Revised

Total Maximum Daily Load

Evaluation

for

Brunswick Harbor

in the

Satilla River Basin

for

Dissolved Oxygen

Submitted to:
The U.S. Environmental Protection Agency
Region 4
Atlanta, Georgia

Submitted by:
The Georgia Department of Natural Resources
Environmental Protection Division
Atlanta, Georgia

August 2019

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EXECUTIVE SUMMARY

The State of Georgia assesses its water bodies for compliance with water quality standards established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into one of three categories, supporting designated use, not supporting designated use or assessment pending, depending on water quality assessment results. These waterbodies are found on Georgia's 2018 305(b) list as required by that section of the CWA that defines the assessment process, and are published in *Water Quality in Georgia 2016-2017*(GA EPD, 2018). This document is available on the Georgia Environmental Protection Division (GA EPD) website.

The subset of the water bodies that do not meet designated uses on the 305(b) list are also assigned to Georgia's 303(d) list, named after that section of the CWA. Although the 305(b) and 303(d) lists are two distinct requirements under the CWA, Georgia reports both lists in one combined format called the Integrated 305(b)/303(d) List, which is found in Appendix A of *Water Quality in Georgia 2016-2017* (GA EPD, 2018). Water bodies on the 303(d) list are denoted as Category 5, and are required to have a Total Maximum Daily Load (TMDL) evaluation for the water quality constituent(s) in violation of the water quality standard.

Water bodies denoted as Category 4a have had a TMDL developed to address pollutants in violation of water quality standards, and the TMDL has been and approved by the U.S. Environmental Protection Agency (USEPA). Water bodies denoted as Category 1 have water quality data that indicate their designated use(s) are being met. Category 1 water bodies may have had TMDLs developed for specific pollutants in the past, but are now supporting their designated uses.

A TMDL is the sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, as well as natural background (40 CFR 130.2) for a given waterbody. The TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body.

In 2001, the U.S. Environmental Protection Agency (USEPA) developed the Brunswick Harbor Dissolved Oxygen (DO) TMDL (2001 USEPA DO TMDL) based on the 2000 303(d) listing of the Brunswick River (11 square miles) and St. Simons Sound (66 square miles) for violations of the numeric DO criteria. The 2001 USEPA DO TMDL established a natural background load allocation (LA) for the Brunswick Harbor system, determined the total allowable from anthropogenic discharges or wasteload allocations (WLA) of ultimate biochemical oxygen demanding material (BODU) for permitted wastewater dischargers, and detailed an oxygen addition requirement for the Brunswick Cellulose Pulp and Paper Facility. The 2001 USEPA DO TMDL did not specify the components of overall BODU attributed to carbonaceous biochemical oxygen demand (CBOD) and nitrogenous biochemical oxygen demand (NBOD). An implicit margin of safety (MOS) was assumed in the TMDL due to conservative modeling practices.

For all waters in the Georgia, the *State of Georgia's Rules and Regulations for Water Quality Control* define water use classifications, general and specific water quality criteria, and other rules relating to water quality enhancement. All waters within the Brunswick Harbor have the water use classification of Fishing. On the 2018 Integrated 305(b)/303(d) List, 19 miles of the Turtle River System, including the Turtle River, Buffalo River and South Brunswick River is assessed as Category 4a for DO, polychlorinated biphenyl (PCB) contamination in fish tissue, and mercury (TWR) contamination in fish tissue. 5 miles of the Brunswick River from the South

Brunswick River to St Simons Sound is assessed as Category 5 for Selenium. A 10 square mile segment of St Simons Sound is listed as assessment pending or Category 3, for arsenic. Arsenic has been found in the tissue of some fish collected from this waterbody. It is currently unknown what fraction of the arsenic in fish tissue is in the more toxic inorganic form. In order to be conservative and protective of human health, fish consumption guidelines have been issued for this water. However, until a study has been completed to determine what fraction of the arsenic is in the inorganic form, the water will remain in Category 3 for 305b/303d purposes. The St. Simons Sound is no longer impaired for dissolved oxygen.

In 2017, Brunswick Cellulose LLC requested that GA EPD allow them to conduct water quality modeling to assess alternative wastewater discharge schedules that might reduce the visibility of its colored effluent in the Brunswick Estuary. Brunswick Cellulose currently discharges its wastewater three hours before and three hours after high tide. HDR Inc., performed nearfield modeling of the discharge, which indicated if Brunswick Cellulose avoided discharging during slack high tide (one hour before and one hour after high tide) while increasing the discharge flow for the remaining four hours, then the surface color would be reduced.

Before GA EPD would approve the proposed change in the wastewater release schedule, they requested additional water quality modeling be performed to evaluate whether the change in the wastewater release schedule would require a modification of the Mill's 5-day biochemical oxygen demand (BOD_5) permit limits and possibly Brunswick Cellulose's supplemental oxygen addition requirements for the March-November period. An updated hydrodynamic/water quality model was developed by HDR to evaluate possible modifications to Brunswick Cellulose's wastewater permit using a time variable effluent approach. The model was used to compute natural background dissolved oxygen (DO) levels for the purpose of determining the allowable delta DO (DO decrease) due to all the point source discharges to the Brunswick Estuary and to revised the 2001 Brunswick Harbor DO TMDL.

An important part of the TMDL analysis is the identification of potential source categories. Sources are broadly classified as either point or nonpoint sources. A point source is defined as a discernible, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Nonpoint sources are diffuse, and generally, but not always, involve accumulated oxygen demanding substances that wash off land surfaces as a result of storm events.

The process of revising the DO TMDL for the Brunswick Harbor includes using a computer model to determine the following:

- The DO levels in the estuary as a result of current oxygen demanding loads to the estuary under existing conditions;
- The natural DO levels in the estuary with all point sources removed;
- The critical DO levels in the estuary resulting from time variable oxygen demanding loads to the estuary from the dischargers;
- The TMDL for similar meteorological conditions to those under which the critical DO was determined; and
- The percent reduction in the current critical ultimate oxygen demand load necessary to achieve the TMDL.

A watershed model for Brunswick Harbor watershed was developed using the Loading Simulation Program in C++ (LSPC). The watershed model simulates the effects of surface runoff on both water quality and flow and was calibrated to available data. The results of this model were used as flow inputs to the estuary hydrodynamic model Estuarine and Coastal

Ocean Model (ECOMSED) and the water quality model Row Column AESOP (RCA). Hydrodynamic models simulate the transport of water into and out of the estuary and the water quality models simulate the fate and transport of oxygen demanding substances into and out of the estuary. The ultimate oxygen demanding loads and are summarized in the table below.

Total Ultimate Oxygen Demanding Loads

Month	Existing UOD (lbs/day)	Total UOD WLAs (lbs/day)	Total UOD LAs (lbs/day)	MOS (lbs/day)	Total UOD Load (lbs/day)	Reduction
January	423,216	79,836	337,000		416,836	1.51%
February	423,216	79,836	337,000		416,836	1.51%
March	417,366	73,986	337,000		410,986	1.53%
April	417,366	73,986	337,000		410,986	1.53%
May	417,366	64,377	337,000	2,665	404,042	3.19%
June	413,466	60,477	337,000	2,665	400,142	3.22%
July	413,466	60,477	337,000	2,665	400,142	3.22%
August	413,466	55,403	337,000	7,740	400,142	3.22%
September	413,466	48,082	337,000	15,061	400,142	3.22%
October	419,316	45,880	337,000	23,374	406,254	3.12%
November	419,316	75,936	337,000		412,936	1.52%
December	423,216	79,836	337,000		416,836	1.51%

Management practices that may be used to help reduce sources of oxygen demanding loads include:

- Compliance with NPDES (wastewater, construction, industrial stormwater, and/or MS4) permit limits and requirements;
- Implementation of recommended Water Quality management practices in the *Coastal Georgia Regional Water Plan* (GA EPD, 2017);
- Implementation of the *Georgia Stormwater Management Manual* (ARC, 2016) to facilitate prevention and mitigation of stream bank erosion due to increased stream flow and velocities caused by urban runoff through structural stormwater BMP installation.
- Implementation of *Georgia EPD Coastal Stormwater Supplement to the Stormwater Management Manual (April 2009)*;
- Implementation of the *Stormwater Utility Handbook (September 200*8);
- Implementation of *Georgia's Best Management Practices for Forestry* (GFC, 2009);
- Implementation of *Best Management Practices for Georgia Agriculture* (GSWCC, 2013)
- Adoption of National Resource Conservation Service (NRCS) Conservation Practices for agriculture;
- Adoption of proper fertilization practices;
- Adherence to the Surface Mining Land Use Plan prepared as part of the Surface Mining Permit Application;
- Implementation of the *Georgia Better Back Roads Field Manual* (GA RCDC, 2009) and adoption of additional practices for proper unpaved road maintenance;

- Implementation of individual Erosion and Sedimentation Control Plans for land disturbing activities; and application of the *Manual for Erosion and Sediment Control in Georgia* (GSWCC, 2016)
- Mitigation and prevention of riparian buffer loss due to land disturbing activities;
- Promulgation and enforcement of local natural resource protection ordinances such as land development, stormwater, water protection, protection of environmentally sensitive areas, and others.

The amount of oxygen demanding substances delivered to a waterbody is difficult to determine; however, by requiring monitoring, the implementation of these management practices can be measured. The effects of the management practices will improve stream water quality and will represent a beneficial measure of TMDL implementation.

1.0 INTRODUCTION

1.1 Background

The State of Georgia assesses its water bodies for compliance with water quality standards established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into one of three categories, supporting designated use, not supporting designated use or assessment pending, depending on water quality assessment results. These water bodies are found on Georgia's 2018 305(b) list as required by that section of the CWA that defines the assessment process, and are published in *Water Quality in Georgia 2016-2017* (GA EPD,2018). This document is available on the Georgia Environmental Protection Division (GA EPD) website.

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The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions. A TMDL is the sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, as well as natural background (40 CFR 130.2) for a given waterbody. The TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body.

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In 2009 GA EPD performed a variety of water quality modeling as required by the Comprehensive State-Wide Water Plan DO assimilative capacity analysis. This process included updated modeling of the Brunswick Harbor estuary for years 2001 through 2007. This modeling indicated that Brunswick Cellulose's requirement to add oxygen to the Turtle River resulted in additional assimilative capacity in the Turtle River. Figures 1a and 1b show the available DO assimilative capacity in the estuary for 2005 and 2006 based on the 2009 modeling effort.

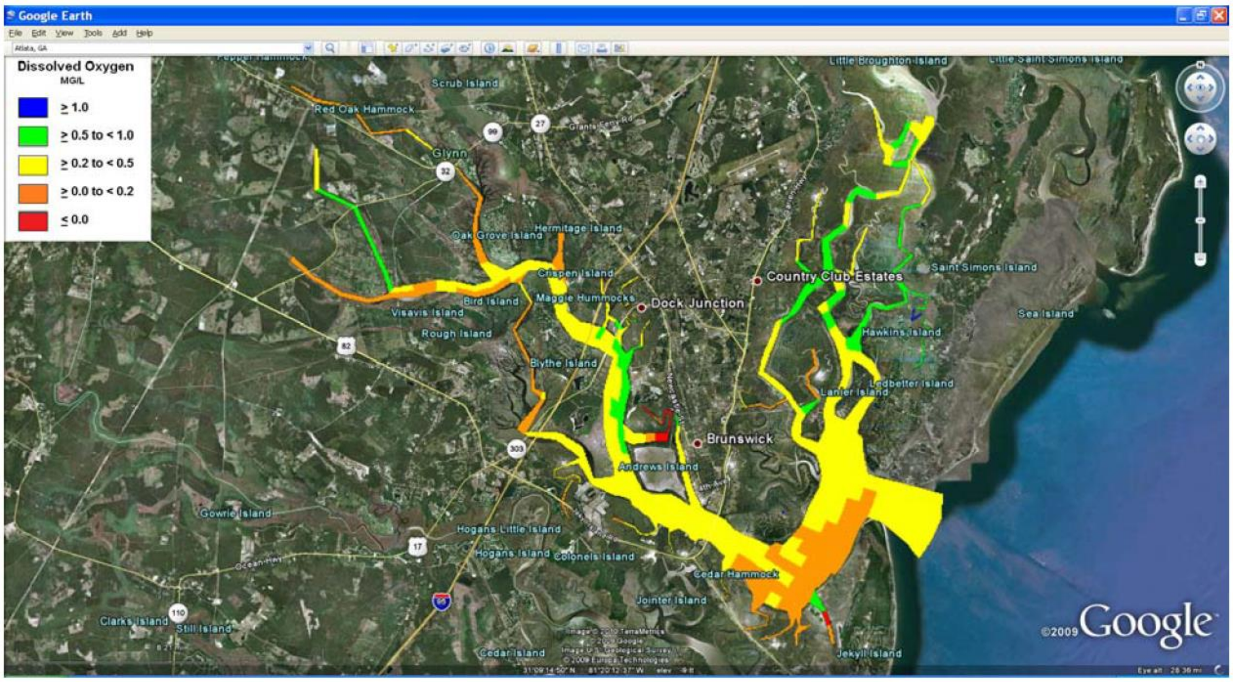

Figure 1a. Available Assimilative Capacity of DO in Brunswick Harbor: 2005

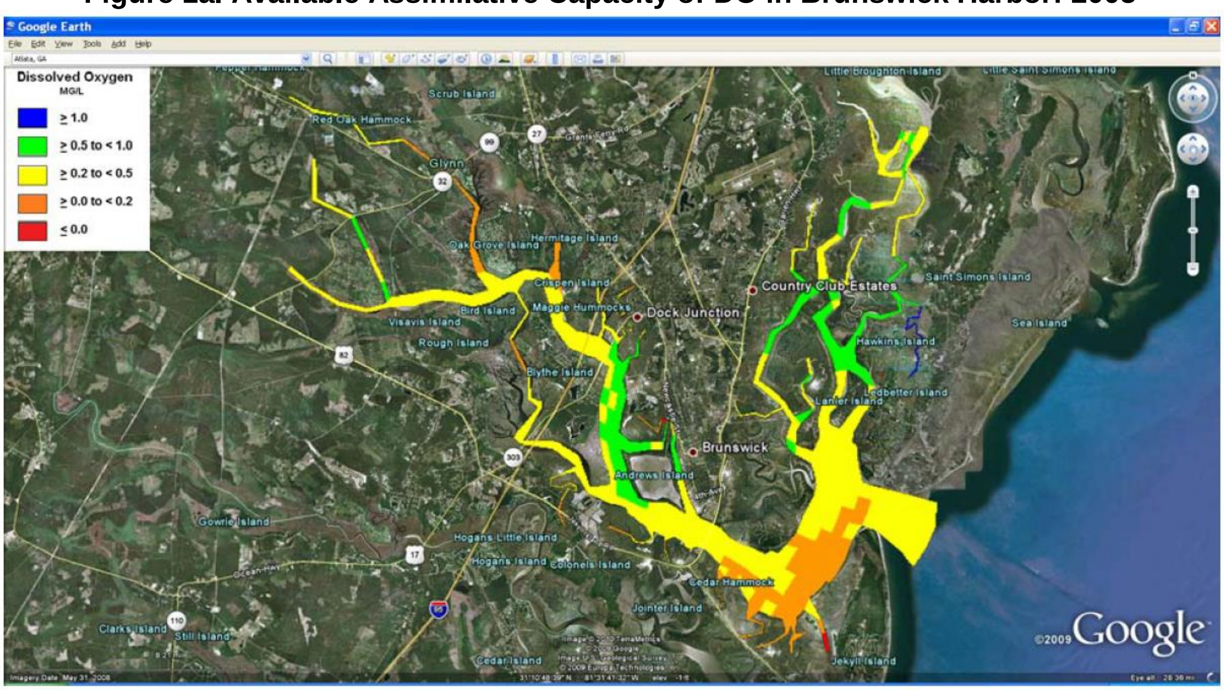

Figure 1b. Available Assimilative Capacity of DO in Brunswick Harbor: 2006

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The 2001 USEPA DO TMDL is based on the 2000 303(d) listing of the Brunswick River (11 square miles) and St. Simons Sound (66 square miles) for dissolved oxygen. The Turtle River System was included as part of the 2004 303(d) list due to violation of the numeric dissolved oxygen criteria. This waterbody was placed in Category 4A since it's impairment was addressed in the 2001 USEPA DO TMDL. The water bodies in the Brunswick Harbor estuary on the 2018 305(b)/303(d) list are given in Table 1. Their assessment category relative to DO criteria and monitoring data are also given

Table 1. Water Bodies in the Brunswick Harbor Estuary and their Assessment Category Relative to Numeric DO Criteria on the 2018 305(b)/303(d) List

Waterbody	Segment Location	Reach ID#	DO Category	Segment SIze	Designated Use
Brunswick River	South Brunswick River to the St. Simons Sound	GAR030702030211	3	5 miles	Fishing
St Simons Sound	Glynn County	GAR030702030503	1	10 square miles	Fishing
Turtle River System	Brunswick: Turtle River, Buffalo River and South Brunswick River	GAR030702030201	4a	19 miles	Fishing

The 2018 305(b)/303(d) List states that GA EPD needs to determine the "natural DO" for the 5 mile segment of the Brunswick River from South Brunswick River to St Simons Sound (GAR030702030211) before it can be determined whether the dissolved oxygen criteria are being met. The updated models developed for this TMDL will determine the natural DO of this segment.

1.2 Watershed Description

The Satilla River Basin is located in the southeastern part of Georgia, occupying an area of approximately 4,200 square miles. The United States Geologic Survey (USGS) has divided the Satilla River Basin into three sub-basins, or Hydrologic Unit Codes (HUCs). These are numbered as HUCs 03070201 through 03070203. Figure 2 shows the location of the Satilla River Basin in Georgia, and Figure 3 shows the sub-basins of the Satilla River. Figure 4 shows Water bodies addressed by this revised DO TMDL in the Brunswick Harbor estuary within the Satilla River HUC 03070203 sub-basin.

Brunswick River and the St Simons Sound are located in the Turtle River watershed in estuary along the Atlantic Coast approximately 80 miles south of Savannah and 70 miles north of Jacksonville, Florida. The upper portions of the estuary are made up of the Brunswick, Turtle and East Rivers. The Brunswick River receives the majority of its inflow from the Turtle River and the South Brunswick River, which are separated from each other by Blythe Island. The Turtle River receives its flow from the Buffalo and Turtle Rivers, and Green and College Creeks; water bodies that start in eastern Wayne and Brantley Counties. The Turtle River and South Brunswick River flow southeast into the Brunswick River and then into St. Simons Sound and the Atlantic Ocean. The Brunswick River and St. Simons Sound watershed has a drainage area of 371 square miles.

The Brunswick Harbor is the deepest natural harbor in the area and is the western-most harbor on the eastern seaboard. The Brunswick River and St Simons Sound watershed is in the Southern Coastal Plain physiographic province that extends throughout the south-eastern United States. It includes the Sea Island Flatwoods and Sea Island/Coastal Marsh.

The land use characteristics of the Brunswick Harbor watershed were determined using data from the Georgia Land Use Trends (GLUT) for Year 2015. This raster land use trend product was developed by the University of Georgia – Natural Resources Spatial Analysis Laboratory (NARSAL) and follows land use trends for years 1974, 1985, 1991, 1998, 2001, 2005, 2008 and 2015. The raster data sets were developed from Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+). Some of the NARSAL land use types were reclassified, aggregated into similar land use types, and used in the final watershed characterization. Table 2 lists the watershed land use distribution contributing to the listed segments and other segments within the Brunswick Harbor estuary.

1.3 State Water Planning

The Georgia Legislature enacted the Metropolitan North Georgia Water Planning District Act in 2001 to create the Metropolitan North Georgia Water Planning District (MNGWPD) to preserve and protect water resources in the 15-county metropolitan Atlanta area. The MNGWPD is charged with the development of comprehensive regional and watershed specific water resource management plans to be implemented by local governments in the metropolitan Atlanta area. The MNGWPD issued its first water resource management plan documents in 2003.

In 2004, the Georgia Legislature enacted the Comprehensive State-wide Water Management Planning Act to ensure management of water resources in a sustainable manner to support the state's economy, to protect public health and natural systems, and to enhance the quality of life for all citizens on a state-wide level. GA EPD later developed the 2008 Comprehensive State-wide Water Management Plan, which established Georgia's ten Regional Water Planning Councils (RWPCs) and laid the groundwork for the RWPCs to develop their own Regional Water Plans. Figure 5 shows the boundaries of the RWPCs and the MNGWPD**.** The

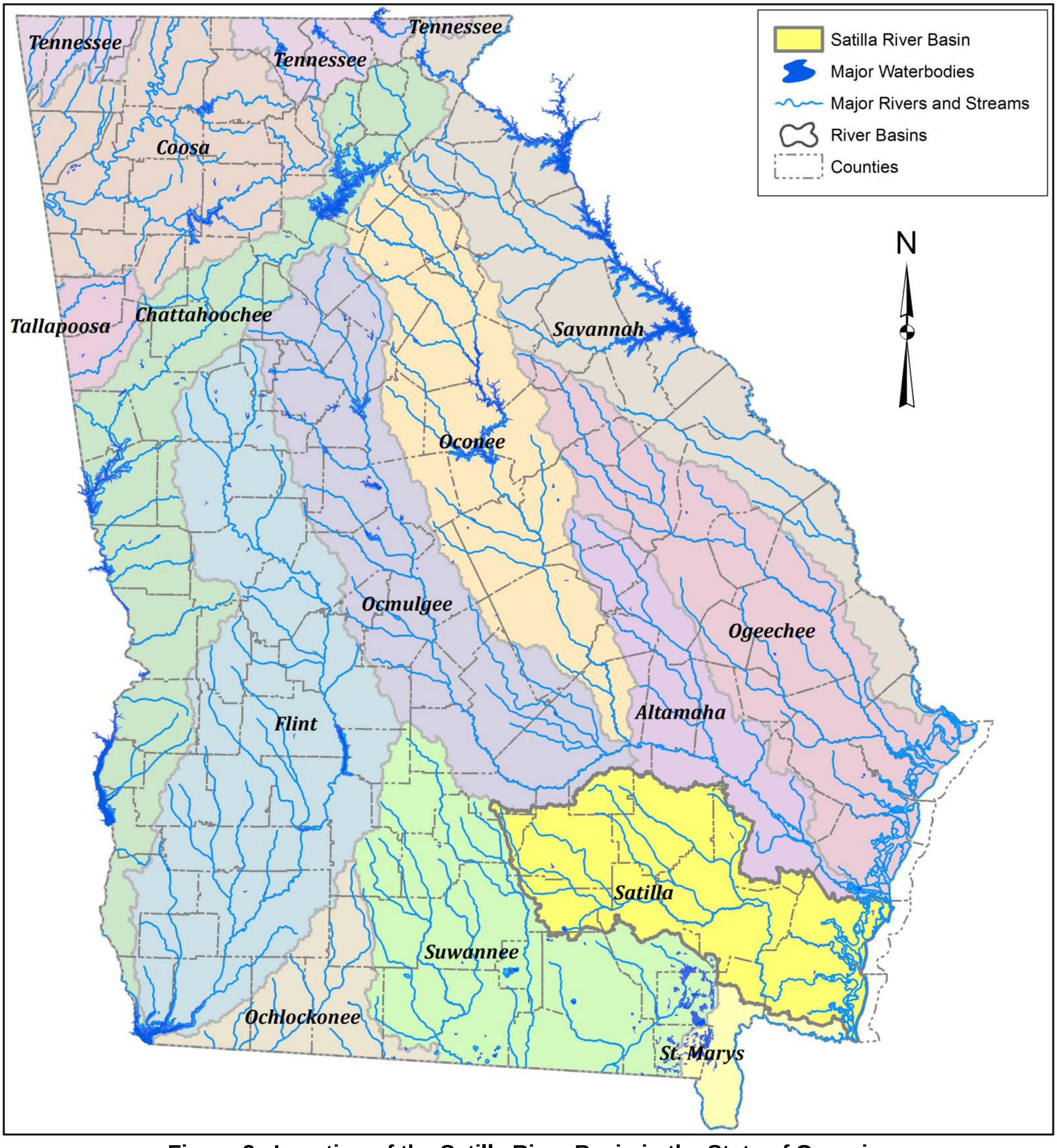

Figure 2. Location of the Satilla River Basin in the State of Georgia

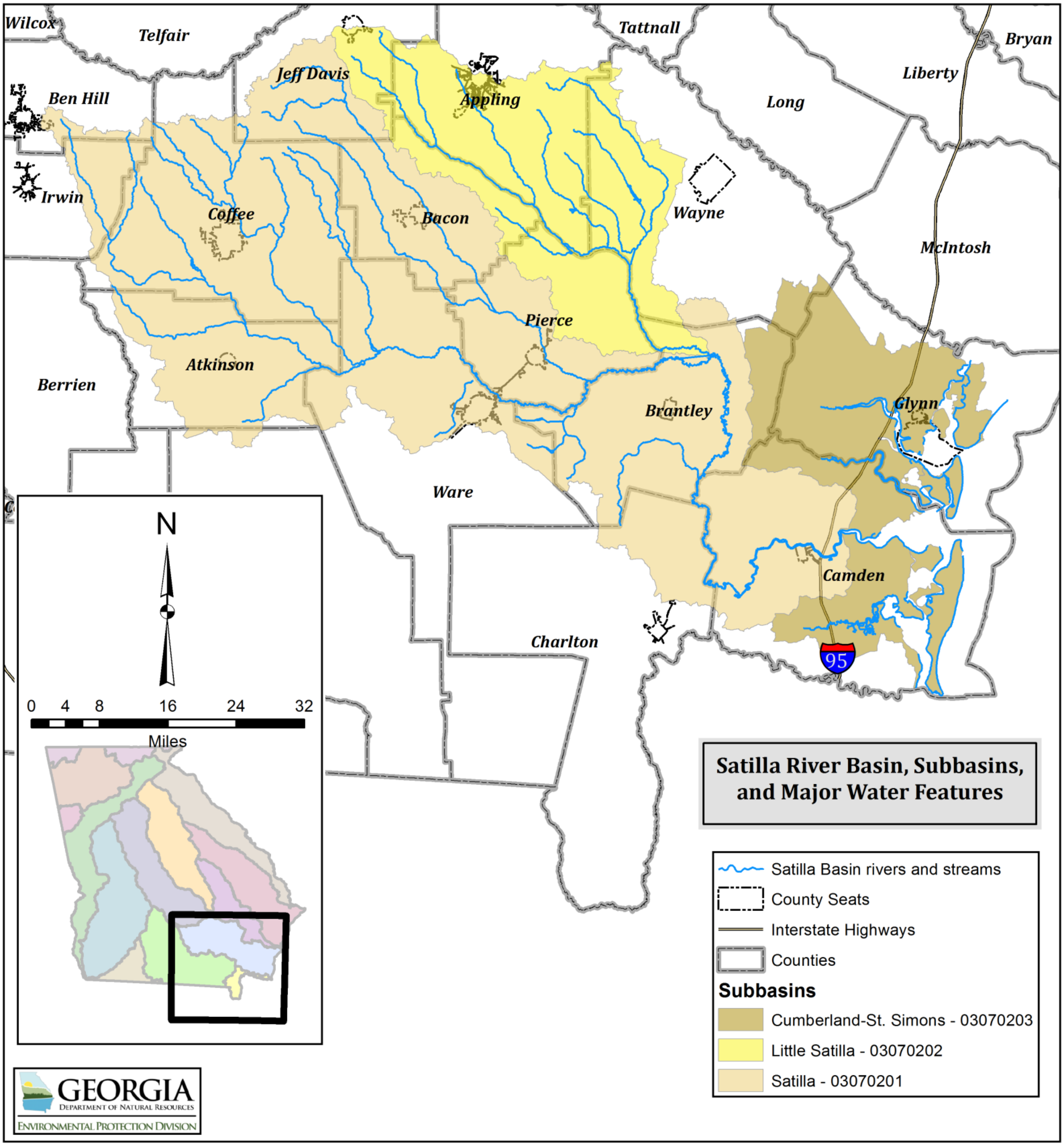

Figure 3. USGS 8-Digit Hydrologic Units for the Satilla River Basin

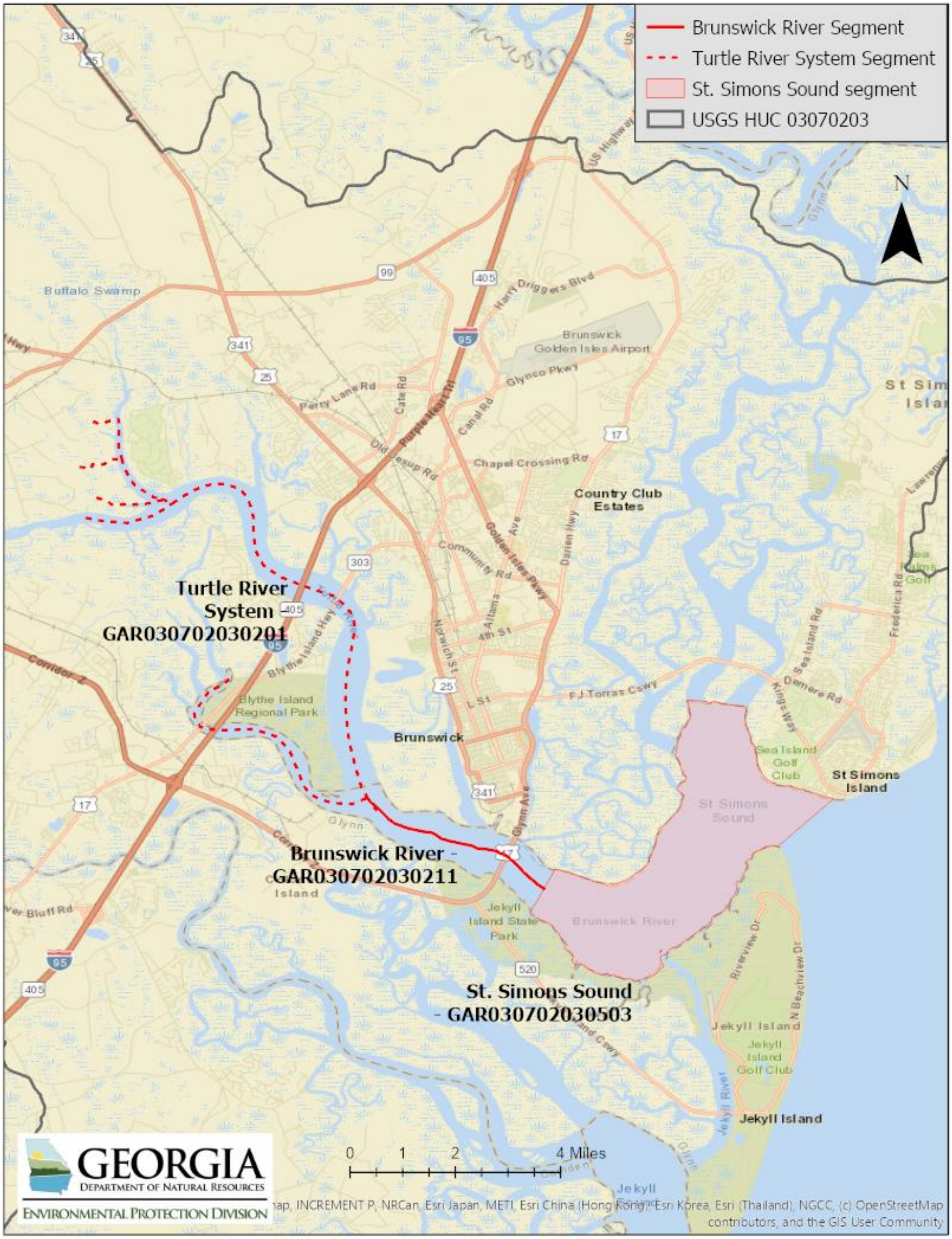

Figure 4. Water Bodies Addressed by the Revised DO TMDL in the Brunswick Harbor Estuary

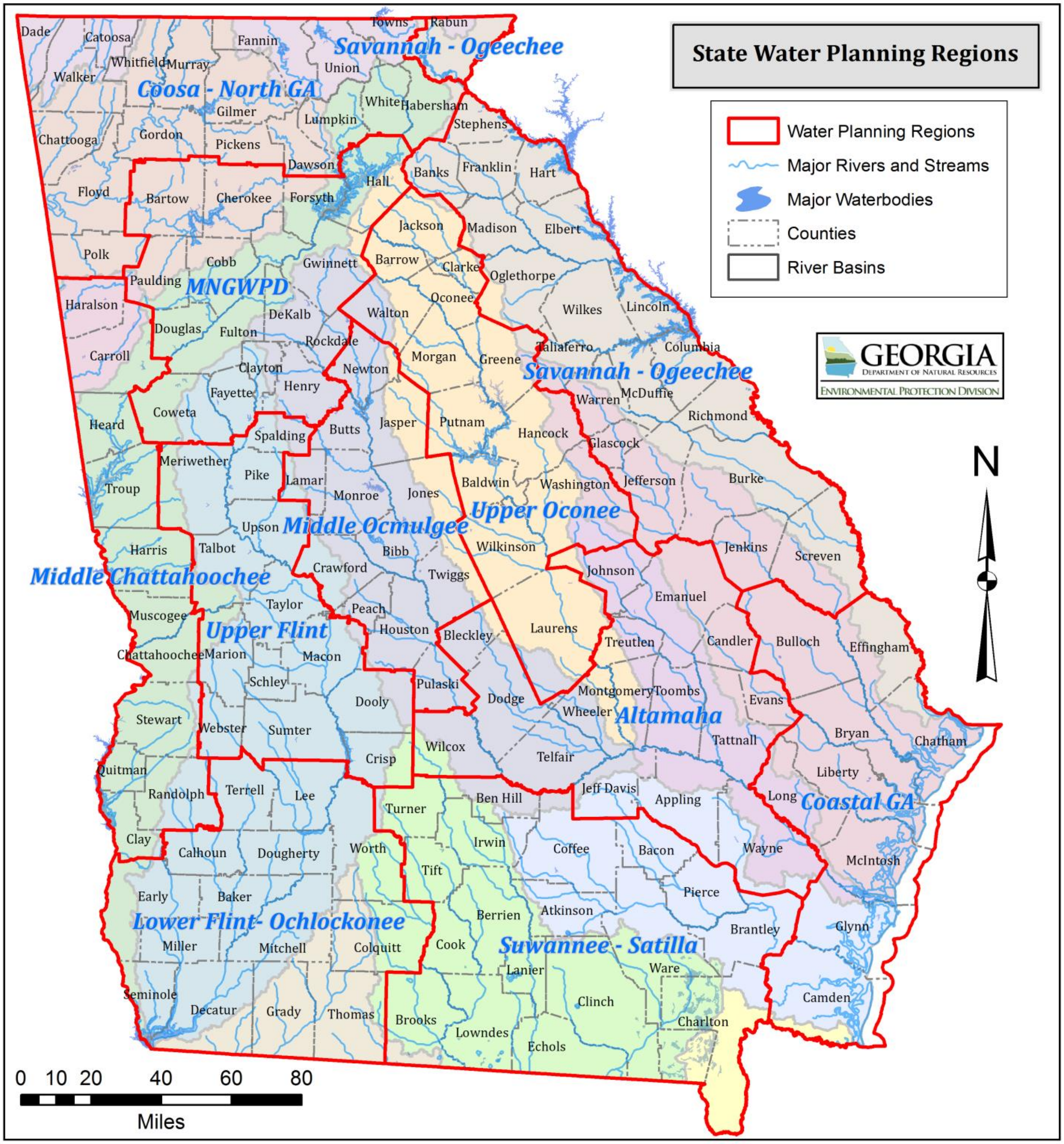

Figure 5. Boundaries of the Regional Water Planning Councils and the Metropolitan North Georgia Water Planning District

Brunswick Harbor Estuary watershed is within the boundaries of the Georgia Coastal Water Planning District and the Coastal Georgia Regional Water Planning Council. In 2011, each RWPC finished development of individualized Regional Water Plans, which were later adopted following GA EPD review. These Regional Water Plans identify a range of actions or management practices to help meet the state's water quality and water supply challenges. The MNGWPD and each RWPC subsequently updated and revised their respective management plan documents in 2017. Implementation of these plans is critical to meeting Georgia's water resource challenges.

1.4 Water Quality Standard

The water use classification for the segments addressed in this TMDLare Fishing. The criterion that was violated was dissolved oxygen. The potential causes listed include urban runoff, nonpoint sources, and municipal and industrial point source discharges. The water quality standards that apply to the Brunswick River, St. Simons Sound, and the Turtle River System as stated in the *State of Georgia's Rules and Regulations for Water Quality Control*, Chapter 391-3-6-.03 (GA EPD, 2015), revised and approved by EPA in October 2015 and are as follows:

(3)(i) "Naturally variable parameters." It is recognized that certain parameters including dissolved oxygen, pH, bacteria, turbidity and water temperature, vary through a given periods of time (such as daily of seasonally) due to natural conditions. Assessment of State waters may allow for a 10% excursion frequency of these parameters.

(m) "Significant Figures." The number of "significant figures" represented in numeric criteria are the number of figures or digits that have meaning as estimated from the accuracy and precision with which the quantity was measured and the data were rounded off. Technical guidance on significant figures, including rules for rounding off following mathematical operations, is provided in the publication entitled *Standard Methods for the Examination of Water and Wastewater*, in "Part 1050 Expression of Results, B. Significant Figures" (American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF); 18th, 19th, 20th, or subsequent Editions).

(6)(c)(i) Dissolved Oxygen: A daily average of 6.0 mg/L and no less than 5.0 mg/L at all times for water designated as trout streams by the Wildlife Resources Division. A daily average of 5.0 mg/L and no less than 4.0 mg/L at all times for waters supporting warm water species of fish.

(7) **Natural Water Quality**. It is recognized that certain natural waters of the state may have a quality that will not be within the general or specific requirements contained herein. These circumstances do not constitute violations of water quality standards. This is especially the case for criteria for dissolved oxygen, temperature, pH and bacteria. NPDES permits and best management practices will be the primary mechanisms for ensuring that the discharges will not create a harmful situation.

EPA's Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Freshwater) EPA440/5-86-003 based on natural water quality is "Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable criteria means or minima or both, the minimum acceptable concentration is 90 percent of the natural concentration."

Georgia identifies the allowable dissolved oxygen deficit based upon the natural dissolved oxygen concentrations such that the "dissolved oxygen allocated to all Permits combined in a given waterbody should be less than 10 percent of the naturally occurring dissolved oxygen." GA EPD has developed a The Georgia DO Permitting Strategy that is presented in Appendix A. The minimum oxygen level allowed after allocation of all permits should be 0.1 mg/L from the natural DO. If significant figures are taken in to account, it would allow for a 0.149 mg/L DO deficit.

Table 2. Brunswick Harbor Estuary Watershed Land Coverage

	Land Use Types - Acres & Percentages																		
	Beaches/Dunes/Mud	Open Water	Utility Swaths	Developed (Open Space)	Developed (Low Intensity)	Developed (Medium Intensity)	Developed (High Intensity)	Clearcut/Sparse	Quarries/Strip Mines	Deciduous Forest	Evergreen Forest	Mixed Forest	Golf Courses	Pasture	Row Crop	Forested Wetland	Non-forested Wetland (Salt/Brackish)	Non-forested Wetland (Freshwater)	Total
Brunswick Harbor Estuary watershed	901.4	19496.0	1133.3	12754.5	6305.6	4527.5	4350.7	8840.6	155.7	10095.6	63654.9	2658.1	825.5	6206.6	162.1	55301.7	38278.1	1803.2	**237451.1**
	0.4	8.2	0.5	5.4	2.7	1.9	1.8	3.7	0.1	4.3	26.8	1.1	0.3	2.6	0.1	23.3	16.1	0.8	**100**

2.0 WATER QUALITY ASSESSMENT

GA EPD collects water quality samples monthly at three locations in the estuary. Figure 6 shows the locations of these water quality monitoring stations. The water quality data from these stations were used to assess water quality standards, see trends in DO, conductivity, and temperature levels, and to assist in developing NPDES permits. The Stream segments were placed on the 303(d) list as not supporting their water use classification based on these water quality sampling data and Appendix B presents plots of these data. The data used to revise this TMDL were collected during calendar years 2001 through 2016.Appendix C present the plots of the data collected by the Coastal Resources Division (CRD) in the St. Simons Sound from 2002 through 2010.

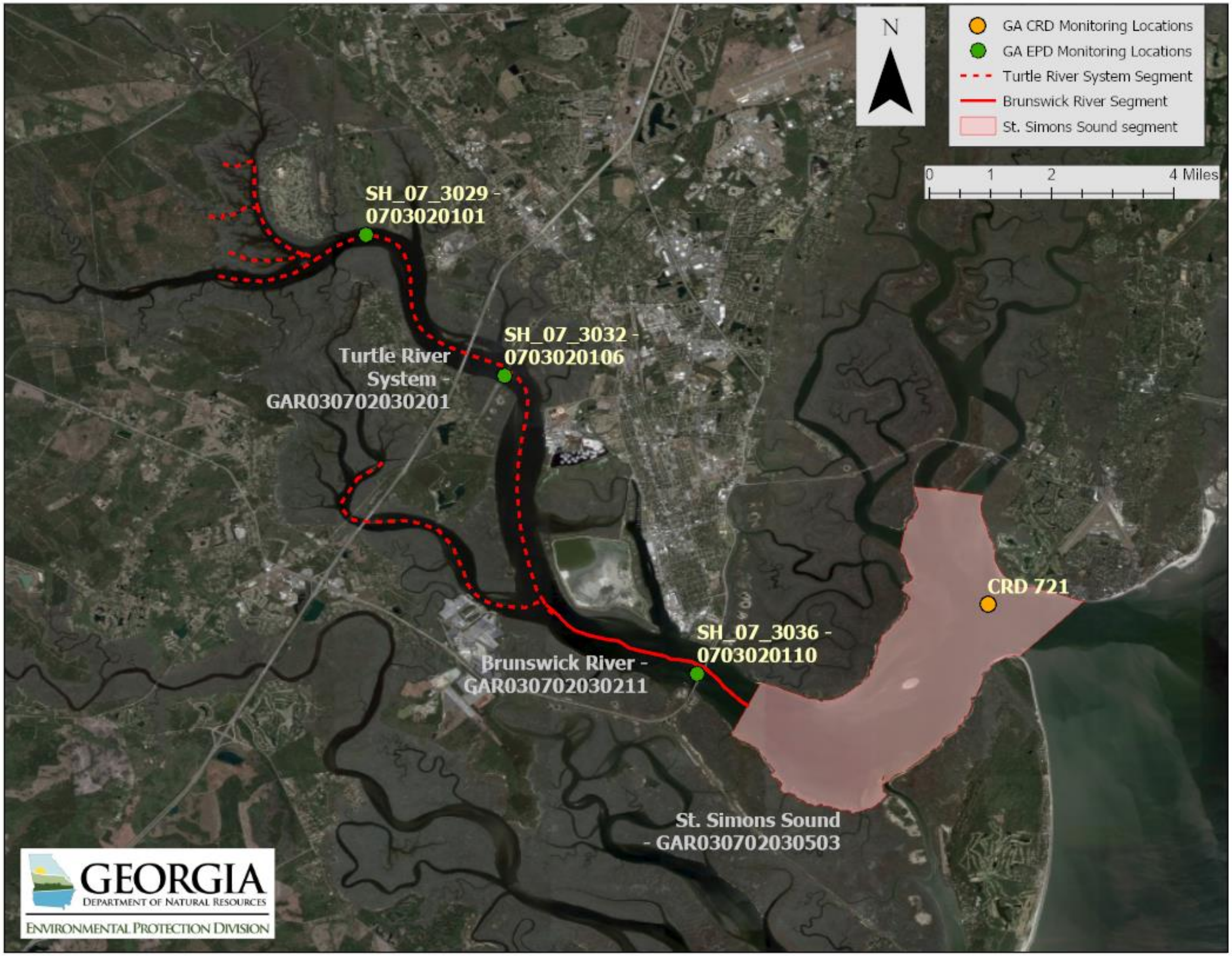

Figure 6. Brunswick Harbor and Turtle River Water Quality Monitoring Stations

3.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of potential source categories. Sources are broadly classified as either point or nonpoint sources. A point source is defined as a discernible, confined, and discrete conveyance from which pollutants are, or may be, discharged to surface waters. Nonpoint sources are diffuse, and generally, but not always, involve accumulation of oxygen demanding substances on land surfaces that wash off as a result of storm events.

3.1 Point Source Assessment

Title IV of the Clean Water Act establishes the National Pollutant Discharge Elimination System (NPDES) permit program. Basically, there are two categories of NPDES permits: 1) municipal and industrial wastewater treatment facilities, and 2) regulated stormwater discharges.

3.1.1 Wastewater Treatment Facilities

In general, industrial and municipal wastewater treatment facilities have NPDES permits with effluent limits. These permit limits are either based on federal and state effluent guidelines (technology-based limits) or on water quality standards (water quality-based limits).

The US Environmental Protection Agency (US EPA) has developed technology-based guidelines, which establish a minimum standard of pollution control for municipal and industrial discharges. These are based on Best Practical Control Technology Currently Available (BPT), Best Conventional Control Technology (BCT), and Best Available Technology Economically Achievable (BAT). The level of control required by each facility depends on the type of discharge and the pollutant.

The US EPA and the states have also developed numeric and narrative water quality standards. Typically, these standards are based on the results of aquatic toxicity tests and/or human health criteria and include a margin of safety. Water quality-based effluent limits are set to protect the receiving stream. These limits are based on water quality standards that have been established for a stream based on its intended use and the prescribed biological and chemical conditions that must be met to sustain that use.

Discharges from municipal and industrial wastewater treatment facilities can contribute oxygen demanding substances to receiving waters. There are nine point source discharges located in the watershed, and two direct point source discharges to Turtle River, for a total of eleven point source dischargers. Of these point sources, two are major municipal facilities, four are private facilities such as mobile home parks and marinas, and five are industrial facilities. Of the five industrial facilities, one is Georgia Power's Plant McManus and another is Seaboard Construction Company Inc. These facilities should not be a source of oxygen demanding substances. In addition, the Brunswick-Glynn County Joint Water and Sewer Commission has requested and received a wasteload allocation for a proposed municipal facility that has yet to be permitted.

Of the remaining nine facilities, two municipal facilities have National Pollutant Discharge Elimination System (NPDES) permitted discharges with flows greater than 1.0 MGD, two facilities have permitted discharges with flows less than 0.04 MGD, three are industrial discharges, and two remaining facilities are classified as Private and Industrial Development (PID) and are covered by General Permits. Figure 7 shows the locations of these point source discharges. Table 3 provides the permitted flows, 5-day Biochemical Oxygen Demand (BOD_5), ammonia (NH_3), and dissolved oxygen load or concentrations. Brunswick Cellulose has a permitted carbonaceous BOD_5 load and a supplement oxygen load that has added to the Turtle River near their discharge point.

Combined sewer systems convey a mixture of raw sewage and stormwater in the same conveyance structure to the wastewater treatment plant. These are considered a component of municipal wastewater treatment facilities. When the combined sewage exceeds the capacity of the wastewater treatment plant, the excess is diverted to a combined sewage overflow (CSO) discharge point. There are no permitted CSO outfalls in the Satilla River Basin.

3.1.2 Regulated Stormwater Discharges

Some stormwater runoff is covered under the NPDES Permit Program as a point source. Some industrial facilities included under the program will have limits similar to traditional NPDES-permitted dischargers, whereas others establish controls: “to the maximum extent practicable” (MEP). Currently, regulated stormwater discharges that may contain oxygen demanding substances consist of those associated with industrial activities and large, medium, and small municipal separate storm sewer systems (MS4s) that serve populations of 50,000 or more.

3.1.2.1 Industrial General Stormwater NPDES Permit

Stormwater discharges associated with industrial activities are currently covered under the 2017 NPDES General Permit for Stormwater Discharges Associated with Industrial Activity (GAR050000), also called the Industrial General Permit (IGP). This permit requires visual monitoring of stormwater discharges, site inspections, implementation of Best Management Practices (BMPs), and record keeping. The IGP requires that stormwater discharging into an impaired stream segment or within one linear mile upstream of, and within the same watershed as, any portion of an impaired stream segment identified as “not supporting” its designated use(s), must satisfy the requirements of Appendix C of the 2017 IGP if the pollutant(s) of concern for which the impaired stream segment has been listed may be exposed to stormwater as a result of industrial activity at the site. If a facility is covered under Appendix C of the IGP, then benchmark monitoring for the pollutant(s) of concern is required. Delineations of both supporting and not supporting water bodies are provided on the GA EPD website, and are available in ESRI ArcGIS shapefile format or in KMZ format for use in Google Earth. Interested parties may evaluate their proximity to not supporting water bodies by utilizing these geospatial files. Industrial facilities covered by the IGP in the Brunswick Harbor Watershed are given in Table 4.

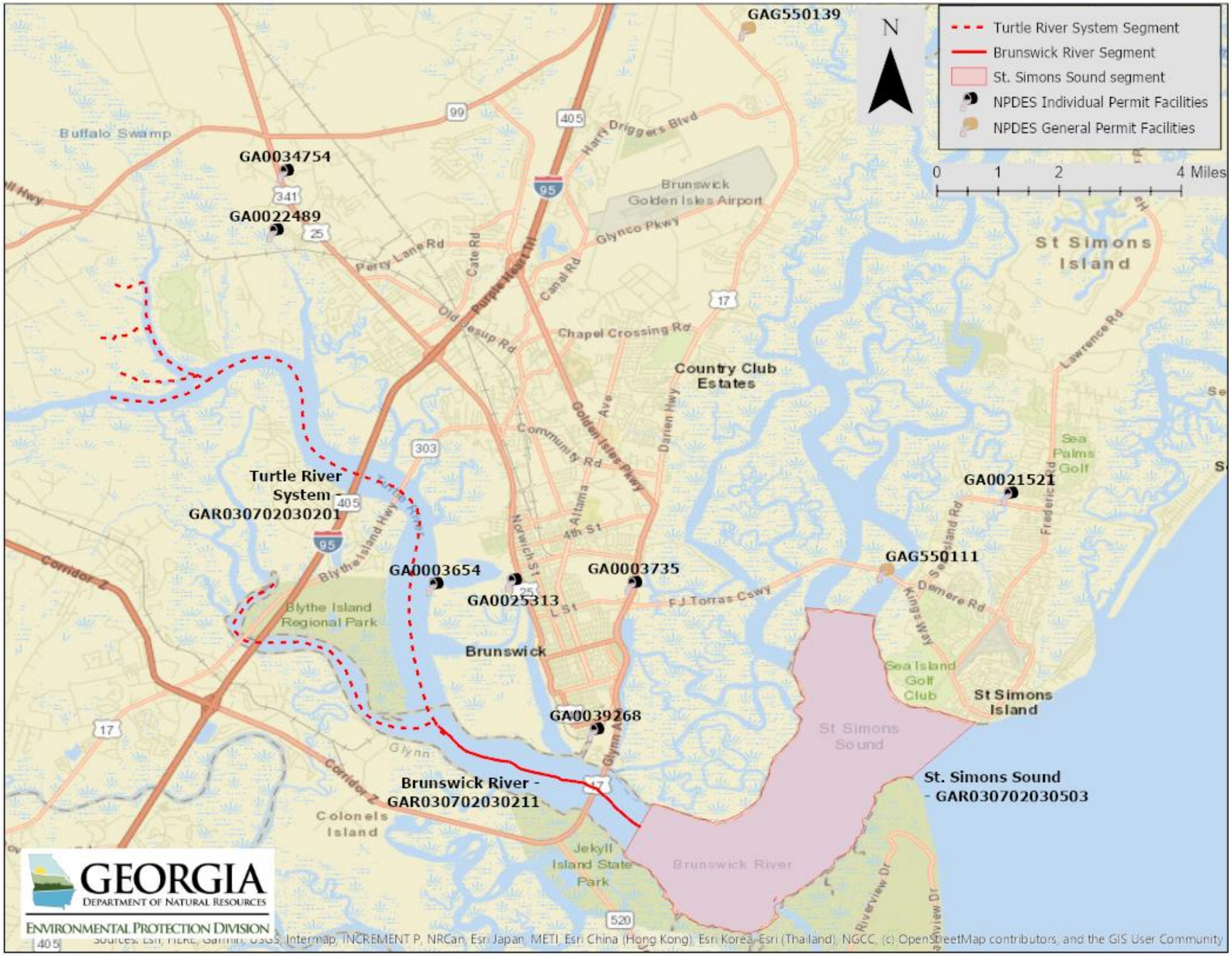

Figure 7. Location of Point Source Discharges

Table 3. NPDES Facilities Discharging to the Brunswick Harbor Watershed

Facility Name	NPDES Permit No.	Receiving Stream	NPDES Permit Limits			
			Average Monthly Flow (MGD)	BOD_5 (mg/L)	NH_3 (mg/L)	DO (mg/L)
New Hope Plantation Mobile Home Park (Outfall 001 and 002)	GAG550139	Ditch	Report	30		
Golden Isles Marina Master Association	GAG550111	Frederica River	Report	30		
Pinova	GA0003735	Dupree Creek	Report	38 (1900 lbs/day)	1.3	5.0
Brunswick-Glynn County JWSC (St Simons Island WPCP)	GA0021521	Dunbar Creek tributary to the Federica River	4.0	5.0	2.0	6.0
Brunswick Shady Acres Mobile Home Park WPCP	GA0022489	Cowpen Creek Tributary to the Turtle River	0.039	30		
Brunswick-Glynn County JWSC (Academy Creek WPCP)	GA0025313	Academy Creek	13.5	20	17.4	2.0
Sterling Mobile Home Park WPCP	GA0034754	Unnamed tributary to Cowpen Creek	0.009	30		
King & Prince Seafood Corporations	GA0039268	Turtle River	Report	30		
Facility Name	**NPDES Permit No.**	**Receiving Stream**	**NPDES Permit Limits**			
			Average Monthly Flow (MGD)	***$CBOD_5$ (lbs/day)**	**NH_3 (mg/L)**	**Oxygen Addition (lbs/day)**
Brunswick Cellulose, LLC	GA0003654	Turtle River	Report	15,000 (Jan) 15,000 (Feb) 13,500 (Mar) 13,500 (Apr) 13,500 (May) 12,500 (Jun) 12,500 (Jul) 12,500 (Aug-Sep) 14,000 (Oct) 14,000 (Nov) 15,000 (Dec)	Report	0 (Jan) 0 (Feb) 0 (Mar) 12,500 (Apr) 12,400 (May) 23,000 (Jun) 18,000 (Jul) 22,000 (Aug-Sep) 12,900 (Oct) 11,400 (Nov) 0 (Dec)

Source: GA EPD * Carbonaceous Biochemical Oxygen Demand (5-day)

Table 4. Facilities Covered by the Industrial General Permit in the Brunswick Harbor Watershed

Industrial Facility
Academy Creek WPCP
Argos USA – Brunswick Ready Mix Plant
Brunswick Cellulose
Brunswick Concrete Plant
Brunswick Golden Isles Airport
Chemex Construction Materials – Brunswick Ready Mix
Coastal R&R Inc. Sand Mine
Colonel's Island Terminal - Southside
DHS Federal Law Enforcement Training Center
Fort Dearborn Company - Brunswick
Georgia Pacific Corp Wood Products LLC (Sterling)
Georgia Pacific Corp Wood Products LLC
Georgia Pacific Gypsum
Georgia Port Authority (Colonel's Island Terminal –
Georgia Power Plant McManus
Glynn Iron and Metal, Inc
GP WFS – Thalman Woodyard
Gulfstream Aerospace
High Performance Tire
Highway 17 North Borrow Pit
Imerys Mineral USA Inc.
Jered LLC
Jered LLC - Shipyard
King & Prince Seafood Corporation
Logistec USA Inc.
Malcolm B. McKinnon Airport – Glynn County
Mayor's Point Terminal
Morgan Corp Brunswick Pugmill
Petersville Road Surface Mine
Rich Products Corporation
Rogers Cartage Company
Rolling Frito Lay Sales, LP – Brunswick BIN
Southland Waste Systems of Georgia - Brunswick
St Simons Island Water Pollution Control Plant
United Parcel Service In. (UPS) - Brunswick
Wall Timber Products
Waste Management of Brunswick
Southland Waste Systems of Georgia - Brunswick
St Simons Island Water Pollution Control Plant
United Parcel Service In. (UPS) - Brunswick
Wall Timber Products
Waste Management of Brunswick

3.1.2.2 MS4 NPDES Permits

Stormwater discharges from MS4s are very diverse in pollutant loadings and frequency of discharge. At present, all cities and counties within the state of Georgia that had a population of greater than 100,000 at the time of the 1990 Census are permitted for their stormwater discharge under Phase I. This includes 58 permittees in Georgia.

Phase I MS4 permits require the prohibition of non-stormwater discharges (i.e., illicit discharges) into the storm sewer systems and controls to reduce the discharge of pollutants to the maximum extent practicable, including the use of management practices, control techniques and systems, as well as design and engineering methods (Federal Register, 1990). A site-specific Storm Water Management Plan (SWMP) outlining appropriate controls is required by and referenced in the permit. There are no Phase I MS4s in the Satilla River Basin.

Small MS4s serving urbanized areas are required to obtain a stormwater permit under the Phase II stormwater regulations. An urbanized area is defined as an area with a residential population of at least 50,000 people and an overall population density of at least 1,000 people per square mile. There are two Phase II MS4s in the Satilla River Basin (Table 5). and 100 percent of the Brunswick Harbor watershed is a Phase II MS4 urbanized area.

Table 5. Phase II Permitted MS4s in the Satilla River Basin

Name	Watershed(s)
Brunswick	Satilla
Glynn County	Satilla, Altamaha

Source: Nonpoint Source Permitting Program, GA DNR, 2015

3.1.3 Concentrated Animal Feeding Operations

Under the Clean Water Act, Concentrated Animal Feeding Operations (CAFOs) are defined as point sources of pollution and are therefore subject to NPDES permit regulations. From 1999 through 2001, Georgia adopted rules for permitting swine and non-swine liquid manure animal feeding operations (AFOs). Georgia rules required medium size AFOs with more than 300 animal units (AU) but less than 1000 AU to apply for a non-discharge State land application system (LAS) waste disposal permit. Large operations with more than 1000 AU were required to apply for an NPDES permit (also non-discharge) as a CAFO. The US EPA CAFO regulations were successfully appealed in 2005. They were revised to comply with the court's decision that NPDES permits only be required for actual discharges. Georgia's rules were amended on August 7, 2012 to reflect the US EPA revisions. The revised state rules will continue LAS permitting of medium size liquid manure AFOs and extend LAS permitting to large liquid manure AFOs with more than 1000 AU, unless they elect to obtain an NPDES permit. There are no known liquid manure CAFOs located in the vicinity of the listed segments in the Satilla River Basin that have NPDES or land application permits.

In 2002, the US EPA promulgated expanded NPDES permit regulations for CAFOs that added dry manure poultry operations larger than 125,000 broilers or 82,000 layers. In accordance with the Georgia rule amendment discussed above, the general permit covering these facilities has been terminated and they are no longer covered under any permit. Georgia is consistently among the top three states in the U.S. in terms of poultry operations. The majority of poultry farms are dry manure operations where the manure is stored for a time and then land applied. Freshly stored litter can be a nonpoint source of oxygen demanding substances. There are no known dry manure poultry operations located in the vicinity of the listed segments in the Satilla River Basin.

3.2 Nonpoint Source Assessment

In general, nonpoint sources cannot be identified as entering a waterbody through a discrete conveyance at a single location. Typical nonpoint sources of oxygen demanding substances come from materials being washed into the rivers and streams during storm events. Constituents that have washed off of land surfaces in previous months or years have either flushed out of the system along with the water column flow or settled out and became part of the estuary bottom. In this manner, settleable material accumulates over time and may remove oxygen from the water column by exerting a sediment oxygen demand (SOD). Constituents of concern from surface washoff include the fractions of ammonia and BOD that become an integral part of channel bottom sediments, thus becoming a potential source of SOD.

Typical nonpoint sources of oxygen demand substances include:

- Wildlife
- Agricultural Livestock
    - Application of manure to pastureland and cropland
    - Application of fertilizers
- Urban Development
    - Application of fertilizers
    - Septic systems
    - Land Application Systems
    - Landfills

In urban areas, a large portion of stormwater runoff may be collected in storm sewer systems and discharged through distinct outlet structures. For large urban areas, these storm sewer discharge points may be regulated as described in Section 3.1.2.

3.2.1 Wildlife

The significance of wildlife as a source of oxygen demand substances in streams varies considerably, depending on the animal species present in the watersheds. Based on information provided by the Wildlife Resources Division (WRD) of GA DNR, the greatest wildlife sources of oxygen demand substances are the animals that spend a large portion of their time in or around aquatic habitats. Of these, waterfowl, (especially ducks and geese), are considered to potentially be the most significant source of oxygen demand substances, because when present, they are typically found in large numbers on the water surface, they deposit their waste directly into the water, and their feces contain high levels of oxygen demoing substances. Other animals regularly found around aquatic environments include racoons, beavers, muskrats, and to a lesser extent, river otters and minks. Recently, rapidly-expanding feral swine populations have become a significant presence in the floodplain areas of all the major rivers in Georgia.

White-tailed deer populations are significant throughout the Satilla River Basin. Oxygen demand substance contributions from deer to water bodies are generally considered less significant than that of waterfowl, racoons, and beavers. This is because a greater portion of their time is spent in terrestrial habitats. This also holds true for other terrestrial mammals such as squirrels and rabbits, and for terrestrial birds (GA WRD, 2007). However, waste deposited on the land surface that contains oxygen demanding substances can result in additional loads to streams during runoff events.

3.2.2 Agricultural Livestock

Manure from agricultural livestock is a potential source of oxygen demand substances to streams in the Brunswick Harbor watershed. The animals grazing on pastureland deposit their feces, which contain oxygen demand substances, onto land surfaces, where it can be transported during storm events to nearby streams. Animal access to pastureland varies monthly, resulting in varying oxygen demand substances loading rates throughout the year. Beef cattle spend all of their time in pastures, while dairy cattle and hogs are periodically confined. In addition, agricultural livestock will often have direct access to streams that pass through their pastures, and can thus impact water quality in a more direct manner (USDA, 2002).

Table 6 provides the annual estimated number of beef cattle, dairy cattle, goats, horse, swine, sheep, and chickens reported by county. The Natural Resources Conservation Service (NRCS) provided these data.

Table 6. Estimated Agricultural Livestock Populations in the Brunswick Harbor Watershed

County	Livestock							
	Beef Cattle	Dairy Cattle	Swine	Sheep	Horses	Goats	Chickens Layers	Chickens-Broilers Sold
Brantley	2,500	-	75	-	100	500	920,000	
Glynn	163	-	-	-	15	76	-	-
Wayne	5,000	350	-	-	150	2,000	337,500	720,384

Source: Center for Agribusiness and Economic Development, UGA 2014

3.2.3 Urban Development

Oxygen demanding substances from urban areas are attributable to multiple sources, including: domestic animals, leaks and overflows from sanitary sewer systems, illicit discharges, septic systems, and leachate from both operational and closed landfills.

Urban runoff can contain high concentrations of oxygen demanding substances from domestic animals and urban wildlife. Oxygen demanding substances enter streams by direct washoff from the land surface, or the runoff may be diverted to a stormwater collection system and discharged through a discrete outlet structure. For large, medium, and small urban areas (populations greater than 50,000), the stormwater outlets are regulated under MS4 permits (see Section 3.1.2). For smaller urban areas, the stormwater discharge outlets currently remain unregulated.

In addition to urban animal sources of oxygen demanding substances, there may be illicit connections to the storm sewer system. As part of the MS4 permitting program, municipalities are required to conduct dry-weather monitoring to identify and then eliminate these illicit discharges. Oxygen demanding substances may also enter streams from leaky sewer pipes, or during storm events when sanitary sewer overflows discharge.

3.2.3.1 Leaking Septic Systems

A portion of the oxygen demanding substances contributions in the Brunswick Harbor watershed may be attributed to septic systems failures and illicit discharges of raw sewage. Table 7 presents the number of septic systems by county of the Brunswick Harbor watershed existing at the end of 2009 and the number existing at the end of 2013. This is based on data provided by the Georgia Department of Public Health and information obtained from the U.S. Census. In addition, an estimate of the number of septic systems installed and repaired during the period from 2009 to 2013 is given. These data show an increase in the number of septic systems in all of counties. Often, this is a reflection of population increases outpacing the expansion of sewage collection systems or the limited access to centralized wastewater treatment systems.

Table 7. Estimated Number of Septic Systems in the Counties in the Brunswick Harbor Watershed

County	Existing Septic Systems (2009)	Existing Septic Systems (2013)	Number of Septic Systems Installed (2009 to 2013)	Number of Septic Systems Repaired (2009 to 2013)
Brantley	8,482	8,933	451	169
Glynn	15,996	16,239	243	186
Wayne	9,500	10,056	5569	18

Source: The Georgia Dept. of Human Resources, Division of Public Health, 2014

3.2.3.2 Land Application Systems

Many smaller communities use land application systems (LAS) for treatment and disposal of their sanitary wastewater. These facilities are required through LAS permits to treat all their wastewater by land application and are to be properly operated as non-discharging systems that contribute no runoff to nearby surface waters. However, runoff during storm events may carry surface residual containing oxygen demanding substances to nearby surface waters. Some of these facilities may also exceed the ground percolation rate when applying the wastewater, resulting in surface runoff from the field. If not properly bermed, this runoff, which probably contains oxygen demanding substances, may be discharged to nearby surface waters. There are no permitted LAS systems located in the Brunswick Harbor watershed.

3.2.3.3 Landfills

Leachate from landfills might contain oxygen demanding substances that may at some point reach surface waters. Sanitary (or municipal) landfills are the most likely to be a source of oxygen demanding substances. These types of landfills receive household wastes, animal manure, offal, hatchery and poultry processing plant wastes, dead animals, and other types of wastes. Older sanitary landfills were not lined and most have been closed. Those that remain active and have not been lined operate as construction/demolition landfills. Currently active sanitary landfills are lined and have leachate collection systems. All landfills, excluding inert landfills, are now required to install environmental monitoring systems for groundwater and methane sampling. There are 19 known landfills in the Brunswick Harbor watershed (Table 8). Of these, two are active landfills and 17 are inactive or closed.

Table 8. Landfills in the Brunswick Harbor Watershed

Name	County	Permit No.	Type	Status
Brunswick Pulp & Paper	Glynn	063-002D(L)	NA	Inactive
Georgia Pacific Brunswick Operation	Glynn	063-002D(LI)	Industrial Landfill	Operating
Glynn County – Lawrence Road	Glynn	063-009(L)	Dry Trash Landfill	Inactive
Glynn County _ Hwy 99	Glynn	063-010D(L)	Dry Trash Landfill	Inactive
Glynn County – McKinnon Airport	Glynn	063-013D(L)	Dry Trash Landfill	Inactive
Glynn County – Cate Road SL	Glynn	063-015D(SL)	Sanitary Landfill	Closed
Glynn County – Frederica Academy SSI	Glynn	063-016D(L)	Dry Trash Landfill	Closed
Paulk-S Harrington Rd SSI (L)	Glynn	063-017D(L)	Dry Trash Landfill	Closed
City of Brunswick - Dolphin Street	Glynn	063-018D(L)	Dry Trash Landfill	Closed
Hutcheson - Petersville Road	Glynn	063-019D(L)	Dry Trash Landfill	Closed
Merrit - SR 303/US 341	Glynn	063-022D(L)	Dry Trash Landfill	Closed
Glynn County - Cate Road L	Glynn	063-024D(L)	Construction & Demolition	Closed
Eller - Whitlock Ave.	Glynn	063-025D(L)	Construction & Demolition	Operating
Lawrence Rd	Glynn	-	NA	Inactive
S. Harrington	Glynn	-	NA	Inactive
Sterling	Glynn	-	NA	Inactive
T Street	Glynn	-	NA	Inactive
Thalmann	Glynn	-	NA	Inactive
Waynesville	Brantley	-	NA	Inactive

Source: Land Protection Branch, GA DNR, 2013

4.0 ANALYTICAL APPROACH

The process of developing the DO TMDLs for the Brunswick Harbor System involved developing an updated hydrodynamic water quality model to evaluate possible modifications to Brunswick Cellulose's wastewater permit using a time variable effluent approach. The model was used to compute natural background dissolved oxygen (DO) levels for the purpose of determining the allowable delta DO (DO decrease) due to all the point source discharges to the Brunswick Estuary and to revise the Brunswick Harbor DO TMDL.

4.1 Hydrodynamic Model Calibration

A three-dimensional, time variable hydrodynamic model was developed and calibrated for the Brunswick Estuary. The hydrodynamic model used was the Estuarine and Coastal Ocean Model (ECOMSED). ECOMSED is a fully integrated three-dimensional hydrodynamic, wave, and sediment transport model developed by HydroQual for application to marine systems. For this particular application, only the hydrodynamic module was employed. The model domain extends along the Atlantic Ocean Coast, from approximately 12 miles north of the Altamaha River Estuary to approximately 20 miles south of St. Simons Sound, and offshore into the Atlantic Ocean approximately 27 miles from St. Simons Sound. Main rivers included in the model are the Turtle, Brunswick, East, and Altamaha Rivers. Some of the small tidal tributaries also included in the model are the Back, MacKay, and Frederick Rivers, and Academy, Dunbar and Dupree Creeks. The major freshwater sources are the Turtle and Altamaha Rivers. Figure 8 presents the model study area and model grid.

The hydrodynamic model was developed employing bathymetry data collected by NOAA, Academy Creek and East River LIDAR depth data, meteorological data from a local airport (Malcolm McKinnon) and tidal elevations provided by NOAA (St. Simons Island # 8677344). All river flows, with the exception of the Altamaha River, were obtained from the Loading Simulation Program in C++ (LSPC) watershed model developed for the calibration of the Brunswick Harbor Environmental Fluid Dynamics Code (EFDC) hydrodynamic and water quality model (Tetra Tech, Inc., 2016). The Altamaha River flow was obtained from USGS station 02226000. Brunswick Cellulose's effluent is currently discharged to the Turtle River 1.7 miles south of the State Route 303 Bridge.

The hydrodynamic model reflects a high resolution grid, in both the horizontal and vertical directions. In the vertical direction the model is defined by 10 sigma layers; in the horizontal direction, for example, in the vicinity of the Brunswick Mill discharge, the estuary width of about 1,100 meters is represented by 12 model cells (model columns along the river width). The high resolution grid was necessary to appropriately represent estuary bathymetry changes and also correctly simulate the local hydrodynamics (e.g., salinity, temperature, currents, etc.) in the Mill's discharge area. Figure 9 depicts the model grid in the vicinity of Brunswick Cellulose discharge.

Model calibration was performed with salinity and temperature data collected for the year 2005. Figure 10 presents the location of the calibration stations and Figures 11 and 12 present measured and computed salinity and temperature, respectively. The model was validated against salinity and temperature data collected for the years 2003, 2004, and 2006 to 2012. Figures 13 and 14 present measured and computed salinity and temperature, respectively, for the entire modeling period (2003-2012).

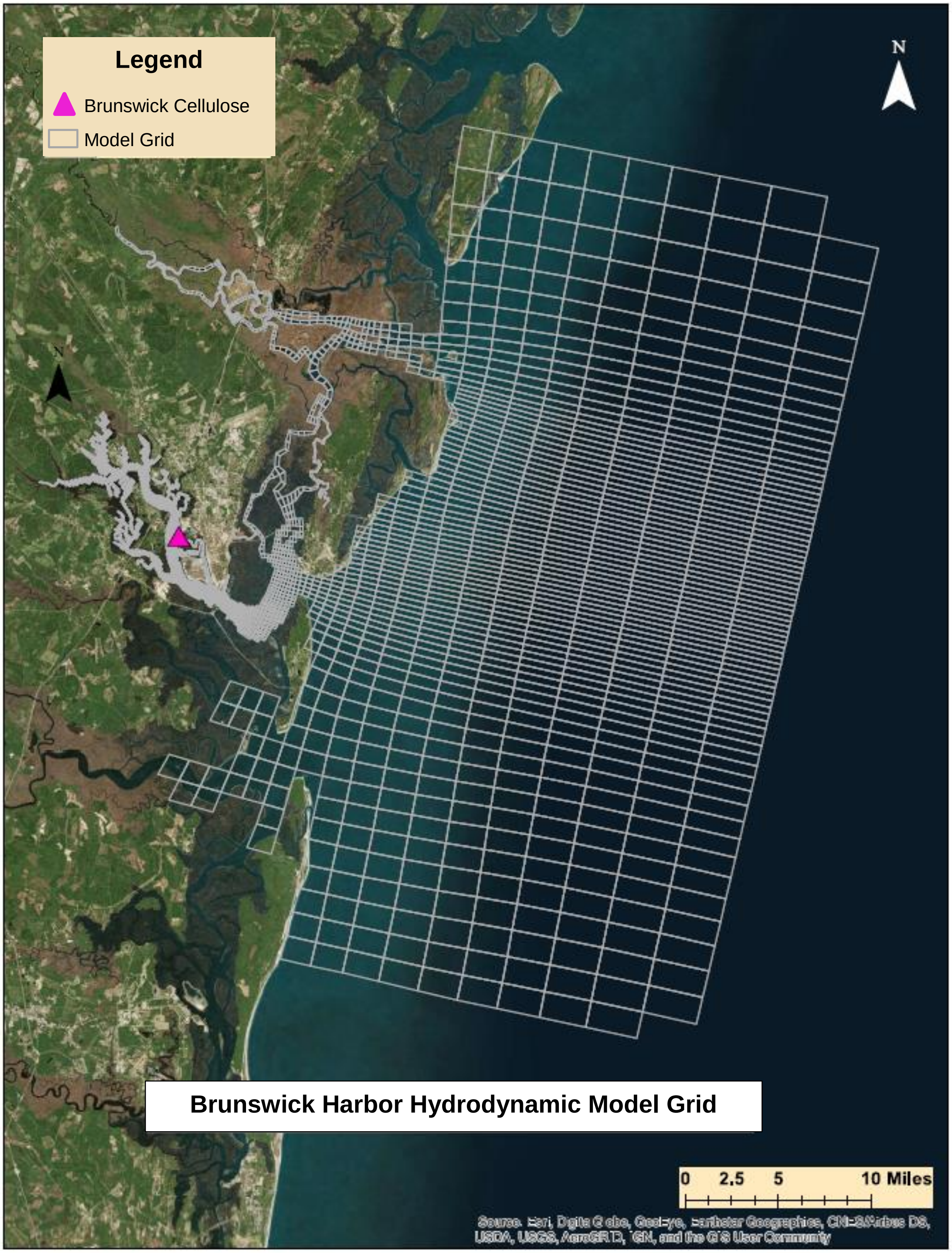

Figure 8. Brunswick Harbor Hydrodynamic Model Grid

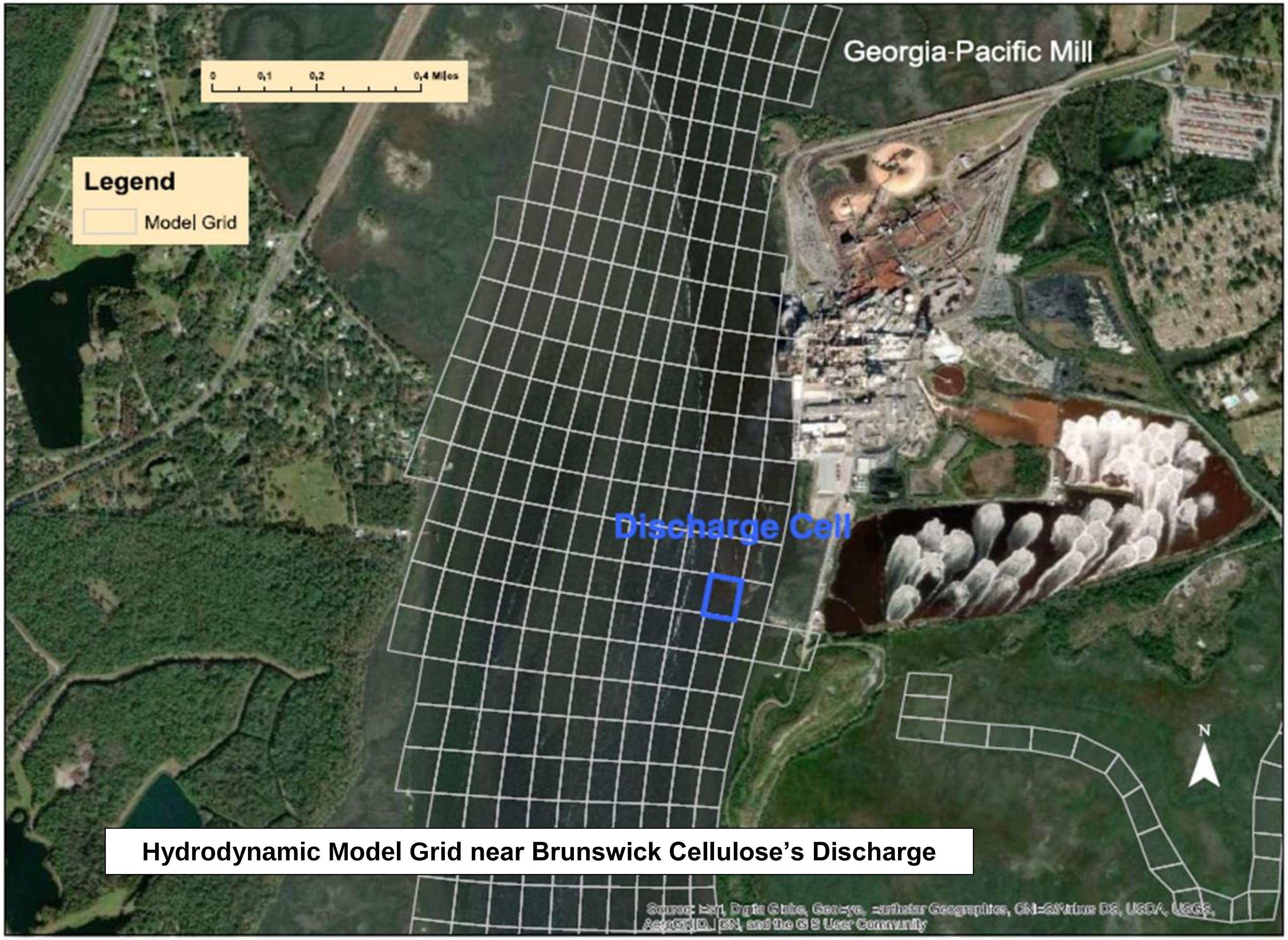

Figure 9. Hydrodynamic Model Grid near Brunswick Cellulose's Discharge

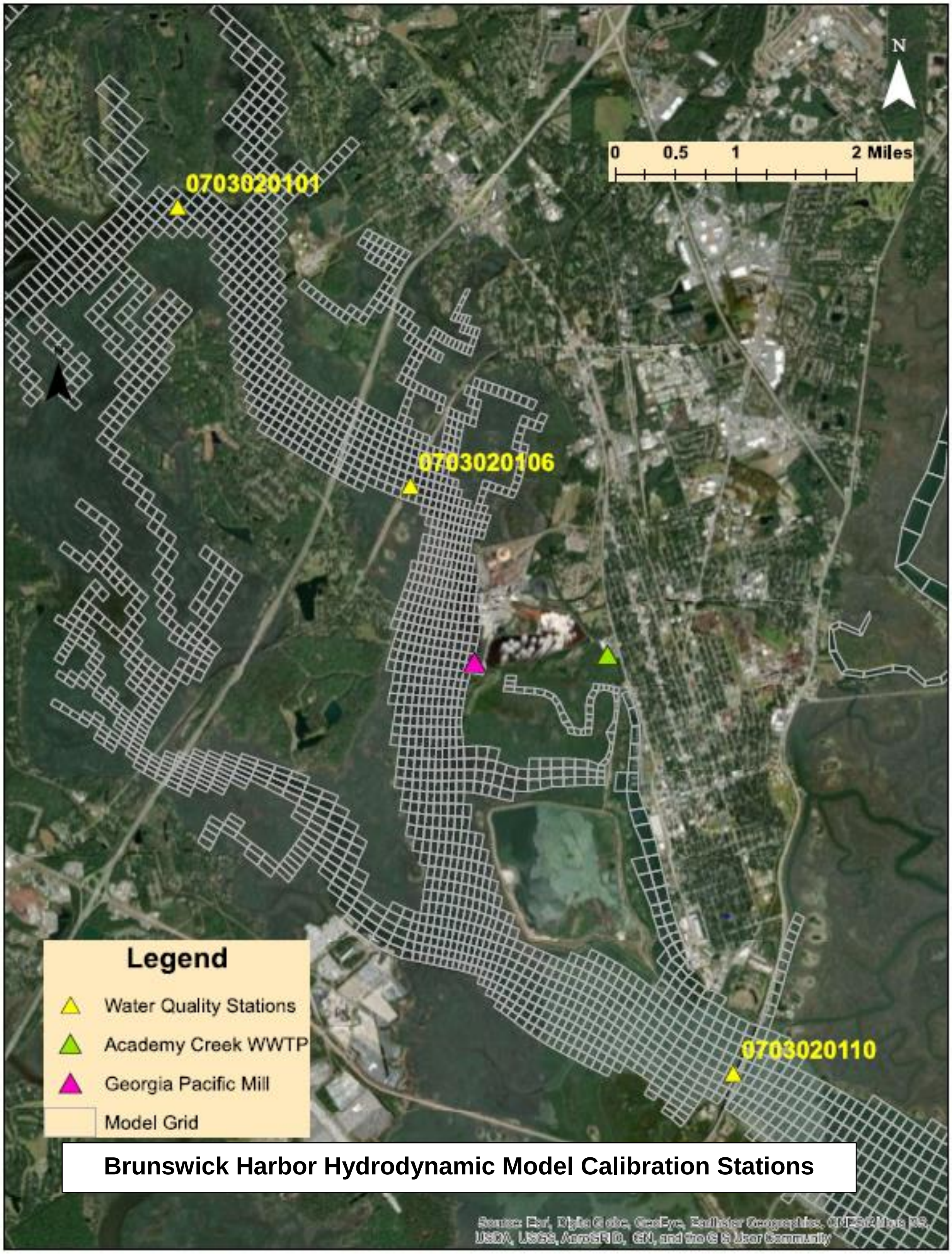

Figure 10. Brunswick Harbor Hydrodynamic Model Calibration Stations

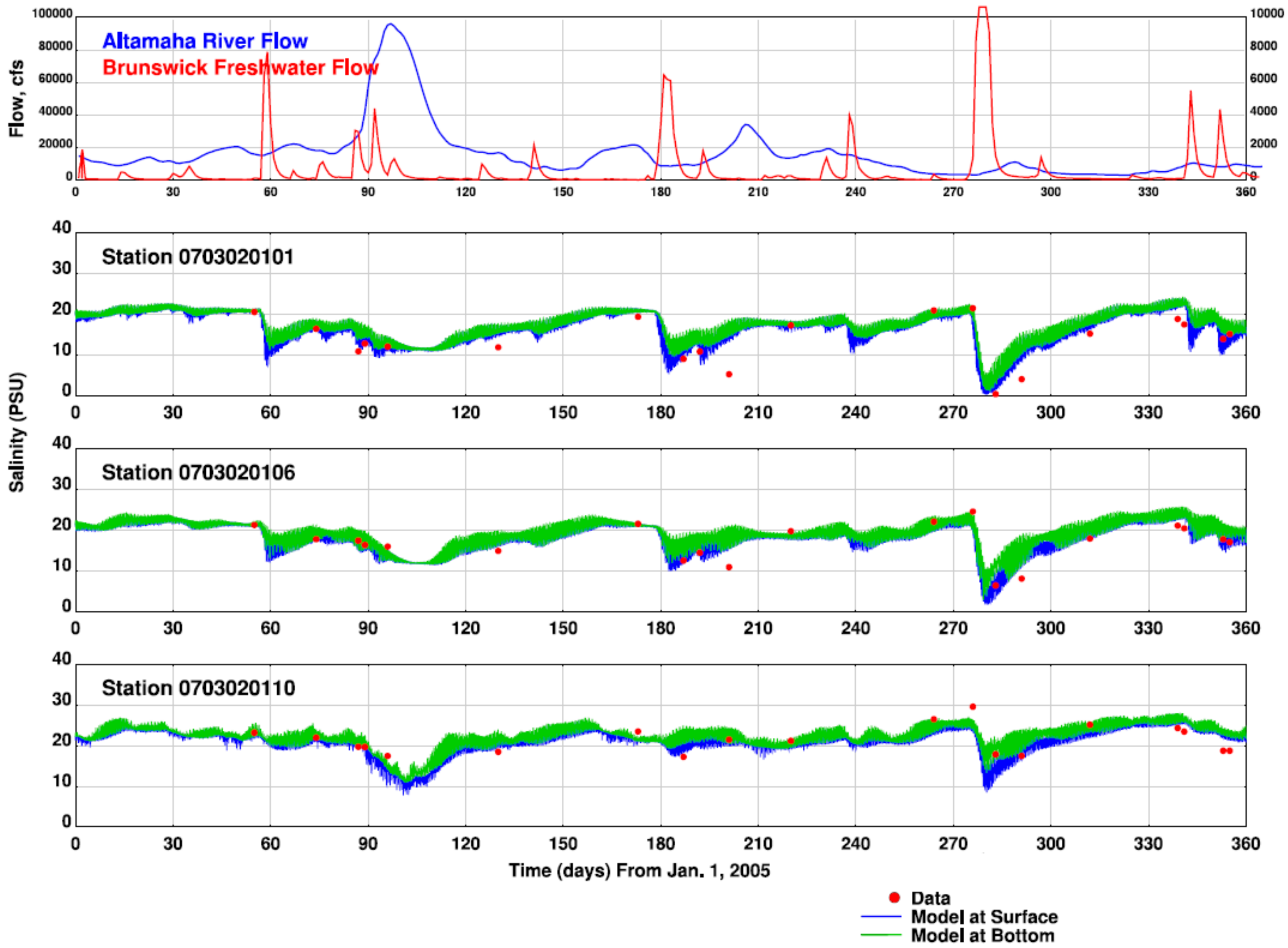

Figure 11. Brunswick Harbor Hydrodynamic Model Calibration – Salinity (2005)

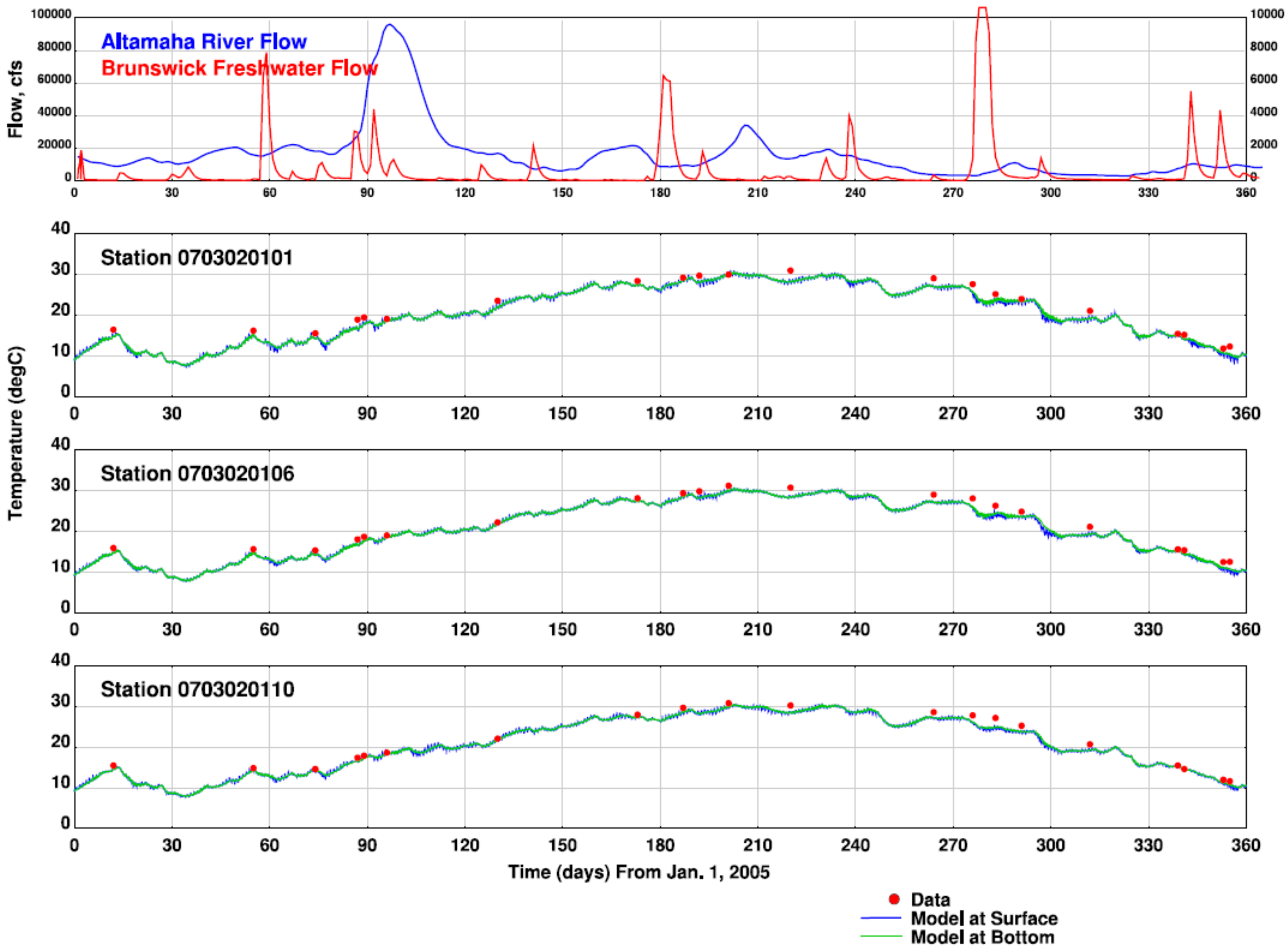

Figure 12. Brunswick Harbor Hydrodynamic Model Calibration – Temperature (2005)

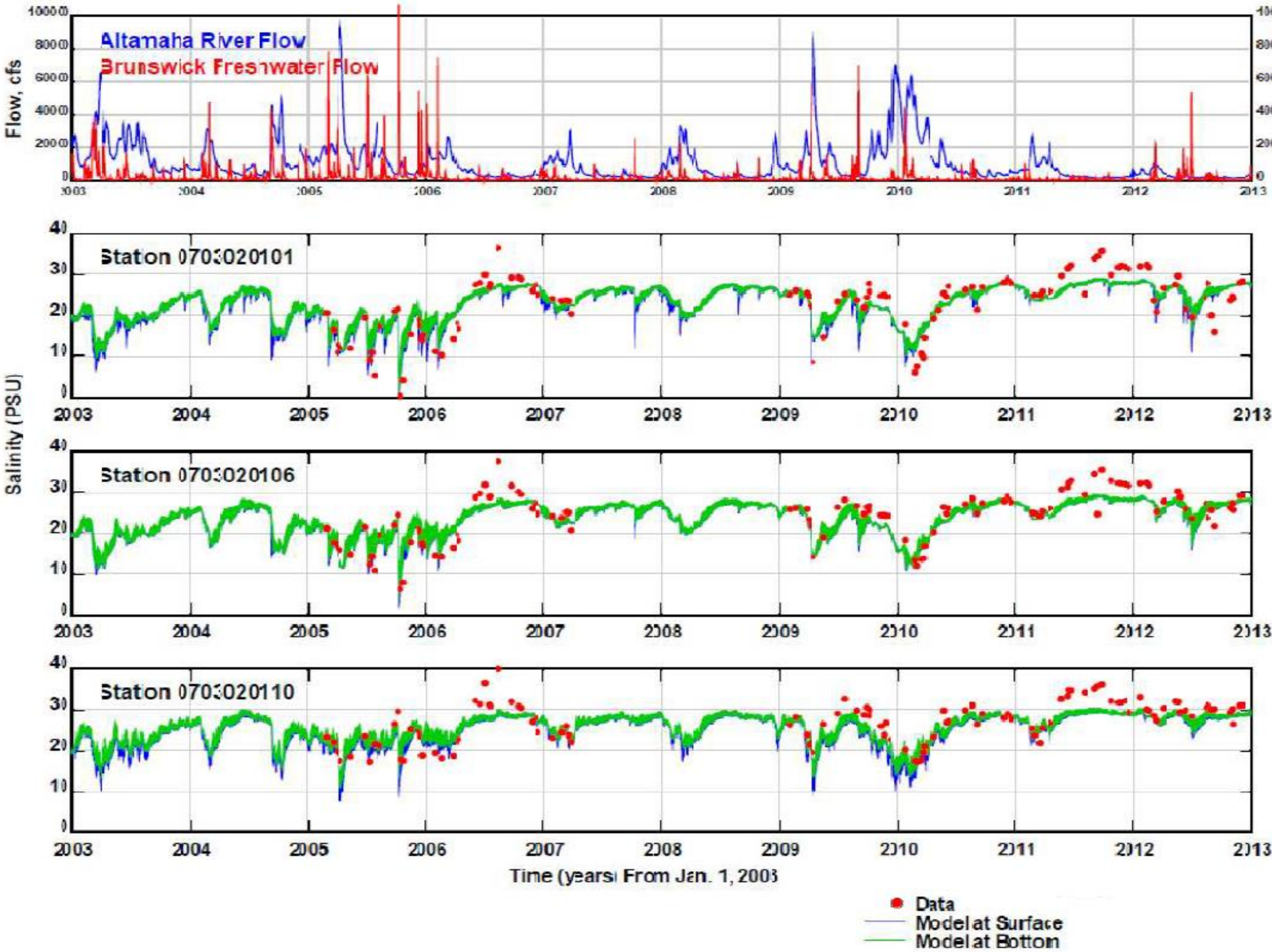

Figure 13. Brunswick Harbor Hydrodynamic Model Validation – Salinity (2003-2012)

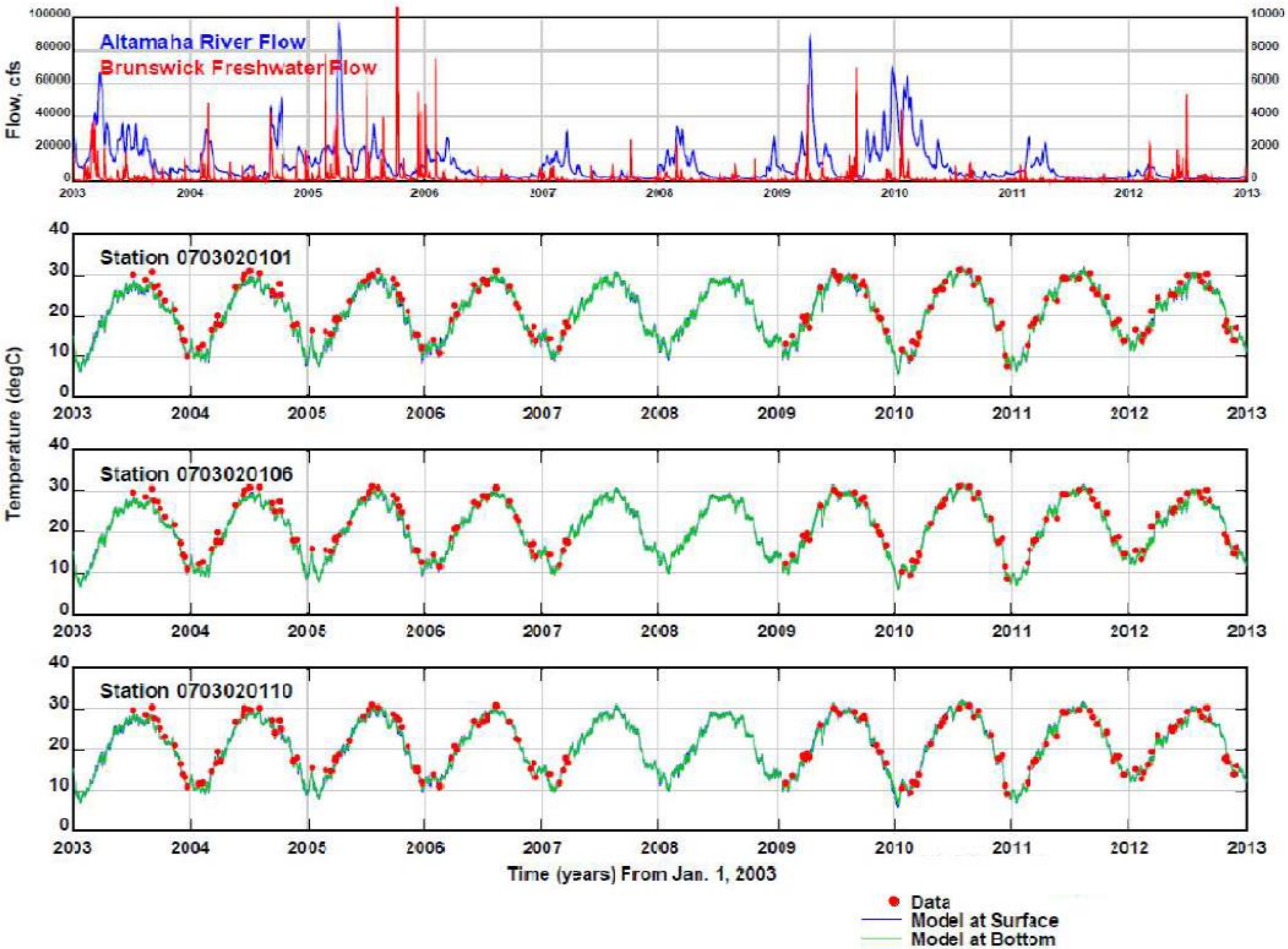

Figure 14. Brunswick Harbor Hydrodynamic Model Validation – Temperature (2003-2012)

4.2 Water Quality Model Calibration

The water quality model developed by HDR is a modification of the water quality model developed by Tetra Tech and summarized in the 2016 Brunswick Harbor Modeling Report (Tetra Tech 2016). The water quality model HDR used is Row Column AESOP (RCA).

The water quality model state variables in HDR's RCA water quality model are listed below:

- Dissolved Oxygen (DO);
- Ammonia (NH3);
- Nitrite + Nitrate (NO2 + NO3);
- Organic Nitrogen;
- Orthophosphate (PO4);
- Organic Phosphorus;
- Organic Carbon (particulate/dissolved - labile and refractory);
- Biochemical Oxygen Demand (BOD5); and
- Algae (as represented by chlorophyll-a).

The computed DO in the water quality model is driven by the oxidation of carbon (CBOD) and ammonia nitrogen (NBOD), sediment oxygen demand (SOD), the net oxygen production by algae (P&R), and the exchange of oxygen between the atmosphere and receiving water (reaeration). In addition, the growth of algae is controlled by the available nutrients (nitrogen and phosphorus) and water clarity (light extinction coefficient). The following sections summarize the sources of the various forms of carbon, nitrogen, and phosphorus to the Brunswick Estuary.

<u>Point Sources</u>

Four point sources were included in the RCA calibration model. These point sources included Brunswick Cellulose, Glynn County Academy Creek Wastewater Treatment Plant, Glynn County Saint Simons Island Wastewater Treatment Plant, and Pinova. Table 9 contains the average effluent flow and water quality concentrations for each of the point sources observed from 2001 to 2012. The location of these point sources is indicated in Figure 15.

Table 9. Brunswick Harbor Point Sources Average Flow and Water Quality Concentrations

Discharger	Receiving Stream	Average Concentration (mg/L)								Flow (MGD)
		RPOC	DOC	NH3	NOx	Org N	PO4	Org P	DO	
St Simon's Island	Dunbar Creek	2	2	0.28	0.61	1.3	1.68	0.72	6.2	2.74
Pinova	Dupree Creek	16.87	16.87	0.66	2.37	0.17	0.3	0.13	5	7.3
Academy Creek	Academy Creek	3.4	3.4	2.65	5.8	1.78	1.47	1.91	6.04	13.47
Brunswick Cellulose	Turtle River	Time Variable	Time Variable	1.64	0.07	2.65	1.65	0.7	5.0	28.3

Five-day BOD (BOD5) is not directly input to the water quality model and must be converted to total organic carbon (TOC). The following equation is used for this conversion.

$$TOC = BOD5 \times \text{f-ratio} / 2.67$$

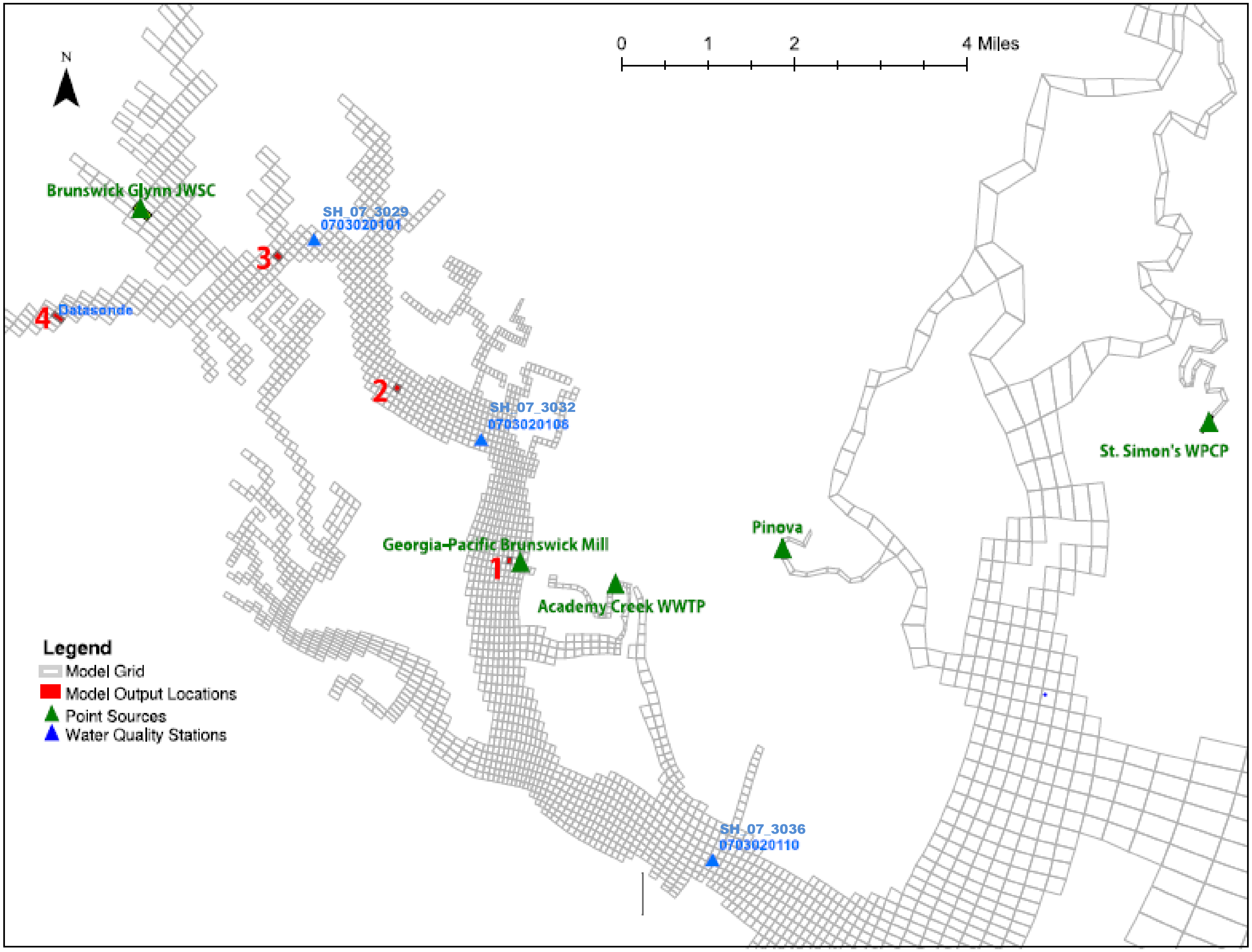

Figure 15. Brunswick Harbor Modeled Point Source Locations

Where f-ratio is the ultimate total carbonaceous oxygen demand ($CBOD_u$) to BOD5 ratio and is determined from long-term BOD studies. The TOC is equivalent to the refractory particulate organic carbon (RPOC) and the dissolved organic carbon (DOC). For all point sources, except Brunswick Cellulose, an f-ratio of 3.5 was used. From long-term BOD studies of the Brunswick Cellulose effluent, GA EPD determined that there are fast and slow reacting components in the Brunswick Cellulose effluent BOD, with the fast component comprising 60% of the total carbonaceous BOD5 and the slow reacting component the remaining 40%. The first order oxidation rates for the fast and slow reacting CBOD components are 0.10/day and 0.01/day, respectively. For these conditions, the equivalent f-ratio for converting the measured BOD_5 to total $CBOD_u$ is 3.9. For the Brunswick Cellulose discharge, the model also includes the permit oxygen addition requirements summarized in Table 3.

Tributaries

Tetra Tech developed a calibrated Loading Simulation Program in C++ (LSPC) model to represent the flow and water quality of tributaries in the Brunswick Estuary watershed. The LSPC model was calibrated and validated for BOD_5, DO, total nitrogen (TN), nitrate + nitrite (NO_2+NO_3), ammonia (NH_3), organic nitrogen, total phosphorus (TP), ortho-phosphate (PO_4), organic phosphorus, and chlorophyll-a (Chl-a) using observed data collected at various stations throughout the Brunswick Estuary watershed. The output from the LSPC watershed model was used to represent the runoff to the Estuary. The LSPC model was calibrated for temperature, dissolved oxygen, nitrate-nitrite, ammonia, organic nitrogen, ortho-phosphorus, organic phosphorus, total suspended solids, and chlorophyll *a*. HDR generally used the results of the LSPC model with minor adjustments to improve calibration of the estuary model. However, the incoming DO for the urban tributaries that discharge to Academy, Dunbar and Dupree Creeks were increased to 70% saturation to represent the reaeration that occurs as stormwater runs off the paved areas. LSPC output parameters do not directly link up with the RCA input parameters. Therefore, the LSPC outputs were “linked” to EFDC, which was then converted to RCA inputs through various equations. Table 10 presents what LSPC parameter is used for each RCA parameter. Note that the LSPC outputs are in English units, whereas the RCA inputs are in metric units. Therefore, the factor of 0.4536 was used to convert from lbs/day to kg/day.

Table 10. Parameter Linkage for LSPC to RCA

Parameter	LSPC Parameters	RCA Parameters
Flow	RO or PERO	Flow
Temperature	TEMP	Temp
Dissolved Oxygen	DOx	DO
Biochemical Oxygen Demand (5-day)	BOD5	LDOC, RPOC LPOC, RDOC
Nitrate + Nitrite	NO3 + NO2	NO23
Ammonia	TAM	NH4T
Organic Nitrogen	ORN	LDON, RPON
Orthophosphate	PO4	PO4T
Organic Phosphorus	ORP	LDOP, RPOP

Selected tributary flows were also distributed closer to the main channel rather than within these small creeks to better represent the flows.

Boundary Conditions

Water quality in the Brunswick Estuary is affected by the water quality at the model boundaries, including the headwaters of the Turtle and Brunswick Rivers, the Altamaha River, and the open ocean tidal boundary. The Turtle and Brunswick Rivers headwater quality was based on the Tetra Tech modeling analysis. The Altamaha River boundary water quality was based on limited water quality data and the open ocean water quality boundary was based on estimates derived from other water quality and model calibration studies. A summary of model boundary water quality inputs is presented in Table 11.

Table 11. Oceanic Boundary Conditions

Parameter	Concentration (mg/L)
Algal Carbon	0.05
RPOP	0.008
LPOP	0.002
RDOP	0.032
LDOP	0.008
PO4T	0.05
RPON	0.08
LPON	0.02
RDON	0.32
LDON	0.08
NH4T	0.025
NO23	0.025
SIUB	0.05
SITA	0.1
RPOC	0.32
LPOC	0.08
RDOC	1.28
LDOC	0.32
DOXG	90 % Saturation
Color	15 PCU

Marsh Loads

Field studies performed in 1982 indicated that TOC is exported from the extensive marshes within the Brunswick Estuary Watershed (Law Engineering, 1983). Tetra Tech, guided by the results of these studies, developed TOC loads from the marshes from a calibration of the Brunswick Estuary TOC and DO levels. The marsh TOC loads were partitioned into refractory particulate organic carbon and labile dissolved organic carbon with oxidation rates of 0.01/day and 0.10/day, respectively. In addition, Tetra Tech assigned a seasonal marsh TOC loading pattern based on literature (Neubauer, et al, 2003). HDR used Tetra Tech's marsh TOC loads for the present study with the exception of eliminating the December and January marsh loads based on model calibration. Table 12 summarizes the monthly marsh TOC loads.

Table 12. Monthly Marsh TOC Loads

Marsh Loads (lbs/day)		
Month	**RPOC**	**DOC**
January	0	0
February	162,702	40,676
March	221,917	55,479
April	217,123	68,031
May	383,196	95,799
June	494,045	123,511
July	554,983	138,746
August	504,849	126,212
September	394,119	98,530
October	282,927	70,732
November	22,160	55,540
December	0	0

Academy Creek's marsh load was moved out of the creek closer to the mainstem so as to not overestimate the effect of the marsh load due to limited marsh load input locations in the estuary.

Sediment Oxygen Demand (SOD)

EPA measured SOD in the Brunswick Estuary in 1982 (Law Engineering, 1983). Based on these SOD measurements and model calibration, HDR assigned SOD values for different zones of the Brunswick Estuary. Figure 16 shows the SOD zones and Table 13 summarizes the SOD values for each zone. The SOD in the small tidal creeks was reduced to 0.34 to account for the very shallow areas that are temporally exposed or dry during certain tidal conditions.

Table 13. SOD Spatial Assignments

SOD Zone	SOD at 20^oC (gO_2/m^2/day)
1	0.4
2	0.6
3	0.8
4	0.6
5	0.3
6	0.8
7	0.3
8	0.34
9	0.4

Color Loads

The color concentration in the Brunswick Estuary is important to the model calibration analyses because it affects the light regime for algal growth and also contributes dissolved organic carbon (DOC) in the estuary. Although there is no estuary color data for the model calibration years, HDR developed a relationship between estuary color and salinity measurements made as part of the Brunswick Estuary 1982 water quality field survey (Law Engineering, 1983). This relationship is indicated by the red squares in Figure 17. Based on limited color measurements, HDR assigned all tributary color concentrations at 400 platinum cobalt units (PCUs), open ocean color at 15 PCU, and a flow dependent color concentration for the Altamaha River. The Brunswick Cellulose effluent color was assigned at 1,000 PCU. With these color inputs, color was calculated with the model for the calibration years 2005, 2006, and 2009, representing high, low and medium river flow conditions. The computed paired color and salinity values were plotted in Figure 17 as small gray squares. The model-computed color salinity relationship reproduces the 1982 data-based relationship indicating the model properly represents color levels in the Brunswick Estuary.

4.3 Model Rates and Constants

A summary of the major model coefficients is presented in Table 14. These coefficients were based on field measurements, previous studies, and model calibration. The model coefficients that most significantly affect the Brunswick Estuary DO balance are the marsh TOC oxidation rates and the atmospheric reaeration rate.

Table 14. Model Parameters and Constants

Parameter	Value	Unit
Saturated Phytoplankton Growth Rate	3	1/day
Saturating Algal Light Intensity	350	LY/day
Basal Respiration Rate	0.1	1/day
Growth-Dependent Respiration Coefficient	0	
Carbon to Chlorophyll ratio	50	mg C/mg Chl-a
Base Algal settling rate	0.1	m/day
RPOP hydrolysis	0.01	1/day
LPOP hydrolysis	0.05	1/day
RDOP mineralization	0.01	1/day
LDOP mineralization	0.05	1/day
RPON hydrolysis	0.01	1/day
LPON hydrolysis	0.05	1/day
RDON mineralization	0.01	1/day
LDON mineralization	0.05	1/day
Nitrification Rate	0.05	1/day
RPOC hydrolysis	0.01	1/day
LPOC hydrolysis	0.01	1/day
RDOC oxidation	0.01	1/day
LDOC oxidation	0.1	1/day
Base Light Extinction Coefficient	1.5	1/m
Chlorophyll Extinction Coefficient	0.017	1/m/ug/L
Color Extinction Coefficient	0.02	1/m/PCU
Oxygen Transfer Rate	1.5	m/day

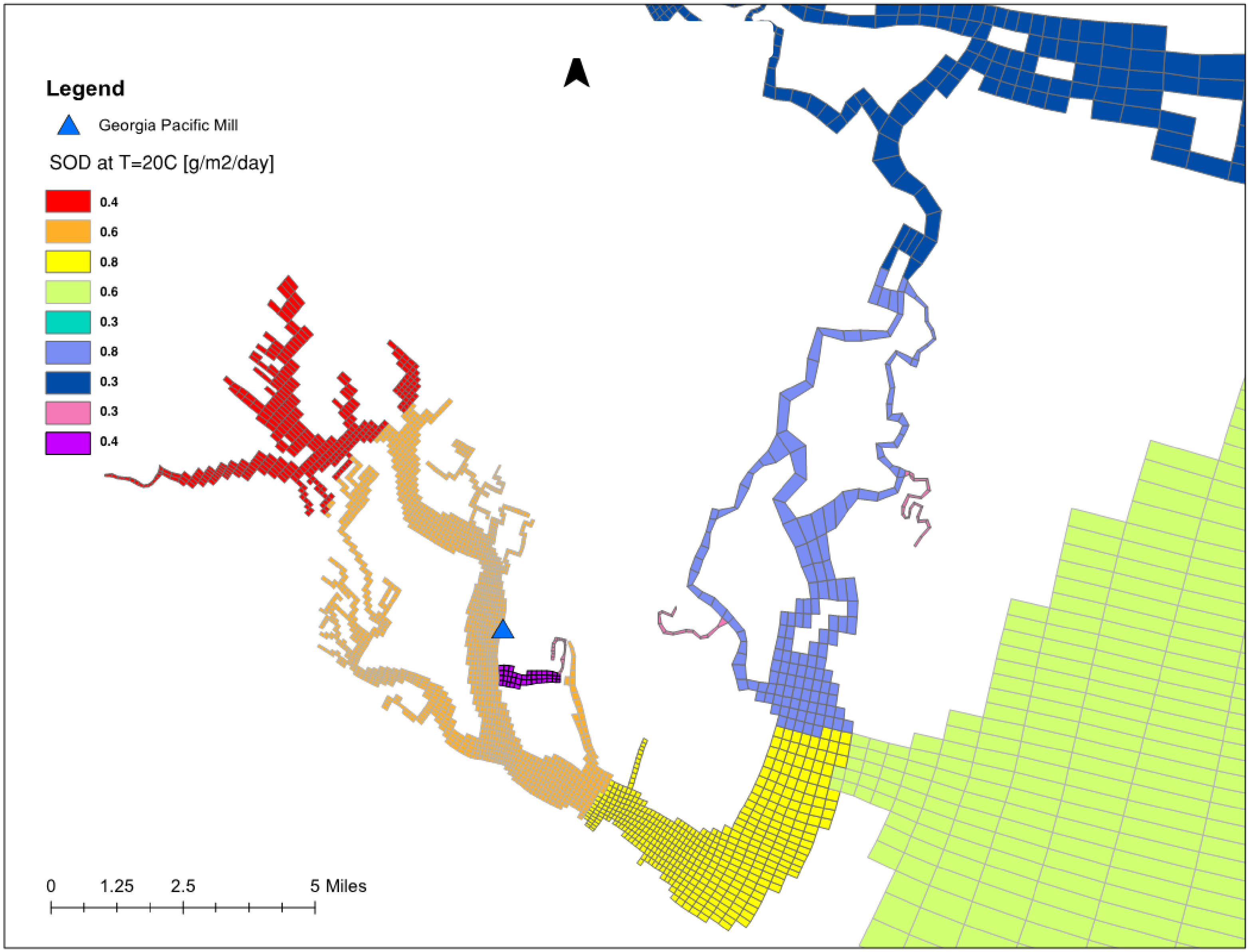

Figure 16. Brunswick Harbor SOD Zones

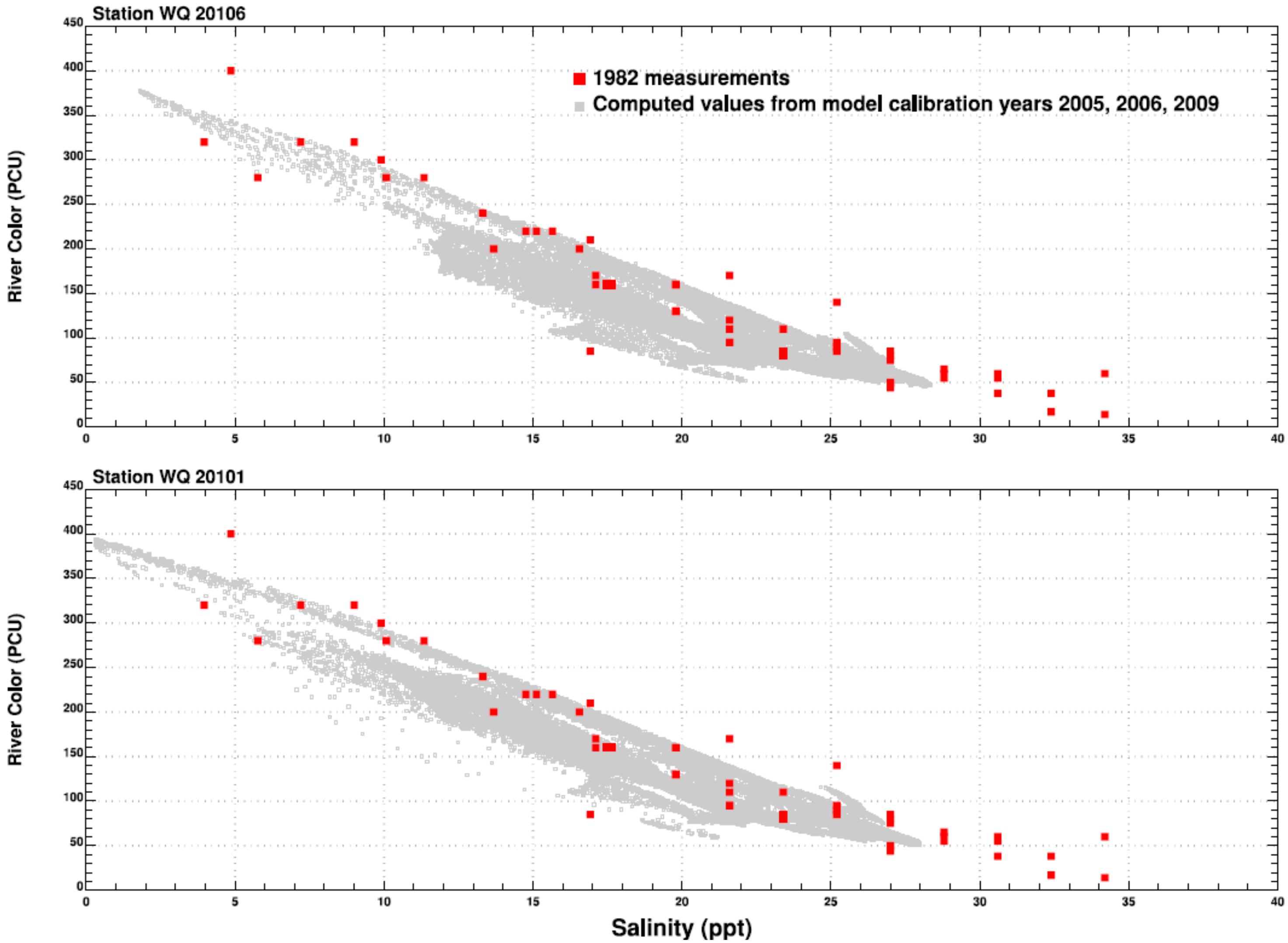

Figure 17. Brunswick RCA Model Color Versus Salinity

4.4 Model Calibration Results

The water quality model calibration was performed for three years representative of high (2005), low (2006) and medium (2009) river flow conditions. The results of the calibration analyses are presented in Figures 18a through 18h. The top panel in each figure is a temporal plot of the freshwater flow in the Turtle River (dark blue – right y-axis) and Altamaha River (light blue – left y-axis). The computed water quality is shown for the three stations indicated in Figure 5.

Figure 18a is a subset of the salinity model calibration comparison presented in Figure 12. It is notable that during high flow events, either in the Turtle River or Altamaha River, estuary salinity values of 10 parts per thousand (ppt) or less are observed at stations 20101 and 20106 indicating that incoming freshwater quality significantly influences estuary water quality.

Figure 18b demonstrates the effect of freshwater inputs with the high computed estuary color concentration during high flows.

Figure 18c is a comparison of model computed TOC versus measured TOC at the three estuary stations. The green line indicates the computed estuary TOC considering only the marsh TOC loads. The red line is the calculated TOC, including the carbon associated with colored dissolved organic matter. Based on literature, TOC (mg/L) was calculated from color (PCU) as 0.06 times color (Molot, Lewis, and Dillon, 1997). Overall, the correlation of computed TOC and measured TOC is good with the exception of the high TOC measurements in early 2009. There is no obvious explanation for this discrepancy, especially in the beginning of 2009 when the river flows are low.

A comparison of the model results for inorganic nitrogen (NH_3 and NO_2+NO_3) and phosphorus (PO_4) required for algal growth are shown in Figures 18d, 18e and 18f. The comparison of model results and measured data is reasonable with both data and model indicating that the nutrient levels are generally above algal growth limiting concentrations. The higher model computed nitrate concentrations may be the result of diffusion of nitrate from the water column to the sediment and subsequent denitrification in the sediment that is not represented in this model framework. Computed Chl-a concentrations are shown in Figure 18g. Although there are no estuary measured Chl-a concentrations during these calibration years, the computed Chl-a concentrations are in the range of values measured during an August 2015 field survey (GA EPD, 2015b).

Figure 18h shows the comparison of model results and measured DO data for the three Turtle River stations for 2005, 2006, and 2009. The water quality model properly represents both the magnitude and seasonal changes in estuary DO levels. The measured DO data show more variability than the model results as expected because the model does not consider potential hour-to-hour variability that may result from variability in marsh TOC loads and marsh primary productivity. The model is considered sufficiently calibrated to perform model projections of expected daily average “natural” background DO levels in the Brunswick Estuary.

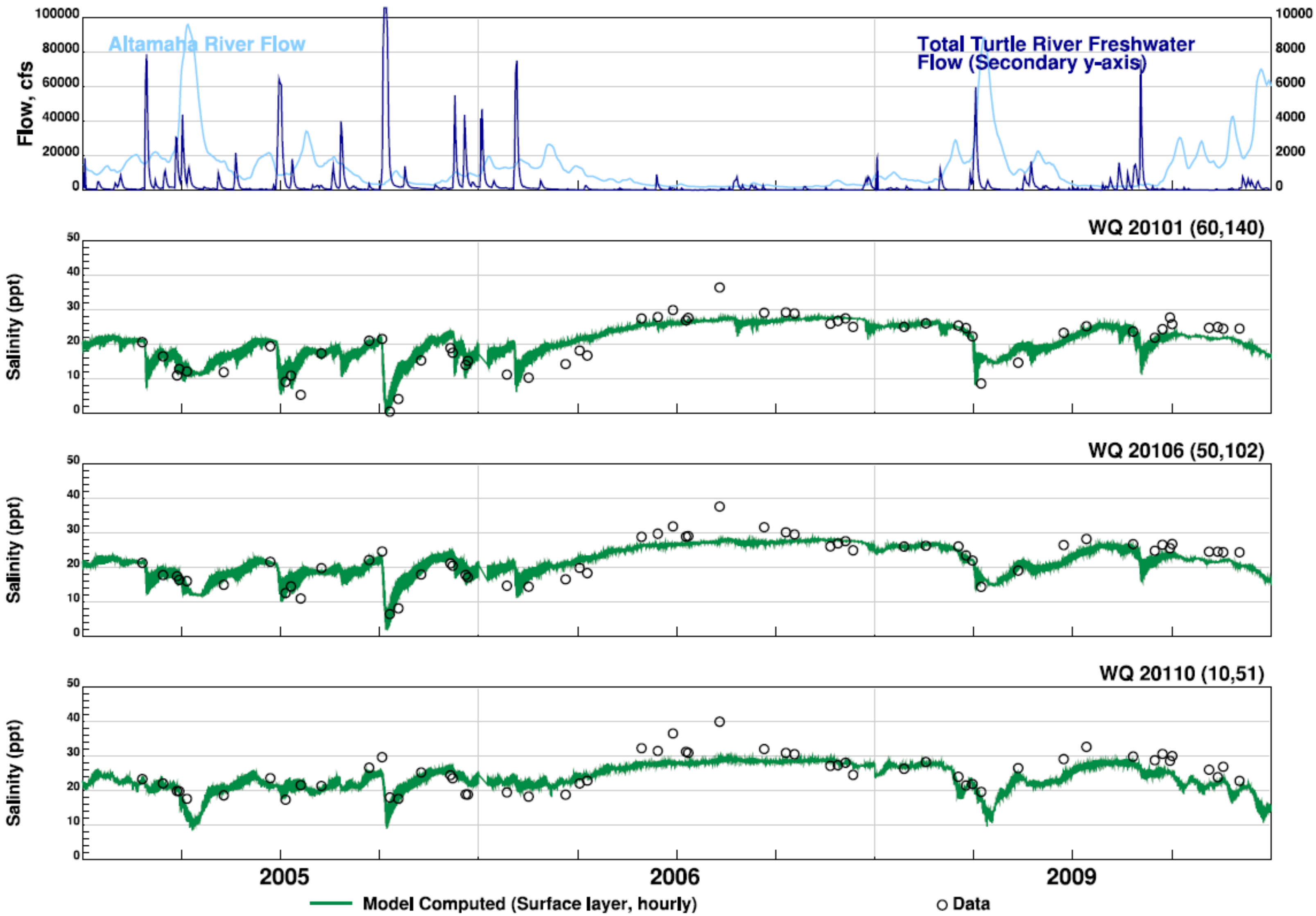

Figure 18a. Salinity Model-Data Comparison at Various Water Quality Stations for 2005, 2006, and 2009

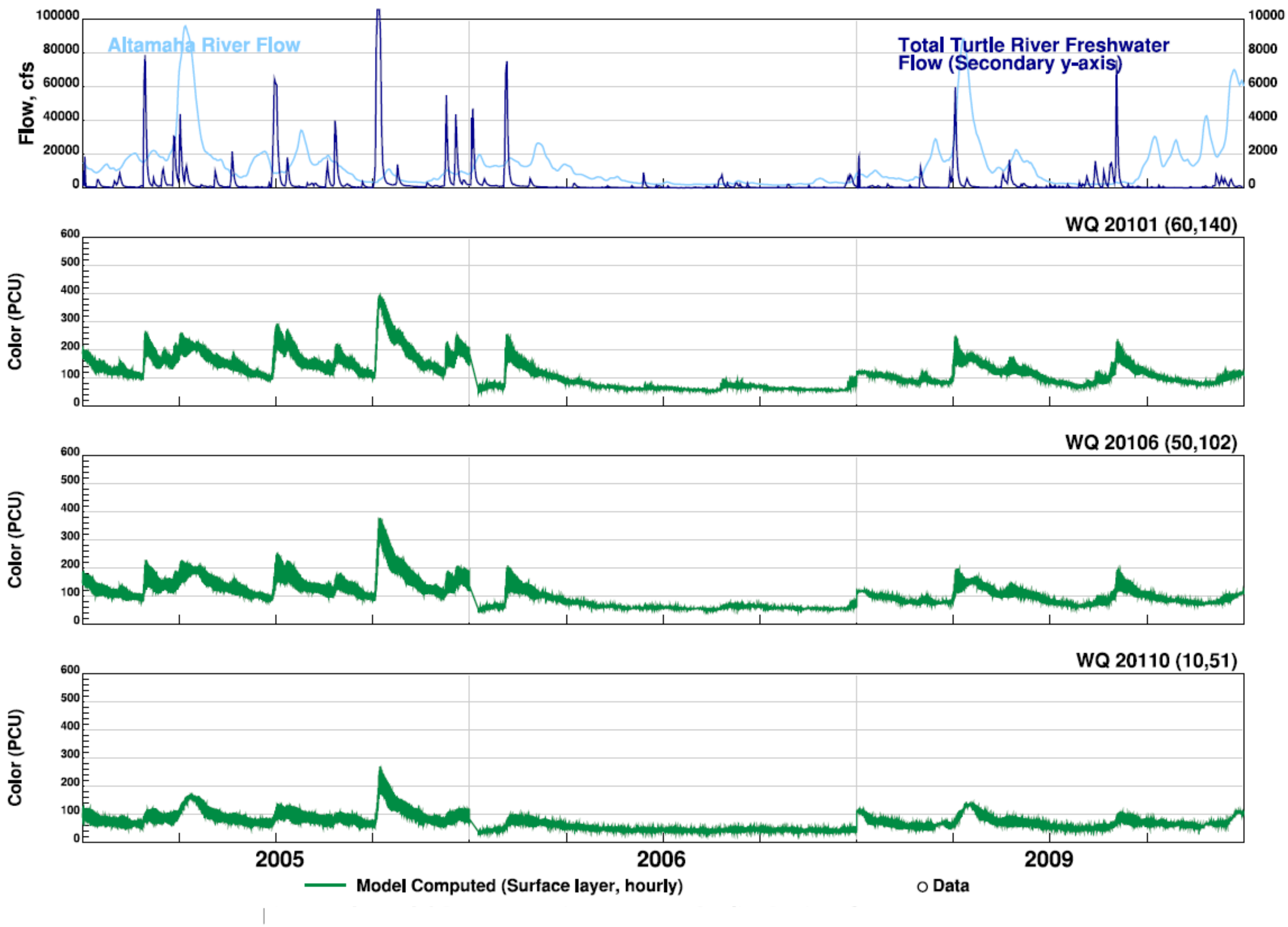

Figure 18b. Color Model-Data Comparison at Various Water Quality Stations for 2005, 2006, and 2009

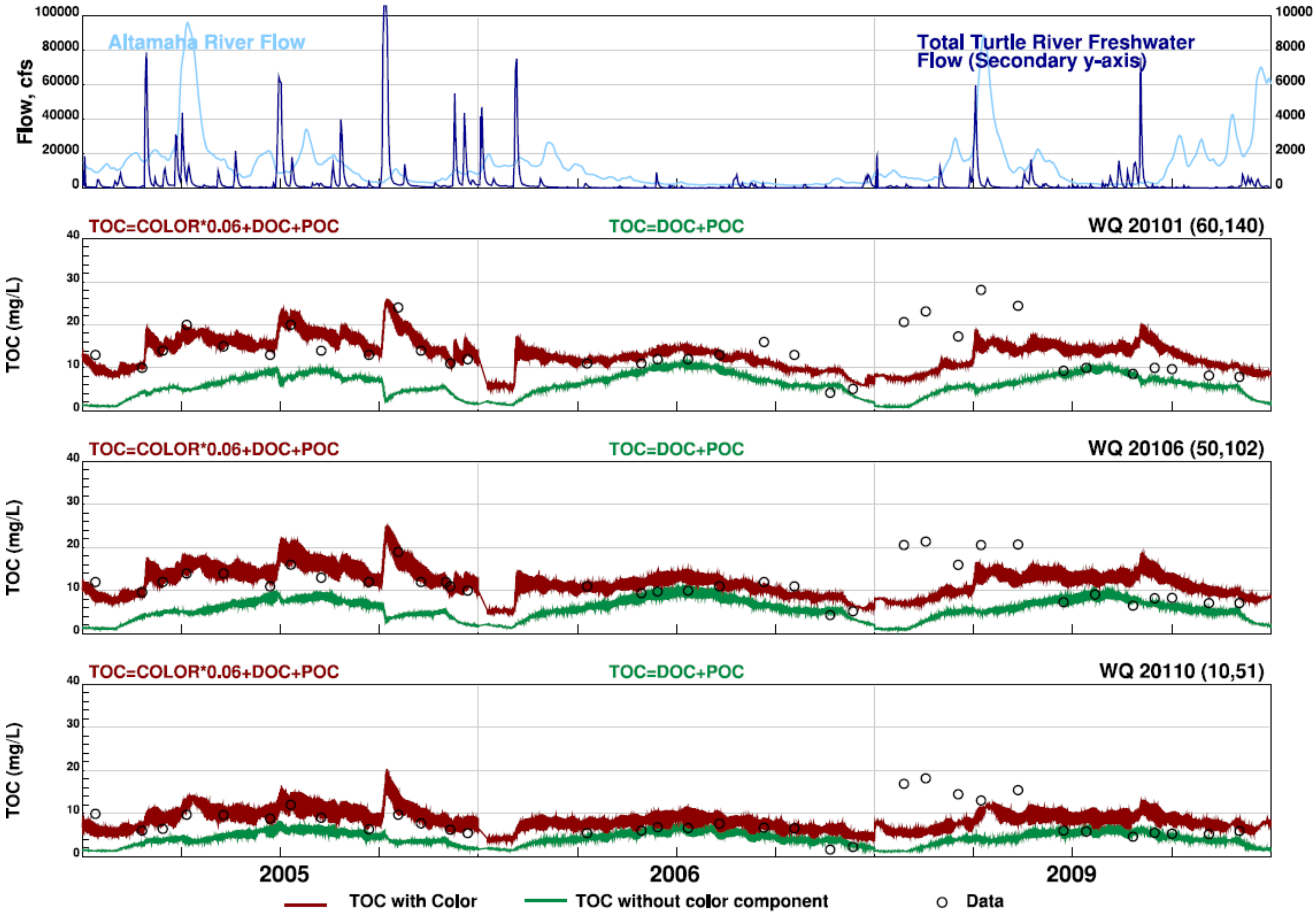

Figure 18c. TOC Model-Data Comparison at Various Water Quality Stations for 2005, 2006, and 2009

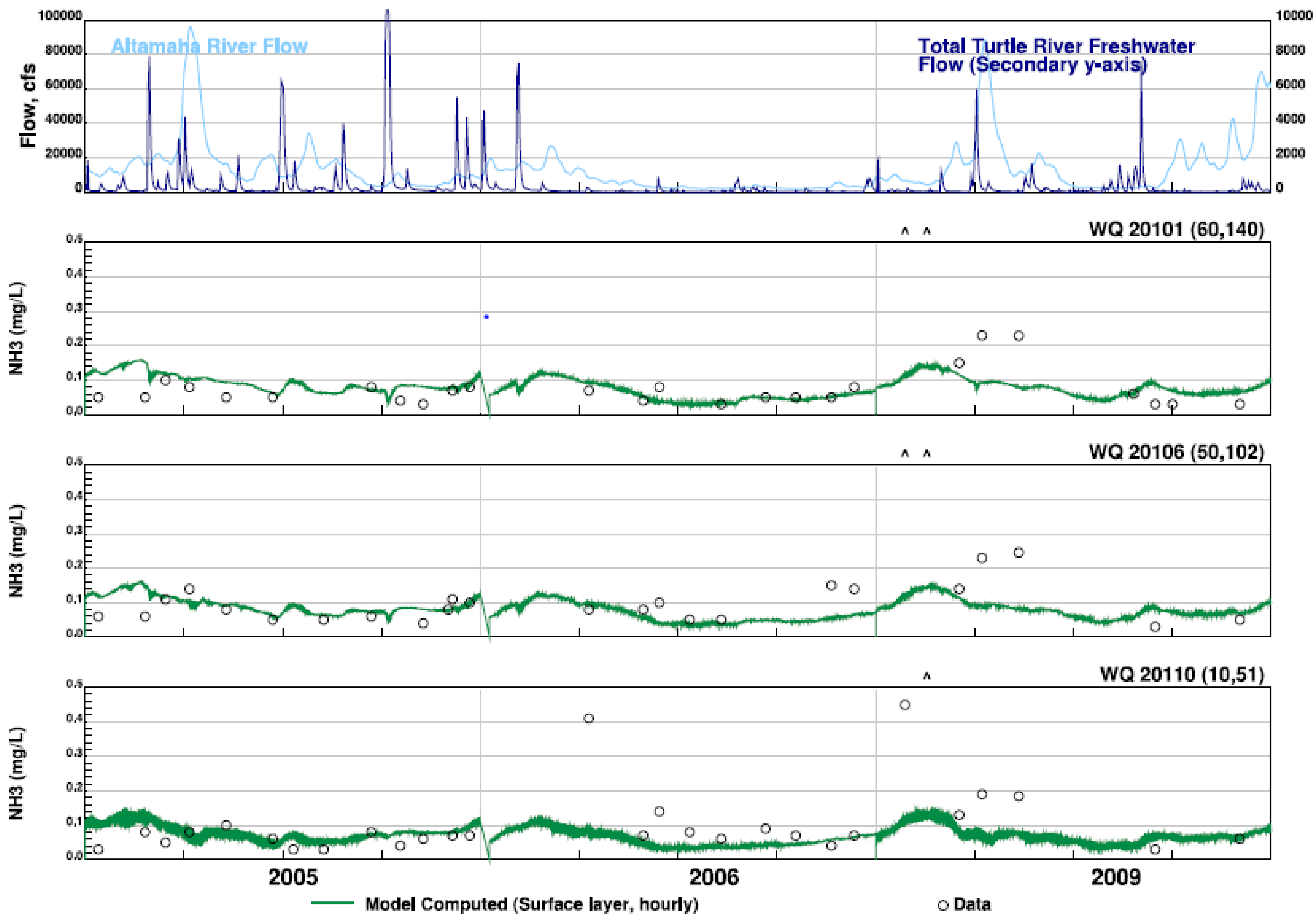

Figure 18d. NH3 Model-Data Comparison at Various Water Quality Stations for 2005, 2006, and 2009

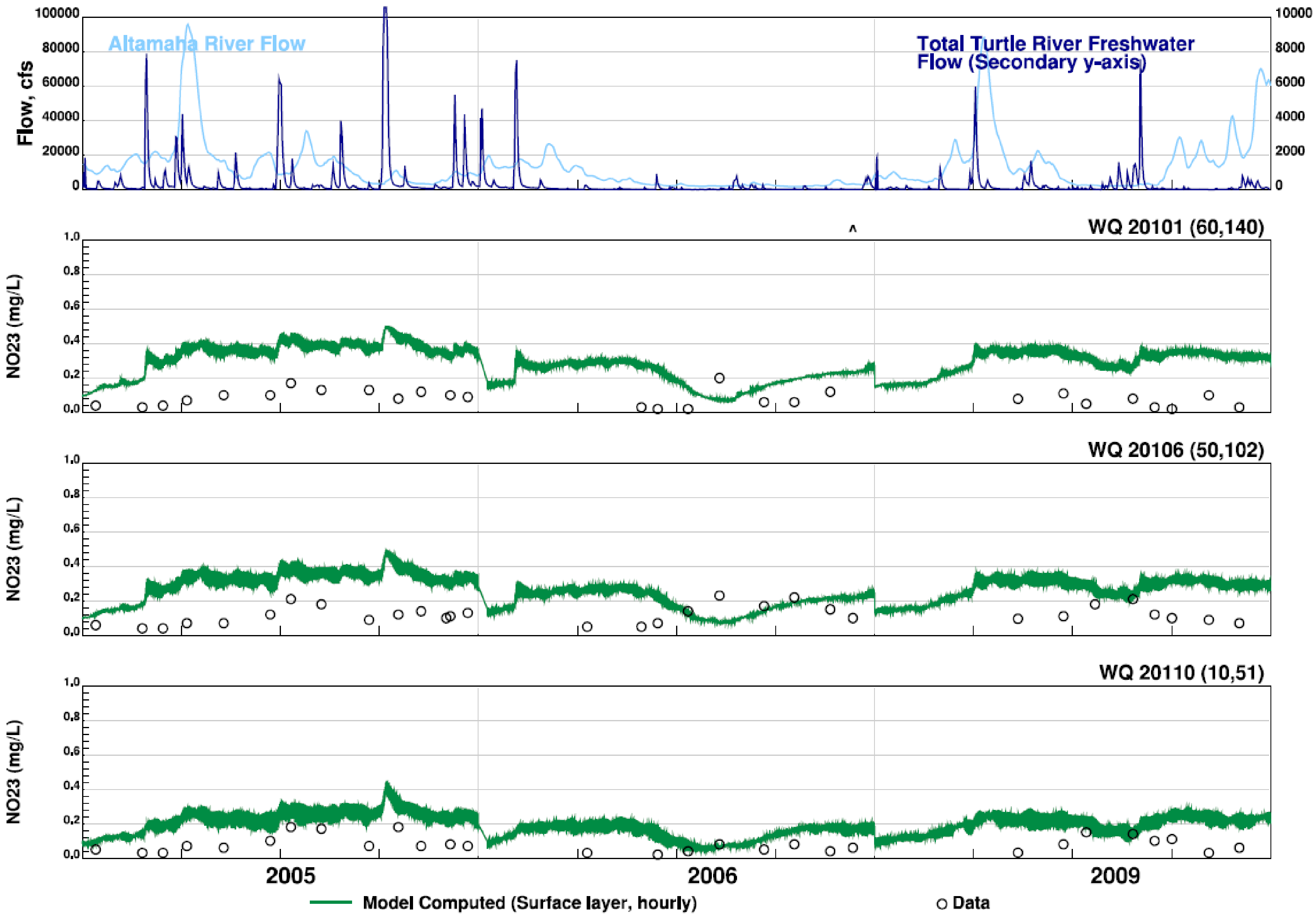

Figure 18e. NO2-NO3 Model-Data Comparison at Various Water Quality Stations for 2005, 2006, and 2009

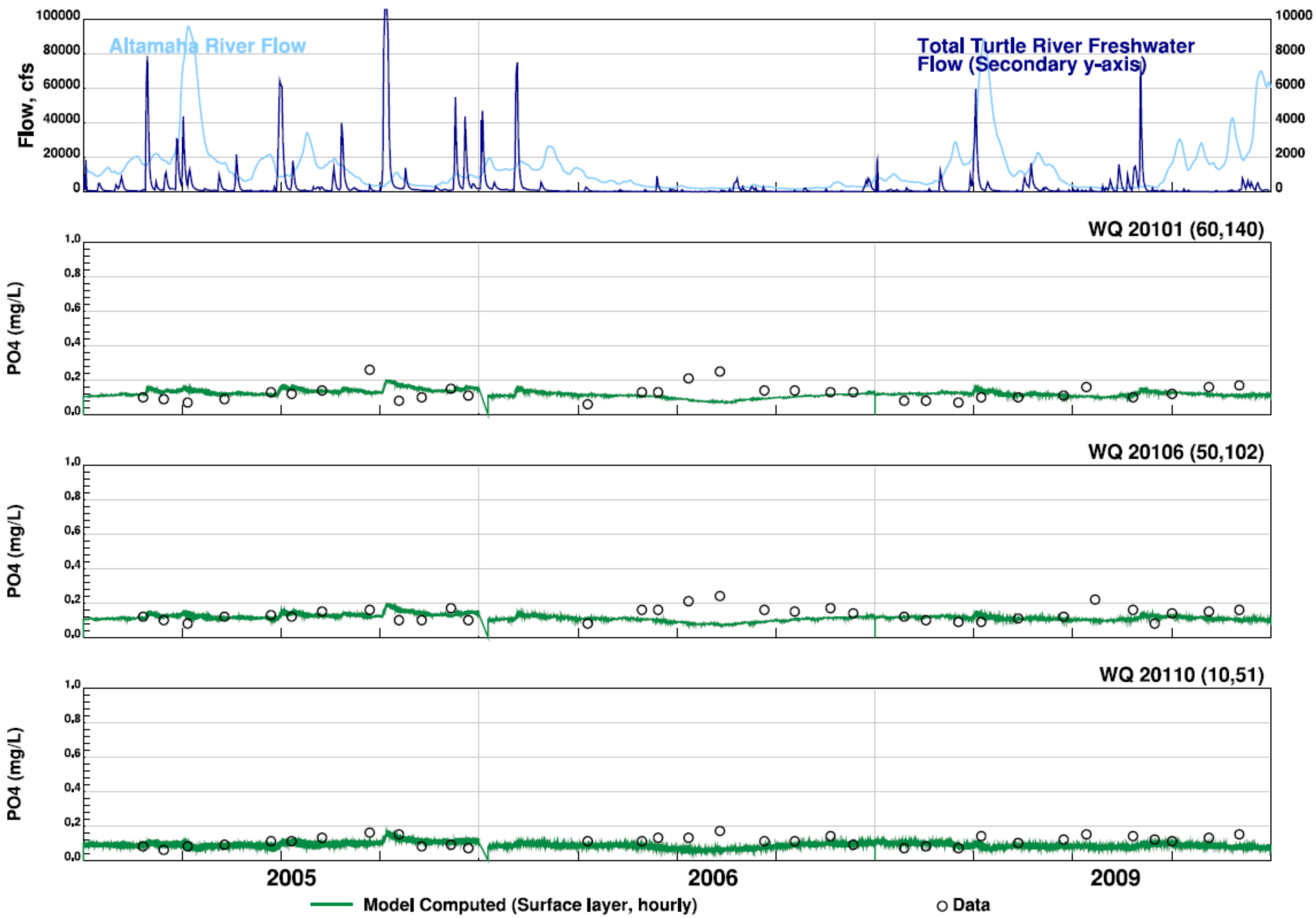

Figure 18f. PO4 Model-Data Comparison at Various Water Quality Stations for 2005, 2006, and 2009

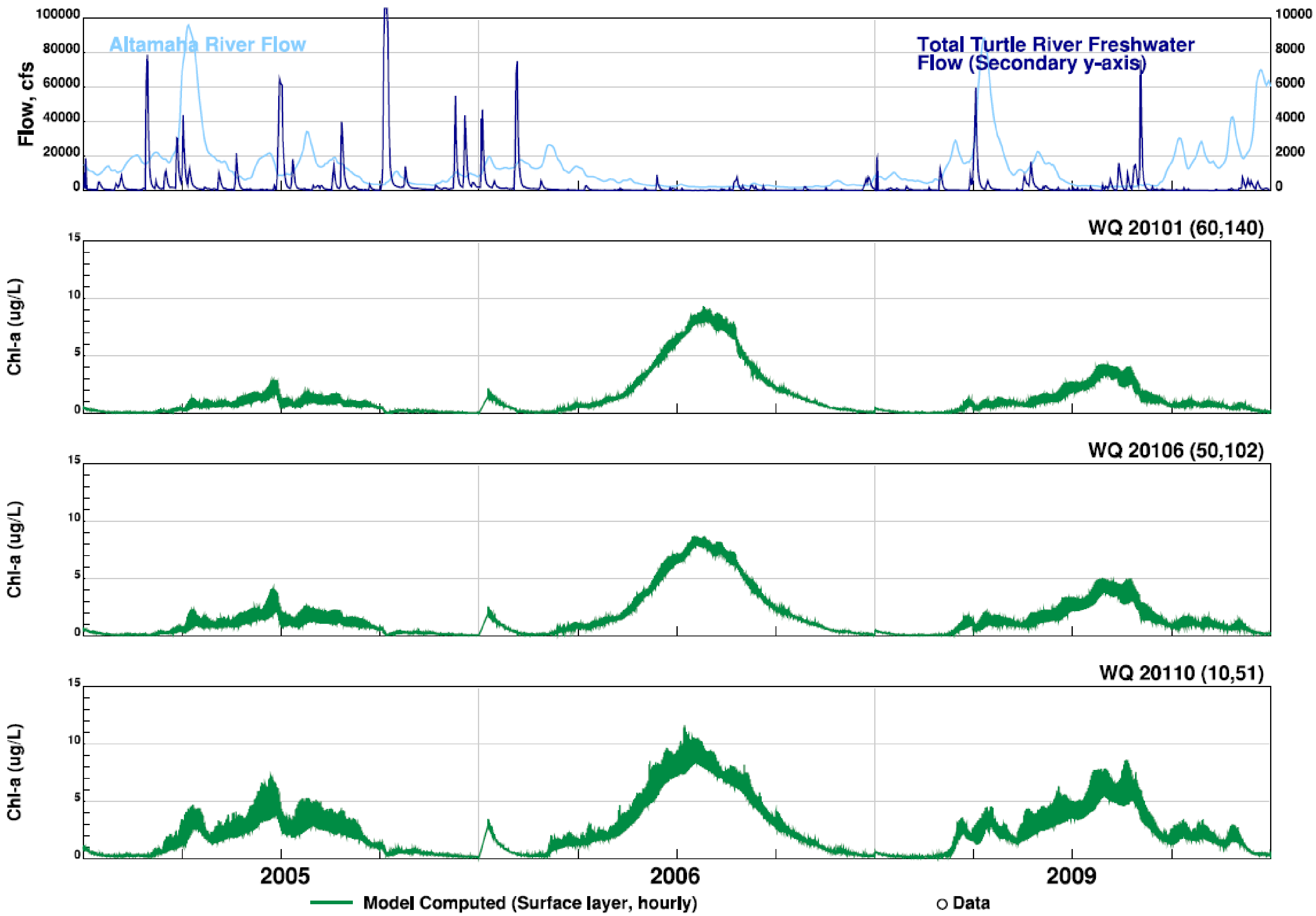

Figure 18g Chl-A Model-Data Comparison at Various Water Quality Stations for 2005, 2006, and 2009

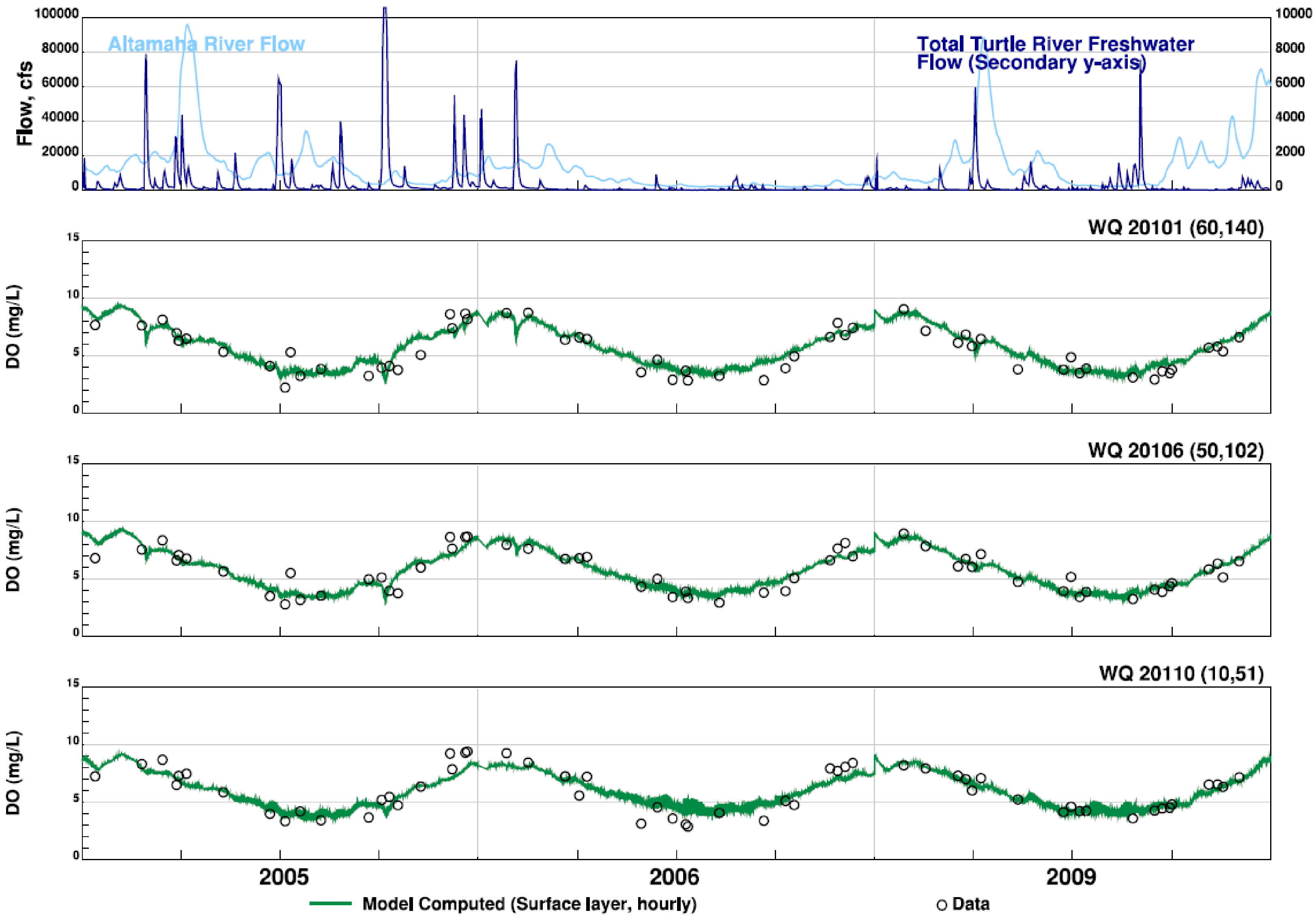

Figure 18h DO Model-Data Comparison at Various Water Quality Stations for 2005, 2006, and 2009

4.5 Model Projection of "Natural" Background DO and the Allowable Deficit

Four point sources were included in the RCA calibration model: Brunswick Cellulose, Glynn County Academy Creek Wastewater Treatment Plant, Glynn County Saint Simons Island Wastewater Treatment Plant, and Pinova. To compute the "natural" background DO for the Brunswick Estuary, the calibrated water model was run for the three years (2005, 2006, and 2009) without any point sources loads. In addition, the oxygen added to the Brunswick Estuary by Brunswick Cellulose was also removed. In the Brunswick and Turtle Rivers at RM 14.4, RM 7.36 and RM 4.11, the "natural" background DO is less than the daily average of 5.0 mg/L DO standard from May through October. In the Turtle River at RM 0.38, the "natural" background DO is less than the daily average of 5.0 mg/L DO standard for all months except November and January. Given that the "natural" background DO levels in the Brunswick Estuary are below 5.0 mg/L for some months of the year, the Coastal DO Permitting Strategy contained in Appendix A was used to establish the allowable DO deficit to be allocated to all permitted point and nonpoint source loads. The maximum allowable DO deficits based on the minimum daily average "natural" background DO levels for the four locations in the Brunswick and Turtle Rivers are given in Table 15. Based on field sampling performed by EPD and Brunswick Cellulose's discharge schedule, it appears the average extent of the effluent is approximately 2.5 miles upstream and 2.75 miles downstream. Therefore, effluent should not extend upstream to RM 0.38, where the allowable DO deficit is only 0.1 mg/L.

Table 15. Allowable DO Deficits and Minimum "Natural" DO Levels in the Turtle and Brunswick Rivers

Month	Brunswick River RM 14.4		Turtle River RM 7.26		Turtle River RM 4.11		Turtle River RM 0.38	
	Minimum Natural DO	Allowable DO Deficit	Minimum Natural DO	Allowable DO Deficit	Minimum Natural DO	Allowable DO Deficit	Minimum Natural DO	Allowable DO Deficit
January	7.72	2.72	7.64	2.64	7.65	2.65	7.43	2.43
February	7.50	2.50	7.16	2.16	6.39	1.39	3.86	0.3
March	6.54	1.54	6.48	1.48	6.36	1.36	4.57	0.4
April	5.48	0.5	5.38	0.5	5.32	0.5	3.15	0.15
May	4.72	0.4	4.54	0.4	4.47	0.4	4.14	0.4
June	3.63	0.3	3.49	0.3	3.43	0.3	3.33	0.3
July	3.31	0.3	3.29	0.29	3.21	0.21	2.68	0.1*
August	3.27	0.27	3.23	0.23	3.24	0.24	2.86	0.1*
September	3.49	0.3	3.34	0.3	3.12	0.12*	2.68	0.1*
October	3.32	0.3	3.00	0.1*	2.85	0.1*	2.71	0.1*
November	5.46	0.5	5.41	0.5	5.41	0.5	5.61	0.61
December	6.69	1.69	6.69	1.69	6.73	1.73	4.7	0.4

*When the Natural DO is less than 3.15 the Allowable DO Deficit will be 0.149 mg/L due to significance figures

Figure 19 is a plot of the computed "Natural" DO in the surface layer for Academy Creek. The maximum allowable DO deficit and minimum daily average "natural" DO for Academy Creek at the 3 locations shown in Figure 20 are given in Table 16.

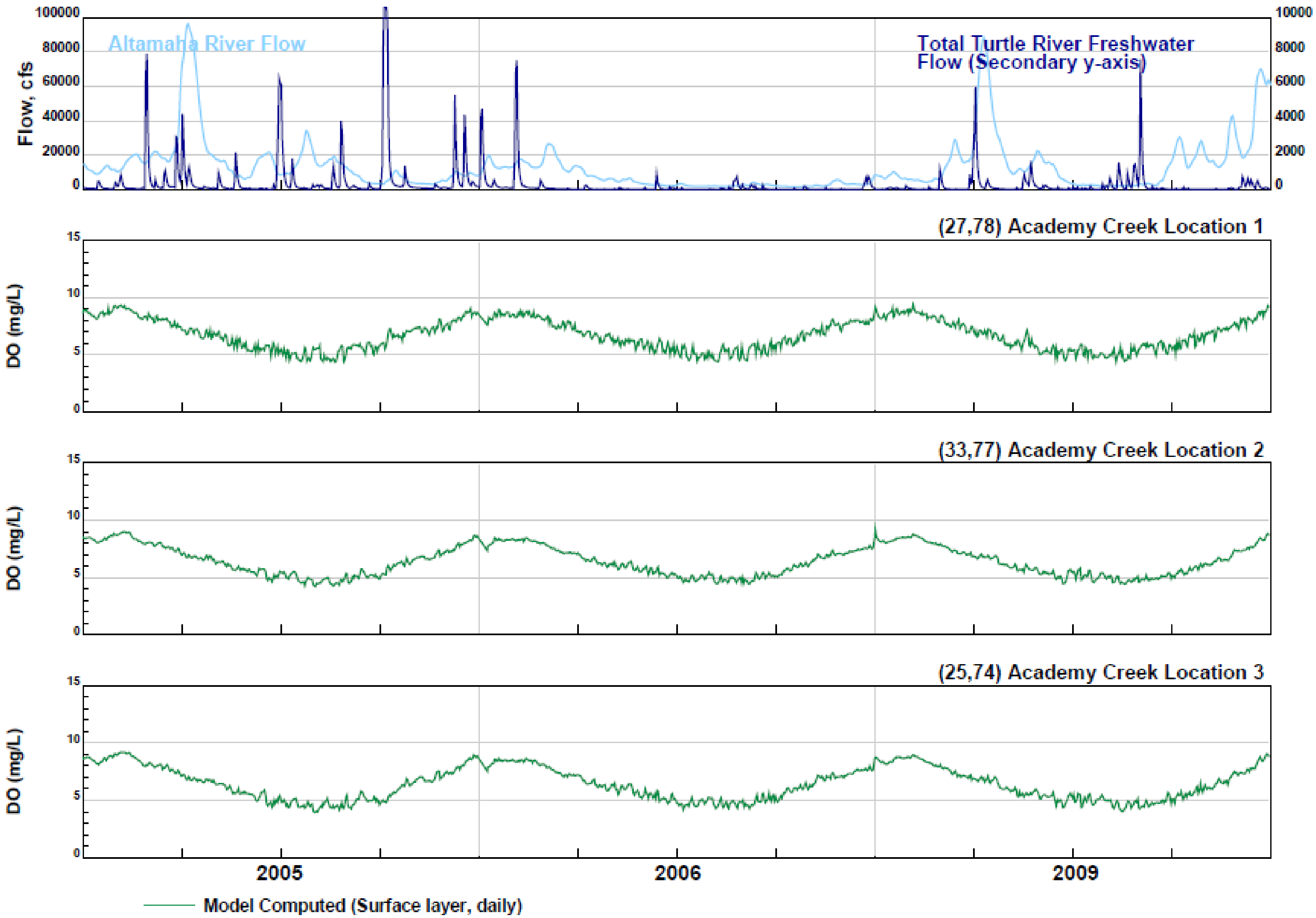

Figure 19. Computed "Natural" DO in the Surface Layer in Academy Creek

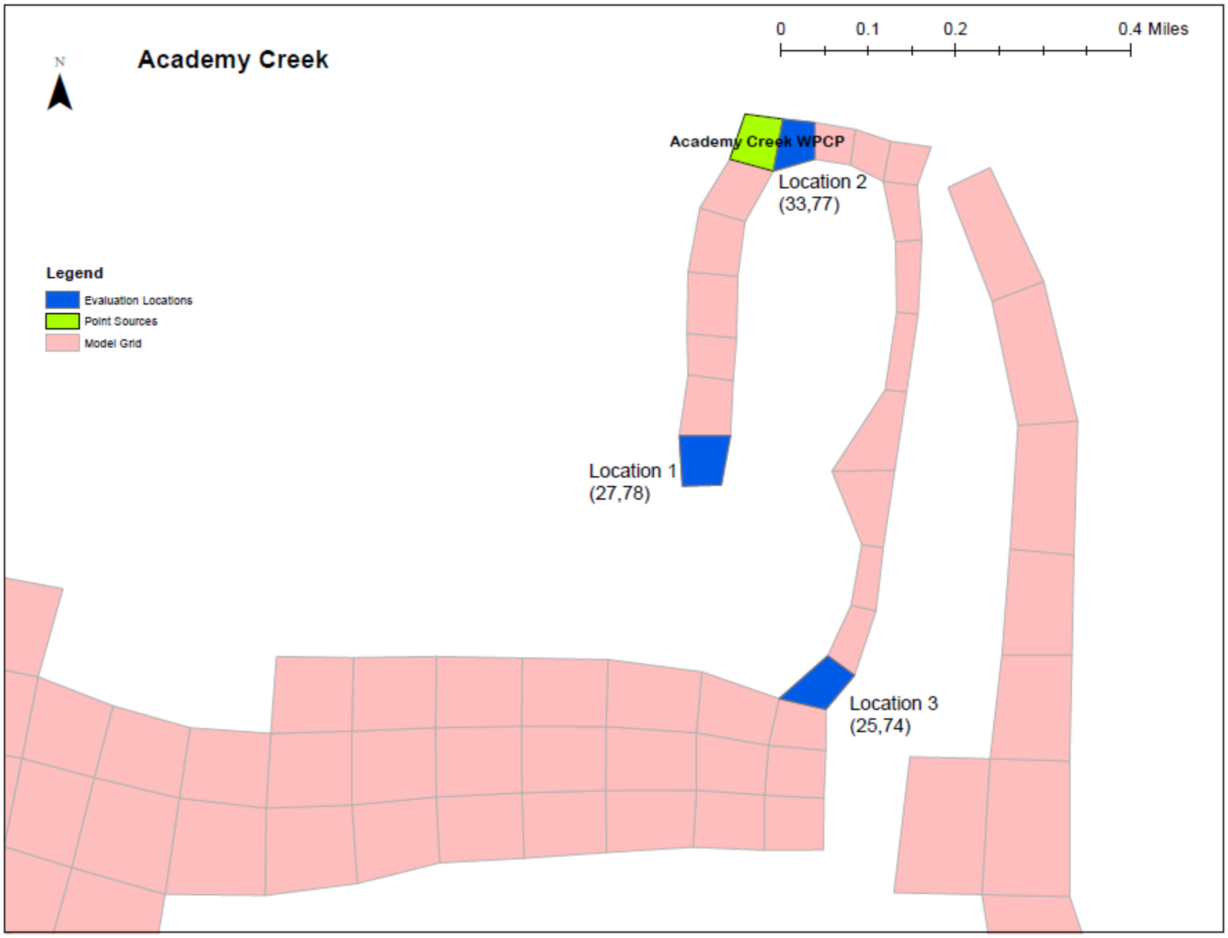

Figure 20. Academy Creek Model Output Locations

Table 16. Allowable DO Deficits and Minimum "Natural" DO in the Academy Creek

Month	Academy Creek Location 1		Academy Creek Location 2		Academy Creek Location 3	
	Minimum Natural DO	Allowable DO Deficit	Minimum Natural DO	Allowable DO Deficit	Minimum Natural DO	Allowable DO Deficit
January	7.60	2.60	7.33	2.33	7.50	2.50
February	7.85	2.85	7.86	2.86	7.93	2.93
March	6.91	1.91	6.85	1.95	6.75	1.75
April	6.00	1.00	5.90	0.90	5.80	0.80
May	5.35	0.50	5.47	0.50	5.17	0.50
June	4.51	0.40	4.46	0.40	4.35	0.40
July	4.43	0.40	4.28	0.40	4.17	0.40
August	4.36	0.40	4.21	0.40	3.94	0.30
September	4.51	0.40	4.43	0.40	4.24	0.40
October	5.05	0.40	4.88	0.40	4.60	0.40
November	6.33	1.33	6.06	1.06	5.96	0.96
December	7.03	2.03	6.94	1.94	6.96	1.96

Figure 21 is a plot of the computed "Natural" DO in the surface layer for Dupree Creek. The maximum allowable DO deficit and minimum daily average "natural" DO for Dupree Creek at the 3 locations shown in Figure 22 are given in Table 17.

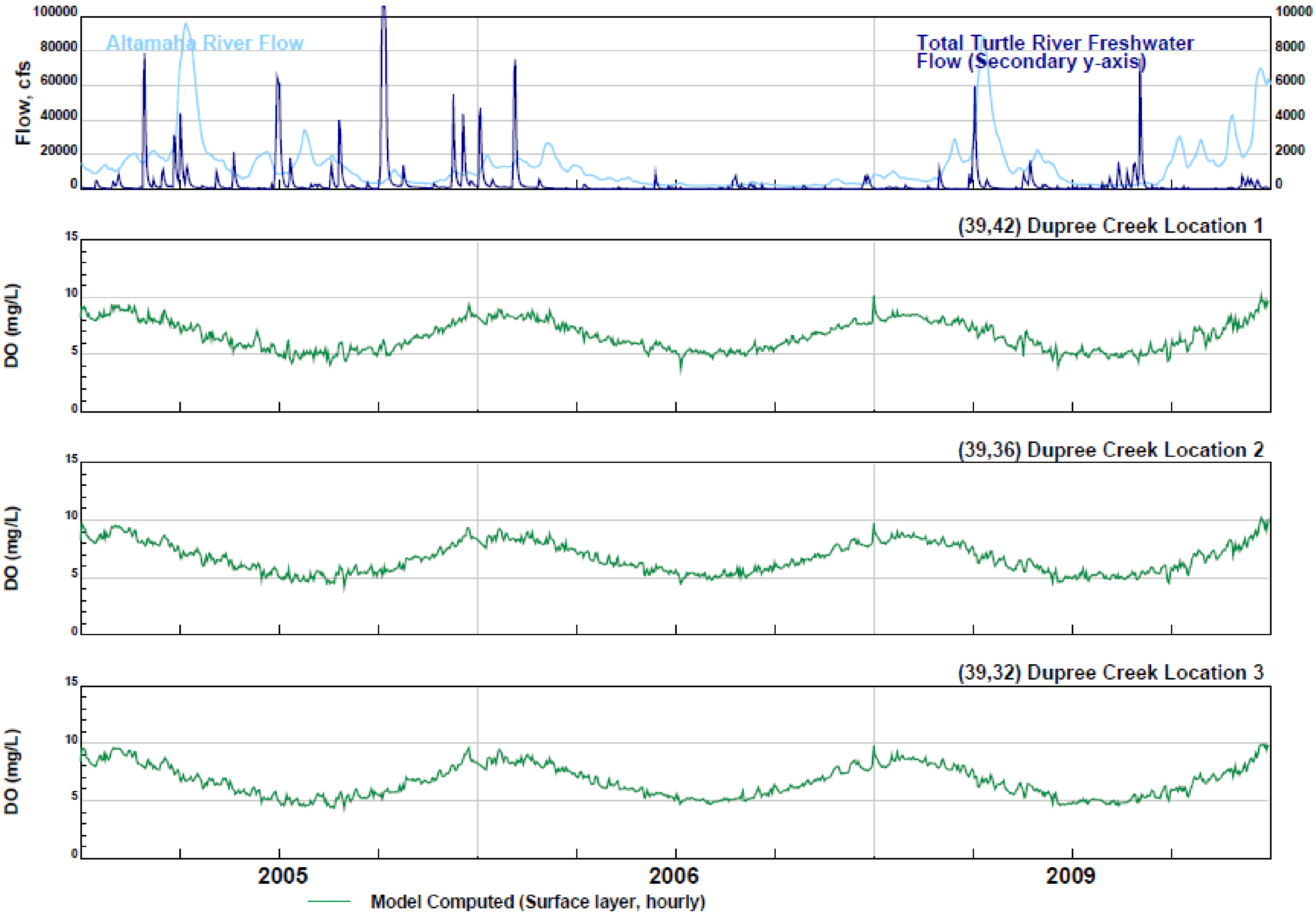

Figure 21. Computed "Natural" DO in the Surface Layer in Dupree Creek

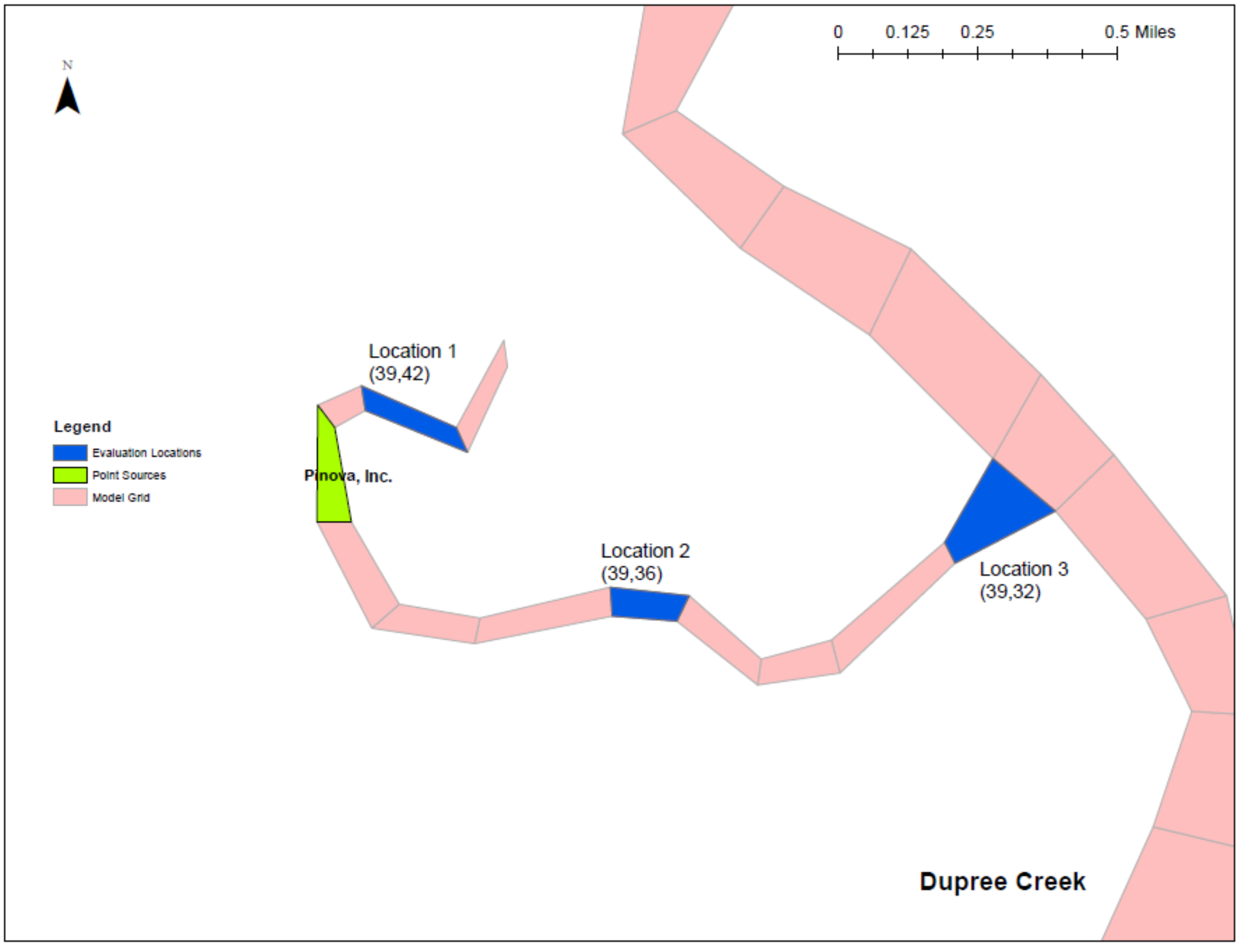

Figure 22. Dupree Creek Model Output Locations

Table 17. Allowable DO Deficits and Minimum "Natural" DO Levels in the Dupree Creek

Month	**Dupree Creek Location 1**		**Dupree Creek Location 2**		**Dupree Creek Location 3**	
	Minimum Natural DO	Allowable DO Deficit	Minimum Natural DO	Allowable DO Deficit	Minimum Natural DO	Allowable DO Deficit
January	7.62	2.62	7.58	2.58	7.71	2.71
February	8.72	2.72	7.93	2.93	7.91	2.91
March	7.05	.05	7.19	2.19	7.11	2.11
April	6.04	1.04	6.00	1.00	6.00	1.00
May	4.83	0.40	5.49	0.50	5.27	0.50
June	3.98	0.30	4.61	0.40	4.58	0.40
July	3.79	0.30	4.48	0.40	4.50	0.40
August	4.08	0.30	4.15	0.40	4.31	0.40
September	4.31	0.40	4.54	0.40	4.82	0.40
October	4.93	0.40	5.17	0.50	5.18	0.50
November	5.61	0.61	6.31	1.31	6.44	1.44
December	7.09	2.09	7.16	2.16	7.15	2.15

Figure 23 is a plot of the computed "Natural" DO in the surface layer for Dunbar Creek. The maximum allowable DO deficit and minimum daily average "natural" DO for Dunbar Creek at the 3 locations shown in Figure 24 are given in Table 18.

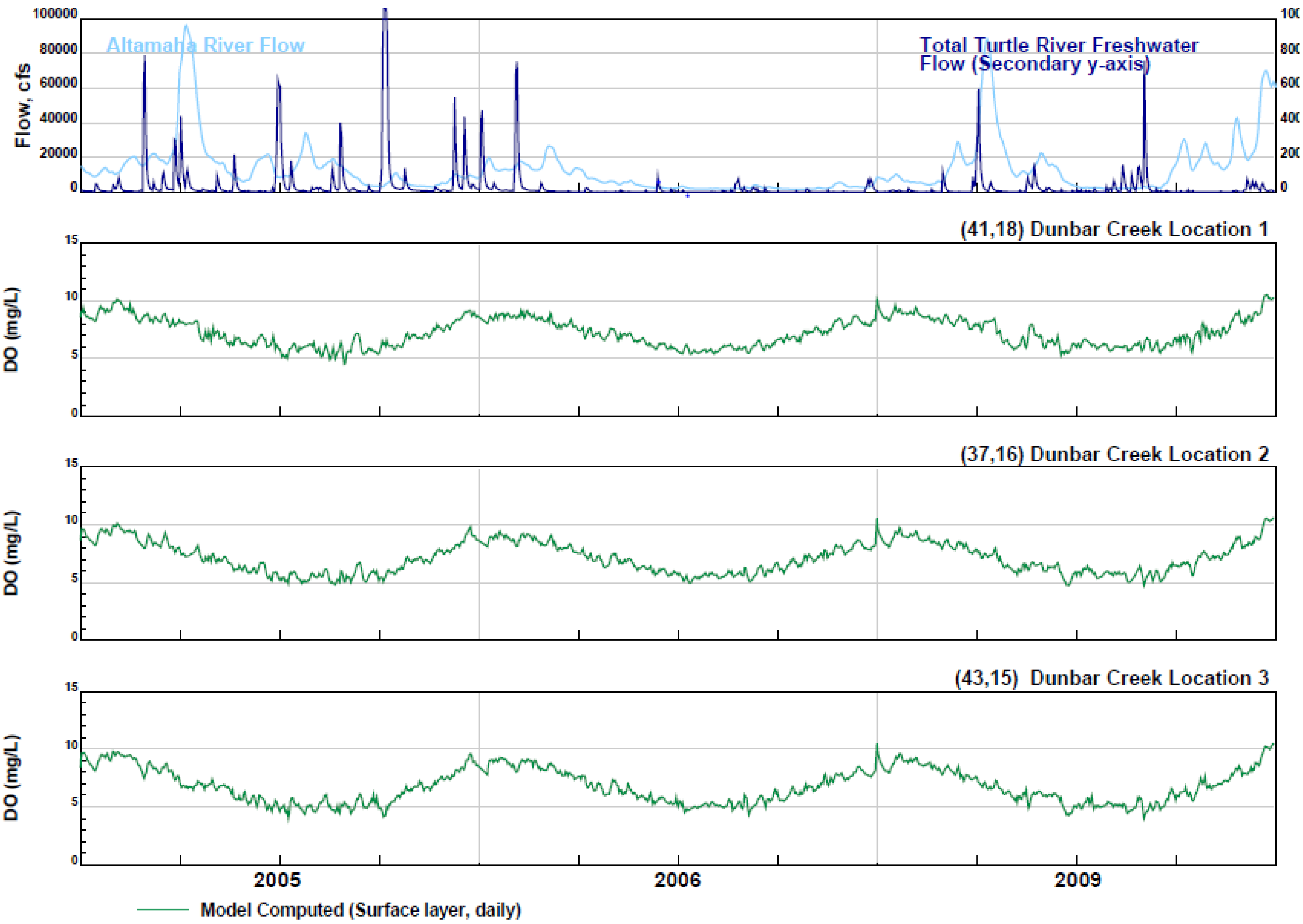

Figure 23. Computed "Natural" DO in the Surface Layer in Dunbar Creek

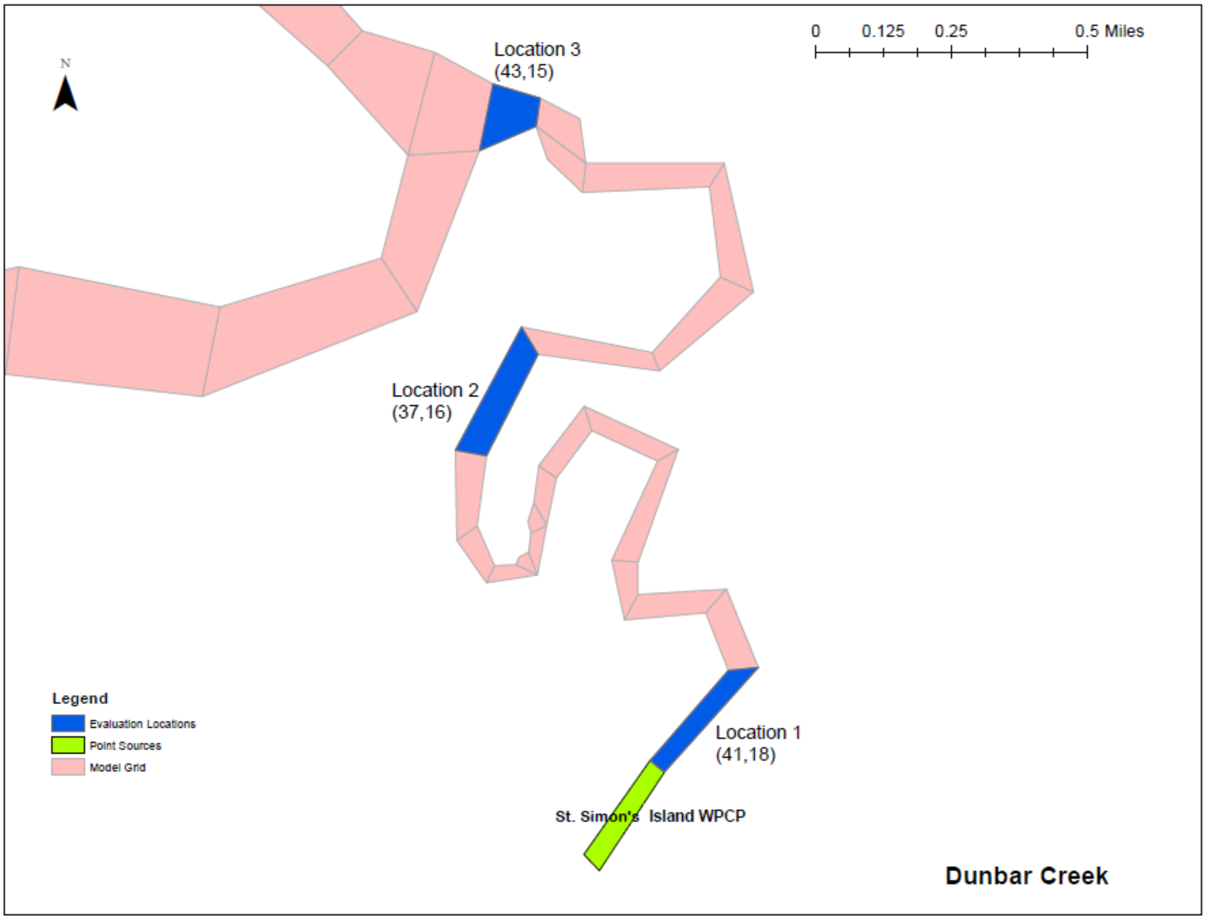

Figure 24. Dunbar Creek Model Output Locations

Table 18. Allowable DO Deficits and Minimum "Natural" DO Levels in the Dunbar Creek

Month	Dunbar Creek Location 1		Dunbar Creek Location 2		Dunbar Creek Location 3	
	Minimum Natural DO	Allowable DO Deficit	Minimum Natural DO	Allowable DO Deficit	Minimum Natural DO	Allowable DO Deficit
January	8.04	3.04	8.07	3.07	7.78	2.78
February	8.09	3.09	7.99	2.99	7.45	2.45
March	7.56	2.56	7.51	2.51	7.24	2.24
April	6.31	1.31	6.26	1.26	5.97	0.97
May	5.76	0.76	5.66	0.66	4.84	0.4
June	5.30	0.50	4.76	0.40	4.27	0.4
July	5.03	0.40	4.92	0.40	3.99	0.3
August	4.54	0.40	4.84	0.40	4.44	0.4
September	5.37	0.50	4.78	0.40	4.02	0.3
October	5.42	0.50	5.07	0.40	4.13	0.4
November	6.70	1.70	6.65	1.65	6.32	1.32
December	7.57	2.57	7.40	2.40	7.28	2.28

4.6 Critical Conditions Models

For an estuarine system, critical conditions are more complex than the critical conditions typically considered for a river system (e.g., summer temperatures and 7Q10 flow). Tidal dynamics play an important role in the DO levels of the Brunswick Harbor. The stream flows, tides, and metrological data from calendar year 2005 (high flow), 2006 (low flow) and 2009 (medium flow) were determined to best represent the range of tidal and flow conditions. The model was used to assess the oxygen demanding loads and DO levels in the Brunswick Estuary to determine if a problem exists requiring regulatory intervention. The complex dynamics simulated by the models demonstrated the critical conditions for uptake of oxygen demanding substances and the corresponding low DO levels in the estuary. These critical conditions include:

- Meteorological conditions
- Watershed flows
- Retention times in the estuary
- High water temperatures
- Marsh loads

Due to the limited available assimilative capacity resulting from the small allowable DO deficits, the point sources were modeled as time-variable BODu loads. The time-variable loads represent the day to day variability in the effluent BOD_5 and ammonia loads in the calculation of daily average decrease in DO levels for a multiple year simulation. Brunswick Cellulose, the only major industrial wastewater discharger, was explicitly modeled using ten years of effluent data (2007-2016) that were run through ten years of hydrology/hydrodynamics (2003-2012) with and without additional oxygen. Running ten years of wastewater discharge loads through ten years of Brunswick Estuary hydrodynamic conditions results in the computation of the equivalent of 100 years or approximately 36,500 daily delta DO values. Figure 25 shows the variability in the Brunswick Cellulose discharge.

As an approximation of the average long-term BOD_5 and NH_3 discharged by the three smaller point sources, they were input in as a constant BODu load equivalent to 50% of their monthly permitted BOD_5 and NH3 limits given in Table 5. For Academy Creek WPCP, which has a permitted ammonia limit of 17.4 mg/L, an ammonia concentration of 2.5 mg/L was used based on historical performance. Tables 19 through 22 show the maximum allowable DO deficit compared to the 90% delta DO resulting from the various dischargers. The yellow highlighted cells indicate the location that required the largest load reduction needed to meet the allowable DO deficit.

4.7 TMDL Scenario

The criterion governing the discharge of wastewater BOD_5 and NH_3 to the Brunswick Estuary is that the maximum decrease in DO during months when the natural DO is less than a daily average of 5.0 mg/L should be less than the allowable DO deficit 90% of the time. The computed delta DO values for all wastewater dischargers in each creek and each assessment location resulting are presented in Tables 19 through 22. The monthly 90^{th} percentile delta DO and allowable DO deficit are provided. The 90^{th} percentile delta DO was chosen since Georgia's water quality rules allow for a 10% exceedance of the DO criteria. Compliance with the criteria is achieved when the 90_{th} percentile delta DO from the addition of all wastewater dischargers' delta DOs at a given creek location are less than the allowable DO deficit.

Since the various dischargers are located in different tidal creeks, it is possible to determine the total ultimate BOD ($TBOD_u$) load reduction needed by the each wastewater discharger to meet the DO criterion in each receiving waterbody. First, model runs were conducted to compute the required permit BOD5 reductions for Brunswick Cellulose during August, September, and October to meet the DO criteria with a margin of safety of 0.05 mg/L. Then, the delta DOs due to Brunswick Cellulose BOD5 load were subtracted from the allowable DO deficit for each of the creeks. The TMDL wasteload allocation for the other three facilities were then determined using a margin of safety of 0.05 mg/L based on the fact that the calculated decrease in the DO for a wastewater discharge is directly proportional to the magnitude of the wastewater $TBOD_u$ as shown in Figures 26 through 28. A facility's $TBOD_u$ load can be calculated using the following equation:

$$TBOD_u = Q \times (CBOD_5 \times \text{f-ratio} + NH_3 \times 4.57) \times 8.34$$

Where: $TBOD_u$ = total ultimate BOD (lbs/day)
Q = Flow (MGD)
$CBOD_5$ = 5-day carbonaceous BOD (mg/L)
f-ratio = $CBOD_u/CBOD_5$
NH_3 = Ammonia (mg/L)
4.57 = mg O_2 required for each mg NH_3-N oxidized
8.34 = conversion factor (lbs/gal)

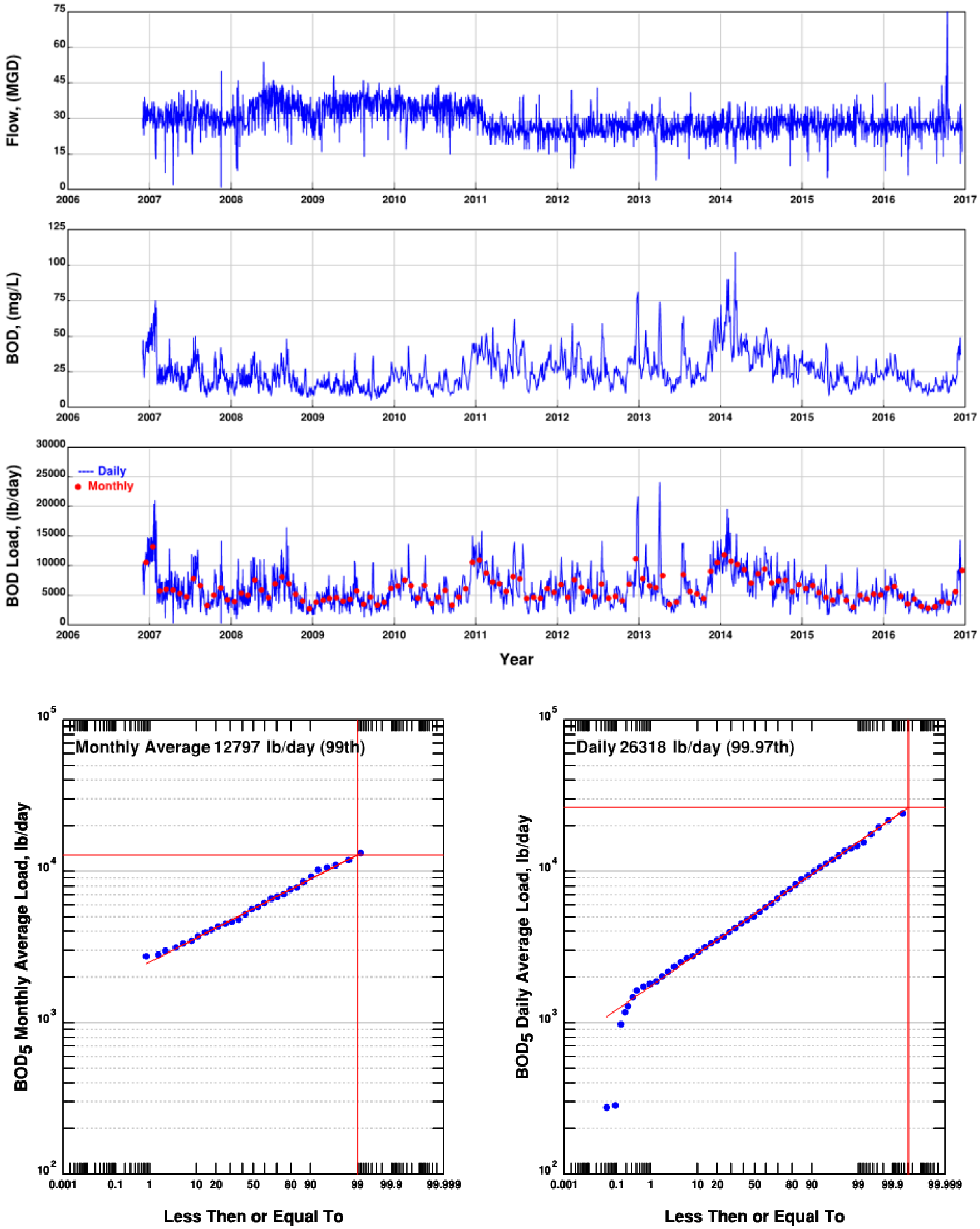

Figure 25. Brunswick Cellulose Effluent Data (2007-2016)

Table 19. Brunswick and Turtle River Critical Condition Model Results for Brunswick Cellulose Time-Variable Effluent Load Without Any Addition of Oxygen

Month	Brunswick River Location 1				Turtle River Location 2				Turtle River Location 3				Turtle River Location 4			
	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)
January	2.72	0.05	0.23	2.44	2.64	0.05	0.22	2.37	2.65	0.05	0.2	2.4	2.43	0.05	0.12	2.26
February	2.5	0.05	0.22	2.23	2.16	0.05	0.23	1.88	1.39	0.05	0.2	1.14	0.3	0.05	0.14	0.11
March	1.54	0.05	0.19	1.3	1.48	0.05	0.19	1.24	1.36	0.05	0.17	1.14	0.4	0.05	0.11	0.24
April	0.5	0.05	0.19	0.26	0.5	0.05	0.19	0.26	0.5	0.05	0.17	0.28	0.15	0.05	0.1	0
May	0.4	0.05	0.17	0.18	0.4	0.05	0.16	0.19	0.4	0.05	0.14	0.21	0.4	0.05	0.08	0.27
June	0.3	0.05	0.19	0.06	0.3	0.05	0.18	0.07	0.3	0.05	0.15	0.1	0.3	0.05	0.07	0.18
July	0.3	0.05	0.21	0.04	0.29	0.05	0.2	0.04	0.21	0.05	0.16	0	0.149	0.05	0.07	0.029
August	0.27	0.05	0.21	0.01	0.23	0.05	0.2	-0.02	0.24	0.05	0.16	0.03	0.149	0.05	0.08	0.019
September	0.3	0.05	0.17	0.08	0.3	0.05	0.17	0.08	0.149	0.05	0.131	-0.032	0.149	0.05	0.06	0.039
October	0.3	0.05	0.16	0.09	0.149	0.05	0.155	-0.056	0.149	0.05	0.12	-0.021	0.149	0.05	0.06	0.039
November	0.5	0.05	0.17	0.28	0.5	0.05	0.17	0.28	0.5	0.05	0.14	0.31	0.61	0.05	0.07	0.49
December	1.69	0.05	0.21	1.43	1.69	0.05	0.21	1.43	1.73	0.05	0.18	1.5	0.4	0.05	0.09	0.26

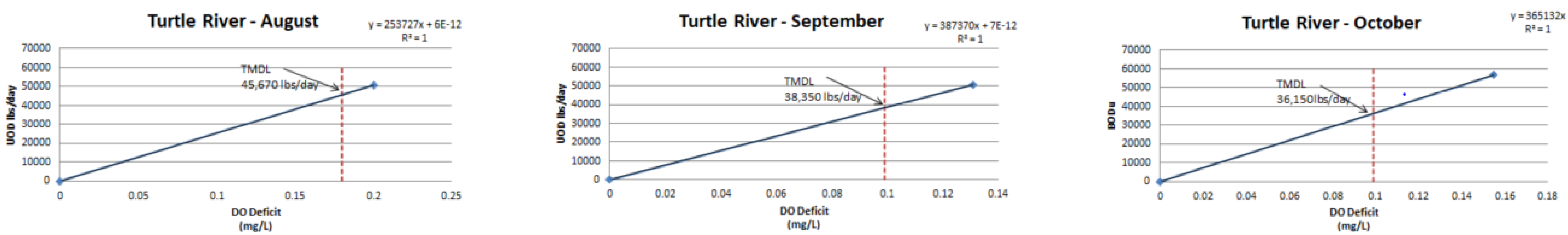

Figure 26. Turtle River UOD TMDL

Table 20. Academy Creek Critical Condition Model Results for Academy Creek WPCP (50% of Permitted Load)

Month	Academy Creek Location 1				Academy Creek Location 2				Academy Creek Location 3			
	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)
January	2.400	0.050	0.309	2.041	2.130	0.050	0.268	1.812	2.300	0.050	0.21	2.040
February	2.650	0.050	0.282	2.318	2.650	0.050	0.245	2.355	2.730	0.050	0.186	2.494
March	1.750	0.050	0.358	1.342	1.680	0.050	0.298	1.332	1.580	0.050	0.214	1.316
April	0.850	0.050	0.412	0.388	0.750	0.050	0.355	0.345	0.650	0.050	0.257	0.343
May	0.370	0.050	0.425	-0.105	0.370	0.050	0.371	-0.051	0.370	0.050	0.263	0.057
June	0.260	0.050	0.457	-0.247	0.260	0.050	0.401	-0.191	0.250	0.050	0.294	-0.094
July	0.240	0.050	0.486	-0.296	0.230	0.050	0.41	-0.230	0.230	0.050	0.301	-0.121
August	0.247	0.050	0.474	-0.277	0.247	0.050	0.403	-0.206	0.147	0.050	0.289	-0.192
September	0.281	0.050	0.479	-0.248	0.281	0.050	0.391	-0.160	0.281	0.050	0.272	-0.041
October	0.291	0.050	0.413	-0.172	0.281	0.050	0.347	-0.116	0.281	0.050	0.249	-0.018
November	1.200	0.050	0.336	0.814	0.920	0.050	0.28	0.590	0.820	0.050	0.204	0.566
December	1.860	0.050	0.287	1.523	1.760	0.050	0.247	1.463	1.780	0.050	0.194	1.536

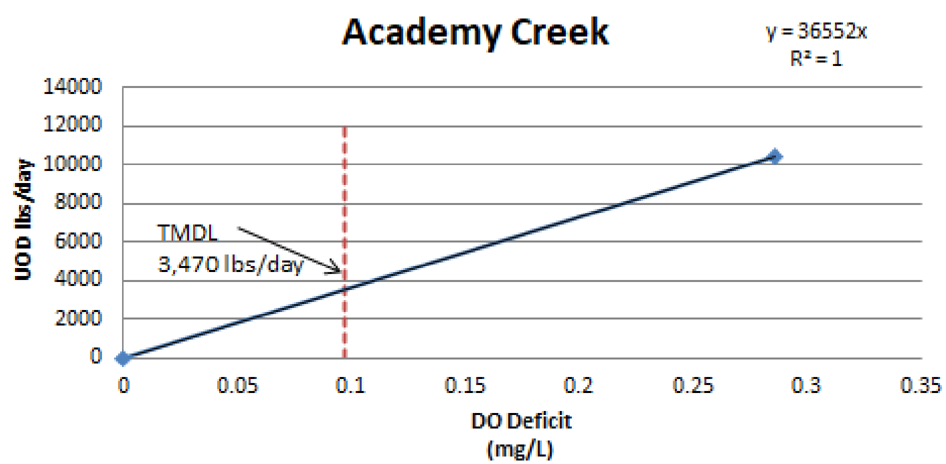

Figure 27. Academy Creek UOD TMDL

Table 21. Dupree Creek Critical Condition Model Results for Pinova (50% of Permitted Load)

Month	Dupree Creek Location 1				Dupree Creek Location 2				Dupree Creek Location 3			
	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)
January	2.590	0.050	0.208	2.332	2.550	0.050	0.149	2.351	2.680	0.050	0.069	2.561
February	2.700	0.050	0.194	2.456	2.910	0.050	0.138	2.722	2.880	0.050	0.065	2.765
March	2.030	0.050	0.282	1.698	2.170	0.050	0.155	1.965	2.090	0.050	0.071	1.969
April	1.030	0.050	0.329	0.651	0.980	0.050	0.180	0.750	0.980	0.050	0.085	0.845
May	0.390	0.050	0.391	-0.051	0.480	0.050	0.228	0.202	0.480	0.050	0.100	0.330
June	0.290	0.050	0.372	-0.132	0.380	0.050	0.253	0.077	0.380	0.050	0.100	0.230
July	0.280	0.050	0.373	-0.143	0.380	0.050	0.256	0.074	0.370	0.050	0.103	0.217
August	0.282	0.050	0.398	-0.166	0.382	0.050	0.264	0.068	0.373	0.050	0.107	0.216
September	0.383	0.050	0.477	-0.144	0.383	0.050	0.260	0.073	0.383	0.050	0.119	0.214
October	0.382	0.050	0.382	-0.050	0.482	0.050	0.249	0.183	0.482	0.050	0.102	0.330
November	0.600	0.050	0.288	0.262	1.290	0.050	0.189	1.051	1.420	0.050	0.086	1.284
December	2.070	0.050	0.208	1.812	2.140	0.050	0.159	1.931	2.120	0.050	0.074	1.996

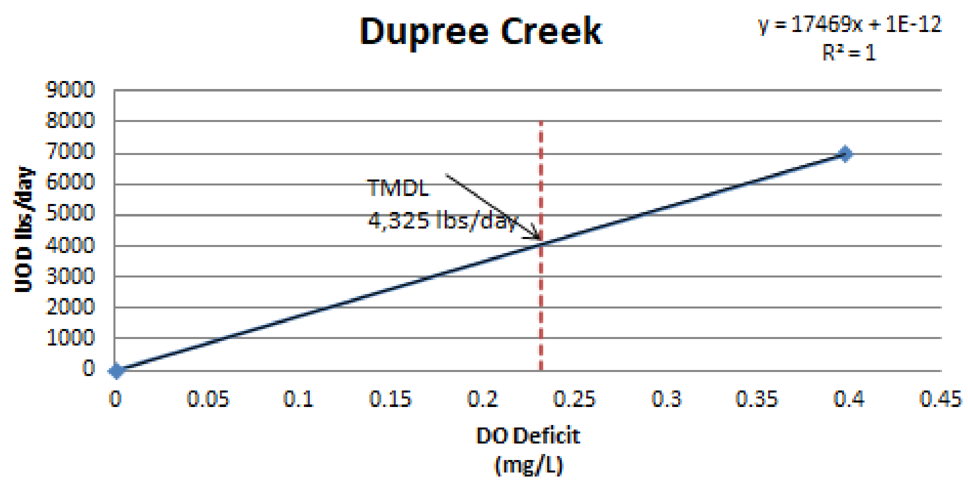

Figure 28. Dupree Creek UOD TMDL

Table 22. Dunbar Creek Critical Condition Model Results for St. Simons WPCP (50% of Permitted Load)

Month	Dunbar Creek Location 1				Dunbar Creek Location				Dunbar Creek Location 3			
	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)	Allowable DO Deficit (mg/L)	MOS DO Deficit (mg/L)	90% Delta DO (mg/L)	Diff (mg/L)
January	3.020	0.050	0.102	2.868	3.050	0.050	0.048	2.952	2.760	0.050	0.021	2.689
February	3.070	0.050	0.106	2.914	2.970	0.050	0.045	2.875	2.430	0.050	0.018	2.362
March	2.540	0.050	0.125	2.365	2.500	0.050	0.053	2.397	2.220	0.050	0.019	2.151
April	1.290	0.050	0.147	1.093	1.250	0.050	0.063	1.137	0.950	0.050	0.025	0.875
May	0.750	0.050	0.129	0.571	0.650	0.050	0.060	0.54	0.380	0.050	0.025	0.305
June	0.490	0.050	0.144	0.296	0.390	0.050	0.066	0.274	0.380	0.050	0.026	0.304
July	0.390	0.050	0.143	0.197	0.390	0.050	0.065	0.275	0.280	0.050	0.026	0.204
August	0.382	0.050	0.142	0.19	0.391	0.050	0.066	0.275	0.382	0.050	0.024	0.308
September	0.491	0.050	0.167	0.274	0.391	0.050	0.072	0.269	0.283	0.050	0.028	0.205
October	0.491	0.050	0.150	0.291	0.391	0.050	0.065	0.276	0.382	0.050	0.024	0.308
November	1.680	0.050	0.122	1.508	1.640	0.050	0.058	1.532	1.300	0.050	0.025	1.225
December	2.550	0.050	0.101	2.399	2.390	0.050	0.050	2.29	2.250	0.050	0.021	2.179

5.0 TOTAL MAXIMUM DAILY LOADS

A Total Maximum Daily Load (TMDL) is the amount of a pollutant that can be assimilated by the receiving waterbody without exceeding the applicable water quality standard, which in this case, is the DO concentration based on the allowable DO deficit. A TMDL is the sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, as well as natural background (40 CFR 130.2) for a given waterbody. The TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measures; for oxygen demanding substances ($CBOD_5$ and ammonia) the TMDLs can be expressed as lbs/day or lbs/yr.

A TMDL is expressed as follows:

$$\text{TMDL} = \Sigma\text{WLAs} + \Sigma\text{LAs} + \text{MOS}$$

The TMDL calculates the WLAs and LAs with margins of safety to meet the estuary's water quality standards. The allocations are based on estimates that use the best available data and provide the basis to establish or modify existing controls so that water quality standards can be achieved. In developing a TMDL, it is important to consider whether adequate information is available to identify the sources, fate, and transport of the pollutant to be controlled.

The allowable loadings are expressed in terms of oxygen-demanding substances as UOD, where:

$$\text{UOD} = \text{CBODu} + \text{NBODu}$$

CBODu = $CBOD_5$ multiplied times a f-ratio
NBODu = ammonia multiplied times 4.57 conversion factor

TMDLs may be developed using a phased approach. Under a phased approach, the TMDL includes: 1) WLAs that confirm existing limits or lead to new limits, and 2) LAs that confirm existing controls or include implementing new controls (US EPA, 1991). A phased TMDL requires additional data be collected to determine if load reductions required by the TMDL are leading to the attainment of water quality standards. In the next phase, implementation strategies will be reviewed and the TMDLs may be refined as necessary.

The TMDL Implementation Plan describes the installation and evaluation of point and nonpoint source control measures, data collection, assessment of water quality standard attainment, and if needed, additional modeling. Future monitoring of the listed segment water quality is then used to evaluate the TMDL, and if necessary, to reallocate the loads. The oxygen demanding loads calculated include the sum of the total loads from all point and nonpoint sources for the segment.

5.1 Waste Load Allocations

The waste load allocation is the portion of the receiving waterbody's loading capacity that is allocated to existing and future point sources. WLAs are provided to the point sources from municipal and industrial wastewater treatment systems with NPDES effluent limits.

The average $CBOD_5$, ammonia, and UOD loads for the wastewater treatment facilities that discharge into the Brunswick Harbor watershed are given in Table 23, along with the UOD percent reduction from the existing permit. The $CBOD_5$ and ammonia permit limits may be reallocated as long as the UOD load is not exceeded. The UOD equation is given below

$$UOD = Q \times (CBOD_5 \times \text{f-ratio} + NH_3 \times 4.57) \times 8.34$$

Where: UOD = ultimate oxygen demand (lbs/day)
Q = Flow (MGD)
$CBOD_5$ = 5-day carbonaceous BOD (mg/L)
f-ratio = $CBOD_u/CBOD_5$
NH_3 = Ammonia (mg/L)
4.57 = mg O_2 required for each mg NH_3-N oxidized
8.34 = conversion factor (lbs/gal)

State and Federal Rules define stormwater discharges covered by NPDES permits as point sources. However, stormwater discharges are from diffuse sources and there are multiple stormwater outfalls. Stormwater sources (point and nonpoint) are different than traditional NPDES permitted sources in four respects: 1) they do not produce a continuous (pollutant loading) discharge; 2) their pollutant loading depends on the intensity, duration, and frequency of rainfall events, over which the permittee has no control; 3) the activities contributing to the pollutant loading may include the various allowable activities of others, and control of these activities is not solely within the discretion of the permittee; and 4) they do not have wastewater treatment plants that control specific pollutants to meet numeric limits.

The allocations for the permitted stormwater discharges is established at background loading conditions and/or oxygen demanding pollutant concentrations such that will not cause or contribute to further lowering of dissolved oxygen in the Brunswick Harbor system. It is expected that stormwater pollution prevention plans will continue to provide for use of best management practices (BMP) to ensure that such stormwater loadings do not increase above natural background levels. As long as stormwater loads continue to be less than, or equivalent to, natural background loads, the TMDL does not necessitate reductions to existing industrial and municipal stormwater sources discharging pursuant to an individual or general NPDES stormwater permit (e.g., (Municipal Separate Storm Sewer System [MS4], industrial and construction general permits).

The intent of stormwater NPDES permits is not to treat the water after collection, but to reduce the exposure of stormwater to pollutants by implementing various controls. It would be infeasible and prohibitively expensive to control pollutant discharges from each stormwater outfall. Therefore, stormwater NPDES permits require the establishment of controls or BMPs to reduce the pollutants entering the environment. At this time, the portion of each pollutant source that goes directly to a permitted storm sewer and that which goes through non-permitted point sources, or is sheet flow or agricultural runoff, has not been clearly defined.

GA EPD evaluated oxygen-demanding loads from industrial and municipal stormwater sources discharging pursuant to an NPDES permit into, or upstream of, the Harbor. These loads were shown to have no measurable impact on the dissolved oxygen levels in the critical areas of concern in the Harbor. During critical periods, permitted stormwater loads were considered to be equivalent to, and part of, the natural background. Therefore, the NPDES regulated sources are aggregated with the natural background loads.

Table 23. UOD WLAs for the Brunswick Harbor Facilities

Facility Name	NPDES Permit No.	Receiving Stream	NPDES Permit Limits				TMDL				
			Average Monthly Flow (MGD)	BOD_5 (mg/L)	NH_3 (mg/L)	DO (mg/L)	Average Monthly Flow (MGD)	$CBOD_5$ (mg/L)	NH_3 (mg/L)	UOD (lbs/day)	% Reduction
New Hope Plantation Mobile Home Park (Outfall 001 and 002)	GAG550139	Ditch	Report	30			Report	30	17.4	15.4	0
Golden Isles Marina Master Association	GAG550111	Frederica River	Report	30			Report	30	17.4	15.4	0
Pinova	GA0003735	Dupree Creek	Report	38 1900 lbs/day	1.3	5.0	Report	May-Oct 23 (1,150 lbs/day)	May-Oct 1.3 (65 lbs/day)	4,325	38
							Report	Nov-Apr 38 (1,900 lbs/day)	Nov-Apr 1.3 (65 lbs/day)	6,950	0
Brunswick-Glynn County JWSC (St Simons Island WPCP)	GA0021521	Dunbar Creek tributary to the Federica River	4.0	5.0	2.0	6.0	4.0	5.0	2.0	890	0
Brunswick Shady Acres Mobile Home Park WPCP	GA0022489	Cowpen Creek Tributary to the Turtle River	0.039	30			0.039	30	17.4	60	0
Brunswick-Glynn County JWSC (Academy Creek WPCP)	GA0025313	Academy Creek	13.5	20	17.4	2.0	13.5	May-Oct 7.5	May-Oct 1	3,470	79
								Nov-Apr 20	Nov-Apr 5	10,450	38
Sterling Mobile Home Park WPCP	GA0034754	Unnamed tributary to Cowpen Creek	0.009	30			0.009	30	17.4	14	0
King & Prince Seafood Corporations	GA0039268	Turtle River	Report	30			Report	30		26	0
Brunswick-Glynn County JWSC North Mainland	Proposed	White Oak Creek / Buffalo Creek	-	-	-	-	5	5	1	920	0

Facility Name	NPDES Permit No.	Receiving Stream	Month	NPDES Permit Limits				TMDL				
				Average Monthly Flow (MGD)	*$CBOD_5$ (lbs/day)	NH_3 (mg/L)	Oxygen Addition (lbs/day)	Average Monthly Flow (MGD)	$CBOD_5$ (lbs/day)	NH_3 (lbs/day)	UOD (lbs/day)	% Reduction
Brunswick Cellulose, LLC	GA0003654	Turtle River	Jan	Report	15,000	Report	0	Report	15,000	991	63,030	0
			Feb	Report	15,000	Report	0	Report	15,000	991	63,030	0
			Mar	Report	13,500	Report	0	Report	13,500	991	57,180	0
			Apr	Report	13,500	Report	12,500	Report	13,500	991	57,180	0
			May	Report	13,500	Report	12,400	Report	13,500	991	57,180	0
			Jun	Report	12,500	Report	23,000	Report	12,500	991	53,280	0
			Jul	Report	12,500	Report	18,000	Report	12,500	991	53,280	0
			Aug	Report	12,500	Report	22,000	Report	11,130	991	47,937	10
			Sep	Report	12,500	Report	22,000	Report	9,160	991	40,254	24
			Oct	Report	14,000	Report	12,900	Report	8,520	991	37,758	36
			Nov	Report	14,000	Report	11,400	Report	14,000	991	59,130	0
			Dec	Report	15,000	Report	0	Report	15,000	991	63,030	0

5.2 Load Allocations

The load allocation is the portion of the receiving water's loading capacity that is attributed to existing or future nonpoint sources or to natural background sources. Nonpoint sources are identified in 40 CFR 130.6 as follows:

- Residual waste;
- Land disposal;
- Agricultural and silvicultural;
- Mines;
- Construction;
- Saltwater intrusion; and
- Urban stormwater (non-permitted).

As described above, there are two types of load allocations: loads to the stream independent of precipitation, including sources such as failing septic systems, leachate from landfills, animals in the stream, leaking sewer system collection lines, and background loads; and loads associated with the accumulation of oxygen demanding substances on land surfaces that is washed off during storm events, including runoff from saturated LAS fields.

The vast majority of the nonpoint source loadings of oxygen-demanding substances are from natural background sources including detritus transported in the stream, detritus from marsh areas flowing directly into the estuary, and tidally-transported detritus from the ocean. These natural background nonpoint source loads are not controllable and therefore additional nonpoint source reduction to improve water quality is not an option.

The contribution of oxygen consuming wastes from non-permitted stormwater sources are minor and thus are considered to be part of the natural background loads. The natural background loadings or load allocation (LA) for the Brunswick Harbor system are as follows:

- Marsh loadings = 337,000 lbs/day
- Ocean boundary conditions for CBODu = 5 mg/L and ammonia= 0.07 mg/L

The ocean influences cause the Brunswick Harbor's natural DO levels to decrease due to the tidal flux for CBODu and ammonia into the Harbor system.

5.3 Seasonal Variation

Seasonal variation is incorporated in this analysis by evaluating multiple years of data. For the hydrodynamic and water quality models, the years of 2005, 2006, and 2009 were evaluated. This analysis recognizes that permit loads can be larger in the winter months when the DO standard of a daily average of 5.0 mg/L not less than 4.0 mg/L applies. The Brunswick Harbor Model was used to develop seasonal wasteload allocations and NPDES permits limits that apply during both critical and non-critical periods.

5.4 Margin of Safety

The MOS is a required component of TMDL development. There are two basic methods for incorporating the MOS: 1) implicitly incorporate the MOS using conservative modeling assumptions to develop allocations; or 2) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations.

An explicit MOS of 0.05 mg/L was used, which accounts for an additional UOD load in Turtle River of 5,363 lbs/day, 12,870 lbs/day and 18,854 lbs/day in August, September, and October, respectively, an additional UOD load in Academy Creek of 17,90 lbs/day, and an additional load in Dupree Creek 875 lbs/day. These loads may be available in the future growth or as an additional WLA if instream data indicates the DO criteria are being met.

5.5 Total Ultimate Oxygen Demand Load

The sum of the Total UOD loads that can be discharged into the Brunswick Harbor watershed, including the WLA, LA, and MOS that may be used for reallocating to existing or future point sources ranges, from 45,745 to 82,370 depending on the month and are given in Table 24. It is within the discretion of the Director of Georgia EPD to reallocate WLAs, as long as the total of the individual WLAs add up to the Total WLAs.

Table 24. Total Ultimate Oxygen Demand Loadings

Month	Existing UOD (lbs/day)	Total UOD WLAs (lbs/day)	Total UOD LAs (lbs/day)	MOS (lbs/day)	Total UOD Load (lbs/day)	Reduction
January	425,751	82,371	337,000		419,371	1.50%
February	425,751	82,371	337,000		419,371	1.50%
March	419,901	76,521	337,000		413,521	1.52%
April	419,901	76,521	337,000		413,521	1.52%
May	419,901	66,912	337,000	2,665	406,577	3.17%
June	416,001	63,012	337,000	2,665	402,677	3.20%
July	416,001	63,012	337,000	2,665	402,677	3.20%
August	416,001	57,669	337,000	8,008	402,677	3.20%
September	416,001	49,986	337,000	15,691	402,677	3.20%
October	421,851	47,490	337,000	21,764	406,254	3.70%
November	421,851	78,471	337,000		415,471	1.51%
December	425,751	82,371	337,000		419,371	1.50%

Water quality trading (also called effluent trading) is an innovative way for water quality agencies and community stakeholders to develop cost-effective solutions to address water quality problems in their watersheds. EPA supports the concept of water quality trading in watersheds with multiple sources of pollutants, and specifically endorses the use of trading to implement the TMDL process. Appropriate trading of pollutant allocations and/or DO deficits between or among sources, or through oxygen injection into the Harbor, is allowed under the TMDL process as long as the total loading does not cause an exceedance of the DO deficit allocated to the regulated point sources. The Brunswick Harbor Model will allow the GA EPD to evaluate and determine UOD (BOD_5 or $CBOD_5$ and ammonia) load and oxygen injection trading proposals to ensure that water quality standards will be met. Any water quality trading will have to be approved by the EPA, and will have to be reflected in the dischargers' NPDES permits.

On January 13, 2003, EPA issued a Water Quality Trading Policy ("policy") to provide guidance to States and Tribes on how trading can occur under the Clean Water Act and the regulations on implementation. The policy discusses Clean Water Act requirements that are relevant to water quality trading including: requirements to obtain permits, anti-backsliding provisions, and development of water quality standards including antidegradation policy, National Pollutant Discharge Elimination System permit regulations, TMDLs and water quality management plans (https://www.epa.gov/npdes/water-quality-trading). EPA has also developed a Water Quality Trading Toolkit that provides additional details about trading and how it works. The toolkit can be found at: (https://www.epa.gov/npdes/water-quality-trading-toolkit-permit-writers).

6.0 RECOMMENDATIONS

The TMDL process consists of an evaluation of the sub-watersheds for each 303(d) listed estuary segment to identify, as best as possible, the sources of the oxygen demanding loads causing the estuary to exceed DO standards. The TMDL analysis was performed using the best available data to specify WLAs and LAs that will meet chlorophyll *a* water quality criteria to support the use classification specified for each listed segment.

This TMDL represents part of a long-term process to reduce ultimate oxygen demanding loadings to meet water quality standards in the Brunswick Harbor. Implementation strategies will be reviewed and the TMDLs will be refined as necessary in the next phase. The phased approach will support progress toward water quality standard attainment in the future. In accordance with USEPA TMDL guidance, these TMDLs may be revised based on the results of future monitoring and source characterization data efforts. The following recommendations emphasize further source identification and involve the collection of data to support the current allocations and subsequent source reductions. If new information becomes available indicating that revisions in the model on which the TMDL is based are needed, GA EPD will undertake revisions and may redo the TMDL based on results of the revised model. The TMDL revisions may indicate that higher or lower levels of point source or nonpoint source controls are required to meet the applicable water quality standards.

6.1 Monitoring

Water quality monitoring is conducted at a number of locations across the State each year. Sampling is conducted statewide by GA EPD personnel in Atlanta, Brunswick, Cartersville, and Tifton. Additional sites are added as necessary.

Compliance with the TMDL will be determined through annual monitoring in the estuary and compliance with water quality standards. GA EPD will expand on its monitoring efforts in the Brunswick and Turtle River Systems to include locations with the lowest allowable D.O. deficit based on model projections. A majority of this monitoring will be done by collecting monthly grab samples and in situ readings at locations throughout the watershed in variable tidal ranges. GA EPD will continue monitoring the three Brunswick/Turtle River trend stations at river mile 14.4, 7.36, and 4.11. This monitoring data will continue to expand upon the already extensive dataset built on decades of data already collected. GA EPD will continue monitoring Academy Creek just downstream of the discharge. Finally, GA EPD will expand its current monitoring of the Brunswick/Turtle River Systems to include St. Simons Sound and Dupree Creek.

6.2 Point Source Approaches

Point sources are defined as discharges of treated wastewater or stormwater into rivers and streams at discrete locations. The NPDES permit program provides a basis for issuing municipal, industrial, and stormwater permits, monitoring and compliance with limitations, and appropriate enforcement actions for violations.

In accordance with GA EPD rules and regulations, all discharges from point source facilities are required to be in compliance with the conditions of their NPDES permit at all times. In the future, municipal and industrial wastewater treatment facilities with the potential for oxygen demanding substances to be present in their discharge will be permitted if it can be shown that the discharge will met applicable water quality standards, which may require a decrease in non-point source loads or another point source load. This may be allowed under a pollutant-trading program that will allow point to point trading, point to nonpoint source trading and/or nonpoint (agricultural) to nonpoint (urban) source trading. The WLA for wastewater treatment facilities may be increased if there is an appropriate pollutant trade that requires reductions in another point source load or the nonpoint source load allocation (LA) and maintenance of those reductions or the net WLAs does not change by having an ultimate oxygen demand trade between point sources. Any trade must be done under the purview of a pollutant trading guidance document for Georgia and it is within the discretion of the Director of Georgia EPD to reallocate WLAs and/or LA within the TMDL in order to meet water quality standards within the Brunswick Harbor. In addition, the permits will include monitoring and reporting requirements.

6.3 Nonpoint Source Approaches

The GA EPD is responsible for administering and enforcing laws to protect the waters of the State. The GA EPD is the lead agency for implementing the State's Nonpoint Source Management Program. Regulatory responsibilities that have a bearing on nonpoint source pollution include establishing water quality standards and use classifications, assessing and reporting water quality conditions, and regulating land use activities that may affect water quality. Georgia is working with local governments and agricultural and forestry agencies such as the Natural Resources Conservation Service, the Georgia Soil and Water Conservation Commission, and the Georgia Forestry Commission, to foster the implementation of BMPs to address nonpoint source pollution. In addition, public education efforts are being targeted to individual stakeholders to provide information regarding the use of BMPs to protect water quality. The following sections describe, in more detail, recommendations to reduce nonpoint source loads of oxygen demanding substances in Georgia's surface waters.

GA EPD issues LAS permits that allow facilities to apply wastewater at agronomic rates. If these systems are operated in accordance with their permits and maintain vegetative buffers to mitigate potential stormwater flows for the sites, it is not expected these systems will have an impact on the estuary. The modeled assumption that some oxygen demanding substances from the LAS may washoff these sites during rainfall events is a conservative assumption and does not reflect a conclusion that these LAS may actually impact the estuary. Determining whether any individual LAS has an impact on the estuary would require a site-specific evaluation.

6.3.1 Urban Sources

Both point and nonpoint sources of oxygen demanding substances can be significant in the Brunswick Harbor watershed urban areas. Urban sources of oxygen demanding substances can best be addressed using a strategy that involves public participation and intergovernmental coordination to reduce the discharge of oxygen demanding substances to the maximum extent practicable. Management practices, control techniques, public education, and other appropriate methods and provisions may be employed. In addition to water quality monitoring programs, discussed in Section 6.1, the following activities and programs conducted by cities, counties, and state agencies are recommended:

- Uphold requirements that all new and replacement sanitary sewage systems be designed to minimize discharges into storm sewer systems;
- Further develop and streamline mechanisms for reporting and correcting illicit connections, breaks, and general sanitary sewer system problems;
- Sustained compliance with stormwater NPDES permit requirements;

- Encourage local governments to implement post construction stormwater ordinances that require the use of green infrastructure/runoff reduction controls to eliminate the discharge of runoff from all storm events up to the first inch for all new construction projects, as well as re-development projects;

- Work with County Health Departments to encourage proper installation and maintenance of septic tanks; and

- Continue efforts to increase public awareness and education towards the impact of human activities in urban settings on water quality, ranging from the consequences of industrial and municipal discharges to the activities of individuals in residential neighborhoods including appropriate application of fertilizers and the use of green infrastructure to reduce and reuse stormwater.

Oxygen demanding substances can bind to sediment. The ultimate oxygen demanding load delivered to the estuary can be reduced by controlling erosion and sedimentation. The Erosion and Sedimentation Act, established in 1975, provides the mechanism for controlling erosion and sedimentation from land-disturbing activities. This Act establishes a permitting process for land-disturbing activities. Many local governments and counties have adopted erosion and sedimentation ordinances and have been given authority to issue and enforce permits for land-disturbing activities. Approximately 113 counties and 237 municipalities in Georgia have been certified as the local issuing authority. In areas where local governments have not been certified as an issuing authority, the GA EPD is responsible for permitting, inspecting, and enforcing the Erosion and Sedimentation Act.

To receive a land-disturbing permit, an applicant must submit an erosion and sedimentation control plan that incorporates specific conservation and engineering BMPs. The *Manual for Erosion and Sediment Control in Georgia*, a*dopted in 2016*, developed by the State Soil and Water Conservation Commission, may be used as a guide to develop erosion and sedimentation control plans (GSWCC, 1997).

Local governments, with oversight by the GA EPD and the Soil and Water Conservation Districts, are primarily responsible for implementing the Georgia Erosion and Sedimentation Act, O.C.G.A. §12-7-1 (amended in 2003). It is recommended that the local and State governments continue to work to implement the provisions of the Georgia Erosion and Sedimentation Act across Georgia.

Once the sediment reaches the estuary, there are concerns that the bound oxygen demanding substances may be released back into the water column. It may be possible to reduce this internal load by removing sediment from the estuary or control the conditions that cause the oxygen demanding substances to be released from the bottom sediments in the estuary.

6.4 Reasonable Assurance

Permitted discharges will be regulated through the NPDES permitting process described in this report. This TMDL looked at the impact of these discharges to the estuary water quality and did not see any significant effects on dissolved oxygen. With implementation of the TMDL, the estuary was shown to meet the allowable DO deficit. Therefore, this TMDL can serve as the antidegradation analysis for facilities with expanded WLAs. If new information becomes available that will require a revision to the TMDL and WLAs, the revised TDML will serve as the antidegradation analysis for oxygen demanding substances.

An allocation to a point source discharger does automatically result in a permit limit or a monitoring requirement. Through its NPDES permitting process, GA EPD will determine whether a new or existing discharger has a reasonable potential of discharging oxygen demanding substances in levels equal to or greater than the total allocated load. The results of this reasonable potential analysis will determine the specific type of requirements in an individual facility's NPDES permit.

Georgia is working with local governments, agricultural and forestry agencies, such as the Natural Resources Conservation Service, the Georgia Soil and Water Conservation Commission, and the Georgia Forestry Commission, to foster the implementation of best management practices to address nonpoint sources. In addition, public education efforts will be targeted to individual stakeholders to provide information regarding the use of best management practices to protect water quality.

6.5 Public Participation

A forty-five-day public notice will be provided for this TMDL. During this time, the availability of the TMDL will be public noticed, a copy of the TMDL will be provided on request, and the public will be invited to provide comments on the TMDL.

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Appendix A

GA EPD's Coastal DO Permitting Strategy

ENVIRONMENTAL PROTECTION DIVISION
Department of Natural Resources
Atlanta, Georgia
March 1993
Coastal DO Permitting Strategy

For the "Fishing" Use Classification

For Natural DO Values:		Maximum Allowable DO Deficit (mg/L)
Greater than or Equal to, (mg/L)	**And Less than, (mg/L)**	
0.0	2.1	0.0
2.1	3.1	0.1
3.1	3.3	(See Note)
3.3	4.1	0.3
4.1	5.1	0.4
5.1	5.5	0.5
5.5	--	(See Note)

"Maximum Allowable DO Deficit" equals the maximum amount of dissolved oxygen that may be allocated to all Permits combined, both point and non-point source, which affect DO levels in a given waterbody." Since the local value for Maximum Allowable Deficit depends on the local value of Natural DO, the numeric value of Maximum Allowable Deficit may vary from point-to-point as Natural DO varies from point-to-point.

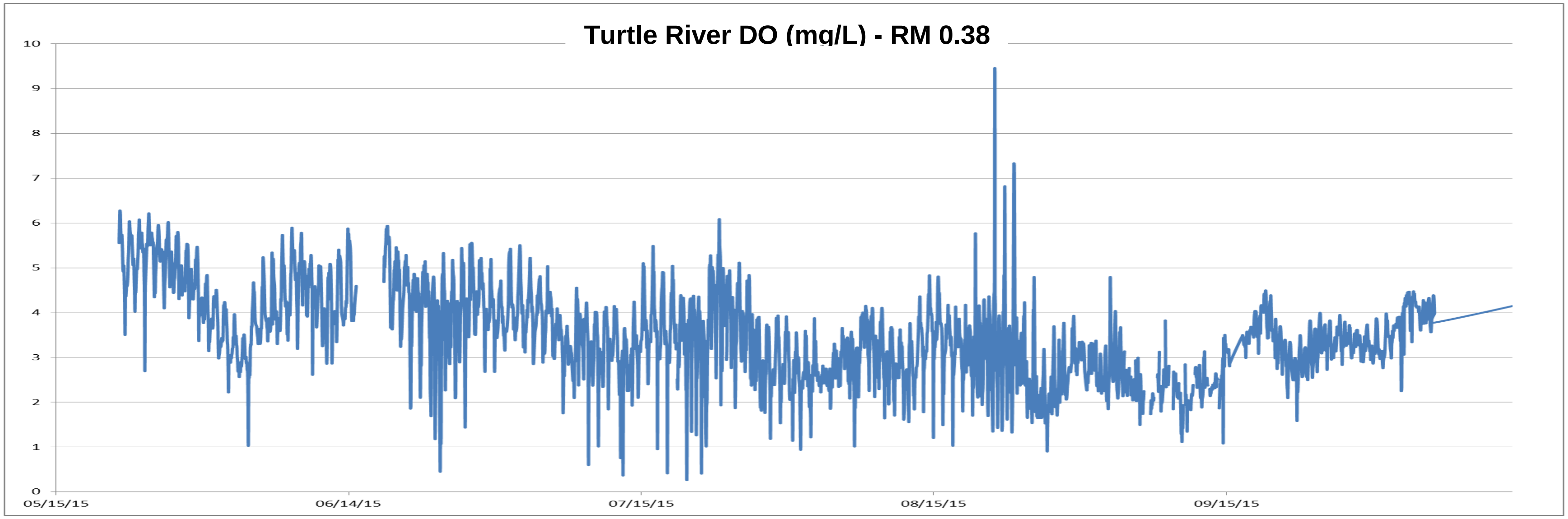
If Natural DO is >= 3.1 mg/L and < 3.3 mg/L, then dissolved oxygen in the water column should not be allowed to drop below 3.0 mg/L.

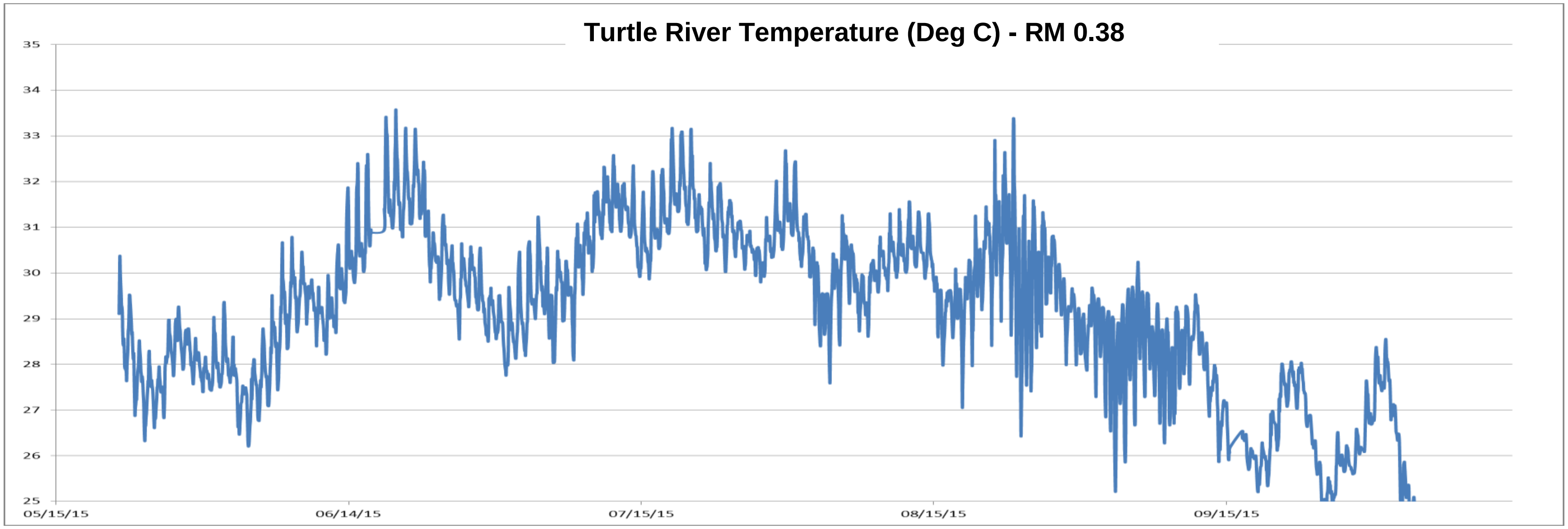
If Natural DO is >= 5.5 mg/L, then dissolved oxygen in the water column should not be allowed to drop below 5.0 mg/L.

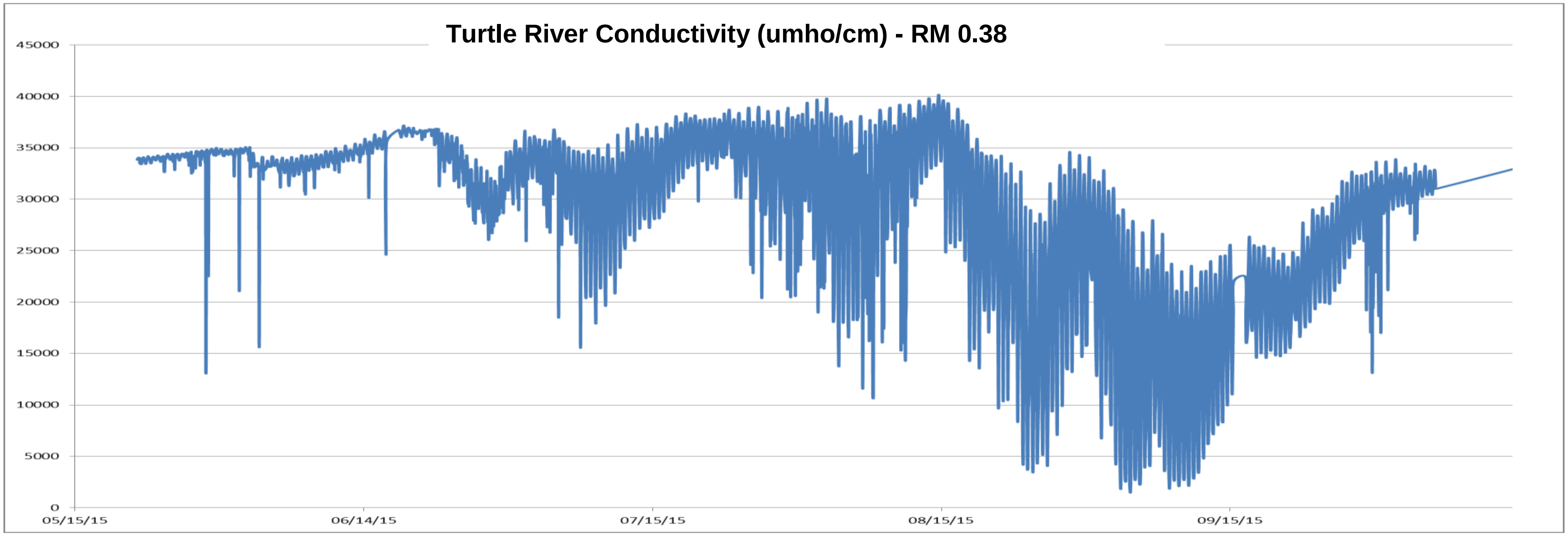
NOTE: All values for Natural DO and Maximum Allowable Deficit for a given waterbody are based on "critical conditions" established specifically for that waterbody.

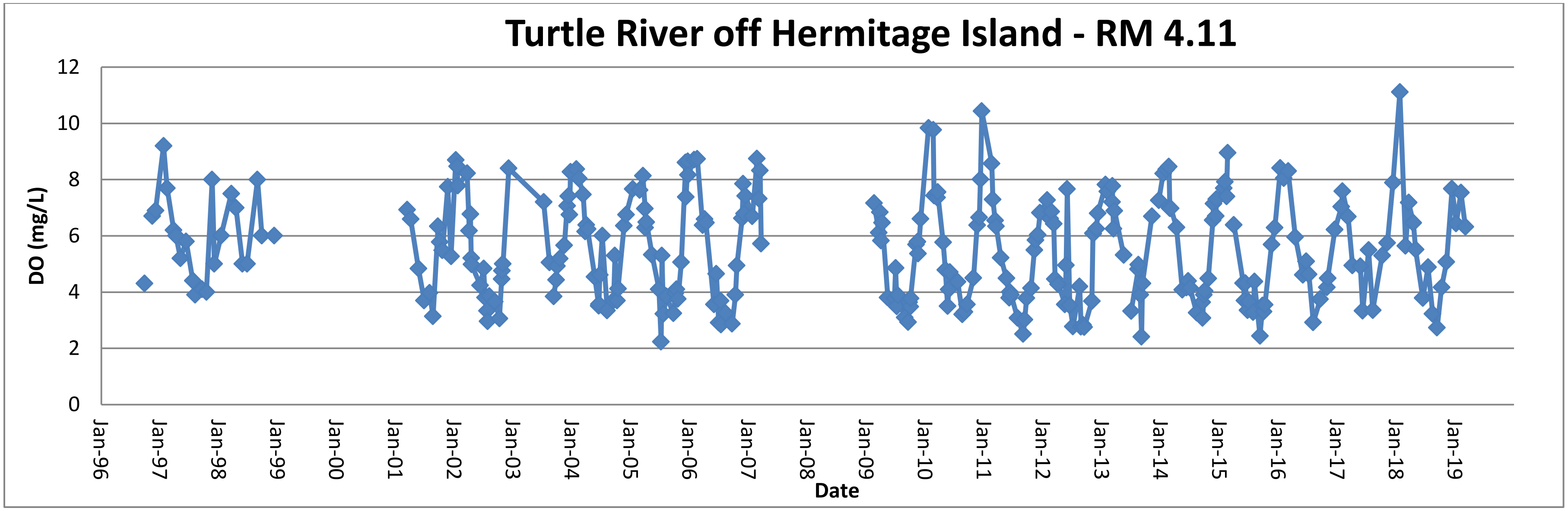
Appendix B

Water Quality Monitoring Data


Turtle River DO (mg/L) - RM 0.38
10
9
8
7
6
5
4
3
2
1
0
05/15/15
06/14/15
07/15/15
08/15/15
09/15/15


Turtle River Temperature (Deg C) - RM 0.38
35
34
33
32
31
30
29
28
27
26
25
05/15/15
06/14/15
07/15/15
08/15/15
09/15/15


Turtle River Conductivity (umho/cm) - RM 0.38
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
05/15/15
06/14/15
07/15/15
08/15/15
09/15/15


Turtle River off Hermitage Island - RM 4.11
DO (mg/L)
0
2
4
6
8
10
12
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
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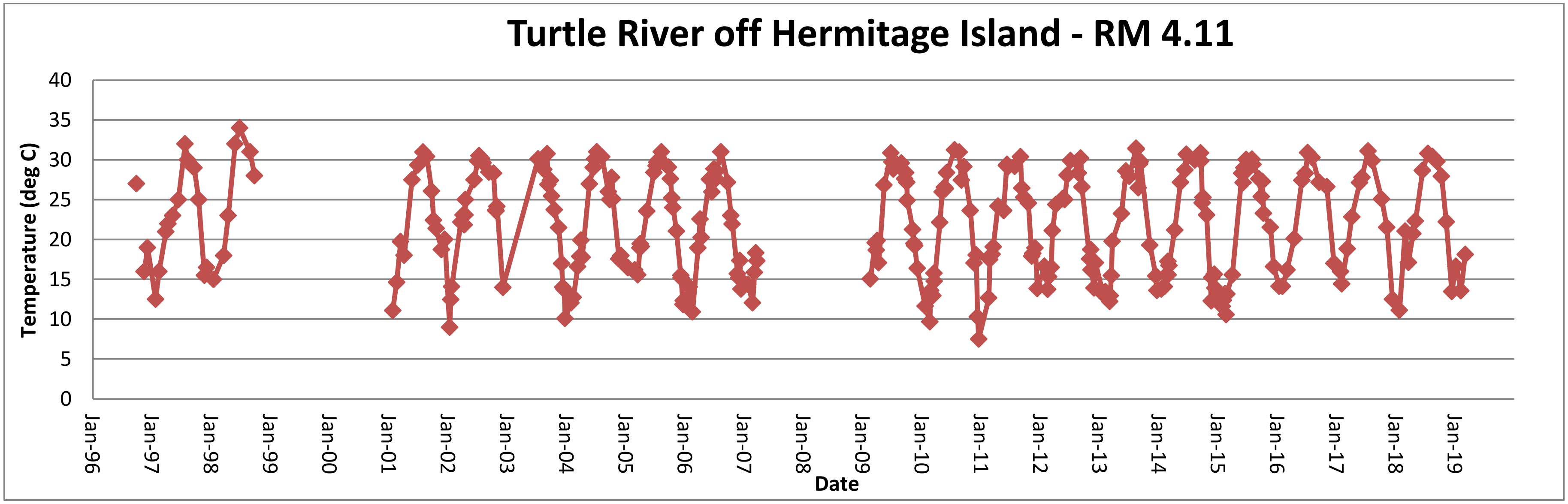
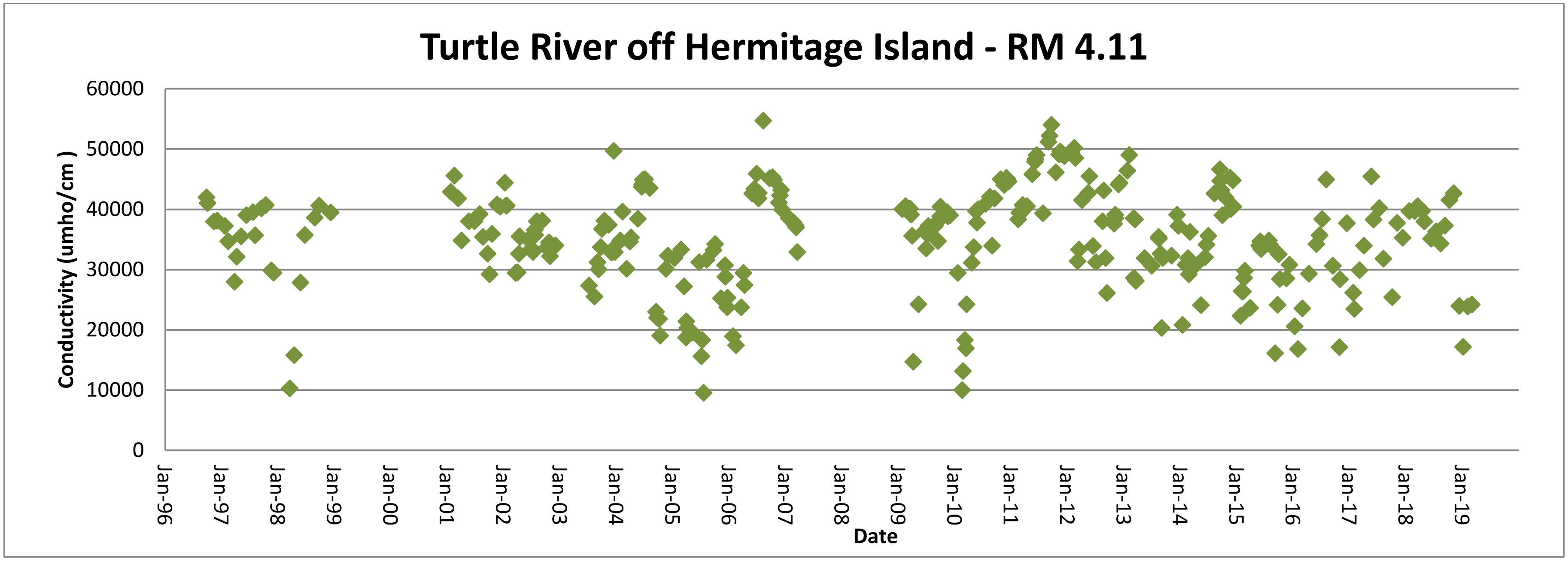
Jan-17
Jan-18
Jan-19
Date


Turtle River off Hermitage Island - RM 4.11
Temperature (deg C)
0
5
10
15
20
25
30
35
40
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Date


Turtle River off Hermitage Island - RM 4.11
Conductivity (umho/cm)
60000
50000
40000
30000
20000
10000
0
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
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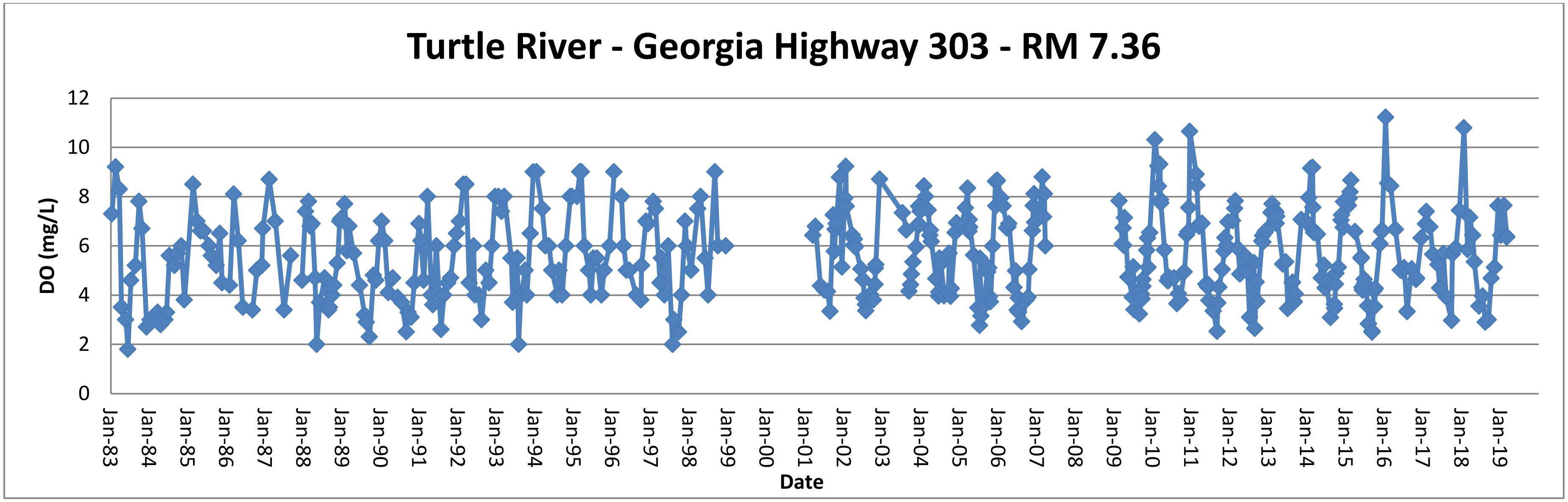
Jan-18
Jan-19
Date


Turtle River - Georgia Highway 303 - RM 7.36
DO (mg/L)
Date
0
2
4
6
8
10
12
Jan-83
Jan-84
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Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
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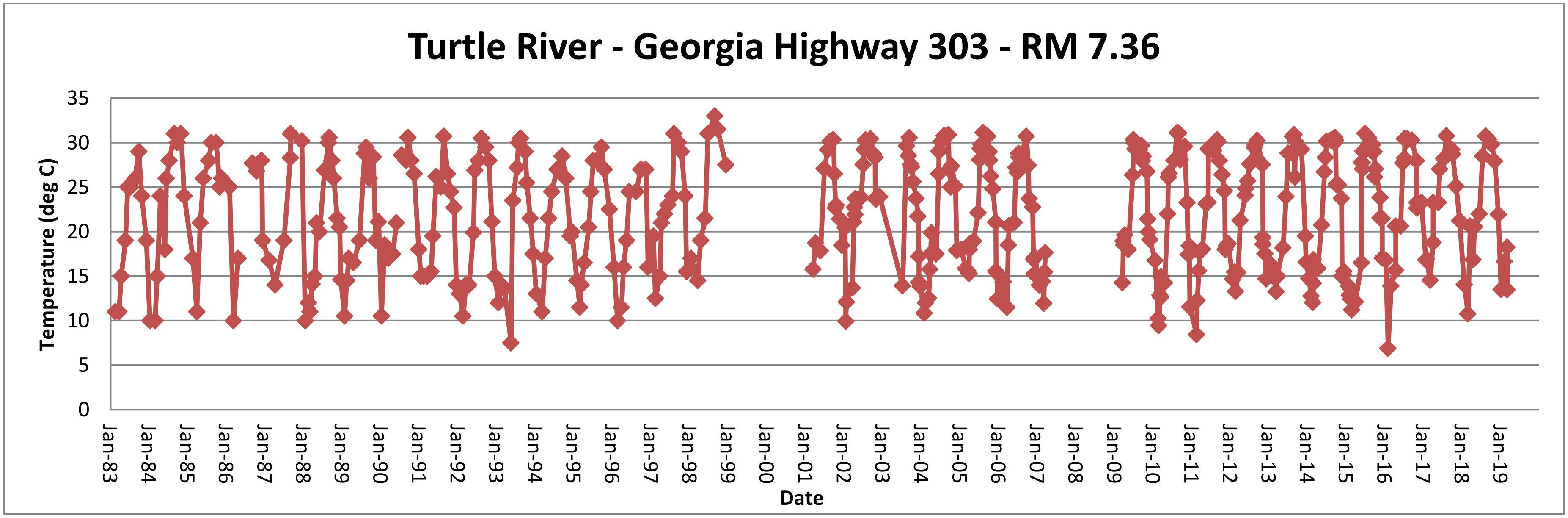
Jan-17
Jan-18
Jan-19


Turtle River - Georgia Highway 303 - RM 7.36
Temperature (deg C)
Date
0
5
10
15
20
25
30
35
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
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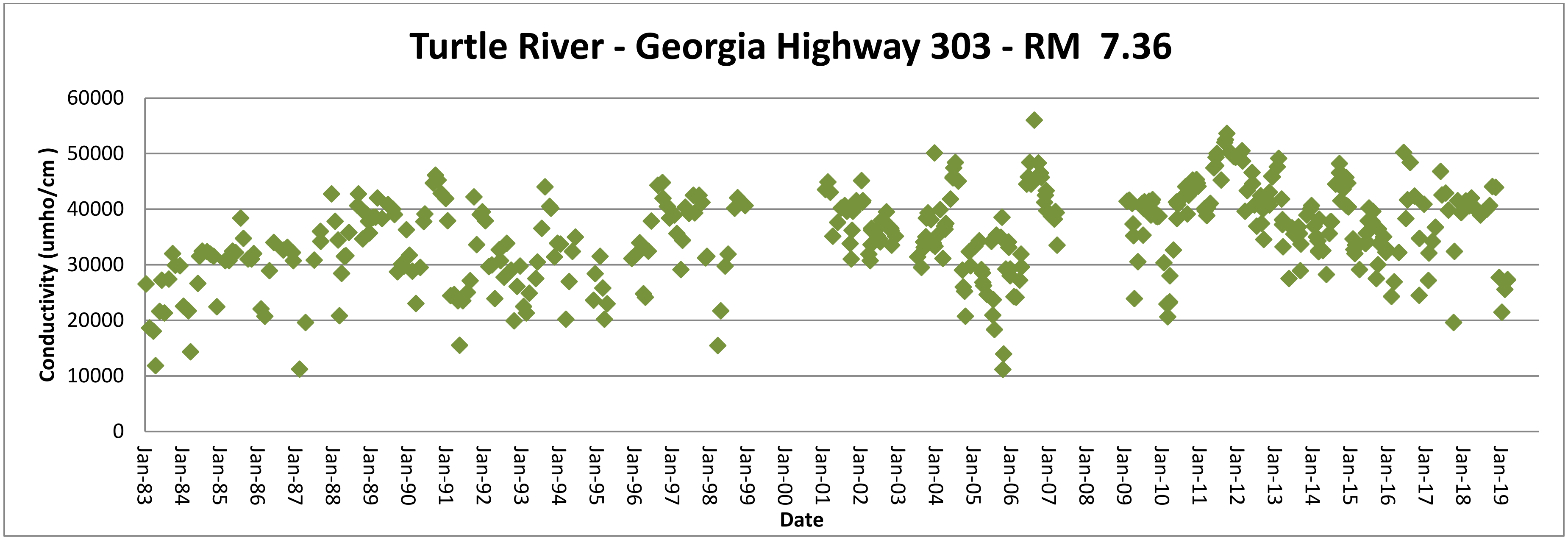
Jan-19


Turtle River - Georgia Highway 303 - RM 7.36
60000
50000
40000
30000
20000
10000
0
Conductivity (umho/cm)
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
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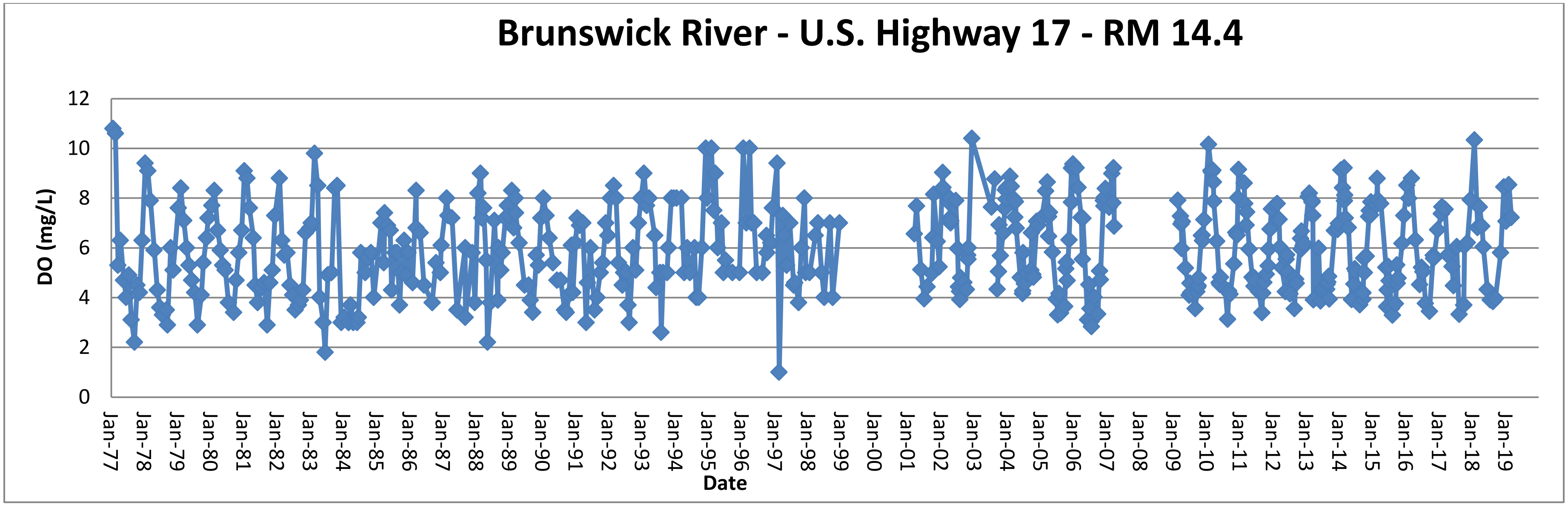
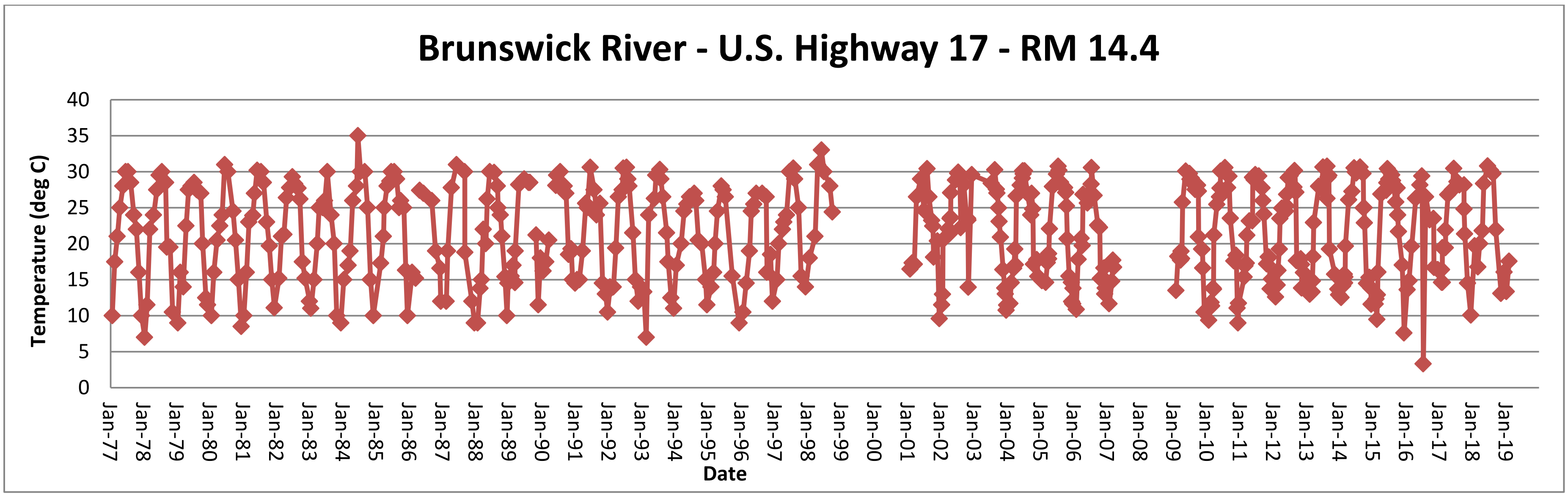
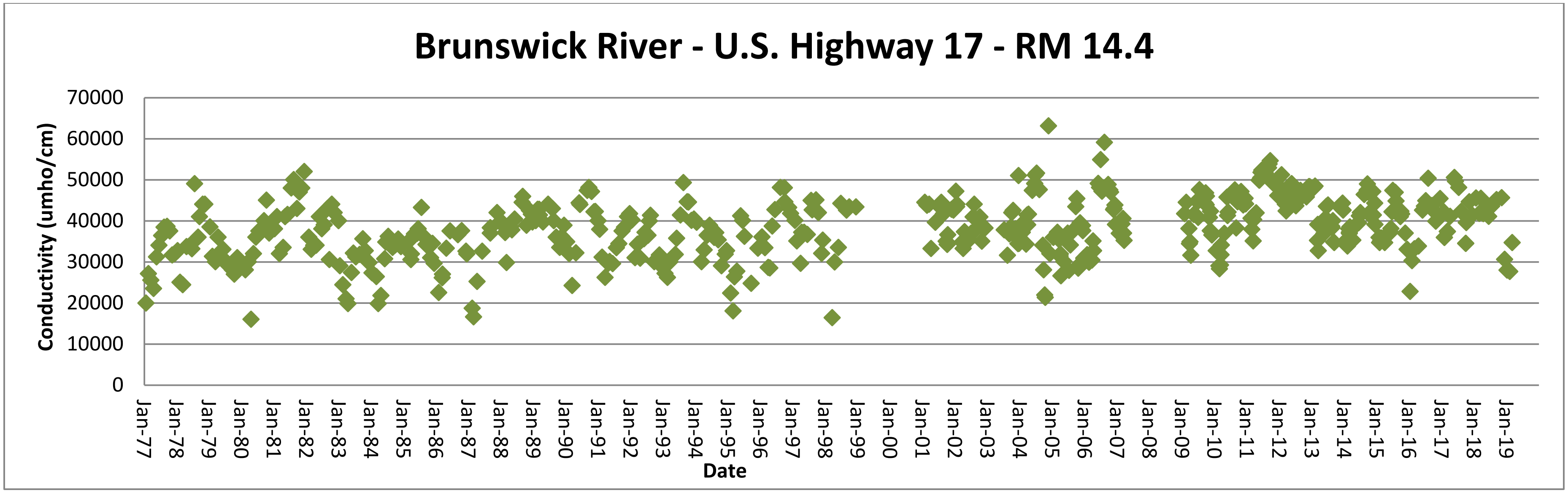
Jan-18
Jan-19
Date


Brunswick River - U.S. Highway 17 - RM 14.4
DO (mg/L)
0
2
4
6
8
10
12
Jan-77 Jan-78 Jan-79 Jan-80 Jan-81 Jan-82 Jan-83 Jan-84 Jan-85 Jan-86 Jan-87 Jan-88 Jan-89 Jan-90 Jan-91 Jan-92 Jan-93 Jan-94 Jan-95 Jan-96 Jan-97 Jan-98 Jan-99 Jan-00 Jan-01 Jan-02 Jan-03 Jan-04 Jan-05 Jan-06 Jan-07 Jan-08 Jan-09 Jan-10 Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19
Date


Brunswick River - U.S. Highway 17 - RM 14.4
Temperature (deg C)
0
5
10
15
20
25
30
35
40
Jan-77 Jan-78 Jan-79 Jan-80 Jan-81 Jan-82 Jan-83 Jan-84 Jan-85 Jan-86 Jan-87 Jan-88 Jan-89 Jan-90 Jan-91 Jan-92 Jan-93 Jan-94 Jan-95 Jan-96 Jan-97 Jan-98 Jan-99 Jan-00 Jan-01 Jan-02 Jan-03 Jan-04 Jan-05 Jan-06 Jan-07 Jan-08 Jan-09 Jan-10 Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19
Date


Brunswick River - U.S. Highway 17 - RM 14.4
Conductivity (umho/cm)
70000
60000
50000
40000
30000
20000
10000
0
Jan-77
Jan-78
Jan-79
Jan-80
Jan-81
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
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Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
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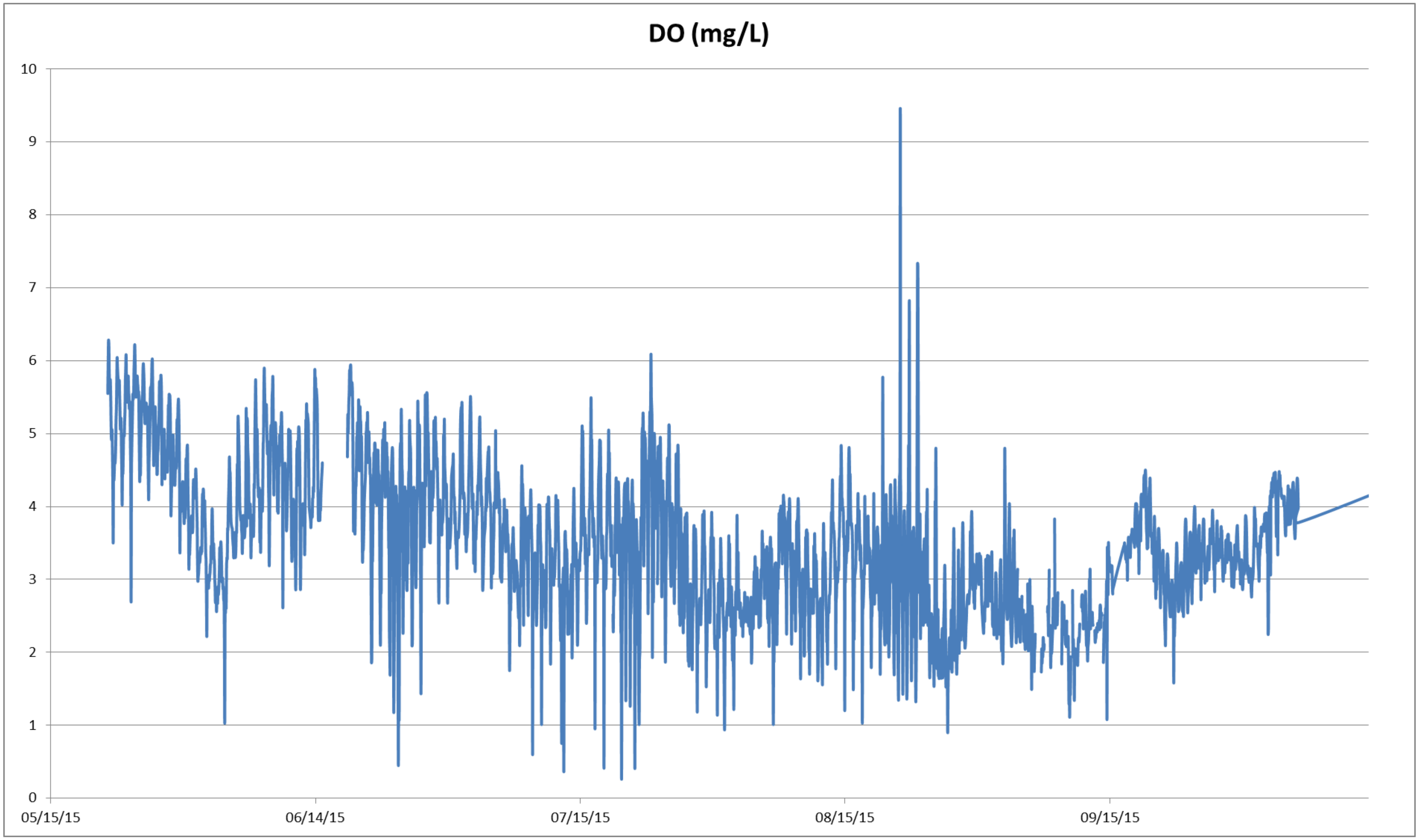
Jan-18
Jan-19
Date


DO (mg/L)
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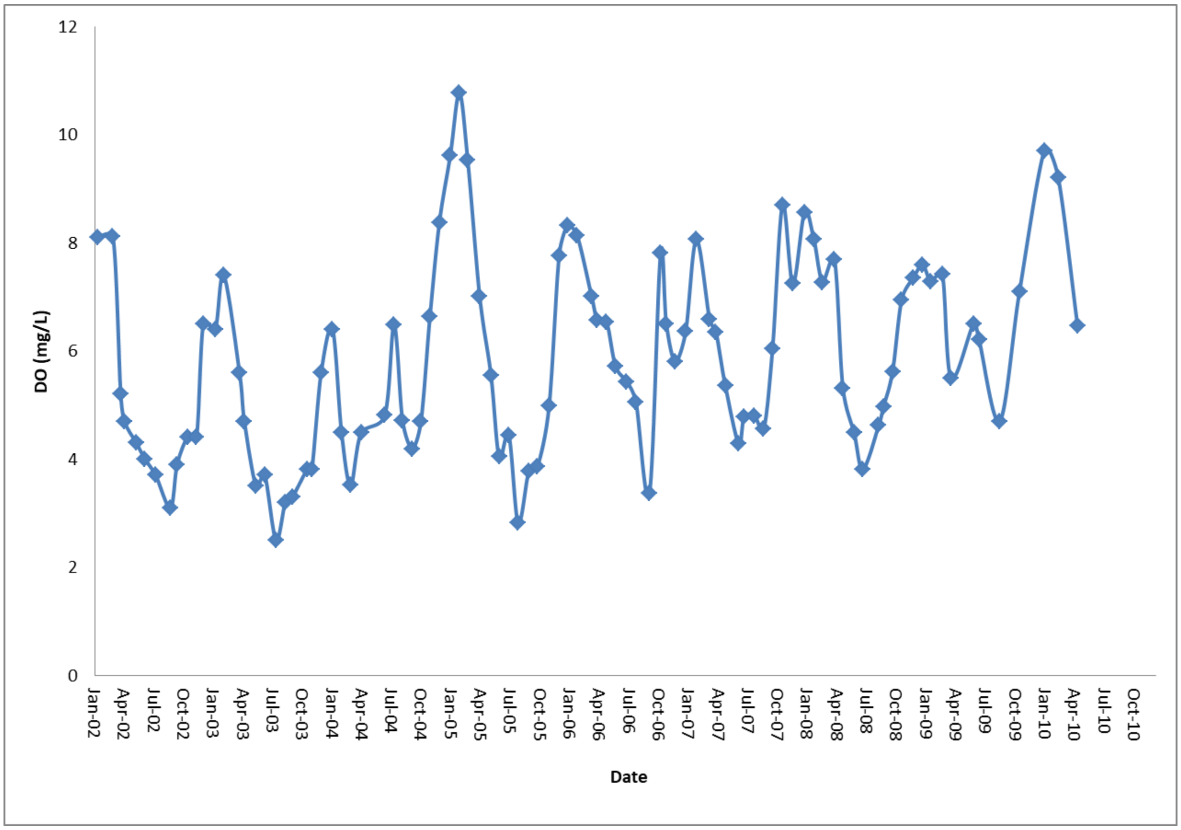
9
8
7
6
5
4
3
2
1
0
05/15/15
06/14/15
07/15/15
08/15/15
09/15/15

Appendix C

CRD Data
Station 721 – St Simons Sound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4
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0
DO (mg/L)
Jan-02
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
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Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
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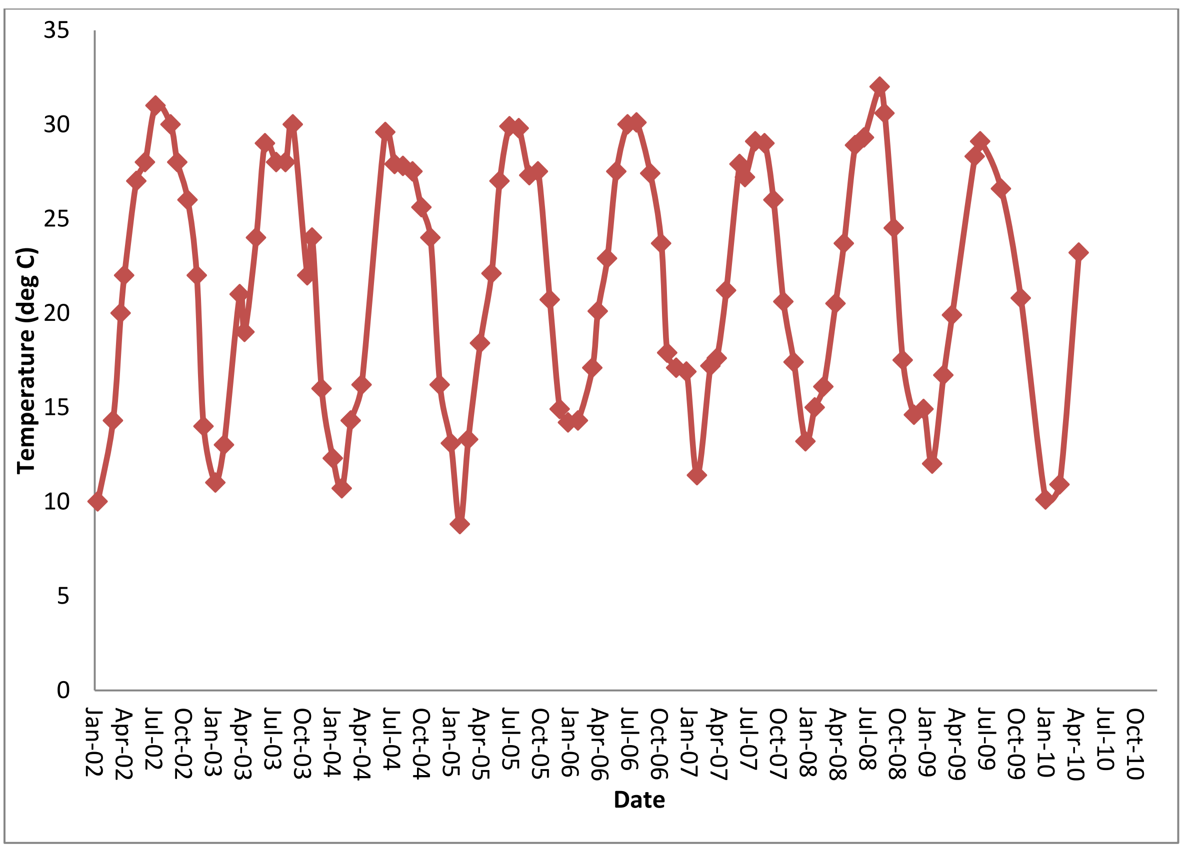
35
30
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15
10
5
0
Temperature (deg C)
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Apr-02
Jul-02
Oct-02
Jan-03
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Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
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Oct-10
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