# Satilla River Basin
# Dissolved Oxygen TMDLs

**Submitted to:**

U.S. Environmental Protection Agency
Region 4
Atlanta, Georgia

**Submitted by:**

Georgia Department of Natural Resources
Environmental Protection Department
Atlanta, Georgia

December 2001

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Appendices

## TMDL Executive Summary

**Basin Name**: **Satilla River**

**Table 1: Listed Segments**

| Segment Number | Name | Priority Ranking | Use Classification | Size (miles) | Location |
|---|---|---|---|---|---|
| **Segment #1** | Big Creek | 2 | Fishing | 5 | S. Prong Big Cr. To Satilla River (Brantley Co.) |
| **Segment #2** | Big Satilla Creek | 2 | Fishing | 34 | Headwaters near Hazlehurst to Sweetwater Cr. Near Baxley (Jeff Davis(/Appling Co.) |
| **Segment #3** | Boggy Creek | 2 | Fishing | 1 | Dry Creek to Little Satilla Cr. N. of Screven (Wayne Co.) |
| **Segment #4** | Broxton Creek | 2 | Fishing | 6 | Seven Creek to Seventeen Mile River near Broxton (Coffee Co.) |
| **Segment #5** | **Colemans Creek** | 2 | Fishing | 17 | Dry Branch S. of Surrency to Big Satilla Creek near Screven (Appling/Wayne Co.) |
| **Segment #6** | **Hog Creek** | 2 | Fishing | 15 | Hurricane Cr. To Satill River S. of Nicholls near Brickley (Coffee/Ware Co.) |
| **Segment #7** | **Hurricane Creek** | 2 | Fishing | 20 | Downstream Little Creek to Ten Mile Creek near Alma (Bacon Co.) |
| **Segment #8** | **Little Hurricane Creek** | 2 | Fishing | 22 | Ga. Hwy. 32 to Hurricane Cr. (Bacon/Ware/Prierce Co.) |
| **Segment #9** | **Little Satilla Creek** | 2 | Fishing | 10 | Keene Bay Branch to Dry Branch near Odum (Wayne Co.) |
| **Segment #10** | **Little Satilla Creek** | 2 | Fishing | 3 | Boggy Cr. To Little Satilla River near Screven (Wayne Co.) |
| **Segment #11** | Pudding Creek | 2 | Fishing | 9 | Park Bay to Satill River N. of Pearson (Atkinson Co.) |
| **Segment #12** | Red Bluff Creek | 2 | Fishing | 7 | Little Red Bluff Creek to Satilla River E. of Pearson (Atkinson Co.) |
| **Segment #13** | Reedy Creek | 2 | Fishing | 13 | Headwaters to Big Satilla Creek near Screven (Appling/Wayne Co.) |
| **Segment #14** | **Roses Creek** | 2 | Fishing | 9 | Upstream Ga. Hwy. 206 to Seventeen Mile River near Broxton (coffee Co) |
| **Segment #15** | **Satilla Creek** | 2 | Fishing | 7 | Hunters Cr. E. of Ocilla to Satilla River (Irwin/Coffee Co.) |
| **Segment #16** | **Satilla River** | 2 | Fishing | 12 | Satilla Cr. To Reedy Creek near Douglas (Coffee Co.) |
| **Segment #17** | **Sweetwater Creek** | 2 | Fishing | 12 | Black Water Cr. To Big Satilla Cr. Near Baxley (Appling Co.) |
| **Segment #18** | **Buffalo Creek** | 2 | Fishing | 6 | Little Buffalo Creek to Satilla River Brantley Co. |
| **Segment #19** | **Little Satilla River** | 2 | Fishing | 10 | Big Satilla Cr. To Sixty Foot Branch (Pierce/Wayne/Brantley Co.) |
| **Segment #20** | **Satilla River** | 2 | Fishing | 8 | Pudding Cr. To Smut Br. Near Pearson (Atkinson Co.) |
| **Segment #21** | **Satilla River** | 2 | Fishing | 19 | Rose Cr. To White Oak Cr. (Camden Co.) |

## Summary of TMDL Analysis and the TMDLs for Listed Segments

The TMDL analysis includes an evaluation of the relationship between the sources and the impact on the receiving water. Due to the many factors that dynamically influence in-stream dissolved oxygen concentrations, this relationship was developed using a complex model linkage. Impaired waterbodies were modeled using both a dynamic receiving water model and a dynamic watershed model. The linkage of these models permitted representation of major processes associated with dissolved oxygen concentration variability. By developing a linked watershed-receiving water model, the impacts of various factors (including all nonpoint and point source loads) on in-stream dissolved oxygen were evaluated. Ultimately, the loading capacity of the waterbody for each critical pollutant affecting the dissolved oxygen concentration was determined. The required source-based loading reduction required to meet the in-stream standard was also calculated. This approach permitted assessment of point source and nonpoint source contributions (including both watershed and leaf litterfall, etc.).

## Applicable Water Quality Standards

The applicable dissolved oxygen water quality criteria for waters in the Satilla River Basin is as follows:

> Numeric. A daily average of 5.0 mg/l and no less than 4.0 mg/l at all times for waters supporting warm water species of fish. 391-3-6-.03 (c) (l)
>
> Natural Water Quality - GAEPD. It is recognized that certain natural waters of the State may have a quality that will not be within the general or specific requirements contained herein. This is especially the case for the criteria for dissolved oxygen, temperature, pH and fecal coliform. NPDES permits and best management practices will be the primary mechanisms for ensuring that the discharges will not create a harmful situation. 391-3-6-.03(7)
>
> Natural Water Quality - EPA. "Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable criteria means or minima or both, the minimum acceptable concentration is 90 percent of the natural concentration." Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Freshwater). EPA440/5-86-003

| | |
|---|---|
| **Critical Condition**: | June – July, 1998 (low flow and high temperature). |
| **MOS:** | Implicit; conservative assumptions include 1) running dynamic model; 2) permitted point sources are loaded into model for allocation runs (average monthly permit values); 3) running model with real flow and temperature during summer instead of 7Q10 and 75% temperature; 4) assumed 41% saturation for upstream DO (Meyer, 1992). |
| **Seasonality:** | Evaluated for all seasons, including high flow winter and low flow summer conditions. |
| **Monitoring:** | Follow-up monitoring according to 5-year River Basin Planning cycle (Georgia EPD, 1996). |
| **Approach:** | NPDES for point sources; Best management practices for nonpoint sources. |
| **Date Submitted:** | Draft - June 2000, Final – December 2001. |

**Table 2: Summary of TMDLs for Listed Segments**

| Listed Segments | TMDL – TOC (lbs/yr) | TMDL – TN (lbs/yr) | TMDL – TP (lbs/yr) |
|---|---|---|---|
| Big Creek - Segment #1 | 6,211,483 | 269,237 | 22,455 |
| Big Satilla Creek - Segment #2 | 15,212,127 | 603,826 | 75,131 |
| Boggy Creek - Segment #3 | 5,559,394 | 139,488 | 14,724 |
| Broxton Creek - Segment #4 | 1,636,840 | 62,778 | 7,602 |
| Colemans Creek - Segment #5 | 7,447,537 | 226,827 | 28,933 |
| Hog Creek - Segment #6 | 15,161,322 | 485,634 | 53,774 |
| Hurricane Creek - Segment #7 | 20,022,212 | 856,806 | 92,002 |
| Little Hurricane Creek - Segment #8 | 13,232,516 | 430,449 | 56,752 |
| Little Satilla Creek - Segment #9 | 8,099,126 | 265,807 | 26,252 |
| Little Satilla Creek - Segment #10 | 14,568,112 | 432,732 | 45,985 |
| Pudding Creek - Segment #11 | 5,081,413 | 149,081 | 20,200 |
| Red Bluff Creek - Segment #12 | 8,112,832 | 256,318 | 28,131 |
| Reedy Creek - Segment #13 | 4,098,397 | 102,703 | 14,983 |
| Roses Creek - Segment #14 | 6,680,978 | 232,023 | 23,569 |
| Satilla Creek - Segment #15 | 3,872,094 | 132,053 | 17,623 |
| Satilla River - Segment #16 | 9,269,620 | 278,806 | 37,324 |
| Sweetwater Creek - Segment #17 | 2,728,370 | 76,937 | 11,986 |
| Buffalo Creek - Segment #18 | 11,893,834 | 380,490 | 29,833 |
| Little Satilla River - Segment #19 | 63,258,155 | 2,125,639 | 254,318 |
| Satilla River - Segment#20 | 26,467,421 | 841,124 | 111,215 |
| Satilla River - Segment#21 | 247,839,581 | 8,463,802 | 917,627 |

Appendix D presents the Waste Load Allocations (WLAs) and the Load Allocations (LAs) as annual loads for the loads contributing to the dissolved oxygen in the impaired segments in the Satilla River Basin.

# 1.0 Introduction

The State of Georgia is required to develop total maximum daily loads (TMDLs) for waters not meeting water quality standards, in accordance with Section 303(d) of the Clean Water Act and the U. S. Environmental Protection Agency (EPA) Water Quality Planning and Management Regulations (40 CFR Part 130). Water quality data collected in 1998 indicate that a number of waterbodies in the Satilla River Basin did not achieve water quality standards for dissolved oxygen. The low dissolved oxygen conditions may be due to naturally occuring conditions. These waterbodies were listed on the Georgia 2000-303(d) list. This document presents the dissolved oxygen TMDLs for the listed waterbodies in the Satilla River Basin, which is located in southeastern Georgia (Figure 1-1).

Four river basins, the Ochlockonee, Suwannee, Satilla, and the St. Marys are the focus of TMDL development in Georgia in 2000. The four river basins are shown in Figure 1-1.

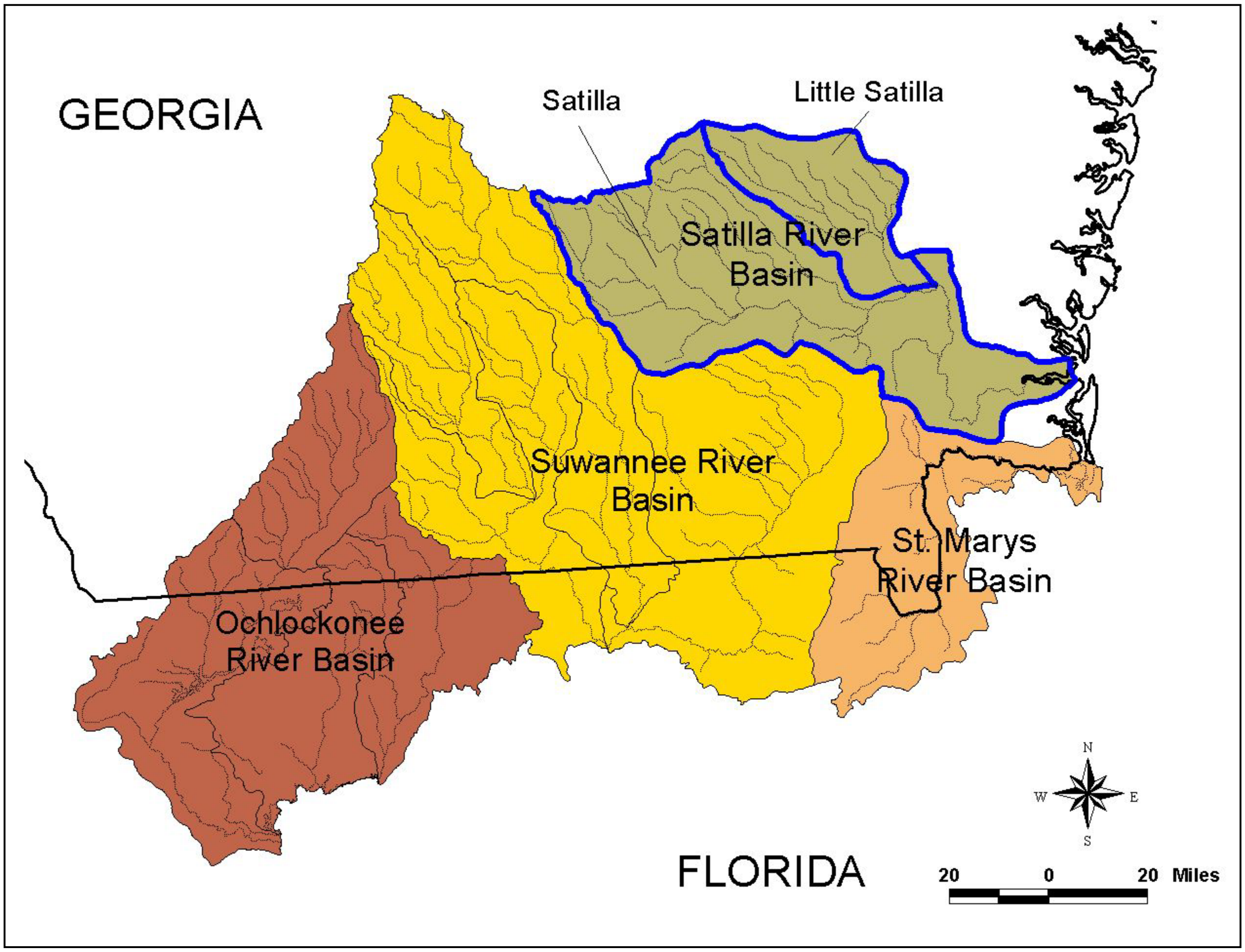


**Figure 1-1. Southern Four Georgia Basins Requiring Dissolved Oxygen TMDL Development (Ochlockonee, Suwannee, Satilla, and St. Marys River Basins)**

## 2.0 Problem Understanding

The Satilla River is the border between Florida and Georgia and its headwaters are located in the Okefenokee Swamp in Georgia. The river basin covers an area of approximately 1,804 $mi^2$. The major Georgia cities in the Satilla River Basin are Waycross, Pearson, Douglas, and Alama shown in the location map in Figure 2-1.

The Satilla River Basin contains 23 waterbody segments that are violating Georgia's dissolved oxygen standards of a daily average of 5.0 mg/l and no less than 4.0 mg/l (Figure 2-2 and see Listed Segments table on page 3). Each of these 23 listed segments contained at least one monitoring station in 1998 used for impairment listing purposes (Figure 2-2).

The GAEPD established water quality monitoring stations for the Ochlockonee, Suwannee, Satilla, and St. Marys River Basins as a part of the Georgia River Basin Planning Program (GAEPD, 1996). There were 138 stations established and sampled in the four river basins in 1998. Thirty-three of the sampling stations were in the Satilla River Basin. The monitoring work was conducted as a cooperative effort between the GAEPD and the United States Geologic Survey (USGS). The four river basins will be monitored again in 2003. It should be noted that core stations in the four basins are monitored each year. During 1998, the USGS measured gage height, water temperature, pH, and dissolved oxygen on-site and collected water samples for laboratory analyses. The laboratory water quality parameters included turbidity, five-day biological oxygen demand (BOD5), ammonia, nitrate-nitrite, total phosphorus, total organic carbon, and fecal coliform. In addition, samples for metals analyses were collected at each station. These data were used to assess compliance with water quality standards and the assessment results were used by the GAEPD in the development of the 2000-303(d) list.

The assessment indicated that 23 waterbody segments were not achieving compliance with water quality standards for dissolved oxygen (Figure 2-2 and see Listed Segments table on page 3). Low dissolved oxygen conditions in the Satilla River basin may be in part due to naturally occuring conditions. The TMDLs for dissolved oxygen for the 23 listed segments were scheduled for development in 2000 and for presentation for public comment in June 2000. This report presents the TMDLS for dissolved oxygen for the listed segments in the Ochlocknee River Basin. A summary of selected water quality data and a map of station locations are presented in Appendix A.

The Satilla River Basin is dominated by forested and wetland areas with some agricultural in the northwestern sections. The basin has watersheds with forested land uses with percentages as high as 65% and cropland areas as high as 51%. The USGS MRLC land use distribution for the early to mid 1990's is shown in Figure 2-3 for the entire basin.

Typical precipitation in this area is 47 inches per year based on examination of nearby precipitation stations in Folkston and Brunswick. A summary of the precipitation data and a map of stations in southern Georgia are included in this report in Appendix A.

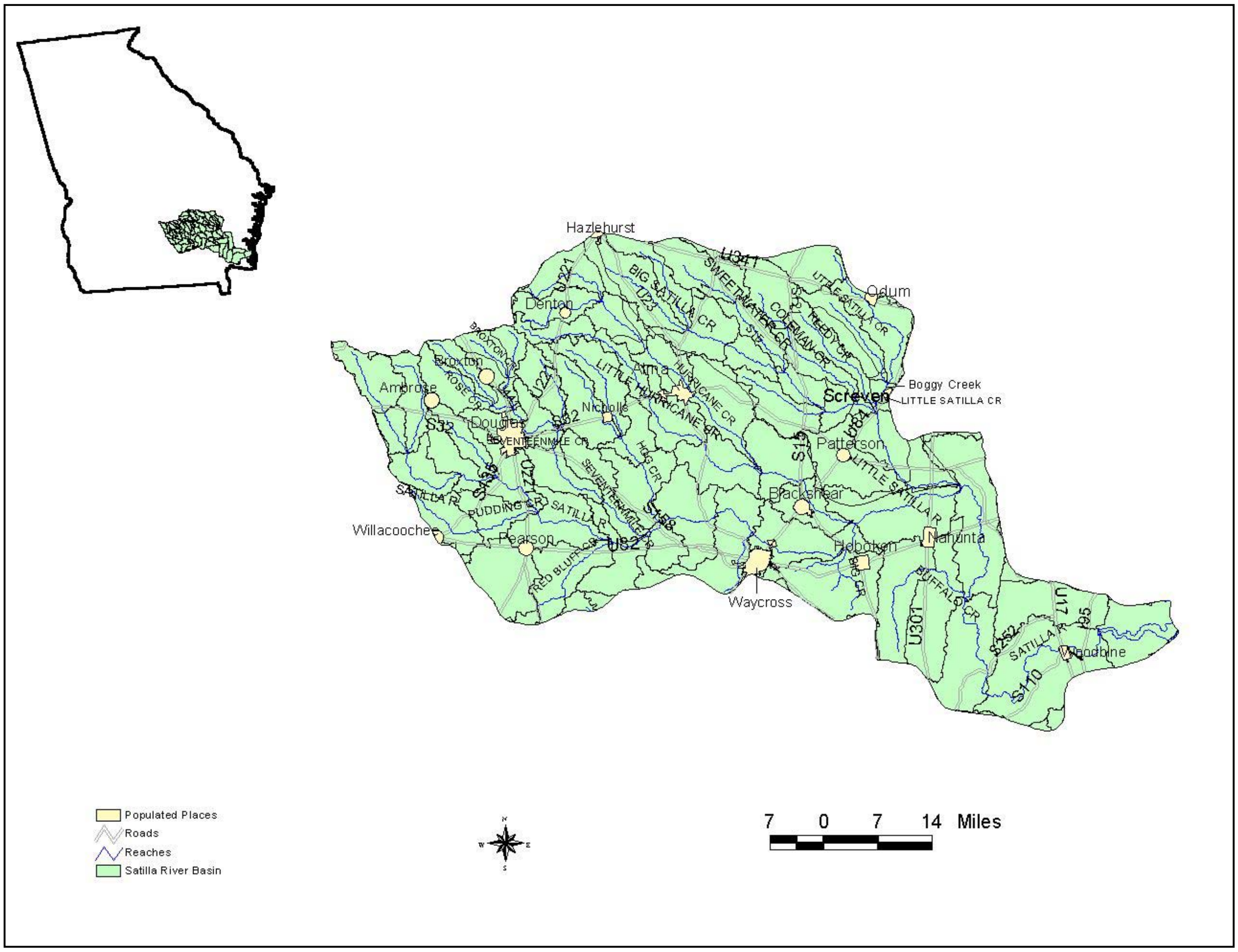


Figure 2-1. Location Map of the Satilla River Basin

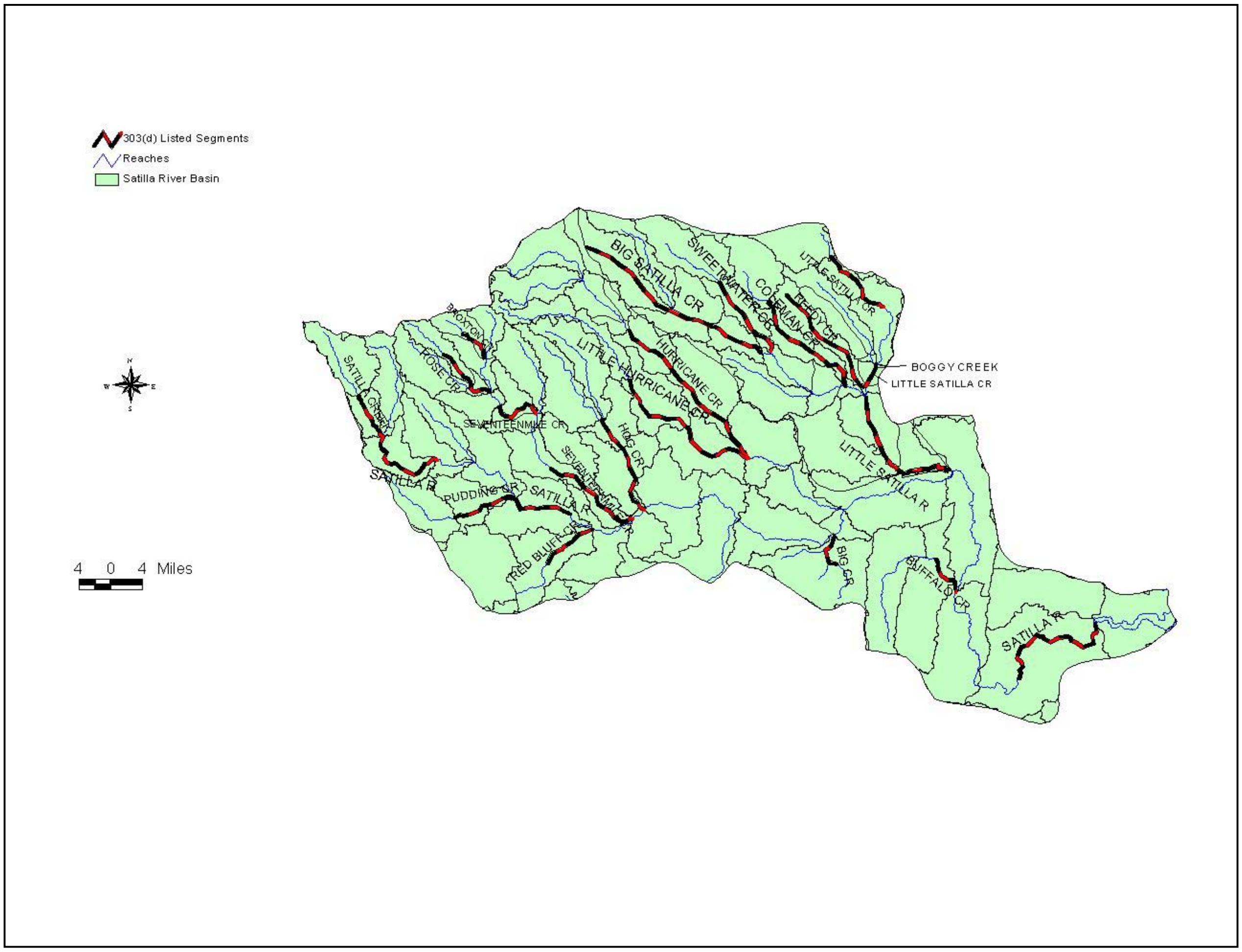


Figure 2-2. 303(d) Listed Segments for Dissolved Oxygen in the Satilla River Basin

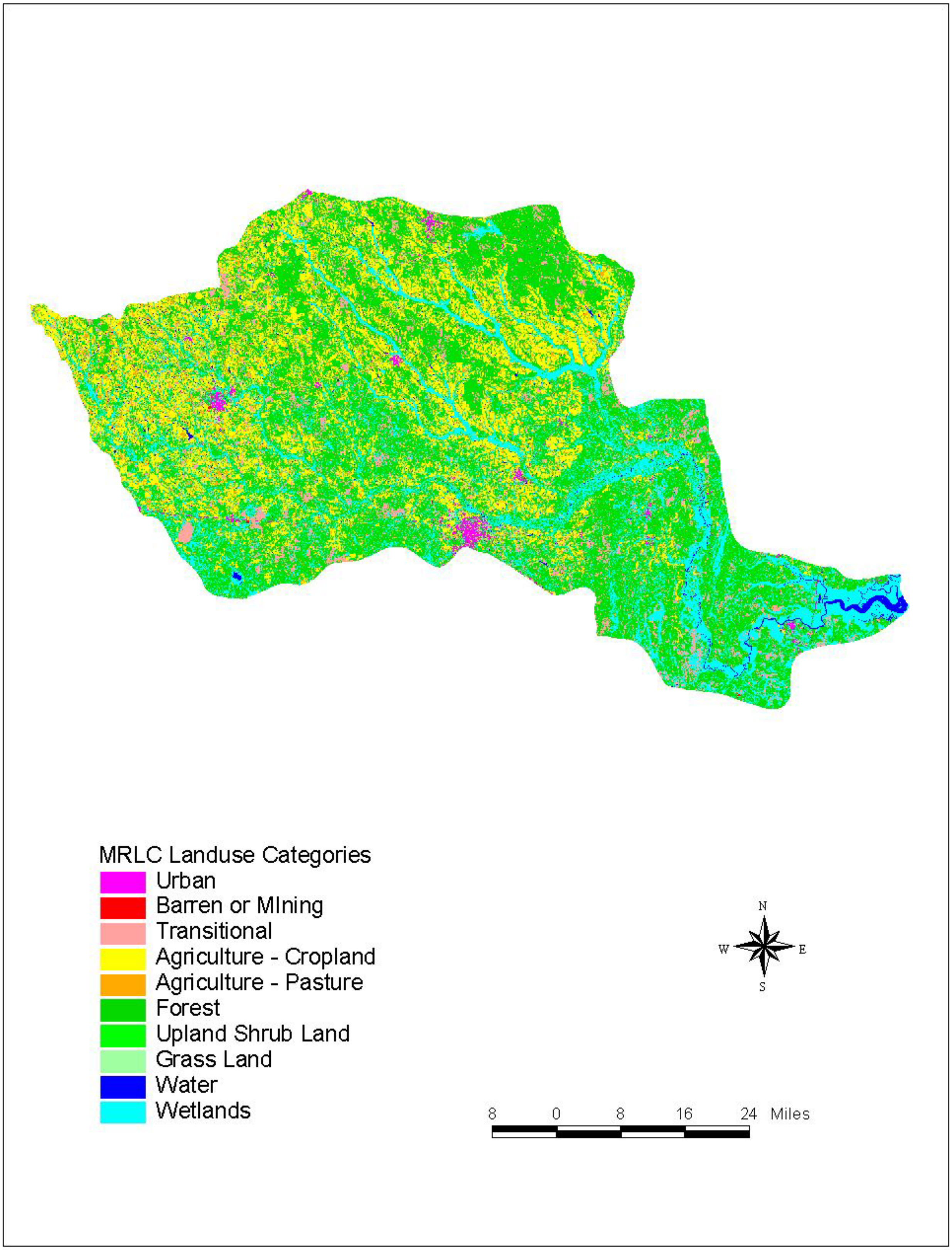


Figure 2-3. Land Use Representation in the Satilla River Basin

## 3.0 Water Quality Standards

All dissolved oxygen impaired waterbodies in the Satilla River Basin are designated by the State of Georgia with a water use classification of fishing. Georgia Water Quality Standards (GAEPD, 1999) have defined water quality criteria for surface waters as those that are used, or have a high potential to be used, for fishing and primary contact recreation. Georgia's water quality standards state the following criteria for measurements of dissolved oxygen with a use classification of fishing:

> *Numeric.* A daily average of 5.0 mg/l and no less than 4.0 mg/l at all times for waters supporting warm water species of fish*. A daily average of 6.0 mg/l and no less than 5.0 mg/l at all times for waters designated as trout streams by the Wildlife Resource Division.

**GAEPD, 1999**

*Waterbodies in the Satilla River Basin are assumed to be classified as supporting warm water species of fish.

Certain waters of the state may have conditions where the dissolved oxygen is naturally lower than the recommended numeric dissolved oxygen criteria and cannot meet the numeric criteria unless reductions in the natural nutrient and carbon loads are obtained. This reduction in the natural forest or wetland contributions is not feasible, practicable or desirable, therefore the EPA Dissolved Oxygen Criteria was instituted and dissolved oxygen target limits were identified for TMDL development. The target limits were identified as 90% of the minimum naturally occurring concentration for impaired waterbodies.

> *Natural Water Quality*. "It is recognized that certain natural waters of the State may have a quality that will not be within the general or specific requirements contained herein. This is especially the case for the criteria for dissolved oxygen, temperature, pH and fecal coliform. NPDES permits and best management practices will be the primary mechanisms for ensuring that the discharges will not create a harmful situation." 391-3-6-.03(7)

**GAEPD, 1999**

U.S. EPA guidelines supplement the Georgia guidelines for naturally low dissolved oxygen conditions by providing numeric targets:

> "Where natural conditions alone create dissolved oxygen concentrations less than 110 percent of the applicable criteria means or minima or both, the minimum acceptable concentration is 90 percent of the natural concentration." Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Freshwater), EPA440/5-86-003, April 1986.

**USEPA, 1986**

Dissolved oxygen violation analyses were performed for all 33 water quality stations in the basin by comparing observation values to numeric water quality standards. The analyses confirmed that the water quality standards were violated for the listed segments.

# 4.0 Source Assessment

The 303(d) listing for the impaired segments identified nonpoint sources as the primary contributors to dissolved oxygen impairment. An examination of permits and land use information for the watershed was used to identify all potential sources of oxygen demanding substances in the basin. These sources (divided into Point and Nonpoint Sources) were considered in the source loading analysis and the subsequent TMDL.

## Point Sources

Potential point sources affecting in-stream dissolved oxygen concentrations include wastewater treatment plants, industrial facilities (e.g., food processing facilities), combined sewer overflows, sanitary sewer overflows, and stormwater runoff. Point sources directly discharge organic and inorganic oxidizable substances into a waterbody, which ultimately affects dissolved oxygen concentrations. Pollutants that are typically monitored by facilities and should be considered in an evaluation of point source effects on in-stream dissolved oxygen concentrations include BOD, NH3, and TSS. Point sources contributing to the listed waters are listed in Table 4-1 and their corresponding discharge characteristics are listed in Table 4-2. The locations of the point sources are shown in Figure 4-1.

**Table 4-1. Point Sources Contributing to Impaired Waterbodies in the Satilla River Basin**

| PERMIT ID | Point Source | Receiving Water |
|---|---|---|
| GA0049573 | DOOR Wayne County State Prison | Dry Creek – Little Satilla Creek |
| GA0049531 | Georgia Baptist Children's Home | Sweetwater Creek |
| GA0024619 | Milliken - Alma Plant | Little Hurricane Creek |
| GA0032328 | Alma WPCP | Hurricane Creek tributary |
| GA0037206 | Patterson Water Reclamation Center | Patterson Creek |
| GA0025445 | Pearson WPCP | Little Red Bluff Creek tributary |
| GA0033774 | Brantley County High School | Buffalo Creek to Satilla River |
| GA0023701 | Woodbine WPCP | Satilla River |

**Table 4-2. Point Sources in Watersheds Contributing to Impaired Segments**

| | | | | Permitted (MAX / AVG) | | | | |
|---|---|---|---|---|---|---|---|---|
| NPDES | HUC Label | Receiving Water | Season | DO (mg/L) | BOD-5 | Flow (mgd) | NH3 | TSS |
| GA0049573 | 3070202 | Dry Creek - Little Satilla Creek | | -- | 45 / 30 mg/L | -- | -- | 120 / 90 mg/L |
| GA0049531 | 3070202 | Sweetwater Creek | | -- | 45 / 30 mg/L | -- | -- | 120 / 90 mg/L |
| GA0024619 | 3070201 | Little Hurricane Creek | | -- | 45 / 30 mg/L | -- | -- | 65 / 45 mg/L |
| GA0032328 | 3070201 | Hurricane Creek tributary | | 2 | 45 / 30 mg/L | 0.94 / 0.75 | 26.1 / 17.4 mg/L | 45 / 30 mg/L |
| GA0037206 | 3070202 | Patterson Creek | 0 | -- | 45 / 30 mg/L | -- | 15 / 10 mg/L | 45 / 30 mg/L |
| | | | 1 | -- | 30 / 20 mg/L | -- | 7.5 / 5 mg/L | |
| GA0025445 | 3070201 | Little Red Bluff Creek tributary | | -- | 38 / 25 mg/L | 0.45 / 0.36 | 8 / 5 mg/L | 45 / 30 mg/L |
| GA0033774 | 3070201 | Buffalo Creek to Satilla River | | -- | 45 / 30 mg/L | 0.014 / 0.014 | -- | 120 / 90 mg/L |
| GA0023701 | 3070201 | Satilla River | | -- | 45 / 30 mg/L | 0.46 / 0.368 | -- | 45 / 30 mg/L |

Note: -- Denotes situations where permitted data are not available.

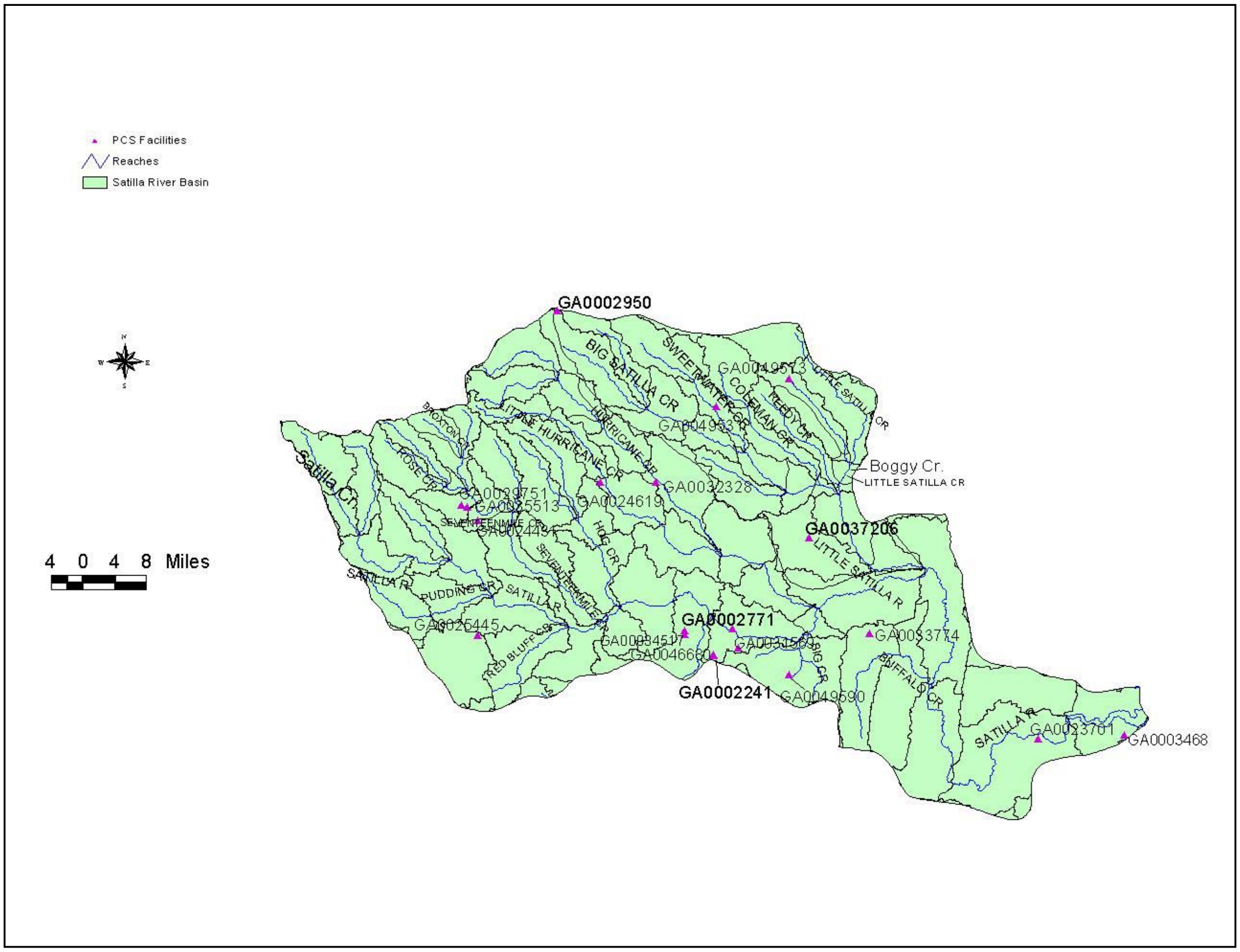


Figure 4-1. Point Sources in the Satilla River Basin Contributing to Impaired Waterbodies

### Nonpoint Sources

Nonpoint sources of oxygen demanding substances are typically separated into urban and rural components. In urban or suburban settings, important sources of loading are surface storm runoff, failing septic systems, and leakage and overflows from sanitary sewer systems. In rural areas, sources of oxygen demanding substances may include diffuse runoff of agricultural fertilizer and animal wastes (from manure application or grazing animals), erosion of sediments, and runoff from concentrated animal operations.

Based on a landuse assessment and review of the literature, nonpoint source contributions from urban, agriculture, and forested areas are all likely in the Satilla River Basin. Croplands, pasture, forest, urban (or built-up) areas, and wetlands were all identified in the basin. The land use distribution for the Georgia 12-digit watersheds contributing to the impaired segments is displayed in Appendix A. Figure 2-3 graphically displays the land use distribution within the study area.

In addition to the aforementioned nonpoint sources of oxygen demanding substances, many southern Georgia streams receive significant contributions of oxygen demanding organic materials from local wetlands and forested stream corridors. In particular, the following sources of organic materials have been identified:

- adjacent wetland/swampy areas that have organically rich bottom sediments
- direct leaf litterfall onto the water surface from overhanging trees and vegetation
- lateral leaf litterfall that has fallen into the floodplains

Leaf litterfall plays a major role in the amount of carbon in the stream water column. The riparian areas of the watershed are the primary source of litterfall. At higher flows, the leaf litterfall in the floodplains are picked up and transported laterally into the stream. Many streams in southern Georgia are referred to as “blackwater” streams due to the humic substances leached from surrounding watersheds that impart color to the water (Meyer, 1992). Low dissolved oxygen in blackwater streams is common in the summer months when the temperatures are high and the flows are low.

## 5.0 Summary of the Technical Approach

The TMDL analysis includes an evaluation of the relationship between the sources and the impact on the receiving water. Due to the many factors that dynamically influence in-stream dissolved oxygen concentrations, this relationship was developed using a complex model linkage.

Impaired waterbodies were modeled using both a dynamic receiving water model and a dynamic watershed model. The linkage of these models permitted representation of major processes associated with dissolved oxygen concentration variability, including:

- Input and oxidation of carbonaceous waste material
- Input and oxidation of nitrogenous waste material
- Input and oxygen demand of sediments in the water body
- Use of oxygen through aquatic plant respiration

- Reaeration
- Oxygen production through photosynthesis

By developing a linked watershed-receiving water model, the impacts of various factors (including all nonpoint and point source loads) on in-stream dissolved oxygen were evaluated. Ultimately, the loading capacity of the waterbody for each critical pollutant affecting the dissolved oxygen concentration was determined. The required source-based loading reduction required to meet the in-stream standard was also calculated. This approach permitted assessment of point source and nonpoint source contributions (including both watershed and leaf litterfall, etc.).

The technical approach is summarized in the following sections:

- Model selection
- Source representation
- In-stream representation
- Model testing

## Model Selection

The Hydrologic Simulation Program Fortran (HSPF), a dynamic watershed model capable of simulating a wide range of water quality parameters, was selected to represent nonpoint source pollutant contributions (and point source contributions as necessary) to the impaired waterbodies. The impaired waterbodies themselves were modeled using the Environmental Fluid Dynamics Code (EFDC), a 3-D hydrodynamic and water quality model capable of simulating dissolved oxygen and a full suite of dissolved oxygen interactions. Output from the HSPF was applied directly to the EFDC, in order to provide the linkage between source and waterbody response.

## Source Representation

Nonpoint and point sources were both represented in the linked models. The watershed model was primarily implemented to represent upstream nonpoint source contributions to the impaired waterbody. Direct contributions of leaf litter (representation of organic materials contributed by overhanging trees and vegetation) to each impaired waterbody were represented in the receiving water model.

Point sources were represented in both the receiving water model and the watershed model. Facilities discharging within the same 12-digit subwatershed as a modeled impaired waterbody were represented in the receiving water model. Facilities discharging to unimpaired reach segments that affect impaired waterbodies, but were not explicitly modeled with the receiving water model, were represented in the watershed model.

### Nonpoint Source Representation

Nonpoint source pollutants likely to impact dissolved oxygen include nutrients, BOD, and sediment. These pollutants have a direct impact on oxygen reducing procedures, including oxidation of carbonaceous and nitrogenous materials and exertion of oxygen demand by sediments. They also affect oxygen replenishment through plant respiration and photosynthesis production.

The watershed model represents the variability of nonpoint source contributions through dynamic representation of hydrology and land practices. In a number of situations, the watershed model additionally accounts for point source contributions (where point sources are located on major streams contributing to an impaired waterbody that are not represented explicitly in the receiving water model). Key components of the watershed model include:

- Watershed segmentation
- Meteorological data
- Simulation period
- Landuse representation
- Hydrologic representation
- Water quality representation

### *Watershed Segmentation*

In order to evaluate the sources contributing to an impaired waterbody and to represent the spatial variability of these sources within the watershed model, the contributing drainage area was represented by a series of subwatersheds. These subwatersheds were represented using the Georgia 12-digit watershed data layer. In some situations, the 12-digit data layer required further subdivision for appropriate hydrologic connectivity and representation.

The watershed model was run for all subwatersheds contributing to each impaired waterbody. Figure 5-1 presents the subwatersheds used in the watershed modeling process. Table 5-1 presents the subwatersheds contributing to individual impaired waterbodies.

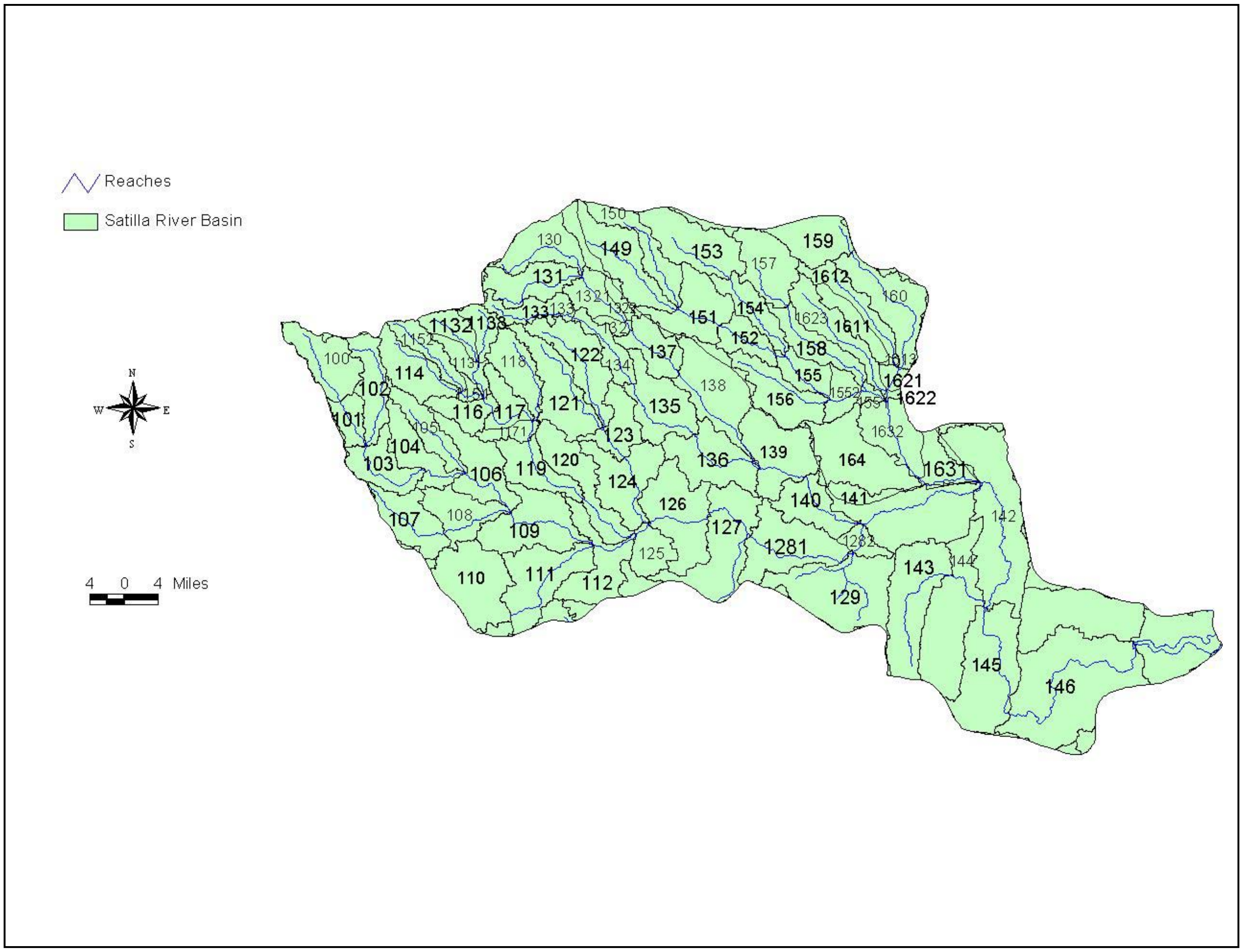


Figure 5-1. Subwatersheds Used in the Watershed Modeling Process (Contributing to Listed Waterbodies)
Note: Subwatersheds are labeled by their model Ids - refer to Table 5-1 for corresponding 12-digit Ids.
Some subwatersheds were further divided to support proper hydrologic representation.

Table 5-1. Subwatersheds Contributing to the Impaired Waterbodies.

| Name | Contributing Watersheds (Model ID) | Contributing Subwatersheds (12-Digit HUC) |
|---|---|---|
| Big Creek Segment #1 | 129 | 030702010705 |
| Big Satilla Creek Segment #2 | 149, 150, 151, 152 | 030702020101, 030702020102, 030702020103, 030702020104 |
| Boggy Creek Segment #3 | 161-1, 161-2, 161-3 | 030702020403(a), 030702020403(b), 030702020403(c) |
| Broxton Creek Segment #4 | 113-2 | 030702010401(b) |
| Colemans Creek Segment #5 | 157, 158 | 030702020303, 030702020304 |
| Hog Creek Segment #6 | 121, 122, 123, 124 | 030702010601, 030702010602, 030702010603, 030702010604 |
| Hurricane Creek Segment #7 | 130, 131, 132, 132-1, 132-2, 137, 138 | 030702010801, 030702010802, 030702010803(a), 030702010803(b), 030702010803(c), 030702011001, 030702011002 |
| Little Hurricane Creek Segment #8 | 133, 134, 135, 136 | 030702010901, 030702010902, 030702010903, 030702010904 |
| Little Satilla Creek Segment #9 | 159, 160 | 030702020401, 030702020402 |
| Little Satilla Creek Segment #10 | 159, 160, 161-1, 161-2, 161-3, 162-1, | 030702020401, 030702020402, 030702020403(a), 030702020403(b), 030702020403(c), 030702020404(a) |
| Pudding Creek Segment #11 | 107, 108 | 030702010204, 030702010205 |
| Red Bluff Creek Segment #12 | 110, 111 | 030702010302, 030702010303 |
| Reedy Creek Segment #13 | 162-3 | 030702020404(c) |
| Roses Creek Segment #14 | 114, 115-1, 115-2 | 030702010402, 030702010403(a), 030702010403(b) |
| Satilla Creek Segment #15 | 100, 101 | 030702010101, 030702010102 |
| Satilla River Segment #16 | 100, 101, 102, 103 | 030702010101, 030702010102, 030702010103, 030702010104 |
| Sweetwater Creek Segment #17 | 154 | 030702020202 |
| Buffalo Creek Segment #18 | 143, 144 | 030702011103, 030702011104 |
| Little Satilla River Segment #19 | 149, 150, 151, 152, 154, 155, 155-1, 155-2, 156, 158, 159, 160, 161-1, 161-2, 161-3, 162-1, 162-2, 162-3, 163-1, 163-2 | 030702020101, 030702020102, 030702020103, 030702020104, 030702020202, 030702020301, 030702020301(a), 030702020301(b), 030702020302, 030702020304, 030702020401, 030702020402, 030702020403(a), 030702020403(b), 030702020403(c), 030702020404(a), 030702020404(b), 030702020404(c), 030702020501(a), 030702020501 (b) |
| Satilla River Segment #20 | 100, 101, 102, 103, 104, 105, 106, 107, 108, 109 | 030702010101, 030702010102, 030702010103, 030702010104, 030702010201, 030702010202, 030702010203, 030702010204, 030702010205, 030702010301 |

| | | |
|---|---|---|
| Satilla River Segment #21 | 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113-1, 113-2, 113-3, 114, 115-1, 115-2, 116, 117, 117-1, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128-1, 128-2, 129, 130, 131, 132, 132-1, 132-2, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 149, 150, 151, 152, 153, 154, 155, 155-1, 155-2, 156, 157, 158, 159, 160, 160-1, 161-1, 161-2, 161-3, 162-1, 162-2, 162-3, 163-1, 163-2, 164 | 030702010101, 030702010102, 030702010103, 030702010104, 030702010201, 030702010202, 030702010203, 030702010204, 030702010205, 030702010301, 030702010302, 030702010303, 030702010304, 030702010401(a), 030702010401(b), 030702010401(c), 030702010402, 030702010403(a), 030702010403(b), 030702010404, 030702010501, 030702010501(a) 030702010502, 030702010503, 030702010504, 030702010601, 030702010602, 030702010603, 030702010604, 030702010701, 030702010702, 030702010703, 030702010704(a), 030702010704(b), 030702010705, 030702010801, 030702010802, 030702010803, 030702010803(a), 030702010803(b), 030702010901, 030702010902, 030702010903, 030702010904, 030702011001, 030702011002, 030702011003, 030702011004, 030702011101, 030702011102, 030702011103, 030702011104, 030702011105, 030702011201, 030702020101, 030702020102, 030702020103, 030702020104, 030702020201, 030702020202, 030702020301, 030702020301(a), 030702020301(b) 030702020302, 030702020303, 030702020304, 030702020401, 030702020402, 030702020402 (a), 030702020403(a), 030702020403(b), 030702020403(c), 030702020404(a), 030702020404(b), 030702020404(c), 030702020501(a), 030702020501(b), 030702020502 |

Note: Contributing Subwatersheds (GA 12-digit) and Corresponding Watershed Model Ids are listed in the same order for each segment. Model Ids are presented for the purpose of visually displaying the subwatersheds in Figure 5-1.

### *Meteorological Data*

Nonpoint source loadings and hydrologic conditions are dependent on weather conditions. Weather parameters required to simulate various components of hydrology and water quality include precipitation, air temperature, dew point, wind speed, solar radiation, and percent cloud cover. Hourly data from weather stations within the boundaries of or in close proximity to the subwatersheds being modeled, were applied to the watershed model.

Weather stations used to represent the Satilla River Basin include Pearson (GA6879), Hazelhurst (GA4204), Folkston 3 SW (GA3460), Brunswick (GA1340), Jesup (GA4671), and Abbeville 4 S (GA0010). Appendix A presents the locations of the weather stations with respect to the modeled subwatersheds.

Examination of the precipitation at these stations shows that the wettest months are typically January, February, March, and July. The driest month is typically October. Monthly and annual patterns are similar for all stations. Appendix A presents rainfall characteristics, including monthly mean and annual total precipitation for each station.

### *Simulation Period*

Selection of an appropriate simulation period is important in nonpoint source modeling due to the variability of hydrologic and source loading conditions over time. The year 1998 was selected as the simulation period. This time period was selected due to its coverage of a wide range of hydrologic conditions, including heavy rainfall and drought conditions. Additionally, this period contained the most extensive monitoring data, which is necessary for model calibration.

The HSPF model was run for 10 years to examine the watershed water quality loading over an extended period of time. The 1998 watershed load was also compared directly to the 1997 loading year to see if there were any anomalies in the loading rates. For some cases, the 1997 load was higher than the 1998 load. In this case, the in-stream model was run during 1997 through 1998 to account for any build-up in the sediment oxygen demand from the higher 1997 loads.

### *Land Use Representation*

The watershed model uses land use data as the basis for representing hydrology and nonpoint source loading. Land use categories for modeling were selected based on the USGS Multi-Resolution Land Classification (MRLC) data set, and included built-up, forest, cropland, pasture, and wetlands. The USGS data represents conditions in the early to middle 1990's. The modeling categories and their corresponding USGS classifications are presented in Table 5-2. The land use representation for the Georgia 12-digit watersheds used in modeling are presented in Appendix A.

**Table 5-2. Land Use Representation**

| Land Categories Represented in the Model | MRLC Land Use Code | MRLC Land Use Classes | % Impervious |
|---|---|---|---|
| Built-up | 21 | Low Intensity Residential | 19 |
| | 22 | High Intensity Residential | 65 |
| | 23 | High Intensity Comm./Ind./Trans. | 80 |
| | 33 | Transitional | 10 |
| Forest | 31 | Bare Rock/Sand/Clay | 0 |
| | 32 | Quarries/Strip Mines/Gravel Pits | 0 |
| | 41 | Deciduous Forest | 0 |
| | 42 | Evergreen Forest | 0 |
| | 43 | Mixed Forest | 0 |
| | 51 | Deciduous Shrubland | 0 |
| | 52 | Evergreen Shrubland | 0 |
| | 53 | Mixed Shrubland | 0 |
| | 71 | Grassland/Herbaceous | 0 |
| | 85 | Other Grasses | 0 |
| Wetland | 91 | Woody Wetlands | 0 |
| | 92 | Emergent Herbaceous Wetlands | 0 |
| Cropland | 61 | Planted/Cultivated | 0 |
| | 82 | Row Crops | 0 |
| | 83 | Small Grains | 0 |
| | 84 | Bare Soil | 0 |
| Pasture | 81 | Pasture/Hay | 0 |

The HSPF model requires division of land uses in each subwatershed into separate pervious and impervious land units. For each land use, this division can be made based on typical imperviousness percentages from individual land use categories, such as those used in the Soil Conservation Service's TR-55 method. For modeling purposes, the percent imperviousness of a give land category can be calculated as an area-weighted average of land use classes encompassing the modeling land category.

### *Hydrologic Representation*

Watershed hydrology plays an important role in the determination of nonpoint source flow and ultimately nonpoint source loadings to a waterbody. The watershed model must appropriately represent the spatial and temporal variability of hydrologic characteristics within a watershed. Key hydrologic characteristics include interception storage capacities, infiltration properties, evaporation and transpiration rates, and watershed slope and roughness. The HSPF modules used to represent watershed hydrology for TMDL development include PWATER (water budget simulation for pervious land units) and IWATER (water budget simulation for impervious land units). A detailed description of relevant hydrologic algorithms is presented in the HSPF User's Manual.

### *Water Quality Representation*

A total of four water quality parameters were simulated using the watershed model: biochemical oxygen demand (BOD,) total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS). These parameters (either directly or indirectly) constitute the primary nonpoint sources contributing to dissolved oxygen depletion and/or replenishment. The buildup and washoff of these pollutants were represented using the PQUAL (simulation of quality constituents for pervious land segments) and IQUAL (simulation of quality constituents for impervious land segments) modules in HSPF. Different buildup and washoff rates were used to represent the different land categories (e.g. fertilizer and manure application generally result in a higher nutrient buildup and washoff from cropland than from urban lands). Upon application to the receiving water model, many of parameters simulated in the watershed model were converted into more applicable constituents for in-stream modeling.

### *Leaf Litterfall Representation*

Loadings of leaf litterfall were assumed to be consistent with a study performed on the Ogeechee River in southern Georgia (Meyer et al. 1997). The direct leaf litterfall was reported as 843 $g/m^2/yr$ and lateral leaf litterfall was reported as 3,520 $g/m^2/yr$. The surface area of the stream channel was used to derive loading rates into the model. The lateral leaf litterfall was flow dependent to simulate the loading increase when the flows are large enough to inundate the floodplains. During the higher flows, the organic material deposited in the floodplain is picked up and transported into the stream.

The leaf litterfall loading was only applied to the receiving water model grid segments (during simulation of each impaired river segment). Loadings from the HSPF model (particularly BOD, which was ultimately converted to TOC) were assumed to account for residual leaf litterfall from upstream segments (transported to the impaired segment). The majority of leaf litter was assumed to be deposited on the stream bottom within each segment, thus forming an organic-enriched bed.

### Point Source Representation

After identifying all point source facility locations in the subwatersheds contributing to the impaired waterbodies, appropriate facilities were represented in the linked models. Depending on location, point sources were either represented in the watershed model or the receiving water model. Facilities discharging within a Georgia 12-digit subwatershed containing an impaired waterbody were represented as direct inputs into the receiving water model. Facilities discharging within a subwatershed representing an unimpaired waterbody were represented in the watershed model.

In the later case, the facilities discharge into waterbodies that eventually feed into an impaired waterbody, and thus must be considered in the source representation. Due to their indirect impact on the impaired waterbody, however, their contributions are subject to fate and transport in the watershed model through a stream system leading to the impaired waterbody.

Point source facilities were represented in both the watershed and receiving water models using a constant flow and pollutant loading. DMR data (flow and pollutant concentrations or loads) were represented in the models to simulate existing conditions – for calibration. Permitted flows and loads were used to represent initial conditions for TMDL development. The monthly average permitted conditions were loaded into the in-stream model for the allocation runs. For example, where BOD5 is permitted at a maximum of 45 mg/L and an average of 30 mg/L, the average of 30 mg/L would be multiplied by the average daily, permitted flow to produce a daily mass loading (lbs/day). The monthly average permitted values, versus the monthly maximum, are more representative in determining assimilative capacity in the system. In special circumstances, such as a major point source discharge, a step-function would be implemented so that the waterbody would receive a maximum daily load during the month, but still maintain the permitted monthly average. Water quality constituents represented include BOD, TN, TSS, and TP. BOD and TSS values were represented using DMR and permitted values. TN values were based on monitored NH3 values for the facilities. TP values were assumed to be 5 mg/L for municipal facilities (due to the absence of DMR data and permitted values). Refer to Table 4-1 for point source flows and loads used in the modeling process.

## In-stream Representation

The receiving water model, EFDC, was used to simulate all in-stream dissolved oxygen processes for the impaired waterbodies. Impaired waterbodies received flow and water quality output from the corresponding HSPF model (which represented watershed contributions). Unimpaired waterbodies located in stream networks contributing to impaired waterbodies were not represented explicitly using EFDC, but instead were represented using HSPF in-stream algorithms. Key components of the in-stream representation include:

- Hydrodynamic representation
- Water quality configuration
- Unimpaired waterbody representation

### Hydrodynamic Representation

Independent grid systems were developed to represent impaired waterbodies using EFDC, except in the case where multiple impaired waterbodies were connected. In these situations extended grids representing the entire impaired system were developed. The longitudinal extent of each waterbody impairment, as defined in the Georgia 303(d) list, was used to determine the grid coverage. In general, the grid for each impairment was extended to the waterbody's intersection with the nearest up- and down-stream Georgia 12-digit subwatershed boundary. This standardized the grid development processes, as well as the watershed model-receiving water model linkage. Under this configuration, the entire extent of each impairment was fully represented.

The extent of impairments in the Satilla River Basin ranged from 2 miles to over 30 miles (when considering connected impairments). Due to the variability in impairment length, each grid was configured using a different number of cells and different cell dimensions. Each cell was rectangular and represented a single vertical water layer (one dimension). Cells were typically on the order of 1 km (0.62 mi) to 3.22 km (2 mi) in length. Lateral dimensions were derived from USGS cross-sectional data obtained from USGS monitoring stations located on each of the impaired segments.

Tributary inflows, point sources, and nonpoint source contributions were applied directly to applicable cells in the grid. For impaired headwaters, the total flow from the contributing 12-digit subwatershed was divided into two portions. The first portion (typically 20% of the flow) was applied directly into the most upstream cell, while the remaining portion (typically 80%) was divided equally among the remaining cells to represent nonpoint source inflows.

For downstream impairments, upstream inflows (represented in the watershed model) were applied directly to the most upstream cell in the grid. Flow from the 12-digit subwatershed(s) in immediate vicinity of the impaired waterbody (also represented in the watershed model) were distributed evenly among the cells. Flow from incoming tributaries (represented as stream networks in the watershed model) and point sources were applied directly to the most appropriate cell in the configuration. Figure 5-2 presents an example of the in-stream configuration for an impaired headwater and its linkage to the watershed model.

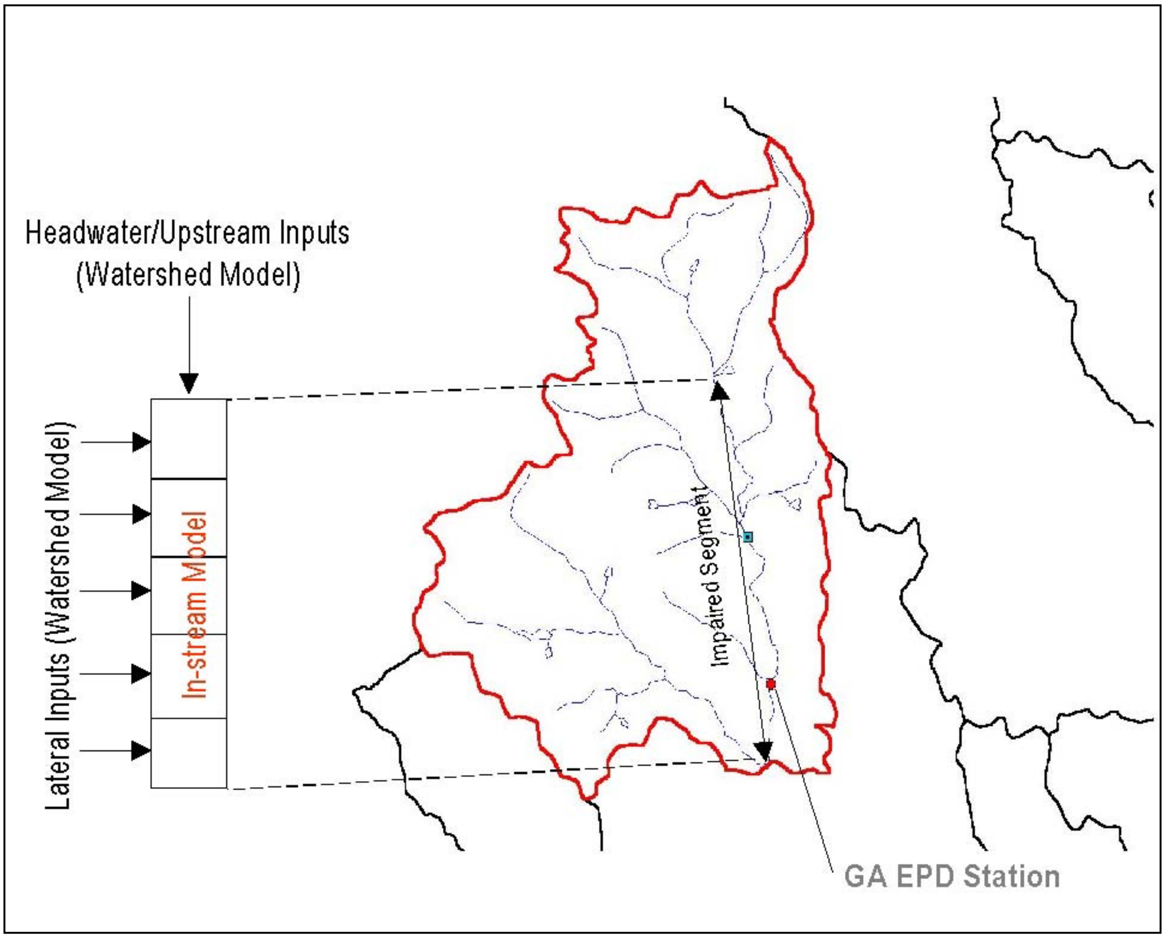


**Figure 5-2. Diagram of In-stream Model Configuration**

The hydrodynamic portion of the EFDC model is designed to solve three-dimensional, vertically hydrostatic, free surface, turbulent averaged equations of motion for a variable-density fluid. The model uses stretched or sigma vertical coordinates and Cartesian or curvilinear, orthogonal horizontal coordinates. Dynamically-coupled transport equations for turbulent kinetic energy, turbulent length scale, salinity and temperature are also solved. The two turbulence parameter transport equations implement the Mellor-Yamada level 2.5 turbulence closure scheme (Mellor & Yamada, 1982) as modified by Galperin et al (1988). The EFDC model also simultaneously solves an arbitrary number of Eulerian transport-transformation equations for dissolved and suspended materials. The EFDC model allows for drying and wetting in shallow areas by a mass conservation scheme. A number of alternatives are in place in the model to simulate general discharge control structures such as weirs, spillways and culverts. The theoretical and computational basis for the model is documented in Hamrick (1992a).

### Water Quality Configuration

Simulation of dissolved oxygen in the receiving water model considered a large suite of model state variables and kinetic processes. The EFDC model simulates the interactions between up to 21 state variables including dissolved oxygen, suspended algae (3 groups), various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria. The kinetic processes included in this model use the Chesapeake Bay three-dimensional water quality model, CE-QUAL.ICM (Cevco & Cole, 1994). Figure 5-3 is a schematic diagram of the EFDC water column water quality model.

The primary sources and sinks of oxygen represented in the EFDC model are:

- algal photosynthesis and respiration
- nitrification
- heterotrophic respiration of dissolved organic carbon
- oxidation of chemical oxygen demand
- surface reaeration
- sediment oxygen demand
- external loads

Refer to *A Three-Dimensional Hydrodynamic-Eutrophication Model (HEM-3D): Description of Water Quality and Sediment Process Submodels (EFDC Water Quality Model)* for a full description of relevant equations and formulations.

In order to represent all sources and sinks of dissolved oxygen, the water quality model required temperature representation and inputs of water quality parameters from the watershed model and point source discharges. For calibration purposes, in-situ temperature data measured concurrently with dissolved oxygen was input into the model. For the allocation model runs, a representative, seasonal distribution of temperature was created for the entire southern four basins. The data used to create the seasonal pattern in the model was collected by the USGS at the 5 monitoring sites in Georgia. The monitoring site that was the closest to the southern four basins in Georgia was at USGS02213700 on the Ocmulgee River near Warner Robbins, Georgia. A sinsusoidal function was fit to the daily maximum and minimum from the Ocmulgee River station to create the representative temperature for the allocation runs.

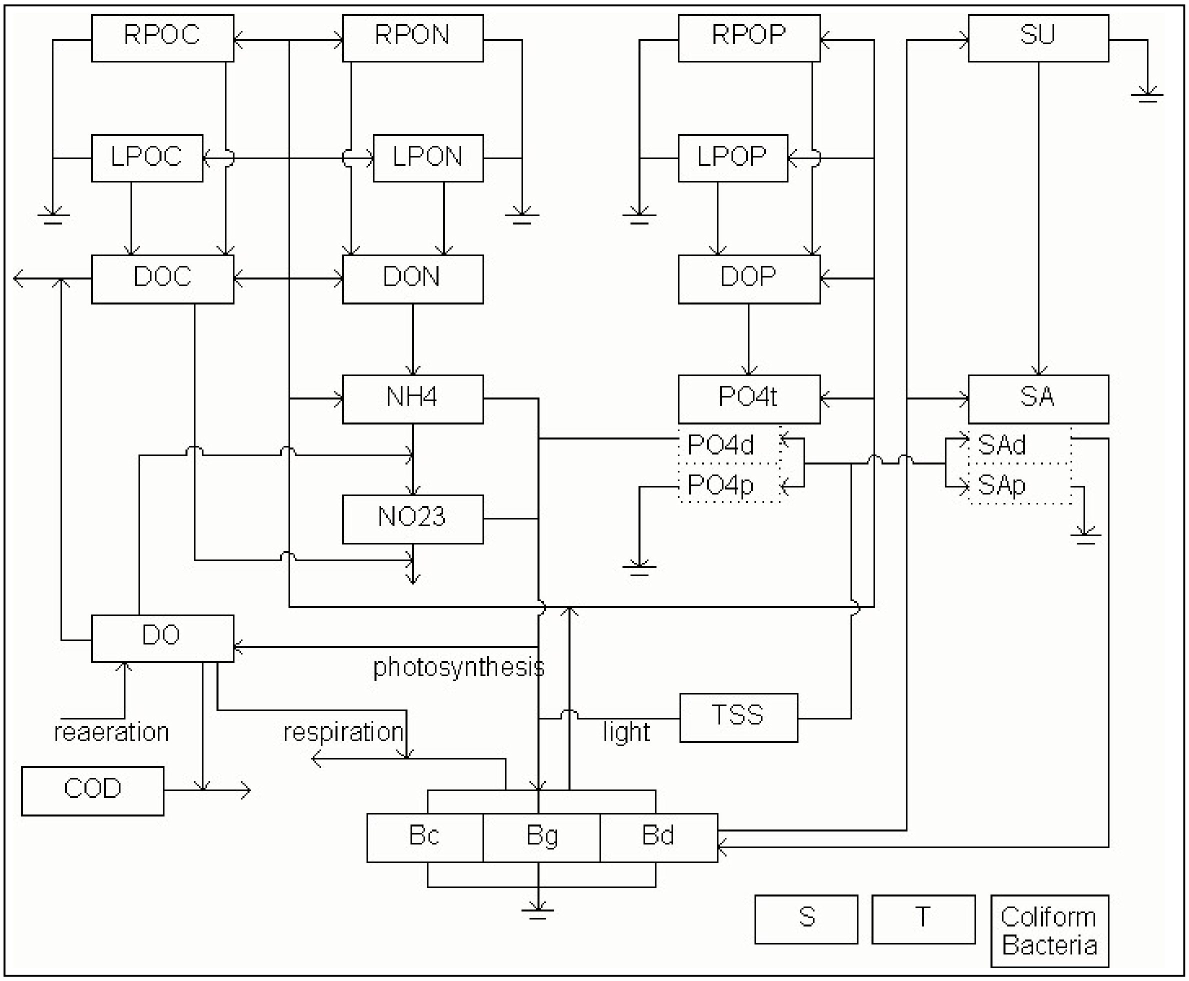


Figure 5-3. EFDC water column water quality model schematics diagram

Water quality parameters were input to cells in the grid using the same procedure as for flow. All upstream inputs, tributary inputs, point sources, and nonpoint source contributions in immediate vicinity of the impaired waterbody were accounted for. Specific parameters transferred from the watershed model (and point sources) to the receiving water model included TSS, BOD, TN, and TP.

### *BOD5 to Total Organic Carbon*

The HSPF subwatershed model runs were calibrated primarily to 5-day biochemical oxygen demand (BOD5) and total suspended solids (TSS). Due to the inherent solutions of the water quality models, it was necessary to convert the BOD5 from the point and nonpoint sources to TOC. The watershed loads simulated by HSPF are with respect to BOD5, TN, TP, and TSS. EFDC is a carbon-based water quality model, and therefore, the model simulates organic matter as carbon rather than BOD. Therefore, to put the watershed loads into the in-stream model, BOD5 had to be converted to TOC. By breaking the ratio down into a BODU/BOD5 and TOC/BODU components, the multiplier was justified by a typical in-stream f-ratio (ratio of ultimate BOD to a 5-day BOD) of 4.0 and literature value for converting ultimate BOD to TOC of 2.7 (Thomann and Mueller, 1987). Therefore, an 11.0 (sensitivity ranged from 10.8 to 11.2) multiplier was initially used to convert BOD5 to TOC.

Two cases were initially setup for the in-stream water quality calibrations. A human-impacted subwatershed and a natural subwatershed were selected to be the range of conditions found in the 4 basins, excluding the effect of point sources. The human-impacted subwatershed selected was the headwater of the Ochlockonee River (SWSID 322). This watershed had almost 70% agricultural land uses, a small urban component, no point sources, and exhibited low flow due its headwater location in the watershed. The natural subwatershed was on the Suwannoochee River (SWSID 203) in the Suwannee River Basin. This subwatershed had over 90% forested and wetland areas and no point sources. The EFDC model was setup for both segments and an attempt was made to create one common input file containing load multipliers, kinetic rates, and coefficients that could be used for all subwatershed types that were within the range that was established for SWSIDs 322 and 203. It became apparent that the two subwatersheds exhibited completely different characteristics of organic loading into the system. From examining measured data for BOD5 and TOC, it became obvious the differences between a carbon load in a watershed with primarily agricultural contributions versus one with primarily forest or wetland contributions. The TOC measured data were an in-stream value that would include all of the contributions of oxygen consuming material, point and nonpoint sources. From examination of the data by predominant landuse, a landuse-based multiplier was derived for each landuse type. The multipliers are listed in Table 5-3.

Table 5-3. Landuse-based Multipliers to Convert BOD5 to TOC.

| Landuse | TOC/BOD5 |
|---|---|
| Forest/Wetland | 20 |
| Agriculture | 7.5 |
| Urban | 2.3 |

### Unimpaired Waterbody Representation

Unimpaired waterbodies contributing to impaired segments were represented as a component of the watershed model. The RCHRES and GQUAL HSPF modules were used to simulate in-stream flow and general water quality. Flow determination using HSPF required development of rating curves for each stream modeled. Rating curves were developed for streams using cross-sectional dimensions estimated from regional watershed area-bankfull channel dimension curves (Rosgen, 1996). No explicit water quality interactions were represented using the GQUAL module. General first-order decay was used to represent all processes typically influencing the fate of water quality parameters, e.g. transformation, settling, etc.

## Model Testing

After developing the watershed and receiving water models to represent source contributions and in-stream response, the models were tested for validity. This testing is typically referred to as model calibration, and it involves the comparison of simulated results to observed data and the subsequent adjustment of model parameter values. Calibration of the linked models was performed for the year 1998, due to the availability of monitoring data. Hydrology and water quality were first calibrated for the watershed model. Once the preliminary calibration results from the watershed model were applied to the receiving water model, calibration of the receiving water model ensued. Calibration of the receiving water model additionally required further calibration of the watershed model, and thus an iterative approach to calibration was taken.

### Watershed Model Hydrology Calibration

Hydrologic calibration involved an adjustment of parameters related to all components of the hydrologic cycle including overland flow, infiltration, groundwater flow, and evapotranspiration. Adjustments were made during a comparison of in-stream flow monitoring data to modeled in-stream flow at a representative location for the region. The location selected was Little Satilla River near Offerman, GA (USGS02227500). The entire drainage area contributing to flow at this station was modeled and results were compared to the monitoring data. After making appropriate adjustments, the model results showed a good correlation with the observed values. The resulting hydrology parameters were validated at two additional stations in the region; Withlacoochee River at McMillan Road near Bemiss, Georgia and Okapilco Creek at Route 33 near Quitman, Georgia. A summary of calibration and validation results for these locations are presented in Appendix B. Once hydrologic parameters were calibrated and validated, the values were applied to the remaining subwatersheds in the basin.

### Watershed Model Water Quality Calibration

Once hydrology was calibrated and validated for the watershed model, calibration of water quality parameters was necessary. Water quality calibration consisted of adjusting TSS, BOD, TN, and TP buildup and washoff parameters within a reasonable range to achieve a good match between model output and in-stream water quality observations. Key considerations in the water quality calibration for the watershed model were baseflow concentrations, background concentrations, seasonal variations, and stormflow concentrations.

Initial buildup and washoff parameters were based on past studies in the southeast, including the *Nonpoint Source Pollutant Loading Evaluation - ACT and ACF Water Allocation Formula - Environmental Impact Statements* and *Water-Quality Improvements in the Lower Mississippi River Valley – Analysis of Nutrient Loadings in the Yazoo River Basin*. Each landuse category was represented by a different buildup and washoff rate, in order to simulate the variability between load contributions from different sources. The parameters were adjusted through a comparison of model output to typical loading rates from various landuses and monitoring data at the 18 water quality monitoring stations. As with the hydrology parameters, water quality parameter values were additionally applied to the remaining subwatersheds in the basin.

### Receiving Water Model Calibration

Calibration of the receiving water model focused on adjustment of kinetic parameters during a comparison of model output and monitoring data for 1998. Preliminary calibration was performed at station USGS02227015 – Hurricane Creek (CR331) Near Alama, GA, and the resulting parameter values were applied to the remaining impaired waterbodies. In some situations the preliminary calibrated parameters required further change. Calibration results for dissolved oxygen at station USGS02227015 are presented in Appendix C. The remaining modeled waterbodies exhibited similar results.

Kinetic parameters that required adjustment included reaeration formula, ratios for nutrient splits, leaf litterfall nutrient split, and density of periphyton. For the in-stream, EFDC model runs, the primary water quality parameters for evaluating a calibrated model were dissolved oxygen and TOC. Secondary parameters include ammonia, nitrate-nitrite, total nitrogen, and total phosphorus. SOD and COD benthic flux were also examined to see how much oxygen demand was derived by the sediment. In addition to the water quality calibration, flow, velocity, and depth were examined to ensure proper calibration of the hydrodynamics.

## 6.0 Loading Capacity

The tested model was ultimately used to identify the allowable loading capacity for the listed segments. The first step in the process was to determine naturally occurring dissolved oxygen concentrations for the impaired waterbodies. By doing so, the applicable water quality standard used for TMDL development was identified.

To determine the naturally occurring dissolved oxygen concentrations, the in-stream models were run using watershed model input representing pristine conditions (entirely forest and wetland contributions) and leaf litterfall. The resultant in-stream dissolved oxygen concentrations represented natural conditions. The minimum daily average dissolved oxygen concentration observed during the critical summer period was compared to the water quality standards. The range of values was representative of naturally low dissolved oxygen concentrations and was below 110% of the state water quality standard, therefore the EPA criteria was instituted and dissolved oxygen target limits were identified for TMDL development. The target limits were identified as 90% of the minimum naturally occurring concentration for impaired waterbodies.

After identifying the dissolved oxygen target limits, the models were run to determine the loading capacity of the waterbody. This was done through a series of simulations aimed at meeting the dissolved oxygen target limit by varying source contributions. The final acceptable scenario represented the TMDL (and loading capacity of the waterbody). Subsequent sections of this report present components of the TMDL.

### Confirmation of Waterbodies Reaching Dry Conditions

An analysis of USGS daily discharge data at selected gaging stations located throughout the southern four Georgia basins suggests that many streams in the region actually exhibit no-flow conditions for extended periods of time. Several of the impaired waterbodies dry for significant periods of time throughout the year. Analysis of water quality is virtually impossible during no-flow conditions and situations where streams contain no flow or pooled non flowing water. Seven stations were selected for the analysis. Each station is located on a unique waterbody representing a drainage area between 139 and 1,260 mi$^2$ (Table 6-1).

Table 6-1. USGS Gaging Stations and Characteristics

| USGS Gaging Station ID | Drainage Area ($mi^2$) | Waterbody | Basin | Period of Record |
|---|---|---|---|---|
| 02227000 | 139 | Hurricane Creek | Satilla | 10/1/51 - 10/8/71 |
| 02227500 | 646 | Little Satilla River | Satilla | 1/27/51 - 9/30/98 |
| 02314500 | 1,260 | Suwannee River | Suwannee | 4/20/37 - 9/30/98 |
| 02316000 | 663 | Alapaha River | Suwannee | 4/26/37 - 9/30/76 |
| 02317755 | 537 | Withlacoochee River | Suwannee | 10/20/76 - 1/4/90 |
| 02318000 | 577 | Little River | Suwannee | 6/12/40 - 9/30/71 |
| 02318700 | 269 | Okapilco Creek | Suwannee | 12/21/79 - 9/30/98 |

The three stations representing the smallest drainage areas (02227000, 02317755, and 02318700) had no-flow days more than 9% of the time. The remaining stations, representing larger watersheds, exhibited no-flow conditions less than 1% of the time. Although the timing of no-flow conditions varied from one waterbody to the next, the most common months exhibiting no-flow conditions were October, November, and June. Precipitation data for the basin supports these trends in that October and November are typically the driest months, and June often exhibits lower rainfall totals (compared to other months). Refer to Appendix A for detailed information regarding precipitation at appropriate weather stations in the basin. Table 6-2 presents information, by station, related to no-flow time periods.

Table 6-2. No-Flow Characteristics for Selected USGS Gaging Stations

| USGS Gaging Station ID | Days with No Flow | Total Days | % of Days with No Flow | Month with Most No-Flow Days |
|---|---|---|---|---|
| 02227000 | 745 | 7306 | 10.20 | June |
| 02227500 | 50 | 17414 | 0.29 | October |
| 02314500 | 74 | 22,444 | 0.33 | November |
| 02316000 | 106 | 14403 | 0.74 | October |
| 02317755 | 142 | 1233 | 11.52 | November |
| 02318000 | 17 | 11433 | 0.15 | June |
| 02318700 | 683 | 6859 | 9.96 | October |

Under no-flow conditions, the development or determination of an appropriate naturally occurring dissolved oxygen water quality standard is not possible or appropriate. Therefore, when using the models to identify minimum dissolved oxygen concentrations under natural conditions, no-flow periods were not considered. The minimum dissolved oxygen concentrations and related loadings were identified only during periods when there was flow in the stream.

## 7.0 Waste Load and Load Allocations

Two critical components of the TMDL are the Waste Load Allocations (WLAs) and the Load Allocations (LAs). The WLAs represent the load allocations to point source facilities contributing to impaired waterbodies, while the LAs represent load allocations to the nonpoint source contributions. LAs are assumed to represent all watershed and leaf litterfall loads to the impaired waterbody. The LAs are divided into subwatersheds (representing all subwatersheds contributing to an impaired waterbody).

The WLAs and LAs presented in Appendix D represent successful allocation scenarios (in which the dissolved oxygen target limit is met). WLAs and LAs sum to represent the entire TMDL, because MOS is implicitly considered through model assumptions.

The partitioning of allocations between point (WLA) and nonpoint (LA) sources was based on modeling results and professional judgment to meet the TMDL. The WLAs may be modified by GAEPD during the NPDES permitting process. The TMDLs will be used to assess the permit renewals in the impaired segments.

The WLA and LAs presented in Appendix D represent allocation scenarios in which the dissolved oxygen standard is met. The analysis on two segments of Seventeen Mile River indicates that NPDES permit limits for the existing discharge are not stringent enough to ensure compliance with the dissolved oxygen standard. As the draft TMDL for dissolved oxygen for these two segments of the Seventeen Mile River did not provide a WLA for the point source, a separate TMDL for the two Seventeen Mile River segments will be developed and public noticed. All other point sources in the Satilla River Basin are addressed in Appendix D.

## 8.0 Margin of Safety

The margin of safety (MOS) is part of the TMDL development process. There are two basic methods for incorporating the MOS (USEPA, 1991):

- Implicitly incorporate the MOS using conservative model assumptions to develop allocations, and
- Explicitly specify a portion of the total TMDL as the MOS; use the remainder for allocations.

The MOS was considered implicitly in the TMDL development process. Conservative modeling assumptions include:

- Running dynamic model,
- Permitted point sources are loaded into model for allocation runs (average monthly permit values), taking into account the daily maximum loads,
- Running model with actual flow and temperature during one or more annual cycles including a critical summer period, and
- 41% saturation for upstream dissolved oxygen (Meyer, 1992).

## 9.0 Seasonal Variation

The Statute and regulations require that a TMDL be established with consideration of seasonal variations. Seasonal variation was considered through dynamic representation of a full calendar year. The model simulations included a wide range of hydrologic and pollutant loading scenarios and led to development of a TMDL corresponding to these scenarios.

## 10.0 Monitoring Plan

The GAEPD has adopted a basin approach to water quality management; an approach that divides Georgia's major river basins into five groups. Each year the GAEPD water quality monitoring resources are concentrated in one of the basin groups. One goal is to continue to monitor 303(d) listed waters. This monitoring will occur in the next monitoring cycle for the Satilla in 2003 and will help further characterize water quality conditions resulting from the implementation of best management practices in the watershed.

## 11.0 Point and Nonpoint Source Approaches

Permitted discharges will be regulated through the NPDES permitting process described in this report. The total organic carbon nonpoint source loading to the streams in the Satilla River is made up of a combination of naturally occuring leaf litter and anthropogenic non-point source loads. Because most, if not all, total organic carbon loading to streams in the Satilla River Basin is the result of nonpoint sources, the implementation goal for nonpoint sources will be to reduce the total organic carbon loading from anthropogenic non-point source loads. The reduction in anthropogenic non-point source loading should lead to the attainment of water quality standards. To ensure that anthropogenic non-point source load reductions occur in the Satilla River Basin, Georgia EPD will work with the Natural Resource Conservation Service (NRCS), the Georgia Soil and Water Conservation Commission (GSWCC), and the Georgia Forestry Commission to implement best management practices (BMPs) to reduce anthropogenic nonpoint source loading of total organic carbon. Implementation of BMPs to reduce anthropogenic non-point source loading of total organic carbon is expected to lead to the attainment of water quality standards.

## 12.0 Public Participation

A sixty-day public notice was provided for this TMDL. During that time the availability of the TMDL was public noticed, a copy of the TMDL was provided as requested, and the public was invited to provide comments on the TMDL.

## 13.0 References

Bicknell, B.R. et al., 1996. Hydrological Simulation Program – Fortran (HSPF) User's Manual for Release 11. Environmental Research Laboratory, Office of Research and Development, USEPA, Athens, GA.

Cerco, C.F. and T.M. Cole, 1994. Three-dimensional eutrophication model of Chesapeake Bay: Volume 1, main report. Technical Report EL-94-4, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

DiToro, D.M. and J.J. Fitzpatrick, 1993. Chesapeake Bay sediment flux model. Contract Report EL-93-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Dyar, T.R. and S.J. Alhadeff, 1997. Stream-Temperature Characteristics in Georgia. United States Geological Survey prepared in cooperation with the Georgia Department on Natural Resources Environmental Protection Division, Water-Resources Investigations Report 96-4203.

Edwards, R.T. and J.L. Meyer, 1987. Metabolism of a subtropical low gradient blackwater river." *Freshwater Biology*, 17:251-263.

Galperin, B., L.H. Kantha, S. Hassid, and A. Rosati, 1988. A quasi-equilibrium turbulent energy model for geophysical flows. *Journal of Atmospheric Sciences*, 45, 55-62.

GAEPD (Georgia Environmental Protection Division), 1996. Georgia's Watershed Protection Approach: River Basin Management Planning, Draft Program Description. February 1996.

GAEPD (Georgia Environmental Protection Division), 1999. *Rules and Regulations for Water Quality Control. Chapter 391-3-6.* Revised July 6th. Georgia Department of Natural Resources. Environmental Protection Division. Atlanta, GA.

Hamrick, J.M., 1992. A three-dimensional environmental fluid dynamics computer code: theoretical and computational aspects. The College of William and Mary, Virginia Institute of Marine Science. Special Report 317, 63pp.

Hamrick, J.M., 1996. User's Manual for the Environmental Fluid Dynamics Computer Code. Special Report No. 331 in Applied Marine Science and Ocean Engineering, Department of Physical Sciences, School of Marine Sciences, Virginia Institute of Marine Sciences.

Mellor, G.L. and T. Yamada, 1982. Development of a turbulence closure model for geophysical fluid problems. *Rev. Geophys. Space. Phys.*, 20, 851-875.

Meyer, J.L., 1992. Seasonal patterns of water quality in blackwater rivers of the Coastal Plain, Southeastern United States. *Water Quality in North American River Systems,* Battelle Press, Columbus, Ohio, pages 249-276.

Meyer et al., 1997. Organic matter dynamics in the Ogeechee River, a blackwater river in Georgia, USA. *Journal of the North American Benthological Society*, 16(1):1.

Novotny et al., 1989. *Karl Imhoff's handbook of urban drainage and wastewater disposal*. Wiley, New York.

Park, K. et al., 1995. A Three-Dimensional Hydrodynamic-Eutrophication Model (HEM-3D) Description of Water Quality and Sediment Process Submodels (EFDC Water Quality Model). Special Report No. 327 in Applied Marine Science and Ocean Engineering, Department of Physical Sciences, School of Marine Sciences, Virginia Institute of Marine Sciences.

Sierra Club v. Hankinson. Civil Action File No. 1: 94-CV-2501-MHS. Consent decree signed 7/15/97.

Thomann, R.V. and J.A. Mueller, 1987. Principles of surface water quality modeling and control. Harper Collins Publishers Inc., New York.

U.S. Army Corps of Engineers. 1998. Nonpoint Source Pollutant Loading Evaluation-ACT and ACF Water Allocation Formula-Snvironmental Impact Statements.

USEPA, 1991. *Guidance for Water Quality Based Decisions: The TMDL Process*. EPA 440/4-91-001. U.S. Environmental Protection Agency; Assessment and Watershed Protection Division, Washington, DC.

USEPA Region 4, 1999. Draft – Water Quality Improvements in the Lower Mississippi River Valley: Analysis of Nutrient Loading in the Yazoo River Basin.

USEPA, 1986. Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Freshwater). Office of Water Regulations and Standards Criteria and Standards Division, EPA440/5-86-003.

USGS, 1999. *National Water Data Storage and Retrieval System (WATSTORE)*. U.S. Geological Survey, Reston, VA.

Wharton, C. H. and M. M. Brinson, 1979. Characteristics of southeastern river systems. Pages 32-40 in R. R. Johnson and J. F. McCormick, editors. Strategies for protection and management of floodplain wetlands and other riparian ecosystems. U. S. Forest Service General Technical Report WO-12. National Technical Information Service, Springfield, VA.

# *Appendix A*

# *Data Used in TMDL Analyses*

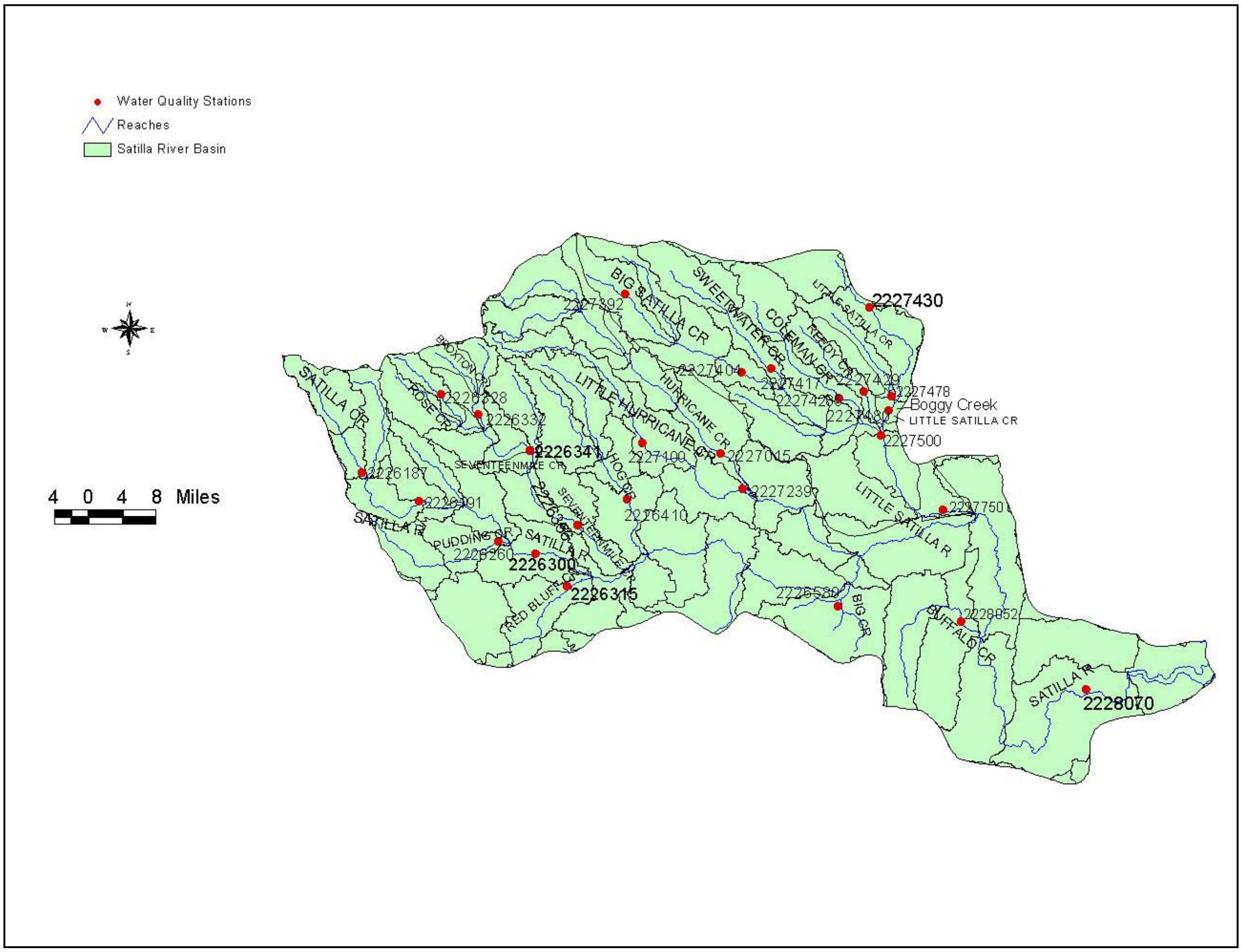


Figure A-1. Water Quality Stations in the Satilla River Basin

**Table A-1. Summary of Dissolved Oxygen Data from Monitoring Stations for 1998**

| USGS ID NO | Station Description | HUC | Dissolved Oxygen (mg/L) | | | No of Meas. |
|---|---|---|---|---|---|---|
| | | | min | max | mean | |
| 2226187 | SATILLA CREEK (CR 559) NEAR HOLT, GA. | 30702010102 | 1 | 11 | 5.4 | 19 |
| 2226191 | SATILLA RIVER (CR 48) NEAR DOUGLAS, GA. | 30702010104 | 0.9 | 11.2 | 5.9 | 18 |
| 2226260 | PUDDING CREEK (SR 31) NEAR PEARSON, GA | 30702010205 | 0.4 | 10.1 | 4.8 | 19 |
| 2226300 | SATILLA RIVER AT ST RT 64 NEAR PEARSON, GA. | 30702010301 | 2.7 | 8.9 | 5.4 | 20 |
| 2226315 | RED BLUFF CREEK NEAR PEARSON, GA | 30702010303 | 0.3 | 9.3 | 4.4 | 20 |
| 2226328 | ROSES CREEK (SR 268) AT BROXTON, GA. | 30702010403 | 0.3 | 10.1 | 5.5 | 19 |
| 2226332 | BROXTON CREEK (CR 358) NEAR BROXTON, GA. | 30702010401 | 0.1 | 9.7 | 5.1 | 19 |
| 2226341 | SEVENTEEN MILE RIVER AT SR 32 NR DOUGLAS, GA. | 30702010501 | 1.2 | 10.5 | 5.1 | 19 |
| 2226356 | SEVENTEEN MILE RIVER AT SR 64 NR STOKESVILLE, GA | 30702010503 | 2.4 | 8.8 | 5.5 | 19 |
| 2226373 | HOG CREEK (SR 32) AT NICHOLLS, GA | 30702010602 | 3.9 | 7.9 | 5.5 | 22 |
| 2226410 | HOG CREEK (CR 467) AT BICKLEY, GA. | 30702010604 | 2.9 | 7.0 | 4.7 | 22 |
| 2226475 | SATILLA RIVER AT WALTERTOWN, GA. | 30702010703 | 4.0 | 8.8 | 6.3 | 20 |
| 2226580 | BIG CREEK NEAR HOBOKEN, GA. | 30702010705 | 1.2 | 8.8 | 4.7 | 20 |
| 2226582 | SATILLA RIVER AT ST RTS 15&121 NEAR HOBOKEN, GA. | 30702010704 | 3.6 | 8.6 | 6.1 | 20 |
| 2226840 | HURRICANE CREEK (CR 294) NEAR DENTON, GA. | 30702010901 | 3.7 | 7.5 | 5.0 | 22 |
| 2227015 | HURRICANE CREEK (CR 331) NEAR ALMA, GA. | 30702011002 | 2.0 | 7.6 | 4.4 | 22 |
| 2227100 | LITTLE HURRICANE CREEK NEAR ALMA, GA. | 30702010903 | 2.1 | 7.6 | 4.2 | 22 |
| 2227239 | LITTLE HURRICANE CREEK (CR 220) NR BLACKSHEAR, GA. | 30702010904 | 2.9 | 7.6 | 4.6 | 22 |
| 2227318 | ALABAHA RIVER (CR 160) NEAR BLACKSHEAR, GA. | 30702011004 | 2.7 | 8.8 | 6.1 | 20 |
| 2227392 | BIG SATILLA CREEK (CR 536) NEAR BAXLEY, GA. | 30702020101 | 3.2 | 6.4 | 4.5 | 22 |
| 2227404 | BIG SATILLA CREEK (SR 203) NEAR BAXLEY, GA. | 30702020104 | 2.0 | 6.3 | 3.7 | 22 |
| 2227417 | SWEETWATER CREEK (SR 203) NEAR BAXLEY, GA. | 30702020202 | 3.1 | 7.6 | 4.7 | 22 |
| 22274285 | COLEMANS CREEK (CR 185) NEAR SCREVEN, GA. | 30702020304 | 0.3 | 8.9 | 5.0 | 19 |
| 2227429 | REEDY CREEK (CR 390) NEAR SCREVEN, GA. | 30702020404 | 0.3 | 9.8 | 4.1 | 19 |
| 2227430 | LITTLE SATILLA CREEK AT US RT 341 AT ODUM, GA. | 30702020402 | 0.8 | 8.2 | 4.4 | 15 |
| 2227478 | BOGGY CREEK (CR 207) AT SCREVEN, GA. | 30702020403 | 0.4 | 9.3 | 3.6 | 20 |
| 2227480 | LITTLE SATILLA CREEK (COUNTY RD) NR SCREVEN, GA. | 30702020404 | 0.4 | 8.6 | 4.2 | 19 |
| 2227500 | LITTLE SATILLA RIVER NEAR OFFERMAN, GA. | 30702020501 | 2.0 | 8.9 | 5.8 | 20 |
| 2227750 | LITTLE SATILLA RIVER (US 301) NR HORTENSE, GA. | 30702020501 | 3.5 | 8.0 | 6.0 | 23 |
| 2228000 | SATILLA RIVER AT ATKINSON, GA. | 30702011102 | 2.8 | 8.9 | 6.2 | 23 |
| 2228052 | BUFFALO CREEK (CR 81) NEAR HICKOX, GA. | 30702011104 | 0.6 | 8.7 | 4.9 | 23 |
| 2228060 | SATILLA RIVER (GA HWY 252) NR BURNT FORT, GA. | 30702011105 | 4.2 | 8.5 | 5.4 | 23 |
| 2228070 | SATILLA RIVER (U.S.HWY.17) AT WOODBINE, GA. | 30702011201 | 2.2 | 7.8 | 4.8 | 22 |

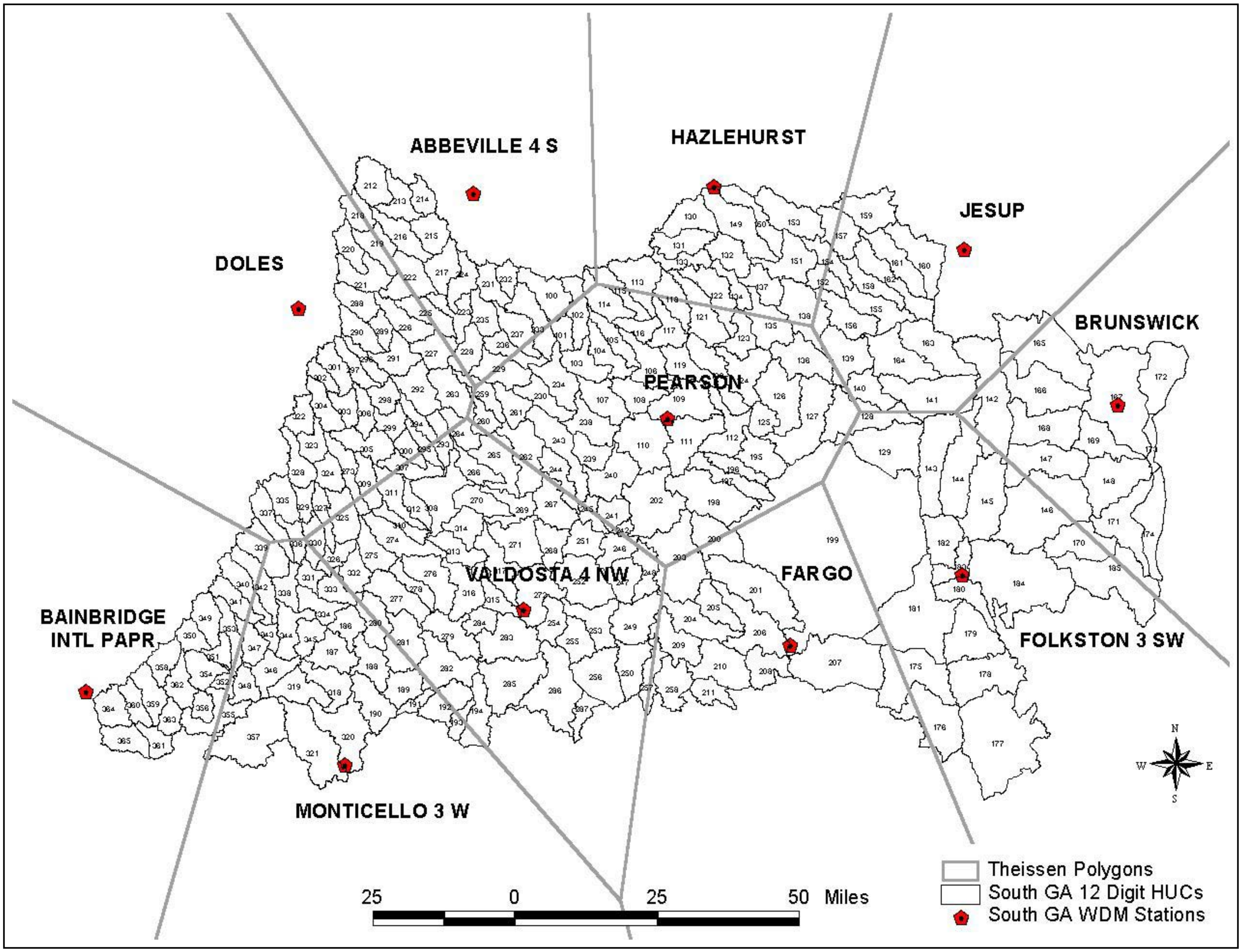


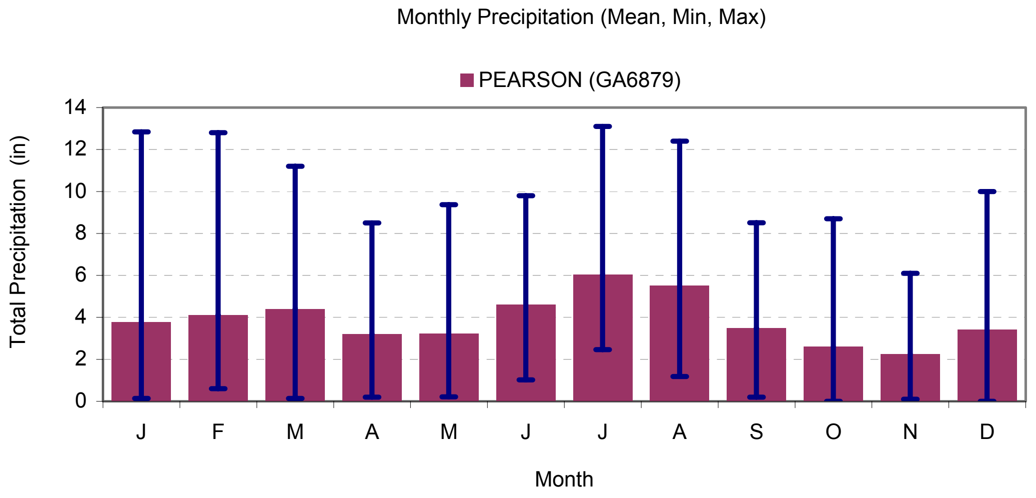
Figure A-2. Meteorological Stations for Southern 4 Basins Used in Watershed Model

**TOTAL MONTLY PRECIPITATION (IN)**

Station: PEARSON (GA6879)

Analysis Period: 50 years (from June, 1948 to May, 1998)

| Month | Count | Mean | Min | Max | St Dev | Median | 25th | 75th |
|---|---|---|---|---|---|---|---|---|
| January | 50 | 3.78 | 0.14 | 12.84 | 2.42 | 3.65 | 1.90 | 5.28 |
| February | 50 | 4.12 | 0.60 | 12.80 | 2.26 | 4.05 | 2.25 | 5.48 |
| March | 50 | 4.40 | 0.14 | 11.20 | 2.52 | 3.80 | 2.52 | 5.62 |
| April | 50 | 3.21 | 0.20 | 8.50 | 2.31 | 2.80 | 1.40 | 4.78 |
| May | 50 | 3.22 | 0.21 | 9.37 | 2.06 | 2.76 | 1.80 | 4.48 |
| June | 50 | 4.61 | 1.02 | 9.80 | 2.12 | 4.41 | 2.87 | 5.52 |
| July | 50 | 6.04 | 2.46 | 13.10 | 2.08 | 5.95 | 4.74 | 7.28 |
| August | 50 | 5.52 | 1.18 | 12.40 | 3.00 | 4.43 | 3.34 | 6.85 |
| September | 50 | 3.49 | 0.20 | 8.51 | 2.10 | 3.27 | 2.03 | 4.98 |
| October | 50 | 2.60 | 0.00 | 8.70 | 2.19 | 1.86 | 1.06 | 3.51 |
| November | 50 | 2.25 | 0.10 | 6.10 | 1.60 | 1.87 | 0.93 | 3.33 |
| December | 50 | 3.41 | 0.00 | 10.00 | 2.09 | 2.85 | 2.03 | 4.57 |



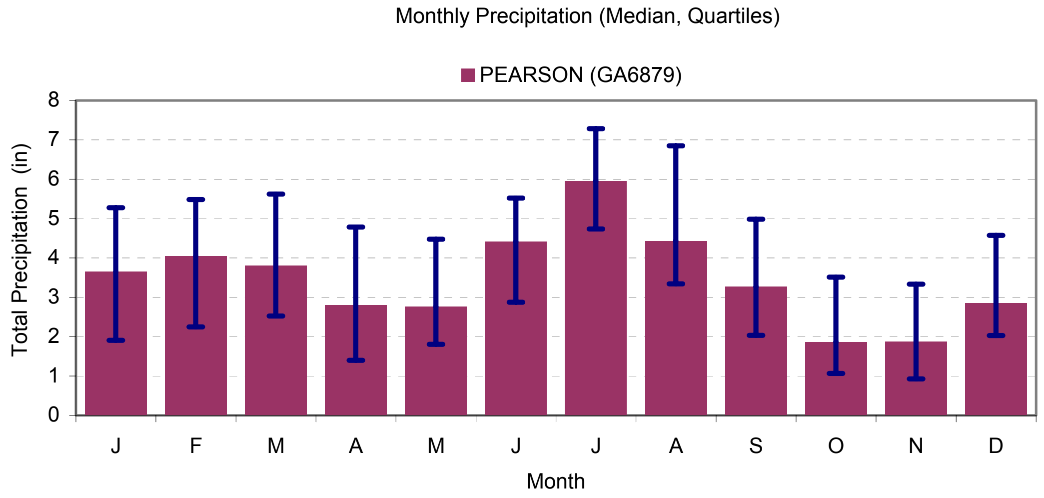
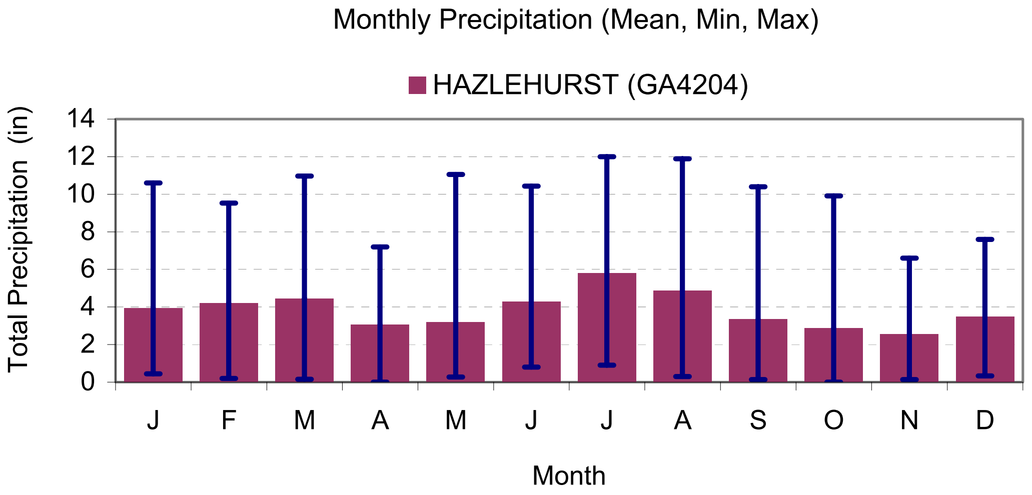


**Figure A-3. Average Monthly Mean Precipitation for Pearson (GA6879)**

## TOTAL MONTLY PRECIPITATION (IN)

Station: HAZLEHURST (GA4204)
Analysis Period: 50 years (from June, 1948 to May, 1998)

| Month | Count | Mean | Min | Max | St Dev | Median | 25th | 75th |
|---|---|---|---|---|---|---|---|---|
| January | 50 | 3.95 | 0.44 | 10.60 | 2.43 | 3.60 | 2.31 | 5.38 |
| February | 50 | 4.19 | 0.20 | 9.53 | 2.27 | 3.98 | 2.28 | 6.07 |
| March | 50 | 4.45 | 0.15 | 10.97 | 2.53 | 3.78 | 2.43 | 6.35 |
| April | 50 | 3.06 | 0.00 | 7.20 | 2.08 | 2.50 | 1.14 | 4.49 |
| May | 50 | 3.19 | 0.27 | 11.05 | 2.35 | 2.65 | 1.51 | 4.02 |
| June | 50 | 4.28 | 0.80 | 10.43 | 2.11 | 3.86 | 2.82 | 5.42 |
| July | 50 | 5.80 | 0.90 | 12.00 | 2.68 | 5.65 | 3.41 | 7.52 |
| August | 50 | 4.87 | 0.30 | 11.89 | 2.91 | 4.24 | 2.29 | 7.03 |
| September | 50 | 3.35 | 0.14 | 10.40 | 2.51 | 2.89 | 1.27 | 4.34 |
| October | 50 | 2.87 | 0.00 | 9.91 | 2.73 | 1.65 | 0.84 | 4.30 |
| November | 50 | 2.54 | 0.14 | 6.60 | 1.91 | 1.67 | 1.01 | 4.23 |
| December | 50 | 3.48 | 0.33 | 7.60 | 1.73 | 3.22 | 2.20 | 4.70 |


Monthly Precipitation (Mean, Min, Max)

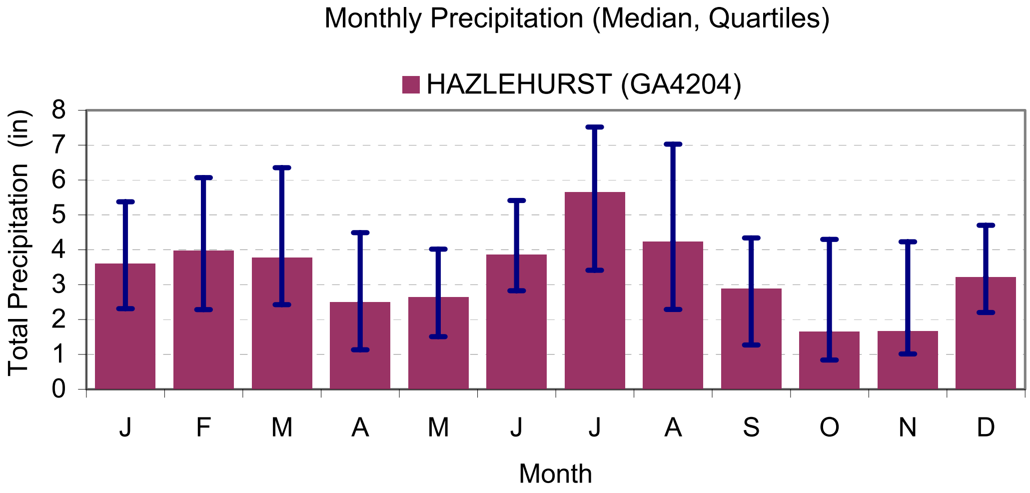

Monthly Precipitation (Median, Quartiles)

**Figure A-4. Average Monthly Mean Precipitation for Hazelhurst (GA4202)**

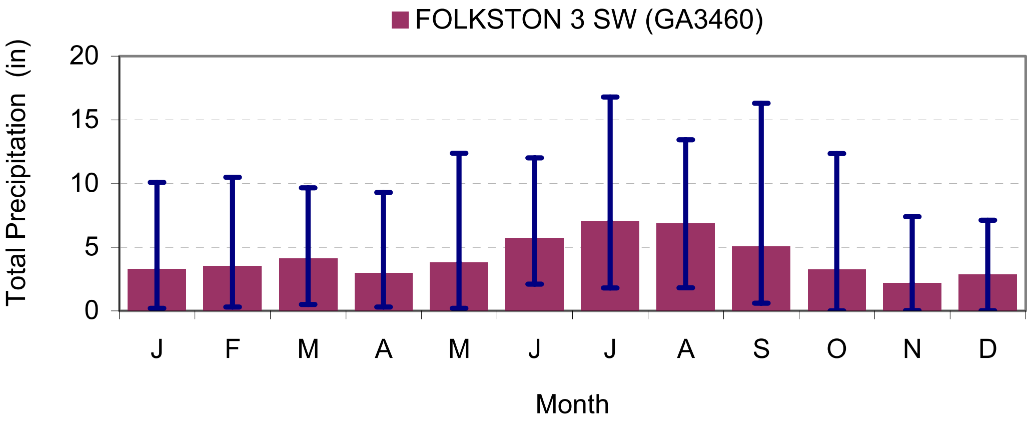
**TOTAL MONTLY PRECIPITATION (IN)**

Station: FOLKSTON 3 SW (GA3460)

Analysis Period: 50 years (from July, 1948 to June, 1998)

| Month | Count | Mean | Min | Max | St Dev | Median | 25th | 75th |
|---|---|---|---|---|---|---|---|---|
| January | 50 | 3.29 | 0.20 | 10.10 | 2.26 | 3.11 | 1.55 | 4.55 |
| February | 50 | 3.54 | 0.30 | 10.50 | 2.12 | 3.20 | 2.22 | 4.51 |
| March | 50 | 4.11 | 0.50 | 9.67 | 2.59 | 3.98 | 1.95 | 5.05 |
| April | 50 | 2.97 | 0.30 | 9.30 | 2.26 | 2.30 | 1.31 | 3.96 |
| May | 50 | 3.81 | 0.20 | 12.39 | 2.63 | 3.07 | 2.12 | 5.34 |
| June | 50 | 5.75 | 2.10 | 12.02 | 2.16 | 6.02 | 3.78 | 7.16 |
| July | 50 | 7.07 | 1.80 | 16.80 | 3.18 | 6.45 | 4.77 | 8.94 |
| August | 50 | 6.85 | 1.81 | 13.44 | 3.12 | 5.99 | 4.52 | 9.48 |
| September | 50 | 5.07 | 0.60 | 16.31 | 3.42 | 4.27 | 2.64 | 6.46 |
| October | 50 | 3.25 | 0.00 | 12.36 | 2.62 | 2.65 | 1.46 | 4.79 |
| November | 50 | 2.20 | 0.02 | 7.40 | 1.55 | 1.78 | 1.10 | 3.23 |
| December | 50 | 2.87 | 0.01 | 7.12 | 1.83 | 2.34 | 1.46 | 4.57 |

Monthly Precipitation (Mean, Min, Max)



Monthly Precipitation (Median, Quartiles)

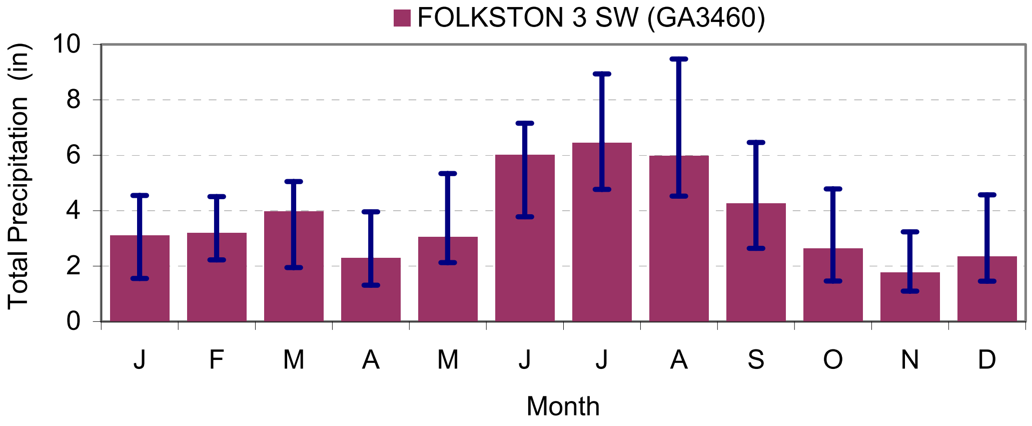


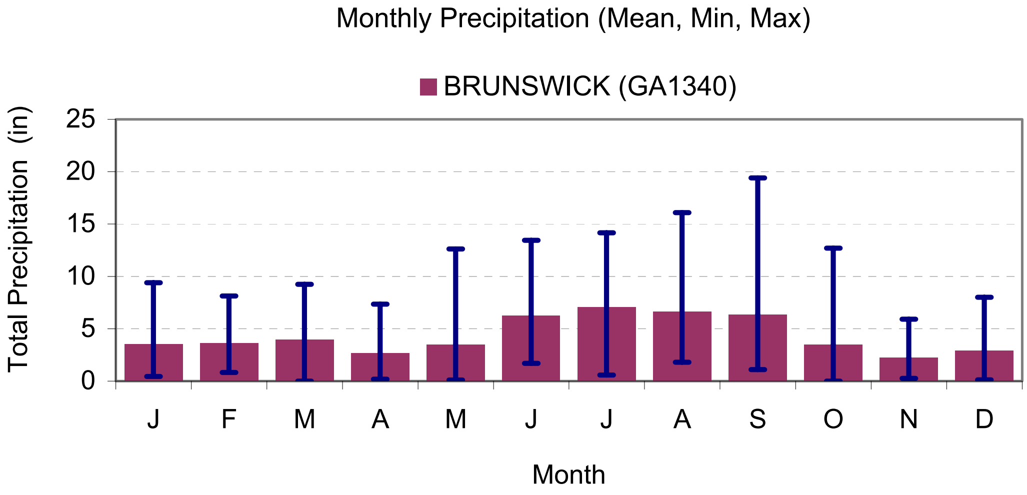
Figure A-5. Average Monthly Mean Precipitation for Folkston 3 SW (GA3460)

**TOTAL MONTLY PRECIPITATION (IN)**

Station: BRUNSWICK (GA1340)

Analysis Period: 34 years (from July, 1964 to November, 1998)

| Month | Count | Mean | Min | Max | St Dev | Median | 25th | 75th |
|---|---|---|---|---|---|---|---|---|
| January | 34 | 3.52 | 0.45 | 9.40 | 2.23 | 3.20 | 1.47 | 5.45 |
| February | 34 | 3.60 | 0.83 | 8.13 | 1.90 | 3.34 | 2.20 | 4.51 |
| March | 34 | 3.96 | 0.00 | 9.24 | 2.35 | 3.94 | 2.23 | 4.82 |
| April | 34 | 2.68 | 0.18 | 7.35 | 1.83 | 2.35 | 1.10 | 3.78 |
| May | 34 | 3.50 | 0.10 | 12.62 | 2.73 | 2.94 | 1.67 | 4.40 |
| June | 34 | 6.23 | 1.70 | 13.44 | 3.03 | 6.16 | 3.55 | 7.98 |
| July | 35 | 7.05 | 0.58 | 14.17 | 3.55 | 6.49 | 4.80 | 10.31 |
| August | 35 | 6.65 | 1.80 | 16.09 | 3.33 | 6.12 | 4.47 | 7.85 |
| September | 35 | 6.37 | 1.10 | 19.41 | 4.18 | 5.97 | 3.73 | 7.57 |
| October | 35 | 3.48 | 0.00 | 12.70 | 2.70 | 3.06 | 1.58 | 4.66 |
| November | 35 | 2.23 | 0.26 | 5.92 | 1.69 | 1.60 | 0.76 | 3.42 |
| December | 34 | 2.90 | 0.12 | 8.00 | 1.82 | 2.42 | 1.59 | 4.19 |



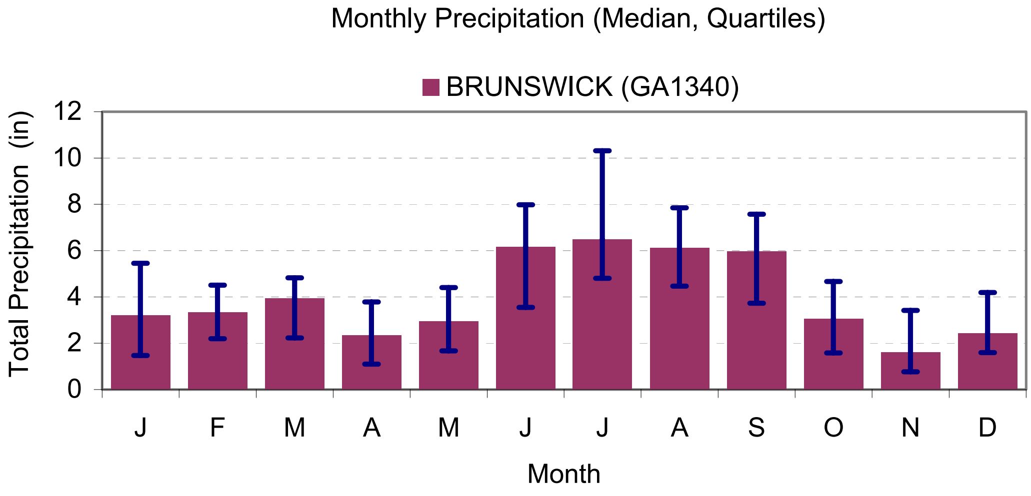
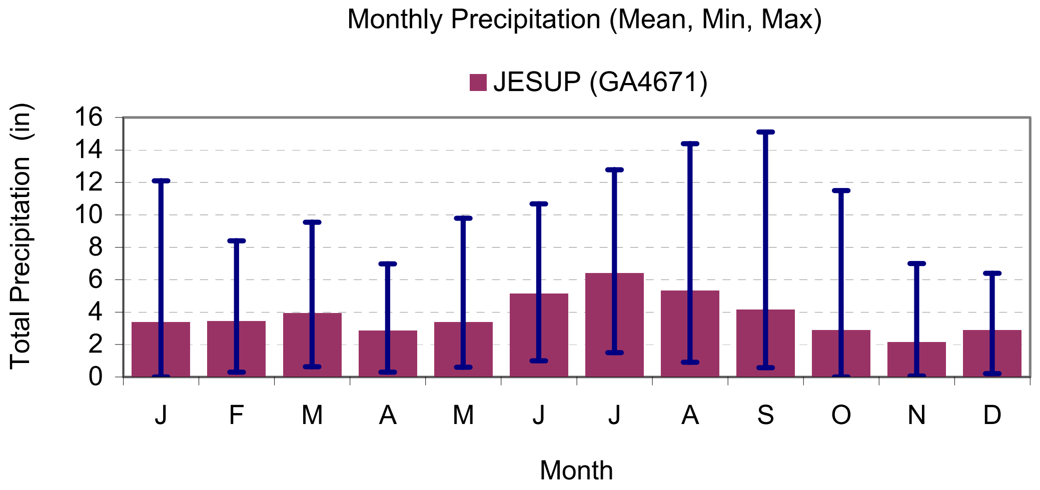


**Figure A-6. Average Monthly Mean Precipitation for Brunswick (GA1340)**

**TOTAL MONTLY PRECIPITATION (IN)**

Station: JESUP (GA4671)
Analysis Period: 50 years (from June, 1948 to May, 1998)

| Month | Count | Mean | Min | Max | St Dev | Median | 25th | 75th |
|---|---|---|---|---|---|---|---|---|
| January | 50 | 3.38 | 0.00 | 12.10 | 2.46 | 3.07 | 1.40 | 4.45 |
| February | 50 | 3.43 | 0.30 | 8.40 | 1.80 | 3.34 | 2.34 | 4.60 |
| March | 50 | 3.95 | 0.63 | 9.54 | 2.37 | 3.30 | 1.91 | 5.48 |
| April | 50 | 2.86 | 0.30 | 6.98 | 1.81 | 2.55 | 1.66 | 3.63 |
| May | 50 | 3.37 | 0.60 | 9.79 | 2.24 | 2.74 | 1.82 | 4.50 |
| June | 50 | 5.13 | 1.00 | 10.68 | 2.41 | 5.05 | 3.19 | 6.83 |
| July | 50 | 6.40 | 1.50 | 12.78 | 2.55 | 6.32 | 4.58 | 7.84 |
| August | 50 | 5.33 | 0.91 | 14.39 | 3.09 | 4.48 | 3.13 | 7.18 |
| September | 50 | 4.14 | 0.57 | 15.10 | 3.12 | 3.71 | 1.99 | 5.32 |
| October | 50 | 2.89 | 0.00 | 11.50 | 2.66 | 2.52 | 0.97 | 4.09 |
| November | 50 | 2.16 | 0.06 | 7.00 | 1.84 | 1.43 | 0.79 | 3.17 |
| December | 50 | 2.87 | 0.21 | 6.40 | 1.61 | 2.59 | 1.65 | 4.40 |



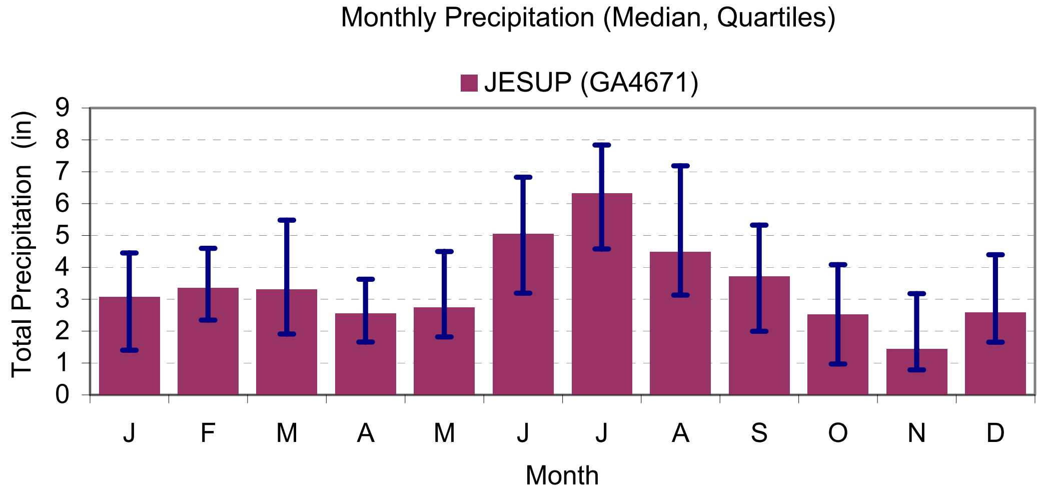


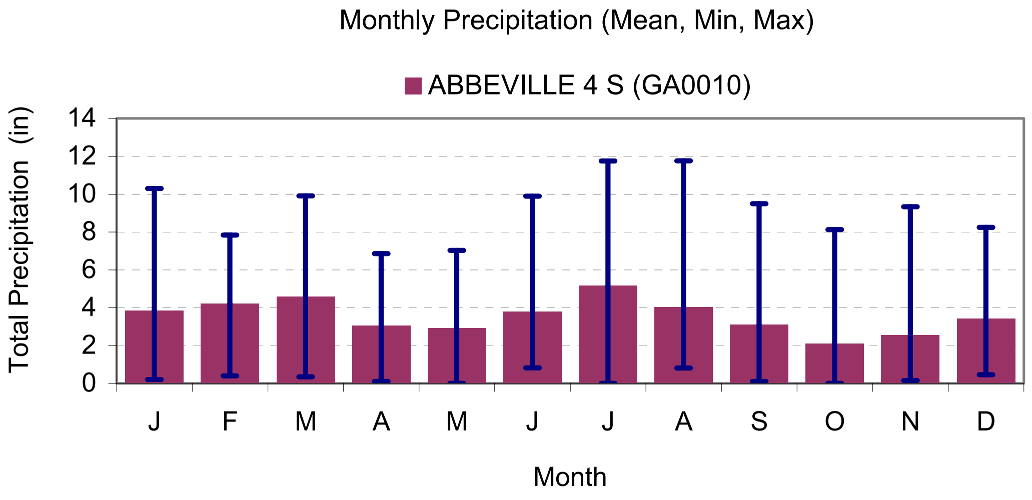
**Figure A-7. Average Monthly Mean Precipitation for Jessup (GA4671)**

**TOTAL MONTLY PRECIPITATION (IN)**

Station: ABBEVILLE 4 S (GA0010)

Analysis Period: 50 years (from June, 1948 to June, 1998)

| Month | Count | Mean | Min | Max | St Dev | Median | 25th | 75th |
|---|---|---|---|---|---|---|---|---|
| January | 50 | 3.85 | 0.20 | 10.30 | 2.46 | 3.44 | 1.91 | 5.28 |
| February | 50 | 4.20 | 0.40 | 7.84 | 2.06 | 4.05 | 2.76 | 5.90 |
| March | 50 | 4.59 | 0.35 | 9.91 | 2.28 | 4.67 | 2.85 | 6.21 |
| April | 50 | 3.05 | 0.10 | 6.86 | 2.02 | 2.79 | 1.15 | 4.28 |
| May | 50 | 2.91 | 0.00 | 7.03 | 1.94 | 2.39 | 1.61 | 3.59 |
| June | 51 | 3.78 | 0.82 | 9.90 | 1.78 | 3.44 | 2.50 | 4.90 |
| July | 50 | 5.16 | 0.00 | 11.76 | 2.85 | 4.87 | 2.82 | 6.70 |
| August | 50 | 4.03 | 0.81 | 11.77 | 2.38 | 3.92 | 2.24 | 5.11 |
| September | 50 | 3.11 | 0.10 | 9.50 | 2.19 | 2.51 | 1.39 | 4.38 |
| October | 50 | 2.10 | 0.00 | 8.13 | 1.96 | 1.65 | 0.61 | 2.99 |
| November | 50 | 2.55 | 0.15 | 9.34 | 2.14 | 2.08 | 0.76 | 3.41 |
| December | 49 | 3.42 | 0.46 | 8.25 | 1.67 | 2.95 | 2.33 | 4.45 |



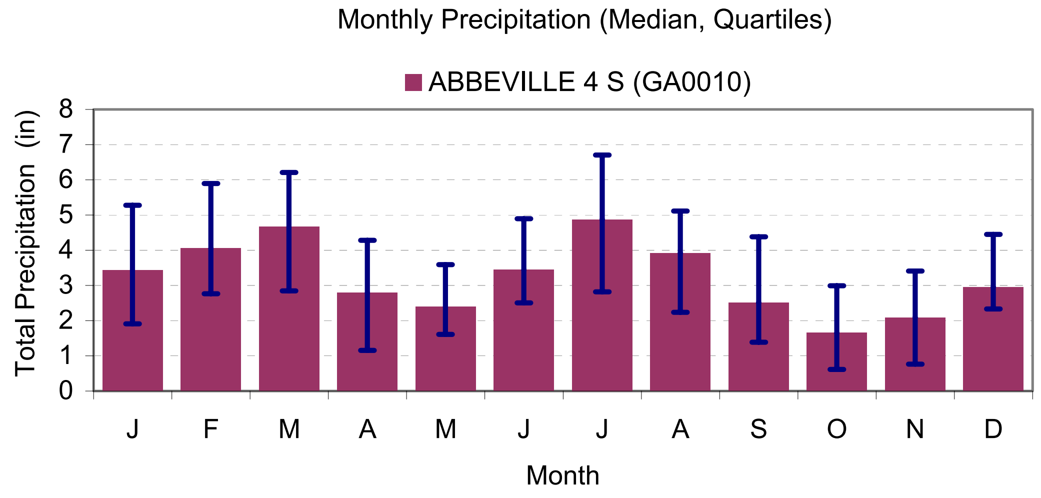


**Figure A-8. Average Monthly Mean Precipitation for Abbeville (GA0010)**

### Table A-2: Land Use Distribution for Impaired Segments

| GA 12-digit Watershed ID | Built-up Impervious (acres) | Built-up Pervious (acres) | Cropland (acres) | Forest (acres) | Pasture (acres) | Wetland (acres) | TOTAL (acres) |
|---|---|---|---|---|---|---|---|
| 30702010102 | 43 | 389 | 3737 | 3312 | 1445 | 2496 | 11422 |
| 30702010104 | 116 | 1035 | 7852 | 6972 | 1812 | 4490 | 22278 |
| 30702010205 | 187 | 1499 | 7846 | 8485 | 1991 | 3765 | 23773 |
| 30702010301 | 527 | 3335 | 10756 | 17171 | 2050 | 6628 | 40467 |
| 30702010303 | 646 | 4503 | 6379 | 21459 | 910 | 6232 | 40129 |
| 30702010401 | 390 | 2972 | 12959 | 11580 | 2875 | 2895 | 33671 |
| 30702010403 | 176 | 1221 | 7225 | 5248 | 2238 | 2286 | 18393 |
| 30702010501 | 748 | 2399 | 6390 | 6854 | 1489 | 3285 | 21165 |
| 30702010503 | 140 | 1251 | 7185 | 8972 | 1562 | 3808 | 22919 |
| 30702010602 | 239 | 2063 | 9292 | 17069 | 1600 | 1614 | 31878 |
| 30702010604 | 250 | 2232 | 5331 | 19570 | 1171 | 5661 | 34215 |
| 30702010703 | 1163 | 4842 | 9226 | 28356 | 1393 | 10517 | 55496 |
| 30702010704 | 2419 | 4907 | 10724 | 18083 | 1953 | 10852 | 48939 |
| 30702010705 | 989 | 6386 | 8032 | 32065 | 2258 | 8940 | 58669 |
| 30702010901 | 280 | 2518 | 3812 | 7988 | 688 | 484 | 15770 |
| 30702010903 | 397 | 1890 | 9706 | 15196 | 1571 | 3884 | 32643 |
| 30702010904 | 190 | 1694 | 8294 | 17786 | 1209 | 6302 | 35474 |
| 30702011002 | 514 | 3438 | 12503 | 20122 | 1734 | 5247 | 43558 |
| 30702011004 | 508 | 1482 | 8233 | 7636 | 1768 | 4135 | 23762 |
| 30702011102 | 788 | 6475 | 2125 | 43610 | 644 | 23778 | 77420 |
| 30702011104 | 461 | 3778 | 3817 | 33738 | 800 | 13564 | 56158 |
| 30702011105 | 767 | 6665 | 1318 | 28622 | 350 | 19285 | 57008 |
| 30702011201 | 1277 | 8878 | 411 | 50822 | 333 | 39775 | 101495 |
| 30702020101 | 547 | 3017 | 14926 | 19700 | 1521 | 3813 | 43523 |
| 30702020104 | 49 | 434 | 5429 | 5763 | 628 | 2546 | 14850 |
| 30702020202 | 78 | 541 | 7193 | 6400 | 1096 | 3026 | 18333 |
| 30702020304 | 70 | 621 | 10804 | 5419 | 1152 | 3181 | 21248 |
| 30702020402 | 267 | 2103 | 9987 | 20364 | 1498 | 3957 | 38177 |
| 30702020403 | 239 | 2139 | 6529 | 19922 | 1551 | 1464 | 31844 |
| 30702020404 | 249 | 1929 | 10806 | 16030 | 1464 | 4104 | 34582 |
| 30702020501 | 459 | 3797 | 3284 | 23353 | 835 | 13359 | 45086 |

Source: USGS MRLC – 1990’s

Note: Built-up includes low and high residential, high and low commercial and barren land uses.

# Appendix B

# Hydrology Calibration and Validations

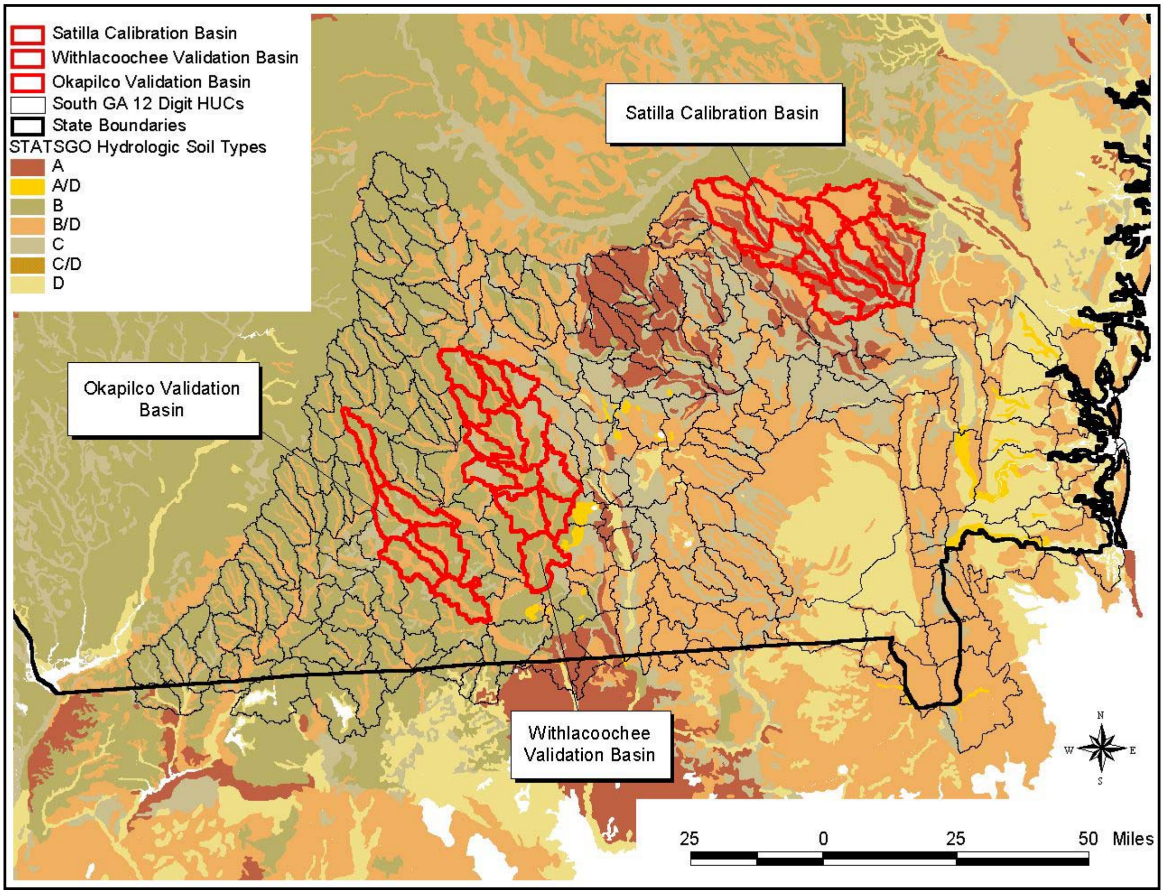


Figure B-1. Location of hydrology calibration and validation basins.

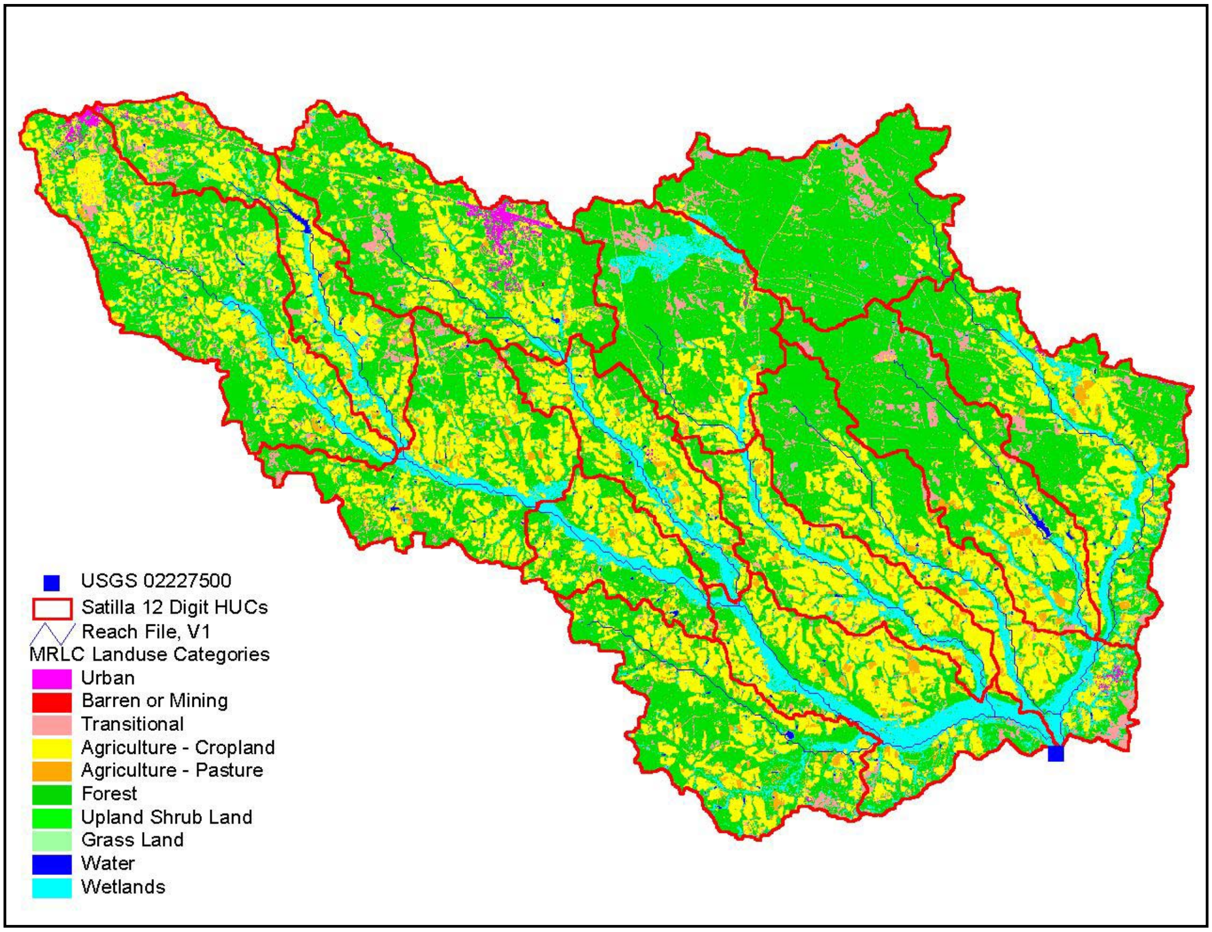


**Figure B-2. Hydrology calibration drainage basin, Little Satilla River near Offerman, GA.**

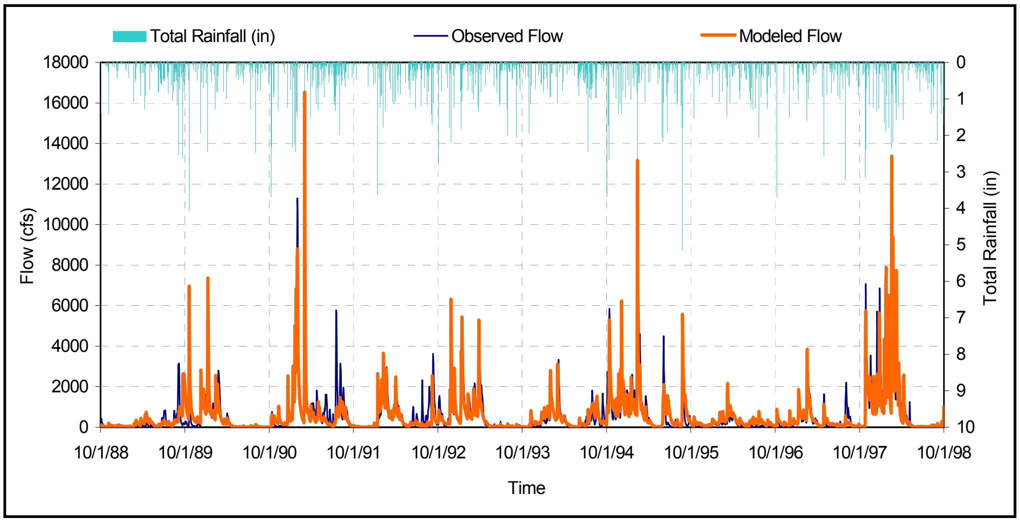


Figure B-3. 10-year calibration (daily flow) at Little Satilla River near Offerman, GA

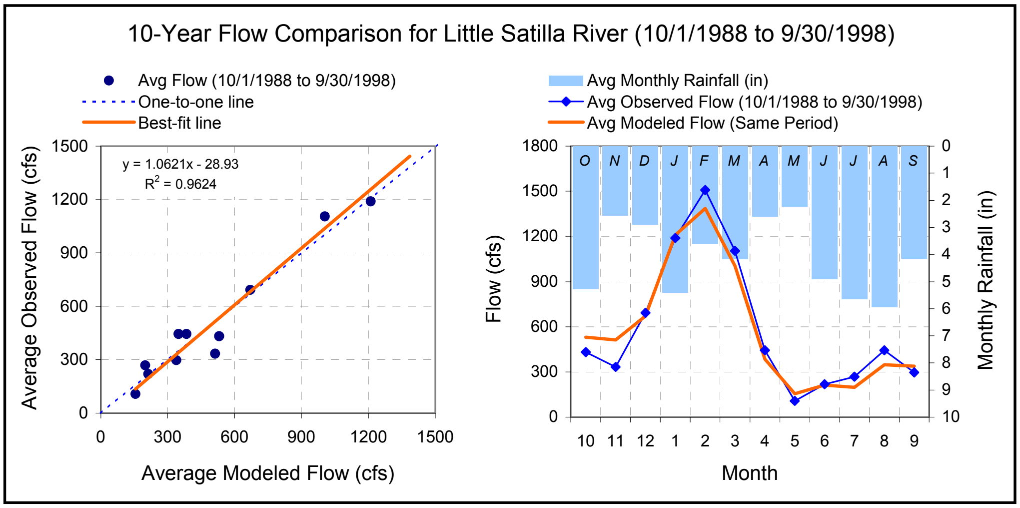


Figure B-4. 10-year calibration (monthly average) at Little Satilla River near Offerman, GA.

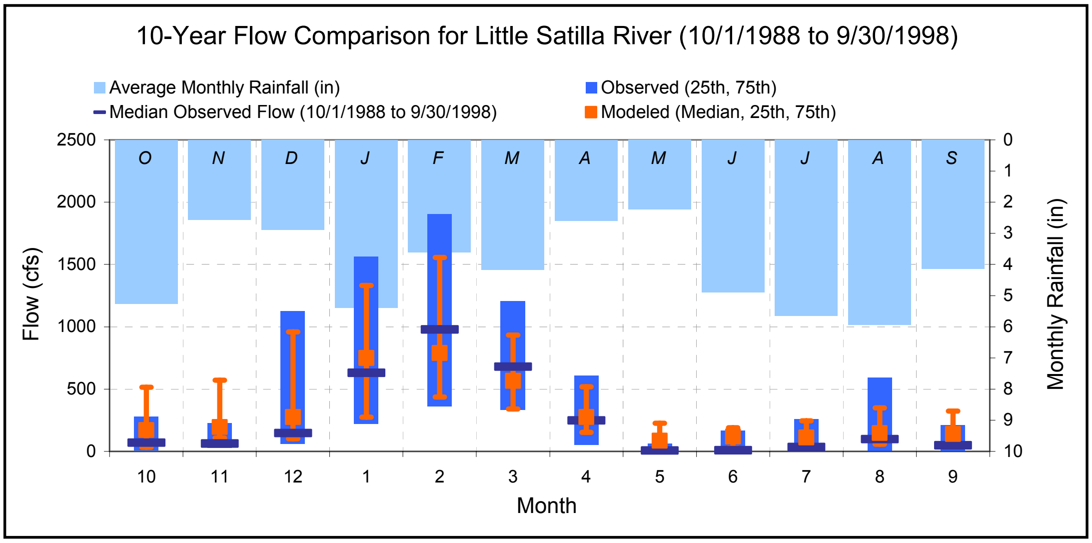


Figure B-5. 10-year calibration (monthly medians), Little Satilla River near Offerman, GA.

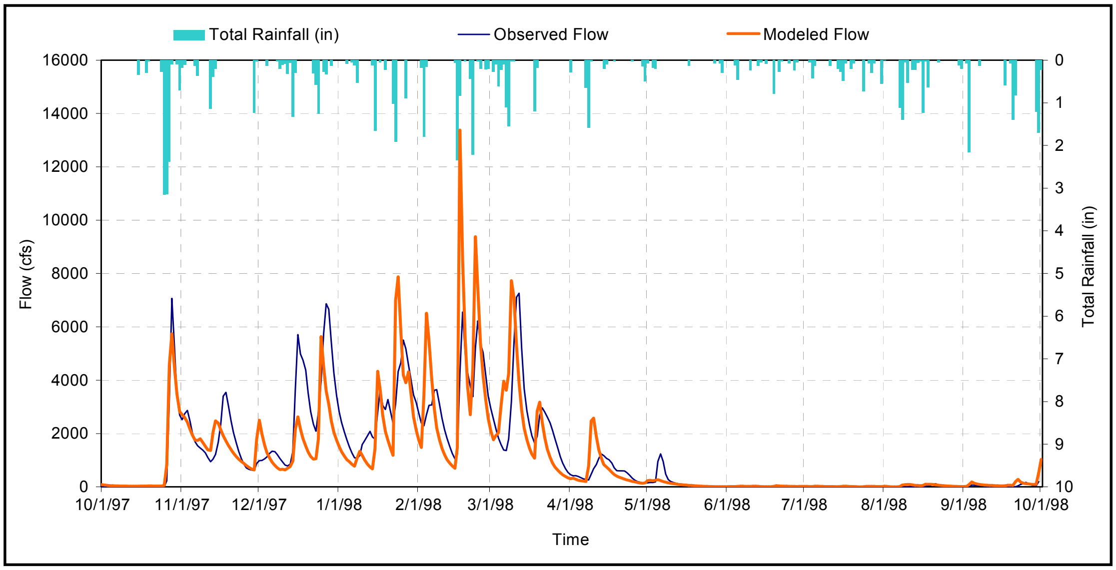


**Figure B-6. Water year 1998 (daily flow), Little Satilla River near Offerman, GA.**

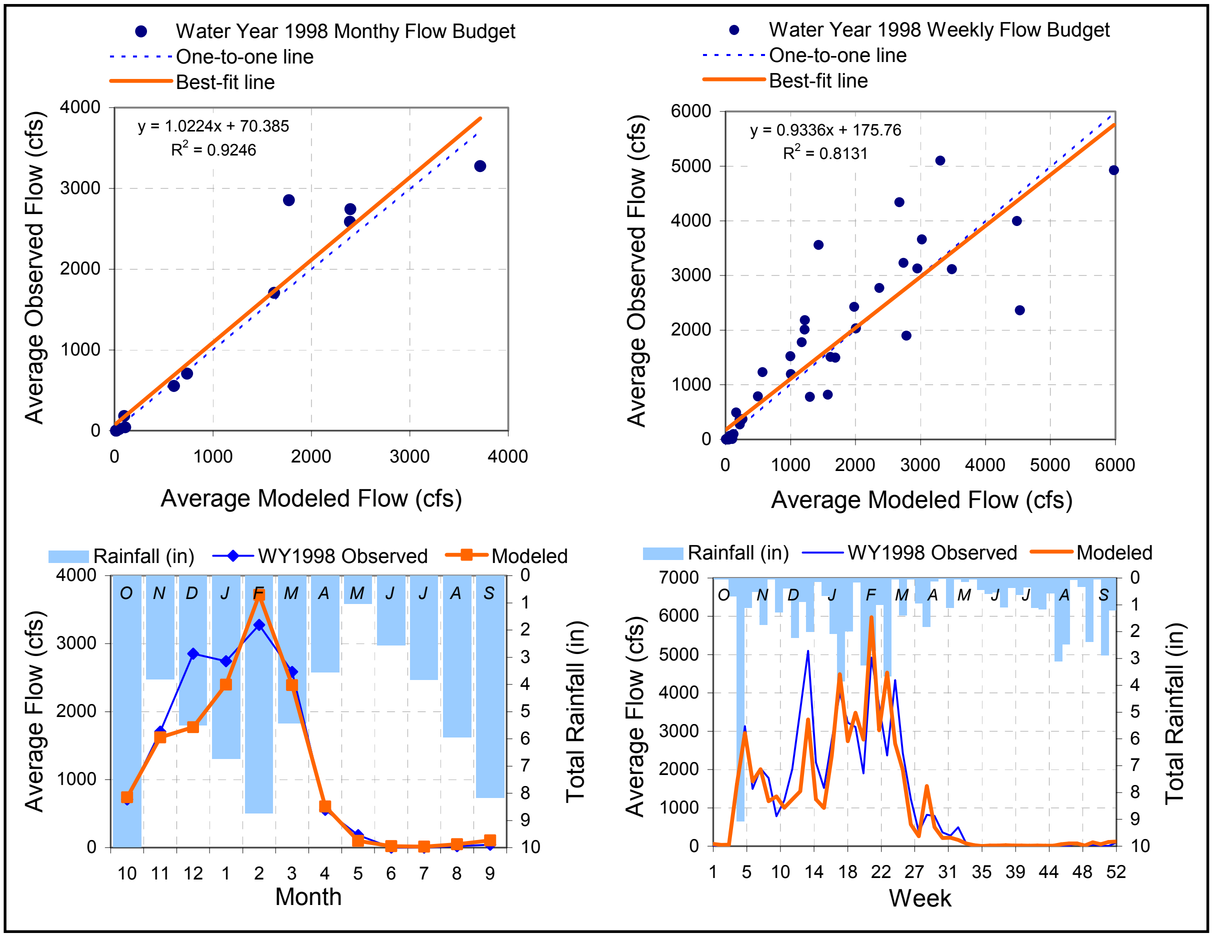


Figure B-7. Water year 1998 (monthly & weekly), Little Satilla River near Offerman, GA.

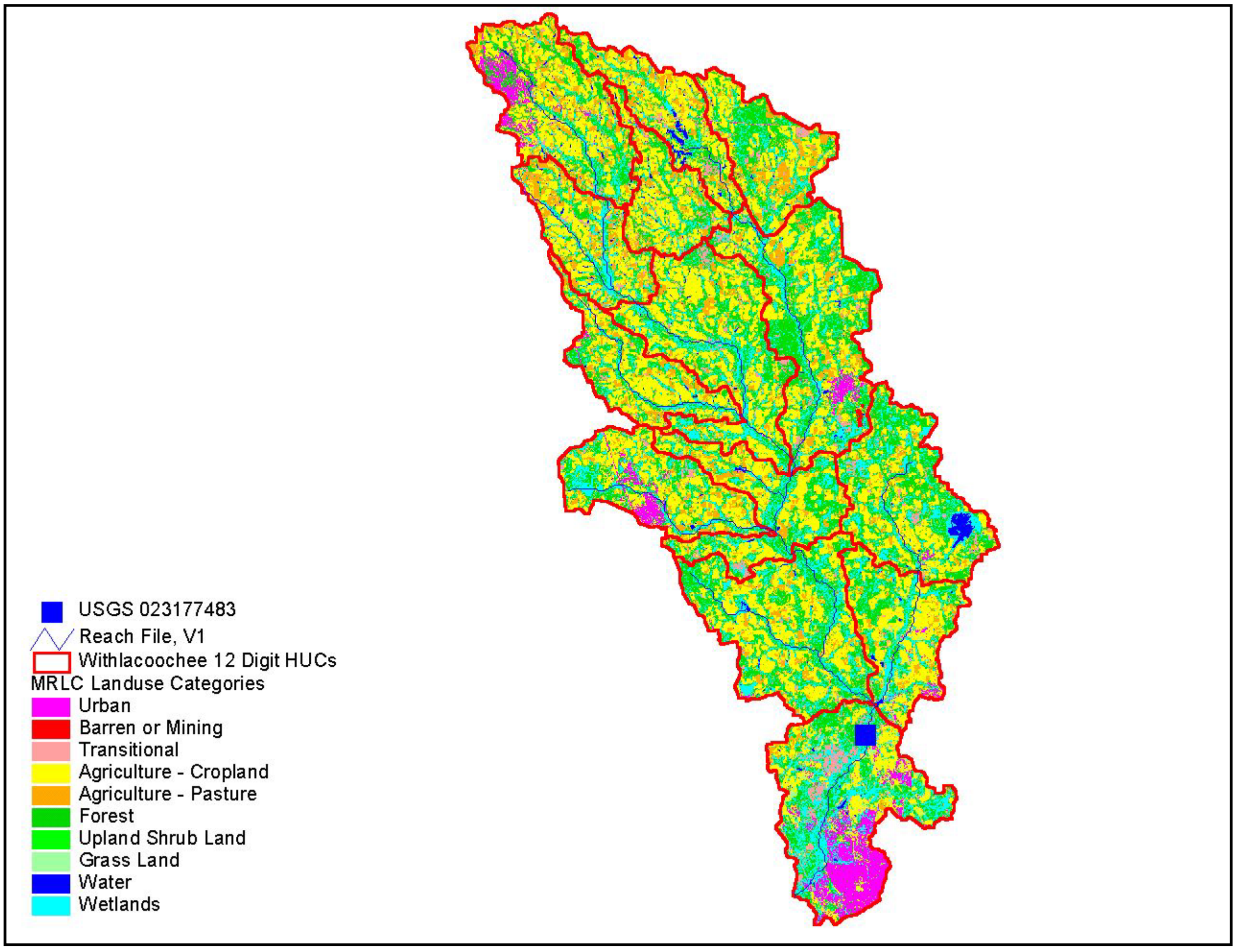


**Figure B-8. Hydrology validation 1 drainage basin, Withlacoochee River at McMillan Rd near Bemiss, GA.**

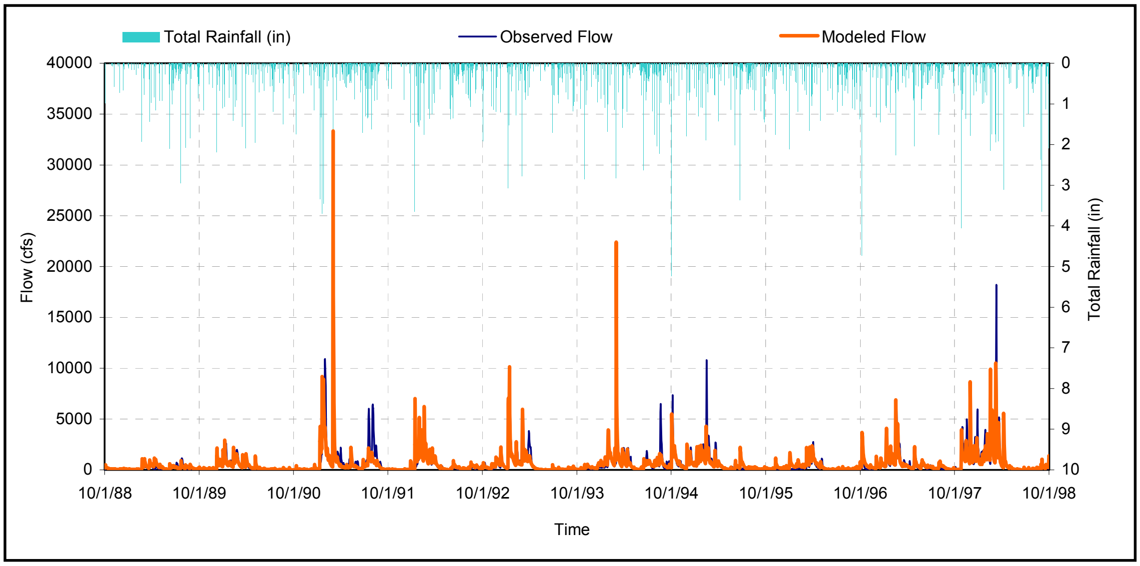


Figure B-9. 10-year validation (daily flow), Withlacoochee River at McMillan Rd near Bemiss, GA.

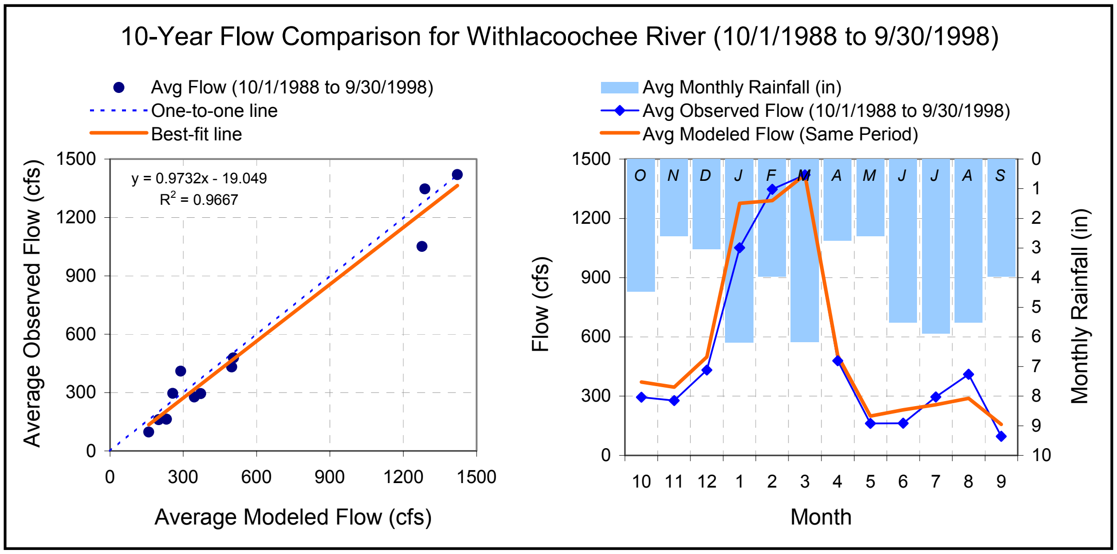


**Figure B-10. 10-year validation (monthly average), Withlacoochee River at McMillan Rd near Bemiss, GA.**

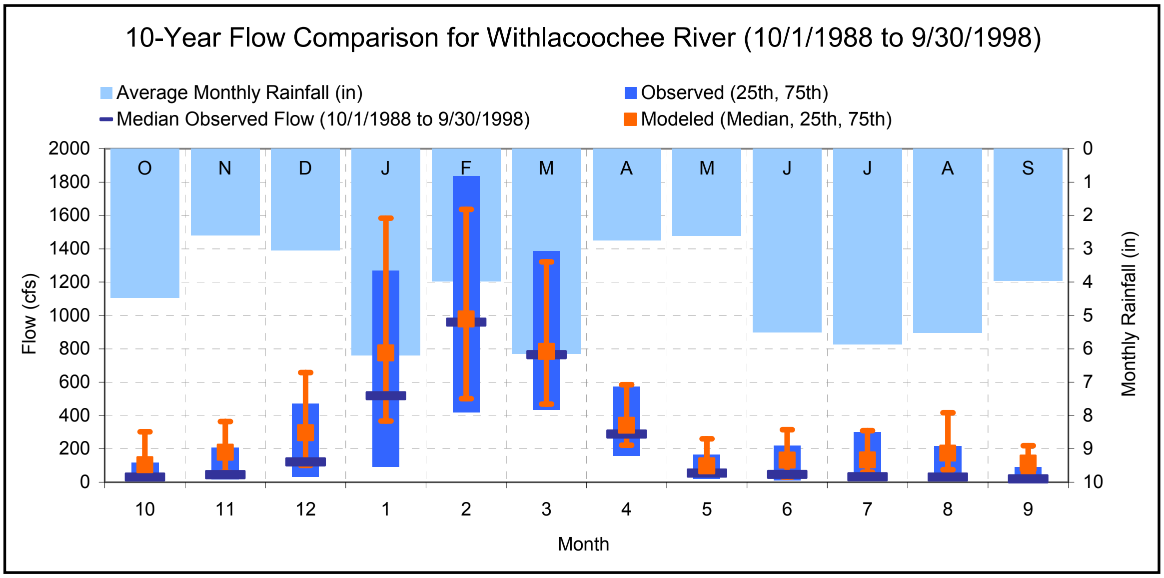


Figure B-11. 10-year validation (monthly medians), Withlacoochee River at McMillan Rd near Bemiss, GA.

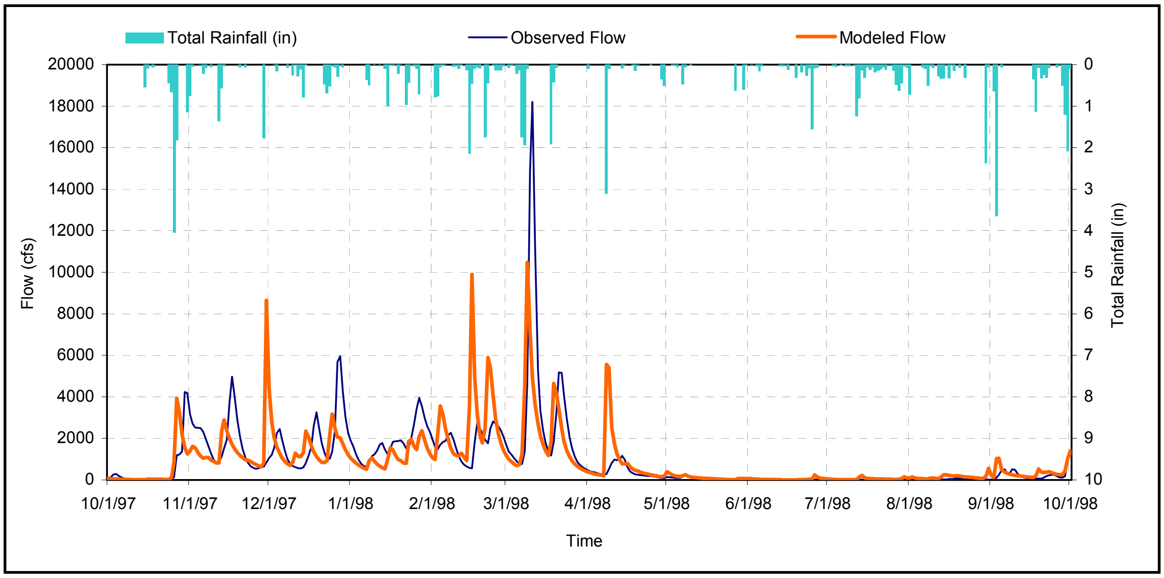


Figure B-12. Water year 1998 (daily flow), Withlacoochee River at McMillan Rd near Bemiss, GA.

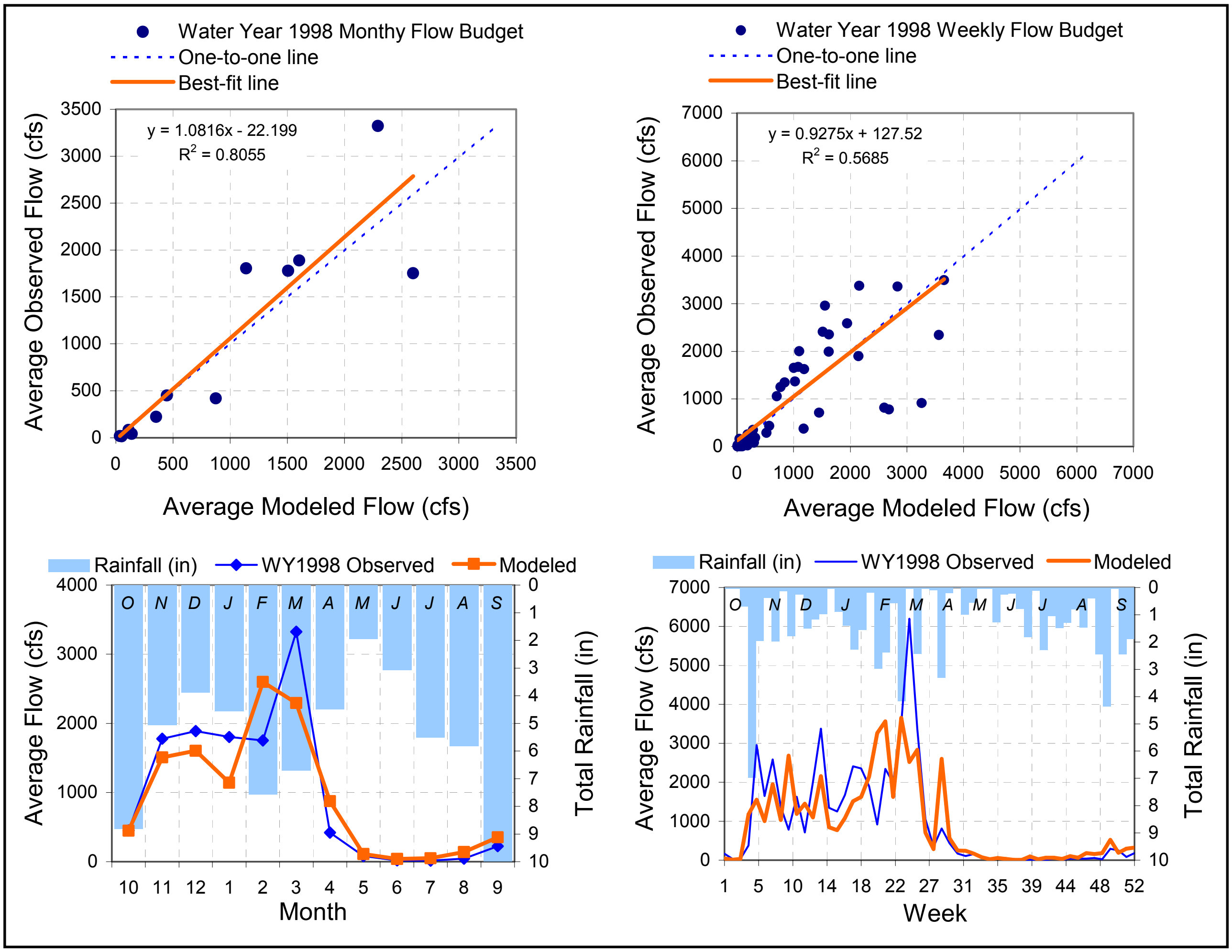


**Figure B-13. Water year 1998 (monthly & weekly), Withlacoochee River at McMillan Rd near Bemiss, GA.**

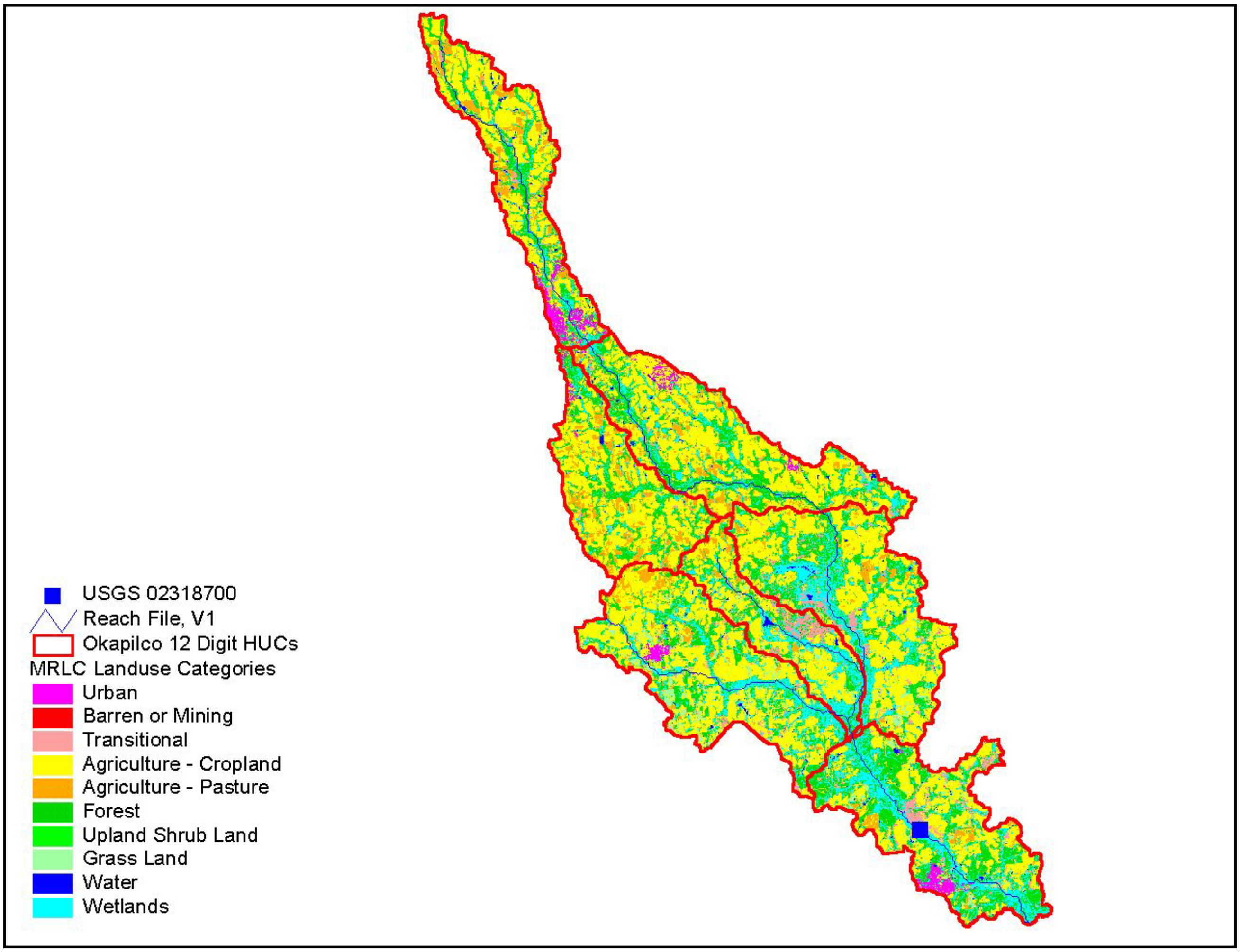


Figure B-14. Hydrology validation 2 drainage basin, Okapilco Creek at RT 33 near Quitman, GA.

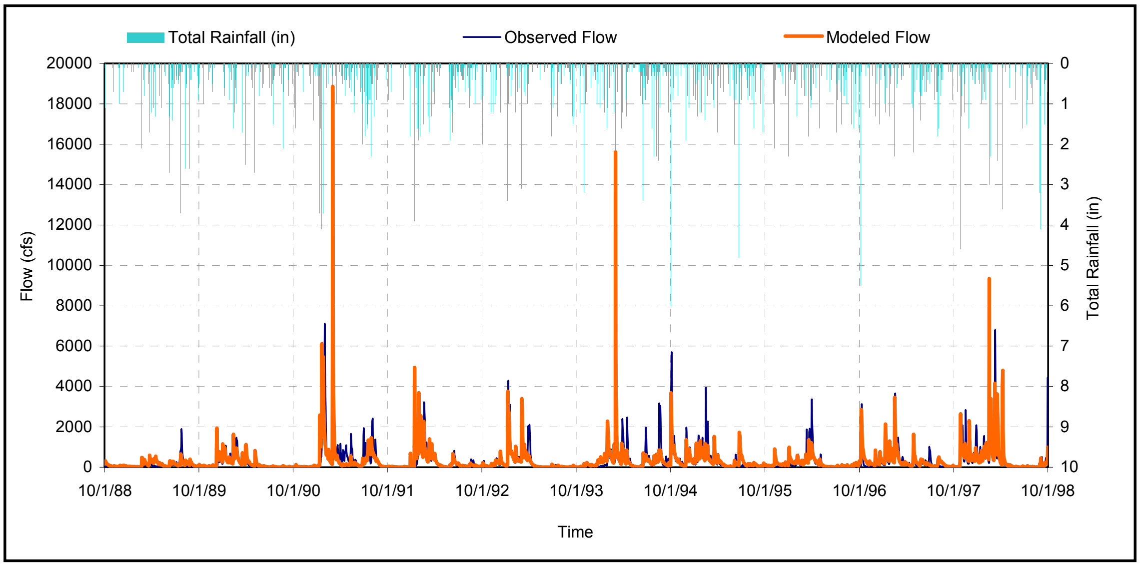


Figure B-15. 10-year validation (daily flow), Okapilco Creek at ST RT 33 near Quitman, GA.

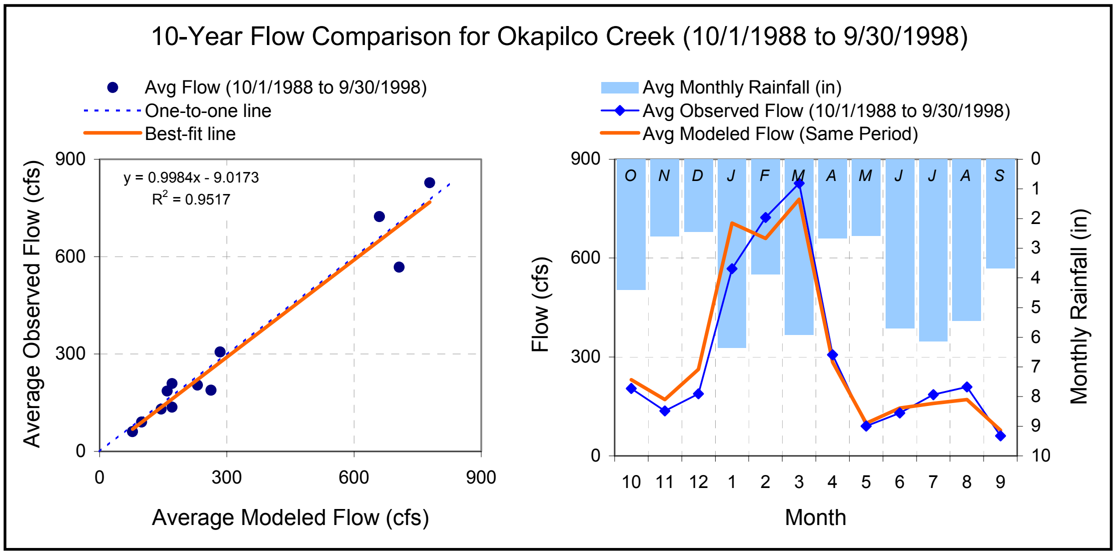


Figure B-16. 10-year validation (monthly average), Okapilco Creek at ST RT 33 near Quitman, GA.

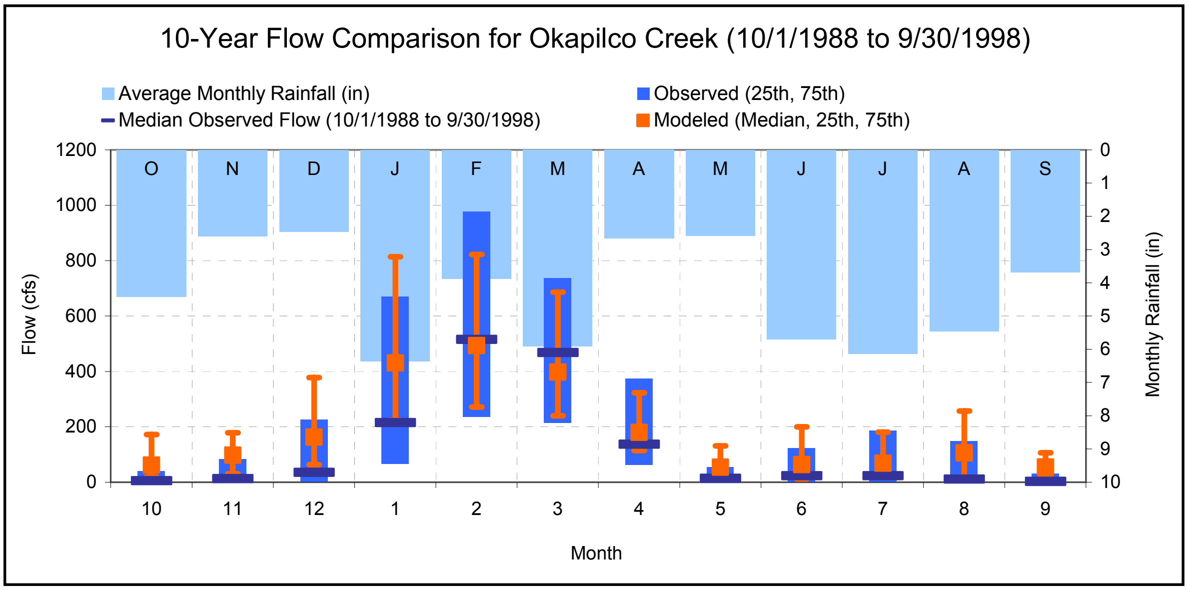


**Figure B-17. 10-year validation (monthly medians), Okapilco Creek at ST RT 33 near Quitman, GA.**

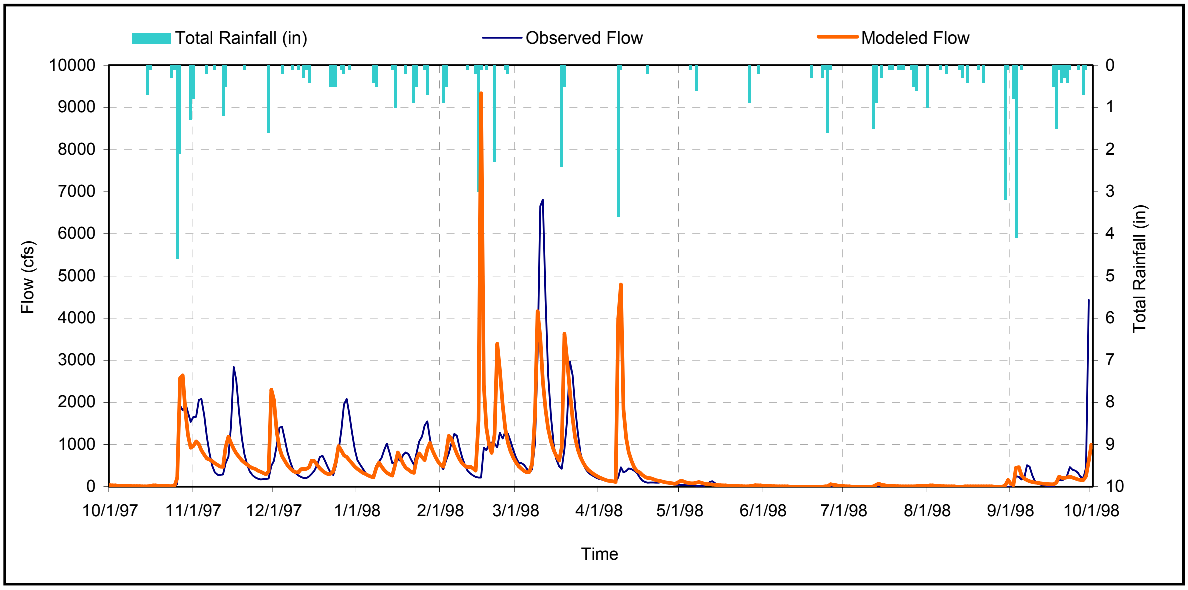


Figure B-18. Water year 1998 (daily flow), Okapilco Creek at ST RT 33 near Quitman, GA.

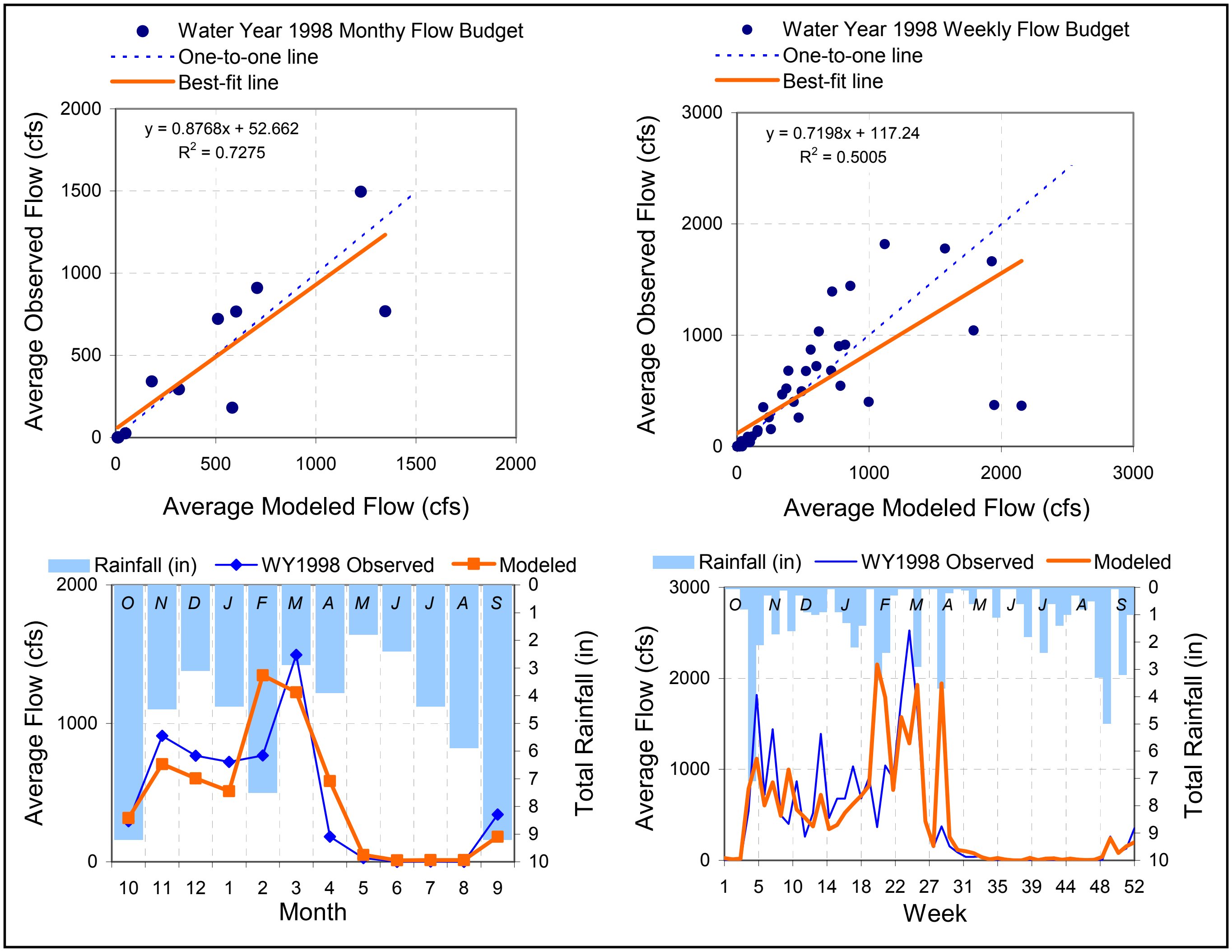


**Figure B-19. Water year 1998 (monthly & weekly), Okapilco Creek at ST RT 33 near Quitman, GA.**

# Appendix C

# In-Stream Dissolved Oxygen Calibration

Figure C-1: In-Stream Water Quality Calibration for DO at USGS02226341 – Seventeen Mile River at SR 32 near Douglas, GA (Subwatershed 117).

Figure C-2: In-Stream Water Quality Calibration for DO at USGS022274285 – Colemans Creek at CR 185 near Screven, GA (Subwatershed 158).

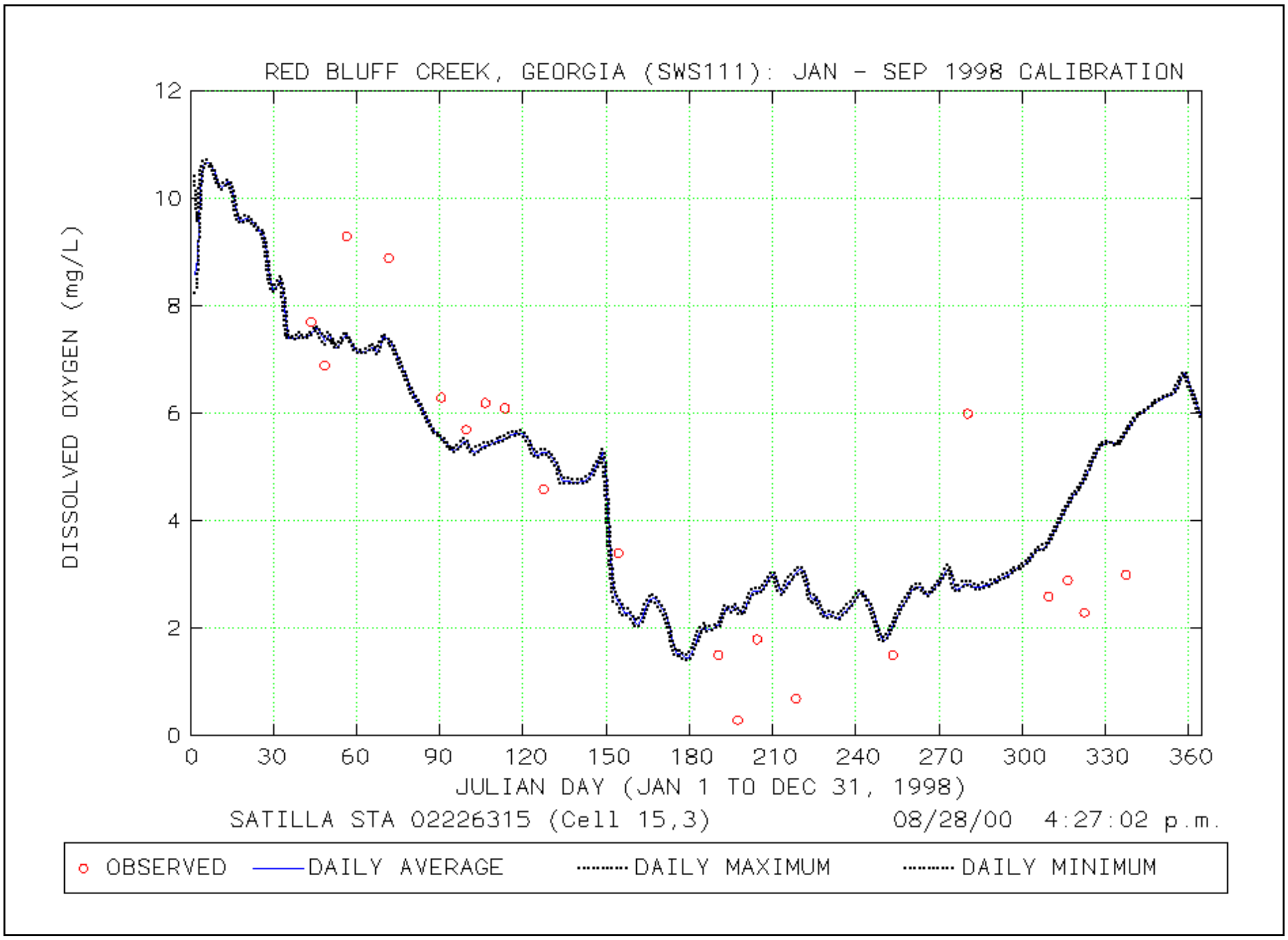


Figure C-3: In-Stream Water Quality Calibration for DO at USGS02226315 – Red Bluff Creek near Pearson, GA (Subwatershed 111).

# *Appendix D*

# *TMDL Components*

Table D-1

| **Big Creek - Segment #1** | | | | | **TMDL = WLA + LA** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | | | |
| | | | | 6,211,483 | 269,237 | 22,455 | | | |
| ***Nonpoint Sources (LA)*** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
| **Contributing Subwatersheds** | | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | |
| 030702010705 | 7,689,853 | 333,317 | 27,799 | 6,211,483 | 269,237 | 22,455 | 19.22 | 19.22 | 19.22 |
| Total | 7,689,853 | 333,317 | 27,799 | 6,211,483 | 269,237 | 22,455 | 19 | 19 | 19 |

Table D-2

| **Big Satilla Creek - Segment #2** | | | | | **TMDL = WLA + LA** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | | | |
| | | | | 15,212,127 | 603,826 | 75,131 | | | |
| ***Nonpoint Sources (LA)*** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
| **Contributing Subwatersheds** | | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | |
| 030702020101 | 6,991,264 | 292,297 | 34,690 | 5,599,838 | 234,123 | 27,786 | 19.90 | 19.90 | 19.90 |
| 030702020102 | 4,967,126 | 192,925 | 22,280 | 4,149,553 | 161,170 | 18,612 | 16.46 | 16.46 | 16.46 |
| 030702020103 | 4,336,986 | 192,491 | 25,247 | 3,297,280 | 146,345 | 19,195 | 23.97 | 23.97 | 23.97 |
| 030702020104 | 2,638,272 | 75,766 | 11,621 | 2,165,456 | 62,188 | 9,538 | 17.92 | 17.92 | 17.92 |
| Total | 18,933,647 | 753,479 | 93,838 | 15,212,127 | 603,826 | 75,131 | 20 | 20 | 20 |

Table D-3

| **Boggy Creek - Segment #3** | | | | | **TMDL = WLA + LA** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | | | |
| | | | | 5,559,394 | 139,488 | 14,724 | | | |
| ***Nonpoint Sources (LA)*** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
| **Contributing Subwatersheds** | | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | |
| 030702020403(a) | 2,647,294 | 55,473 | 6,726 | 2,327,995 | 48,782 | 5,914 | 12.06 | 12.06 | 12.06 |
| 030702020403(b) | 3,357,705 | 97,187 | 9,291 | 2,912,823 | 84,310 | 8,060 | 13.25 | 13.25 | 13.25 |
| 030702020403(c ) | 346,257 | 6,951 | 815 | 318,575 | 6,395 | 750 | 7.99 | 7.99 | 7.99 |
| Total | 6,351,256 | 159,611 | 16,831 | 5,559,394 | 139,488 | 14,724 | 12 | 13 | 13 |

Table D-4

| **Broxton Creek - Segment #4** | | | | | **TMDL = WLA + LA** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | | | |
| | | | | 1,636,840 | 62,778 | 7,602 | | | |
| ***Nonpoint Sources (LA)*** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
| **Contributing Subwatersheds** | | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | |
| 030702010401 | 2,575,904 | 98,794 | 11,963 | 1,636,840 | 62,778 | 7,602 | 36.46 | 36.46 | 36.46 |
| Total | 2,575,904 | 98,794 | 11,963 | 1,636,840 | 62,778 | 7,602 | 36 | 36 | 36 |

Table D-5

| **Colemans Creek - Segment #5** | | | | | **TMDL = WLA + LA** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | | | |
| | | | | 7,447,537 | 226,827 | 28,933 | | | |
| ***Nonpoint Sources (LA)*** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
| **Contributing Subwatersheds** | | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | |
| 030702020303 | 4,269,460 | 141,097 | 13,075 | 3,690,808 | 121,974 | 11,303 | 13.55 | 13.55 | 13.55 |
| 030702020304 | 4,245,893 | 118,506 | 19,925 | 3,756,729 | 104,853 | 17,630 | 11.52 | 11.52 | 11.52 |
| Total | 8,515,353 | 259,603 | 33,000 | 7,447,537 | 226,827 | 28,933 | 13 | 13 | 12 |

**Table D-6**

**Hog Creek - Segment #6**

| TMDL = WLA + LA | | |
|---|---|---|
| TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
| 15,161,322 | 485,634 | 53,774 |

| *Nonpoint Sources (LA)* | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
|---|---|---|---|---|---|---|---|---|---|
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702010601 | 5,169,504 | 161,858 | 17,607 | 4,691,409 | 146,889 | 15,979 | 9.25 | 9.25 | 9.25 |
| 030702010602 | 5,614,879 | 198,469 | 22,475 | 4,988,197 | 176,317 | 19,966 | 11.16 | 11.16 | 11.16 |
| 030702010603 | 2,207,823 | 70,135 | 7,638 | 1,958,567 | 62,217 | 6,776 | 11.29 | 11.29 | 11.29 |
| 030702010604 | 3,954,284 | 112,475 | 12,405 | 3,523,150 | 100,212 | 11,052 | 10.90 | 10.90 | 10.90 |
| Total | 16,946,490 | 542,936 | 60,125 | 15,161,322 | 485,634 | 53,774 | 11 | 11 | 11 |

**Table D-7**

**Hurricane Creek - Segment #7**

| TMDL = WLA + LA | | |
|---|---|---|
| TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
| 20,022,212 | 856,806 | 92,002 |

| *Nonpoint Sources (LA)* | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
|---|---|---|---|---|---|---|---|---|---|
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702040303 | 4,917,170 | 212,748 | 24,865 | 4,069,488 | 176,072 | 20,578 | 17.24 | 17.24 | 17.24 |
| 030702010801 | 4,329,070 | 181,671 | 18,697 | 3,599,839 | 151,068 | 15,547 | 16.84 | 16.84 | 16.84 |
| 030702011001 | 584,156 | 37,120 | 2,919 | 468,994 | 29,802 | 2,343 | 19.71 | 19.71 | 19.71 |
| 030702010801(a) | 2,632,204 | 37,120 | 2,919 | 2,186,507 | 30,834 | 2,425 | 16.93 | 16.93 | 16.93 |
| 030702010803(b) | 1,195,094 | 37,120 | 2,919 | 1,057,546 | 32,848 | 2,583 | 11.51 | 11.51 | 11.51 |
| 030702011002 | 3,246,542 | 122,862 | 14,508 | 2,661,349 | 100,716 | 11,893 | 18.03 | 18.03 | 18.03 |
| 030702010802 | 6,700,980 | 294,829 | 31,116 | 5,430,551 | 238,933 | 25,217 | 18.96 | 18.96 | 18.96 |
| Total | 23,605,216 | 923,469 | 97,942 | 19,474,274 | 760,273 | 80,586 | 18 | 18 | 18 |
| | | | | | | | | | |
| ***Point Sources (WLA)*** | **Existing Loads** | | | **Allocation Loads (WLA)** | | | **% Reduction** | | |
| Alma WPCP (GA0032328) | 547,938 | 96,533 | 11,415 | 547,938 | 96,533 | 11,415 | 0.00 | 0.00 | 0.00 |
| Total | 547,938 | 96,533 | 11,415 | 547,938 | 96,533 | 11,415 | 0 | 0 | 0 |

**Table D-8**

**Little Hurricane Creek - Segment #8**

| TMDL = WLA + LA | | |
|---|---|---|
| TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
| 13,232,516 | 430,449 | 56,752 |

| *Nonpoint Sources (LA)* | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
|---|---|---|---|---|---|---|---|---|---|
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702010901 | 3,243,406 | 158,681 | 11,681 | 4,069,488 | 176,072 | 20,578 | 20.02 | 20.02 | 20.02 |
| 030702010902 | 2,964,884 | 84,097 | 12,390 | 2,372,251 | 67,287 | 9,914 | 19.99 | 19.99 | 19.99 |
| 030702010903 | 4,187,697 | 126,681 | 17,155 | 3,132,552 | 94,762 | 12,832 | 25.20 | 25.20 | 25.20 |
| 030702010904 | 4,255,916 | 113,059 | 15,506 | 3,468,274 | 92,135 | 12,637 | 18.51 | 18.51 | 18.51 |
| Total | 14,651,902 | 482,519 | 56,732 | 13,042,565 | 430,257 | 55,961 | 11 | 11 | 1 |
| | | | | | | | | | |
| ***Point Sources (WLA)*** | **Existing Loads** | | | **Allocation Loads (WLA)** | | | **% Reduction** | | |
| Milliken - Alma Plant (GA0024619) | 189,952 | 192 | 791 | 189,952 | 192 | 791 | 0.00 | 0.00 | 0.00 |
| Total | 189,952 | 192 | 791 | 189,952 | 192 | 791 | 0 | 0 | 0 |

**Table D-9**

**Little Satilla Creek - Segment #9**

| TMDL = WLA + LA | | |
|---|---|---|
| TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
| 8,099,126 | 265,807 | 26,252 |

| *Nonpoint Sources (LA)* | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
|---|---|---|---|---|---|---|---|---|---|
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702020401 | 3,683,713 | 142,284 | 9,225 | 2,873,199 | 110,978 | 7,196 | 22.00 | 22.00 | 22.00 |
| 030702020402 | 6,248,265 | 185,118 | 22,784 | 5,225,927 | 154,829 | 19,056 | 16.36 | 16.36 | 16.36 |
| Total | 9,931,979 | 327,402 | 32,009 | 8,099,126 | 265,807 | 26,252 | 18 | 19 | 18 |

**Table D-10**

**Little Satilla Creek - Segment #10**

| TMDL = WLA + LA | | |
|---|---|---|
| **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
| 14,568,112 | 432,732 | 45,985 |

| ***Nonpoint Sources (LA)*** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
|---|---|---|---|---|---|---|---|---|---|
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702020401 | 3,683,713 | 142,284 | 9,225 | 2,873,199 | 110,978 | 7,196 | 22.00 | 22.00 | 22.00 |
| 030702020402 | 6,248,265 | 185,118 | 22,784 | 5,225,927 | 154,829 | 19,056 | 16.36 | 16.36 | 16.36 |
| 030702020403(a) | 2,647,294 | 55,473 | 6,726 | 2,327,995 | 48,782 | 5,914 | 12.06 | 12.06 | 12.06 |
| 030702020403(b) | 3,357,705 | 97,187 | 9,291 | 2,912,823 | 84,310 | 8,060 | 13.25 | 13.25 | 13.25 |
| 030702020403(c ) | 346,257 | 6,951 | 815 | 318,575 | 6,395 | 750 | 7.99 | 7.99 | 7.99 |
| 030702020404(a) | 949,119 | 31,046 | 3,957 | 836,534 | 27,363 | 3,487 | 11.86 | 11.86 | 11.86 |
| Total | 17,232,354 | 518,059 | 52,798 | 14,495,053 | 432,658 | 44,463 | 16 | 16 | 16 |
| | | | | | | | | | |
| ***Point Sources (WLA)*** | **Existing Loads** | | | **Allocation Loads (WLA)** | | | **% Reduction** | | |
| DOOR Wayne Co St Prison (GA0049573) | 73,058 | 74 | 1,522 | 73,058 | 74 | 1,522 | 0.00 | 0.00 | 0.00 |
| Total | 73,058 | 74 | 1,522 | 73,058 | 74 | 1,522 | 0 | 0 | 0 |

**Table D-11**

**Pudding Creek - Segment #11**

| TMDL = WLA + LA | | |
|---|---|---|
| **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
| 5,081,413 | 149,081 | 20,200 |

| ***Nonpoint Sources (LA)*** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
|---|---|---|---|---|---|---|---|---|---|
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702010204 | 4,021,997 | 111,415 | 15,478 | 2,827,078 | 78,314 | 10,880 | 29.71 | 29.71 | 29.71 |
| 030702010205 | 3,281,785 | 103,020 | 13,568 | 2,254,335 | 70,767 | 9,320 | 31.31 | 31.31 | 31.31 |
| Total | 7,303,782 | 214,435 | 29,047 | 5,081,413 | 149,081 | 20,200 | 30 | 30 | 30 |

**Table D-12**

**Red Bluff Creek - Segment #12**

| TMDL = WLA + LA | | |
|---|---|---|
| **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
| 8,112,832 | 256,318 | 28,131 |

| ***Nonpoint Sources (LA)*** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
|---|---|---|---|---|---|---|---|---|---|
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702010302 | 5,163,109 | 137,585 | 13,373 | 3,890,874 | 103,683 | 10,077 | 24.64 | 24.64 | 24.64 |
| 030702010303 | 5,202,582 | 181,081 | 16,343 | 4,002,783 | 139,321 | 12,574 | 23.06 | 23.06 | 23.06 |
| Total | 10,365,691 | 318,665 | 29,716 | 7,893,657 | 243,003 | 22,652 | 24 | 24 | 24 |
| | | | | | | | | | |
| ***Point Sources (WLA)*** | **Existing Loads** | | | **Allocation Loads (WLA)** | | | **% Reduction** | | |
| Pearson WPCP (GA0025445) | 219,175 | 13,315 | 5,479 | 219,175 | 13,315 | 5,479 | 0.00 | 0.00 | 0.00 |
| Total | 219,175 | 13,315 | 5,479 | 219,175 | 13,315 | 5,479 | 0 | 0 | 0 |

**Table D-13**

**Reedy Creek - Segment #13**

| TMDL = WLA + LA | | |
|---|---|---|
| **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
| 4,098,397 | 102,703 | 14,983 |

| ***Nonpoint Sources (LA)*** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
|---|---|---|---|---|---|---|---|---|---|
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702020404(c ) | 4,859,380 | 121,773 | 17,766 | 4,098,397 | 102,703 | 14,983 | 15.66 | 15.66 | 15.66 |
| Total | 4,859,380 | 121,773 | 17,766 | 4,098,397 | 102,703 | 14,983 | 16 | 16 | 16 |

**Table D-14**

**Roses Creek - Segment #14**

| TMDL = WLA + LA | | |
|---|---|---|
| **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
| 6,680,978 | 232,023 | 23,569 |

| ***Nonpoint Sources (LA)*** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
|---|---|---|---|---|---|---|---|---|---|
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702010402 | 3,916,922 | 119,340 | 15,840 | 4,002,783 | 139,321 | 12,574 | 38.87 | 38.87 | 38.87 |
| 030702010303(a) | 743,306 | 22,808 | 2,387 | 515,864 | 15,829 | 1,657 | 30.60 | 30.60 | 30.60 |
| 030702010303(b) | 3,296,049 | 117,178 | 14,233 | 2,162,330 | 76,873 | 9,338 | 34.40 | 34.40 | 34.40 |
| Total | 7,956,277 | 259,326 | 32,460 | 6,680,978 | 232,023 | 23,569 | 16 | 11 | 27 |

**Table D-15**

| Satilla Creek - Segment #15 | | | | TMDL = WLA + LA | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | | | |
| | | | | 3,872,094 | 132,053 | 17,623 | | | |
| *Nonpoint Sources (LA)* | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
| Contributing Subwatersheds | Existing Loads | | | Allocation Loads (LA) | | | % Reduction | | |
| 030702010101 | 3,660,090 | 145,144 | 18,848 | 2,541,772 | 100,796 | 13,089 | 30.55 | 30.55 | 30.55 |
| 030702010102 | 1,841,232 | 43,261 | 6,276 | 1,330,322 | 31,257 | 4,534 | 27.75 | 27.75 | 27.75 |
| Total | 5,501,322 | 188,405 | 25,123 | 3,872,094 | 132,053 | 17,623 | 30 | 30 | 30 |

**Table D-16**

| Satilla River - Segment #16 | | | | TMDL = WLA + LA | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | | | |
| | | | | 9,269,620 | 278,806 | 37,324 | | | |
| *Nonpoint Sources (LA)* | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
| Contributing Subwatersheds | Existing Loads | | | Allocation Loads (LA) | | | % Reduction | | |
| 030702010101 | 3,660,090 | 145,144 | 18,848 | 2,541,772 | 100,796 | 13,089 | 30.55 | 30.55 | 30.55 |
| 030702010102 | 1,841,232 | 43,261 | 6,276 | 1,330,322 | 31,257 | 4,534 | 27.75 | 27.75 | 27.75 |
| 030702010103 | 4,002,404 | 113,134 | 14,165 | 2,946,851 | 83,297 | 10,429 | 26.37 | 26.37 | 26.37 |
| 030702010104 | 3,422,024 | 88,607 | 12,947 | 2,450,675 | 63,456 | 9,272 | 28.39 | 28.39 | 28.39 |
| Total | 12,925,750 | 390,147 | 52,235 | 9,269,620 | 278,806 | 37,324 | 28 | 29 | 29 |

**Table D-17**

| Sweetwater Creek - Segment #17 | | | | TMDL = WLA + LA | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | | | |
| | | | | 2,728,370 | 76,937 | 11,986 | | | |
| *Nonpoint Sources (LA)* | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
| Contributing Subwatersheds | Existing Loads | | | Allocation Loads (LA) | | | % Reduction | | |
| 030702020202 | 3,533,264 | 99,996 | 15,303 | 2,718,142 | 76,927 | 11,773 | 23.07 | 23.07 | 23.07 |
| Total | 3,533,264 | 99,996 | 15,303 | 2,718,142 | 76,927 | 11,773 | 23 | 23 | 23 |
| | | | | | | | | | |
| *Point Sources (WLA)* | Existing Loads | | | Allocation Loads (WLA) | | | % Reduction | | |
| GA Baptist Children's Home (GA0049531) | 10,228 | 10 | 213 | 10,228 | 10 | 213 | 0.00 | 0.00 | 0.00 |
| Total | 10,228 | 10 | 213 | 10,228 | 10 | 213 | 0 | 0 | 0 |

**Table D-18**

| Buffalo Creek - Segment #18 | | | | TMDL = WLA + LA | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | | | |
| | | | | 11,893,834 | 380,490 | 29,833 | | | |
| *Nonpoint Sources (LA)* | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
| Contributing Subwatersheds | Existing Loads | | | Allocation Loads (LA) | | | % Reduction | | |
| 030702011103 | 7,110,859 | 229,282 | 15,718 | 6,311,912 | 203,521 | 13,952 | 11.24 | 11.24 | 11.24 |
| 030702011104 | 6,405,580 | 203,444 | 18,014 | 5,571,694 | 176,959 | 15,669 | 13.02 | 13.02 | 13.02 |
| Total | 13,516,439 | 432,726 | 33,731 | 11,883,606 | 380,480 | 29,620 | 12 | 12 | 12 |
| | | | | | | | | | |
| *Point Sources (WLA)* | Existing Loads | | | Allocation Loads (WLA) | | | % Reduction | | |
| Brantley Co HS (GA0033774) | 10,228 | 10 | 213 | 10,228 | 10 | 213 | 0.00 | 0.00 | 0.00 |
| Total | 10,228 | 10 | 213 | 10,228 | 10 | 213 | 0 | 0 | 0 |

Table D-19

| Little Satilla River - Segment #19 | | | | TMDL = WLA + LA | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | | | |
| | | | | 63,258,155 | 2,125,639 | 254,318 | | | |
| *Nonpoint Sources (LA)* | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702020101 | 6,991,264 | 292,297 | 34,690 | 5,599,838 | 234,123 | 27,786 | 19.90 | 19.90 | 19.90 |
| 030702020102 | 4,967,126 | 192,925 | 22,280 | 4,149,553 | 161,170 | 18,612 | 16.46 | 16.46 | 16.46 |
| 030702020103 | 4,336,986 | 192,491 | 25,247 | 3,297,280 | 146,345 | 19,195 | 23.97 | 23.97 | 23.97 |
| 030702020104 | 2,638,272 | 75,766 | 11,621 | 2,165,456 | 62,188 | 9,538 | 17.92 | 17.92 | 17.92 |
| 030702020201 | 5,456,377 | 279,325 | 26,301 | 3,829,623 | 196,048 | 18,460 | 29.81 | 29.81 | 29.81 |
| 030702020202 | 3,533,264 | 99,996 | 15,303 | 2,718,142 | 76,927 | 11,773 | 23.07 | 23.07 | 23.07 |
| 030702020301 | 2,587,225 | 67,279 | 11,407 | 2,323,816 | 60,429 | 10,246 | 10.18 | 10.18 | 10.18 |
| 030702020301(a) | 652,645 | 12,986 | 1,175 | 597,695 | 11,892 | 1,076 | 8.42 | 8.42 | 8.42 |
| 030702020301(b) | 2,164,063 | 70,500 | 9,532 | 1,895,750 | 61,759 | 8,350 | 12.40 | 12.40 | 12.40 |
| 030702020302 | 4,789,262 | 146,947 | 20,419 | 4,239,294 | 130,073 | 18,074 | 11.48 | 11.48 | 11.48 |
| 030702020303 | 4,269,460 | 141,097 | 13,075 | 3,690,808 | 121,974 | 11,303 | 13.55 | 13.55 | 13.55 |
| 030702020304 | 4,245,893 | 118,506 | 19,925 | 3,756,729 | 104,853 | 17,630 | 11.52 | 11.52 | 11.52 |
| 030702020401 | 3,683,713 | 142,284 | 9,225 | 2,873,199 | 110,978 | 7,196 | 22.00 | 22.00 | 22.00 |
| 030702020402 | 6,248,265 | 185,118 | 22,784 | 5,225,927 | 154,829 | 19,056 | 16.36 | 16.36 | 16.36 |
| 030702020403(a) | 2,647,294 | 55,473 | 6,726 | 2,327,995 | 48,782 | 5,914 | 12.06 | 12.06 | 12.06 |
| 030702020403(b) | 3,357,705 | 97,187 | 9,291 | 2,912,823 | 84,310 | 8,060 | 13.25 | 13.25 | 13.25 |
| 030702020403(c ) | 346,257 | 6,951 | 815 | 318,575 | 6,395 | 750 | 7.99 | 7.99 | 7.99 |
| 030702020404(a) | 949,119 | 31,046 | 3,957 | 836,534 | 27,363 | 3,487 | 11.86 | 11.86 | 11.86 |
| 030702020404(b) | 448,764 | 28,156 | 1,588 | 404,474 | 25,377 | 1,431 | 9.87 | 9.87 | 9.87 |
| 030702020404(c ) | 4,859,380 | 121,773 | 17,766 | 4,098,397 | 102,703 | 14,983 | 15.66 | 15.66 | 15.66 |
| 030702020501(a) | 2,527,393 | 57,775 | 5,196 | 2,287,657 | 52,294 | 4,703 | 9.49 | 9.49 | 9.49 |
| 030702020501(b) | 4,030,146 | 148,400 | 10,294 | 3,556,387 | 130,955 | 9,084 | 11.76 | 11.76 | 11.76 |
| Total | 75,729,874 | 2,564,278 | 298,617 | 63,105,950 | 2,111,769 | 246,708 | 17 | 18 | 17 |
| | | | | | | | | | |
| *Point Sources (WLA)* | **Existing Loads** | | | **Allocation Loads (WLA)** | | | **% Reduction** | | |
| Patterson WRC (GA0037206) | 152,205 | 13,870 | 7,610 | 152,205 | 13,870 | 7,610 | 0.00 | 0.00 | 0.00 |
| Total | 152,205 | 13,870 | 7,610 | 152,205 | 13,870 | 7,610 | 0 | 0 | 0 |

Table D-20

| Satilla River - Segment#20 | | | | TMDL = WLA + LA | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | | | |
| | | | | 26,467,421 | 841,124 | 111,215 | | | |
| *Nonpoint Sources (LA)* | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702020101 | 3,660,090 | 145,144 | 18,848 | 2,541,772 | 100,796 | 13,089 | 30.55 | 30.55 | 30.55 |
| 030702020102 | 1,841,232 | 43,261 | 6,276 | 1,330,322 | 31,257 | 4,534 | 27.75 | 27.75 | 27.75 |
| 030702020103 | 4,002,404 | 113,134 | 14,165 | 2,946,851 | 83,297 | 10,429 | 26.37 | 26.37 | 26.37 |
| 030702020104 | 3,422,024 | 88,607 | 12,947 | 2,450,675 | 63,456 | 9,272 | 28.39 | 28.39 | 28.39 |
| 030702020202 | 2,713,936 | 98,729 | 13,867 | 2,101,725 | 76,458 | 10,739 | 22.56 | 22.56 | 22.56 |
| 030702020301 | 3,596,148 | 96,977 | 13,538 | 3,048,524 | 82,210 | 11,476 | 15.23 | 15.23 | 15.23 |
| 030702020301 | 3,859,191 | 148,062 | 19,624 | 3,003,203 | 115,221 | 15,271 | 22.18 | 22.18 | 22.18 |
| 030702020301 | 4,021,997 | 111,415 | 15,478 | 2,827,078 | 78,314 | 10,880 | 29.71 | 29.71 | 29.71 |
| 030702020302 | 3,281,785 | 103,020 | 13,568 | 2,254,335 | 70,767 | 9,320 | 31.31 | 31.31 | 31.31 |
| 030702020304 | 5,043,367 | 177,339 | 20,623 | 3,962,936 | 139,348 | 16,205 | 21.42 | 21.42 | 21.42 |
| Total | 35,442,173 | 1,125,690 | 148,933 | 26,467,421 | 841,124 | 111,215 | 25 | 25 | 25 |

Table D-21

**Satilla River - Segment#21**

| TMDL = WLA + LA | | |
|---|---|---|
| **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
| 247,839,581 | 8,463,802 | 917,627 |

| ***Nonpoint Sources (LA)*** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** | **TOC(lb/yr)** | **TN(lb/yr)** | **TP(lb/yr)** |
|---|---|---|---|---|---|---|---|---|---|
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702020101 | 3,660,090 | 145,144 | 18,848 | 2,541,772 | 100,796 | 13,089 | 30.55 | 30.55 | 30.55 |
| 030702020102 | 1,841,232 | 43,261 | 6,276 | 1,330,322 | 31,257 | 4,534 | 27.75 | 27.75 | 27.75 |
| 030702020103 | 4,002,404 | 113,134 | 14,165 | 2,946,851 | 83,297 | 10,429 | 26.37 | 26.37 | 26.37 |
| 030702020104 | 3,422,024 | 88,607 | 12,947 | 2,450,675 | 63,456 | 9,272 | 28.39 | 28.39 | 28.39 |
| 030702020202 | 2,713,936 | 98,729 | 13,867 | 2,101,725 | 76,458 | 10,739 | 22.56 | 22.56 | 22.56 |
| 030702020301 | 3,596,148 | 96,977 | 13,538 | 3,048,524 | 82,210 | 11,476 | 15.23 | 15.23 | 15.23 |
| 030702020301 | 3,859,191 | 148,062 | 19,624 | 3,003,203 | 115,221 | 15,271 | 22.18 | 22.18 | 22.18 |
| 030702020301 | 4,021,997 | 111,415 | 15,478 | 2,827,078 | 78,314 | 10,880 | 29.71 | 29.71 | 29.71 |
| 030702020302 | 3,281,785 | 103,020 | 13,568 | 2,254,335 | 70,767 | 9,320 | 31.31 | 31.31 | 31.31 |
| 030702020304 | 5,043,367 | 177,339 | 20,623 | 3,962,936 | 139,348 | 16,205 | 21.42 | 21.42 | 21.42 |
| 030702010302 | 5,163,109 | 137,585 | 13,373 | 3,890,874 | 103,683 | 10,077 | 24.64 | 24.64 | 24.64 |
| 030702010302 | 5,202,582 | 181,081 | 16,343 | 4,002,783 | 139,321 | 12,574 | 23.06 | 23.06 | 23.06 |
| 030702010304 | 3,440,087 | 136,856 | 12,416 | 3,033,100 | 120,665 | 10,947 | 11.83 | 11.83 | 11.83 |
| 030702020403(a) | 1,410,402 | 80,931 | 9,164 | 651,889 | 37,407 | 4,236 | 53.78 | 53.78 | 53.78 |
| 030702020403(b) | 2,575,904 | 98,794 | 11,963 | 1,636,840 | 62,778 | 7,602 | 36.46 | 36.46 | 36.46 |
| 030702020403(c) | 2,198,698 | 97,785 | 9,405 | 1,443,595 | 64,202 | 6,175 | 34.34 | 34.34 | 34.34 |
| 030702010402 | 3,916,922 | 119,340 | 15,840 | 2,394,423 | 72,953 | 9,683 | 38.87 | 38.87 | 38.87 |
| 030702020404(a) | 743,306 | 22,808 | 2,387 | 515,864 | 15,829 | 1,657 | 30.60 | 30.60 | 30.60 |
| 030702020501(b) | 3,296,049 | 117,178 | 14,233 | 2,162,330 | 76,873 | 9,338 | 34.40 | 34.40 | 34.40 |
| 030702010404 | 1,665,497 | 89,421 | 9,767 | 806,410 | 43,296 | 4,729 | 51.58 | 51.58 | 51.58 |
| 030702010501(a) | 2,104,950 | 73,903 | 7,770 | 1,291,267 | 45,336 | 4,767 | 38.66 | 38.66 | 38.66 |
| 030702010501(b) | 1,026,027 | 45,484 | 4,813 | 803,899 | 35,637 | 3,771 | 21.65 | 21.65 | 21.65 |
| 030702010502 | 3,531,642 | 97,779 | 12,981 | 2,871,410 | 79,499 | 10,555 | 18.69 | 18.69 | 18.69 |
| 030702010503 | 3,372,419 | 90,201 | 12,399 | 2,711,630 | 72,527 | 9,969 | 19.59 | 19.59 | 19.59 |
| 030702010504 | 3,726,878 | 124,925 | 14,131 | 3,317,352 | 111,197 | 12,578 | 10.99 | 10.99 | 10.99 |
| 030702010601 | 5,169,504 | 161,858 | 17,607 | 4,691,409 | 146,889 | 15,979 | 9.25 | 9.25 | 9.25 |
| 030702010602 | 5,614,879 | 198,469 | 22,475 | 4,988,197 | 176,317 | 19,966 | 11.16 | 11.16 | 11.16 |
| 030702010603 | 2,207,823 | 70,135 | 7,638 | 1,958,567 | 62,217 | 6,776 | 11.29 | 11.29 | 11.29 |
| 030702010604 | 3,954,284 | 112,475 | 12,405 | 3,523,150 | 100,212 | 11,052 | 10.90 | 10.90 | 10.90 |
| 030702010701 | 1,455,221 | 58,951 | 4,379 | 1,269,452 | 51,425 | 3,820 | 12.77 | 12.77 | 12.77 |
| 030702010702 | 4,628,603 | 170,561 | 16,978 | 4,075,719 | 150,188 | 14,950 | 11.94 | 11.94 | 11.94 |
| 030702010703 | 5,530,466 | 219,795 | 22,179 | 4,821,683 | 191,626 | 19,337 | 12.82 | 12.82 | 12.82 |
| 030702010704(a) | 6,177,581 | 277,587 | 26,454 | 5,492,987 | 246,825 | 23,522 | 11.08 | 11.08 | 11.08 |
| 030702010704(b) | 1,307,472 | 23,127 | 3,140 | 1,186,791 | 20,993 | 2,850 | 9.23 | 9.23 | 9.23 |
| 030702010705 | 7,689,853 | 333,317 | 27,799 | 6,211,483 | 269,237 | 22,455 | 19.22 | 19.22 | 19.22 |
| 030702010801 | 4,917,170 | 212,748 | 24,865 | 4,069,488 | 176,072 | 20,578 | 17.24 | 17.24 | 17.24 |
| 030702010802 | 4,329,070 | 181,671 | 18,697 | 3,599,839 | 151,068 | 15,547 | 16.84 | 16.84 | 16.84 |
| 030702010803 | 584,156 | 37,120 | 2,919 | 468,994 | 29,802 | 2,343 | 19.71 | 19.71 | 19.71 |

Table D-21 **Satilla River - Segment#21** (CONTINUED)

| *Nonpoint Sources (LA)* | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) | TOC(lb/yr) | TN(lb/yr) | TP(lb/yr) |
|---|---|---|---|---|---|---|---|---|---|
| **Contributing Subwatersheds** | **Existing Loads** | | | **Allocation Loads (LA)** | | | **% Reduction** | | |
| 030702010803(a) | 2,632,204 | 104,945 | 11,754 | 2,186,507 | 87,175 | 9,764 | 16.93 | 16.93 | 16.93 |
| 030702010803(b) | 1,195,094 | 42,505 | 3,704 | 1,057,546 | 37,613 | 3,278 | 11.51 | 11.51 | 11.51 |
| 030702010901 | 3,243,406 | 158,681 | 11,681 | 2,593,974 | 126,908 | 9,342 | 20.02 | 20.02 | 20.02 |
| 030702010902 | 2,964,884 | 84,097 | 12,390 | 2,372,251 | 67,287 | 9,914 | 19.99 | 19.99 | 19.99 |
| 030702010903 | 4,187,697 | 126,681 | 17,155 | 3,132,552 | 94,762 | 12,832 | 25.20 | 25.20 | 25.20 |
| 030702010904 | 4,255,916 | 113,059 | 15,506 | 3,468,274 | 92,135 | 12,637 | 18.51 | 18.51 | 18.51 |
| 030702011001 | 3,246,542 | 122,862 | 14,508 | 2,661,349 | 100,716 | 11,893 | 18.03 | 18.03 | 18.03 |
| 030702011002 | 6,700,980 | 294,829 | 31,116 | 5,430,551 | 238,933 | 25,217 | 18.96 | 18.96 | 18.96 |
| 030702011003 | 4,791,693 | 187,792 | 26,943 | 4,178,192 | 163,748 | 23,493 | 12.80 | 12.80 | 12.80 |
| 030702011004 | 3,810,466 | 144,139 | 17,807 | 3,408,567 | 128,936 | 15,929 | 10.55 | 10.55 | 10.55 |
| 030702011101 | 7,727,183 | 190,513 | 19,890 | 6,849,601 | 168,876 | 17,631 | 11.36 | 11.36 | 11.36 |
| 030702011102 | 8,493,526 | 237,722 | 18,837 | 7,565,012 | 211,734 | 16,777 | 10.93 | 10.93 | 10.93 |
| 030702011103 | 7,110,859 | 229,282 | 15,718 | 6,311,912 | 203,521 | 13,952 | 11.24 | 11.24 | 11.24 |
| 030702011104 | 6,405,580 | 203,444 | 18,014 | 5,571,694 | 176,959 | 15,669 | 13.02 | 13.02 | 13.02 |
| 030702011105 | 7,470,888 | 286,039 | 17,542 | 6,620,092 | 253,465 | 15,544 | 11.39 | 11.39 | 11.39 |
| 030702011201 | 12,815,023 | 393,797 | 25,262 | 11,346,398 | 348,667 | 22,367 | 11.46 | 11.46 | 11.46 |
| 030702020101 | 6,991,264 | 292,297 | 34,690 | 5,599,838 | 234,123 | 27,786 | 19.90 | 19.90 | 19.90 |
| 030702020102 | 4,967,126 | 192,925 | 22,280 | 4,149,553 | 161,170 | 18,612 | 16.46 | 16.46 | 16.46 |
| 030702020103 | 4,336,986 | 192,491 | 25,247 | 3,297,280 | 146,345 | 19,195 | 23.97 | 23.97 | 23.97 |
| 030702020104 | 2,638,272 | 75,766 | 11,621 | 2,165,456 | 62,188 | 9,538 | 17.92 | 17.92 | 17.92 |
| 030702020201 | 5,456,377 | 279,325 | 26,301 | 3,829,623 | 196,048 | 18,460 | 29.81 | 29.81 | 29.81 |
| 030702020202 | 3,533,264 | 99,996 | 15,303 | 2,718,142 | 76,927 | 11,773 | 23.07 | 23.07 | 23.07 |
| 030702020301 | 2,587,225 | 67,279 | 11,407 | 2,323,816 | 60,429 | 10,246 | 10.18 | 10.18 | 10.18 |
| 030702020301(a) | 652,645 | 12,986 | 1,175 | 597,695 | 11,892 | 1,076 | 8.42 | 8.42 | 8.42 |
| 030702020301(b) | 2,164,063 | 70,500 | 9,532 | 1,895,750 | 61,759 | 8,350 | 12.40 | 12.40 | 12.40 |
| 030702020302 | 4,789,262 | 146,947 | 20,419 | 4,239,294 | 130,073 | 18,074 | 11.48 | 11.48 | 11.48 |
| 030702020303 | 4,269,460 | 141,097 | 13,075 | 3,690,808 | 121,974 | 11,303 | 13.55 | 13.55 | 13.55 |
| 030702020304 | 4,245,893 | 118,506 | 19,925 | 3,756,729 | 104,853 | 17,630 | 11.52 | 11.52 | 11.52 |
| 030702020401 | 3,683,713 | 142,284 | 9,225 | 2,873,199 | 110,978 | 7,196 | 22.00 | 22.00 | 22.00 |
| 030702020402 | 6,248,265 | 185,118 | 22,784 | 5,225,927 | 154,829 | 19,056 | 16.36 | 16.36 | 16.36 |
| 030702020403(a) | 2,647,294 | 55,473 | 6,726 | 2,327,995 | 48,782 | 5,914 | 12.06 | 12.06 | 12.06 |
| 030702020403(b) | 3,357,705 | 97,187 | 9,291 | 2,912,823 | 84,310 | 8,060 | 13.25 | 13.25 | 13.25 |
| 030702020403(c ) | 346,257 | 6,951 | 815 | 318,575 | 6,395 | 750 | 7.99 | 7.99 | 7.99 |
| 030702020404(a) | 949,119 | 31,046 | 3,957 | 836,534 | 27,363 | 3,487 | 11.86 | 11.86 | 11.86 |
| 030702020404(b) | 448,764 | 28,156 | 1,588 | 404,474 | 25,377 | 1,431 | 9.87 | 9.87 | 9.87 |
| 030702020404(c ) | 4,859,380 | 121,773 | 17,766 | 4,098,397 | 102,703 | 14,983 | 15.66 | 15.66 | 15.66 |
| 030702020501(a) | 2,527,393 | 57,775 | 5,196 | 2,287,657 | 52,294 | 4,703 | 9.49 | 9.49 | 9.49 |
| 030702020501(b) | 4,030,146 | 148,400 | 10,294 | 3,556,387 | 130,955 | 9,084 | 11.76 | 11.76 | 11.76 |
| 030702020502 | 6,024,766 | 174,647 | 22,552 | 5,351,459 | 155,129 | 20,032 | 11.18 | 11.18 | 11.18 |
| Total | 301,189,307 | 10,356,882 | 1,122,447 | 247,570,726 | 8,463,530 | 912,026 | 18 | 18 | 19 |
| | | | | | | | | | |
| *Point Sources (WLA)* | **Existing Loads** | | | **Allocation Loads (WLA)** | | | **% Reduction** | | |
| Woodbine WPCP (GA0023701) | 268,855 | 272 | 5,601 | 268,855 | 272 | 5,601 | 0.00 | 0.00 | 0.00 |
| Total | 268,855 | 272 | 5,601 | 268,855 | 272 | 5,601 | 0 | 0 | 0 |