat traffic by increasing public access in the middle of the most sensitive (most sharp bends) area doesn't make sense to me. The added damage up river has got to outweigh any improvements in the large section of the river downstream. (I don't live near the proposed site)

4) Two specific challenges to the data in the plan. This has the effect of undermining the credibility of the report. The sea level "linear" representation needs more work. I can assure you that the mean low tide has not increased 1 foot in the period that I have lived directly on the river, as indicated in the graph included in the report. The estuary needs protection now - regardless of the global warming issue. And I don't see anything in the plan that could manage that significant level of sea rise. Inclusion adds an issue that doesn't really give the plan more weight/emphasis. There is significant distrust of the Marine Fisheries, that clearly is directed by the EPA. The Red Snapper management is seriously weakened by poor data collection/analysis, from which decisions are made. I would suggest you not allow the "connection" that many folks will easily accept.

5) The second data issue is mercury contamination. I have read serious technical assessments that would suggest this is a trait of this particular watershed, with significant natural deterioration of leaves/trees/grasses. The immediate comparison is Big Creek Lake - mercury from air pollution is also deposited in our fresh water supply. I have never read any report suggesting any contamination in BCL. If it's true, then there's an issue that EPA needs to pursue.

6) I would like to participate in the Implementation Team. I have a technical education, with an MBA; and managed several large paper making facilities in the Northeast requiring much attention to environmental concerns/issues. The last facility I managed returned water to the Housatonic river cleaner than the upstream EPA assessment.

Again, thanks for the opportunity......

Richard Craig

F. PUBLIC COMMENTS

From: kanesfowlriver@bellsouth.net
To: James Robinson
Subject: Comments-Fowl River WMP
Date: Sunday, February 21, 2016 12:51:50 PM

These comments apply to the proposed boat launch at the end of Murray Road. My family has owned property on the river for 87 years. I have been fortunate enough to use the river for recreation and fishing for the past 78 years. During this period of time the river has undergone many changes with the majority of the changes occurring after Hurricane Camille. Since 1969 we have had numerous hurricanes. Boats have changed from 25 hp motors on 16-ft boats to 300 hp motors on 30-ft boats. While I am a fulltime resident of the river I do not live in the immediate neighborhood of Murray Road.

I am against the boat ramp for the following reasons: 1) Murray Road serves a residential area in which there are no commercial enterprises; 2) There are a number of private homes whose residents use Murray Road for ingress and egress to their property. Murray Road would have to undergo extensive renovation (widening, paving, drainage, etc.) which would present disruption to the neighborhood; 3) There would have to be a large parking area to accommodate vehicles and trailers which would increase the runoff into the river due to the decrease of foliage in the area; 4) The neighborhood would be disrupted with early morning and late afternoon traffic to and from the launch area; 5) The launch would be far removed from River Road and due to the isolation of the area this area could easily turn into a convenient spot for unlawful activities such as drug use, drug sales, consumption of alcohol by minors, etc.

I can think of no positive advantages to the river and the Fowl River community for having a boat ramp at the end of Murray Road. We must remember that Fowl River is a relatively small river and the boat traffic during the summer is heavy now. The proposed ramp would only increase the traffic resulting in more potential damage to the pristine nature of the river.

Sincerely,

Jack Kane

F. PUBLIC COMMENTS

From:	David Wittendorfer
To:	James Robinson
Subject:	Comments-Fowl River WMP
Date:	Sunday, February 21, 2016 1:49:04 PM

Dear Mr. Robinson,

I grew up boating, swimming and fishing on Fowl River. Ten years ago I was fortunate enough to build and now live year round on Fowl River. I'm sure I am not telling you anything new when I say boat traffic caused most of the damages to the shore lines of the river. So what I don't understand is why the county feels it is necessary to add another access point to an already over crowded river, especially with two access point already available? Anyone wishing to use Fowl River, whether living on the river or not can easily do so with the existing public boat ramps.

Sincerely,

David W. Wittendorfer

From:	Michael Fosdick
To:	James Robinson
Cc:	Renee Fosdick
Subject:	Fowl River WMP Comments
Date:	Sunday, February 21, 2016 2:07:24 PM

I have been a property owner and resident of Fowl River for 14 years and previously my parents owned and lived on Fowl River from the lated 1960's to the late 1980's. I have seen a continuous increase in full time residences and activity on Fowl River. I have read parts of the Fowl River WMP and I was most concerned about the section under Public Access.

In this document, it indicates an initiative to increase public access by purchasing properties and converting them to a public boat ramp. I am totally opposed to this action.

As a resident of Fowl River, especially near the proposed new public boat ramp in Figure 8.12, I do not see the need for additonal public access. The current access at Memories and The Pelican Reef serves the public very well. The public does not appear to be hindered as seen by the number of boats and activity on the river on any given day in the warm season especially on the weekend. The capacity of the river to accept more boaters during these times is extremely limited and already gives concern over safe boat operations. On any given weekend in the summer, there will be multiple boats anchored in the area of the proposed ramp near Murray road. This potential new access would only make the area more crowded and dangerous. A public access would in these areas would be un-supervised and would significantly increase the potential for pollution and runoff into the river, create an safety and security issues of the near by residences, and definitely reduce the property values of all owners on Fowl River. The beauty of living on Fowl River is the access to the river and its cleanliness and wildlife. The life of Fowl River ecosystem would be negatively impacted by these new access points on the River.

Thank you for accepting these comments.

Michael R. Fosdick

F. PUBLIC COMMENTS

From: Ray Mayhall [mailto:rmayhall01@bellsouth.net]
Sent: Thursday, February 18, 2016 8:44 AM
Subject: Fowl River Watershed Management Plan

Over the last twelve months there has been a tremendous amount of work being done creating the Fowl River Watershed Management Plan. This plan was done by environmental consultants hired by the Mobile Bay National Esturaries. The plan was completed with scientific methodology and input of a citizens steering committee. The draft plan is now complete and in online for public viewing and comments. It can be viewed and commented on the website www.fowlriverforever.com . There are instructions at that site for submitting comments. I would like to call your attention to on part of the plan that I believe is flawed and should not be implemented. It deals with the "Public Access" section (section 8.8, page 231).

The recommendation is to place a public access boat ramp at the end of Murray Road. This recommendation is wrong for a number of reasons. The location proposed is in the middle of a single family residential area. Placing public access ramps in residential neighborhoods is an extremely poor idea as it will increase vehicular traffic, compromise safety, and decrease property values. Additionally, placing a ramp at the end of a dirt road will greatly increase water erosion and runoff directly into the river. We should never do anything that takes away from the pristine waters of our river.

Please consider sending comments in opposition to this section of the plan. Time is short; the comment period ends this Sunday, February 22.

Thank you for your action in this matter.

Ray

F. PUBLIC COMMENTS

From: "Sam St. John" <sam@logicalus.com>
Date: February 21, 2016 at 11:48:10 AM CST
To: Lee Walters <lee.walters@gmcnetwork.com>
Cc: Roberta Swann <rswann@mobilebaynep.com>
Subject: RE: Fowl River Watershed Management Plan

The public reacts quickly and are dedicated to preserving private property, safety, Fowl River and their use of it.
Another issue is going to be the new priority project made up by the watershed engineering team at Bellingrath Gardens that will take priority over all other projects that have been under priority consideration for 8 years.
This will also be a huge issue for public access as this is the primary spot for most visitors to dock their boats to swim, rope swing, eat, drink, ski, tube, etc. from the beautiful sandy beach.(Technically maybe owned by State Lands?)
In addition this is the highest wake area in the River as virtually all boats, large and small pass this point. Visiting boats and visiting water skiers use the area from the bridge to Tapia point. After that is it more dangerous so they turn around. The length of this course is just long enough for a good ski circuit. The width of the River in this area supports the many boats participating.
The plan calls for a new marsh to be created there covering the beach and with no rip rap. It will likely fail almost immediately due to boat wakes. Trying to make it no wake will cause even more outrage as this is what they come to the River to do.
There are far more serious priority projects that will save the same amount of marsh in the same ecological value area. The marsh at Bellingrath also appears to be very healthy per recent aerial photographs on February 20, 2016 as compared to the other priority areas.
I would be happy to work with your team to revisit this situation quickly before residents and visitors learn of this.
Thanks,
Sam

F. PUBLIC COMMENTS

From: stephen wilber
To: James Robinson
Subject: opposition to public access on Murray Road
Date: Sunday, February 21, 2016 5:29:25 PM

Dear Mr. Robinson,

I am a resident of Fowl River, and I am deeply opposed to the suggestion in the draft of the Watershed Management Plan to place a public access at the end of Murray Road. My home is located at The proposed boat launch is in a single-family residential area. The launch itself as proposed on Murray Road would be directly adjacent to 3 family dwellings. The cove in which we live has at least 12-15 single family dwellings that would be directly impacted by the added boat traffic a launch would create. This has always been a quiet, private and safe area for fishermen, swimmers and residents to enjoy the river. To place a launch here will certainly adversely affect our quiet neighborhood and its residents.

As you know, Murray Road is a single lane dirt road. When traversing the road, it is necessary to pull over to the side and allow other neighbors to pass. There is not sufficient room for two cars to pass at once. The addition of public traffic, especially those towing boat trailers, is sure to cause extensive damage to the road and lead to increased traffic issues for my neighbors and me.
One of the main reasons we purchased a home on Murray Road was that it is part of a quiet cove inhabited by good people who share our love for the river and surrounding area. There are many young children being raised in this neighborhood. This area provides a safe place for my own four children to swim, kayak, fish and play. This is where our kids have the freedom to enjoy the water and play outdoors without concern of strangers. We certainly already get our share of boat traffic and water skiers during the busy months and holidays. To turn Murray Road into a public access area would change everything here for the worse and cause us to be constantly concerned about strangers and the safety of children in the neighborhood.

The environmental impact of establishing a public access in our area would lead to numerous environmental problems. A boat launch would lead to erosion in our area, a constant concern along Fowl River. There have been extensive measures placed for combating existing erosion of surrounding wetlands. It seems senseless to increase erosion with increased boat traffic and the addition of a ramp in a residential area. It would also lead to pollution of the cove as the public would potentially use it as a trash dumping ground, a common problem in public access areas along the water.

Fowl River Marina already offers an underutilized public access launch. This launch is very affordable for the public with far less environmental impact. The marina access is already existing and provides better access to the river and Mobile Bay. Further, the marina has ample parking for vehicles and trailers, which does not exist at the Murray Road location.

Additionally, I ask that you please be considerate of the residents of the area, this is NOT like placing a boat launch in an area surrounded by commercial property or an uninhabited spit of land. These are our homes.

Steve and Monica Wilber

From: John B Howell
To: James Robinson
Subject: comments fowl river wmp
Date: Sunday, February 21, 2016 6:51:16 PM

I am a resident of Fowl River, and I am opposed to the proposal contained in the draft of the Watershed Management Plan to place a public access at the end of Murray Road. My home is located at but more importantly located on a bay that would be affected by the proposed boat launch at the end of Murray Road. The launch would be in a single-family residential area. The cove itself has at least 12-15 single family dwellings that would be directly impacted by the boat traffic. To place a launch here will certainly adversely affect our quiet neighborhood and its residents.

The current roadway infrastructure is not designed to handle 2 way traffic, much less parking and trash removal that would be necessary with a public access road.

I bought this particular property second to the low boating traffic as we have a very large group that enjoys swimming, already during the weekends with the current topography of the shallows we have had multiple "visitors" to Fowl river come very close to the Dock and closer than boating laws allow to the swimmers.

We have already do not have the marine police support that we once did as the current officer is stretched between Dog River and Fowl River, I do not expect they will be able to increase their presence in our area enough to keep out the more unsavory boaters this will bring into this bay.

Please place my letter in the record as opposing the portion of the proposal that suggests a public access on Murray Road.

Dr. John B. Howell.

F. PUBLIC COMMENTS

From: AE Stuardi
To: James Robinson
Subject: FW: Fowl River Waste MNAGEMENT PLAN
Date: Monday, February 22, 2016 10:03:58 AM

-----Original Message-----
From: AE Stuardi [mailto:stumu@bellsouth.net]
Sent: Monday, February 22, 2016 9:55 AM
To: 'James.Robinson@gmlnetwork.com'
Subject: Fowl River Waste MNAGEMENT PLAN

Mr. Robinson:

I strongly oppose the section of the Fowl River Waste Management Plan that proposes to put a public access boat ramp at the end of Murray Road.:(public access Section 8.8, page 231) Allowing the public access and use of an area in a single family residence quiet neighborhood is a very bad idea.

Ed Stuardi

From: Sam St. John [mailto:sam@logicalus.com]
Sent: Sunday, February 21, 2016 12:33 PM
To: Roberta Swann <rswann@mobilebaynep.com>
Cc: Lee Walters <lee.walters@gmcnetwork.com>
Subject: Fowl River Public Access

Roberta,
Everyone who has contacted me about the Public access section of the FRWMP believes there is more than sufficient Public boat launch access to Fowl River now. The existing launches are rarely busy. I don't know about free kayak launch but we could likely convince Memories and Pelican Reef to offer it. We could certainly add litter receptacles and signage at those sites. I have identified great locations for Public Access on both ends of the Fowl River bridge and have mentioned them to the County before. They are perfect for launching Kayaks and for fishing.
I think parking would be easy since trailers are not necessary for Kayaks.
The Mon Louis point site could be great for public access if Bay Haas would sell it.
Also the Steiner site across the River was a public marina in the past and would be an excellent public boat launch, kayak launch and fishing site!
Thanks,
Sam

F. PUBLIC COMMENTS

From: Sam St. John [mailto:sam@logicalus.com]
Sent: Sunday, February 21, 2016 12:36 PM
To: Roberta Swann <rswann@mobilebaynep.com>
Cc: Lee Walters <lee.walters@gmcnetwork.com>
Subject: Public site 2

This site is at the South end of Fowl River Bridge. The Public already uses it for fishing. The State owns the right of way and the property has been for sale on both sides.

From: Sam St. John [mailto:sam@logicalus.com]
Sent: Sunday, February 21, 2016 12:38 PM
To: Roberta Swann <rswann@mobilebaynep.com>
Cc: Lee Walters <lee.walters@gmcnetwork.com>
Subject: Public access 3

This is the Steiner property. He was working with BT Roberts to make this a private marina but now I see the Roberts property is up for sale.

:sam@logicalus.com]
Sent: Sunday, February 21, 2016 12:43 PM
To: Roberta Swann <rswann@mobilebaynep.com>
Cc: Lee Walters <lee.walters@gmcnetwork.com>
Subject: Public Access 4

Mon Louis Point is currently a defunct marina. It would also work as a public marina, kayak launch and great fishing spot. Already a commercial property.

West Fowl at Delta Port is now a Public Launch and is a highly productive fishery utilized heavily by the public using boats and Kayaks.
The “cut” between East and West Fowl is ultra narrow and not useful for fishing or more than minimum boat traffic.

From: Ray Mayhall
To: James Robinson
Cc: "Glen Coffee"
Subject: FW:
Date: Friday, February 26, 2016 10:50:27 PM

James I wanted to be sure that you had this information as comments on the "public access" portion on the Fowl River Watershed draft.

From: Glen Coffee [mailto:coffeegl@aol.com]
Sent: Thursday, February 25, 2016 2:54 PM
To: rmayhall01@bellsouth.net
Subject: Fwd:

Ray:

This is to follow-up my below message to make sure you got it.

Glen Coffee
251/873-4404
251/873-4404 fax
251/599-6925 cell

-----Original Message-----
From: Glen Coffee <coffeegl@aol.com>
To: rmayhall01 <rmayhall01@bellsouth.net>
Sent: Mon, Feb 22, 2016 8:11 am
Subject: Fwd:

Ray:

This is to follow-up our discussion at last Thursday's community meeting about the status of the launching ramp at the former Delta Port Marina site. It took me a little bit of time to get the information that I needed because I had to search four areas to confirm the State of Alabama now owns the site and that it will be maintained as a public access area.

> First, I went to the Department of Conservation and Natural Resoures website to confirm the site exists. However, the site did not clearly indicate it was owned by the State: http://www.outdooralabama.com/delta-port-marina
>
> Second, I accessed the Mobile County Department of Review's property ownership records. They have not yet updated their records which still indicate the site is owned by M&R Properties.
>
> Third, I talked with some commercial fishermen who are now launching their net boats from the old marina ramp.
>
> Fourth, I finally contacted the former owner of the property who now lives on the West Coast. Below is his e-mail response.

So it is clear, the overall Fowl River system now has at least three access points that are reasonably scattered as to provide easy access to all of its water areas. I would wager, the present three access points are strategically better located within the Fowl River system than in any other watershed surrounding Mobile Bay.

F. PUBLIC COMMENTS

From:	Dwain Mangold
To:	James Robinson
Subject:	Re: Fowl River Watershed Management Draft Plan Comments February 2016
Date:	Saturday, February 27, 2016 7:10:00 AM

Fowl River Watershed Management Plan Draft Comments– February 2016

Environmental Impact on River

1. **Murray Road Storm Water Runoff**

   Murray Road is currently a single lane shell road bordered by dense vegetation which limits the negative effect of storm water runoff into Fowl River. In order to accommodate vehicles with boats, the road would have to be widened, paved, and rain water runoff ditches installed which would significantly increase the flow of runoff into the river. Murray Road slopes to the river from River Road. Currently, even though the lots bordering Murray Road are all residential, only 8 families are current residents which limits any litter winding up in the river. Certainly, widening Murray Road and allowing public access to a boat ramp will significantly increase trash in the river. We would likely have another Dog River type problem. The two existing boat ramps available to the public (Memories and The Pelican Reef) are privately owned businesses that provide site clean up at no cost to taxpayers.

2. **Boat Traffic Pattern**

   I am retired and have been living on Fowl Rive for 10 years. I spend a significant amount of time on my dock and boating on the river. I have observed the boat traffic patterns related to the Memories and Pelican Reef launch sites. The proposed boat ramp on Murray Road is approximately equidistant from the mouth of Fowl River to the springs that feed the river.

   Memories: A majority of the boats launched from Memories are fresh water bass, bream, and crappie fishermen and they mostly stay inside the no wake zone or just outside of it since this is the part of the river where the abundance of fresh water species fish reside. Fresh water fishermen boats launched from the proposed site on Murray Road will significantly increase boat traffic from the launch to the no wake zone (a environmentally delicate part of Fowl River). A lot of the fresh water fishermen drive high powered bass boats.

   Pelican Reef Launch Site: Many of the boats launched at the Pelican are fishermen/boaters who go directly into Mobile Bay. If these boats launch from the proposed Murray Road site. It will increase boat traffic from the Murray Road site to Mobile Bay.

3. **Current Launch Sites Negative Business Impact**

   The current launch sites at The Pelican and Memories are small business owners who have been serving the public with launching and other ancillary services for the public to enjoy Fowl River access for years. Their launch fee is minimal. They provide launch maintenance, site clean up and disposal containers, security, lighting, and parking area maintenance at no cost to taxpayers. They currently have adequate facilities to serve the public who wish to have access to Fowl River.

4. **Murray Road Launch Site River Access Logistical Issue**

   The proposed launch site is on a bay which contains two large sunken islands which are not visible. The water on these two islands varies from 1 to 4 feet during low tide. These islands provide a wake barrier for this part of the river and are a safety issue if the boater is not aware of their location. Removing these islands would be detrimental to the river ecology and marking them with danger bouys would be a situation which would have to be constantly monitored and maintained, at taxpayer cost, to provide adequate public safety.

5. **On Going Maintenance Cost of Public Launch Access**

   I believe the Watershed Plan should include the details of the maintenance plan and on going taxpayer cost of the access road, launch site, and river ecology stability.

   Dwain Mangold

From: David Ray
To: James Robinson
Subject: Fowl River Watershed management Fowl River Watershed Plan drafted February 2016
Date: Tuesday, March 01, 2016 7:46:39 AM

To:
james.robinson@gmcnetwork.com
Re: Fowl River Watershed management
Plan drafted February 2016

My name is David Bradley and my wife Linda & I live at Theodore Al. I have been made aware of a proposed boat launch development up for consideration. As a former real estate broker, I have always been pro development if it makes sense. This project would negatively impact the owners on this road , some who for generations have enjoyed the privacy and security that this location has provided for them and their children over a long period of time. Fowl River already has multiple launches that visitors can access our beautiful river with. This development would forever change the quiet lifestyle the residents here have become accustomed to.

I'm sure there are other alternatives if you feel another launch is needed that would not impact homeowners so badly. We would strongly and respectfully ask that you deny this application for the reasons stated.

David & Linda Bradley

F. PUBLIC COMMENTS

From: Judy Haner <jhaner@TNC.ORG>
Date: March 1, 2016 at 7:49:53 AM CST
To: "lee.walters@gmcnetwork.com" <lee.walters@gmcnetwork.com>
Subject: Fowl River Plan page 218

Hey Lee,
I was flipping through the Fowl River plan and noticed that the landowner cost-share program is mentioned on page 218. It's not a program yet. We have a couple of more things that need to be vetted. What you mentioned is the ideal and we'd actually like to have the municipalities themselves run it. Coastal Resilience is the tool we would use to help them review applications, but the layers aren't full done or in the correct level of detail yet. Of course, we'd love for Fowl River to be the test site for the program once we have the framework set.

The partners mentioned were part of a proposal we put in to finish developing the framework and they might not want to be mentioned as part of a yet to be finalized program. Can we revise that to reflect it as a potential program?
Thanks!!
Judy

Judy Haner
Marine and Freshwater Programs Director

jhaner@tnc.org
(251) 433-1150 Ext. 103
(251) 281-4022 (Mobile)
(251) 433-1160 (Fax)

The Nature Conservancy
Alabama Coastal Program Office
56 St. Joseph Street
Suite 704
Mobile, AL 36602

The Nature Conservancy
Protecting nature. Preserving life.™

nature.org

F. PUBLIC COMMENTS

From:	Nicholas, Joyce - NRCS, Mobile, AL
To:	Lee Walters; rswann@mobilebaynep.com; James Robinson
Cc:	Ramsey, Charles - NRCS, Grove Hill, AL; glenn.nicholas@gmail.com; Craig Hall (craig.hall@mudbrickmedia.com); BKeller10@aol.com
Subject:	Fowl River Watershed boundaries: Please see the official map 12 HUC code map compared to Goodwyn/Mills/Caywood map.
Date:	Wednesday, March 02, 2016 11:19:10 AM
Attachments:	FowlRiver_HUC12_0302_2016.pdf response to Fowl River.docx Draft-Fowl River WMP _ high res version-G-M-K.pdf

Hey Lee, Roberta and Jamie,

While reviewing the document, I made a few observations: See the word document attached.

While looking at the many maps in the plan, I keep seeing a difference of your maps and the maps that NRCS has on file as official watershed boundary maps:

- I recommend that an official Watershed Boundary map be placed in this document.

According to the maps NRCS has on record, for watershed boundaries, the map in the document appears to have omitted a portion of the "official watershed boundary."

Is the omitted site accounted for in this plan? It appears to be industry sites.

Please review my findings.

Thank you, I look forward to getting conservation practices on the ground in all of our watersheds in Mobile County.

Thank you,

Joyce Nicholas
District Conservationist
Mobile Field Office
1070 Schillingner Rd N
Mobile, Al 36608
Joyce.nicholas@al.usda.gov
251-441-6505 ext 102
251-331-1155-cell

F. PUBLIC COMMENTS

NRCS Comments - Joyce Nicholas

James,

Hope you are well. We each have our unique perspective: mine is just that and does not necessarily speak for the whole farming community. I have a brief list of points I believe deserve attention:

1. The Soil Conservation Service is no longer a valid entity so; please replace that with the Natural Resources Conservation Service.

2. The Mobile County Soil & Water Conservation District should be listed and/or added as an entity that is willing to work towards improving private lands, through wise use of natural resources.

3. The large number of sites you listed for NRCS and NFWF to pay for entirely.
    a. Other agencies to consider for funding opportunities:
        - USFWS
        - Forever Wild—State of Alabama
        - Alabama Coastal Nonpoint Pollution Control Program Mobile Branch –Coastal Programs Field Operation Division, Alabama Department of Environmental Management
        - ADEM-319
        - Mobile County Soil & Water Conservation District—Mobile County-habitat Improvement Program—NFWF funded 2016/2017

4. By USDA-NRCS compliance rules, the farm sites are not in violation of any rule or regulation and are legal farming operations. Should that statement be documented in the plan?

I agree wholeheartedly that there is room for conservation improvements. However, Jamie, at first glance, it seems to me that you all are picking on the farmers in this management plan.

- Was much stated about degraded sites where industry has been allowed to build or did I miss that?

- Where are the industry photos pointed out, the wetlands they have impacted and any restoration plans to the sites demolished by those?

- Seems like parking lots and industry runoff would have a negative impact, such as, vehicle oil and gas leaks.

- Will there be a big push to have outreach for the sub-divisions where the runoff is higher or as high from the farmers?

- Collectively all of the development and industry that is located in the watershed has had a more negative impact then the actions of our farmers.

I look forward to working to improve the land and our natural resources in this watershed as well as all others in Mobile County.

F. PUBLIC COMMENTS

From: Christian Miller
To: Lee Walters
Cc: James Robinson
Subject: Fowl River WMP Coments
Date: Friday, March 04, 2016 2:34:07 PM

Lee/James,

I've really only got a couple comments to throw onto the heap. I've read through the copy that Roberta marked up and the only big things I'd add to hers are the following:

1. We need to include the Clean Marina Program in Section 8/Implementation. I'll be happy to provide the content. I (and LaDon) want to make sure we get the Clean Marina Program included on all of the watershed plans that have marinas (or potential to have marinas) in order to open up the possibility of additional funding opportunities for implementation and getting more marinas into the program. Marinas have a big impact on water quality in a lot of our coastal watersheds, and I think that's important to note.

2. I think we need a bit more detail on the volunteer monitoring/AWW. There's a brief mention of it on pg 233, under the initial implementation measures, but I think we should include a bit more of a treatment. probably under the Education/Outreach program (8.5). I also would like to see a map included of key locations for volunteer WQ monitoring efforts (or maybe the development of this map being a recommendation in the plan under the initial implementation section).

Best regards,

Christian L. Miller
NPS Outreach Specialist
Auburn University Marine Extension & Research Center
118 N. Royal St. Suite 800
Mobile, AL 36602

Office 1: (251) 438-5690
Office 2: (251) 431-6409
Fax: (251) 438-5670

Creating a Clean Water Future!

Mississippi-Alabama Sea Grant Consortium
Mobile Bay National Estuary Program
Alabama Clean Water Partnership

F. PUBLIC COMMENTS

From:	Christian Miller
To:	Lee Walters
Cc:	James Robinson
Subject:	Fw: Fowl River WMP comment period extended
Date:	Friday, March 04, 2016 4:23:25 PM

See below, comments from Patric Harper

From: Harper, Patric <patric_harper@fws.gov>
Sent: Friday, March 4, 2016 4:14 PM
To: Christian Miller
Subject: Re: Fowl River WMP comment period extended

I really like this Plan and only have a couple comments.

1) Section 4.5.1, p. 138. I seriously question these species numbers just for this one watershed. Can they be verified? (I have a feeling those numbers may be for the entire NEP study area?)

2) Sections 4.5.3 and 8.6, pp. 141 and 230 (resp.) Are we sure this species has been proven to be the invasive form and not the Gulf Coast type? Did anyone do the DNA? I agree that it's not always the best species to have around but there are worse things - maybe it should be referred to as a nuisance instead? Or a "less-preferred" species that we'd replace with a more favorable one?

Sorry to be picky

Patric Harper
Northern Gulf Coastal Program Coordinator
AL Restoration Biologist - Gulf Restoration Program
US Fish and Wildlife Service
Grand Bay Coastal Resources Center
6005 Bayou Heron Road
Moss Point, MS 39562
228-475-0765 x 105 office
251-424-0716 work cell
228-475-1834 fax

F. PUBLIC COMMENTS

From:	Jason Kudulis
To:	James Robinson
Cc:	Casi Callaway
Subject:	Mobile Baykeeper Draft Fowl River WMP Comments
Date:	Friday, March 04, 2016 4:50:29 PM
Attachments:	DraftFowlRiverWMPcommentsMobileBaykeeper2016-3-2.pdf

Mr. Robinson,

Please find the attached comments from Mobile Baykeeper regarding the Draft Fowl River WMP.

Please confirm receipt of these comments.

Thank you,

--
Jason Kudulis
Program Director
Mobile Baykeeper
450-C Government Street
Mobile, Alabama 36602
Phone 251-433-4229
Cell 251-583-5789
Fax 251-432-8197
jkudulis@mobilebaykeeper.org

"Clean Water, Clean Air, Healthy Communities"

F. PUBLIC COMMENTS

Providing citizens a means to protect the beauty, health and heritage of the Mobile Bay Watershed, Alabama's waterways and coastal communities.

MOBILE BAYKEEPER®

450-C Government Street
Mobile, Alabama 36602
(251) 433-4229
Fax: (251) 432-8197
Website: www.mobilebaykeeper.org
Email: info@mobilebaykeeper.org

March 3, 2016

Re: Draft Fowl River Watershed Management Plan

Sent via email to james.robinson@gmcnetwork.com

To Whom It May Concern:

We are Mobile Baykeeper, a nineteen-year-old nonprofit organization with the mission of providing citizens a means to protect the beauty, health and heritage of the Mobile Bay Watershed, Alabama's waterways and coastal communities. We are submitting comments on behalf of our board, officers, staff and more than 4,000 members regarding the Draft Fowl River Watershed Management Plan (WMP).

Mobile Baykeeper would like to express our appreciation to the Mobile Bay National Estuary Program, Goodwin, Mills and Cawood and all partners, volunteers and supporters involved whose efforts have created this draft Fowl River WMP. After a thorough review of the document we wish to provide the following comments.

- The satellite imagery used in Figure 4.3 does not allow one to pinpoint sampling locations and has no markers or major roads for reference. In addition, the labeling used to identify station names is too small to accurately differentiate.
- Section 4.7 is referenced in Section 5.1 and 5.3, however no such section can be found in the document.
- Figure 5.7 depicting "priority wetland preservation areas" is too small for helpful viewing. Perhaps a narrative paragraph or table could be included listing the areas in addition to a larger image.
- Include some explanation why the eighteen priority sample collection locations were identified in Table 10.1. Also, provide the exact location of the sampling sites in Section 10 or the Appendices for plan recommended monitoring programs.
- More emphasis could be placed on the coastal assessment survey (Section 10.2.13) in order to track the health of estuarine shorelines, in particular to track the success or failure of the recommended high priority projects in Section 8.2.1 after implementation.
- The language in Section 10.2.13 stating the lower estuarine shorelines depicted in Figure 4.2 are considered "healthy and show little to no signs of habitat loss" reads contradictory to Section 5.3 and Section 8.2.2, which identifies habitat loss as a critical issue, specifically "along the lower reaches of Fowl River as a result of erosion caused by high flow events, boat wakes, and sea level rise." In addition, Section 8.2 priorities place coastal zone projects (Section 8.2.1) very high to address locations for stabilization and marsh enhancements further adding to the confusion of the language in Section 10.2.13.

Thank you in advance for your consideration of these comments. Please feel free to contact us with any questions at (251)-433-4229.

Sincerely,

Casi Callaway
Executive Director
Mobile Baykeeper

Jason Kudulis
Program Director
Mobile Baykeeper

F. PUBLIC COMMENTS

From: David Ray
To: James Robinson
Subject: Scan Mar 1, 2016, 7.48 AM
Date: Tuesday, March 01, 2016 7:49:44 AM
Attachments: Scan Mar 1, 2016, 7.48 AM.pdf
ATT00001.txt

Comments on Proposed Public Access Facility on Murray Road – Fowl River. in regard to Fowl River Watershed Management Plan Draft - February 2016

I live on Murray Road and I am against this Proposal.

Kathryn E. Shourt

Comments from Sam St. John (March 3, 2016)

1. Page 126: We state bacteria and relate that back to human/potential failing septic tanks. Our source tracking showed no human bacteria. We should likely remove this statement.

2. General question (no edits needed but he is just curious) Report mentions cadmium and copper levels at Rebel Road. Where was this data from and can we show the location where this was sampled?

3. There is a photo on Exec. Summary cover page (and may be elsewhere in the document). Photo credit to Sam St. John

4. Sam (and NEP agrees) it would be nice to have a simple table that shows EPA water quality standards on one side and Fowl River data on the other side. This will likely be an easy way to show the overall high quality of Fowl River.

5. Sam (and NEP agrees) that our Implementation section is more of a list rather than a ranking. We seem to lose which ones are priorities. We could clean this up in a concise manner that pulls out which of the initiatives will be our immediate focus. Of the general categories: Sam ranked them this way in level of importance 1)signage 2) Litter (trash pickup/dumpsters) 3) Education and outreach.

F. PUBLIC COMMENTS

From: JOEY & RHONDA SEARCY [mailto:rhondasearcy@bellsouth.net]
Sent: Saturday, March 12, 2016 8:55 AM
To: Lee Walters <lee.walters@gmcnetwork.com>
Subject: Re: Extension: Fowl River Comment Period

Hello I apologize for a late comment, but here it goes...On Bellingrath south of Half Mile, we've sadly been watching Industrial property increasing getting closer to the Cold Creek area, it's alarming to think what magnitude of damage it can cause our rivers, if this continues. I pray an ordinance can be placed on what type of industry can be placed so close to waterways, if nothing can be done with the existing grandfather and monitor closely. Thanks for your time reading my rant and have a great day. Rhonda