NUTRIENT CONDITIONS AND NUMERIC NUTRIENT CRITERIA IN SOUTHEASTERN UNITED STATES ESTUARIES

by

WENDY KAY WRIGHT

(Under the Direction of Todd C. Rasmussen)

ABSTRACT

The US Environmental Protection Agency (USEPA) mandated in 2008 that all states, territories, and tribes develop a plan for determining numeric nutrient criteria (NNC), which are used to maintain healthy aquatic ecosystems and to restore nutrient-impaired ecosystems. NNC are important to the US National Park Service (USNPS) because maintaining healthy ecosystems is part of their goal for protecting and preserving National Parks. The goal of this research is to examine methods for determining appropriate coastal NNC near and within Georgia's National Parks that lie in coastal areas, including Cumberland Island National Seashore, Fort Frederica National Monument, and Fort Pulaski National Monument. Methods are demonstrated using available nutrient and water-quality data from Federal, state, and local agencies that have water-quality monitoring programs. Statistical analyses are performed to determine baseline nutrient levels, estimate nutrient stressors on aquatic systems, and identify ecosystem responses to these stressors. Baseline nutrient levels are characterized both spatially and temporally.

INDEX WORDS: Estuary, estuarine, water quality, nutrients, nitrogen, phosphorus, numeric nutrient criteria

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DEDICATION

For my three children, Katie, Dustin and Meghann, who have raised the bar with each one of their successes, and who never fail to inspire me, and my Mom, Kathy Meyer, who taught me the value of strength and determination, and the ability to build something incredible from rubble and ruin.

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1. INTRODUCTION

1.1 Motivation

Estuarine areas provide important habitat for fish, crustaceans, and shellfish, as well as forage areas for birds and mammals (Wall et al. 2011). Georgia's coastal and estuarine regions are important tourist destinations, and provide many recreational and commercial opportunities along with ancillary economic benefits.

Nitrogen and phosphorus are essential nutrients that support ecosystem productivity. While insufficient nutrient availability can limit biological systems, excessive amounts are the primary cause of eutrophication. Nutrient enrichment is associated with poor water quality, including increased turbidity (or decreased water clarity) and chlorophyll *a*, and nuisance algae (Sindermann 2006), hypoxia, anoxia, fish kills, and a loss of shellfish habitat. Degradation of seagrass beds may occur, and accumulation of toxins in shellfish may pose a risk to human health (National Research Council 2000, Sindermann 2006). These problems are often most severe in lentic systems, such as lakes, wetlands, and estuaries, which feature long residence times due to low water flow relative to water volume.

Nutrient overabundance originates from multiple sources, including direct inputs from agricultural runoff and urban stormwater runoff, and relative nutrient levels due to changes in freshwater inputs (flood, drought) that can change salinity, wetland loss, sea level rise that changes estuarine salinities (Jun et al. 2013) and increased freshwater withdrawals.

1.2 Legislative Mandate

Beginning in 1998, the U.S. Environmental Protection Agency (EPA) recommended that individual states develop and adopt numeric nutrient criteria (NNC) for all water bodies (United States Environmental Protection Agency 1998, 2008).

In response, the Georgia Environmental Protection Division (GAEPD) has issued a plan for developing NNC (Georgia Department of Natural Resources 2008) , which was updated in August of 2013 (Georgia Department of Natural Resources 2013), and has a projected deadline of 2020 for establishing NNC for estuaries and coastal waters.
NNC are of direct interest to the NPS because of their overarching mission to protect the natural resources under their jurisdiction, including several coastal Georgia National Parks, and to keep them unimpaired for future generations.

The NPS's Southeast Coast Network (SECN) Inventory and Monitoring (I&M) Program is responsible for monitoring water quality, including estuarine health and nutrient levels, in the vicinity of coastal National Parks from Cape Hatteras National Seashore in North Carolina southward to Canaveral National Seashore in Florida (Figure 1.1)

This area is part of what is known as the South Atlantic Bight, the continental shelf bounded by Cape Hatteras to the North, and Palm Beach to the South. At the center of the south Atlantic bight is the Georgia coast, with Timucuan Ecological and Historical Preserve just to the south of Georgia, in Jacksonville, Florida. On the northern boundary is Fort Pulaski National Monument, in Savannah Georgia. The U.S. National Park Service (NPS) manages three units along the Georgia coast, including Fort Pulaski National Monument, Cumberland Island National Seashore, and Fort Frederica National Monument, all of which are located within estuarine systems (Figure 1.1).

1.3 Study Objectives

The objective for this research is to develop an overall picture of current and recent aquatic health conditions and nutrient levels, and provide a baseline from which to develop site- or area- specific nutrient criteria. This research focuses on coastal water NNC in Georgia, Florida and South Carolina, with a special emphasis on the coastal waters surrounding Cumberland Island National Seashore, Fort Pulaski National Monument, and Timucuan Ecological and Historic Preserve.

Historical data are available to determine baseline levels of nitrogen, phosphorus and chlorophyll *a*. These parameters, along with salinity, climatology, pH, and other factors are assessed to determine current conditions. Limited data for response factors such as chlorophyll *a*, dissolved oxygen, and turbidity are also available.

Additionally, conditions in the immediate vicinity of National Park units can be placed in a regional perspective by qualitatively comparing these areas with other estuarine areas in the central South Atlantic Bight area.

The primary research objectives for this study are:

1. To compile and synthesize water-quality data across multiple agencies and years, with consistent quality assurance and quality control protocols, establishing a regional water-quality dataset, which allows for more comprehensive estuarine data analysis and sub-region comparison of ecological and aquatic health across multiple estuaries.
2. To establish baseline nutrient levels (both spatial and temporal) along the southeastern coast and within the estuaries and tidal creeks adjacent to and within the Cumberland Island National Seashore (CUIS), Fort Pulaski National Monument (FOPU) and Timucuan Ecological and Historic Preserve (TIMU).
3. To compare nutrient concentrations for nitrogen and phosphorus within Georgia's National Park Service coastal units to regional concentrations to gain a qualitative perspective on National Park water quality conditions.
4. To develop a regression analysis that correlates TN and TP levels to DIN and DIP values currently used regionally for site condition assessments by the EPA, and to apply this analysis both on a basin level and a more specific reach level.

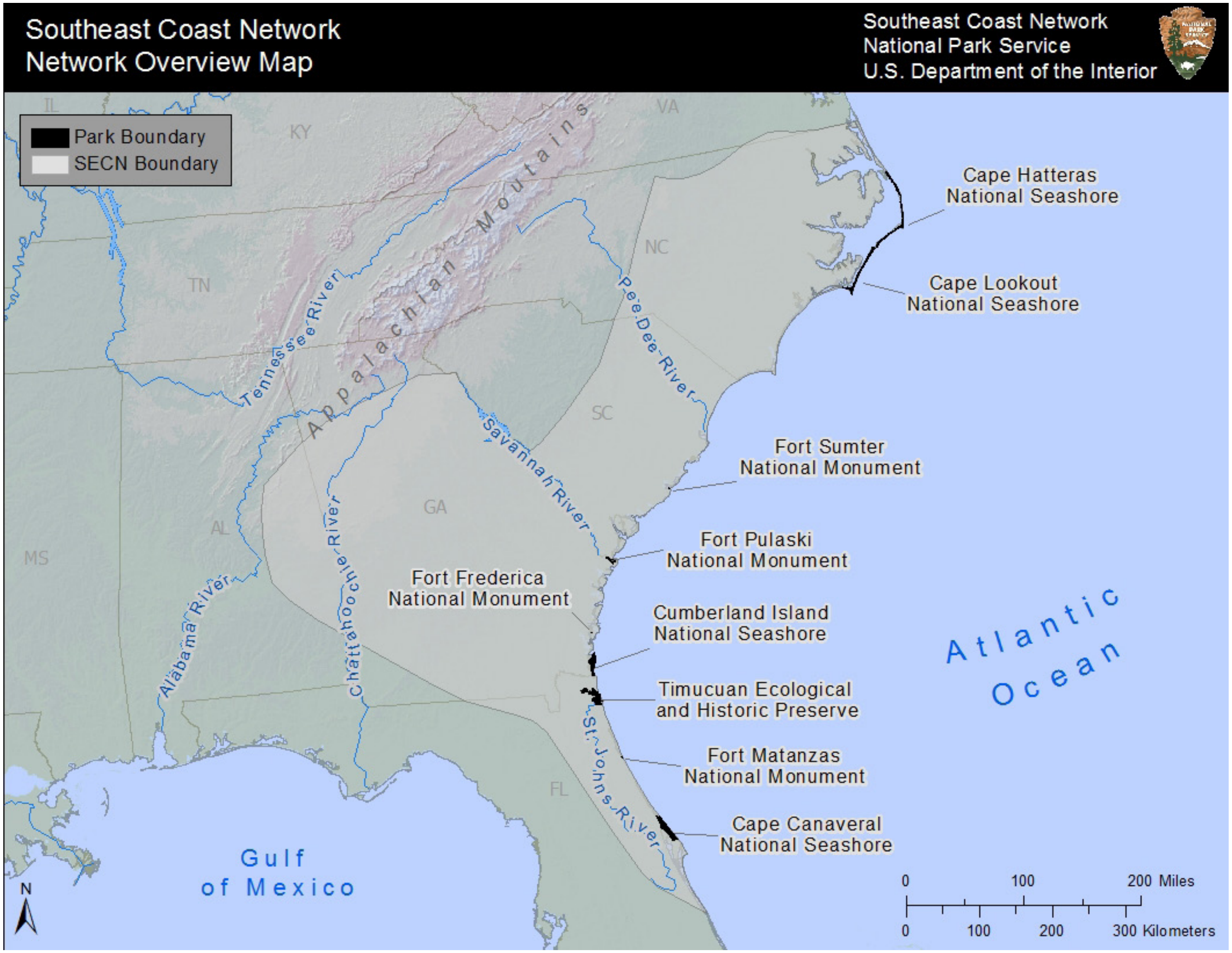


Figure 1.1 SEN Coastal Overview Map

2. LEGISLATIVE BACKGROUND

2.1 Federal Legislation

In 1998, President Bill Clinton, along with Vice President Al Gore, released a Clean Water Action Plan with three major goals; "To enhance protection from public health threats posed by water pollution, more effective control of polluted runoff, and promotion of water quality restoration and protection on a watershed basis (USEPA 1998)."

As part of this Action Plan, the EPA was mandated to work with States and Tribes to accelerate scientific research in the field of nutrient pollution and develop enforceable water quality standards for nutrients. The planned approach is laid out in The National Strategy for Development of Regional Nutrient Criteria (USEPA 1998).

Numeric nutrient criteria are to be developed for four waterbody types: Streams, lakes, coastal waters, and wetlands. The EPA offers support to States and Tribes for development of NNC in the Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Marine Waters (USEPA 2001).

In 2008, the USEPA released an update on State's progress in the report State Adoption of Numeric Nutrient Standards (1998-2008)(USEPA 2008). The current status of each state's compliance with NNC development can be found at the EPA website "State Development of Numeric Criteria for Nitrogen and Phosphorus Pollution" at http://cfpub.epa.gov/wqsits/nnc-development/.

2.2 Georgia Legislation

The Georgia Department of Natural Resources, Environmental Protection Division (GAEPD) put forth its initial plan for the development of NNC in Georgia's Plan for the Adoption of Water Quality Standards for Nutrients, Revision 1.0 (GAEPD 2008). Key strategic components include identification and classification of all state waterbodies; deciding which parameters to use as criteria; developing technical approaches, and coming to mutual agreement with the USEPA on assessment methods.

For estuarine and coastal areas, it was deemed likely that site-specific criteria would be necessary based on the uniqueness of the estuarine area, and that the technical approaches would be developed before proceeding with development of NNC. The projected adoption date for NNC was December 31, 2014.

In July 2013, an updated plan was published with Georgia's Plan for the Adoption of Water Quality Standards for Nutrients, Revision 2.0 (Georgia Department of Natural Resources 2013). It was determined that both causal and response parameters would be assessed, including nitrogen, phosphorus, turbidity, Secchi depth (water clarity) and dissolved oxygen. The projected date for adoption of NNC for estuarine areas and coastal marine waters was delayed, with a current anticipated completion date of December 31, 2020.

2.3 South Carolina Legislation

The State of South Carolina's Adoption Plan for Numeric Nutrient Water Quality Criteria was originally published in 2007 (SCDHEC 2007), and called for NNC to be implemented in 2011. An updated version of the adoption plan was released in 2010 (SCDHEC 2010). According to David Chestnut, Senior Scientist at SCDHEC, South Carolina is currently focusing on additional data collection which will continue through next summer, and do not have a planned date for implementation of NNC (David Chestnut, personal communication).

2.4 Florida Legislation

Of the three states, Florida has made the most progress on NNC development for estuaries, with complete NNC in place and approved by the USEPA. Status of NNC for Florida can be found in the FDEP's Report to the Governor and Legislature: Status of Efforts to Establish Numeric Interpretations of the Narrative Nutrient Criterion for Florida Estuaries and Current Nutrient Conditions of Unimpaired Waters (Florida Department of Environmental

Protection Division of Environmental Assessment and Restoration 2013).

Additional information about past and current legislation regarding the development of NNC in Georgia, Florida, and South Carolina can be found in Table 2.1.

Table 2.1 Legislation and Documentation Links

US Environmental Protection Agency	
National Strategy for the Development of Regional Nutrient Criteria	http://www2.epa.gov/sites/production/files/documents/nutrient_strategy_1998.pdf
State Adoption of Numeric Nutrient Standards (1998-2008)	http://www2.epa.gov/sites/production/files/documents/nutrient_report1998-2008.pdf
Criteria Development Guidance: Estuarine and Coastal Waters	http://www2.epa.gov/nutrient-policy-data/criteria-development-guidance-estuarine-and-coastal-waters
Georgia	
Georgia's Plan for the Adoption of Water Quality Standards for Nutrients, Revision 1.0	http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/ga_plan_2008.pdf
Georgia's Plan for the Adoption of Water Quality Standards for Nutrients, Revision 2.0	https://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/GA_NutrientCriteria_Plan_Aug_2013_Rev.pdf
Florida	
State of Florida Numeric Nutrient Criteria Development Plan	http://cfpub.epa.gov/wqsits/nnc-development/ncdp/flplan2007.pdf
FDEP GIS Data Review Numeric Nutrient Criteria	http://www.dep.state.fl.us/water/wqssp/nutrients/docs/fdep_epa_nnc_coverage_comparison.pdf
Report to the Governor and Legislature: Status of Efforts to Establish Numeric Interpretations of the Narrative Nutrient Criterion for Florida Estuaries and Current Nutrient Conditions of Unimpaired Waters	http://www.dep.state.fl.us/water/wqssp/nutrients/docs/NNC-report-governor-legislature.pdf
Technical Support Document for U.S. EPA's Proposed Rule for Numeric Nutrient Criteria for Florida's Estuaries, Coastal Waters, and South Florida Inland Flowing Waters, Volume 1 Estuaries [DCN 1-1498]	http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OW-2010-0222-0002

South Carolina	
The State of South Carolina's Adoption Plan for Numeric Nutrient Water Quality Criteria	http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/South-Carolina-Adoption-Plan-for-Numeric-Nutrient-Water-Quality-Criteria.pdf
The State of South Carolina's Adoption Plan for Numeric Nutrient Water Quality Criteria *(revised)*	http://cfpub.epa.gov/wqsits/nnc-development/ncdp/scplan2010.pdf

3. ECOLOGICAL BACKGROUND

3.1 Eutrophication

Eutrophication occurs when organic enrichment in a water system, or an increase in biomatter, affects the ecology of that system. An increase in nutrients such as nitrogen and phosphorus can increase the rate of growth of algal bacteria. In response, there is an increased demand for dissolved oxygen due to increased respiration by harmful algal biomass. This can lead to a decrease in dissolved oxygen available for wildlife. When dissolved oxygen concentrations are less than 2.0 mg/L, it is referred to as hypoxia. When there is no dissolved oxygen present, conditions are considered anoxic (National Research Council 2000). Presence of light can contribute to eutrophication, as plant matter require light for photosynthesis. Hypoxia can cause changes in benthic communities (National Research Council 2000), and harmful algal blooms such as red or brown tides (National Research Council 2000).

3.2 Salinity

Salinity levels can affect nutrient concentrations, and how nutrients are processed in the water column (Jun et al. 2013). Nitrogen can decrease as salinity increases, and phosphorus levels are lowest at sites with higher saline content (Więski et al. 2010). Sea-level rise induced saltwater intrusion can increase the amount of nitrogen released into the water column (Jun et al. 2013). Nitrogen levels can also increase at low tides (Haines 1979). Salinity can affect the density of the water and inhibit mixing in the water column, leading to stagnant areas (Bortone 2005). Additionally, gradual temporal changes in salinity can contribute to a change the makeup of submerged aquatic vegetation (SAV) in an estuary, as varying species of seagrass have difference salinity tolerance levels. Changes in salinity also contribute to algal blooms (Liu and Buskey 2000).

3.3 Geographic Location

Synoptic studies (Coastal Assessments) done by the NPS at the four Parks have shown a great deal of spatial disparity in nutrient levels (Gregory et al. 2010a, Gregory et al. 2010b, Gregory et al. 2010c, Gregory et al. 2011, Wright et al. 2013) . These assessments have also raised questions about the relationship of nitrogen and phosphorus with waterbody type (e.g., tidal creek or open water), proximity to urban areas, salinity levels, tidal fluctuations, and climatic conditions, especially high intensity rainfall.

3.4 Physical Processes

Tidal fluctuations occur semi-diurnally (twice a day) along the mid-Atlantic coast. Tidal currents cause a change in salinity as fresh water and saline water are exchanged, with higher salinity at high tides, and lower salinity at low tides, when the fresh water influence is greater (Bortone 2005). The difference in tidal influences across estuaries can cause erratic residence times, or the time it takes nutrients loaded by freshwater to flush out of the estuaries (Sheldon and Alber 2002, Bortone 2005). This difference in flushing time contributes to uniqueness of nutrient concentrations in individual estuaries.

River inflows also vary between estuarine systems, both naturally (size and flow of river) and artificially due to human intervention such as dams (Bortone 2005), which can affect residence times and nutrient levels.

3.5 Rationale for Existing Criteria

Nitrogen and phosphorus are found in many forms in estuarine waters, both dissolved and particulate, and organic and non-organic. Dissolved inorganic nutrient measurements are important because they indicate the amount of nutrients bioavailable to plants. Particulate nutrients are also important, as they can affect water clarity.

The most common forms of nitrogen found in estuarine waters are ammonia (or ammonium) and nitrate (or nitrite) which together make up dissolved inorganic nitrogen. Orthophosphate (dissolved inorganic phosphorus) is the most common form of phosphorus.

The National Coastal Condition Report is compiled by the USEPA, and intended to provide a snapshot of conditions in coastal areas, fisheries, and other areas. Coastal monitoring data is compiled from the USEPA's National Coastal Assessment (NCA) program and other sources. Because the data provided includes information about dissolved inorganic nitrogen and dissolved inorganic phosphorus, cutpoints were determined for those two parameters (USEPA 2012).

DIN and DIP are the portions of nitrogen and phosphorus remaining after nutrient sorption to sediment or integration by plant growth. While they are measured by filtering water samples before analysis, and are not the same measure as TN and TP, they are considered to give a good indication, along with other parameters such as water clarity and dissolved oxygen, of water quality conditions (USEPA 2012).

The current USEPA cutpoints for DIN, DIP, chlorophyll *a*, and dissolved oxygen for the southeastern United States coast are found in Table 3.1, which is found in each National Coastal Condition Report (USEPA 2012).

Table 3.1 USEPA NCA cutpoints.

Rating	Chlorophyll a (µg/L)	Dissolved Inorganic Nitrogen (mg/L)	Dissolved Inorganic Phosphorus (mg/L)	Dissolved Oxygen (mg/L)
Good	<5	<0.1	<0.01	>5
Fair	5–20	0.1–0.5	0.01–0.05	2–5
Poor	>20	>0.5	>0.05	<2

Since these levels of DIN and DIP are considered good indications of the ecological health of coastal waters, it is assumed that if a relationship between DIN and TN, as well as DIP and TP, can be determined, that the extrapolated values of TN and TP would be acceptable as criteria.

3.6 Existing Methods

According to the USEPA's Technical Guidance Report (USEPA 2001), there are several measures that can be used to predict nutrient enrichment of an estuary relative to reference conditions. All methods are based upon the same philosophy; determining in a scientifically defensible manner the point at which nutrient concentrations become harmful to an ecosystem. Using nutrients (nitrogen, phosphorus, and silica) as a stressor, or causal factor, compared to response factors such as chlorophyll *a*, plant biomass, water clarity or dissolved oxygen can give an indication of what levels of nutrient concentrations are harmful to the ecological health of an estuary (stressor-response evaluation).

Recommended methods include using empirical or mathematical models to analyze data, determine reference conditions, and produce criteria.

4. METHODS

4.1 Data Sources

Data were obtained from existing government agency water quality programs, including the National Park Service (NPS), the National Estuarine Research Reserve System (NERRS), the Georgia Department of Natural Resources, Environmental Protection Division (GAEPD), the City of Jacksonville, Florida, the Florida Department of Environmental Protection (FDEP), and the South Carolina Department of Health and Environmental Control (SCDHEC).

NPS SECN data were obtained directly from the SECN database. Data for SCDHEC, FDEP, the City of Jacksonville, Florida, and the GAEPD, were obtained from STORET. Additional data for Timucuan Ecological and Historic Preserve were obtained from Betsy Deuerling, City of Jacksonville, Florida. All water data for NERRS were obtained directly from NERRS centralized data management office (http://cdmo.baruch.sc.edu/).

4.1.1 National Park Service

The SECN has established water-quality monitoring programs in seven coastal National Park units, including Cumberland Island National Seashore and Fort Pulaski National Monument on the coast of Georgia, and Timucuan Historic and Ecological Preserve on the northern Florida coast near Jacksonville. Data gathered in this monitoring effort is intended to help park managers understand trend and variability related to water-quality conditions in and around National Parks, as well as protect our national resources.

As part of the SECN coastal monitoring effort near Cumberland Island National Seashore, fixed-station continuous data and monthly nutrient data have been collected since 2005, and two 30-site synoptic nutrient assessments (a sampling protocol that involves taking several spatially diverse samples in a short period of time) were conducted in July and August of 2007 and 2012. At Fort Pulaski, two multi-site synoptic studies were conducted, in 2007 and 2014, with continuous data logging beginning in 2006, and at Fort Frederica, one multi-site synoptic study was conducted in 2008.

At Timucuan Ecological and Historic Preserve, continuous data has been gathered since 2000, some in partnership with the City of Jacksonville. Two multi-site synoptic studies were conducted, in 2008 and 2013

4.1.2 Other Data sources

Data are also available from the Georgia Department of Natural Resources, Environmental Protection Division, the National Estuarine Research and Reserve System (NERRS), a branch of the National Oceanic and Atmospheric Administration (NOAA), and the City of Jacksonville, Florida, water quality division. Data obtained includes nitrogen and phosphorus concentration levels, salinity, pH, temperature, depth, chlorophyll *a* levels, water clarity, Secchi depth, GIS coordinates of all sites, and other parameters. Not all parameters are available for all datasets, as each agency's sampling protocol differs in sampling times, length of dataset, and variables collected.

4.2 Data Management

All data were imported into a Microsoft Access (Access) database. The R Statistical Package (R Core Team 2013) was used to determine the number of observations for nutrients, and all sites with $n < 20$ were removed from the dataset to eliminate sites with only one or two sampling occurrences. Additionally, duplicate observations for the City of Jacksonville database were removed, as were all observations in the SCDHEC dataset reported as 'Below Detection Limit (BDL)', as it was determined that some data reported as BDL were actually values that could not be calculated.

All values that were specified as below detection limit (other than South Carolina) were changed to one-half the method detection limit (MDL) for each specific analytical method (United States Geological Survey 2014). Additionally, all negative and zero values were also changed to one-half the MDL for the purpose of calculating the log of the actual value. Lachat MDL's were used for the corresponding USEPA methods (Lachat Instruments 2009).

Data parameters across agencies varied in labeling, analytical methods, and protocols. Because of this, nutrient data from these agencies were aggregated into the following categories, based on analytical method, assigned variable name, and agency data collection protocols: Ammonia (including ammonium), nitrate-nitrite, Kjeldahl nitrogen, total nitrogen, orthophosphate, total phosphorus, chlorophyll *a* corrected, and chlorophyll *a* uncorrected (United States Geological Survey 2014).

All sites were then assigned a basin using the Hydrologic Unit Code (HUC8) for the purpose of performing analyses by basin.

A summary of data flow is illustrated in Figure 4.1.

4.3 Data analysis

To determine which parameters were best represented in the dataset, the number of observations for each individual category were obtained (Table 4.1).

4.3.1 Geometric Means

Annual and long-term geometric means were calculated for concentrations of total nitrogen, total phosphorus, and chlorophyll *a* (corrected and uncorrected) by site. There was not a criteria for a minimum number of observations (annual geometric mean may represent a single observation), however, the number of observations used for each calculation are available in Tables 4.2 through 4.5.

4.3.2 Baseline concentration Levels

Methods outlined in the USEPA's technical support document for developing baselines in estuarine areas indicate that for unimpaired streams, the upper quartile, or 75th percentile, should be used. In moderately degraded streams, the median is appropriate. For mixed data, the 25th percentile is used to develop a baseline for concentrations of total nitrogen, total phosphorus, and chlorophyll *a* (USEPA 2001). For the purpose of this study, the 25th percentile was used to calculate baseline concentration levels for total nitrogen, total phosphorus, and chlorophyll *a,* both corrected and uncorrected.

4.3.3 Regression analysis

The methods for performing a regression analysis were:

1. DIN was calculated for all sites that had ammonia and nitrate/nitrite data using the formula:

   [DIN = ammonia (NH3 reported in mg N/L) OR ammonium ($NH4^-$ reported as mg N/L) plus NO23 (nitrate + nitrite)].

2. TN was calculated for all sites that had both Kjeldahl nitrogen measurements and nitrate-nitrite using the formula:

   [Total Nitrogen = Kjeldahl nitrogen (TKN) plus nitrate-nitrite nitrogen (NO23)].

3. A regression analysis of TN as a function of DIN [$TN = \beta + \beta_{DIN} + \varepsilon$], and a regression analysis of TP as a function of DIP [$TP = \beta + \beta_{DIP} + \varepsilon$] were performed for basins that had sufficient data.

4. Regression results were compared to existing Florida criteria for total N and total P using data for the sites located within Timucuan Ecologic and Historic Preserve (See 4.3.4).

4.3.4 Comparison of Regression Results to Florida Criteria

To compare the results of the model to Florida's existing criteria for the Nassau River basin, data for Timucuan Ecological and Historic Preserve were extracted from the data used to run the initial regressions for nitrogen and phosphorus. This data was then subdivided by reach, to correspond with Florida's method for criteria determination for the Nassau River basin. Regressions were run using a log-log transformation. The log of 0.1 for nitrogen and 0.01 for phosphorus (the values corresponding to good DIN and DIP criteria, respectively) were put into the models, and the exponential of the result was then compared to Florida's existing criteria for total N and total P in each reach.

4.3.5 National Parks in a Regional Perspective

Because the SECN does not sample for total nitrogen or total phosphorus at its fixed-station sites located within the parks (only for coastal assessments), additional analyses were done to compare the Park Unit's conditions to other southeastern coastal estuarine systems.

1. A range of percentiles, in 10% increments, was calculated for the values of all sites in the database for ammonia or ammonium(NH3 or NH4), nitrate plus nitrite (NO23), orthophosphate (PO4), and corrected chlorophyll *a*.
2. The median of all observations within each Park unit (Cumberland Island National Seashore and Fort Pulaski National Monument) were calculated for the same four parameters.
3. The median values for ammonium, nitrate plus nitrite, orthophosphate, and corrected chlorophyll *a* within the two parks were compared to the range of percentiles for all sites to obtain a qualitative comparison of concentrations for the four parameters between the Park units and the southeastern coast.

4.3.6 Evaluating and Proposing Numeric Nutrient Criteria

The primary methods for evaluating and proposing a method for determining NNC were:

1. Regression analyses were run to determine a simple model to extrapolate total nitrogen values from dissolved inorganic nitrogen and total phosphorus values from dissolved inorganic phosphorus.
2. Dissolved inorganic nitrogen values of 0.1 mg N/L and 0.5 mg N/L, and dissolved inorganic phosphorus values of 0.01 mg P/L and 0.05 mg P/L were run with the resulting models, to determine values that corresponded to the USEPA's NCA assessment values for "good," "fair," and "poor."
3. A range of basin specific criteria were proposed for total nitrogen and total phosphorus (for basins that had sufficient data for the regression analyses) that corresponded to the USEPA's good, fair, and poor designations for coastal conditions (USEPA 2012).

4.4 Chapter 4 Tables

Table 4.1. Number of observations by site and category across all years

Site	Chl *a*, uncorrected	Chl *a* corrected	Total N	Total P	Orthophosphate	Ammonia	Nitrate + Nitrite	Kjeldahl Nitrogen	pH	Secchi depth	Specific Conductance
104060201	14	--	--	9	6	9	9	9	10	--	10
109060602	--	--	--	81	48	78	83	65	146	--	142
109060607	--	--	--	7	--	9	9	--	16	--	16
109060608	--	--	--	9	--	11	11	--	19	--	19
109060612	--	--	--	9	--	11	11	5	19	--	19
109060614	--	--	--	10	--	12	12	--	20	--	20
109060615	--	--	--	10	--	12	12	--	20	--	20
202060601	--	--	--	41	12	42	42	22	64	--	63
202060603	--	--	--	11	1	11	11	7	25	--	25
202060604	--	--	--	41	--	42	42	34	36	--	35
204010102	--	--	--	11	--	11	11	--	19	--	19
204010103	--	--	--	9	9	9	9	9	10	--	9
204010104	--	--	--	23	--	23	23	11	31	--	31
204010202	26	--	--	28	--	28	28	27	--	--	--
204010203	26	--	--	28	--	28	28	27	--	--	--
204010204	26	--	--	28	--	28	28	27	--	--	--
204010205	25	--	--	28	--	28	28	27	--	--	--
204010206	25	--	--	28	--	28	28	27	--	--	--
204010207	25	--	--	28	--	28	28	27	--	--	--
204020101	--	--	--	7	--	7	7	7	8	--	8
204020104	11	--	--	10	6	10	10	10	11	--	11
204030402	7	--	--	7	6	7	7	7	8	--	8
204040101	--	--	--	21	7	21	21	21	25	--	24
204040103	13	--	--	10	6	10	10	10	13	--	13
204040107	--	--	--	12	--	12	12	10	16	--	15
204040109	30	--	--	31	--	31	31	31	--	--	--
204040202	30	--	--	31	--	31	31	31	--	--	--

Site	Chl *a*, uncorrected	Chl *a* corrected	Total N	Total P	Orthophosphate	Ammonia	Nitrate + Nitrite	Kjeldahl Nitrogen	pH	Secchi depth	Specific Conductance
204040203	30	--	--	31	--	31	31	31	--	--	--
204050203	30	--	--	31	--	31	31	31	--	--	--
204050204	30	--	--	31	--	31	31	31	--	--	--
204060201	30	--	--	31	--	31	31	30	--	--	--
204070202	30	--	--	31	--	31	31	31	--	--	--
204070203	30	--	--	29	--	29	29	29	--	--	--
204070302	30	--	--	31	--	31	31	31	--	--	--
204070303	30	--	--	31	--	31	31	31	--	--	--
204070304	30	--	--	31	--	31	31	31	--	--	--
204070305	30	--	--	30	--	31	31	31	--	--	--
204070306	30	--	--	29	--	29	29	29	--	--	--
204080105	30	--	--	31	--	31	31	31	--	--	--
204080106	30	--	--	31	--	31	31	31	--	--	--
204080107	30	--	--	31	--	31	31	31	--	--	--
604050101	--	--	--	17	11	17	17	11	58	--	58
606050203	--	--	--	12	--	12	12	12	11	--	11
606050204	12	--	--	20	9	20	20	12	39	--	39
606050205	--	--	--	9	--	9	9	--	25	--	25
606050206	--	--	--	8	--	8	8	--	23	--	23
701120101	--	--	--	36	--	36	36	22	48	--	47
701120304	11	--	--	12	8	12	12	12	14	--	14
703010201	--	--	--	10	--	12	12	2	19	--	19
703020101	--	--	--	59	--	61	58	30	126	--	125
703020102	--	--	--	23	--	25	25	1	39	--	39
703020106	--	--	--	58	--	59	58	27	126	--	126
703020107	--	--	--	8	--	9	9	--	16	--	16
703020109	--	--	--	7	--	7	7	--	12	--	12
703020110	--	--	--	54	--	54	53	27	125	--	126
703030201	--	--	--	8	--	8	8	--	16	--	16

Site	Chl *a*, uncorrected	Chl *a* corrected	Total N	Total P	Orthophosphate	Ammonia	Nitrate + Nitrite	Kjeldahl Nitrogen	pH	Secchi depth	Specific Conductance
703030202	--	--	--	8	--	8	8	--	16	--	16
703030212	31	--	--	31	--	31	31	31	--	--	--
703030213	31	--	--	31	--	31	31	31	--	--	--
703030214	31	--	--	31	--	31	31	31	--	--	--
703030215	31	--	--	31	--	31	31	31	--	--	--
703030216	31	--	--	31	--	31	31	31	--	--	--
703030217	30	--	--	31	--	31	31	31	--	--	--
703040105	30	--	--	31	--	31	31	31	--	--	--
703040207	30	--	--	31	--	31	31	31	--	--	--
703040208	15	--	--	13	8	13	13	13	14	--	14
703050101	--	--	--	10	--	11	11	--	17	--	17
703050202	30	--	--	31	--	31	31	31	--	--	--
703050203	30	--	--	31	--	31	31	31	--	--	--
703050309	30	--	--	31	--	31	31	31	--	--	--
703050310	30	--	--	31	--	31	31	31	--	--	--
703050311	30	--	--	31	--	31	31	31	--	--	--
1015001	--	--	--	21	--	21	21	--	71	--	36
1018001	--	--	--	21	--	21	21	--	70	--	37
19010001	--	--	--	8	10	9	6	9	--	--	--
19010008	--	--	--	10	10	10	8	9	--	--	--
19010011	--	--	--	12	12	12	11	12	--	--	--
19010012	--	--	--	11	11	10	11	11	--	--	--
19010013	--	--	--	10	11	8	10	11	--	--	--
19010024	--	--	--	11	10	6	8	11	--	--	--
19010056	--	--	--	7	12	10	12	8	--	--	--
19010062	--	--	--	8	9	7	9	9	--	--	--
19020015	--	--	--	10	10	11	10	10	--	--	--
19020016	--	--	--	10	11	10	10	10	--	--	--
19020018	--	--	--	11	11	10	11	12	--	--	--

Site	Chl *a*, uncorrected	Chl *a* corrected	Total N	Total P	Orthophosphate	Ammonia	Nitrate + Nitrite	Kjeldahl Nitrogen	pH	Secchi depth	Specific Conductance
19020019	--	--	--	9	11	10	11	9	--	--	--
2150001	--	--	--	12	--	12	12	--	39	--	22
2350001	--	--	--	42	1	42	42	2	42	--	42
2450001	--	--	--	12	--	12	12	--	39	--	22
3537	1	1	--	154	93	149	140	153	--	--	--
3544	--	--	--	151	91	141	140	151	--	--	--
7004001	--	--	--	40	2	45	45	2	51	--	51
7005201	--	--	--	40	2	45	45	2	51	--	51
7005801	--	--	--	40	2	45	45	2	50	--	51
7028001	--	--	--	11	--	11	11	--	11	--	11
Big Bay	--	260	--	--	258	262	258	--	--	--	--
CUISoldc	--	41	--	--	12	12	--	--	--	42	--
CUISplum	--	40	--	--	12	12	--	--	--	40	--
CUISseac	--	27	--	--	8	8	--	--	--	25	--
Fishing Creek	--	256	--	--	254	258	253	--	--	--	--
FOPUlazz	--	73	--	--	22	22	--	--	--	69	--
MD-001	--	--	30	100	--	49	53	59	--	--	--
MD-004	--	--	33	100	--	46	61	62	--	--	--
MD-039	--	--	67	100	--	64	87	82	--	--	--
MD-043	--	--	93	119	--	79	123	94	--	--	--
MD-045	--	--	79	109	--	59	118	80	--	--	--
MD-052	--	--	72	106	--	45	99	81	--	--	--
MD-069	--	--	27	105	--	40	61	50	--	--	--
MD-071	--	--	41	87	--	42	64	56	--	--	--
MD-115	--	--	37	112	--	54	56	89	--	--	--
MD-116	--	--	25	104	--	43	42	56	--	--	--
MD-120	--	--	69	115	--	77	97	90	--	--	--
MD-130	--	--	10	104	--	43	21	52	--	--	--
MD-173	--	--	18	108	--	44	33	62	--	--	--

Site	Chl *a*, uncorrected	Chl *a* corrected	Total N	Total P	Orthophosphate	Ammonia	Nitrate + Nitrite	Kjeldahl Nitrogen	pH	Secchi depth	Specific Conductance
MD-174	--	--	25	109	--	53	39	72	--	--	--
MD-176	--	--	21	107	--	55	37	60	--	--	--
MD-202	--	--	37	110	--	52	65	79	--	--	--
MD-206	--	--	30	109	--	39	47	61	--	--	--
MD-209	--	--	32	109	--	53	57	68	--	--	--
MD-247	--	--	32	85	--	34	60	46	--	--	--
MD-248	--	--	90	118	--	76	124	92	--	--	--
MD-252	--	--	63	115	--	61	92	84	--	--	--
MD-253	--	--	61	113	--	54	88	82	--	--	--
MD-254	--	--	36	93	--	43	54	70	--	--	--
MD-255	--	--	33	90	--	47	44	75	--	--	--
MD-256	--	--	23	111	--	50	38	61	--	--	--
MD-257	--	--	36	109	--	42	51	74	--	--	--
MD-258	--	--	49	109	--	40	78	81	--	--	--
MD-259	--	--	75	117	--	47	116	84	--	--	--
MD-260	--	--	67	113	--	54	94	85	--	--	--
MD-261	--	--	37	110	--	53	65	71	--	--	--
MD-262	--	--	20	109	--	46	41	49	--	--	--
MD-264	--	--	56	110	--	47	97	73	--	--	--
MD-273	--	--	13	108	--	49	22	69	--	--	--
MD-274	--	--	15	89	--	35	28	49	--	--	--
Mosquito Creek	--	257	--	--	255	259	253	--	--	--	--
StPierre	--	260	--	--	258	262	258	--	--	--	--
SV-191	--	--	82	99	--	56	104	82	--	--	--
TIM1	--	34	93	109	102	108	105	109	--	--	--
TIM10	--	28	75	87	80	77	87	84	--	--	--
TIM11	--	27	--	--	--	--	--	--	--	--	--
TIM11A	--	19	25	25	25	27	27	25	--	--	--
TIM12	--	21	--	--	--	--	--	--	--	--	--

Site	Chl *a*, uncorrected	Chl *a* corrected	Total N	Total P	Orthophosphate	Ammonia	Nitrate + Nitrite	Kjeldahl Nitrogen	pH	Secchi depth	Specific Conductance
TIM13A	--	37	54	55	55	57	57	55	--	--	--
TIM2	--	33	80	92	84	89	91	92	--	--	--
TIM3	--	33	79	90	83	87	89	90	--	--	--
TIM4	--	35	81	93	87	89	94	93	--	--	--
TIM4A	--	16	23	23	16	25	25	23	--	--	--
TIM5	--	32	63	71	67	71	71	71	--	--	--
TIM6	--	31	73	83	79	80	82	82	--	--	--
TIM7	--	28	78	88	82	84	88	88	--	--	--
TIM8	--	35	78	88	79	78	88	88	--	--	--
TIM9A	--	33	71	82	76	73	81	80	--	--	--
Total		1657	2407	7130	2450	6259	6805	5345	1684	176	1573

Table 4.2. Total nitrogen, number of observations per year

Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
MD-001	2	4	3	4	7	5	1	2	--	--	--	1	1	30
MD-004	2	3	2	8	6	5	2	2	--	--	2	--	1	33
MD-039	3	7	5	9	10	10	5	9	9	--	--	--	--	67
MD-043	4	5	8	11	11	11	5	12	9	6	3	5	3	93
MD-045	2	4	7	10	12	10	4	9	9	5	--	5	2	79
MD-052	4	3	7	9	12	9	4	9	--	4	4	5	2	72
MD-069	--	1	1	4	9	4	2	--	2	--	--	1	3	27
MD-071	1	3	6	5	9	6	--	3	8	--	--	--	--	41
MD-115	--	4	4	6	8	4	2	3	3	--	1	--	2	37
MD-116	--	3	--	4	6	3	3	2	--	1	--	2	1	25
MD-120	2	3	6	8	9	9	3	8	9	4	1	4	3	69
MD-130	--	--	--	4	4	--	--	--	--	1	1	--	--	10
MD-173	--	1	2	4	6	--	2	--	1	1	--	--	1	18
MD-174	1	2	1	6	9	3	2	--	--	--	--	--	1	25
MD-176	1	3	1	5	6	1	--	2	--	1	--	1	--	21
MD-202	--	3	3	6	7	4	1	4	3	2	2	2	--	37
MD-206	2	4	4	5	7	2	--	1	2	1	--	1	1	30
MD-209	1	3	3	5	7	5	--	--	3	2	--	1	2	32
MD-247	1	3	5	5	8	2	3	2	3	--	--	--	--	32
MD-248	4	4	7	11	11	10	5	12	9	6	4	5	2	90
MD-252	5	4	5	9	8	6	2	7	8	4	--	3	2	63
MD-253	3	4	6	10	10	6	3	6	5	1	2	3	2	61
MD-254	3	5	3	7	8	3	1	2	4	--	--	--	--	36
MD-255	3	4	1	4	9	5	2	2	3	--	--	--	--	33
MD-256	--	1	1	8	6	4	1	--	1	--	1	--	--	23
MD-257	1	3	5	6	7	4	3	1	1	2	--	2	1	36
MD-258	1	4	5	7	7	7	5	5	3	--	2	1	2	49

Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
MD-259	1	9	6	8	11	8	6	10	5	3	1	4	3	75
MD-260	3	4	5	10	11	8	3	8	6	1	2	3	3	67
MD-261	2	3	3	4	9	5	1	3	2	1	1	1	2	37
MD-262	--	2	3	4	7	--	--	2	--	1	--	--	1	20
MD-264	1	4	8	7	11	6	1	4	5	1	2	3	3	56
MD-273	--	2	--	4	5	1	--	--	--	1	--	--	--	13
MD-274	--	1	1	4	6	2	--	1	--	--	--	--	--	15
SV-191	6	6	6	10	12	11	11	10	10	--	--	--	--	82
TIM1	5	5	13	12	12	12	12	12	9	1	--	--	--	93
TIM10	5	5	13	4	8	12	12	11	4	1	--	--	--	75
TIM11A	--	--	--	--	--	--	10	10	5	--	--	--	--	25
TIM13A	--	--	--	--	--	2	18	20	13	1	--	--	--	54
TIM2	4	5	12	5	8	12	12	12	9	1	--	--	--	80
TIM3	5	5	11	5	7	12	12	12	9	1	--	--	--	79
TIM4	4	4	9	7	8	12	13	15	8	1	--	--	--	81
TIM4A	--	--	--	--	--	--	10	8	5	--	--	--	--	23
TIM5	3	2	7	5	8	10	9	10	8	1	--	--	--	63
TIM6	2	5	9	5	8	12	12	12	7	1	--	--	--	73
TIM7	3	5	12	5	9	12	12	12	7	1	--	--	--	78
TIM8	5	5	11	5	8	12	12	12	7	1	--	--	--	78
TIM9A	3	4	11	5	8	12	11	10	6	1	--	--	--	71
	98	164	241	289	375	299	238	297	220	60	29	53	44	2407

Table 4.3. Total phosphorus, number of observations per year

Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
104060201	--	--	--	--	--	--	--	--	--	--	--	5	4	9
109060602	--	--	--	6	7	1	5	14	12	12	12	12	--	81
109060607	--	--	--	7	--	--	--	--	--	--	--	--	--	7
109060608	--	--	--	9	--	--	--	--	--	--	--	--	--	9
109060612	--	--	--	9	--	--	--	--	--	--	--	--	--	9
109060614	--	--	--	10	--	--	--	--	--	--	--	--	--	10
109060615	--	--	--	10	--	--	--	--	--	--	--	--	--	10
202060601	--	--	--	--	7	--	12	--	--	--	3	9	10	41
202060603	--	--	--	--	--	--	4	--	--	--	--	7	--	11
202060604	--	--	--	--	7	--	--	--	--	--	--	18	16	41
204010102	--	--	--	--	--	--	11	--	--	--	--	--	--	11
204010103	--	--	--	--	--	--	--	--	--	--	--	9	--	9
204010104	--	--	--	--	--	--	12	--	--	11	--	--	--	23
204010202	--	--	--	--	--	--	--	--	--	--	5	12	11	28
204010203	--	--	--	--	--	--	--	--	--	--	5	12	11	28
204010204	--	--	--	--	--	--	--	--	--	--	5	12	11	28
204010205	--	--	--	--	--	--	--	--	--	--	5	12	11	28
204010206	--	--	--	--	--	--	--	--	--	--	5	12	11	28
204010207	--	--	--	--	--	--	--	--	--	--	5	12	11	28
204020101	--	--	--	--	--	--	--	--	--	--	--	--	7	7
204020104	--	--	--	--	--	--	--	--	--	--	1	6	3	10
204030402	--	--	--	--	--	--	--	--	--	--	--	5	2	7
204040101	--	--	--	--	--	--	--	--	--	--	--	11	10	21
204040103	--	--	--	--	--	--	--	--	--	--	1	6	3	10
204040107	--	--	--	2	--	--	--	--	--	--	--	--	10	12
204040109	--	--	--	--	--	--	--	--	--	--	7	12	12	31
204040202	--	--	--	--	--	--	--	--	--	--	7	12	12	31
204040203	--	--	--	--	--	--	--	--	--	--	7	12	12	31

Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
204050203	--	--	--	--	--	--	--	--	--	--	7	12	12	31
204050204	--	--	--	--	--	--	--	--	--	--	7	12	12	31
204060201	--	--	--	--	--	--	--	--	--	--	7	12	12	31
204070202	--	--	--	--	--	--	--	--	--	--	7	12	12	31
204070203	--	--	--	--	--	--	--	--	--	--	7	10	12	29
204070302	--	--	--	--	--	--	--	--	--	--	7	12	12	31
204070303	--	--	--	--	--	--	--	--	--	--	7	12	12	31
204070304	--	--	--	--	--	--	--	--	--	--	7	12	12	31
204070305	--	--	--	--	--	--	--	--	--	--	7	12	11	30
204070306	--	--	--	--	--	--	--	--	--	--	7	10	12	29
204080105	--	--	--	--	--	--	--	--	--	--	7	12	12	31
204080106	--	--	--	--	--	--	--	--	--	--	7	12	12	31
204080107	--	--	--	--	--	--	--	--	--	--	7	12	12	31
604050101	--	--	--	--	--	--	--	--	6	--	--	--	11	17
606050203	--	--	--	--	--	--	--	--	--	--	--	--	12	12
606050204	--	--	--	--	--	--	--	--	8	2	1	6	3	20
606050205	--	--	--	--	--	--	--	--	9	--	--	--	--	9
606050206	--	--	--	--	--	--	--	--	8	--	--	--	--	8
701120101	--	--	--	--	--	2	--	12	--	--	11	--	11	36
701120304	--	--	--	--	--	--	--	--	--	2	1	4	5	12
703010201	--	--	--	--	--	--	--	10	--	--	--	--	--	10
703020101	--	--	--	4	9	9	3	--	6	4	3	11	10	59
703020102	--	--	--	1	11	--	--	11	--	--	--	--	--	23
703020106	--	--	--	4	9	9	3	--	6	3	3	11	10	58
703020107	--	--	--	--	8	--	--	--	--	--	--	--	--	8
703020109	--	--	--	--	7	--	--	--	--	--	--	--	--	7
703020110	--	--	--	3	6	9	3	--	6	3	3	11	10	54
703030201	--	--	--	--	--	8	--	--	--	--	--	--	--	8
703030202	--	--	--	--	--	8	--	--	--	--	--	--	--	8

Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
703030212	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703030213	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703030214	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703030215	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703030216	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703030217	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703040105	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703040207	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703040208	--	--	--	--	--	--	--	--	--	1	1	6	5	13
703050101	--	--	--	--	10	--	--	--	--	--	--	--	--	10
703050202	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703050203	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703050309	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703050310	--	--	--	--	--	--	--	--	--	--	7	12	12	31
703050311	--	--	--	--	--	--	--	--	--	--	7	12	12	31
1015001	--	12	9	--	--	--	--	--	--	--	--	--	--	21
1018001	--	12	9	--	--	--	--	--	--	--	--	--	--	21
19010001	--	--	--	8	--	--	--	--	--	--	--	--	--	8
19010008	--	--	--	10	--	--	--	--	--	--	--	--	--	10
19010011	1	--	--	11	--	--	--	--	--	--	--	--	--	12
19010012	--	--	--	11	--	--	--	--	--	--	--	--	--	11
19010013	--	--	--	10	--	--	--	--	--	--	--	--	--	10
19010024	--	--	--	11	--	--	--	--	--	--	--	--	--	11
19010056	--	--	2	5	--	--	--	--	--	--	--	--	--	7
19010062	--	--	2	6	--	--	--	--	--	--	--	--	--	8
19020015	--	--	2	8	--	--	--	--	--	--	--	--	--	10
19020016	--	--	2	8	--	--	--	--	--	--	--	--	--	10
19020018	1	--	--	10	--	--	--	--	--	--	--	--	--	11
19020019	--	--	--	9	--	--	--	--	--	--	--	--	--	9

Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
2150001	--	12	--	--	--	--	--	--	--	--	--	--	--	12
2350001	12	12	13	5	--	--	--	--	--	--	--	--	--	42
2450001	--	12	--	--	--	--	--	--	--	--	--	--	--	12
3537	13	12	12	12	11	12	12	12	12	12	12	12	10	154
3544	12	12	12	11	12	12	12	11	12	12	12	11	10	151
7004001	10	11	11	8	--	--	--	--	--	--	--	--	--	40
7005201	10	11	11	8	--	--	--	--	--	--	--	--	--	40
7005801	10	11	11	8	--	--	--	--	--	--	--	--	--	40
7028001	--	--	11	--	--	--	--	--	--	--	--	--	--	11
MD-001	4	8	12	12	12	12	11	8	--	6	6	5	4	100
MD-004	3	8	12	12	12	12	11	8	--	6	6	6	4	100
MD-039	7	12	11	12	12	12	12	12	10	--	--	--	--	100
MD-043	8	9	12	12	11	11	12	12	10	6	6	6	4	119
MD-045	6	8	11	12	12	11	11	12	10	6	--	6	4	109
MD-052	7	9	11	11	12	11	12	12	--	6	6	6	3	106
MD-069	--	8	11	11	11	11	12	11	10	6	6	5	3	105
MD-071	2	7	11	11	12	11	12	10	11	--	--	--	--	87
MD-115	3	9	11	10	12	11	11	12	10	6	6	7	4	112
MD-116	1	7	12	11	12	12	11	9	9	6	5	6	3	104
MD-120	6	7	11	12	12	11	12	12	10	6	6	6	4	115
MD-130	--	7	11	12	12	11	11	10	10	5	6	6	3	104
MD-173	1	8	11	11	12	11	11	10	10	6	6	7	4	108
MD-174	2	8	10	11	12	11	11	11	10	6	6	7	4	109
MD-176	1	7	12	11	12	12	11	10	10	6	5	6	4	107
MD-202	5	7	10	10	12	12	12	10	10	6	6	6	4	110
MD-206	3	7	11	12	12	11	11	12	10	5	6	6	3	109
MD-209	3	6	11	12	12	12	11	12	10	5	5	6	4	109
MD-247	1	8	11	11	11	11	12	11	9	--	--	--	--	85
MD-248	7	9	11	12	12	11	12	12	10	6	6	6	4	118

Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
MD-252	7	9	12	12	12	11	12	10	9	6	6	6	3	115
MD-253	6	8	12	12	12	12	12	10	8	6	6	6	3	113
MD-254	5	8	12	12	12	12	12	10	9	--	1	--	--	93
MD-255	4	8	11	12	12	13	11	9	10	--	--	--	--	90
MD-256	2	9	12	12	12	12	11	8	10	6	6	7	4	111
MD-257	2	8	11	11	12	12	11	11	9	6	5	7	4	109
MD-258	3	8	11	11	12	11	11	10	9	6	6	7	4	109
MD-259	3	17	12	12	12	10	11	9	9	6	6	7	3	117
MD-260	5	8	12	12	12	11	12	11	9	5	6	6	4	113
MD-261	4	6	11	12	12	11	11	12	10	5	6	6	4	110
MD-262	2	6	11	12	12	12	11	11	11	5	6	6	4	109
MD-264	3	8	11	12	11	11	10	12	10	6	6	6	4	110
MD-273	2	7	11	13	12	11	11	11	10	5	6	6	3	108
MD-274	2	8	11	12	12	11	11	12	10	--	--	--	--	89
SV-191	7	12	12	12	12	12	12	10	10	--	--	--	--	99
TIM1	11	14	13	12	12	12	12	12	9	2	--	--	--	109
TIM10	11	10	13	4	8	12	12	11	4	2	--	--	--	87
TIM11A	--	--	--	--	--	--	10	10	5	--	--	--	--	25
TIM2	10	10	12	5	8	12	12	12	9	2	--	--	--	92
TIM3	10	10	11	5	7	12	12	12	9	2	--	--	--	90
TIM4	9	9	9	7	8	12	13	15	9	2	--	--	--	93
TIM4A	--	--	--	--	--	--	10	8	5	--	--	--	--	23
TIM5	7	5	7	5	8	10	9	10	8	2	--	--	--	71
TIM6	6	10	9	5	8	12	12	12	7	2	--	--	--	83
TIM7	7	10	12	5	9	12	12	12	7	2	--	--	--	88
TIM8	10	9	11	5	8	12	12	12	7	2	--	--	--	88
TIM9A	9	8	11	5	8	12	11	10	6	2	--	--	--	82
	286	501	610	689	604	587	612	578	482	243	456	749	678	7075

Table 4.4. Chlorophyll *a*, uncorrected, number of observations per year

Site	2010	2011	2012	2013	Total
104060201	--	--	7	7	14
204010202	--	5	11	10	26
204010203	--	5	11	10	26
204010204	--	5	11	10	26
204010205	--	4	11	10	25
204010206	--	4	11	10	25
204010207	--	4	11	10	25
204020104	--	3	5	3	11
204030402	--	--	5	2	7
204040103	--	3	6	4	13
204040109	--	6	12	12	30
204040202	--	6	12	12	30
204040203	--	6	12	12	30
204050203	--	6	12	12	30
204050204	--	6	12	12	30
204060201	--	6	12	12	30
204070202	--	6	12	12	30
204070203	--	6	12	12	30
204070302	--	6	12	12	30
204070303	--	6	12	12	30
204070304	--	6	12	12	30
204070305	--	6	12	12	30
204070306	--	6	12	12	30
204080105	--	6	12	12	30
204080106	--	6	12	12	30
204080107	--	6	12	12	30
606050204	2	2	5	3	12

701120304	2	2	2	5	11
703030212	--	7	12	12	31
703030213	--	7	12	12	31
703030214	--	7	12	12	31
703030215	--	7	12	12	31
703030216	--	7	12	12	31
703030217	--	6	12	12	30
703040105	--	7	11	12	30
703040207	--	7	11	12	30
703040208	2	1	5	7	15
703050202	--	7	11	12	30
703050203	--	7	11	12	30
703050309	--	7	11	12	30
703050310	--	7	11	12	30
703050311	--	7	11	12	30
3537	--	--	--	1	1
Total	6	224	442	440	1112

Table 4.5 Chlorophyll *a*, corrected, number of observations per year

Site	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
3537	--	--	--	--	--	--	--	--	--	--	--	1	1
Big Bay	22	24	24	24	24	24	24	22	24	24	24	--	260
CUISoldc	--	--	--	--	--	10	12	12	7	--	--	--	41
CUISplum	--	--	--	--	--	10	11	12	7	--	--	--	40
CUISseac	--	--	--	--	--	--	--	--	3	5	7	12	27
Fishing Creek	20	24	24	24	24	24	24	22	22	24	24	--	256
FOPUlazz	--	--	--	--	2	12	12	12	10	6	7	12	73
Mosquito Creek	20	23	24	24	24	24	24	22	24	24	24	--	257
StPierre	22	24	24	24	24	24	24	22	24	24	24	--	260
TIM1	--	--	--	--	1	6	6	6	3	4	2	6	34
TIM10	--	--	--	--	1	5	5	2	4	5	2	4	28
TIM11	--	--	--	--	1	4	5	4	4	5	2	2	27
TIM11A	--	--	--	--	1	4	5	4	3	2	--	--	19
TIM12	--	--	--	--	1	1	4	4	4	5	--	2	21
TIM13A	--	--	--	--	2	7	11	9	5	3	--	--	37
TIM2	--	--	--	--	1	5	6	6	3	4	2	6	33
TIM3	--	--	--	--	1	5	5	6	3	5	2	6	33
TIM4	--	--	--	--	1	5	7	6	3	5	2	6	35
TIM4A	--	--	--	--	1	4	3	4	2	2	--	--	16
TIM5	--	--	--	--	1	5	6	6	3	5	4	2	32
TIM6	--	--	--	--	1	5	6	5	3	5	4	2	31
TIM7	--	--	--	--	1	5	6	5	3	5	3	--	28
TIM8	--	--	--	--	1	6	6	5	3	5	5	4	35
TIM9A	--	--	--	--	1	5	6	4	3	5	5	4	33
Total	84	95	96	96	114	200	218	200	170	172	143	69	1657

4.5 Chapter Four Figures

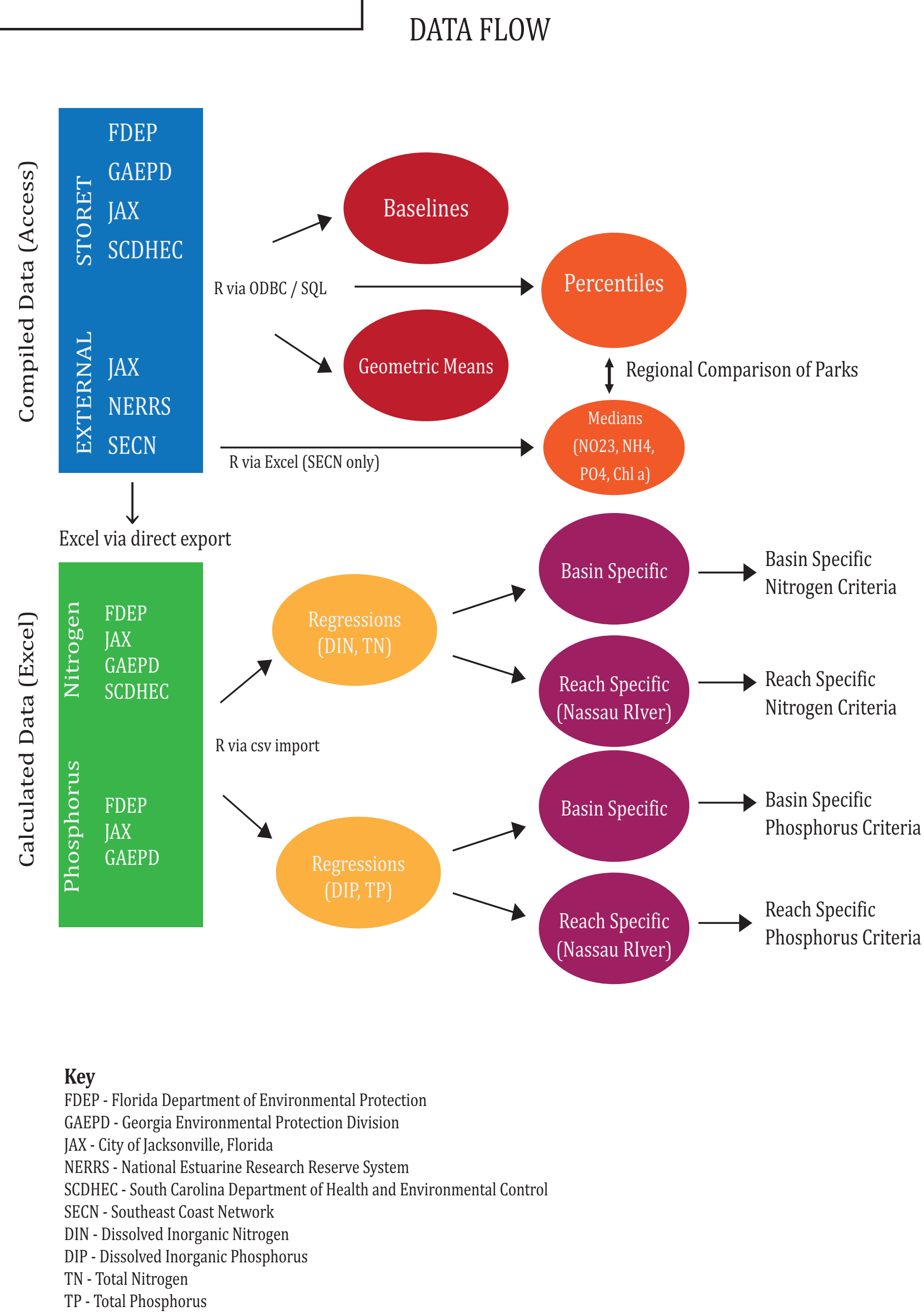


Figure 4.1 Data Flow

5. RESULTS

5.1 Database

The final database consisted of 41,057 total unique observations, with data collected from five agencies and 14 river basins (HUC 8 designations). The observations ranged temporally from 1/2/2001 to 12/19/2013. A breakdown of the number of observations by category and by basin can be found in Table 4.1. A map of the sites by basin can be found in Figure 5.39.

5.2 Data Analysis on Compiled Database

5.2.1 Geometric Means

Annual and long-term geometric means were calculated for all sites for the categories of total nitrogen concentrations, total phosphorus concentrations, and chlorophyll *a* concentrations, both corrected and uncorrected. Long-term geometric means were calculated using all available results in each category. These results are found in Tables 5.1 (nitrogen), 5.2 (phosphorus), 5.3 (chlorophyll *a*, uncorrected), and Table 5.4 (chlorophyll *a*, corrected).

Long-term geometric means are depicted graphically in maps in the appendix for total nitrogen (Figure 5.40), total phosphorus (Figure 5.41) and chlorophyll *a* (Figure 5.42).

5.2.2 Baselines

Baseline results for total nitrogen, total phosphorus, and chlorophyll *a* can be found in Table 5.5.

5.2.3 Regression analysis

The regression analysis for nitrogen [$TN = \beta + \beta_{DIN} + \varepsilon$] was performed using a total of 3,277 paired (samples collected at the same site visit) observations for DIN and TN. The observations were categorized by basin, and 14 regressions run, one for each basin that had sufficient data. The resulting models of the nitrogen regression for each basin are found in Table 5.6.

The regression analysis for phosphorus [TP =β + β_{DIP} + ε] was performed using a total of 1,016 paired observations for DIP and TP. The observations were categorized by basin, and six regressions run, one for each basin with sufficient phosphorus data. The resulting models of the phosphorus regression for each basin are found in Table 5.7.

5.2.4 Comparison of Regression Results to Florida Criteria

The models resulting from the regressions done for individual reaches within Timucuan Ecological and Historic Preserve are found in Table 5.12 for nitrogen and 5.13 for phosphorus.

5.2.5 National Park Units in a Regional Perspective

A range of percentile values was calculated for all sites for ammonia, nitrate plus nitrite, orthophosphate, and corrected chlorophyll *a*. They are found in Table 5.8. Median values for Cumberland Island National Seashore and Fort Pulaski National Monument were calculated for nitrate plus nitrite, orthophosphate, and corrected chlorophyll *a* (Table 5.9). The median values for the two Parks were compared to the range of percentiles for all sites to quantitatively rank the median concentrations at the Parks with all other sites. This comparison is also found in Figures 5.31 through 5.34.

5.2.6 Criteria Determination

Criteria were calculated as proposed in the methods section (4.3.6). The results can be found in Table 5.10 for total nitrogen concentrations and Table 5.11 for total phosphorus concentrations.

5.3 Chapter Five Tables and Figures

Table 5.1. Geometric means – Total Nitrogen concentrations.

Annual and long-term geometric means of total nitrogen concentration, in mg N/L. Included are modeled criteria limits for ‘good’ and ‘fair designations (‘poor’ designation is anything that exceeds the ‘fair’ limit)that correspond to USEPA coastal criteria found in the National Coastal Condition Report (USEPA 2012). ** Indicates the model for that basin had a p-value that was not statistically significant.

Basin	Proposed TN *‘Good’*	Proposed TN *‘Fair’*	site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Long term
Broad - St. Helena	0.657	1.118	MD-001	0.160	0.443	0.556	0.361	0.482	0.301	0.240	0.277	--	--	--	0.181	0.711	0.369
			MD-004	0.181	0.377	0.495	0.401	0.432	0.261	0.181	0.149	--	--	0.250	--	0.439	0.319
			MD-116	--	0.354	--	0.429	0.345	0.476	0.204	0.153	--	0.161	--	0.317	1.000	0.329
			MD-176	0.131	0.296	0.754	0.311	0.514	0.560	--	0.193	--	0.312	--	0.580	--	0.361
			MD-254	0.590	0.417	0.542	0.441	0.546	0.420	0.180	0.958	0.261	--	--	--	--	0.458
Calibogue Sound - Wright River	None	None	MD-173	--	0.460	0.580	0.410	0.460	--	0.831	--	0.274	0.233	--	--	0.610	0.467
			MD-174	0.237	0.480	0.419	0.413	0.441	0.186	0.453	--	--	--	--	--	0.260	0.377
			MD-257	0.227	0.461	0.510	0.395	0.394	0.190	0.321	0.490	0.513	0.213	--	0.202	0.212	0.343
			MD-258	0.294	0.343	0.567	0.470	0.504	0.252	0.392	0.191	0.430	--	0.362	0.222	0.385	0.368
Cooper	0.389	0.761	MD-039	0.848	0.746	1.052	0.777	0.700	0.459	0.514	0.479	0.535	--	--	--	--	0.625
			MD-043	0.313	0.357	0.605	0.550	0.589	0.337	0.494	0.283	0.461	0.429	0.396	0.273	0.409	0.419
			MD-045	0.352	0.361	0.543	0.435	0.497	0.302	0.371	0.248	0.276	0.364	--	0.241	0.305	0.355
			MD-052	0.403	0.434	0.466	0.444	0.540	0.390	0.476	0.287	--	0.366	0.603	0.364	0.481	0.426
			MD-069	--	0.410	0.422	0.312	0.285	0.186	0.716	--	0.222	--	--	0.207	0.276	0.288
			MD-071	0.228	0.340	0.394	0.367	0.376	0.233	--	0.228	0.232	--	--	--	--	0.303
			MD-115	--	0.483	0.624	0.641	0.466	0.274	0.229	0.296	0.300	--	0.280	--	0.537	0.427
			MD-247	0.143	0.257	0.421	0.297	0.364	0.282	0.407	0.200	0.147	--	--	--	--	0.298
			MD-248	0.305	0.332	0.543	0.465	0.538	0.365	0.380	0.281	0.349	0.415	0.357	0.517	0.532	0.401
			MD-264	0.263	0.303	0.404	0.398	0.485	0.272	1.156	0.217	0.228	0.204	0.442	0.265	0.303	0.344
Edisto River	0.403	0.719	MD-120	0.806	0.765	0.816	0.587	0.564	0.391	0.276	0.277	0.469	0.355	0.584	0.340	0.443	0.466
			MD-209	0.369	0.322	0.404	0.425	0.311	0.234	--	--	0.261	0.246	--	0.356	0.405	0.319
			MD-260	0.346	0.515	0.782	0.527	0.489	0.522	0.377	0.380	0.505	0.331	0.215	0.431	0.452	0.471
			MD-261	0.424	0.380	0.605	0.356	0.342	0.232	0.211	0.183	0.245	0.315	0.131	0.482	0.496	0.321
			MD-262	--	0.193	0.329	0.322	0.339	--	--	0.247	--	0.247	--	--	0.276	0.298

Basin	Proposed TN *'Good'*	Proposed TN *'Fair'*	site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Long term
Lower Savannah	0.4	0.976	MD-259	0.285	0.401	0.612	0.520	0.474	0.347	0.450	0.210	0.578	0.344	0.278	0.220	0.367	0.388
			SV-191	0.640	0.906	1.132	0.970	0.748	0.756	0.858	0.434	0.567	--	--	--	--	0.737
Lower St. Johns	0.703	0.783	TIM13A	--	--	--	--	--	0.490	0.844	0.777	0.607	0.430	--	--	--	0.732
Nassau	0.909	1.962	TIM1	1.044	1.171	1.276	1.220	0.913	0.951	1.023	1.158	1.150	0.800	--	--	--	1.089
			TIM10	0.273	0.575	0.554	0.565	0.668	0.656	0.478	0.438	0.386	0.190	--	--	--	0.507
			TIM11A	--	--	--	--	--	--	0.262	0.497	0.738	--	--	--	--	0.416
			TIM2	0.947	1.020	1.111	1.261	1.207	0.927	0.981	1.099	1.095	0.800	--	--	--	1.057
			TIM3	0.532	0.993	0.878	0.949	1.062	0.831	0.734	0.714	0.698	0.760	--	--	--	0.797
			TIM4	0.468	0.949	0.796	0.923	0.972	0.812	0.661	0.620	0.525	0.550	--	--	--	0.717
			TIM4A	--	--	--	--	--	--	0.705	0.671	0.581	--	--	--	--	0.664
			TIM5	0.566	0.935	0.740	0.676	0.864	0.804	0.614	0.588	0.536	0.400	--	--	--	0.674
			TIM6	0.366	0.793	0.804	0.627	0.849	0.780	0.625	0.476	0.513	0.310	--	--	--	0.644
			TIM7	0.443	0.834	0.663	0.583	0.697	0.685	0.557	0.457	0.439	0.330	--	--	--	0.583
			TIM8	0.214	0.663	0.571	0.428	0.720	0.634	0.415	0.323	0.298	0.160	--	--	--	0.448
			TIM9A	0.249	0.806	0.585	0.563	0.563	0.625	0.480	0.487	0.392	0.230	--	--	--	0.520
Salke hatchie **	0.506	0.567	MD-252	0.463	0.476	0.940	0.501	0.898	0.624	0.349	0.407	0.412	0.284	--	0.374	0.669	0.519
			MD-253	0.398	0.480	0.813	0.518	0.568	0.363	0.487	0.216	0.358	0.261	0.261	0.446	0.498	0.444
			MD-255	0.258	0.430	0.340	0.430	0.548	0.362	0.150	0.497	0.298	--	--	--	--	0.388
South Carolina Coastal	0.332	0.726	MD-130	--	--	--	0.335	0.355	--	--	--	--	0.140	0.550	--	--	0.330
			MD-202	--	0.380	0.777	0.468	0.376	0.293	0.373	0.333	0.283	0.305	0.459	0.595	--	0.398
			MD-206	0.290	0.246	0.478	0.312	0.322	0.268	--	0.187	0.444	0.302	--	0.251	0.423	0.320
			MD-273	--	0.222	--	0.593	0.289	0.143	--	--	--	0.229	--	--	--	0.322
			MD-274	--	0.370	0.327	0.434	0.383	0.208	--	0.590	--	--	--	--	--	0.371
St. Helena Island	0.279	0.671	MD-256	--	0.420	0.563	0.372	0.480	0.180	0.172	--	0.124	--	1.050	--	--	0.346

Table 5.2. Geometric means – Total phosphorus concentrations.

Annual and long-term geometric means of total phosphorus concentration, in mg P/L. Included are modeled criteria limits for 'good' and 'fair' designations ('poor' designation is anything that exceeds the 'fair' limit) that correspond to USEPA coastal criteria found in the National Coastal Condition Report (United States Environmental Protection Agency 2012). ** Indicates the model for that basin had a p-value that was not statistically significant.

Basin	site	Pro-posed Good	Pro-posed Fair	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Long term
Altamaha	604050101			--	--	--	--	--	--	--	--	0.139	--	--	--	0.108	0.118
	606050203			--	--	--	--	--	--	--	--	--	--	--	--	0.088	0.088
	606050204			--	--	--	--	--	--	--	--	0.110	0.094	0.090	0.096	0.100	0.101
	606050205			--	--	--	--	--	--	--	--	0.154	--	--	--	--	0.154
	606050206			--	--	--	--	--	--	--	--	0.181	--	--	--	--	0.181
Broad - St. Helena	MD-001			0.078	0.068	0.101	0.114	0.115	0.070	0.062	0.051	--	0.064	0.143	0.053	0.047	0.080
	MD-004			0.077	0.072	0.077	0.132	0.096	0.058	0.067	0.044	--	0.058	0.062	0.056	0.044	0.071
	MD-116			0.140	0.041	0.060	0.090	0.076	0.045	0.060	0.050	0.040	0.058	0.079	0.058	0.046	0.058
	MD-176			0.140	0.039	0.091	0.061	0.065	0.054	0.052	0.048	0.047	0.073	0.078	0.046	0.052	0.058
	MD-254			0.083	0.063	0.148	0.104	0.074	0.073	0.065	0.061	0.050	--	0.065	--	--	0.078
Calibogue Sound - Wright River	MD-173			0.054	0.052	0.061	0.083	0.078	0.043	0.046	0.051	0.045	0.069	0.076	0.056	0.059	0.058
	MD-174			0.076	0.058	0.060	0.087	0.069	0.064	0.054	0.054	0.044	0.076	0.097	0.060	0.057	0.063
	MD-257			0.079	0.050	0.070	0.133	0.093	0.056	0.049	0.048	0.043	0.072	0.050	0.048	0.038	0.062
	MD-258			0.069	0.049	0.083	0.110	0.079	0.067	0.044	0.054	0.047	0.061	0.078	0.047	0.043	0.063
Cooper	MD-039			0.094	0.079	0.084	0.080	0.100	0.077	0.084	0.088	0.064	--	--	--	--	0.082
	MD-043			0.042	0.029	0.031	0.044	0.048	0.038	0.040	0.053	0.039	0.058	0.042	0.053	0.040	0.042
	MD-045			0.045	0.031	0.032	0.040	0.041	0.037	0.036	0.041	0.041	0.048	--	0.041	0.077	0.040
	MD-052			0.083	0.079	0.056	0.066	0.097	0.088	0.069	0.075	--	0.087	0.088	0.074	0.054	0.076
	MD-069			--	0.039	0.037	0.046	0.041	0.043	0.051	0.041	0.049	0.063	0.070	0.053	0.042	0.046
	MD-071			0.068	0.044	0.041	0.048	0.046	0.046	0.047	0.042	0.056	--	--	--	--	0.046
	MD-115			0.064	0.041	0.035	0.040	0.032	0.036	0.036	0.038	0.045	0.063	0.056	0.051	0.070	0.042
	MD-247			0.120	0.033	0.033	0.042	0.042	0.035	0.044	0.042	0.038	--	--	--	--	0.039
	MD-248			0.046	0.031	0.033	0.038	0.051	0.037	0.033	0.047	0.040	0.046	0.047	0.037	0.038	0.040
	MD-264			0.048	0.032	0.033	0.041	0.038	0.032	0.036	0.040	0.041	0.044	0.060	0.049	0.034	0.039

Basin	site	Pro-posed Good	Pro-posed Fair	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Long term
Cumberland - St. Simons	7004001	0.032	0.080	0.139	0.150	0.106	0.146	--	--	--	--	--	--	--	--	--	0.133
	7005201			0.138	0.158	0.111	0.149	--	--	--	--	--	--	--	--	--	0.137
	7005801			0.115	0.098	0.073	0.094	--	--	--	--	--	--	--	--	--	0.093
	701120304			--	--	--	--	--	--	--	--	--	0.169	0.090	0.071	0.068	0.082
	703010201			--	--	--	--	--	--	--	0.094	--	--	--	--	--	0.094
	703020101			--	--	--	0.137	0.119	0.138	0.114	--	0.125	0.089	0.100	0.088	0.071	0.104
	703020102			--	--	--	0.140	0.142	--	--	0.172	--	--	--	--	--	0.156
	703020106			--	--	--	0.145	0.122	0.157	0.133	--	0.147	0.111	0.120	0.109	0.084	0.120
	703020107			--	--	--	--	0.081	--	--	--	--	--	--	--	--	0.081
	703020109			--	--	--	--	0.102	--	--	--	--	--	--	--	--	0.102
	703020110			--	--	--	0.090	0.093	0.120	0.113	--	0.126	0.112	0.105	0.093	0.093	0.103
	703030201			--	--	--	--	--	0.160	--	--	--	--	--	--	--	0.160
	703030202			--	--	--	--	--	0.119	--	--	--	--	--	--	--	0.119
	703030212			--	--	--	--	--	--	--	--	--	--	0.085	0.088	0.095	0.090
	703030213			--	--	--	--	--	--	--	--	--	--	0.125	0.123	0.117	0.121
	703030214			--	--	--	--	--	--	--	--	--	--	0.099	0.122	0.121	0.116
	703030215			--	--	--	--	--	--	--	--	--	--	0.094	0.122	0.105	0.109
	703030216			--	--	--	--	--	--	--	--	--	--	0.080	0.093	0.093	0.090
	703030217			--	--	--	--	--	--	--	--	--	--	0.109	0.119	0.132	0.121
	703040105			--	--	--	--	--	--	--	--	--	--	0.073	0.080	0.080	0.078
	703040207			--	--	--	--	--	--	--	--	--	--	0.087	0.079	0.092	0.086
	703040208			--	--	--	--	--	--	--	--	--	0.080	0.090	0.043	0.044	0.048
	703050101			--	--	--	--	0.111	--	--	--	--	--	--	--	--	0.111
	703050202			--	--	--	--	--	--	--	--	--	--	0.066	0.067	0.061	0.064
	703050203			--	--	--	--	--	--	--	--	--	--	0.057	0.067	0.066	0.064
	703050309			--	--	--	--	--	--	--	--	--	--	0.072	0.076	0.075	0.075
	703050310			--	--	--	--	--	--	--	--	--	--	0.085	0.083	0.067	0.077
	703050311			--	--	--	--	--	--	--	--	--	--	0.063	0.064	0.059	0.062

Basin	site	Pro-posed Good	Pro-posed Fair	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Long term
Edisto River	MD-120			0.079	0.060	0.058	0.058	0.063	0.048	0.043	0.053	0.059	0.071	0.064	0.056	0.052	0.057
	MD-209			0.065	0.049	0.048	0.055	0.066	0.049	0.045	0.048	0.036	0.075	0.084	0.060	0.052	0.053
	MD-260			0.066	0.076	0.068	0.083	0.132	0.053	0.046	0.062	0.051	0.069	0.064	0.066	0.044	0.067
	MD-261			0.076	0.053	0.046	0.055	0.056	0.038	0.039	0.055	0.046	0.084	0.117	0.050	0.037	0.052
	MD-262			0.055	0.047	0.036	0.044	0.051	0.039	0.040	0.037	0.040	0.060	0.075	0.043	0.051	0.044
Lower Savannah **	1015001	0.214	0.205	--	0.116	0.100	--	--	--	--	--	--	--	--	--	--	0.109
	1018001			--	0.080	0.084	--	--	--	--	--	--	--	--	--	--	0.082
	109060602			--	--	--	0.106	0.096	0.150	0.156	0.144	0.161	0.126	0.178	0.283	--	0.155
	109060607			--	--	--	0.077	--	--	--	--	--	--	--	--	--	0.077
	109060608			--	--	--	0.067	--	--	--	--	--	--	--	--	--	0.067
	109060612			--	--	--	0.063	--	--	--	--	--	--	--	--	--	0.063
	109060614			--	--	--	0.084	--	--	--	--	--	--	--	--	--	0.084
	109060615			--	--	--	0.104	--	--	--	--	--	--	--	--	--	0.104
	MD-259			0.063	0.048	0.068	0.099	0.110	0.057	0.047	0.051	0.063	0.070	0.057	0.051	0.033	0.063
	SV-191			0.126	0.092	0.066	0.095	0.078	0.106	0.147	0.137	0.094	--	--	--	--	0.100
Lower St. Johns	TIM13A	0.041	0.090	--	--	--	--	--	0.140	0.091	0.089	0.082	0.079	--	--	--	0.089
Nassau	3537	0.123	0.135	0.162	0.163	0.164	0.129	0.127	0.115	0.108	0.164	0.154	0.113	0.121	0.161	0.158	0.140
	19020015			--	--	0.087	0.093	--	--	--	--	--	--	--	--	--	0.092
	19020016			--	--	0.080	0.093	--	--	--	--	--	--	--	--	--	0.090
	19020018			0.082	--	--	0.097	--	--	--	--	--	--	--	--	--	0.096
	19020019			--	--	--	0.081	--	--	--	--	--	--	--	--	--	0.081
	TIM1			0.165	0.163	0.167	0.169	0.140	0.188	0.114	0.112	0.141	0.110	--	--	--	0.148
	TIM10			0.071	0.124	0.145	0.132	0.088	0.143	0.093	0.069	0.062	0.046	--	--	--	0.099
	TIM11A			--	--	--	--	--	--	0.081	0.067	0.058	--	--	--	--	0.070
	TIM2			0.133	0.147	0.169	0.138	0.134	0.183	0.122	0.114	0.126	0.125	--	--	--	0.140
	TIM3			0.128	0.199	0.203	0.123	0.136	0.182	0.114	0.087	0.082	0.088	--	--	--	0.133
	TIM4			0.144	0.176	0.171	0.133	0.127	0.185	0.118	0.081	0.078	0.059	--	--	--	0.124
	TIM4A			--	--	--	--	--	--	0.115	0.084	0.062	--	--	--	--	0.090
	TIM5			0.108	0.128	0.163	0.105	0.106	0.151	0.123	0.073	0.073	0.084	--	--	--	0.109

Basin	site	Pro-posed Good	Pro-posed Fair	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Long term
Nassau	TIM6	0.123	0.135	0.082	0.089	0.168	0.123	0.109	0.191	0.114	0.082	0.064	0.077	--	--	--	0.109
	TIM7			0.086	0.084	0.135	0.108	0.097	0.137	0.109	0.072	0.066	0.049	--	--	--	0.097
	TIM8			0.086	0.084	0.119	0.105	0.065	0.116	0.109	0.073	0.046	0.042	--	--	--	0.087
	TIM9A			0.101	0.133	0.152	0.166	0.087	0.134	0.089	0.068	0.056	0.057	--	--	--	0.103
Ogeechee Coastal	2150001	0.069	0.118	--	0.149	--	--	--	--	--	--	--	--	--	--	--	0.149
	2350001			0.084	0.108	0.091	0.069	--	--	--	--	--	--	--	--	--	0.090
	2450001			--	0.097	--	--	--	--	--	--	--	--	--	--	--	0.097
	104060201			--	--	--	--	--	--	--	--	--	--	--	0.058	0.057	0.058
	202060601			--	--	--	--	0.062	--	0.104	--	--	--	0.193	0.189	0.095	0.111
	202060603			--	--	--	--	--	--	0.682	--	--	--	--	0.889	--	0.807
	202060604			--	--	--	--	0.077	--	--	--	--	--	--	0.115	0.097	0.101
	204010102			--	--	--	--	--	--	0.250	--	--	--	--	--	--	0.250
	204010103			--	--	--	--	--	--	--	--	--	--	--	0.220	--	0.220
	204010104			--	--	--	--	--	--	0.350	--	--	0.286	--	--	--	0.318
	204010202			--	--	--	--	--	--	--	--	--	--	0.051	0.069	0.060	0.062
	204010203			--	--	--	--	--	--	--	--	--	--	0.060	0.066	0.060	0.063
	204010204			--	--	--	--	--	--	--	--	--	--	0.069	0.075	0.067	0.071
	204010205			--	--	--	--	--	--	--	--	--	--	0.059	0.066	0.072	0.067
	204010206			--	--	--	--	--	--	--	--	--	--	0.056	0.059	0.067	0.062
	204010207			--	--	--	--	--	--	--	--	--	--	0.060	0.070	0.069	0.068
	204020101			--	--	--	--	--	--	--	--	--	--	--	--	0.079	0.079
	204020104			--	--	--	--	--	--	--	--	--	--	0.140	0.084	0.065	0.082
	204030402			--	--	--	--	--	--	--	--	--	--	--	0.084	0.069	0.080
	204040101			--	--	--	--	--	--	--	--	--	--	--	0.120	0.078	0.098
	204040103			--	--	--	--	--	--	--	--	--	--	0.070	0.065	0.068	0.066
	204040107			--	--	--	0.075	--	--	--	--	--	--	--	--	0.091	0.088
	204040109			--	--	--	--	--	--	--	--	--	--	0.128	0.137	0.108	0.123
	204040202			--	--	--	--	--	--	--	--	--	--	0.100	0.105	0.114	0.107
	204040203			--	--	--	--	--	--	--	--	--	--	0.073	0.103	0.096	0.093
	204050203			--	--	--	--	--	--	--	--	--	--	0.086	0.123	0.095	0.102

Basin	site	Pro-posed Good	Pro-posed Fair	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Long term
Ogeechee Coastal	204050204			--	--	--	--	--	--	--	--	--	--	0.091	0.092	0.079	0.086
	204060201			--	--	--	--	--	--	--	--	--	--	0.133	0.094	0.086	0.098
	204070202			--	--	--	--	--	--	--	--	--	--	0.156	0.088	0.106	0.108
	204070203			--	--	--	--	--	--	--	--	--	--	0.116	0.098	0.090	0.098
	204070302			--	--	--	--	--	--	--	--	--	--	0.099	0.083	0.090	0.089
	204070303			--	--	--	--	--	--	--	--	--	--	0.112	0.080	0.079	0.086
	204070304			--	--	--	--	--	--	--	--	--	--	0.093	0.075	0.084	0.082
	204070305			--	--	--	--	--	--	--	--	--	--	0.103	0.066	0.080	0.079
	204070306			--	--	--	--	--	--	--	--	--	--	0.211	0.177	0.128	0.161
	204080105			--	--	--	--	--	--	--	--	--	--	0.105	0.093	0.083	0.091
	204080106			--	--	--	--	--	--	--	--	--	--	0.147	0.096	0.102	0.108
	204080107			--	--	--	--	--	--	--	--	--	--	0.089	0.108	0.119	0.108
Salke-hatchie	MD-252			0.100	0.063	0.150	0.111	0.107	0.080	0.065	0.070	0.057	0.068	0.078	0.074	0.043	0.083
	MD-253			0.074	0.066	0.174	0.093	0.104	0.047	0.055	0.066	0.053	0.070	0.083	0.059	0.057	0.075
	MD-255			0.067	0.068	0.079	0.103	0.087	0.061	0.054	0.052	0.053	--	--	--	--	0.069
Satilla	7028001			--	--	0.121	--	--	--	--	--	--	--	--	--	--	0.121
	701120101			--	--	--	--	--	0.191	--	0.199	--	--	0.219	--	0.135	0.182
SC Coastal	MD-130			--	0.039	0.036	0.049	0.047	0.036	0.048	0.042	0.040	0.101	0.064	0.059	0.039	0.046
	MD-202			0.092	0.064	0.056	0.063	0.050	0.058	0.048	0.043	0.044	0.062	0.075	0.060	0.054	0.056
	MD-206			0.061	0.049	0.038	0.055	0.055	0.038	0.053	0.064	0.049	0.095	0.082	0.073	0.045	0.054
	MD-273			0.071	0.047	0.042	0.063	0.058	0.040	0.052	0.069	0.044	0.106	0.077	0.088	0.037	0.056
	MD-274			0.071	0.050	0.039	0.062	0.049	0.040	0.049	0.046	0.048	--	--	--	--	0.048
St. Helena Island	MD-256			0.064	0.045	0.069	0.119	0.102	0.069	0.059	0.063	0.050	0.100	0.060	0.066	0.058	0.070

Basin	site	Pro-posed Good	Pro-posed Fair	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Long term
St. Marys	3544	0.051	0.089	0.051	0.057	0.051	0.047	0.049	0.036	0.038	0.049	0.042	0.037	0.040	0.050	0.049	0.045
	19010001			--	--	--	0.067	--	--	--	--	--	--	--	--	--	0.067
	19010008			--	--	--	0.070	--	--	--	--	--	--	--	--	--	0.070
	19010011			0.078	--	--	0.078	--	--	--	--	--	--	--	--	--	0.078
	19010012			--	--	--	0.083	--	--	--	--	--	--	--	--	--	0.083
	19010013			--	--	--	0.079	--	--	--	--	--	--	--	--	--	0.079
	19010024			--	--	--	0.084	--	--	--	--	--	--	--	--	--	0.084
	19010056			--	--	0.083	0.083	--	--	--	--	--	--	--	--	--	0.083
	19010062			--	--	0.089	0.101	--	--	--	--	--	--	--	--	--	0.098

Table 5.3 Geometric means – Chlorophyll *a,* uncorrected for pheophytin.

Annual and long-term geometric mean of uncorrected chlorophyll *a* concentrations, in μg/L

Basin	site	2010	2011	2012	2013	Long-term
Altamaha	606050204	5.6	10.49	10.11	7.43	8.54
	701120304	5.12	10.38	8.61	5.04	6.35
	703030212	--	15.07	13.03	9.64	11.98
	703030213	--	10.1	9.76	9.58	9.76
	703030214	--	12.48	9.7	9.75	10.29
	703030215	--	12.53	11.39	8.7	10.49
	703030216	--	12.39	12.83	11.73	12.3
	703030217	--	14.69	11.21	11.58	11.99
Cumberland - St. Simons	703040105	--	12.8	9.8	8.28	9.75
	703040207	--	16.08	12.49	10.32	12.28
	703040208	2.42	7.6	4.26	1.02	2.11
	703050202	--	10.05	8.95	6.73	8.2
	703050203	--	8.32	8.04	6.98	7.66
	703050309	--	10.57	8.32	6.91	8.17
	703050310	--	10.37	9	7.88	8.82
	703050311	--	9.57	9.29	6.78	8.25
Nassau	3537	--	--	--	3.2	3.2
	104060201	--	--	6.36	3.25	4.55
	204010202	--	8.15	7.85	6.84	7.5
	204010203	--	5.37	6.04	5.54	5.71
	204010204	--	4.62	7.11	7.15	6.56
Ogeechee Coastal	204010205	--	6.47	5.61	7.79	6.55
	204010206	--	7.62	5.69	7.02	6.48
	204010207	--	7.98	8.56	9.24	8.72
	204020104	--	12.66	8.11	4.07	7.59
	204040103	--	10.97	8.28	8.03	8.75

Basin	site	2010	2011	2012	2013	Long-term
	204040109	--	8.67	6.49	6.36	6.82
	204040202	--	12.63	11.78	10.26	11.3
	204040203	--	12.89	9.33	7.94	9.33
	204050203	--	10.83	6.27	7.45	7.49
	204050204	--	15.7	8.93	8.9	9.98
	204060201	--	24.79	10.28	8.44	11.33
	204070202	--	31.79	12.3	11.04	14.24
Ogeechee Coastal	204070203	--	31.06	11.46	10.45	13.49
	204070302	--	19.32	8.87	8.44	10.16
	204070303	--	25.31	9.45	10.38	11.95
	204070304	--	23.35	10.29	10.86	12.39
	204070305	--	22.7	10	10.18	11.87
	204070306	--	35.99	13.85	13.93	16.8
	204080105	--	25.01	11.01	9.35	12.15
	204080106	--	30.56	13.64	12.54	15.5
	204080107	--	30.19	17.09	17.5	19.33

Table 5.4 Geometric means – Chlorophyll *a*, corrected for pheophytin.

Annual and long-term geometric mean of corrected chlorophyll *a* concentrations, in ug/L

Basin	site	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	long. term
Cumberland - St. Simons	CUISoldc	--	--	--	--	--	10.71	9.09	8.22	8.53	--	--	--	9.09
	CUISplum	--	--	--	--	--	8.6	8.19	6.27	8.1	--	--	--	7.64
	CUISseac	--	--	--	--	--	--	--	--	6.46	4.25	3.97	4.8	4.62
Edisto River	Fishing Creek	11.5	6.83	12.2	9.16	10.07	15.17	10.44	6.05	5.51	8.17	10.86	--	9.27
	Mosquito Creek	7.71	5.84	10.5	8.79	10.07	10.41	8.61	8.58	9.43	7.6	5.91	--	8.36
	StPierre	3.69	4.65	4.51	3.67	3.56	4.95	4.12	5.09	4.8	3.47	3.04	--	4.08
Lower Savannah	FOPUlazz	--	--	--	--	5.5	10.48	10.61	8.68	7.91	7.94	5.38	7.24	8.3
	TIM13A	--	--	--	--	3.31	6.01	9.94	10.42	8.55	8.17	--	--	8.31
Nassau	3537	--	--	--	--	--	--	--	--	--	--	--	2.7	2.7
	TIM1	--	--	--	--	9.57	14.16	5.56	3.77	4.65	13.12	2.75	6.59	6.7
	TIM10	--	--	--	--	4.97	7.76	6.07	2.79	6.23	5.23	4	7.51	5.83
	TIM11	--	--	--	--	6.16	9.55	7.1	4.49	5.76	6.84	6.99	2.3	6.1
	TIM11A	--	--	--	--	7.51	4.97	7.88	6.96	6.75	3.73	--	--	6.27
	TIM12	--	--	--	--	5.69	4.87	8.07	4.51	6.13	6.11	--	17.9	6.64
	TIM2	--	--	--	--	9.73	10.46	6.68	3.8	6.17	7.9	3.24	6.44	6.29
	TIM3	--	--	--	--	13.89	8.09	11.07	5.66	8.07	8.31	5.6	6.01	7.52
	TIM4	--	--	--	--	15.59	9.21	9.79	5.59	6.48	7.43	5.93	6.17	7.44
	TIM4A	--	--	--	--	12.02	8.95	13.54	10.34	8.34	7.27	--	--	9.87
	TIM5	--	--	--	--	11.42	9.34	10.68	5.98	6.76	8.79	8.42	8.2	8.34
	TIM6	--	--	--	--	12.51	12.24	12.55	6.36	6.81	6.24	11.26	8.6	9.08
	TIM7	--	--	--	--	11.49	10.68	9.67	6.49	6.54	6.51	11.69	--	8.41
	TIM8	--	--	--	--	12.94	12.52	8.89	6.32	5.18	9.08	10.31	4.94	8.3
	TIM9A	--	--	--	--	4.94	10.8	9.07	5.1	6.34	6.85	7.21	5.43	7.18
South Carolina Coastal	Big Bay	2.63	4.41	5.12	4.03	4.31	5.28	5	6.58	6.34	4.54	4.2	--	4.65

Table 5.5 Baseline results.
Baseline results for chlorophyll *a* (corrected and uncorrected), total nitrogen, and total phosphorus.

Basin	site	Chlorophyll *a*, corrected	Chlorophyll *a*, uncorrected	Total Nitrogen	Total Phosphorus
Altamaha	604050101	--	--	--	0.090
	606050203	--	--	--	0.070
	606050204	--	6.90	--	0.088
	606050205	--	--	--	0.110
	606050206	--	--	--	0.148
Broad - St. Helena	MD-001	--	--	0.268	0.050
	MD-004	--	--	0.215	0.046
	MD-116	--	--	0.241	0.044
	MD-176	--	--	0.262	0.044
	MD-254	--	--	0.339	0.056
Calibogue Sound - Wright River	MD-173	--	--	0.292	0.040
	MD-174	--	--	0.260	0.049
	MD-257	--	--	0.220	0.043
	MD-258	--	--	0.246	0.044
Cooper	MD-039	--	--	0.474	0.064
	MD-043	--	--	0.291	0.034
	MD-045	--	--	0.267	0.032
	MD-052	--	--	0.331	0.055
	MD-069	--	--	0.196	0.033
	MD-071	--	--	0.216	0.037
	MD-115	--	--	0.322	0.031
	MD-247	--	--	0.197	0.030
	MD-248	--	--	0.314	0.032
	MD-264	--	--	0.238	0.028
Cumberland - St. Simons	7004001	--	--	--	0.118
	7005201	--	--	--	0.120
	7005801	--	--	--	0.070

Basin	site	Chlorophyll *a*, corrected	Chlorophyll *a*, uncorrected	Total Nitrogen	Total Phosphorus
Cumberland - St. Simons (Continued)	701120304	--	4.40	--	0.060
	703010201	--	--	--	0.068
	703020101	--	--	--	0.080
	703020102	--	--	--	0.135
	703020106	--	--	--	0.100
	703020107	--	--	--	0.068
	703020109	--	--	--	0.090
	703020110	--	--	--	0.080
	703030201	--	--	--	0.155
	703030202	--	--	--	0.118
	703030212	--	6.88	--	0.080
	703030213	--	6.16	--	0.095
	703030214	--	7.45	--	0.090
	703030215	--	6.45	--	0.085
	703030216	--	9.48	--	0.065
	703030217	--	8.12	--	0.100
	703040105	--	7.31	--	0.070
	703040207	--	9.11	--	0.070
	703040208	--	2.45	--	0.040
	703050101	--	--	--	0.090
	703050202	--	5.89	--	0.050
	703050203	--	5.51	--	0.060
	703050309	--	5.49	--	0.065
	703050310	--	7.00	--	0.060
	703050311	--	6.20	--	0.050
	CUISoldc	5.92	--	--	--
	CUISplum	5.78	--	--	--
	CUISseac	3.51	--	--	--

Basin	site	Chlorophyll *a*, corrected	Chlorophyll *a*, uncorrected	Total Nitrogen	Total Phosphorus
Edisto River	Fishing Creek	5.23	--	--	--
	MD-120	--	--	0.347	0.044
	MD-209	--	--	0.250	0.038
	MD-260	--	--	0.333	0.045
	MD-261	--	--	0.247	0.039
	MD-262	--	--	0.233	0.033
	Mosquito Creek	5.59	--	--	--
	StPierre	2.82	--	--	--
Lower Savannah	1015001	--	--	--	0.100
	1018001	--	--	--	0.070
	109060602	--	--	--	0.120
	109060607	--	--	--	0.066
	109060608	--	--	--	0.052
	109060612	--	--	--	0.050
	109060614	--	--	--	0.065
	109060615	--	--	--	0.073
	FOPUlazz	5.88	--	--	--
	MD-259	--	--	0.284	0.040
	SV-191	--	--	0.603	0.073
Lower St. Johns	TIM13A	4.39	--	0.555	0.070
Nassau	19020015	--	--	--	0.067
	19020016	--	--	--	0.074
	19020018	--	--	--	0.081
	19020019	--	--	--	0.074
	3537	2.70	3.20	--	0.100
	TIM1	3.10	--	0.960	0.110
	TIM10	3.84	--	0.394	0.061
	TIM11	4.32	--	--	--

Basin	site	Chlorophyll *a*, corrected	Chlorophyll *a*, uncorrected	Total Nitrogen	Total Phosphorus
Nassau	TIM11A	5.17	--	0.314	0.060
	TIM12	4.50	--	--	--
	TIM2	3.00	--	0.925	0.110
	TIM3	5.20	--	0.623	0.090
	TIM4	5.30	--	0.525	0.082
	TIM4A	7.85	--	0.530	0.065
	TIM5	6.67	--	0.492	0.077
	TIM6	7.00	--	0.489	0.071
	TIM7	5.91	--	0.460	0.065
	TIM8	6.20	--	0.332	0.058
	TIM9A	4.94	--	0.403	0.070
Ogeechee Coastal	104060201	--	4.10	--	0.050
	202060601	--	--	--	0.080
	202060603	--	--	--	0.525
	202060604	--	--	--	0.090
	204010102	--	--	--	0.175
	204010103	--	--	--	0.180
	204010104	--	--	--	0.230
	204010202	--	4.81	--	0.050
	204010203	--	3.71	--	0.050
	204010204	--	5.46	--	0.050
	204010205	--	4.66	--	0.050
	204010206	--	4.48	--	0.050
	204010207	--	6.19	--	0.054
	204020101	--	--	--	0.065
	204020104	--	5.45	--	0.060
	204030402	--	6.55	--	0.070
	204040101	--	--	--	0.080

Basin	site	Chlorophyll *a*, corrected	Chlorophyll *a*, uncorrected	Total Nitrogen	Total Phosphorus
Ogeechee Coastal	204040103	--	7.40	--	0.060
	204040107	--	--	--	0.078
	204040109	--	5.37	--	0.100
	204040202	--	9.03	--	0.075
	204040203	--	8.06	--	0.070
	204050203	--	5.40	--	0.080
	204050204	--	6.83	--	0.070
	204060201	--	7.34	--	0.080
	204070202	--	8.24	--	0.080
	204070203	--	8.40	--	0.070
	204070302	--	6.12	--	0.068
	204070303	--	7.52	--	0.070
	204070304	--	8.24	--	0.070
	204070305	--	8.43	--	0.060
	204070306	--	11.08	--	0.090
	204080105	--	8.48	--	0.080
	204080106	--	9.55	--	0.080
	204080107	--	12.25	--	0.080
	2150001	--	--	--	0.128
	2350001	--	--	--	0.073
	2450001	--	--	--	0.078
Salkehatchie	MD-252	--	--	0.375	0.055
	MD-253	--	--	0.291	0.050
	MD-255	--	--	0.279	0.048
Satilla	701120101	--	--	--	0.125
	7028001	--	--	--	0.095

Basin	site	Chlorophyll *a*, corrected	Chlorophyll *a*, uncorrected	Total Nitrogen	Total Phosphorus
South Carolina Coastal	Big Bay	3.49	--	--	--
	MD-130	--	--	0.211	0.034
	MD-202	--	--	0.307	0.042
	MD-206	--	--	0.253	0.040
	MD-273	--	--	0.229	0.042
	MD-274	--	--	0.214	0.032
St. Helena Island	MD-256	--	--	0.224	0.048
St. Marys	19010001	--	--	--	0.064
	19010008	--	--	--	0.068
	19010011	--	--	--	0.071
	19010012	--	--	--	0.073
	19010013	--	--	--	0.077
	19010024	--	--	--	0.069
	19010056	--	--	--	0.076
	19010062	--	--	--	0.090
	3544	--	--	--	0.036

Table 5.6 Regression results for nitrogen.
Expected TN values are in mg N/L

"Good" condition (< 0.1 DIN)										
basin	n	p	df	R^2	intercept	SE	slope	SE	"Good" DIN	Expected TN
Altamaha	35	7.34E-04	33	0.296	0.5415	0.0635	1.1535	0.3099	0.1	0.657
Broad - St. Helena	81	4.24E-14	79	0.516	0.2412	0.0308	0.9264	0.1009	0.1	0.334
Cooper	379	5.17E-10	377	0.098	0.2959	0.0328	0.9310	0.1459	0.1	0.389
Cumberland - St. Simons	518	2.20E-16	516	0.266	0.4255	0.0287	0.9365	0.0684	0.1	0.519
Edisto River	146	6.65E-07	144	0.158	0.3241	0.0325	0.7893	0.1517	0.1	0.403
Lower Savannah	153	2.93E-14	151	0.319	0.2558	0.0582	1.4397	0.1713	0.1	0.400
Lower St. Johns	33	2.26E-16	31	0.957	0.6828	0.0398	0.2007	0.0076	0.1	0.703
Nassau	708	2.26E-16	706	0.142	0.6457	0.0243	2.6320	0.2434	0.1	0.909
Ogeechee Coastal	812	1.67E-01	810	0.002	0.5717	0.1215	0.5928	0.4281	0.1	0.631
Salkehatchie	86	4.75E-01	84	0.006	0.4912	0.0541	0.1523	0.2121	0.1	0.506
Satilla	22	1.11E-01	20	0.122	1.5596	0.1244	-1.0535	0.6316	0.1	1.454
South Carolina Coastal	48	1.22E-07	46	0.459	0.2331	0.0336	0.9864	0.1578	0.1	0.332
St. Helena Island	11	5.09E-05	9	0.852	0.1807	0.0481	0.9801	0.1361	0.1	0.279
St. Marys	188	1.70E-02	186	0.030	0.9756	0.0479	0.9074	0.3767	0.1	1.066

"Fair" condition (< 0.5 DIN)										
basin	n	p	df	R^2	intercept	SE	slope	SE	"Fair" DIN	Expected TN
Altamaha	35	7.34E-04	33	0.296	0.5415	0.0635	1.1535	0.3099	0.5	1.118
Broad - St. Helena	81	4.24E-14	79	0.516	0.2412	0.0308	0.9246	0.1009	0.5	0.704
Cooper	379	5.17E-10	377	0.098	0.2959	0.0328	0.9310	0.1459	0.5	0.761
Cumberland - St. Simons	518	2.20E-16	516	0.266	0.4255	0.0287	0.9365	0.0684	0.5	0.894
Edisto River	146	6.65E-07	144	0.158	0.3241	0.0325	0.7893	0.1517	0.5	0.719
Lower Savannah	153	2.93E-14	151	0.319	0.2558	0.0582	1.4397	0.1713	0.5	0.976
Lower St. Johns	33	2.26E-16	31	0.957	0.6828	0.0398	0.2007	0.0076	0.5	0.783
Nassau	708	2.26E-16	706	0.142	0.6457	0.0243	2.6320	0.2434	0.5	1.962

Ogeechee Coastal	812	1.67E-01	810	0.002	0.5717	0.1215	0.5928	0.4281	0.5	0.868
Salkehatchie	86	4.75E-01	84	0.006	0.4912	0.0541	0.1523	0.2121	0.5	0.567
Satilla	22	1.11E-01	20	0.122	1.5596	0.1244	-1.0535	0.6316	0.5	1.033
South Carolina Coastal	48	1.22E-07	46	0.459	0.2331	0.0336	0.9864	0.1578	0.5	0.726
St. Helena Island	11	5.09E-05	9	0.852	0.1807	0.0481	0.9801	0.1361	0.5	0.671
St. Marys	188	1.70E-02	186	0.030	0.9756	0.0479	0.9074	0.3767	0.5	1.429

Table 5.7 Regression results for phosphorus.

Expected TP values are in mg P/L

"Good" condition (< 0.01 DIP)										
basin	**n**	**p**	**df**	**R^2**	**intercept**	**SE**	**slope**	**SE**	**"Good" DIP**	**Expected TP**
Cumberland - St. Simons	22	9.26E-03	20	0.2931	0.0202	0.0278	1.1902	0.4133	0.01	0.0321
Lower Savannah	48	7.19E-01	46	0.0028	0.2163	0.0432	-0.2224	0.6148	0.01	0.2141
Lower St. Johns	34	3.13E--07	32	0.5638	0.0283	0.0109	1.2406	0.1929	0.01	0.0407
Nassau	695	9.34E-04	693	0.0157	0.1196	0.0063	0.3016	0.0907	0.01	0.1226
Ogeechee Coastal	54	5.36E-11	52	0.5578	0.0567	0.0131	1.2214	0.1483	0.01	0.0689
St. Marys	163	5.29E-06	161	0.1185	0.0420	0.0052	0.9303	0.1976	0.01	0.0513
"Fair" condition (< 0.05 DIP)										
basin	**n**	**p**	**df**	**R^2**	**intercept**	**SE**	**slope**	**SE**	**"Fair" DIP**	**Expected TP**
Cumberland - St. Simons	22	9.26E-03	20	0.2931	0.0202	0.0278	1.1902	0.4133	0.05	0.0797
Lower Savannah	48	7.19E-01	46	0.0028	0.2163	0.0432	-0.2224	0.6148	0.05	0.2052
Lower St. Johns	34	3.13E--07	32	0.5638	0.0283	0.0109	1.2406	0.1929	0.05	0.0903
Nassau	695	9.34E-04	693	0.0157	0.1196	0.0063	0.3016	0.0907	0.05	0.1347
Ogeechee Coastal	54	5.36E-11	52	0.5578	0.0567	0.0131	1.2214	0.1483	0.05	0.1177
St. Marys	163	5.29E-06	161	0.1185	0.0420	0.0052	0.9303	0.1976	0.05	0.0886

Table 5.8 Percentile ranges.
Percentile ranges for all sites for concentrations of ammonia, nitrate plus nitrite, orthophosphate, and corrected chlorophyll *a*.

	10%	20%	25%	30%	40%	50%	60%	70%	75%	80%	90%
Ammonia	0.010	0.030	0.039	0.045	0.059	0.070	0.089	0.120	0.140	0.169	0.244
Chlorophyll *a*, corrected	2.90	3.71	4.15	4.51	5.46	6.33	7.66	9.21	10.20	11.50	16.03
Orthophosphate	0.020	0.027	0.030	0.032	0.040	0.049	0.054	0.064	0.070	0.077	0.100
Nitrate-Nitrite	0.001	0.010	0.016	0.020	0.027	0.034	0.047	0.062	0.072	0.086	0.136

Table 5.9 Median values within SECN Parks.
Media values for concentrations of ammonia, nitrate plus nitrite, orthophosphate, and corrected chlorophyll *a*.

Site	Ammonia	Nitrate-Nitrite	Orthophosphate	Chlorophyll *a*, corrected
CUIS	0.020	0.015	0.022	6.95
FOPU	0.019	0.071	0.024	8.11

Table 5.10 Proposed criteria for total N, by basin

Estimated Total Nitrogen Concentration Criteria (mg N/L)							
	≤ 0.1 DIN		0.1 DIN to 0.5 DIN			> 0.5 DIN	
	Good		Fair			Poor	
Altamaha	≤	0.657	0.657	to	1.118	>	1.118
Broad - St. Helena	≤	0.334	0.334	to	0.704	>	0.704
Cooper	≤	0.389	0.389	to	0.761	>	0.761
Cumberland - St. Simons	≤	0.519	0.519	to	0.894	>	0.894
Edisto River	≤	0.403	0.403	to	0.719	>	0.719
Lower Savannah	≤	0.400	0.400	to	0.976	>	0.976
Lower St. Johns	≤	0.703	0.703	to	0.783	>	0.783
Nassau	≤	0.909	0.909	to	1.962	>	1.962
Ogeechee Coastal	≤	0.631	0.631	to	0.868	>	0.868
Salkehatchie	≤	0.506	0.506	to	0.567	>	0.567
Satilla	≤	1.454	1.454	to	1.033	>	1.033
South Carolina Coastal	≤	0.332	0.332	to	0.726	>	0.726
St. Helena Island	≤	0.279	0.279	to	0.671	>	0.671
St. Marys	≤	1.066	1.066	to	1.429	>	1.429

Table 5.11 Proposed Criteria for total P, by basin

Estimated Total Phosphorus Concentration Criteria (mg P/L)							
	≤ 0.01 DIP		0.01 DIP to 0.05 DIP			> 0.05 DIP	
	Good		Fair			Poor	
Cumberland - St. Simons	≤	0.032	0.032	to	0.080	>	0.080
Lower Savannah	≤	0.214	0.214	to	0.205	>	0.205
Lower St. Johns	≤	0.041	0.041	to	0.090	>	0.090
Nassau	≤	0.123	0.123	to	0.135	>	0.135
Ogeechee Coastal	≤	0.069	0.069	to	0.118	>	0.118
St. Marys	≤	0.051	0.051	to	0.089	>	0.089

Table 5.12 Nassau River Basin nitrogen regression (log-log)

"Good" condition (< 0.1 DIN)										
basin	**n**	**p**	**df**	**R^2**	**intercept**	**SE**	**slope**	**SE**	**Final**	**Florida Criteria**
All Nassau	537	2.50E-15	535	0.111	0.2881	0.0862	0.2367	0.0290	1.05	
Upper Nassau	164	7.54E-05	162	0.092	0.4188	0.1084	0.1718	0.0423	1.28	1.29
Middle Nassau	164	1.25E-03	162	0.062	0.0016	0.1220	0.1320	0.0402	0.88	0.83
Lower Nassau	101	4.71E-02	99	0.030	-0.1923	0.2461	0.1522	0.0757	0.71	0.80
Fort George	108	9.34E-01	106	0.000	-0.7383	0.2228	-0.0058	0.0703	0.48	0.60

Table 5.13 Nassau River Basin phosphorus regression (log-log)

"Good" condition (< 0.1 DIP)										
basin	**n**	**p**	**df**	**R^2**	**intercept**	**SE**	**slope**	**SE**	**Final**	**Florida Criteria**
All Nassau	564	3.33E-09	562	0.060	-1.5367	0.1115	0.1995	0.0332	0.144	
Upper Nassau	174	1.18E-01	172	0.014	-1.6938	0.1763	0.0955	0.0608	0.152	0.191
Middle Nassau	173	2.10E-02	171	0.031	-1.6265	0.2431	0.1688	0.0725	0.140	0.137
Lower Nassau	103	8.81E-01	101	0.000	-2.4592	0.2894	-0.0115	0.0766	0.087	0.107
Fort George	116	8.32E-02	114	0.026	-1.7532	0.3443	0.1669	0.0955	0.124	0.107

5.4 Chapter 5 Figures

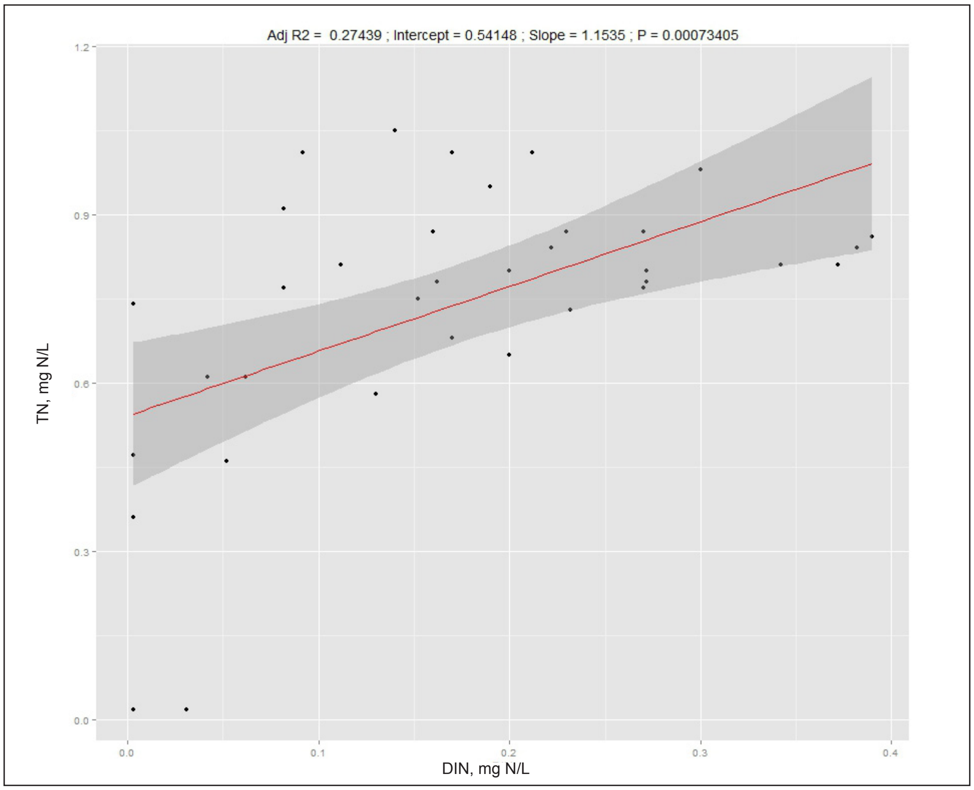


Figure 5.1 Regression plot for the Altamaha River Basin - Nitrogen

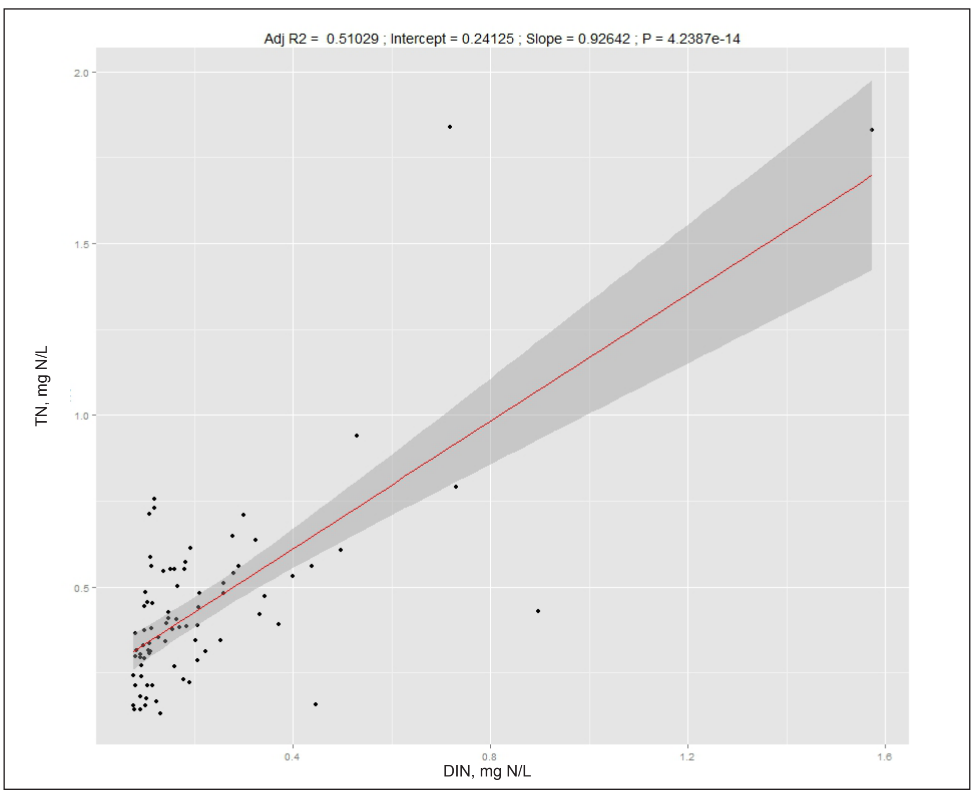


Figure 5.2 Regression plot for the Broad St. Helena River Basin - Nitrogen

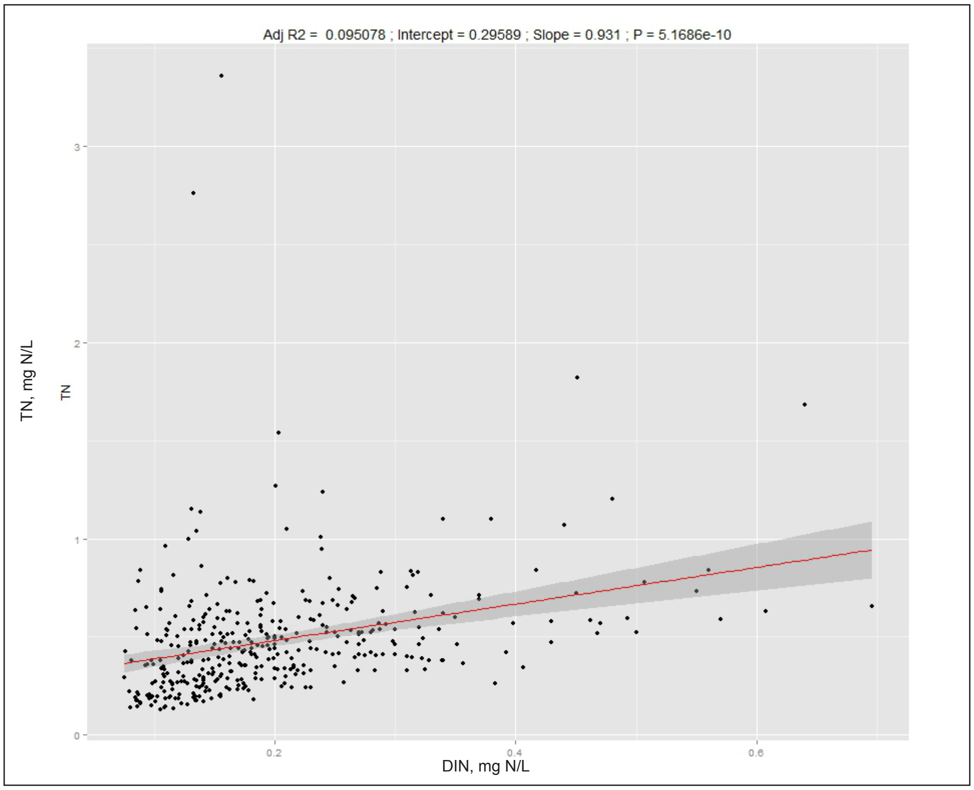


Figure 5.3 Regression plot for the Cooper River Basin - Nitrogen

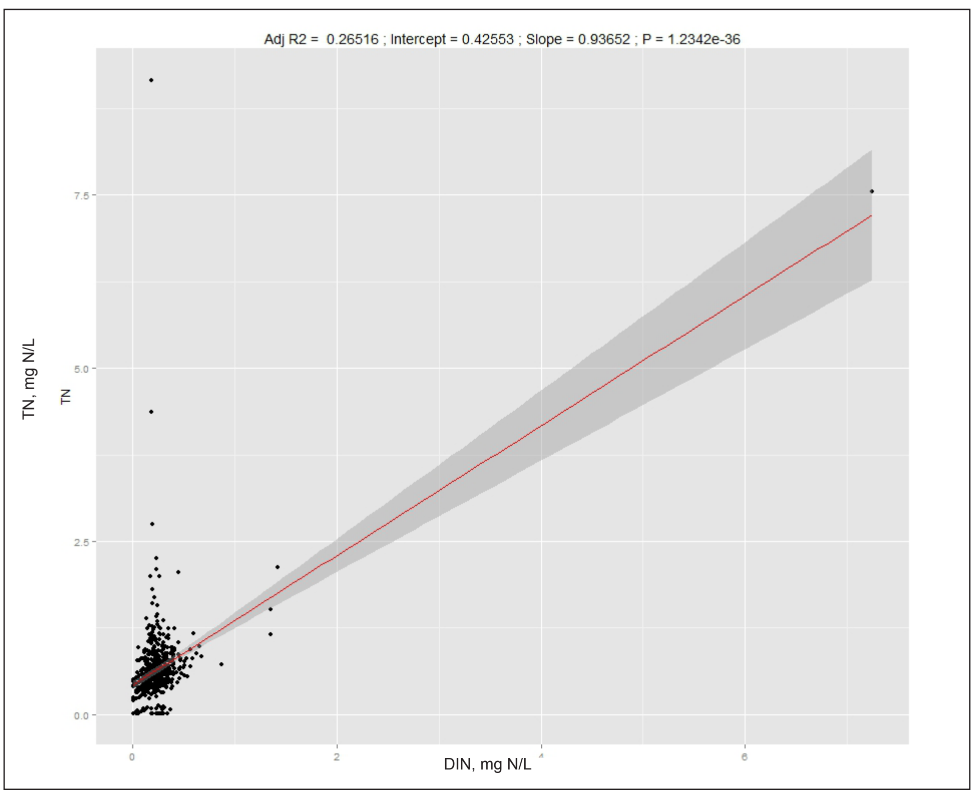


Figure 5.4 Regression plot for the Cumberland River Basin - Nitrogen

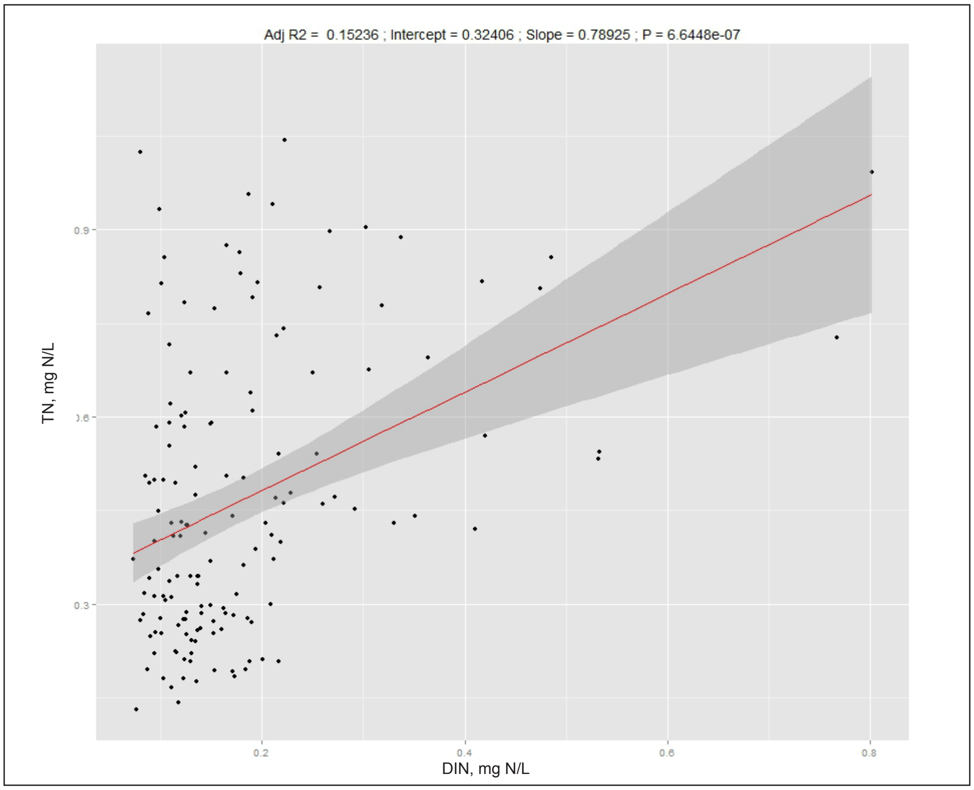


Figure 5.5 Regression plot for the Edisto River Basin - Nitrogen

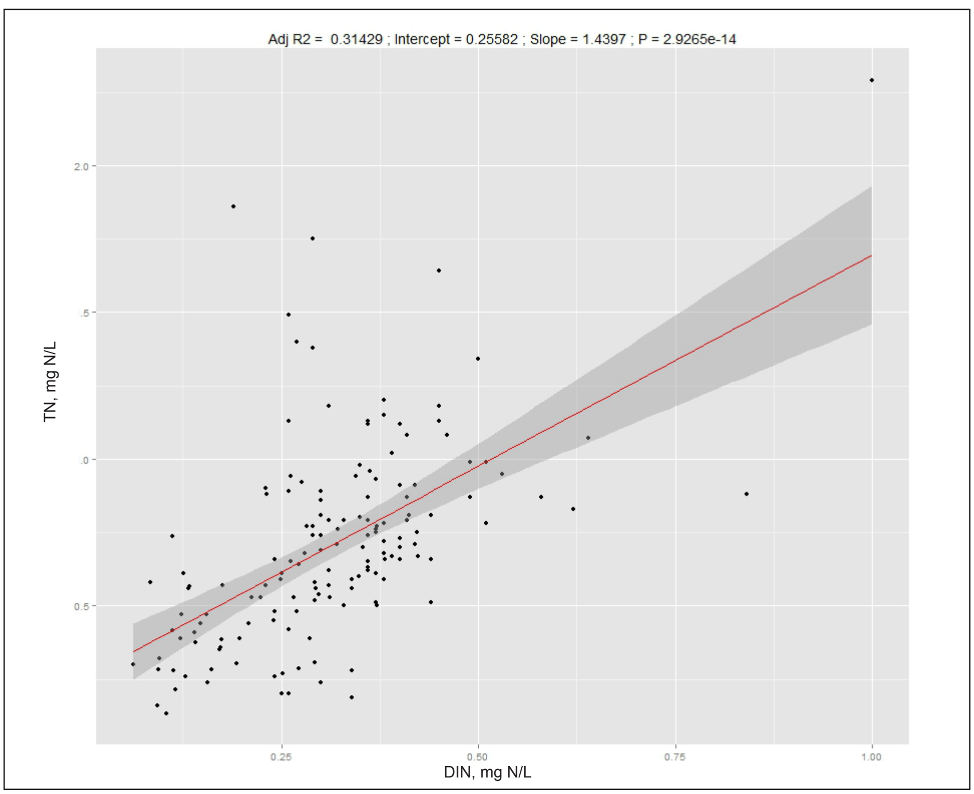


Figure 5.6 Regression plot for the Lower Savannah River Basin - Nitrogen

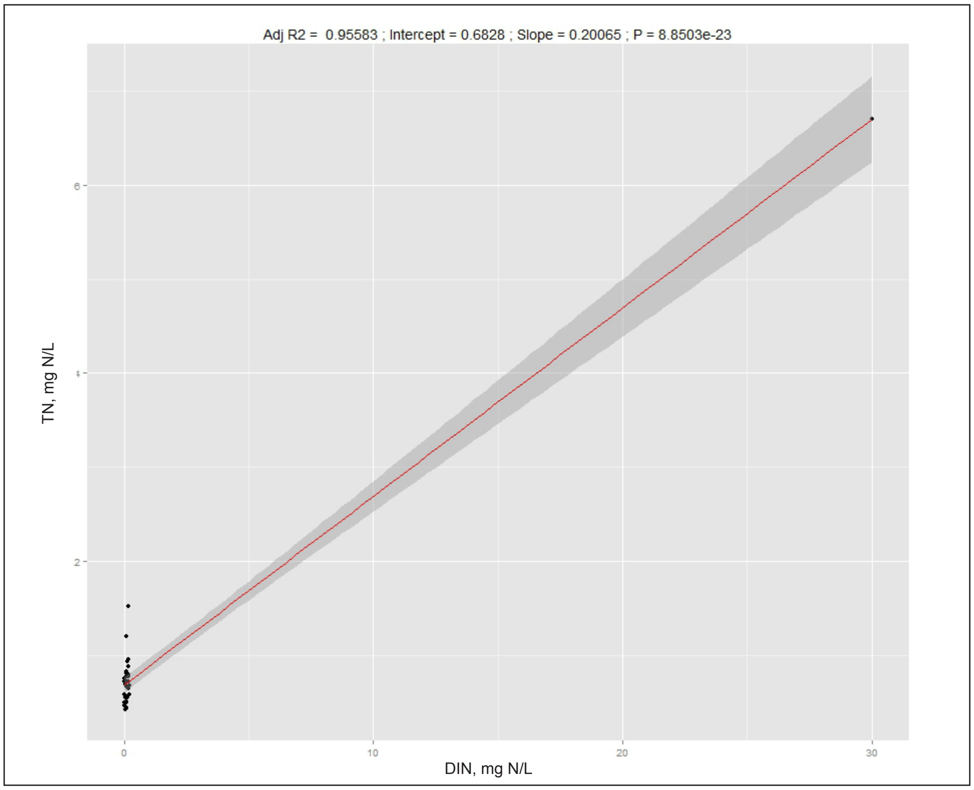


Figure 5.7 Regression plot for the Lower St. Johns River Basin - Nitrogen

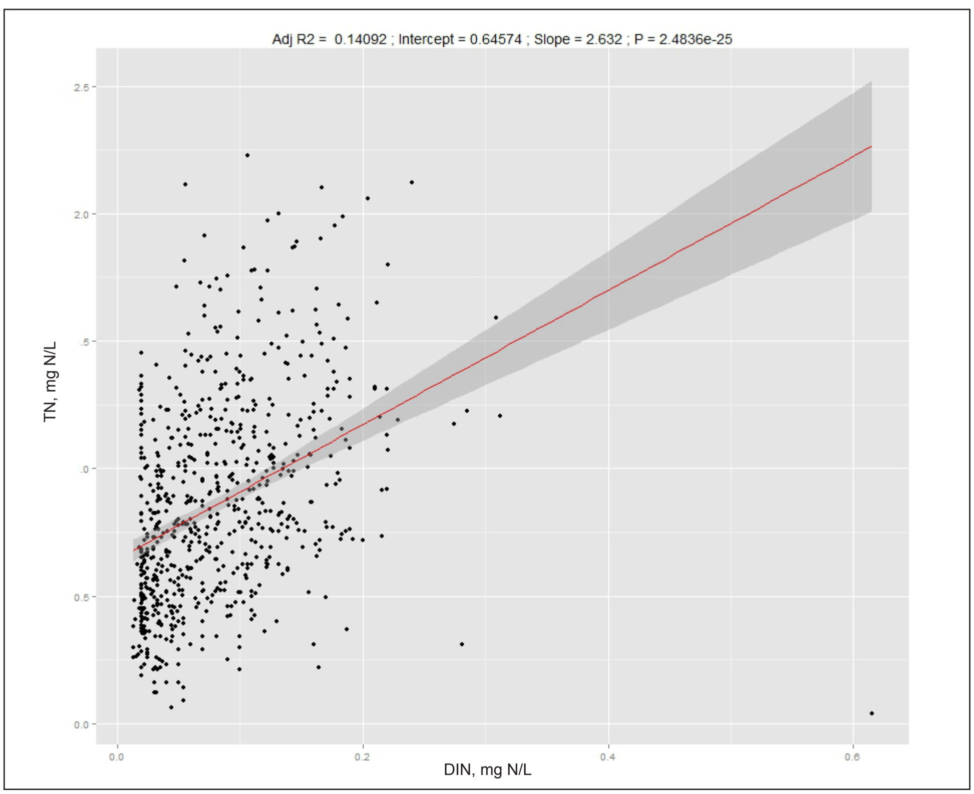


Figure 5.8 Regression plot for the Nassau River Basin - Nitrogen

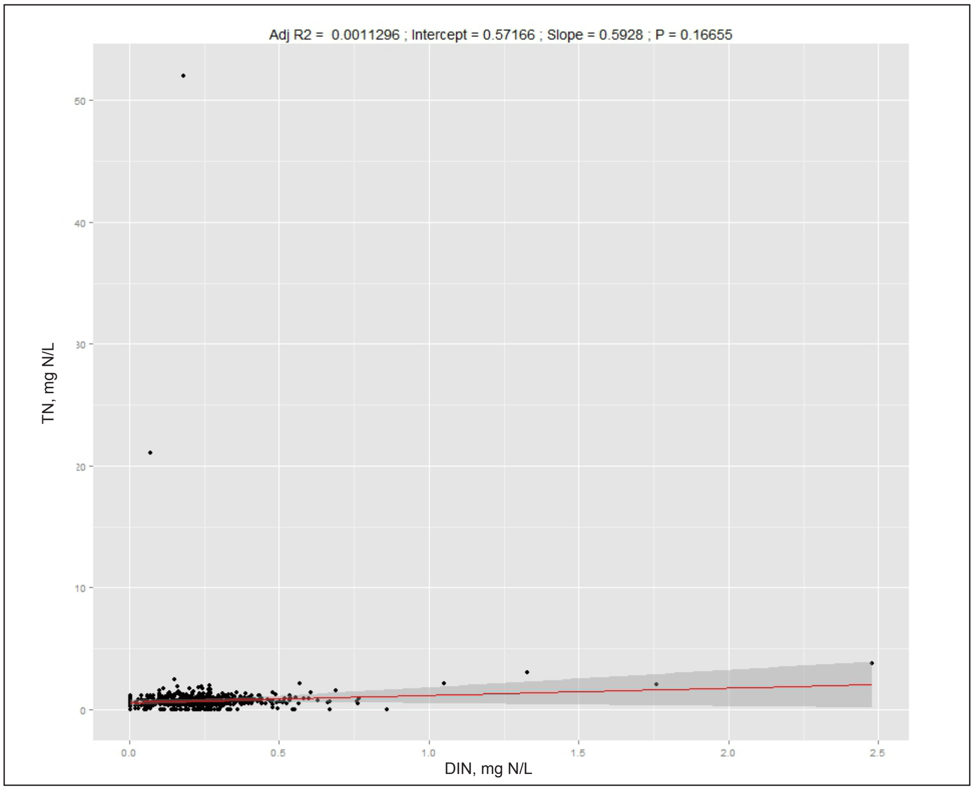


Figure 5.9 Regression plot for the Ogeechee Coastal River Basin - Nitrogen

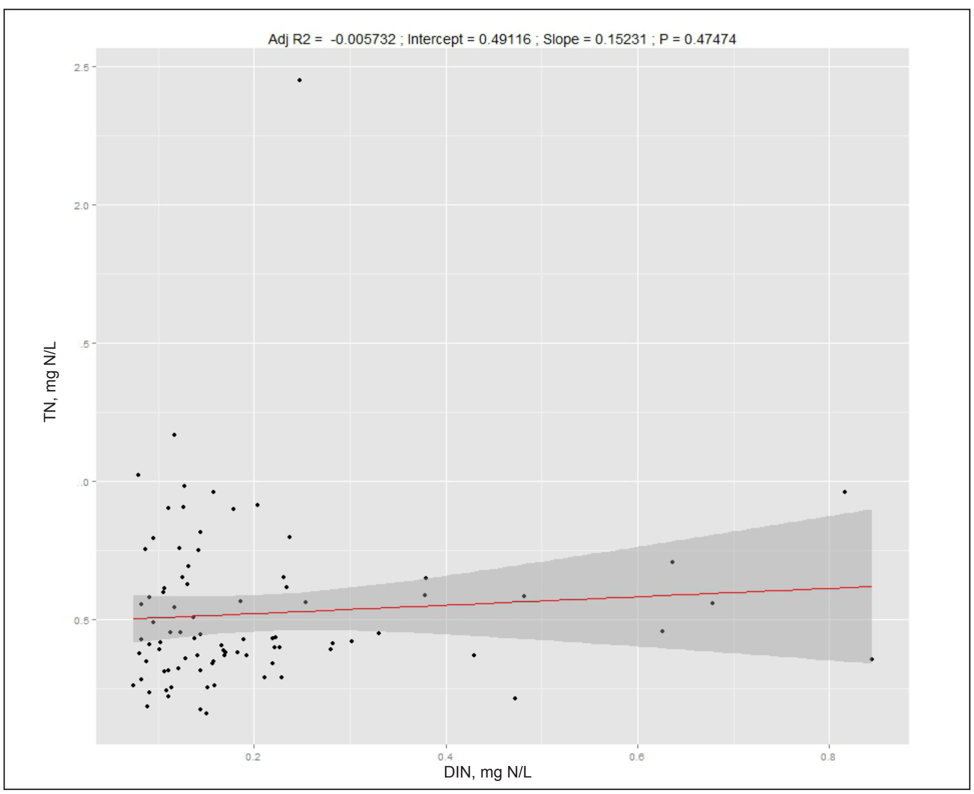


Figure 5.10 Regression plot for the Salkehatchie River Basin - Nitrogen

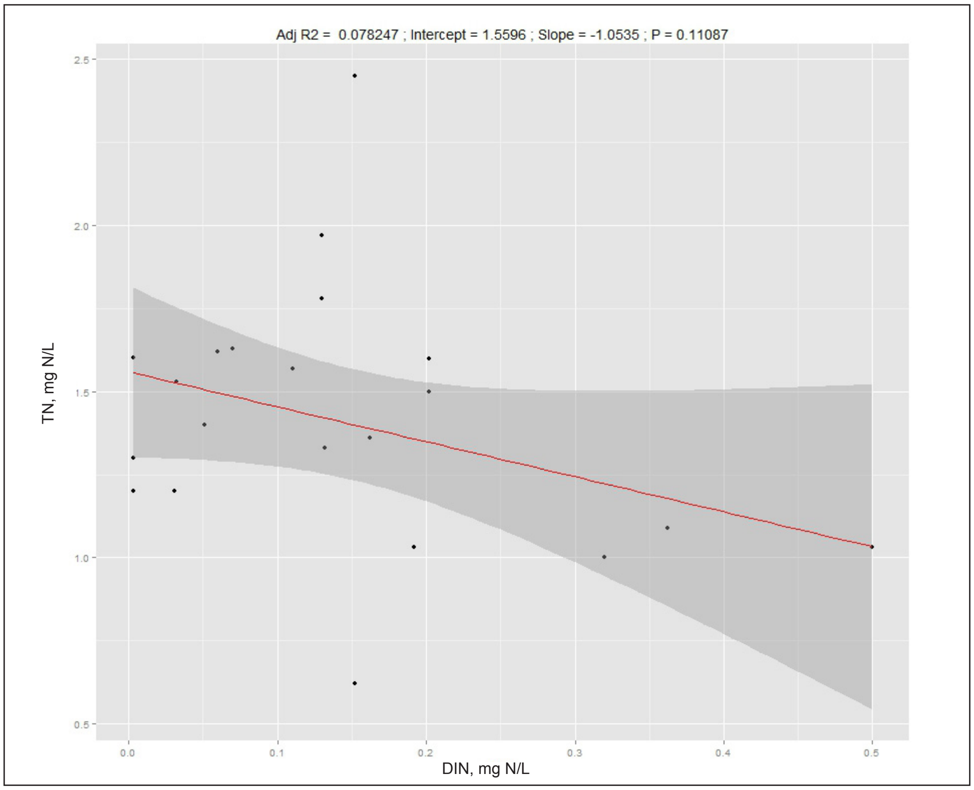


Figure 5.11 Regression plot for the Satilla River Basin - Nitrogen

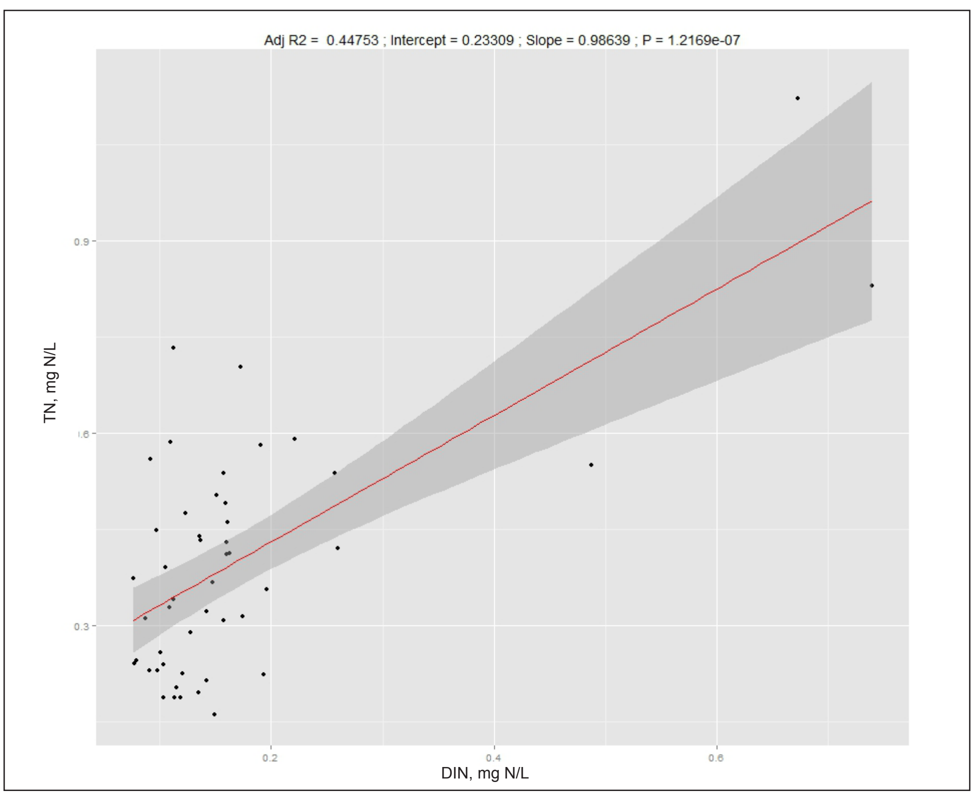


Figure 5.12 Regression plot for the SC Coastal River Basin - Nitrogen

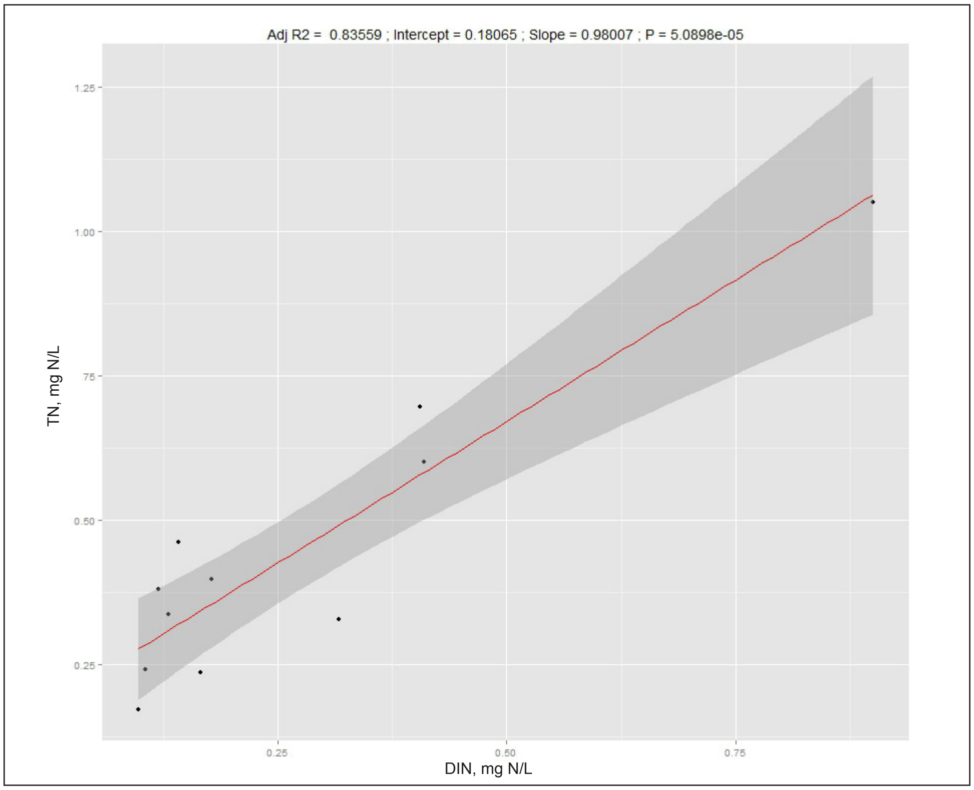


Figure 5.13 Regression plot for the St. Helena River Basin - Nitrogen

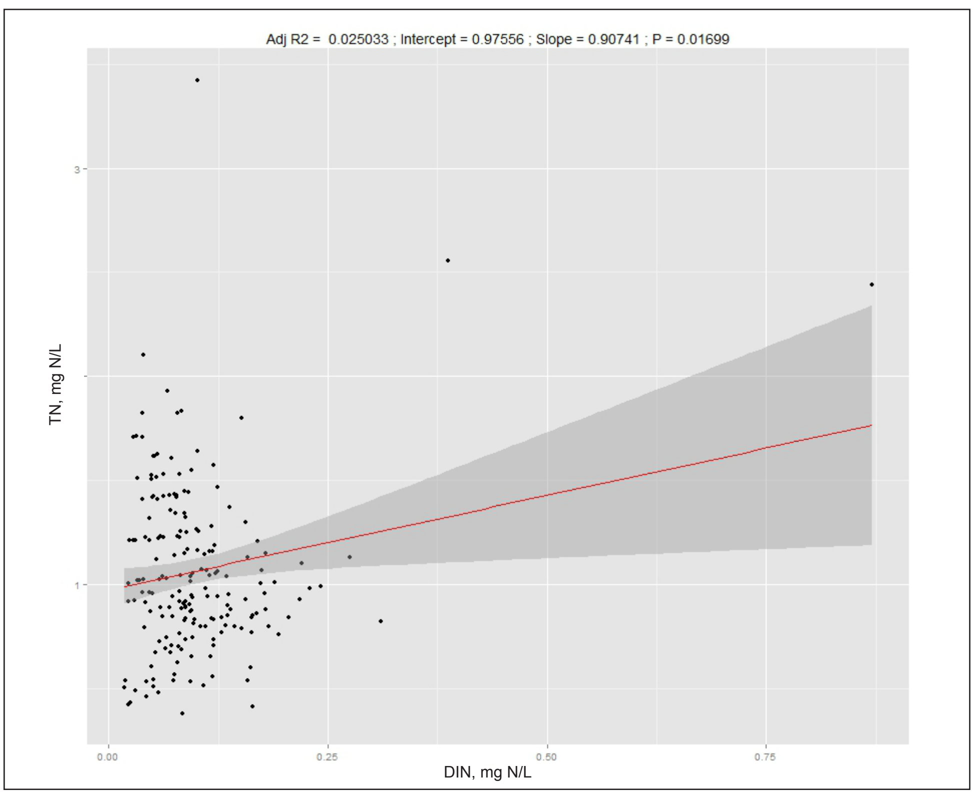


Figure 5.14 Regression plot for the St. Marys River Basin - Nitrogen

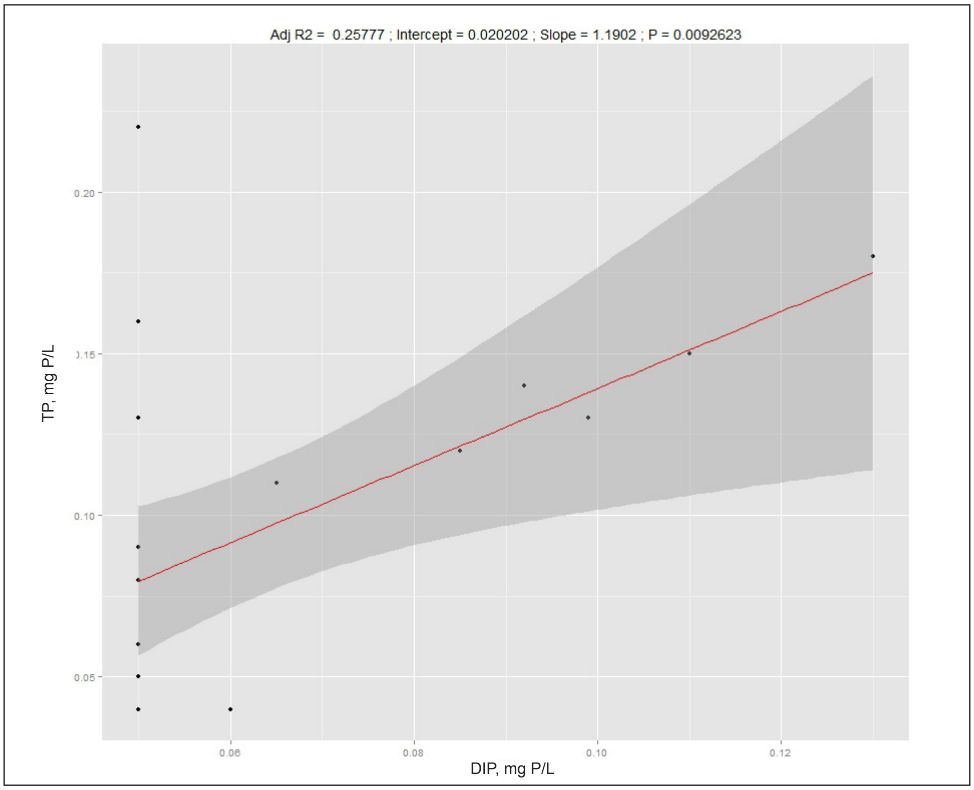


Figure 5.15 Regression plot for the Cumberland River Basin - Phosphorus

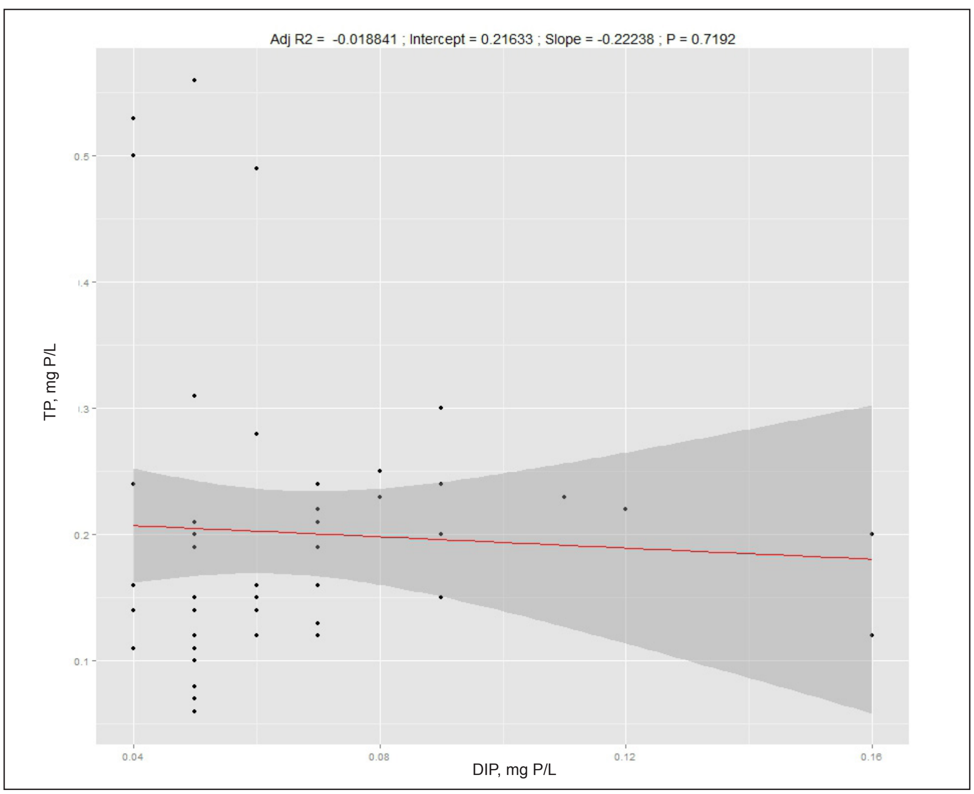


Figure 5.16 Regression plot for the Lower Savannah River Basin - Phosphorus

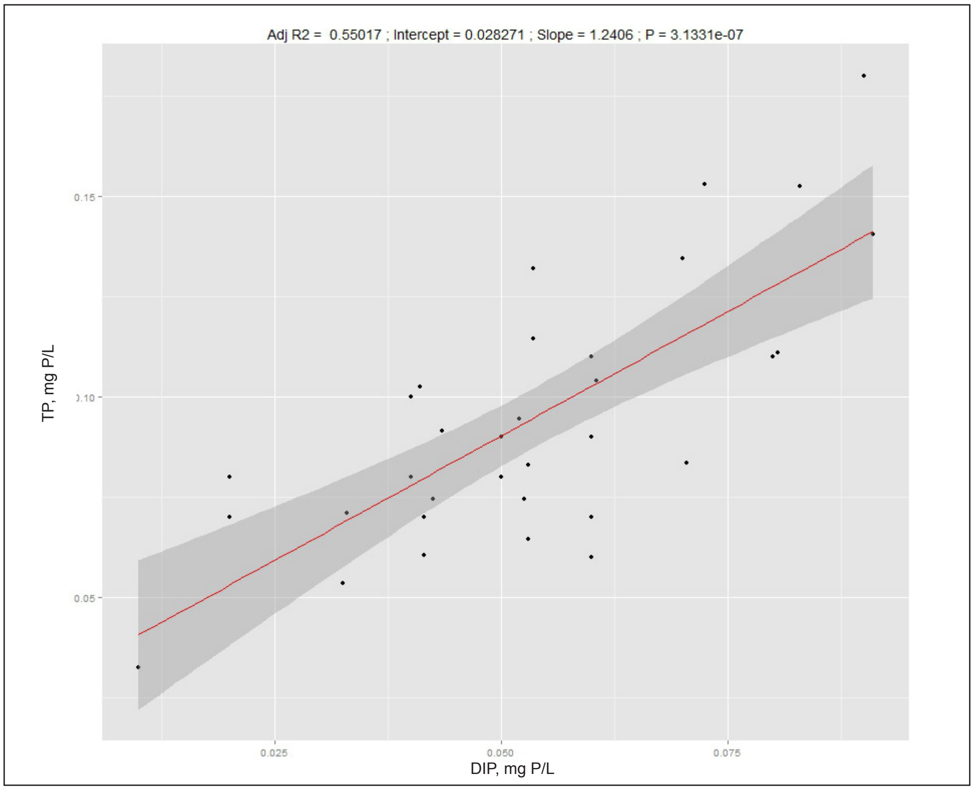


Figure 5.17 Regression plot for the Lower St. Johns River Basin - Phosphorus

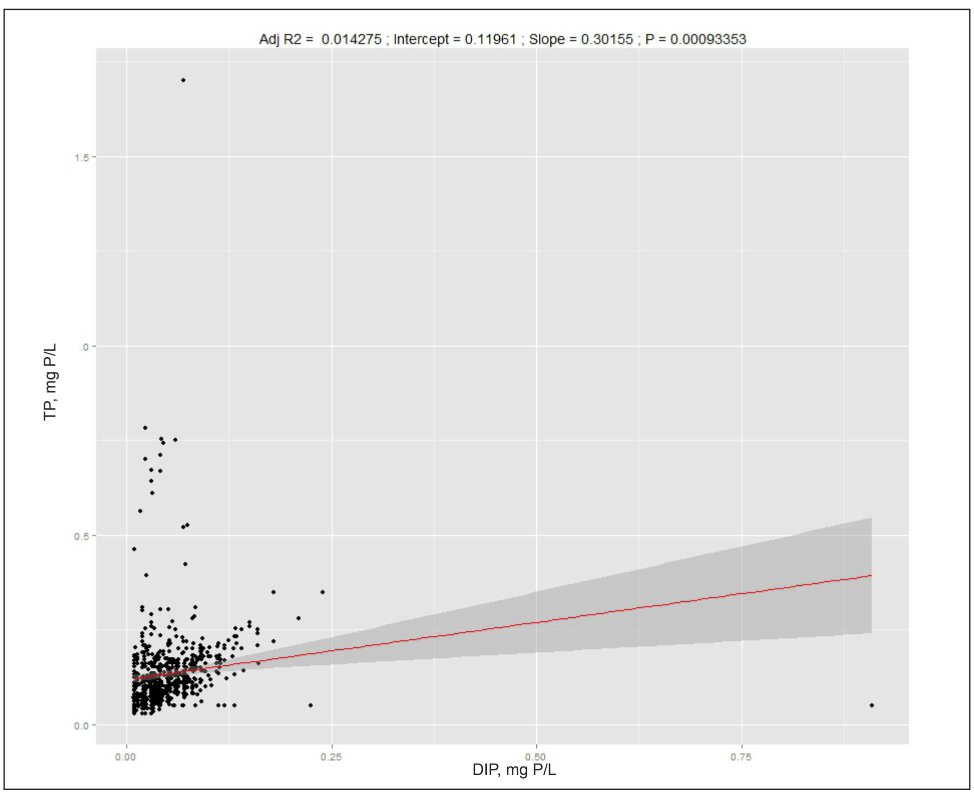


Figure 5.18 Regression plot for the Nassau River Basin - Phosphorus

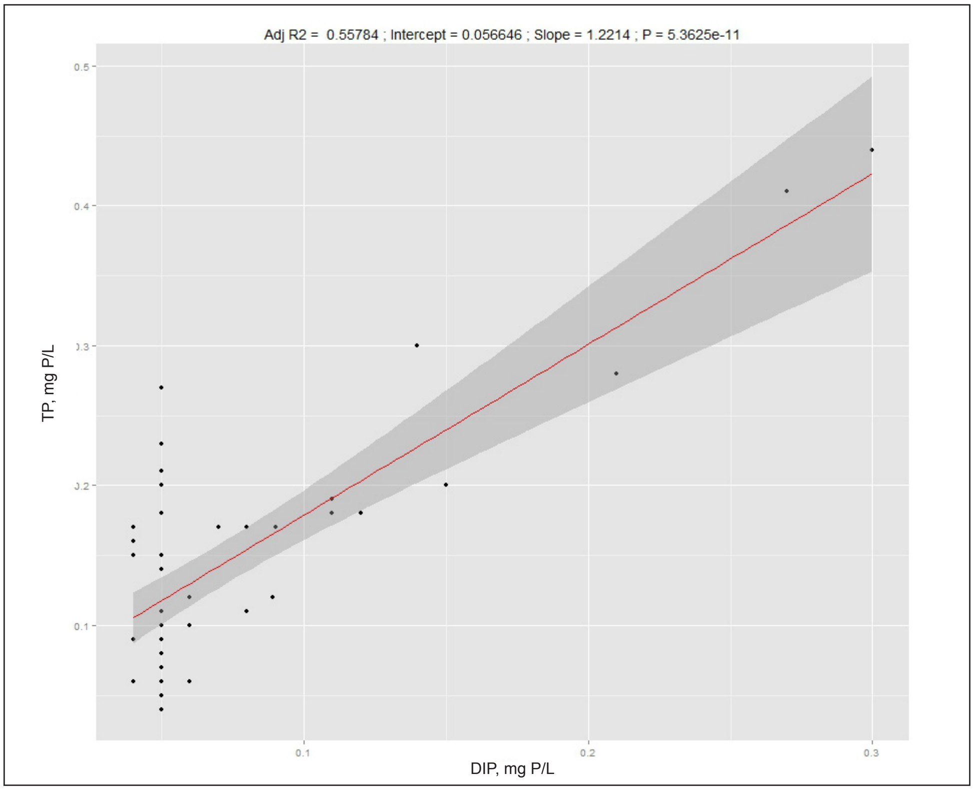


Figure 5.19 Regression plot for the Ogeechee Coastal River Basin - Phosphorus

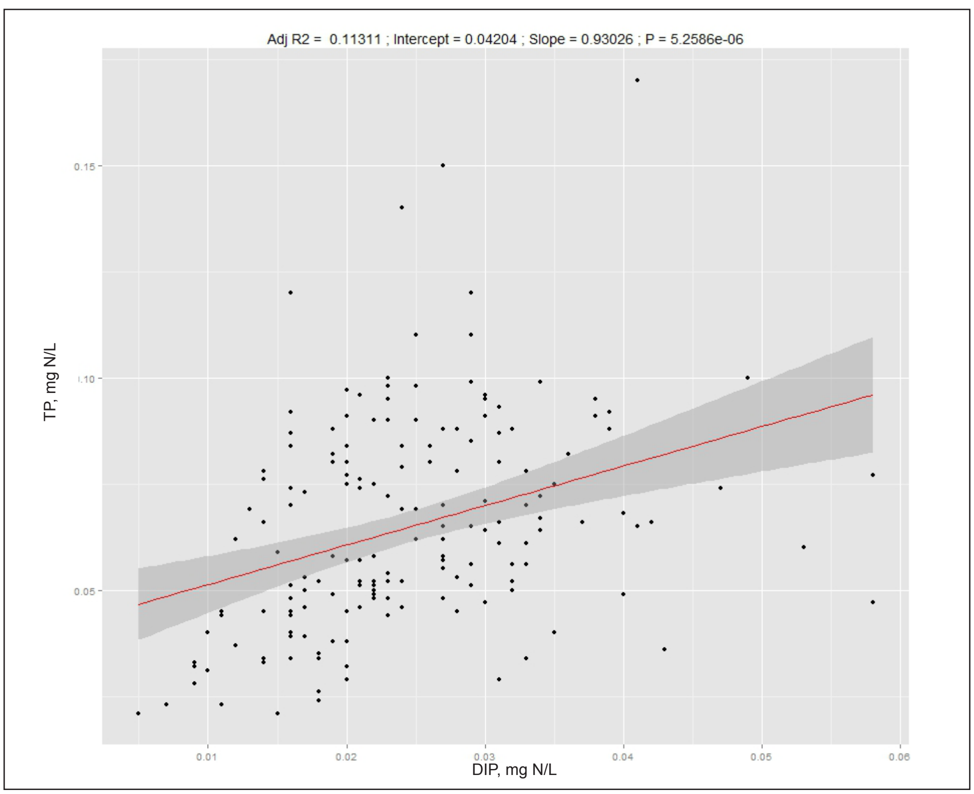


Figure 5.20 Regression plot for the St. Marys River Basin - Phosphorus

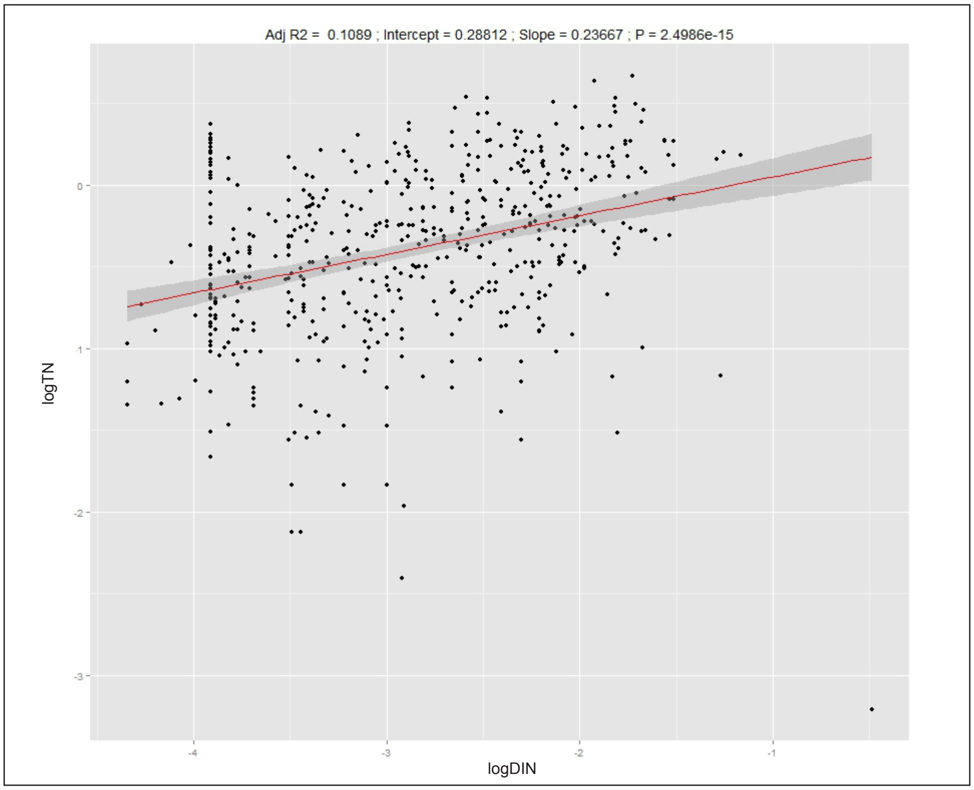


Figure 5.21 Regression plot for the Nassau River Basin - Nitrogen

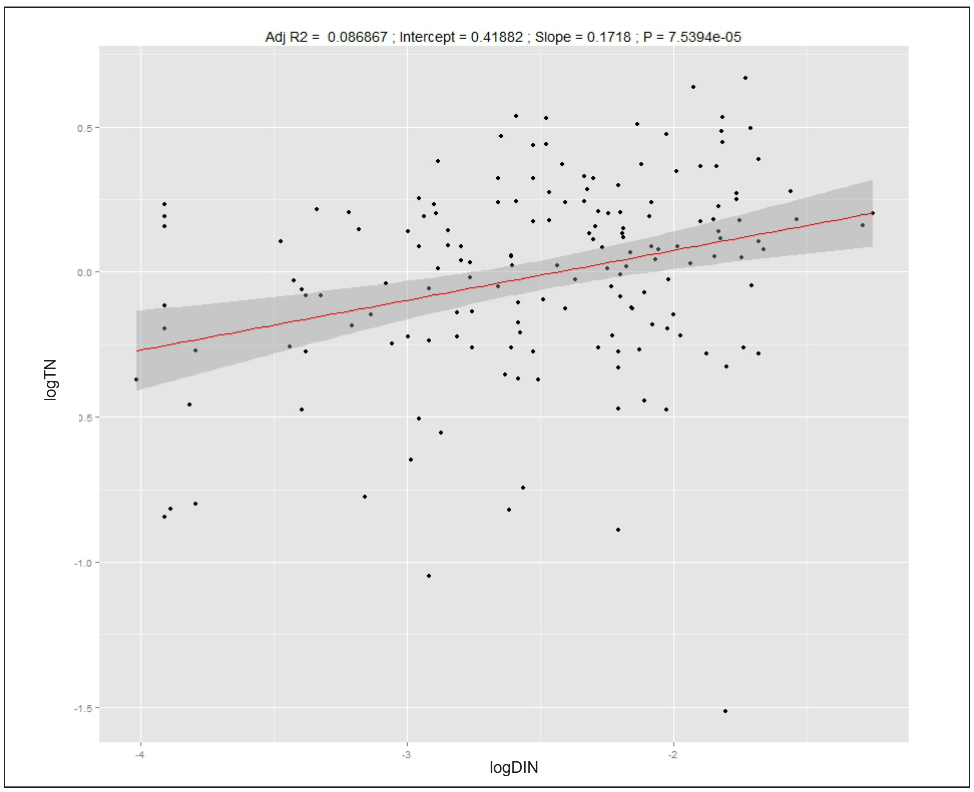


Figure 5.22 Regression plot for the Upper Nassau Reach - Nitrogen

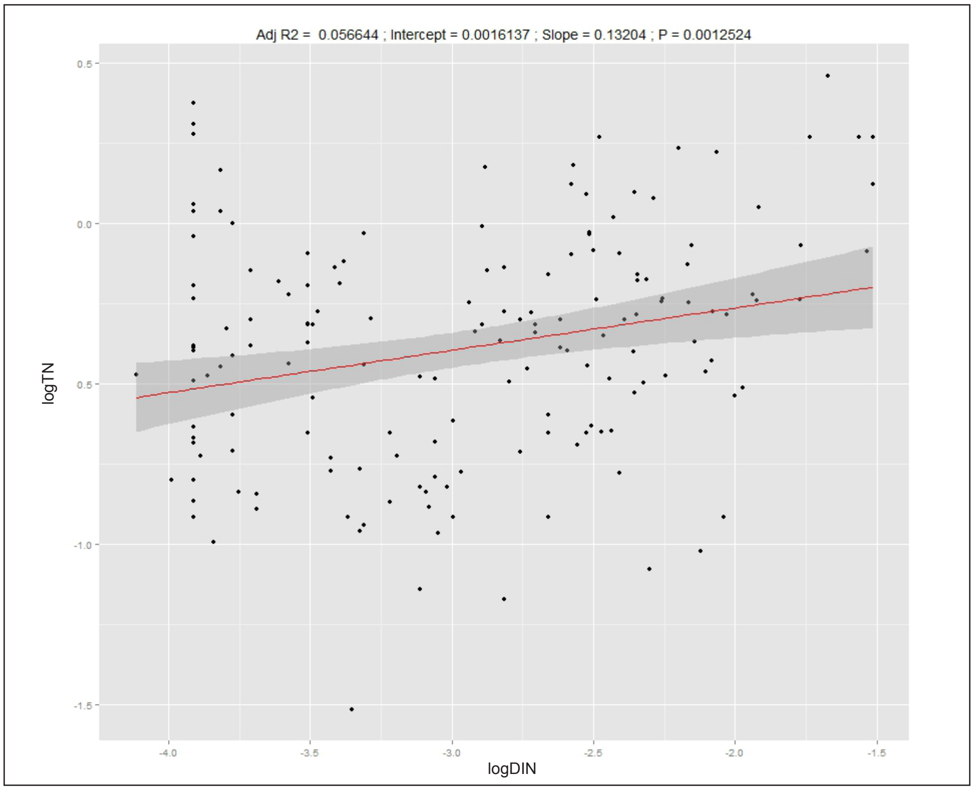


Figure 5.23 Regression plot for the Middle Nassau Reach - Nitrogen

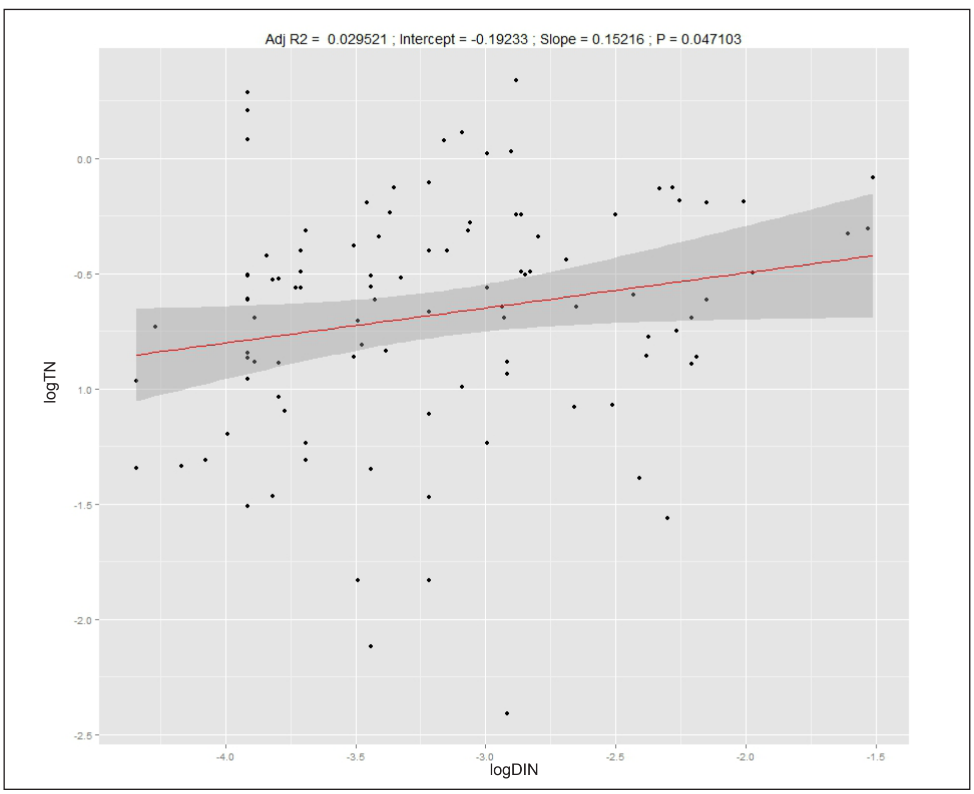


Figure 5.24 Regression plot for the Lower Nassau reach - Nitrogen

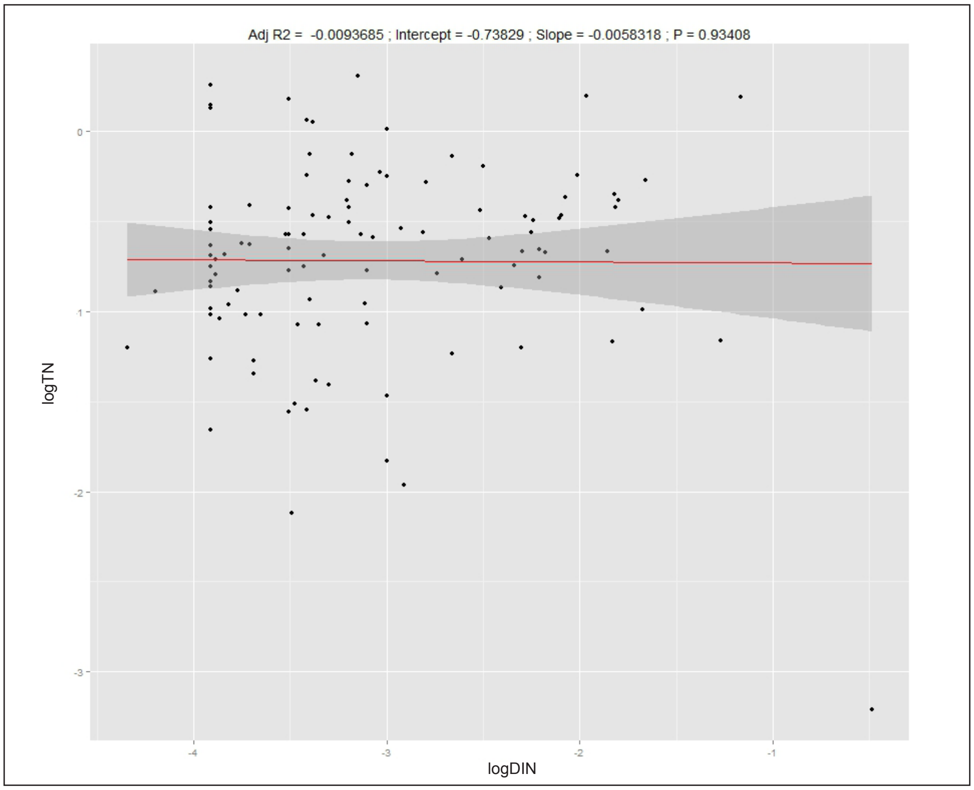


Figure 5.25 Regression plot for the Fort George reach - Nitrogen

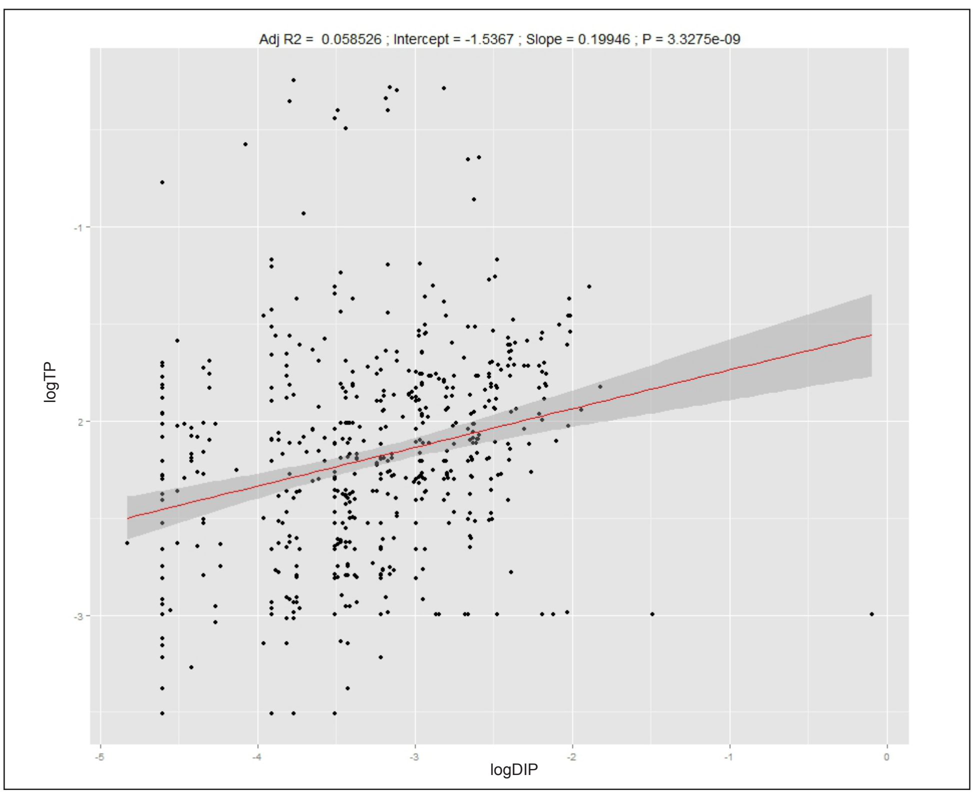


Figure 5.26 Regression plot for the Nassau River Basin - Phosphorus

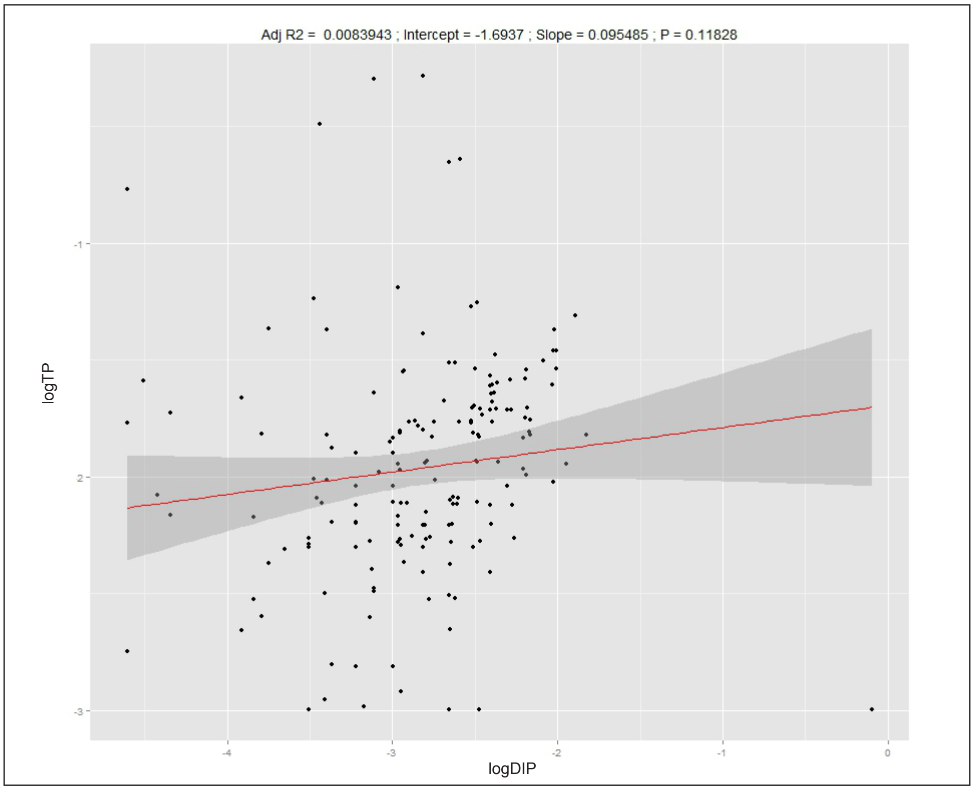


Figure 5.27 Regression plot for the Upper Nassau reach - Phosphorus

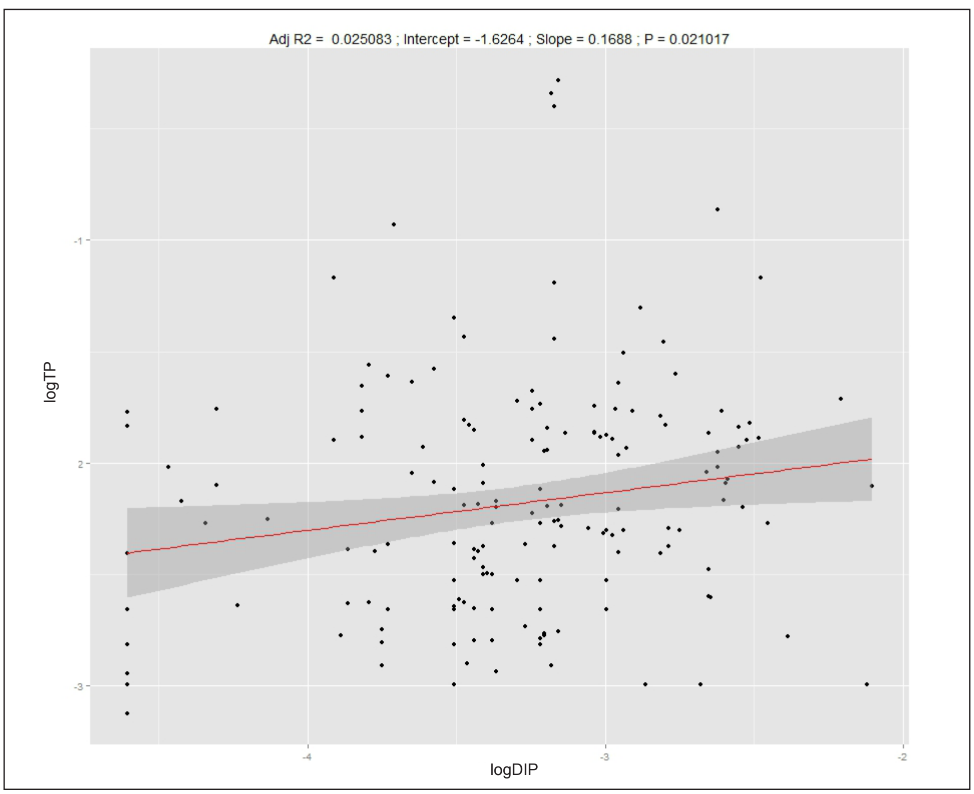


Figure 5.28 Regression plot for the Middle Nassau reach - Phosphorus

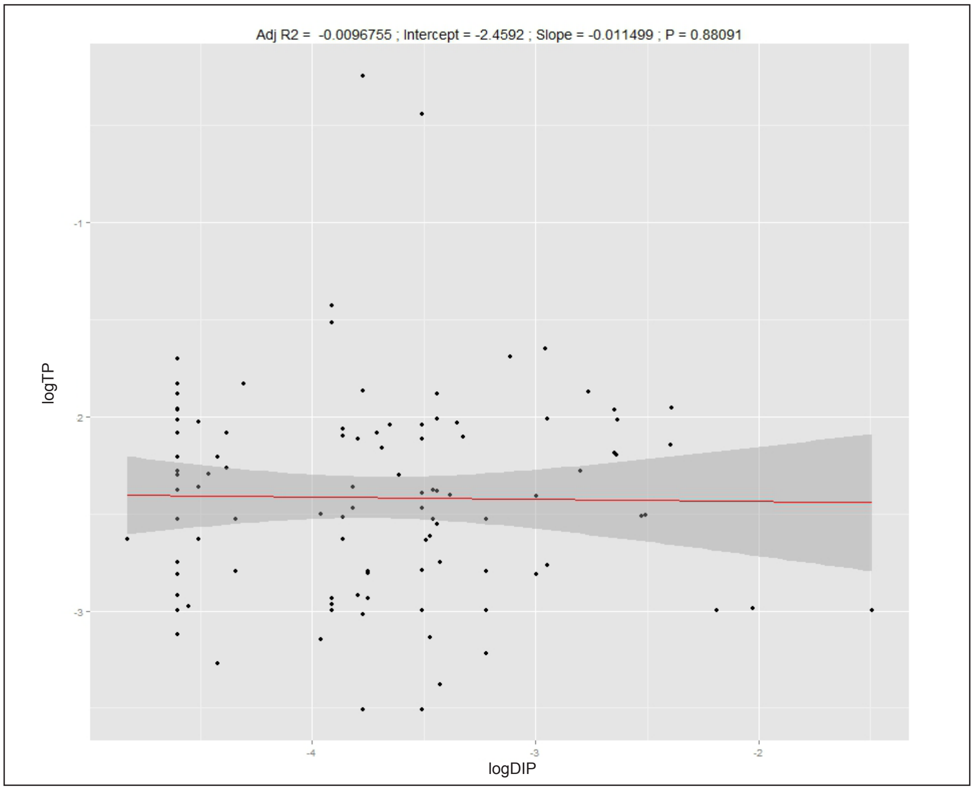


Figure 5.29 Regression plot for the Lower Nassau reach - Phosphorus

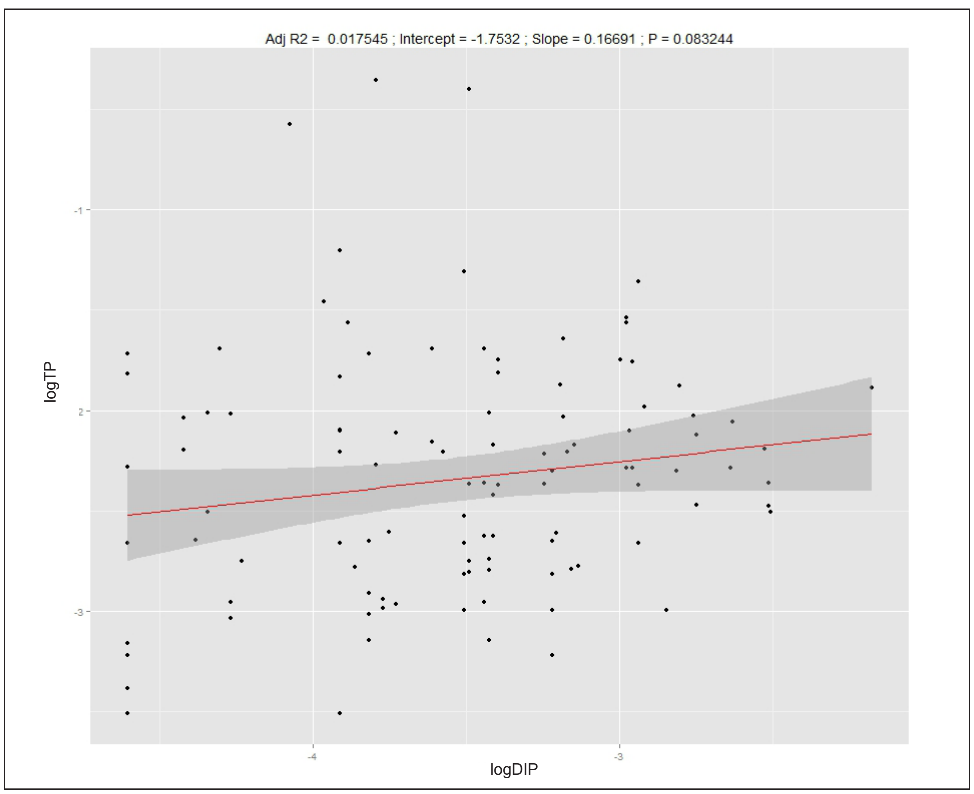


Figure 5.30 Regression plot for the Fort George reach - Phosphorus

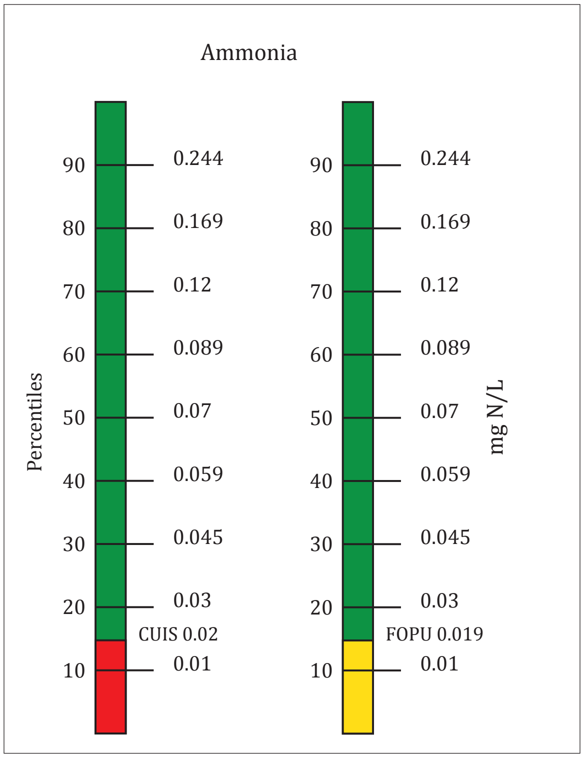


Figure 5.31 Ammonia/ammonium percentiles and NPS medians

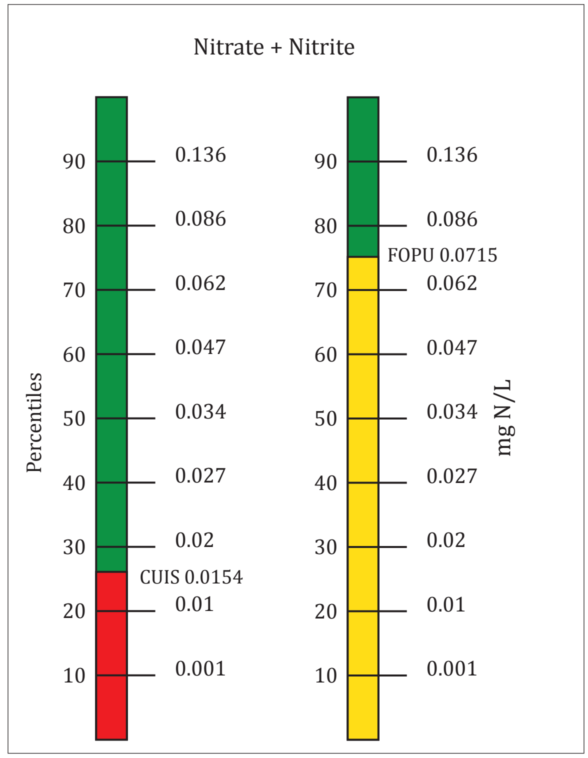


Figure 5.32 Nitrate + nitrite percentiles and NPS medians

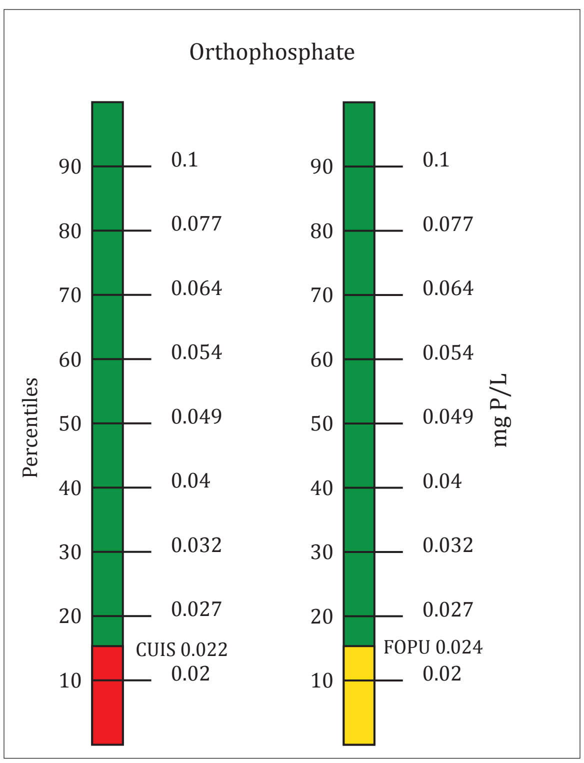
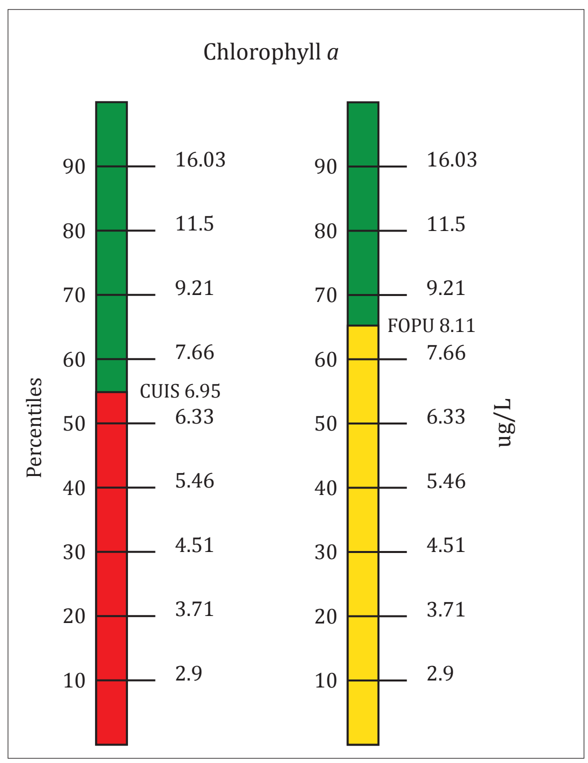


Figure 5.33 Orthophosphate percentiles and NPS mediansFigure



5.34 Chlorophyll *a* percentiles and NPS medians

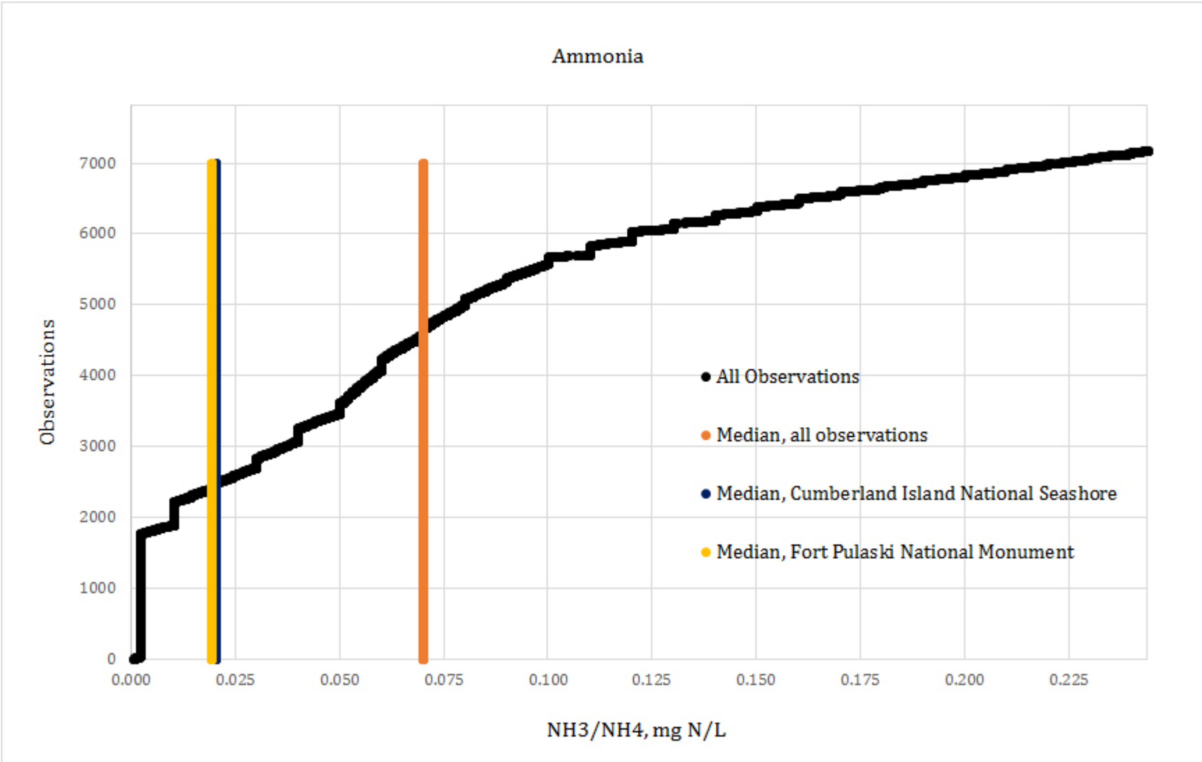


Figure 5.35 Ammonia medians

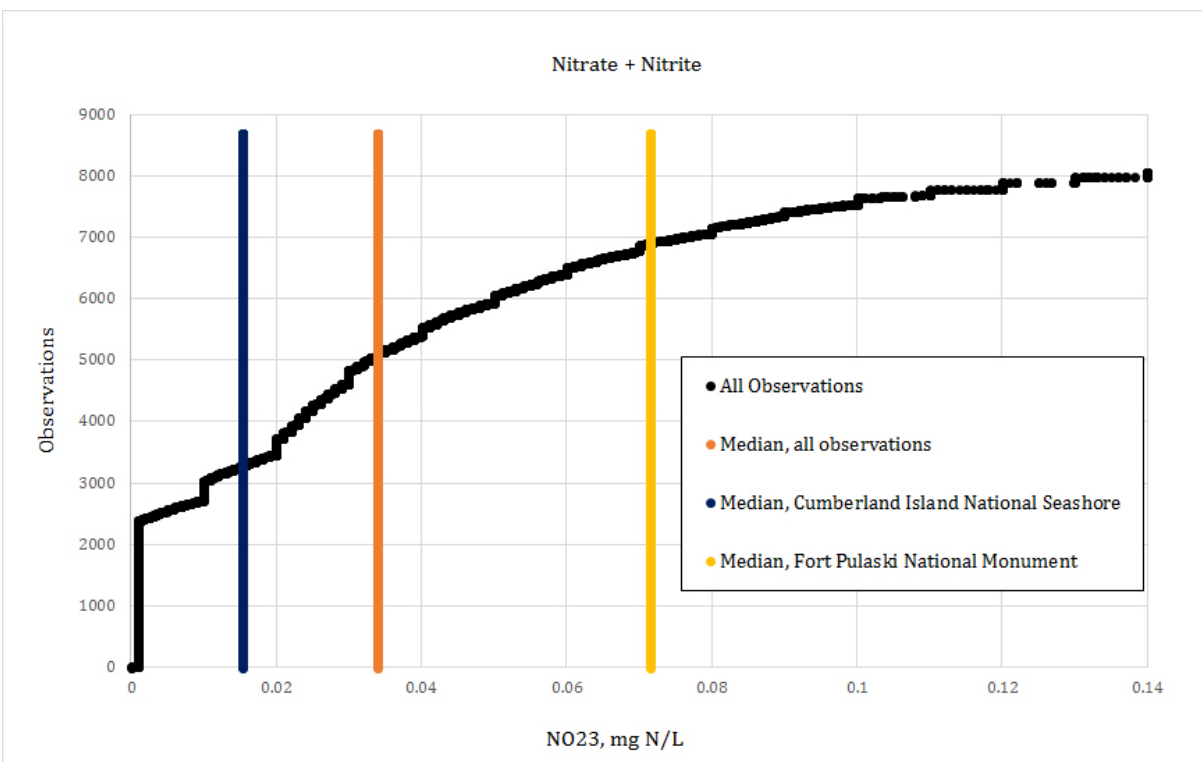


Figure 5.36 Nitrate + Nitrite medians

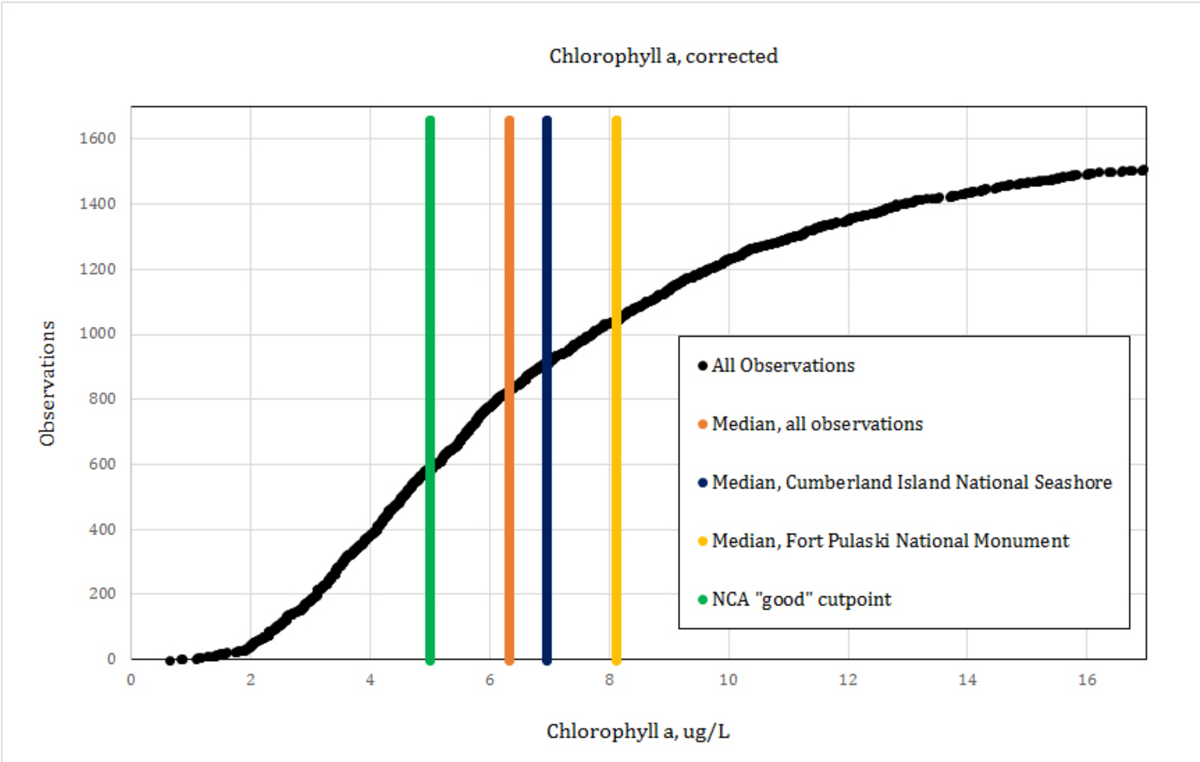


Figure 5.37 Corrected Chlorophyll *a* medians

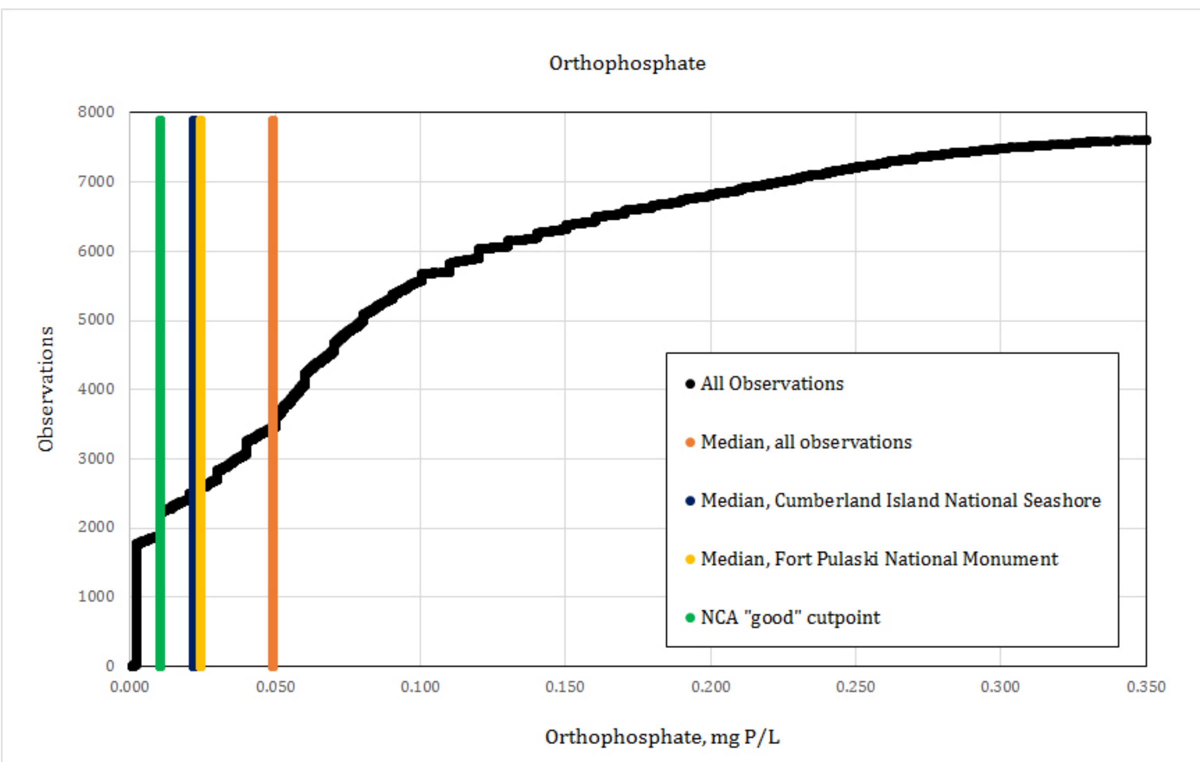


Figure 5.38 Orthophosphate medians

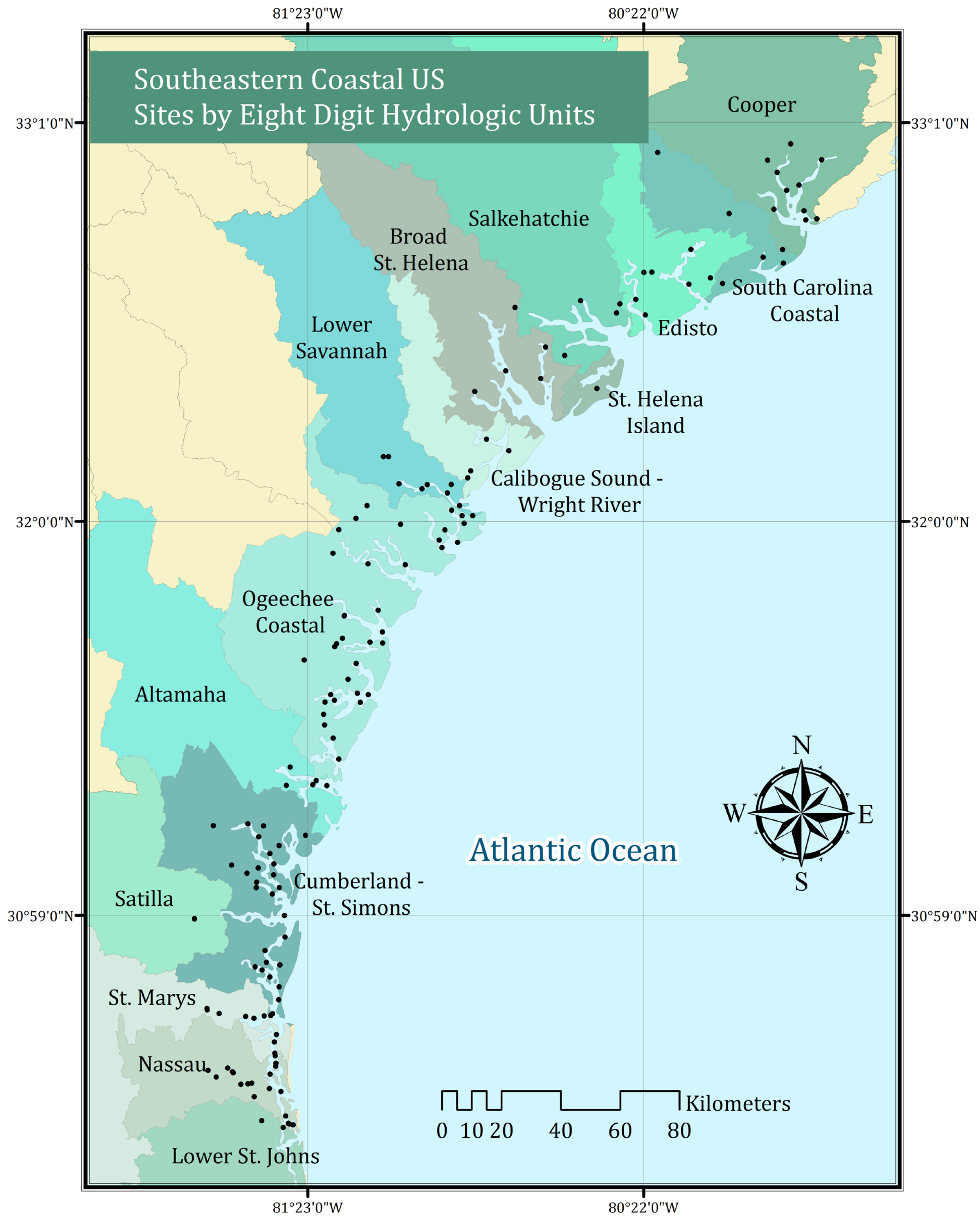


Figure 5.39 Map of sites by hydrologic unit code (HUC 8)

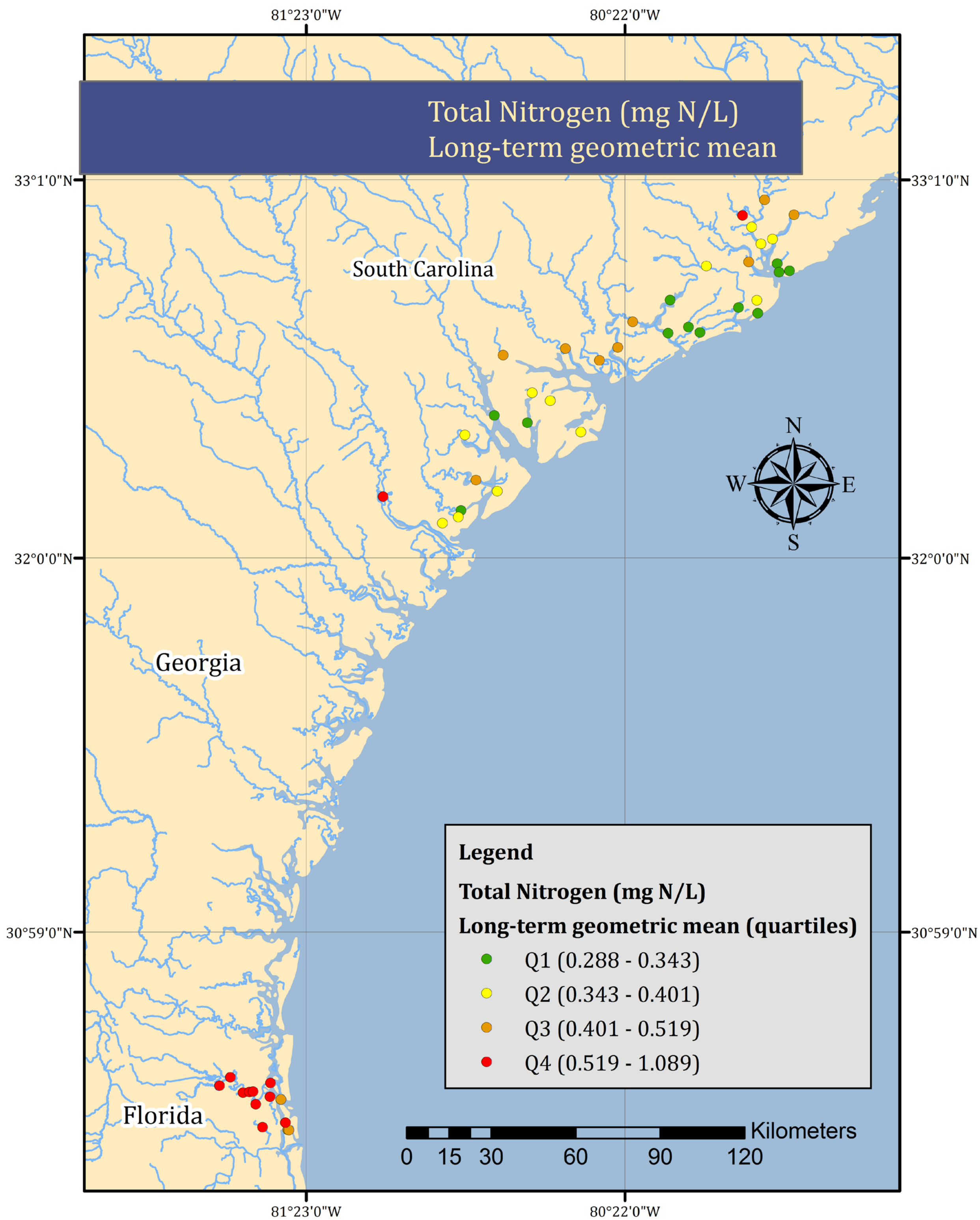


Figure 5.40 Total nitrogen (mg N/L), long-term geometric mean

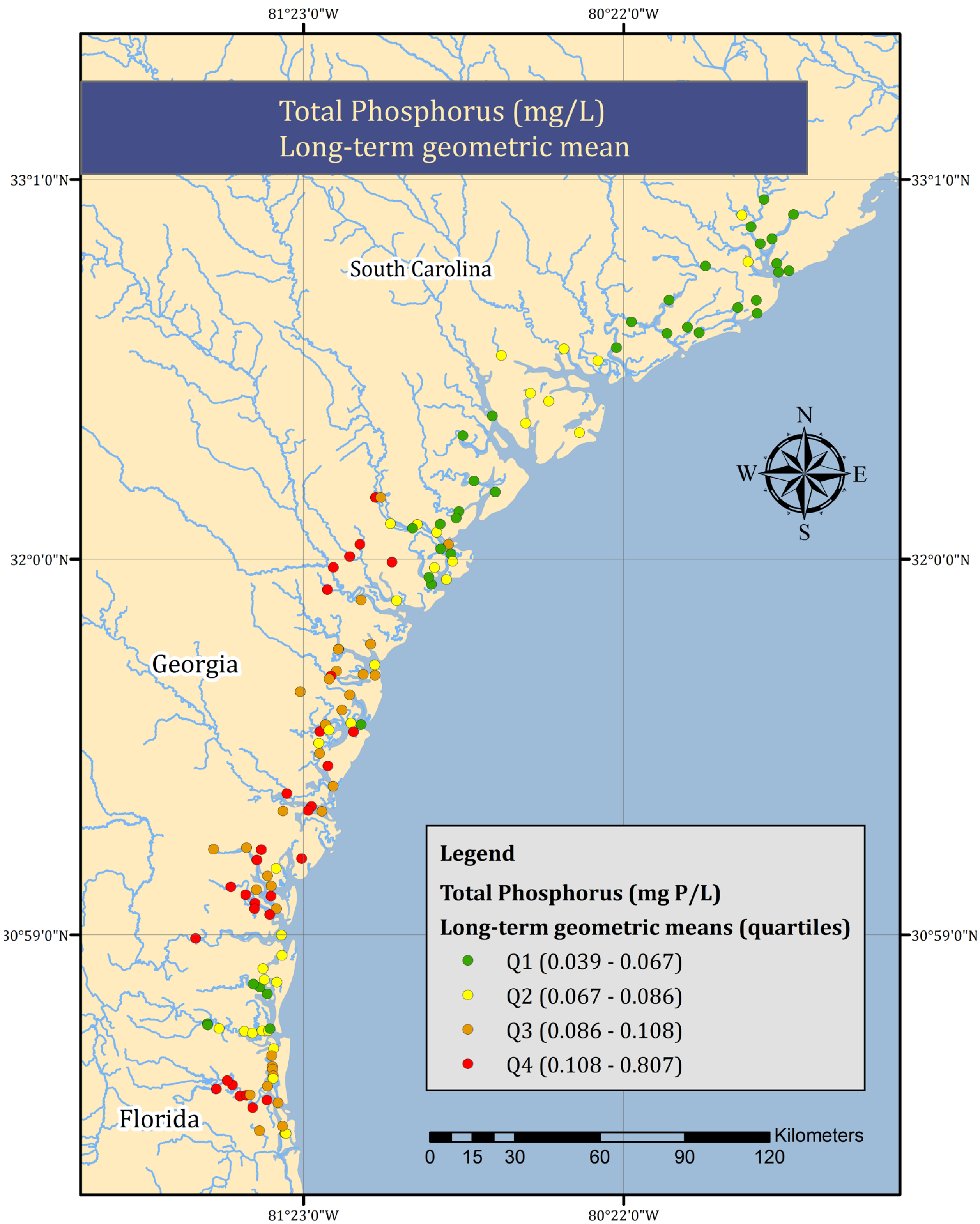


Figure 5.41 Total phosphorus (mg P/L), long-term geometric mean

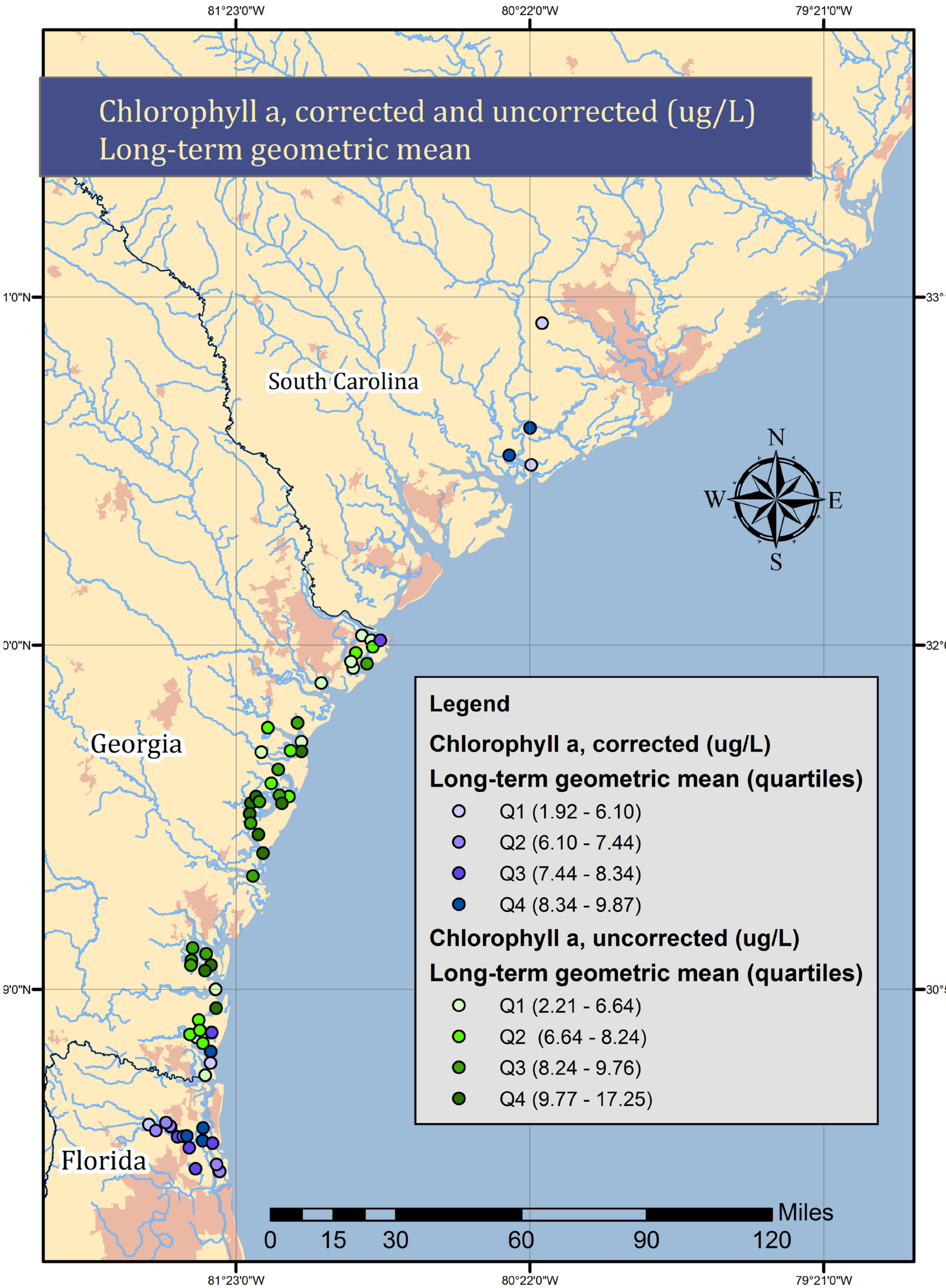


Figure 5.42 Chlorophyll a, ug/L), long-term geometric mean

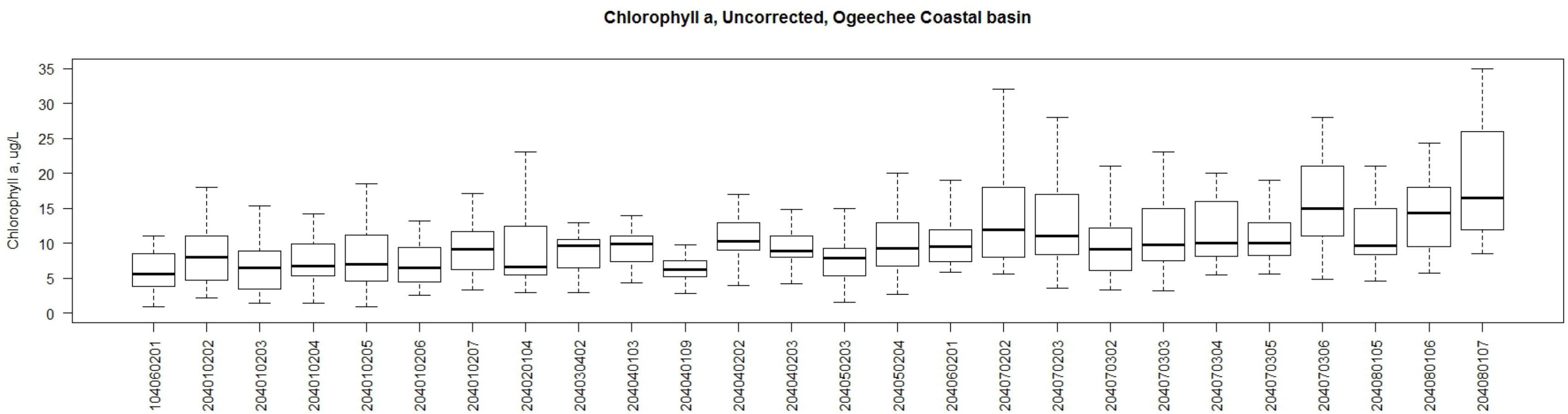


Figure 5.43 Boxplots, Chlorophyll a, uncorrected, Ogeechee.

Median and interquartile range for uncorrected chlorophyll a in the Ogeechee River Basin.

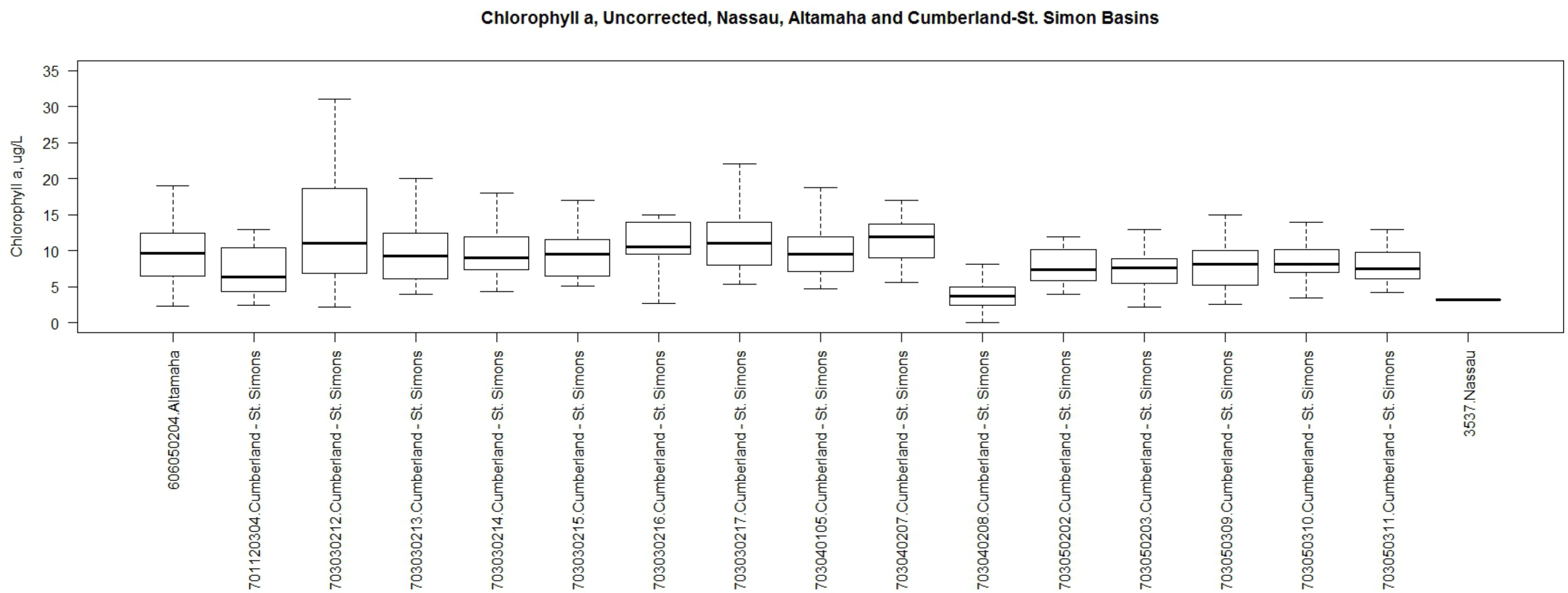


Figure 5.44 Boxplots, Chlorophyll *a*, uncorrected, other basins.

Median and interquartile range for uncorrected chlorophyll *a* in the Nassau, Altamaha and Cumberland - St. Simons River Basins.

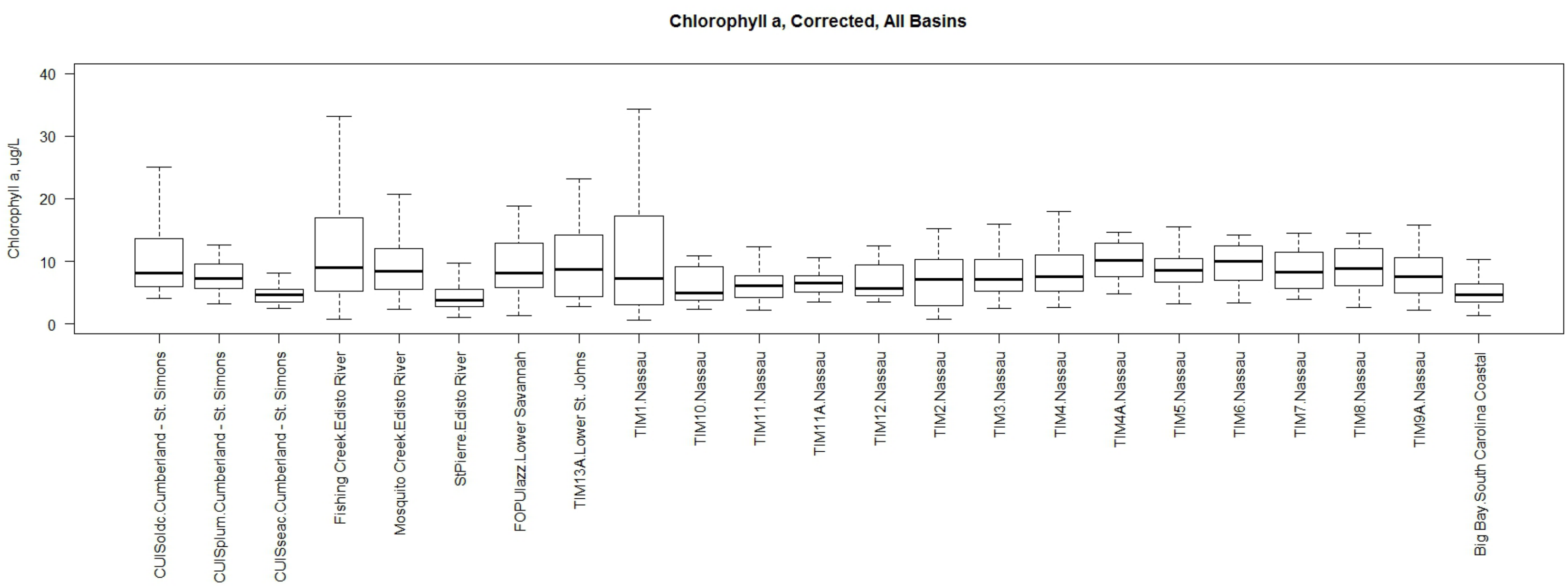


Figure 5.45 Boxplots, Chlorophyll *a*, corrected.

Median and interquartile range for corrected chlorophyll *a* in all river basins.

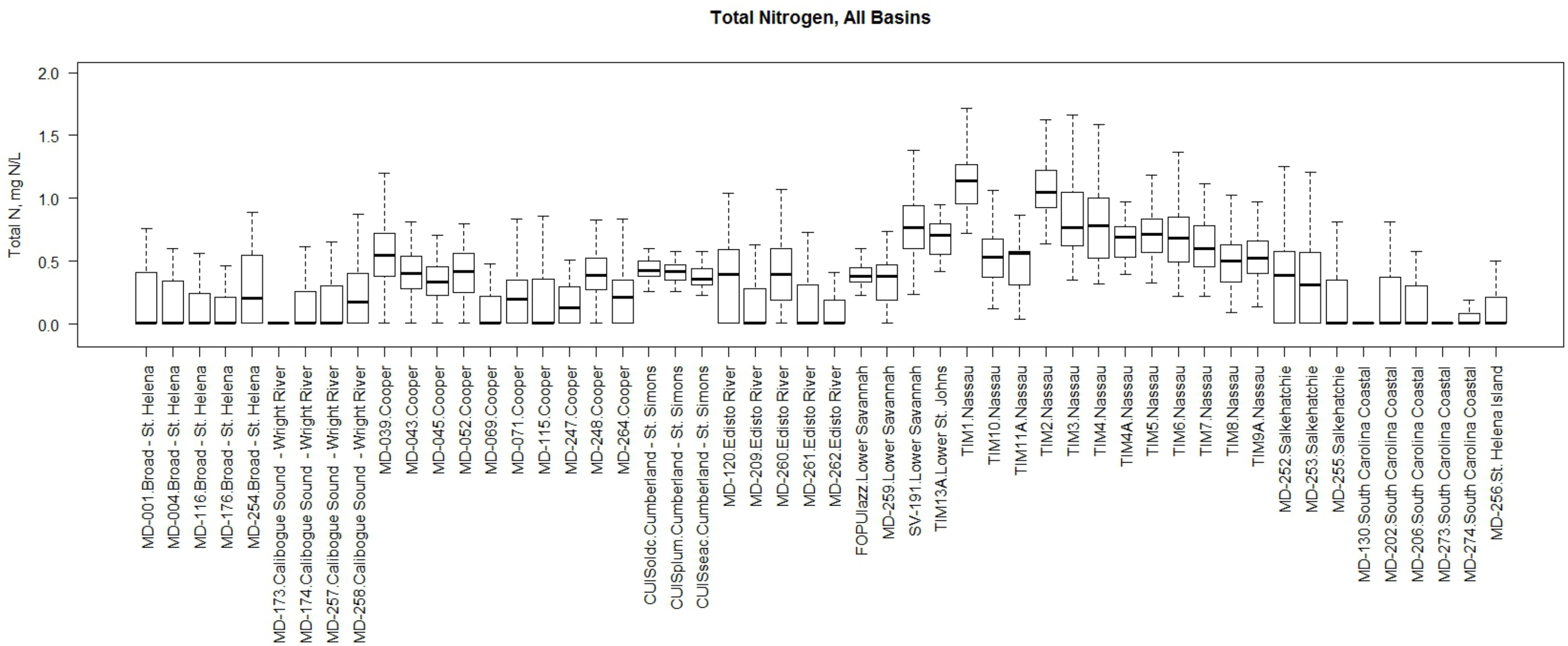


Figure 5.46 Boxplots, total nitrogen.

Median and interquartile range for total nitrogen in all river basins.

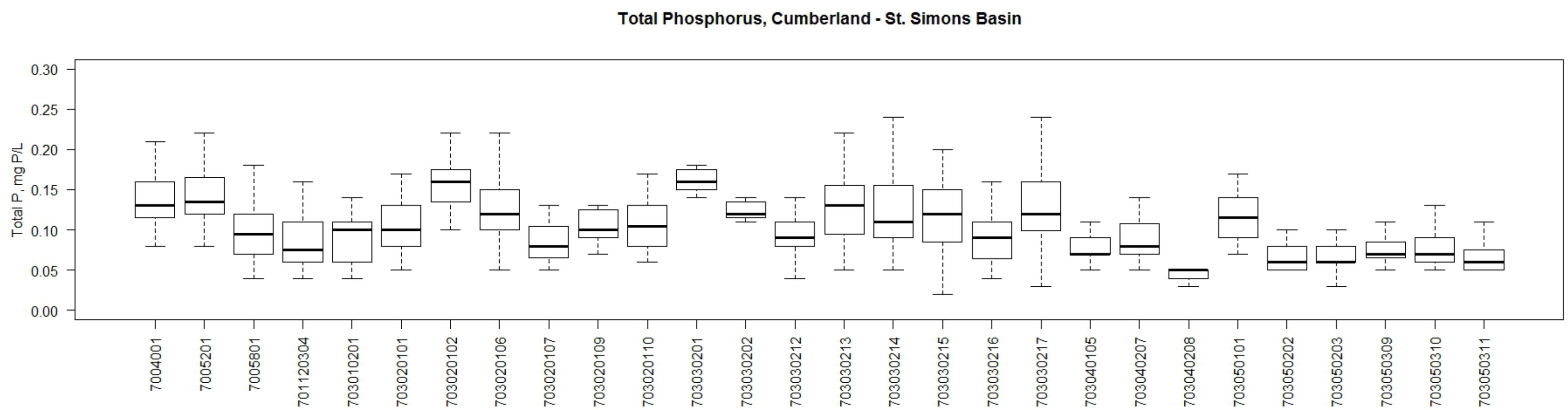


Figure 5.47 Boxplots, total phosphorus, Cumberland.

Median and interquartile range for total phosphorus in the Cumberland - St. Simon River basin.

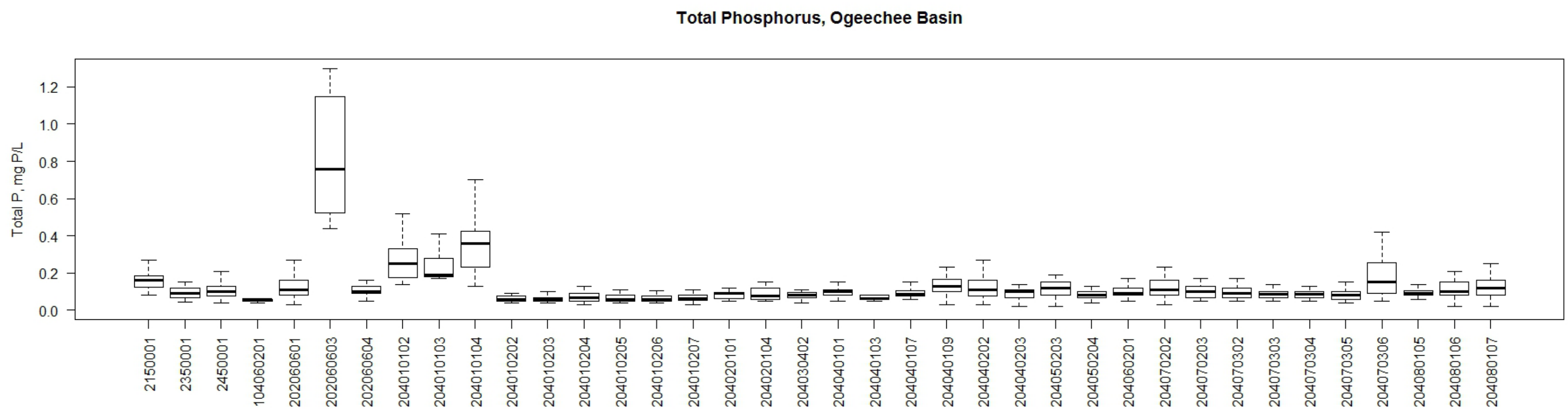


Figure 5.48 Boxplots, total phosphorus, Ogeechee.

Median and interquartile range for total phosphorus in the Ogeechee River basin.

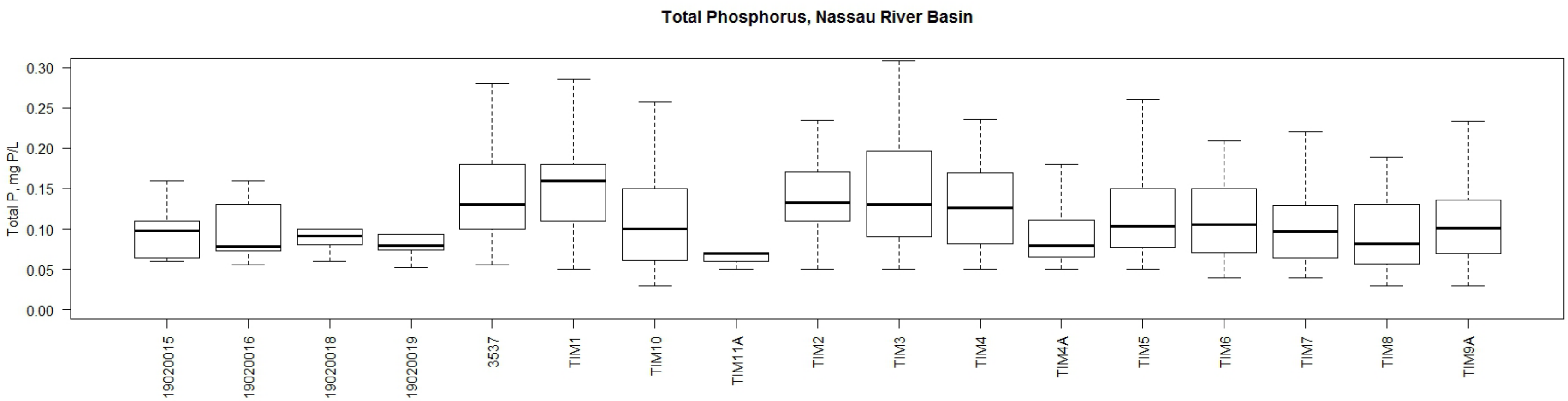


Figure 5.49 Boxplots, total phosphorus, Nassau.

Median and interquartile range for total phosphorus in the Nassau River basin.

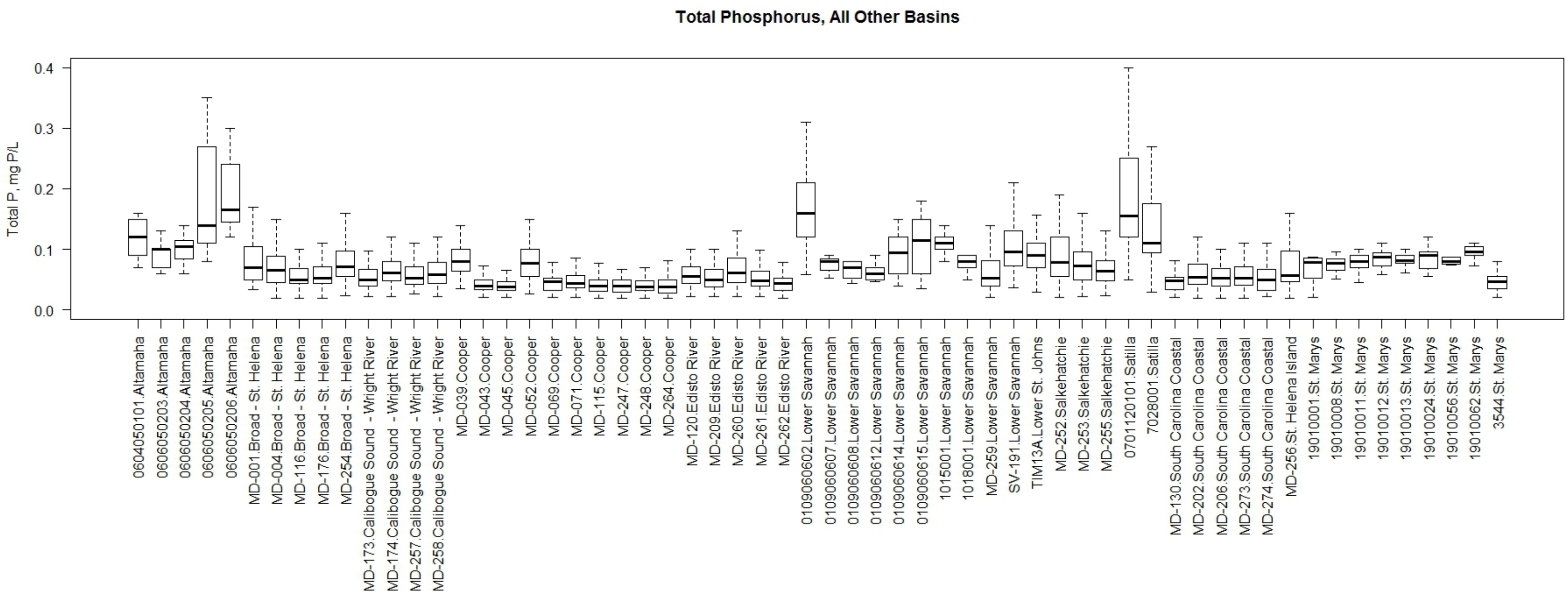


Figure 5.50 Boxplots, total phosphorus, other basins.

Median and interquartile range for total phosphorus in all other river basins.

6. DISCUSSION

6.1 Database Construction

In assembling a cross-agency database, the overwhelming issue is inconsistency. Parameters with different names often refer to the same measurement (i.e. PO4, DIN, orthophosphate). While analytical methods are helpful to aggregate parameters, each agency may use different analytical methodologies (i.e., USEPA, Lachat, or undefined).

Site naming conventions are also an issue, especially when inconsistencies are within one agency (some sites sampled for nutrients began with a leading zero, the same sites sampled for chlorophyll *a* did not, making them appear in the database as two separate sites).

Values in the stored dataset may be misleading; values that can not be calculated were found to be reported as "Below Detection Limit", and these must be removed from the dataset before analyses.

Data storage inconsistency is also problematic. While STORET seems to be the best method for data retrieval, not all agencies make use of STORET. The SECN uploads coastal assessment data to STORET, but has a data backlog for nutrient data. NERRS does not store nutrient data in STORET, but has a comprehensive data set with thorough metadata on its own website. Sites within Timucuan Ecological and Historic Preserve are sampled by the City of Jacksonville. Nutrient data is housed in STORET but currently has a three year delay, and chlorophyll *a* sampling within Timucuan, which is collected by the City of Jacksonville but funded by the SECN, is also data backlogged.

Inconsistency across parameters tested is an issue for any type of regional multivariate analysis, and precluded this compiled dataset for being used for this purpose. Some sites are tested for dissolved inorganic nitrogen but not total nitrogen, and some for orthophosphate but not total phosphorus. While NERRS and the SECN have extensive datasets, there are no results for total nitrogen or phosphorus, which excluded those two datasets from regression, and other, analyses. Chlorophyll *a* results also differ among datasets, with some reported as corrected for pheophytin, and some uncorrected. While these are two different measures of the same concentration, it was decided to not combine them.

The treatment of values reported as below detection limits (BDL) is also problematic. The assignment of one-half the method detection limit is a common practice, but is not ideal. These values are useful for summary statistics, but may not be accurate for in-depth analyses. Without having in-depth knowledge of each individual dataset, however, a need for consistent treatment of BDL values was necessary

6.2 Data Analysis

6.2.1 Geometric Means

The tables containing compiled geometric mean data (Table 5.1, total nitrogen; Table 5.2, total phosphorus; Table 5.3, chlorophyll *a*, uncorrected; and Table 5.4, chlorophyll *a*, corrected) present a general picture of temporal variation within each site, as well as spatial variation within and between individual basins. They provide a good spatial regional overview when presented graphically in GIS format.

6.2.2 Baseline Concentrations

Long-term baseline concentration calculations are found in Table 5.5. Like the geometric means, they provide a long-term overview of spatial variations within and between basins, as well as a value to compare with current concentrations and proposed criteria. Annual baselines were not calculated.

6.2.3 Regression Analysis

The oversimplified linear regressions performed for nitrogen and phosphorus do not presume a linear relationship between the dissolved and particulate components of nutrients. Many factors contribute to the ratio of dissolved and particulate nutrients as a part of the total. Proximity to urban areas, flushing times, location (whether inland or coastal) and salinity levels, along with several other contributing factors, can change this ratio spatially over a few miles or temporally in a matter of days.

The purpose of these regressions, performed with the data at hand, is to demonstrate that if sites are delineated according to commonalities, where the ratio between dissolved and total nutrients is consistent enough for total nutrient levels to be extrapolated from dissolved levels, a range of acceptable criteria for total concentrations can be determined. These numbers can then validate, or be confirmed by, other methods.

Regressions for nitrogen were performed for a total of 14 river basins. Models for the Ogeechee Coastal (n=812), Salkehatchie (n=86), and Satilla River (n=22) basins had p-values > 0.05, and were considered unsuccessful. Additionally, models for the St. Marys (n=188) and Cooper (n=379) River basins had low R^2 values (0.03 and 0.098, respectively) and are not considered reliable. It is unknown if the cause for the failure of these regressions is quality of data, variance among sites in large basins with a large number of observations, or a very small n, such as the Satilla, with only 22 observations. The fact that the Nassau River basin model returned a very small p-value and (borderline) acceptable R^2, but did not translate well across all reaches in the Nassau River basin, demonstrates the need for further stratification of sites before regressions are performed.

Phosphorus regressions were run on six river basins. The Lower Savannah basin had a very large p-value (0.72) and was considered unsuccessful. The Nassau River basin model also had a very low R^2. A lack of phosphorus data relative to nitrogen data contributed to the uncertainty of the phosphorus models, with only two models (Nassau and St. Marys) having more than 100 observations.

Regression graphs for all basin wide regressions are found in Figures 5.1 through 5.20.

6.2.4 Comparison of Regression Results to Florida Criteria

The regressions run for the Nassau River basin and its four reaches are found in Tables 5.12 and 5.13. The modeled 'good' criteria for Nitrogen for the entire Nassau River basin was higher than Florida's criteria for the Middle and Lower Nassau and Fort George reaches. It was lower than the criteria for the Upper Nassau reach. however, when the data was split up by reach and separate regressions were run, the modeled 'good' criteria were very close for all regressions with a significant p-value. The modeled criteria for the Upper Nassau was 1.28 mg N/l, within 1% of Florida's 1.29 mg N/L. The modeled 'good' criteria for the Mddle Nassau reach was 0.88 mg N/L, 6% higher than Florida's existing criteria of 0.83 mg N/L, and the modeled 'good' criteria for the Lower Nassau reach was 0.71 mg N/L, 11% lower than Florida's criteria of 0.8 mg N/L. The Fort George reach modeled criteria was 20% lower than Florida's criteria, but the Fort George regression did not have a significant p-value.

For phosphorus, only the modeled criteria for the entire Nassau River basin and the Middle Nassau reach had signiicant p-values. The 'good' modeld criteria for TP for the Middle Nassau was .140 mg P/L, 2% higher than Florida's criteria of 0.137 mg P/L.

Regression graphs for all reach specific criteria are ound in Figures 5.21 through 5.30.

6.2.5 National Parks in a Regional Perspective

The median values for ammonium concentrations for Cumberland Island National Park (0.020 mg N/L) and Fort Pulaski National Monument (0.019 mg N/L) both fell in the 10-20th percentile range for all sites along the southeastern coast.

The median value for nitrate plus nitrite (NO23) for Cumberland was 0.015 mg N/L, which fell in the 20-30th percentile range, but within the first quartile, and for Fort Pulaski was 0.072 mg N/L, which was in the 70-80th percentile range.

For Cumberland Island, the median value of orthophosphate was .0215 mg P/L, and for Fort Pulaski was .0241 mg P/L, which both fell into the 10-20th percentile range.

Corrected chlorophyll *a* median values were 6.95 µg/L at Cumberland Island, in the 50-60th percentile range, and at Fort Pulaski were 8.11 µg/L, in the 60-70th percentile range. Median values for chlorophyll *a* at both Parks met the 'fair' NCA standards of 5-20 µg/L.

Overall, ammonia and phosphorus concentrations were good when compared to other estuarine areas. Nitrate-nitrite values in Fort Pulaski, and chlorophyll *a* concentrations at both sites, while not high enough to be alarming, were high relative to other areas. The fact that both of these parks are relatively close to urban areas which may contribute to increased nitrogen loading demonstrates that NNC for these basins (Lower Savannah and St. Marys) that would lower nitrate-nitrite concentrations may be beneficial to water quality in the vicinity of these two Parks, especially if the elevated chlorophyll *a* levels are a response to higher concentrations of nitrate-nitrite.

The percentile ranges for orthophospate was noteworthy, as the NCA recommendation for orthophospate is 0.01 mg P/L, which fell under the 10^{th} percentile of 0.02 mg P/L, indicating that either greater than 90% of the sites sampled for orthophosphate are in fair to poor condition, or that the recommendation itself is too stringent for the southeastern coast.

Median values for the Parks were compared to 6,259 values for ammonia, 6,805 values for nitrate plus nitrite, 2,450 values for orthophosphate, and 1,657 values for corrected chlorophyll *a*.

Figures 5.31 through 5.34 graphically display percentiles and Park medians, while Figures 5.35 through 5.38 illustrate all observations and medians. For the purpose of scale, all observations were graphed through the 90^{th} precentile.

6.2.6 Criteria Determination

Criteria recommendations are summarized in Table 5.10 for nitrogen and 5.11 for phosphorus. As demonstrated, broad basin-wide criteria do not apply well to stratified or individual sites. However, the criteria do show a qualitative comparison of total nutrient expectations.

The expected total nitrogen ranged from 0.334 mg N/L for the Broad - St. Helena basin, up to 1.454 mg N/L for the Satilla. A closer examination of these criteria, with respect to location and attributes of each individual basin, could reveal information about the relationship between dissolved and total nitrogen, and further research is warranted here.

Expected total phosphorus ranged from 0.032 mg P/L at Cumberland-St. Simons to 0.214 for the Lower Savannah. While there is a qualitative component to the models for expected total phosphorus, the small number of basins with phosphorus data and lack of overall success with the phosphorus models lower the value of this comparison.

7. CONCLUSION

The initial purpose of this project was to compile a reliable regional dataset for use with multivariate analyses across state and agency borders, and to use these analyses to propose a method of determining statistically valid criteria for total nitrogen and total phosphorus. Inconsistencies across datasets, a lack of in-depth knowledge of each data set and reporting protocols, and a striking lack of available field data to support reported nutrient data prevented this compiled dataset from being successful for multivariate analyses. However, a regional view of summary statistics such as annual and long-term geometric mean and baseline values was possible.

Regressions were successfully run to model total nitrogen and total phosphorus against DIN and DIP, but not all models were statistically significant. These regressions were successfully used to recommend criteria for total nitrogen and total phosphorus by river basin, but would not meet strict USEPA standards for criteria.

While the nitrogen models performed relatively well when compared to the existing Florida criteria for the four reaches of the Nassau River, these reaches were isolated enough to insure commonalities among each reach.

This method could be successful if an individual agency were armed with a full dataset, including field observations. Delineation of sites, by salinity gradient, turbidity, or other common factors, would have to be determined for the criteria to be specific enough to be useful. Basin-wide criteria, as demonstrated by the difference in results for a broad Nassau River model and individual reach models, is too broad to be applicable to individual sites or reaches.

With salinity data, sites could be classified by salinity (i.e., mesohaline, polyhaline), and with turbidity or water clarity data, as well as pH, further multivariate regressions could be performed to determine a more accurate relationship between dissolved and total nutrients. This is especially true in the case of phosphorus, where the relationship between orthophosphate and total phosphorus is much more complex than that of nitrogen.

With a complete dataset of nutrient lab data and field observations, covering an extensive time period (with enough observations to perform a successful regression), in areas delineated to be considered similar in both water quality and ecological makeup, this method could be used as a validation for other methods, or possibly as a determination method in itself.

The most important result of this thesis is the illustration of the need for physical and chemical homogeneity when determing criteria. Sweeping criteria for estuarine areas would result in some sites becoming ecologically impaired while never exceeding criteria, while other sites with a healthy ecosystem could consistently exceed criteria and be considered impaired or not meeting designated use standards.

Additional research is suggested to identify potential source areas for nutrient enrichment to coastal estuaries. An End Member Mixing Analysis (EMMA) could be used to identify water quality inputs, and then the correlation of these end members with nutrient signatures could be used to estimate proportional loads from each source. Potential end members include offshore (oceanic) sources, shallow and deep groundwater sources, surface water inputs from terrestrial sources (e.g., stormwater, river flows), and bed sediments disturbed by dredging.

Water quality variables that may assist in identifying end members include salinity for oceanic inputs, radium isotopes for groundwater inputs (Moore and Shaw, 2008), mineral sediments for dredging inputs, and specific conductance for surface water inputs.

8. APPENDIX

8.1 Tables

Table 8.1.1 List of sites by agency, state, and coordinates.

FDEP – Florida Department of Environmental Protection, SECN I&M – National Park Service Southeast Coast Network Inventory and Monitoring, SJWMD – Saint John's Water Management District (Florida), Jacksonville – City of Jacksonville (Florida), SCDHEC – South Carolina Department of Health and Environmental Control, GADNR – Georgia Department of Natural Resources.

Agency	Station ID	State	County	Basin	Station Latitude	Station Longitude
FDEP	3537	FLORIDA	NASSAU	Nassau	30.574444	-81.608887
FDEP	3544	FLORIDA	NASSAU	St. Marys	30.737778	-81.687225
GDNR	1015001	GEORGIA	CHATHAM	Lower Savannah	32.165798	-81.153900
GDNR	1018001	GEORGIA	CHATHAM	Lower Savannah	32.095798	-81.107201
GDNR	2150001	GEORGIA	CHATHAM	Ogeechee Coastal	32.007301	-81.236801
GDNR	2350001	GEORGIA	LIBERTY	Ogeechee Coastal	31.677500	-81.301399
GDNR	2450001	GEORGIA	MCINTOSH	Ogeechee Coastal	31.643000	-81.393600
GDNR	7004001	GEORGIA	GLYNN	Cumberland - St. Simons	31.220301	-81.564201
GDNR	7005201	GEORGIA	GLYNN	Cumberland - St. Simons	31.186899	-81.531403
GDNR	7005801	GEORGIA	GLYNN	Cumberland - St. Simons	31.116400	-81.485802
GDNR	7028001	GEORGIA	CAMDEN	Satilla	30.974400	-81.725800
FDEP	19010001	FLORIDA	NASSAU	St. Marys	30.741583	-81.688141
FDEP	19010008	FLORIDA	NASSAU	St. Marys	30.728420	-81.651382
FDEP	19010011	FLORIDA	NASSAU	St. Marys	30.720940	-81.570930
FDEP	19010012	FLORIDA	NASSAU	St. Marys	30.716171	-81.545380
FDEP	19010013	FLORIDA	NASSAU	St. Marys	30.722221	-81.514725
FDEP	19010024	FLORIDA	NASSAU	St. Marys	30.723028	-81.495399
FDEP	19010056	FLORIDA	NASSAU	St. Marys	30.673611	-81.477776
FDEP	19010062	FLORIDA	NASSAU	St. Marys	30.654444	-81.484169
FDEP	19020015	FLORIDA	NASSAU	Nassau	30.624962	-81.482422
FDEP	19020016	FLORIDA	NASSAU	Nassau	30.618130	-81.481285
FDEP	19020018	FLORIDA	NASSAU	Nassau	30.599167	-81.479584
FDEP	19020019	FLORIDA	NASSAU	Nassau	30.591583	-81.479942
GDNR	0104060201	GEORGIA	CHATHAM	Ogeechee Coastal	31.932417	-80.977112
GDNR	0109060602	GEORGIA	CHATHAM	Lower Savannah	32.165833	-81.153900
GDNR	0109060607	GEORGIA	CHATHAM	Lower Savannah	32.095833	-81.107224
GDNR	0109060608	GEORGIA	CHATHAM	Lower Savannah	32.093887	-81.021667
GDNR	0109060612	GEORGIA	CHATHAM	Lower Savannah	32.083332	-81.037224
GDNR	0109060614	GEORGIA	CHATHAM	Lower Savannah	32.072224	-80.960556
GDNR	0109060615	GEORGIA	CHATHAM	Lower Savannah	32.039722	-80.923332

Agency	Station ID	State	County	Basin	Station Latitude	Station Longitude
GDNR	0202060601	GEORGIA	CHATHAM	Ogeechee Coastal	31.978239	-81.288712
GDNR	0202060603	GEORGIA	BRYAN	Ogeechee Coastal	31.917973	-81.307159
GDNR	0202060604	GEORGIA	BRYAN	Ogeechee Coastal	31.890612	-81.200775
GDNR	0204010102	GEORGIA	CHATHAM	Ogeechee Coastal	32.039898	-81.203720
GDNR	0204010103	GEORGIA	CHATHAM	Ogeechee Coastal	32.007320	-81.236824
GDNR	0204010104	GEORGIA	CHATHAM	Ogeechee Coastal	31.992378	-81.101868
GDNR	0204010202	GEORGIA	CHATHAM	Ogeechee Coastal	32.028290	-80.947250
GDNR	0204010203	GEORGIA	CHATHAM	Ogeechee Coastal	32.014069	-80.915871
GDNR	0204010204	GEORGIA	CHATHAM	Ogeechee Coastal	31.994770	-80.910072
GDNR	0204010205	GEORGIA	CHATHAM	Ogeechee Coastal	31.977409	-80.967888
GDNR	0204010206	GEORGIA	CHATHAM	Ogeechee Coastal	31.951719	-80.985321
GDNR	0204010207	GEORGIA	CHATHAM	Ogeechee Coastal	31.945681	-80.929802
GDNR	0204020101	GEORGIA	LIBERTY	Ogeechee Coastal	31.758139	-81.272163
GDNR	0204020104	GEORGIA	BRYAN	Ogeechee Coastal	31.715469	-81.156799
GDNR	0204030402	GEORGIA	CHATHAM	Ogeechee Coastal	31.888229	-81.087982
GDNR	0204040101	GEORGIA	MCINTOSH	Ogeechee Coastal	31.642958	-81.393562
GDNR	0204040103	GEORGIA	MCINTOSH	Ogeechee Coastal	31.554108	-81.200363
GDNR	0204040107	GEORGIA	LIBERTY	Ogeechee Coastal	31.698868	-81.278282
GDNR	0204040109	GEORGIA	LIBERTY	Ogeechee Coastal	31.685120	-81.295670
GDNR	0204040202	GEORGIA	LIBERTY	Ogeechee Coastal	31.687130	-81.156326
GDNR	0204040203	GEORGIA	LIBERTY	Ogeechee Coastal	31.689421	-81.194267
GDNR	0204050203	GEORGIA	LIBERTY	Ogeechee Coastal	31.756830	-81.272430
GDNR	0204050204	GEORGIA	CHATHAM	Ogeechee Coastal	31.771130	-81.169983
GDNR	0204060201	GEORGIA	MCINTOSH	Ogeechee Coastal	31.634199	-81.236519
GDNR	0204070202	GEORGIA	MCINTOSH	Ogeechee Coastal	31.535000	-81.331001
GDNR	0204070203	GEORGIA	MCINTOSH	Ogeechee Coastal	31.553930	-81.313904
GDNR	0204070302	GEORGIA	MCINTOSH	Ogeechee Coastal	31.593430	-81.261169
GDNR	0204070303	GEORGIA	MCINTOSH	Ogeechee Coastal	31.539379	-81.302330
GDNR	0204070304	GEORGIA	MCINTOSH	Ogeechee Coastal	31.503450	-81.335197
GDNR	0204070305	GEORGIA	MCINTOSH	Ogeechee Coastal	31.557751	-81.232933
GDNR	0204070306	GEORGIA	MCINTOSH	Ogeechee Coastal	31.534321	-81.224327
GDNR	0204080105	GEORGIA	MCINTOSH	Ogeechee Coastal	31.475849	-81.331917
GDNR	0204080106	GEORGIA	MCINTOSH	Ogeechee Coastal	31.441999	-81.305801
GDNR	0204080107	GEORGIA	MCINTOSH	Ogeechee Coastal	31.387409	-81.289124
GDNR	0604050101	GEORGIA	MCINTOSH	Altamaha	31.367222	-81.436111
GDNR	0606050203	GEORGIA	GLYNN	Altamaha	31.319721	-81.448059
GDNR	0606050204	GEORGIA	MCINTOSH	Altamaha	31.319166	-81.324997
GDNR	0606050205	GEORGIA	MCINTOSH	Altamaha	31.332092	-81.357681
GDNR	0606050206	GEORGIA	MCINTOSH	Altamaha	31.321266	-81.367973
GDNR	0701120101	GEORGIA	CAMDEN	Satilla	30.974443	-81.725830
GDNR	0701120304	GEORGIA	CAMDEN	Cumberland - St. Simons	30.983162	-81.453239
GDNR	0703010201	GEORGIA	GLYNN	Cumberland - St. Simons	31.215879	-81.668694
GDNR	0703020101	GEORGIA	GLYNN	Cumberland - St. Simons	31.220278	-81.564163

Agency	Station ID	State	County	Basin	Station Latitude	Station Longitude
GDNR	0703020102	GEORGIA	GLYNN	Cumberland - St. Simons	31.215080	-81.516853
GDNR	0703020106	GEORGIA	GLYNN	Cumberland - St. Simons	31.186943	-81.531387
GDNR	0703020107	GEORGIA	GLYNN	Cumberland - St. Simons	31.164167	-81.470001
GDNR	0703020109	GEORGIA	GLYNN	Cumberland - St. Simons	31.143612	-81.497498
GDNR	0703020110	GEORGIA	GLYNN	Cumberland - St. Simons	31.116400	-81.485802
GDNR	0703030201	GEORGIA	CAMDEN	Cumberland - St. Simons	31.113800	-81.613457
GDNR	0703030202	GEORGIA	CAMDEN	Cumberland - St. Simons	31.092421	-81.566948
GDNR	0703030212	GEORGIA	GLYNN	Cumberland - St. Simons	31.106001	-81.532997
GDNR	0703030213	GEORGIA	CAMDEN	Cumberland - St. Simons	31.069380	-81.537468
GDNR	0703030214	GEORGIA	CAMDEN	Cumberland - St. Simons	31.054979	-81.538803
GDNR	0703030215	GEORGIA	GLYNN	Cumberland - St. Simons	31.088619	-81.486504
GDNR	0703030216	GEORGIA	GLYNN	Cumberland - St. Simons	31.055000	-81.469002
GDNR	0703030217	GEORGIA	CAMDEN	Cumberland - St. Simons	31.038679	-81.490051
GDNR	0703040105	GEORGIA	CAMDEN	Cumberland - St. Simons	30.892031	-81.512047
GDNR	0703040207	GEORGIA	CAMDEN	Cumberland - St. Simons	30.927420	-81.452133
GDNR	0703040208	GEORGIA	CAMDEN	Cumberland - St. Simons	30.728073	-81.489792
GDNR	0703050101	GEORGIA	GLYNN	Cumberland - St. Simons	31.190496	-81.389397
GDNR	0703050202	GEORGIA	CAMDEN	Cumberland - St. Simons	30.841221	-81.521317
GDNR	0703050203	GEORGIA	CAMDEN	Cumberland - St. Simons	30.849430	-81.542297
GDNR	0703050309	GEORGIA	CAMDEN	Cumberland - St. Simons	30.861219	-81.507767
GDNR	0703050310	GEORGIA	CAMDEN	Cumberland - St. Simons	30.854799	-81.467484
GDNR	0703050311	GEORGIA	CAMDEN	Cumberland - St. Simons	30.823080	-81.498016
NERRS	Big Bay	SOUTH CAROLINA		South Carolina Coastal	32.941002	-80.324097
SECN	CUISoldc	GEORGIA	Camden	Cumberland - St. Simons	30.798071	-81.470001
SECN	CUISplum	GEORGIA	Camden	Cumberland - St. Simons	30.854866	-81.467232
SECN	CUISseac	GEORGIA	Camden	Cumberland - St. Simons	30.764303	-81.471199
NERRS	Fishing Creek	SOUTH CAROLINA		Edisto River	32.635799	-80.365501
SECN	FOPUlazz	GEORGIA	Chatham	Lower Savannah	32.014137	-80.884117
SCDHEC	MD-001	SOUTH CAROLINA	BEAUFORT	Broad - St. Helena	32.445633	-80.663223
SCDHEC	MD-004	SOUTH CAROLINA	BEAUFORT	Broad - St. Helena	32.365292	-80.677895
SCDHEC	MD-039	SOUTH CAROLINA	BERKELEY	Cooper	32.921246	-79.991280
SCDHEC	MD-043	SOUTH CAROLINA	BERKELEY	Cooper	32.962898	-79.921234
SCDHEC	MD-045	SOUTH CAROLINA	CHARLESTON	Cooper	32.845329	-79.933472
SCDHEC	MD-052	SOUTH CAROLINA	CHARLESTON	Cooper	32.796555	-79.971939
SCDHEC	MD-069	SOUTH CAROLINA	CHARLESTON	Cooper	32.772827	-79.842209
SCDHEC	MD-071	SOUTH CAROLINA	CHARLESTON	Cooper	32.792828	-79.881241
SCDHEC	MD-115	SOUTH CAROLINA	BERKELEY	Cooper	32.922810	-79.827339
SCDHEC	MD-116	SOUTH CAROLINA	BEAUFORT	Broad - St. Helena	32.384777	-80.783806
SCDHEC	MD-120	SOUTH CAROLINA	CHARLESTON	Edisto River	32.636581	-80.341850
SCDHEC	MD-130	SOUTH CAROLINA	CHARLESTON	South Carolina Coastal	32.659618	-79.943344
SCDHEC	MD-173	SOUTH CAROLINA	BEAUFORT	Calibogue Sound - Wright River	32.210381	-80.842270
SCDHEC	MD-174	SOUTH CAROLINA	BEAUFORT	Calibogue Sound	32.180420	-80.774017

Agency	Station ID	State	County	Basin	Station Latitude	Station Longitude
SCDHEC	MD-176	SOUTH CAROLINA	BEAUFORT	Broad - St. Helena	32.332302	-80.877365
SCDHEC	MD-202	SOUTH CAROLINA	CHARLESTON	South Carolina Coastal	32.785728	-80.107483
SCDHEC	MD-206	SOUTH CAROLINA	CHARLESTON	South Carolina Coastal	32.674435	-80.004593
SCDHEC	MD-209	SOUTH CAROLINA	CHARLESTON	Edisto River	32.622307	-80.164337
SCDHEC	MD-247	SOUTH CAROLINA	CHARLESTON	Cooper	32.769707	-79.875359
SCDHEC	MD-248	SOUTH CAROLINA	CHARLESTON	Cooper	32.890549	-79.962700
SCDHEC	MD-252	SOUTH CAROLINA	COLLETON	Salkehatchie	32.564251	-80.556976
SCDHEC	MD-253	SOUTH CAROLINA	COLLETON	Salkehatchie	32.532967	-80.448441
SCDHEC	MD-254	SOUTH CAROLINA	BEAUFORT	Broad - St. Helena	32.546612	-80.755638
SCDHEC	MD-255	SOUTH CAROLINA	BEAUFORT	Salkehatchie	32.424351	-80.605415
SCDHEC	MD-256	SOUTH CAROLINA	BEAUFORT	St. Helena Island	32.339947	-80.507820
SCDHEC	MD-257	SOUTH CAROLINA	BEAUFORT	Calibogue Sound	32.128830	-80.889870
SCDHEC	MD-258	SOUTH CAROLINA	JASPER	Calibogue Sound	32.110962	-80.898582
SCDHEC	MD-259	SOUTH CAROLINA	JASPER	Lower Savannah	32.094318	-80.948875
SCDHEC	MD-260	SOUTH CAROLINA	CHARLESTON	Edisto River	32.567265	-80.390068
SCDHEC	MD-261	SOUTH CAROLINA	CHARLESTON	Edisto River	32.694733	-80.222961
SCDHEC	MD-262	SOUTH CAROLINA	CHARLESTON	Edisto River	32.605907	-80.229332
SCDHEC	MD-264	SOUTH CAROLINA	CHARLESTON	Cooper	32.858421	-79.895905
SCDHEC	MD-273	SOUTH CAROLINA	CHARLESTON	South Carolina Coastal	32.608009	-80.127426
SCDHEC	MD-274	SOUTH CAROLINA	CHARLESTON	South Carolina Coastal	32.694260	-79.946045
NERRS	Mosquito Creek	SOUTH CAROLINA		Edisto River	32.555801	-80.438004
SJWMD	NAS17W	FLORIDA	NASSAU	Nassau	30.576450	-81.610619
SJWMD	NRID	FLORIDA	NASSAU	Nassau	30.580860	-81.684578
NERRS	StPierre	SOUTH CAROLINA		Edisto River	32.527901	-80.361504
SCDHEC	SV-191	SOUTH CAROLINA	JASPER	Lower Savannah	32.165794	-81.138123
JAX	TIM1	FLORIDA	DUVAL	Nassau	30.562902	-81.659775
JAX	TIM10	FLORIDA	DUVAL	Nassau	30.442076	-81.441887
SECN	TIM11	FLORIDA	DUVAL	Nassau	30.438770	-81.427170
JAX	TIM11A	FLORIDA	DUVAL	Nassau	30.441160	-81.439079
SECN	TIM12	FLORIDA	NASSAU	Nassau	30.431276	-81.457451
JAX	TIM13A	FLORIDA	DUVAL	Lower St. Johns	30.449167	-81.522667
JAX	TIM2	FLORIDA	DUVAL	Nassau	30.586313	-81.625107
JAX	TIM3	FLORIDA	DUVAL	Nassau	30.543886	-81.585129
JAX	TIM4	FLORIDA	NASSAU	Nassau	30.545511	-81.564514
JAX	TIM4A	FLORIDA	DUVAL	Nassau	30.547251	-81.552780
JAX	TIM5	FLORIDA	DUVAL	Nassau	30.511948	-81.544708
JAX	TIM6	FLORIDA	DUVAL	Nassau	30.532701	-81.498901
JAX	TIM7	FLORIDA	NASSAU	Nassau	30.570484	-81.497276
JAX	TIM8	FLORIDA	DUVAL	Nassau	30.525137	-81.464218
JAX	TIM9A	FLORIDA	DUVAL	Nassau	30.461849	-81.449867

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