TOTAL MAXIMUM DAILY LOADS (TMDLs)

For

Fecal Coliform

In

Lower and Little Ocmulgee River Basin

February 2002

United States Environmental Protection Agency

Region 4 serving the southeast

In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et.seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S Environmental Protection Agency is hereby establishing Total Maximum Daily Loads (TMDLs) for fecal coliform for §303(d) listed stream segments in the Lower and Little Ocmulgee River Basin. Subsequent actions must be consistent with this TMDL.

______________________________ ______________________________

Beverly H. Banister, Director
Water Management Division

Date

TABLE OF CONTENTS

¾ ¾

1.0 INTRODUCTION 1

2.0 WATERSHED DESCRIPTION 1

3.0 PROBLEM DEFINITION 2

4.0 TARGET IDENTIFICATION 3

5.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET 3

6.0 SOURCE ASSESSMENT 3

6.1 Point Sources 4
6.2 Nonpoint Source Assessment 4

7.0 ANALYTICAL APPROACH 6

7.1 Model Selection 7
7.2 Model Set Up 7

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD 8

8.2 Existing Conditions 9
8.3 Margin of Safety (MOS) 9
8.4 Determination of TMDL, WLA, and LA 9

9.0 RECOMMENDATIONS 11

9.1 Point Source Facilities 11
9.2 Urban Sources of Fecal Coliform Loading 12
9.3 Agricultural Sources of Fecal Coliform Loading 12
9.4 Stream Monitoring 12
9.5 Future Efforts 12

10.0 Public Participation 13

11.0 Implementation 13

References 27

FIGURES

TABLES

APPENDIX A Hydrology Calibrations

APPENDIX B Water Quality Calibrations

APPENDIX C Simulated 30-Day Geometric Mean Concentrations for Existing and TMDL Conditions

LIST OF FIGURES

Figure 1 Lower and Little Ocmulgee River Basin

Figure 2 Land Use Distribution, Lower Ocmulgee and Little Ocmulgee River Basins

Figure 3 Subwatersheds and 303(d) Listed Streams, Lower and Little Ocmulgee River Basins

LIST OF TABLES

Table 1 Land Use Distribution for Lower and Little Ocmulgee River Basins

Table 2 Waterbodies Listed for Fecal Coliform Bacteria in the Lower and Little Ocmulgee River Basins

Table 3 1999 Water Quality Monitoring Stations

Table 4 Water Quality Monitoring Data

Table 5 NPDES Facilities Discharging Fecal Coliform in the Lower and Little Ocmulgee River Basins

Table 6 Livestock Distribution By County In Lower and Little Ocmulgee River Basins

Table 7 Fecal Coliform Loading Rates for Existing Conditions During Critical Period

Table 8 TMDL Components

Table 9 Management Measure Selection Table

LIST OF ABBREVIATIONS

BMP	Best Management Practices
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
DNR	Department of Natural Resources
DWPC	Division of Water Pollution Control
EPA	Environmental Protection Agency
EPD	Environmental Protection Division (State of Georgia)
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - FORTRAN
HUC	Hydrologic Unit Code
LA	Load Allocation
MGD	Million Gallons per Day
MOS	Margin of Safety
MPN	Most Probable Number
MRLC	Multi-Resolution Land Characteristic
NPDES	National Pollutant Discharge Elimination System
NPSM	Nonpoint Source Model
NRCS	Natural Resources Conservation Service
Rf3	Reach File 3
RM	River Mile
STORET	STORage RETrieval database
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WCS	Watershed Characterization System
WLA	Waste Load Allocation

SUMMARY
Proposed Total Maximum Daily Loads (TMDLs)
303(d) Listed Streams in Lower and Little Ocmulgee River Basins - HUC 03070104 and HUC 03070105

State: Georgia

Counties: Crawford, Peach, Twiggs, Macon, Houston, Bleckley, Pulaski, Dodge, Wilcox, Wheeler, Montgomery, Dodge, Laurens, and Telfair.

Major River Basin: Ocmulgee River

Constituent(s) of Concern: Fecal Coliform Bacteria

Summary of 303(d) Listed Waterbody Information and Allocation by Stream Segment

Stream Name	Segment Description	Hydrologic Unit(s)	Use Classification	Segment Length (miles)	Drainage Area (miles^2)	WLA (#/30 days)	LA (#/30 days)	MOS (#/30 days)	TMDL (#/30 days)	Percent Reduction
Alligator Creek	Batson Creek to Lime Sink Creek	030701050302 030701050301	Fishing	12	68.81	1.14×10^{10}	9.19×10^{12}	1.02×10^{11}	9.20×10^{12}	74
Bay Creek	Headwaters to Beaver Creek	030701040202	Fishing	9	23.39	2.50×10^{11}	4.68×10^{10}	5.20×10^{9}	3.02×10^{11}	98
Big Indian Creek	Mossy Creek to Ocmulgee River	030701040207	Fishing	7	257.38	1.73×10^{12}	1.39×10^{12}	1.54×10^{11}	3.27×10^{12}	92
House Creek	Ball Creek to Little House Creek	030701040603	Fishing	8	51.86	0	1.36×10^{11}	1.51×10^{10}	1.51×10^{11}	84
Ocmulgee River	Sandy Run Creek to Big Indian Creek	030701040107	Fishing	23	2722.99	8.20×10^{15}	9.40×10^{14}	1.04×10^{14}	9.24×10^{15}	16
Turnpike Creek	Hwy 280 to Sugar Creek	030701050403 030701050402	Fishing	24	80.29	0	6.99×10^{12}	7.77×10^{11}	7.76×10^{12}	14

Note: All future NPDES facilities discharging fecal coliform shall not cause or contribute to water quality impairment.

Applicable Water Quality Standard for Drinking Water and Fishing use classifications:

Section 391-3-6-.03 (6) of the *State of Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6 Revised, July, 2000:*
May through October - fecal coliform is not to exceed a geometric mean of 200 per 100 ml based on at least four samples collected from a given sampling site

over a 30-day period at intervals not less than 24 hours. Should water quality and sanitary studies show fecal coliform levels from non-human sources exceed 200 per 100 ml (geometric mean) occasionally, then the allowable geometric mean fecal coliform shall not exceed 300 per 100 ml in lakes and reservoirs and 500 per 100 ml in free flowing freshwater streams.

November through April - fecal coliform is not to exceed a geometric mean of 1,000 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours and not to exceed a maximum of 4,000 per 100 ml for any sample. The geometric mean standard is the target value for the TMDLs

TMDL Development - Analysis/Modeling:

The Hydrologic Simulation Program Fortran (HSPF) watershed model was used to develop these TMDLs. An hourly time step was used to simulate hydrologic and water quality conditions with results expressed as daily averages. A simulation period of 6 years was used to assess the water quality standards for these TMDLs representing a range of hydrologic and meteorological conditions.

FECAL COLIFORM TOTAL MAXIMUM DAILY LOADS (TMDLs) for 303(d) listed stream segments in the LOWER AND LITTLE OCMULGEE RIVER BASIN

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions. This allows water quality based controls to be developed and implemented in an effort to reduce pollution, and restore and maintain compliance with water quality standards.

The TMDLs proposed in this report represent the first phase of a long-term process to reduce fecal coliform loading to meet water quality standards in 303(d) listed streams in the Lower and Little Ocmulgee River Basins. The reduction scenario proposed for the TMDLs in this document represent one possible allocation scenario that can be used to meet water quality standards. Stakeholders in the impaired watersheds may choose other allocation scenarios to meet the required load reductions. Implementation strategies will be reviewed and the TMDLs will be refined as necessary in the next phase (next five-year cycle). The phased approach will support progress toward water quality standards attainment in the future. In accordance with EPA TMDL guidance (EPA, 1991), these TMDLs may be revised based on results of future monitoring and source characterization data efforts.

2.0 WATERSHED DESCRIPTION

The Ocmulgee River is located in Central Georgia originating southeast of the City of Atlanta on the downstream side of Lake Jackson, where the South River, the Yellow River and the Alcovy River converge (Figure 1). The Ocmulgee River flows south and southeast for a distance of approximately 160 miles, until it joins the Oconee River near the City of Hazlehurst, to form the Altamaha River. The confluence of the Ocmulgee and Oconee Rivers form the Altamaha River, which continues in a southeaster direction to the Atlantic Ocean. The Ocmulgee River basin includes three United States Geologic Survey (USGS) eight-digit hydrologic units, HUC 03070103 (Upper Ocmulgee River watershed), HUC 03070104 (Lower Ocmulgee River watershed), and HUC 03070105 (Little Ocmulgee River watershed). The Lower Ocmulgee River is the portion of the Ocmulgee River extending approximately from Echeconnee Creek near Warner Robins to the Oconee River near Hazelhurst. The Lower and Little Ocmulgee River basins are the subject of this TMDL report.

The Lower and Little Ocmulgee River watersheds are multifaceted watersheds with portions of the watersheds located in the Level IV Southern Outer Piedmont (45b), the Sand Hills (65c), the Coastal Plain Red Uplands (65k) and the Atlantic Southern Loam Plains (65l) (EPA, 2000). There is also a corridor, running the length of the river and extending (approximately) one half to two miles inland on each side of the river, which lies in the Southeastern Floodplains and Low Terraces (65p) subecoregion. Typical characteristics for these subecoregions are as follows:

- Southern Outer Piedmont (45b) - this region contains this region contains mostly rolling to hilly terrain with slightly lower elevations and less relief than 45a; mostly red clayey soils; southern most boundary occurs at the fall line; major forest type is loblolly short-leafed pine.

- Sand Hills (65c) – rolling to hilly, highly dissected coastal plain belt; generally low nutrient sand and clay soils.

- Coastal Plain Red Uplands (65k) - this region contains mostly well drained soils composed of red sand and clay; the majority of the land is utilized as cropland or pasture.

- Atlantic Southern Loam Plains (65l) - this region contains soils ranging from poorly drained to excessively drained; longleaf pine, oak and some distinctive evergreen shrubs are common vegetation.

- Southeastern Floodplains and Low Terraces (65p) – this region contains large sluggish rivers and backwaters with ponds, swamps and oxbow lakes; terraces are typically covered by oak forests, while forests of bald cypress and water tupelo grow in the swamps and river areas.

The Ocmulgee River basin contains approximately 9,349 miles of Reach File 3 (Rf3) level streams and drains a total area of approximately 6,102 square miles. Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1994. MRLC land use in the Lower and Little Ocmulgee River basins is summarized in Table 1. Figures 2 and 3 shows MRLC land use for the Lower and Little Ocmulgee River watersheds, respectively, which contains the 303(d) listed segments for which a TMDL has been proposed in this report.

For purposes of calculating fecal coliform loading rates, the MRLC data were summarized into six broad categories: urban pervious, urban impervious, cropland, pastureland, forest and, wetlands. Fecal coliform loading rates were assigned to land coverages based on literature values (NCSU, 1994; EPA, 2001). The loadings from forest and wetlands were assumed to be background. The loadings from urban, cropland, and pasturelands were subject to reductions in the TMDL analysis.

3.0 PROBLEM DEFINITION

EPA Region 4 approved Georgia's final 2000 303(d) list on August 28, 2000. This 303(d) list was then updated for the Altamaha, Ocmulgee, and Oconee River Basins and was finalized and approved by EPA Region 4 in June 2001. The list identified the waterbodies for the Ocmulgee River basin shown in Table 2, as either not supporting or partially supporting designated use classifications, due to exceedence of water quality standards for fecal coliform bacteria. Fecal coliform bacteria are used as an indicator of the potential presence of pathogens in a stream.

Pursuant to the Consent Decree in the case of Sierra Club v. EPA, 1:94-cv-2501-MHS (N.D. Ga.), the State or EPA shall develop TMDLs for all waterbodies on the State of Georgia's current 303 (d) List by a prescribed schedule. On June 30, 2001, The Georgia Environmental Protection Division (EPD) proposed a Fecal Coliform TMDL for the Little Commissioner Creek. The objective of this study is to develop fecal coliform TMDLs for Bay Creek, House Creek, Big Indian Creek, and Ocmulgee River in the Lower Ocmulgee River Basin and Alligator Creek and Turnpike Creek in the Little Ocmulgee River Basin.

4.0 TARGET IDENTIFICATION

The TMDLs proposed in this report all have a designated use classification of fishing. The fecal coliform water quality criteria for protection of the fishing use classification is established by the *State of Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6 Revised, July, 2000*, and will be used as the target level for fecal coliform TMDL development.

Section 391-3-6-.03 (6) of the *State of Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6 Revised, July, 2000,* states that during the months of May through October, when water contact recreation activities are expected to occur, fecal coliform is not to exceed a geometric mean of 200 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours. Should water quality and sanitary studies show fecal coliform levels from non-human sources exceed 200/100 ml (geometric mean) occasionally, then the allowable geometric mean fecal coliform shall not exceed 300 per 100 ml in lakes and reservoirs and 500 per 100 ml in free flowing freshwater streams. For the months of November through April, fecal coliform is not to exceed a geometric mean of 1,000 per 100 ml based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours and not to exceed a maximum of 4,000 per 100 ml for any sample.

The geometric mean standard of 200 counts/100mL is the primary target value for the TMDLs. The State of Georgia does not have an instantaneous fecal coliform criterion for the summer months when water contact activities are expected to occur. Therefore, the geometric mean is the only applicable criterion to show compliance with the designated use. The TMDLs are expressed in terms of a 10-year geometric mean plot. The purpose of the ten-year period is to show that the proposed reductions comply with the geometric mean criteria for all seasons. To address uncertainty in the model, a margin of safety (MOS) of 10 percent of the load allocation is included in the TMDLs.

5.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

Compliance with the applicable fecal coliform water quality criteria was assessed for each of the current 303(d) listed streams, based on monitoring data collected from the monitoring stations listed in Table 3.

Water quality data collected during calendar year 1999 for the current 303(d) listed stream segments, which met the regulatory criteria for calculation of a valid geometric mean, are summarized in Table 4. A geometric mean in excess of 200 counts per 100 milliliters during the period May – October, or in excess of 1000 counts per 100 milliliters during the period November – April, provides a basis for adding a stream segment to the 303(d) listing. A single sample in excess of 4000 counts per 100 milliliters can also provide a basis for adding a stream segment to the 303(d) listing. Stream segments that do not have 1999 monitoring data exceeding the above geometric mean or single sample criteria were placed on the 303(d) as a result of data collected prior to 1999.

6.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of source categories, source subcategories, or individual sources of fecal coliform bacteria in the watershed and the amount of loading contributed by each of these sources. Sources are broadly classified as either point or nonpoint sources. Point sources comprise the waste load allocation (WLA) component of the TMDL whereas nonpoint sources comprise the load allocation (LA) component of the TMDL.

A point source can be defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Point source discharges of industrial wastewater and treated sanitary wastewater must be authorized by National Pollutant Discharge Elimination System (NPDES) permits. NPDES permitted facilities discharging treated sanitary wastewater are considered primary point sources of fecal coliform bacteria.

Nonpoint sources of fecal coliform bacteria are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. These sources generally, but not always, involve accumulation of fecal coliform bacteria on land surfaces and washoff as a result of storm events. Typical nonpoint sources of fecal coliform bacteria include:

- Wildlife
- Land application of agricultural manure
- Livestock grazing
- Leaking septic systems
- Urban development (including leaking sewer collection lines)
- Animals having access to streams

6.1 Point Sources

There are eight permitted point source discharges located in the drainage areas of the 303(d) listed stream segments. These facilities are primarily municipal water pollution control plants (WPCP). The average discharge flow and flow-weighted average fecal coliform loading for the NPDES facilities, as calculated from CY1999 Discharge Monitoring Report (DMR) data were provided by EPD and are summarized in Table 5. Design flows, and fecal coliform loading based on monthly fecal coliform permit limits, are also provided in Table 5. In the water quality models, the fecal coliform loading rates from these facilities was calculated using the design flow and the permit concentration of 200 counts/ 100 ml. This load is considered a conservative estimate of the WLA component as most of the NPDES facilities discharging fecal coliform use disinfection prior to discharge.

6.2 Nonpoint Source Assessment

6.2.1 Wildlife

Wildlife deposit feces onto land surfaces where it can be transported during storm events to nearby streams. In the water quality model, the wildlife fecal coliform contribution is accounted for in the deer population, as population estimates of raccoons, waterfowl, and other wildlife are not readily available. The deer population is estimated to be 30 to 45 animals per square mile in this area (Georgia WRD, 1999). The upper limit of 45 deer per square mile has been chosen to account for deer and all other wildlife present in the watershed. It is assumed that the wildlife population remains constant throughout the year, and that wildlife is uniformly distributed on all land classified in the MRLC database as forest, pasture, cropland, and wetlands.

The fecal coliform concentration assigned to deer is approximately 5.0×10^{8} counts/animal/day (EPA, best professional judgment). The resulting load attributed to wildlife is about 3.5×10^{7} counts/acre-day.

6.2.2 Agricultural Animals

Agricultural animals are also a potential source of several types of fecal coliform loading to streams in the Lower and Little Ocmulgee River basins. Livestock data are reported by county and published by the USDA in the Census of Agriculture (USDA, 1997). The available livestock data include population estimates for cattle, beef cows, dairy cows, hogs, sheep, and poultry (broilers and layers). Livestock data for the counties comprising the 303-(d) listed streams are shown in Table 6. Cattle numbers reported in the census data also represent other breeds of cattle and calves in addition to dairy and beef. Assumptions regarding agricultural animals and resource management practices were provided by NRCS (USDA, 2001) and are summarized as follows:

- As with wildlife, agricultural livestock grazing on pastureland or forestland deposit their feces onto land surfaces where it can be transported during storm events to nearby streams.

- Confined livestock operations also generate manure, which can be applied to pastureland and cropland as a fertilizer. Processed agricultural manure from confined hog, dairy cattle, and some poultry operations is generally collected in lagoons and applied to land surfaces during the growing season, at rates which often vary on a monthly basis. Data sources for agricultural animals are tabulated by county and are based on information obtained from the Census of Agriculture (USDA, 1997). Fecal coliform loading rates for livestock in the watershed are estimated to be: 1.06×10^{11} counts/day/beef cow, 1.24×10^{10} counts/day/hog, 1.04×10^{11} counts/day/dairy cow, 1.38×10^{8} counts/day/layer chicken, and 1.22×10^{10} counts/day/sheep (NCSU, 1994).

- Agricultural livestock and other unconfined animals (i.e., deer and other wildlife) also often have direct access to streams that pass through pastures. Feces deposited into these streams by grazing animals are included in the water quality model as a point source having constant flow and concentration. To calculate the amount of fecal coliform bacteria introduced into streams by cattle, it is assumed that 50 percent of the beef cows in the watershed have access to the streams, and of those, 25 percent defecate in or near the stream banks during a portion of the day (personal communication, EPA, Georgia Agribusiness Council, NRCS, University of Georgia, et. al.). The resulting percentage of time fecal coliform bacteria is discharged into the stream from grazing animals is 0.025 percent.

Assumptions regarding manure management practices for specific agricultural livestock operations areas are similar to those used to develop the TMDLs for the South Georgia Four Basins in 2000 and include:

- Poultry litter is normally piled for a period before it is applied to the land. Within the Lower and Little Ocmulgee River basins it is estimated that approximately 60 percent of poultry litter (i.e., broiler and layers) is applied to pastureland and 40 percent is applied to cropland. It is assumed that the poultry litter is applied primarily during the period between March and October (inclusive), and that application rates vary monthly.

- Hog farms operate by confining the animals or allowing them to graze in small pastures or pens. It is assumed that all of the hog manure produced by either farming method is applied to available pastureland, with negligible amounts applied to cropland. Application rates of hog manure to pastureland vary monthly according to management practices. Manure is applied during the period between March and October (inclusive).

- On dairy farms, the cows are confined for a limited period each day during which time they are fed and milked. This is estimated to be four hours per day for each dairy cow. It is assumed that 60 percent of manure collected during confinement is applied to pastureland and 40 percent is applied to cropland. It is also assumed that the dairy cow manure is applied during the period between February and October (inclusive), as well as in November. Application rates vary monthly according to management practices.

- Beef cattle are assumed to be in pasture year round. Therefore, beef cow manure is applied only to pastureland and at a constant monthly rate. This rate varies between watersheds, as the rate is a function of the number of beef cows in the watershed.

6.2.3 Leaking Septic Systems

Fecal coliform loading in the Lower and Little Ocmulgee River basin may also be attributed to septic system failures. Loading rates are based on estimates from county census data of people in each listed stream watershed utilizing septic systems and literature values for fecal coliform concentrations in human waste. These estimates were updated based on a county-by-county survey conducted by EPD in April-May 2001. It is estimated that there are approximately 2.37 people per household on septic systems (EPA, best professional judgment). For modeling purposes, it is assumed that ten percent of the septic systems in the watershed leak. Leaking septic systems are included in the water quality model as a point source having constant flow and concentration. The average fecal coliform concentration of the septic system wastewater reaching a stream was assumed to be 1×10^4 counts per 100 ml (EPA, 2001).

6.2.4 Urban Development

Fecal coliform loading from urban areas is potentially attributable to multiple sources including storm water runoff, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals. Urban runoff and storm water processes are considered to be significant contributors to fecal coliform concentrations in some of the impaired subwatersheds.

7.0 ANALYTICAL APPROACH

Establishing the relationship between in-stream water quality and source loading is an important component of TMDL development. It allows the determination of the relative contribution of sources to total pollutant loading and the evaluation of potential changes to water quality resulting from implementation of various management options. This relationship can be developed using a variety of techniques ranging from qualitative assumptions based on scientific principles to numerical computer modeling. In this section, the numerical modeling techniques developed to simulate fecal coliform bacteria fate and transport in the watershed are discussed.

7.1 Model Selection

A dynamic computer model was selected for fecal coliform analysis in order to: a) simulate the time varying nature of fecal coliform deposition on land surfaces and transport to receiving waters; b) incorporate seasonal effects on the production and fate of fecal coliform bacteria; and c) identify the critical condition for the TMDL analysis. Several computer-based tools were also utilized to generate input data for the model.

The Nonpoint Source Model (NPSM) is a watershed model capable of simulating nonpoint source runoff and associated pollutant loadings, account for point source discharges, and performing flow and water quality routing through stream reaches. NPSM is based on the Hydrologic Simulation Program - Fortran (HSPF). In these TMDLs, NPSM was used to simulate point source discharges, simulate the deposition and transport of fecal coliform bacteria from land surfaces, and compute the resulting water quality response. In-stream decay of fecal coliform bacteria is included in the model at a rate of 0.048 per hour. This rate represents the median value reported in the literature (EPA, 1985), that reports decay rates from 0.008 per hour to 0.13 per hour.

In addition to NPSM, the Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support water quality model simulations (EPA, 2001). This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics. Results of the WCS characterization are input to a spreadsheet developed by Tetra Tech, Inc. to estimate NPSM input parameters associated with fecal coliform buildup (loading rates). The spreadsheet is also used to estimate direct sources of fecal coliform loading to water bodies from leaking septic systems and animals having access to streams. Information from the WCS and spreadsheet tools were used as initial input for variables in the NPSM model.

7.2 Model Set Up

The Lower Ocmulgee River basin was divided into four projects with each project containing between 7 and 13 delineated subwatersheds. The Little Ocmulgee River basin was divided into two projects with each project containing between 11 and 14 subwatersheds. The delineated watersheds contain the impaired streams and correspond to the 12 digit HUCs established by the State of Georgia (Figure 3). Watershed delineation was based on the Reach File 3 (Rf3) stream coverage and Digital Elevation Model (DEM) data. This discretization allows management and load reduction alternatives to be varied by subwatershed.

An important factor influencing model results is the precipitation data contained in the meteorological data file used in the simulation. The pattern and intensity of rainfall affects the build-up and wash-off of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream.

7.3 Model Calibration

Calibration of the watershed model included both hydrology and water quality components. The hydrology calibration was performed first and involved adjustment of the model parameters used to represent the hydrologic cycle until acceptable agreement was achieved between simulated flows and historic stream flow data from a USGS stream gaging station in the watershed for the same period of time. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge. Hydrology calibrations are presented in Appendix A, along with USGS gages used for the flow calibrations. Calibrated models were then subjected to model validation to ensure that generated model streamflows for each of the impaired segments were acceptable.

The model was also calibrated for water quality. Appropriate model parameters were adjusted to obtain acceptable agreement between simulated instream fecal coliform concentrations and observed data collected at the sampling stations indicated in Table 3. Water quality calibrations are presented in Appendix B.

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (WLAs), nonpoint source loads (LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

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

The objective of a TMDL is to allocate loads among known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time (e.g., pounds per day), toxicity, or other appropriate measure. For fecal coliform bacteria, the TMDLs are expressed as counts per 30 days. The TMDL represents the maximum load that can occur over a 30-day period while maintaining water quality standards.

8.1 Critical Conditions

The critical condition for nonpoint source fecal coliform loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal coliform bacteria builds up on the land surface, and is washed off by rainfall. The critical condition for point source loading occurs during periods of low stream flow when dilution is minimized. Both conditions are simulated in the water quality model.

A definitive time period was used to simulate a continuous 30-day geometric mean concentration to compare to the target. For TMDLs in the Lower and Little Ocmulgee Basins, this time period is ten years. This time period covers a range of hydrological conditions that included both low and high stream flows.

The simulated 30-day geometric mean concentrations for existing conditions are presented in Appendix C. From these figures, critical conditions can be determined. The 30-day critical period in the model is the period preceding the largest simulated violation of the geometric mean standard (EPA, 1991). During periods where the model predicted extremely low stream flows, the model often became unstable and exhibited extreme positive or negative spikes. These portions of the simulation were excluded from consideration of the critical period. Meeting water quality standards during the critical period ensures that water quality standards can be achieved throughout the reviewed time period. For the listed segments in the Lower and Little Ocmulgee River basins, the critical period used in development of the TMDLs is given in Table 7.

8.2 Existing Conditions

The existing fecal coliform load for each of the 303(d) listed waterbodies was determined in the following manner:

- The calibrated model, corresponding to the portion of the impaired stream that is upstream of the pour point of the listed waterbody segment was run for a time period that included the critical condition. This critical time period is provided for each listed segment in Table 7.

- The existing fecal coliform load for each listed segment is represented as the sum of the NPDES permitted fecal coliform load from all point discharges (at design limits), the daily discharge load of other modeled direct sources (e.g., other direct sources such as animal access to streams, illicit discharges of fecal coliform bacteria, failing septic systems, or leaking sewer collection lines), and the daily fecal coliform load indirectly going to surface waters from all land uses (e.g., surface runoff), over the 30 day critical period.

Model results indicate that nonpoint sources related to urban and agricultural land uses have the greatest impact on the fecal coliform bacteria loading in the impaired streams. Direct inputs of fecal coliform bacteria from "other sources" (i.e., animal access to streams, illicit discharges of fecal coliform bacteria, failing septic systems, and leaking sewer collection lines) are also shown to increase bacteria loading in the watershed. Reductions in these loading rates reduce the in-stream fecal coliform bacteria levels. Nonpoint source loading rates representing existing conditions during the critical period are shown in Table 7.

In general, point source loads from NPDES facilities, do not significantly contribute to the impairment of the listed stream segments since discharges from these facilities are required to be treated to levels corresponding to instream water quality criteria. Table 5 provides point source loads from NPDES facilities based on DMRs (when available), and loads based on permitted facility flows and limits. As shown in this table, most facilities for which data are available have existing (i.e., based on DMR reporting) loads that are significantly lower than the maximum load at the permit limits.

8.3 Margin of Safety (MOS)

There are two methods for incorporating a MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. Both an explicit and an implicit MOS were incorporated in these TMDLs. Implicit MOS include conservative modeling assumptions and a continuous simulation that incorporates a range of meteorological events. Conservative modeling assumptions used include: septic systems discharging directly into the streams; development of the TMDL using loads based on the design flow and fecal coliform permit limits of NPDES facilities; and all land areas considered to be connected directly to streams. An explicit MOS was included in the TMDLs by reducing the load allocation by 10 percent.

8.4 Determination of TMDL, WLA, and LA

The TMDL is the total amount of pollutant that can be assimilated by a water body while maintaining water quality standards. Fecal coliform bacteria TMDLs are expressed as counts per 30-day period as the water quality standard is expressed in terms of the 30-day geometric mean. The TMDL, therefore, represents the maximum fecal coliform bacteria load that can be assimilated by a stream during the critical 30-day period while maintaining the fecal coliform bacteria water quality standard of 200 counts / 100 ml. As previously stated, the TMDL is calculated using the equation:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

With MOS equal to10 percent of the LA value, the TMDL, ∑WLA, and ∑LA were determined according to the following procedure:

- The calibrated model, corresponding to the portion of the watershed that is upstream of the pour point of the listed waterbody segment was run for a time period that included the critical condition as specified in Table 7.

- Existing NPDES permitted facilities and any known future facility discharges were assumed to discharge at design flows and the fecal coliform permit limit of 200-counts/100 ml.

- Fecal coliform land loading variables and the magnitude of loading from sources modeled as "other direct sources" were adjusted within a reasonable range of known values until the resulting fecal coliform concentration at the pour point of the listed water body segment was less than or equal to 200 counts/100ml.

- The ∑WLA is the load associated with the daily discharge loads of all modeled NPDES permitted facilities summed over the 30-day critical period. The discharge load for each facility represents the design flow at a fecal coliform concentration of 200-counts/100 ml (permit limit).

- The ∑LA is the daily fecal coliform load indirectly going to surface waters from all modeled land use areas as a result of buildup/washoff processes plus the daily discharge load sources modeled as "other direct sources" and the result summed over the 30-day critical period. The resultant load was reduced by 10 percent and represents the MOS.

The TMDL components for the listed water bodies are summarized in Table 8.

8.4.1 Waste Load Allocations

In the Lower Ocmulgee River basin, there are two NPDES facilities discharging fecal coliform bacteria into the impaired segment of the Ocmulgee River. There is one NPDES facility discharging fecal coliform into Bay Creek. The Upper Ocmulgee basin below Lake Jackson contains numerous NPDES facilities that drain into the impaired Ocmulgee River watershed. In the Little Ocmulgee River basin, only one NPDES facility discharges to an impaired stream and this is to Alligator Creek. In the TMDL, the WLA assigned to each impaired segment is the sum of the load from all NPDES facilities in the drainage basin of the impaired segment. Future facility permits will require end-of-pipe limits equivalent to the water quality standard of 200-counts/100 ml.

8.4.2 Load Allocations

There are two modes of transport for nonpoint source fecal coliform bacteria loading in the model.

First, loading from failing septic systems, animals in the stream, and leaking sewer system collection lines are modeled as “other direct sources” to the stream and are independent of precipitation. The second mode involves loading resulting from fecal coliform accumulation on land surfaces and wash-off during storm events. Fecal coliform applied to land is subject to a die-off rate and an absorption rate before it is transported to the stream.

Model results were analyzed to determine which sources of fecal coliform have the greatest impact on the fecal coliform bacteria loadings in the impaired watersheds. In general, nonpoint source runoff contributes the greatest fecal coliform load to the streams. Reductions in both urban and agricultural loads to the stream as well as reductions in direct sources to the stream (i.e., animal access to streams and leaking septic systems) are shown to improve water quality conditions. The percent reductions required from nonpoint source loads to the impaired streams are shown in Table 8.

Best management practices (BMPs) that could be used to implement this TMDL include controlling pollution from agriculture and urban runoff, identification and elimination of illicit discharges and other unknown “direct sources” of fecal coliform bacteria to the streams, and repair of leaking sewer collection lines and failing septic systems. Loading from agricultural sources may be minimized by adoption of NRCS resource management practices. NRCS practices include measures such as covering manure stacks exposed to the environment; reducing animal access to streams; and applying manure to agricultural lands at agronomic rates. Measures which can reduce urban contributions include: repair and renovation of leaking sewer collection systems; reduction of sewer overflows and surcharges by use of separate conduit systems for domestic wastewater and stormwater; encouragement of households and businesses to connect to public sewer systems and reduce the population using septic systems.

8.4.3 Seasonal Variation

Seasonal variation was incorporated in the continuous simulation water quality model by using varying monthly loading rates, daily meteorological data, and a long-term time period.

9.0 RECOMMENDATIONS

The TMDL analysis was performed using the best data available to specify WLAs and LAs that will meet the water quality criteria for fecal coliform in the Lower and Little Ocmulgee River basins so as to support the use classification specified for each of the listed segments in Table 2. The following recommendations and strategies are targeted toward source identification, collection of data to support additional modeling and evaluation, and subsequent reduction in sources that are causing impairment of water quality.

9.1 Point Source Facilities

All discharges from point source facilities are required to be in compliance with the conditions of their NPDES permit at all times. All future facilities with the potential to discharge fecal coliform should be given limits that do not cause or contribute to water quality impairment.

9.2 Urban Sources of Fecal Coliform Loading

Urban sources of fecal coliform can best be addressed using a strategy which involves public participation and intergovernmental coordination to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques, public education, and other appropriate methods and provisions. The following activities and programs conducted by cities, counties, and state agencies are recommended:

- Monitoring programs to identify the types and extent of fecal coliform water quality problems, relative degradation or improvement over time, areas of concern, and source identification;
- Requirements that all new and replacement sanitary sewage systems are designed to minimize discharges from the system into storm sewer systems;
- Mechanisms for reporting and correcting illicit connections, breaks, surcharges, and general sanitary sewer system problems;
- Sustained compliance with NPDES permit discharge requirements.

9.3 Agricultural Sources of Fecal Coliform Loading

The Georgia Environmental Protection Division (EPD) should coordinate with the Georgia Soil and Water Conservation Commission, and the Natural Resources Conservation Service (NRCS) to address issues concerning fecal coliform loading from agricultural lands in the Ocmulgee River basin. It is recommended that information (such as livestock populations by subwatershed, animal access to streams, manure application practices, etc.) be evaluated periodically so that watershed models can be updated to reflect current conditions. It is further recommended that BMPs be utilized to reduce the amount of fecal coliform bacteria transported to surface waters from agricultural sources to the maximum extent practicable.

9.4 Stream Monitoring

Further monitoring of the fecal coliform concentrations at current and additional water quality monitoring stations in the watershed is needed to characterize sources of fecal coliform bacteria and document future reduction of loading. Georgia's watershed management approach specifies a five-year cycle for planning and assessment. Watersheds will be examined (or re-examined) as appropriate, on a rotating basis.

9.5 Future Efforts

This TMDL represents the first phase of a long-term process to reduce fecal coliform loading to meet water quality standards in the impaired watersheds. Implementation strategies will be reviewed and the TMDLs will be refined as necessary in the next phase (next five-year cycle). The phased approach will support progress toward water quality standards attainment in the future. In accordance with USEPA TMDL guidance, these TMDLs may be revised based on results of future monitoring and source characterization data efforts.

10.0 Public Participation

A sixty-day public comment period was provided for this TMDL document. During the comment period, the availability of the TMDLs was public noticed, the TMDLs were posted on EPA's website, and copy of the TMDLs were provided, as requested, to the public for their comments. The response to comments received on the TMDLs can be found in the document entitled "*Responsiveness Summary Concerning EPA's August 30, 2001 Pubic Notice Proposing Fecal Coliform TMDLs For Waters in the State of Georgia*" (EPA, 2002).

11.0 Implementation

EPD has coordinated with EPA to prepare this Initial TMDL Implementation Plan for this TMDL. EPD has also established a plan and schedule for development of a more comprehensive implementation plan after this TMDL is established. EPD and EPA have executed a Memorandum of Understanding that documents the schedule for developing the more comprehensive plans. This Initial TMDL Implementation Plan includes a list of best management practices and provides for an initial implementation demonstration project to address one of the major sources of pollutants identified in this TMDL while State and/or local agencies work with local stakeholders to develop a revised TMDL implementation plan. It also includes a process whereby EPD and/or Regional Development Centers (RDCs) or other EPD contractors (hereinafter, "EPD Contractors") will develop expanded plans (hereinafter, "Revised TMDL Implementation Plans").

This Initial TMDL Implementation Plan, written by EPD and for which EPD and/or the EPD Contractor are responsible, contains the following elements.

1. EPA has identified a number of management strategies for the control of nonpoint sources of pollutants, representing some best management practices. Table 9, "Management Measure Selector Table", identifies these management strategies by source category and pollutant. Nonpoint sources are the primary cause of excessive pollutant loading in most cases. Any wasteload allocations in this TMDL will be implemented in the form of water-quality based effluent limitations in NPDES permits issued under CWA Section 402. See 40 C.F.R. § 122.44(d)(1)(vii)(B). NPDES permit discharges are a secondary source of excessive pollutant loading, where they are a factor, in most cases.

2. EPD and the EPD Contractor will select and implement one or more best management practice (BMP) demonstration projects for each River Basin. The purpose of the demonstration projects will be to evaluate by River Basin and pollutant parameter the site-specific effectiveness of one or more of the BMPs chosen. EPD intends that the BMP demonstration project be completed before the Revised TMDL Implementation Plan is issued. The BMP demonstration project will address the major category of contribution of the pollutant(s) of concern for the respective River Basin as identified in the TMDLs of the watersheds in the River Basin. The demonstration project need not be of a large scale, and may consist of one or more measures from the Table or equivalent BMP measures proposed by the EPD Contractor and approved by EPD. Other such measures may include those found in EPA's "Best Management Practices Handbook", the "NRCS National Handbook of Conservation Practices, or any similar reference, or measures that the volunteers, etc., devise that EPD approves. If for any reason the EPD Contractor does not complete the BMP

demonstration project, EPD will take responsibility for doing so.

3. As part of the Initial TMDL Implementation Plan the EPD brochure entitled "Watershed Wisdom -- Georgia's TMDL Program" will be distributed by EPD to the EPD Contractor for use with appropriate stakeholders for this TMDL, and a copy of the video of that same title will be provided to the EPD Contractor for its use in making presentations to appropriate stakeholders, on TMDL Implementation plan development.

4. If for any reason an EPD Contractor does not complete one or more elements of a Revised TMDL Implementation Plan, EPD will be responsible for getting that (those) element(s) completed, either directly or through another contractor.

5. The deadline for development of a Revised TMDL Implementation Plan is the end of August 2003.

6. The EPD Contractor helping to develop the Revised TMDL Implementation Plan, in coordination with EPD, will work on the following tasks involved in converting the Initial TMDL Implementation Plan to a Revised TMDL Implementation Plan:
   A. Generally characterize the watershed;
   B. Identify stakeholders;
   C. Verify the present problem to the extent feasible and appropriate, (e.g., local monitoring);
   D. Identify probable sources of pollutant(s);
   E. For the purpose of assisting in the implementation of the load allocations of this TMDL, identify potential regulatory or voluntary actions to control pollutant(s) from the relevant nonpoint sources;
   F. Determine measurable milestones of progress;
   G. Develop monitoring plan, taking into account available resources, to measure effectiveness; and
   H. Complete and submit to EPD the Revised TMDL Implementation Plan.

7. The public will be provided an opportunity to participate in the development of the Revised TMDL Implementation Plan and to comment on it before it is finalized.

8. The Revised TMDL Implementation Plan will supersede this Initial TMDL Implementation Plan when the Revised TMDL Implementation Plan is approved by EPD.

Table 1 Land Use Distribution for Ocmulgee River Basin (Source: MRLC, 1993)

Stream/Segment	Land Use Categories - in units of acres (percent)																
	Bare Rock/Sand/Clay	Deciduous Forest	Emergent Herbaceous Wetlands	Evergreen Forest	High Intensity Commercial/Industrial/Transportation	Low Intensity Commercial/Industrial/Transportation	High Intensity Residential	Low Intensity Residential	Mixed Forest	Open Water	Other Grasses Urban/Recreational	Pasture/Hay	Quarries/Strip Mines/Gravel Pits	Row Crops	Transitional	Woody Wetlands	Unclassified
Alligator Creek (Batson Creek to Lime Sink Creek)	20 (0.0)	6035 (13.7)	7 (0.0)	10912 (24.8)	8 (0.0)	0 (0.0)	6 (0.0)	52 (0.1)	3092 (7.0)	242 (0.5)	2 (0.0)	3744 (8.5)	9 (0.0)	13295 (30.2)	4152 (9.4)	2465 (5.6)	0 (0.0)
Bay Creek (Headwaters to Beaver Creek)	24 (0.1)	2029 (10.3)	2 (0.0)	2000 (10.2)	456 (2.3)	0 (0.0)	141 (0.7)	338 (1.7)	1459 (7.4)	25 (0.1)	132 (0.7)	4690 (23.9)	22 (0.1)	6126 (31.2)	761 (3.9)	1407 (7.2)	0 (0.0)
Big Indian Creek (Mossy Creek to Ocmulgee River)	201 (0.1)	35977 (15.3)	27 (0.0)	30725 (13.1)	2230 (1.0)	0 (0.0)	636 (0.3)	3819 (1.6)	15766 (6.7)	1186 (0.5)	1619 (0.7)	40452 (17.2)	379 (0.2)	65871 (28.1)	11571 (4.9)	24057 (10.3)	0 (0.0)
House Creek (Ball Creek to Little House Creek)	26 (0.0)	6163 (11.7)	21 (0.0)	13182 (25.1)	11 (0.0)	0 (0.0)	7 (0.0)	4 (0.0)	3786 (7.2)	282 (0.5)	0 (0.0)	5351 (10.2)	10 (0.0)	16437 (31.3)	5533 (10.5)	1778 (3.4)	0 (0.0)
Ocmulgee River (Sandy Run Creek to Big Indian Creek)	1573 (0.1)	643257 (30.0)	1621 (0.1)	444636 (20.7)	46708 (2.2)	0 (0.0)	26395 (1.2)	110857 (5.2)	350396 (16.4)	26072 (1.2)	23771 (1.1)	185457 (8.7)	7411 (0.3)	120788 (5.6)	51819 (2.4)	102128 (4.8)	0 (0.0)
Turnpike Creek (Hwy 280 to Sugar Creek)	13 (0.1)	5666 (22.6)	7 (0.0)	16601 (66.2)	22 (0.1)	0 (0.0)	2 (0.0)	129 (0.5)	4401 (17.6)	288 (1.1)	6 (0.0)	3995 (15.9)	6 (0.0)	10868 (43.3)	7267 (29.0)	2116 (8.4)	0 (0.0)

Table 2 Waterbodies Listed for Fecal Coliform Bacteria in the Ocmulgee River Basin (Source: EPD)

Stream Name	Segment Description	Segment Length (miles)	Designated Use Classification	Partially Supporting Designated Uses	Not Supporting Designated Uses
Bay Creek	Headwaters to Beaver Creek	9	Fishing		X
Big Indian Creek	Mossy Creek to Ocmulgee River	7	Fishing	X	
House Creek	Ball Creek to Little House Creek	8	Fishing		X
Alligator Creek	Batson Creek to Lime Sink Creek	12	Fishing		X
Turnpike Creek	Hwy 280 to Sugar Creek	24	Fishing		X
Ocmulgee River	Sandy Run Creek to Big Indian Creek	23	Fishing	X	

Table 3 1999 Water Quality Monitoring Stations (Source: EPD)

Stream Name	Segment Description	USGS Monitoring Station No.	Monitoring Station Description
Alligator Creek	Batson Creek to Lime Sink Creek	02216028	Alligator Creek at State Road 46 near McRae, Georgia
Turnpike Creek	Hwy 280 to Sugar Creek	02216187	Turnpike Creek at Cedar Park Dowdyville Road near Lumber City, Georgia
Bay Creek	Headwaters to Beaver Creek	02214472	Bay Creek at State Road 96 near Fort Valley, Georgia
Big Indian Creek	Mossy Creek to Ocmulgee River	02214835	Big Indian Creek at State Road 247 near Kathleen, Georgia
House Creek	Ball Creek to Little House Creek	02215276	House Creek at Sea Graves Road near Forest Glen, Georgia
Ocmulgee River	Sandy Run Creek to Big Indian Creek	02214265	Ocmulgee River - Georgia Highway 96

*Georgia monitoring station number; no corresponding USGS station

Table 4 Water Quality Monitoring Data (Source: EPD)

Stream/Segment	Sample Dates	Fecal Coliform Bacteria (MPN/100 ml.)	Geometric Mean (#/100 ml.)	Sample Dates	Fecal Coliform Bacteria (MPN/100 ml.)	Geometric Mean (#/100 ml.)	Sample Dates	Fecal Coliform Bacteria (MPN/100 ml.)	Geometric Mean (#/100 ml.)	Sample Dates	Fecal Coliform Bacteria (MPN/100 ml.)	Geometric Mean (#/100 ml.)
Alligator Creek (Batson Creek to Lime Sink Creek)	04/06/1999 04/15/1999 04/22/1999 04/28/1999	80 490 1700 4900	756	05/20/1999 05/27/1999 06/10/1999 06/17/1999	490 460 490 1700	658	07/29/1999	490		08/12/1999	490	
Big Indian Creek (Mossy Creek to Ocmulgee River)	01/19/1999 01/27/1999 02/02/1999 02/18/1999	20 230 1700 180	194	04/01/1999 04/14/1999 04/21/1999 04/28/1999	130 50 50 40	60	06/23/1999 06/30/1999 07/14/1999 07/21/1999	130 940 1700 65	341	09/22/1999 09/29/1999 10/05/1999 10/20/1999	170 110 50 50	83
Bay Creek (Headwaters to Beaver Creek)	01/19/1999 01/27/1999 02/02/1999 02/18/1999	2400 92000 >24000 92000	26424	04/01/1999 04/14/1999 04/21/1999 04/28/1999	1300 3300 3500 4900	2929	06/23/1999 06/30/1999 07/14/1999 07/21/1999	92000 5400 >24000 17000	21218	09/22/1999 09/29/1999 10/05/1999 10/20/1999	14950 230 1100 10000	2480
House Creek (Ball Creek to Little House Creek)	04/06/1999 04/15/1999 04/22/199 04/28/1999	460 230 20 270	155	07/29/1999 08/12/1999 08/19/1999 08/26/1999	130 1100 130 1400	402	11/18/1999	20				
Ocmulgee River (Sandy Run Creek to Big Indian Creek)	01/19/1999 01/27/1999 02/02/1999 02/18/1999	20 490 490 170	169	04/01/1999 04/14/1999 04/21/1999 04/28/1999	130 50 <20 80	57	06/23/1999 06/30/1999 07/14/1999 07/21/1999	40 330 790 490	267	09/22/1999 09/29/1999 10/05/1999 10/20/1999	80 80 490 <20	89
Turnpike Creek (Hwy 280 to Sugar Creek)	04/01/1999 04/08/1999 04/14/1999 04/21/1999	6400 110 490 110	441	05/19/1999 07/28/1999 08/11/1999	160 170 <20		12/08/1999 12/15/1999	20 110				

Table 5 NPDES Facilities Discharging Fecal Coliform in the Ocmulgee River Basin

Facility Name	NPDES Permit No.	1999 Discharge Monitoring Reports		NPDES Permit Limits	
		Avg. Flow (MGD)	Avg. Fecal Coliform Loading[a] (counts/hr)	Avg. Flow (MGD)	Avg. Fecal Coliform Loading[b] (counts/hr)
Cagle's Inc Perry	GA0002844	No data available		3.50	1.11×10^9
Cadwell WPCP	GA0025887	No data available		0.05	1.58×10^7
Fort Valley WPCP	GA0031046	1.47	3.56×10^8	2.20	6.95×10^8
Perry WPCP	GA0021334	2.02	2.52×10^8	3.00	9.48×10^8
USAF Robins AFB	GA0002852	No data available		2.10	6.64×10^8
Warner Robins Sandy Run Creek	GA0030325	5.60	9.99×10^7	9.00	2.84×10^9

a Loadings based on CY 1999 average fecal coliform concentration and mean flow reported on DMRs.

b Loadings based on Monthly Average fecal coliform permit limit at monthly average permitted flow (design flow used for facilities without a permitted monthly flow limit). A fecal coliform loading of 200 counts/100 mL was assumed for facilities without a fecal coliform bacteria permit limit.

Table 6 Livestock Distribution By County (Source: USDA, 1977)

Stream/Segment	Livestock						
	Beef Cow	Milk Cow	Cattle	Chicken Layers	Chickens-Broilers Sold	Hogs	Sheep
Twiggs	0	0	2501	0	0	556	0
Bleckley	3011	90	5414	0	0	1142	0
Dodge	6324	55	11204	0	0	10159	0
Montgomery	1846	23	3706	0	0	2259	0
Houston	3919	855	8165	0	4618401	680	0
Wheeler	0	0	3754	0	0	0	0
Wilcox	5059	840	9996	0	12693000	1993	0
Peach	764	1281	2844	0	0	12	0
Pulaski	0	0	1918	0	79	368	0
Macon	2155	9570	16665	0	13711000	150	0
Crawford	0	0	2429	0	2380500	0	0
Laurens	7888	455	14726	0	0	10159	0
Telfair	3164	15	5590	0	116	3240	0

Table 7 Loading Rates and Instream Fecal Coliform Concentrations for Existing Conditions During Critical Period

Stream/Segment	Critical Conditions Period	Loading from NPDES Discharges (counts/30 days)	Loading from Surface Runoff and Other Direct Sources (counts/30 days)
Bay Creek - (Headwaters to Beaver Creek)	4/28/95 – 5/27/95	5.00×10^{11}	1.42×10^{13}
Big Indian Creek - (Mossy Creek to Ocmulgee River)	6/12/90 – 7/11/90	1.98×10^{12}	3.87×10^{13}
House Creek - (Ball Creek to Little House Creek)	8/10/90 – 9/8/90	0	8.49×10^{11}
Ocmulgee River - (Sandy Run Creek to Big Indian Creek)	7/19/93 – 8/17/93	8.80×10^{15}	2.12×10^{15}
Alligator Creek (Batson Creek to Lime Sink Creek)	5/10/95 – 6/8/95	1.14×10^{10}	3.88×10^{13}
Turnpike Creek (Hwy 280 to Sugar Creek)	5/10/95 – 6/8/95	0	9.03×10^{12}

Table 8 TMDL Components

Stream/Segment	WLAs (counts/30 days)	LAs (counts/30 days)	Margin of Safety (counts/30 days)	TMDL (counts/30 days)
Alligator Creek - (Batson Creek to Lime Sink Creek)	1.14×10^{10}	9.19×10^{12}	1.02×10^{11}	9.30×10^{12}
Bay Creek - (Headwaters to Beaver Creek)	2.50×10^{11}	4.68×10^{10}	5.20×10^{9}	3.02×10^{11}
Big Indian Creek - (Mossy Creek to Ocmulgee River)	1.73×10^{12}	1.39×10^{12}	1.54×10^{11}	3.27×10^{12}
House Creek - (Ball Creek to Little House Creek)	0	1.36×10^{11}	1.51×10^{10}	1.51×10^{11}
Ocmulgee River - (Sandy Run Creek to Big Indian Creek)	8.20×10^{15}	9.40×10^{14}	1.04×10^{14}	9.24×10^{15}
Turnpike Creek - (Hwy 280 to Sugar Creek)	0	6.99×10^{12}	7.77×10^{11}	7.76×10^{12}

Table 9. Management Measure Selector Table (Source: EPD)

Land Use	**Management Measures**	Fecal Coliform	Dissolved Oxygen	pH	Sediment	Temperature	*Toxicity*	*Mercury*	Metals (copper, lead, zinc, cadmium)	PCBs, toxaphene
Agriculture	1. Sediment & Erosion Control	_	_		_	_				
	2. Confined Animal Facilities	_	_							
	3. Nutrient Management	_	_							
	4. Pesticide Management		_							
	5. Livestock Grazing	_	_		_	_				
	6. Irrigation		_		_	_				
Forestry	1. Preharvest Planning				_	_				
	2. Streamside Management Areas	_	_		_	_				
	3. Road Construction &Reconstruction		_		_	_				
	4. Road Management		_		_	_				
	5. Timber Harvesting		_		_	_				
	6. Site Preparation & Forest Regeneration		_		_	_				
	7. Fire Management	_	_	_	_	_				
	8. Revegetation of Disturbed Areas	_	_	_	_	_				

Land Use	**Management Measures**	Fecal Coliform	Dissolved Oxygen	pH	Sedimen t	Temperature	*Toxicity*	*Mercury*	Metals (copper, lead, zinc, cadmium)	PCBs, toxaphene
	9. Forest Chemical Management		–			–				
	10. Wetlands Forest Management	–	–	–		–		–		
Urban	1. New Development	–	–		–	–			–	
	2. Watershed Protection & Site Development	–	–		–	–		–	–	
	3. Construction Site Erosion and Sediment Control		–		–	–				
	4. Construction Site Chemical Control		–							
	5. Existing Developments	–	–		–	–			–	
	6. Residential and Commercial Pollution Prevention	–	–							
Onsite Wastewater	1. New Onsite Wastewater Disposal Systems	–	–							
	2. Operating Existing Onsite Wastewater Disposal Systems	–	–							
Roads, Highways and Bridges	1. Siting New Roads, Highways & Bridges	–	–		–	–			–	
	2. Construction Projects for Roads, Highways and Bridges		–		–	–				
	3. Construction Site Chemical Control for Roads, Highways		–							

Land Use	**Management Measures**	Fecal Coliform	Dissolved Oxygen	pH	Sedimen t	Temperature	*Toxicity*	*Mercury*	Metals (copper, lead, zinc, cadmium)	PCBs, toxaphene
	and Bridges									
	4. Operation and Maintenance- Roads, Highways and Bridges	–	–			–			–	

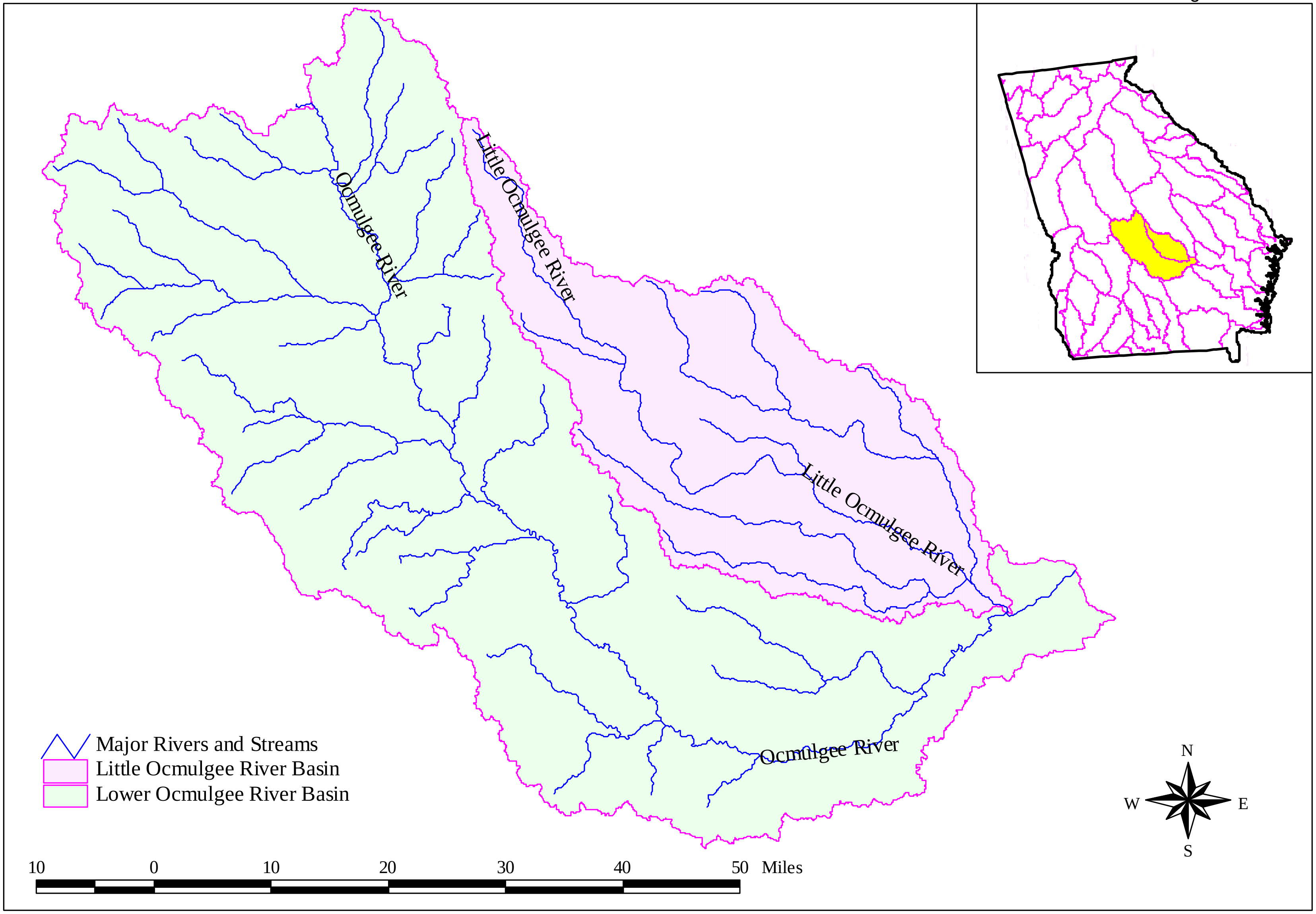


Figure 1. Lower Ocmulgee and Little Ocmulgee River Basins.

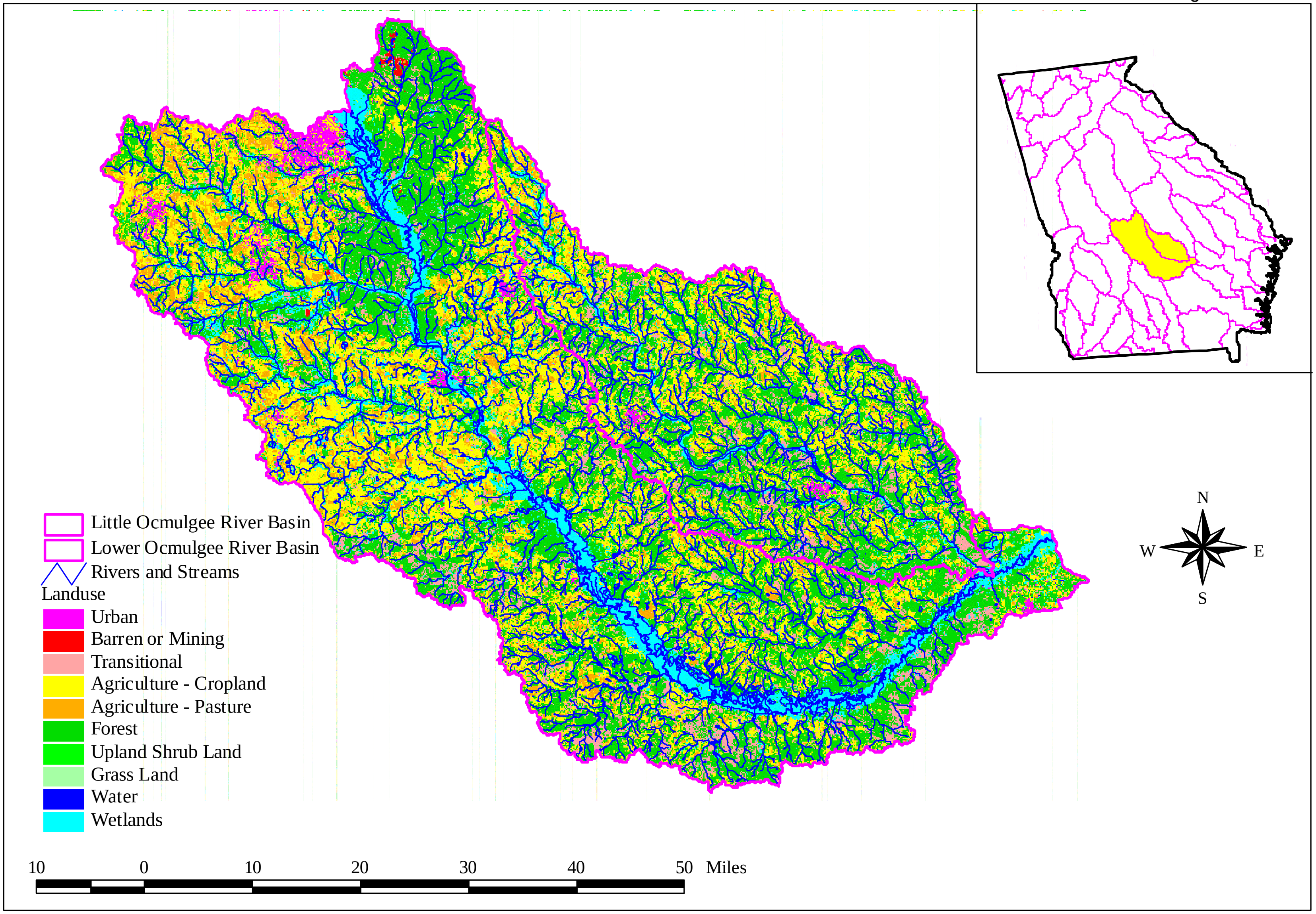


Figure 2. Landuse Distribution, Lower Ocmulgee and Little Ocmulgee River Basins.

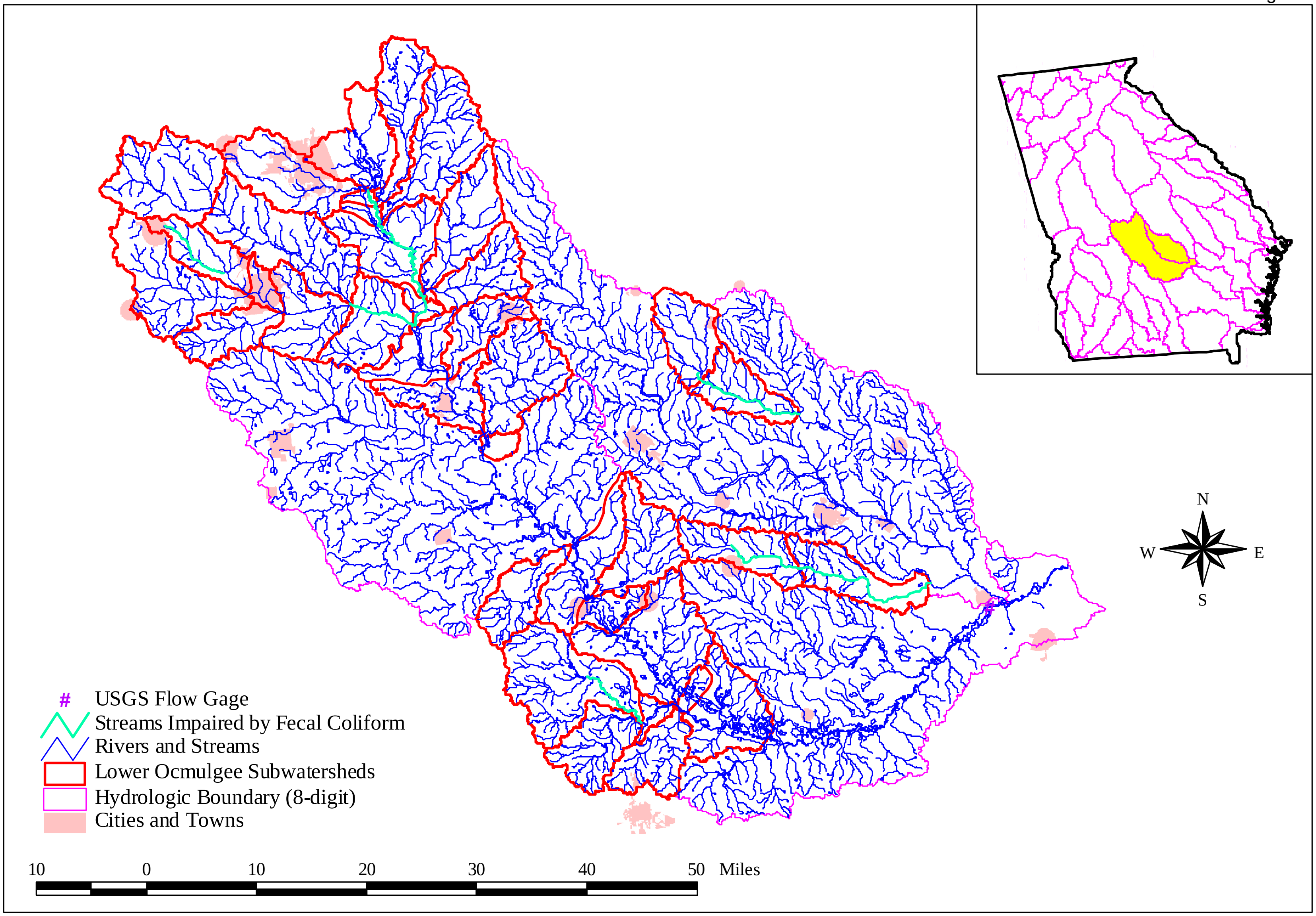


Figure 3. Subwatersheds and 303(d) Listed Streams, Lower Ocmulgee and Little Ocmulgee River Basins.

REFERENCES

North Carolina State University (NCSU), 1994. *Livestock Manure Production and Characterization in North Carolina*, North Carolina Cooperative Extension Service, North Carolina State University College of Agriculture and Life Sciences, Raleigh, January 1994.

Georgia EPD, 2000. *Final Georgia 2000 §303(d) / §305(b) List, August 2000 (As Revised April, 2001).* State of Georgia, Department of Natural Resources, Environmental Protection Division, Water Protection Branch.

Georgia EPD, 2000. *State of Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6 Revised, July, 2000.* State of Georgia, Department of Natural Resources, Environmental Protection Division, Water Protection Branch.

Georgia WRD, 1999. Personal Communications with a representative from the Wildlife Resources Division, Georgia Department of Natural Resources, 2070 U.S. Hwy 278, SE, Social Circle, GA. November, 1999.

USDA, 1977. *1997 Census of Agriculture, Volume 1, Geographic Area Series, Part 42,*U.S. Department of Agriculture, National Agricultural Statistics Service. AC97-A-42, March 1999.

USDA, 2001. Personal Communications with Mr. Jimmy Bramblett, Water Resources Specialist, U.S. Department of Agriculture – NRCS, 355 East Hancock Ave., Athens, GA. March-May, 2001.

USEPA, 2002. *Responsiveness Summary Concerning EPA's August 30, 2001 Pubic Notice Proposing Fecal Coliform TMDLs For Waters in the State of Georgia*. U.S. Environmental Protection Agency, Region 4, Atlanta, Georgia.

USEPA. Region 4. 2001. Watershed Characterization System – User's Manual. U.S. Environmental Protection Agency, Region 4, Atlanta, Georgia.

USEPA, 2001. *Protocol for Developing Pathogen TMDLs, First Edition.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-841-R-00-002, January 2001.

USEPA. 2000. *Draft Level III and IV Ecoregion of Georgia*. U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Corvallis, Oregon.

USEPA, 1998. *Better Assessment Science Integrating Point and Nonpoint Sources (BASINS), Version 2.0 User's Manual*, U.S. Environmental Protection Agency, Office of Water, Washington D.C.

USEPA, 1991. *Guidance for Water Quality–based Decisions: The TMDL Process.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-440/4-91-001, April 1991.

USEPA, 1985. *Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling*. 2nd ed. EPA 600/3-85/040. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA.

APPENDIX A:

HYDROLOGY CALIBRATIONS

Table A1 - Calibration and Validation Stations for Hydrological Parameters
Above the GA Fall Line (Piedmont)

Station Number	Station Name	Type	Drainage Area (acres)	Reference WDM station
02204070	South River at Klondike Road	Calibration	117978	Atlanta Hartsfield
02219000	Apalachee River near Bostwick, GA	Validation	119738	Monroe
02217500	Middle Oconee River near Athens, GA	Validation	252006	Jefferson
02220900	Little River near Eatonton, GA	Validation	174445	Milledgeville
02221525	Murder Creek Below Eatonton, GA	Validation	121690	Milledgeville
02208450	Alcovy River above Covington, GA	Validation	122720	Monroe
02213000	Ocmulgee River at Macon, GA	Validation	1450880	Macon Lewis

Figure A.1. Location of Hydrology Calibration and Validation Stations

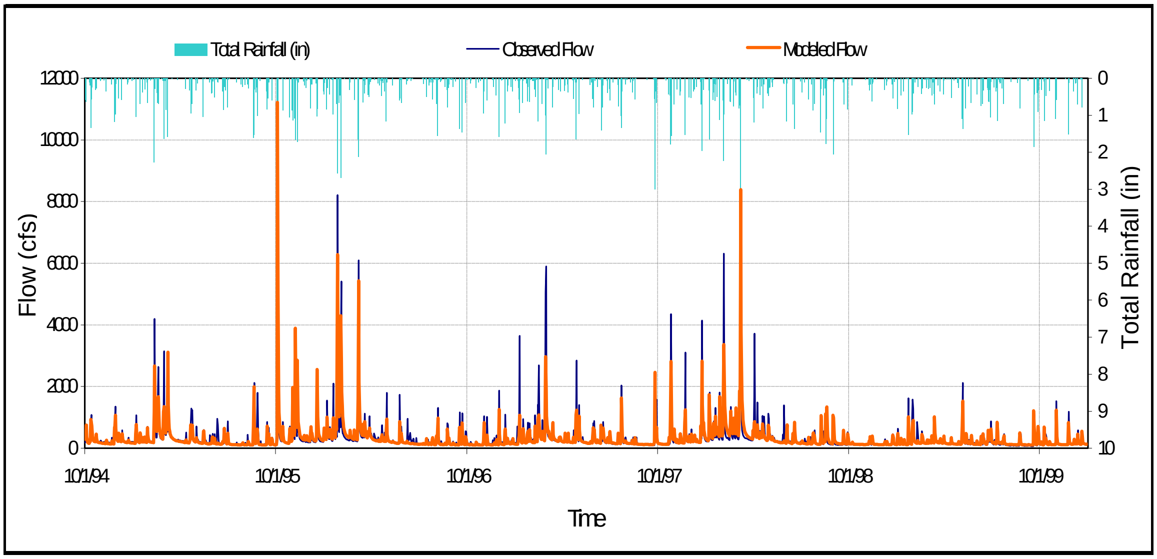


Figure A.2. 5.2-Year Calibration (Daily Flow) at 02204070 – South River at Klondike Road.

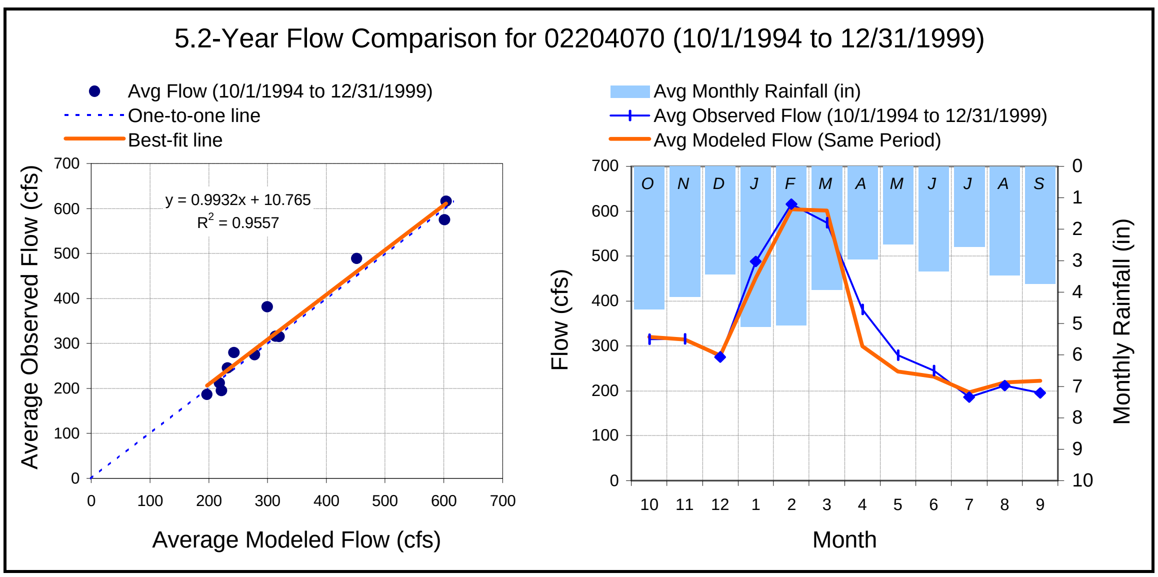


Figure A.3. 5.2-Year Calibration (Monthly Average) at 02204070 – South River at Klondike Road.

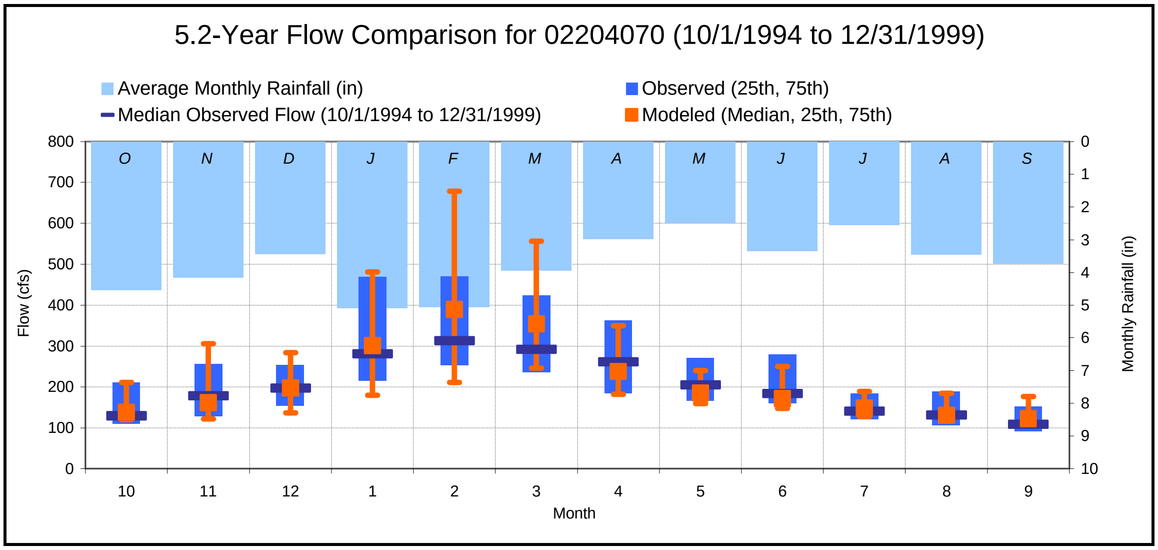


Figure A.4. 5.2-Year Calibration (Monthly Medians) at 02204070 – South River at Klondike Road.

Simulation Name:	02204070	**Simulation Period:**	
		Watershed Area (ac):	117978
Period for Flow Analysis			
Begin Date:	**10/01/94**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/99**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**127.39**	Total Observed In-stream Flow:	**130.44**
Total of highest 10% flows:	**50.64**	Total of Observed highest 10% flows:	**58.20**
Total of lowest 50% flows:	**27.00**	Total of Observed Lowest 50% flows:	**26.39**
Simulated Summer Flow Volume (months 7-9):	**19.70**	Observed Summer Flow Volume (7-9):	**18.35**
Simulated Fall Flow Volume (months 10-12):	**33.85**	Observed Fall Flow Volume (10-12):	**33.63**
Simulated Winter Flow Volume (months 1-3):	**50.13**	Observed Winter Flow Volume (1-3):	**50.76**
Simulated Spring Flow Volume (months 4-6):	**23.70**	Observed Spring Flow Volume (4-6):	**27.71**
Total Simulated Storm Volume:	**85.31**	Total Observed Storm Volume:	**98.06**
Simulated Summer Storm Volume (7-9):	**9.62**	Observed Summer Storm Volume (7-9):	**10.67**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-2.40**	10	
Error in 50% lowest flows:	**2.25**	10	
Error in 10% highest flows:	**-14.92**	15	
Seasonal volume error - Summer:	**6.87**	30	
Seasonal volume error - Fall:	**0.65**	30	
Seasonal volume error - Winter:	**-1.24**	30	
Seasonal volume error - Spring:	**-16.90**	30	
Error in storm volumes:	**-14.94**	20	
Error in summer storm volumes:	**-10.85**	50	

Figure A.5. 5.2-Year Calibration Statistics at 02204070 – South River at Klondike Road.

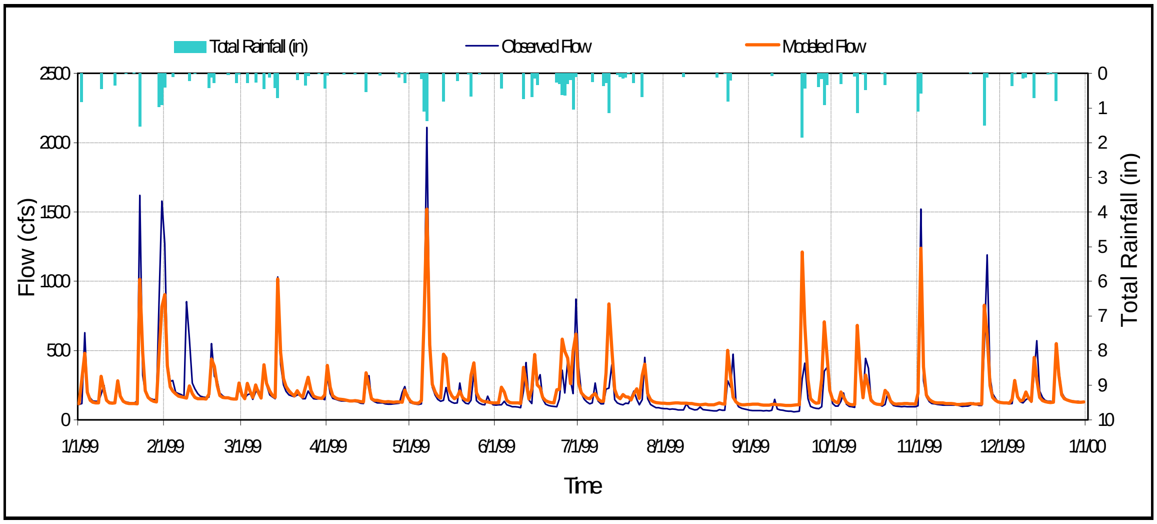


Figure A.6. Calendar Year 1999 (Daily Flow) at 02204070 – South River at Klondike Road.

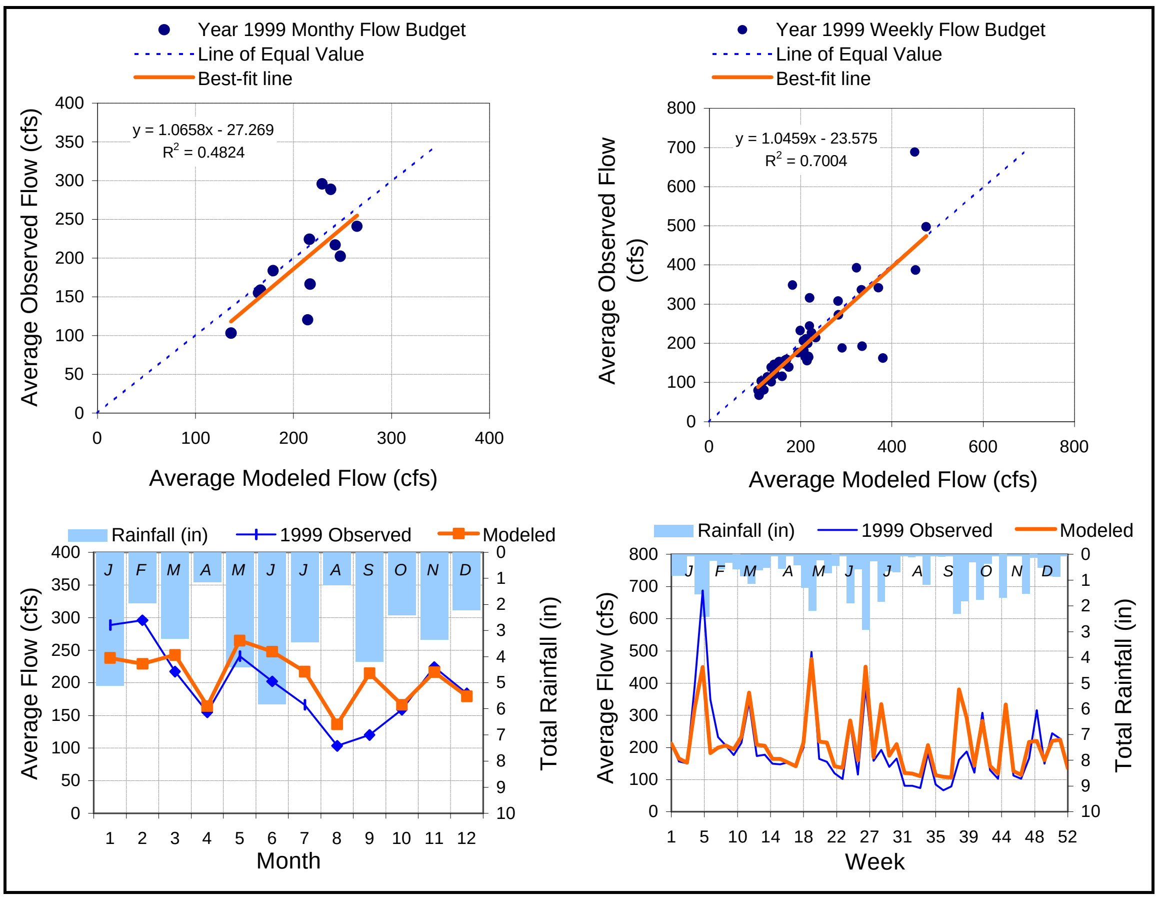


Figure A.7. Calendar Year 1999 (Monthly and Weekly) at 02204070 – South River at Klondike Road.

Simulation Name:	02204070	**Simulation Period:**	
		Watershed Area (ac):	117978
Selected a Year for Flow Analysis:	**1999**		
Type of Year (1=Calendar, 2=Water Year)	**1**	**Baseflow PERCENTILE:**	2.5
Calendar Year 1999:		*Usually 1%-5%*	
1/1/1999 to 12/31/1999			
Total Simulated In-stream Flow:	**15.43**	Total Observed In-stream Flow:	**14.41**
Total of highest 10% flows:	**4.80**	Total of Observed highest 10% flows:	**5.09**
Total of lowest 50% flows:	**4.55**	Total of Observed Lowest 50% flows:	**3.79**
Simulated Summer Flow Volume (months 7-9):	**3.51**	Observed Summer Flow Volume (7-9):	**2.41**
Simulated Fall Flow Volume (months 10-12):	**3.47**	Observed Fall Flow Volume (10-12):	**3.50**
Simulated Winter Flow Volume (months 1-3):	**4.30**	Observed Winter Flow Volume (1-3):	**4.83**
Simulated Spring Flow Volume (months 4-6):	**4.15**	Observed Spring Flow Volume (4-6):	**3.67**
Total Simulated Storm Volume:	**7.54**	Total Observed Storm Volume:	**9.61**
Simulated Summer Storm Volume (7-9):	**1.52**	Observed Summer Storm Volume (7-9):	**1.21**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**6.63**	10	
Error in 50% lowest flows:	**16.82**	10	
Error in 10% highest flows:	**-6.11**	15	
Seasonal volume error - Summer:	**31.30**	30	
Seasonal volume error - Fall:	**-0.75**	30	
Seasonal volume error - Winter:	**-12.36**	30	
Seasonal volume error - Spring:	**11.63**	30	
Error in storm volumes:	**-27.51**	20	
Error in summer storm volumes:	**20.76**	50	

Figure A.8. Calendar Year 1999 Statistics at 02204070 – South River at Klondike Road.

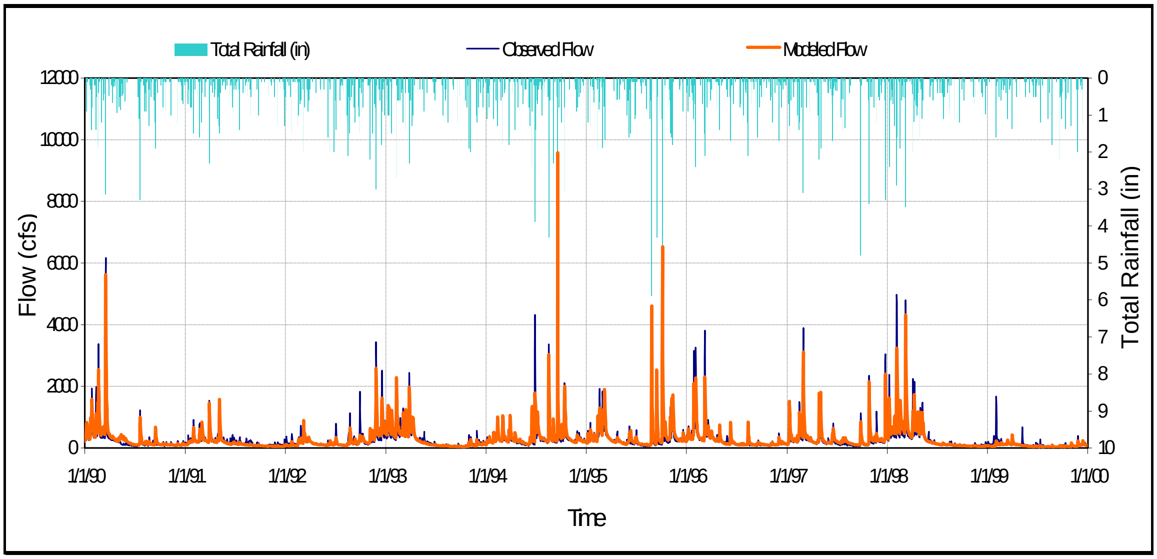


Figure A.9. 10-Year Validation (Daily Flow) at 02219000 – Apalachee River near Bostwick, GA.

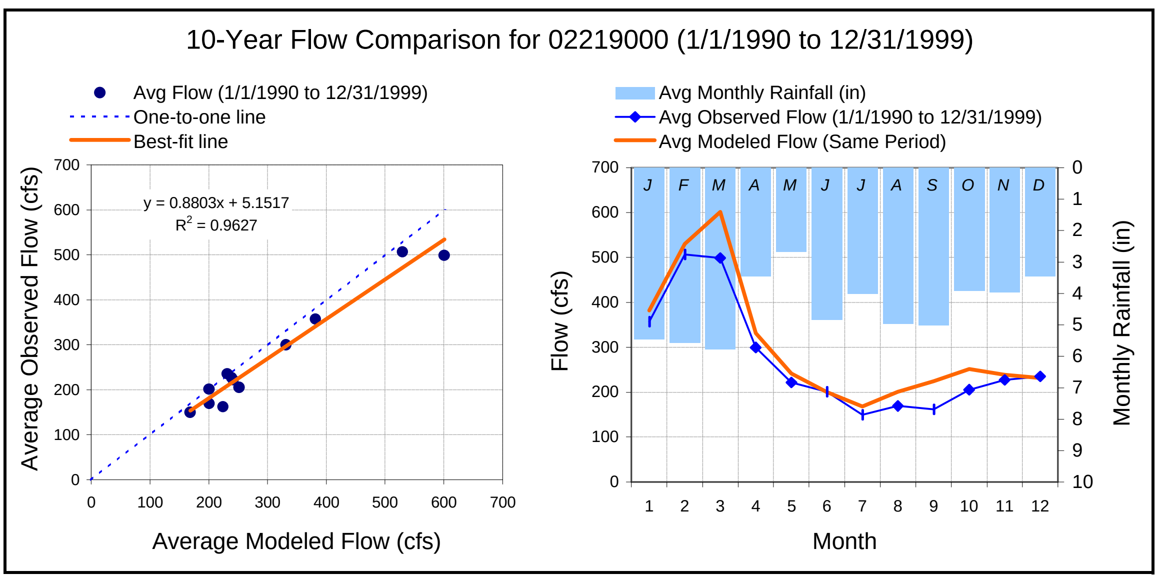


Figure A.10. 10-Year Validation (Monthly Average) at 02219000 – Apalachee River near Bostwick, GA.

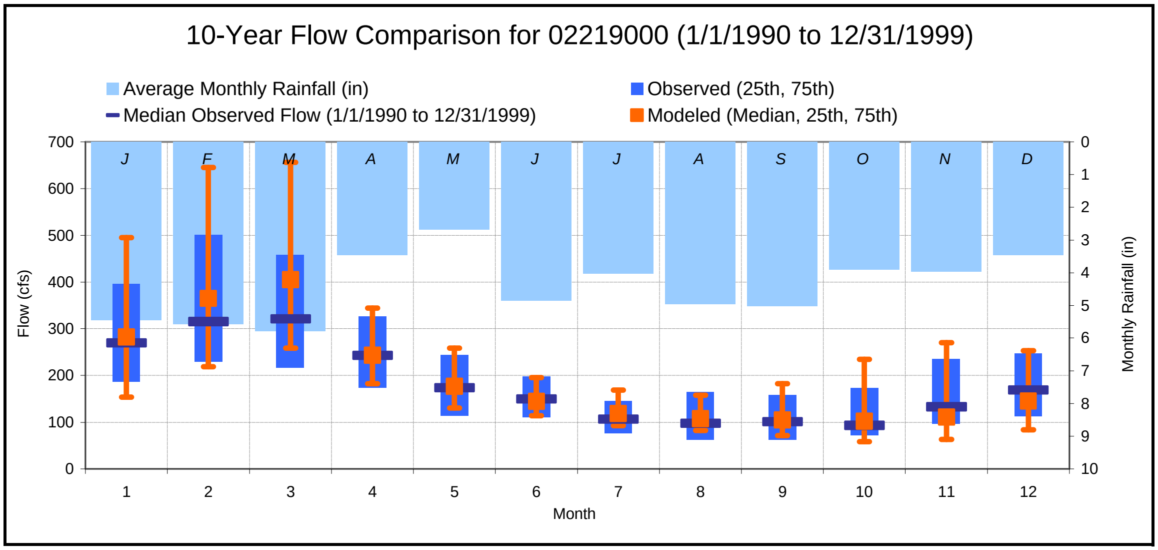


Figure A.11. 10-Year Validation (Monthly Medians) at 02219000 – Apalachee River near Bostwick, GA.

Simulation Name:	02219000	**Simulation Period:**	
		Watershed Area (ac):	119738
Period for Flow Analysis			
Begin Date:	**01/01/90**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/99**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**217.08**	Total Observed In-stream Flow:	**194.66**
Total of highest 10% flows:	**90.29**	Total of Observed highest 10% flows:	**78.55**
Total of lowest 50% flows:	**35.38**	Total of Observed Lowest 50% flows:	**37.57**
Simulated Summer Flow Volume (months 7-9):	**36.16**	Observed Summer Flow Volume (7-9):	**29.31**
Simulated Fall Flow Volume (months 10-12):	**44.03**	Observed Fall Flow Volume (10-12):	**40.69**
Simulated Winter Flow Volume (months 1-3):	**90.27**	Observed Winter Flow Volume (1-3):	**81.15**
Simulated Spring Flow Volume (months 4-6):	**46.62**	Observed Spring Flow Volume (4-6):	**43.51**
Total Simulated Storm Volume:	**185.93**	Total Observed Storm Volume:	**162.94**
Simulated Summer Storm Volume (7-9):	**28.43**	Observed Summer Storm Volume (7-9):	**21.48**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**10.33**	10	
Error in 50% lowest flows:	**-6.21**	10	
Error in 10% highest flows:	**13.01**	15	
Seasonal volume error - Summer:	**18.93**	30	
Seasonal volume error - Fall:	**7.60**	30	
Seasonal volume error - Winter:	**10.10**	30	
Seasonal volume error - Spring:	**6.66**	30	
Error in storm volumes:	**12.36**	20	
Error in summer storm volumes:	**24.43**	50	

Figure A.12. 10-Year Validation Statistics at 02219000 – Apalachee River near Bostwick, GA.

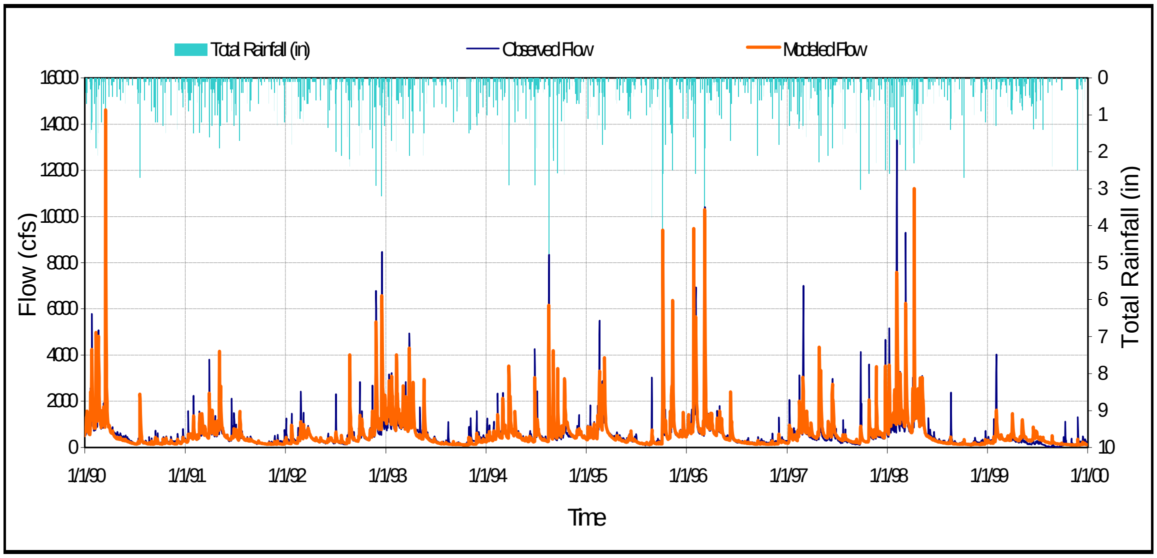


Figure A.13. 10-Year Validation (Daily Flow) at 02217500 – Middle Oconee River near Athens, GA.

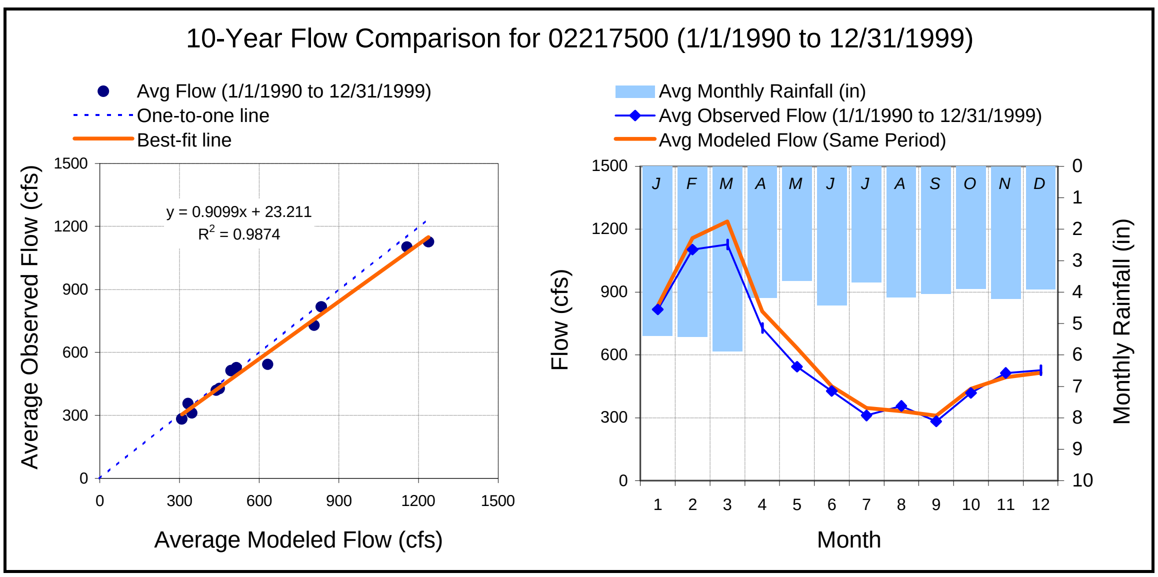


Figure A.14. 10-Year Validation (Monthly Average) at 02217500 – Middle Oconee River near Athens, GA.

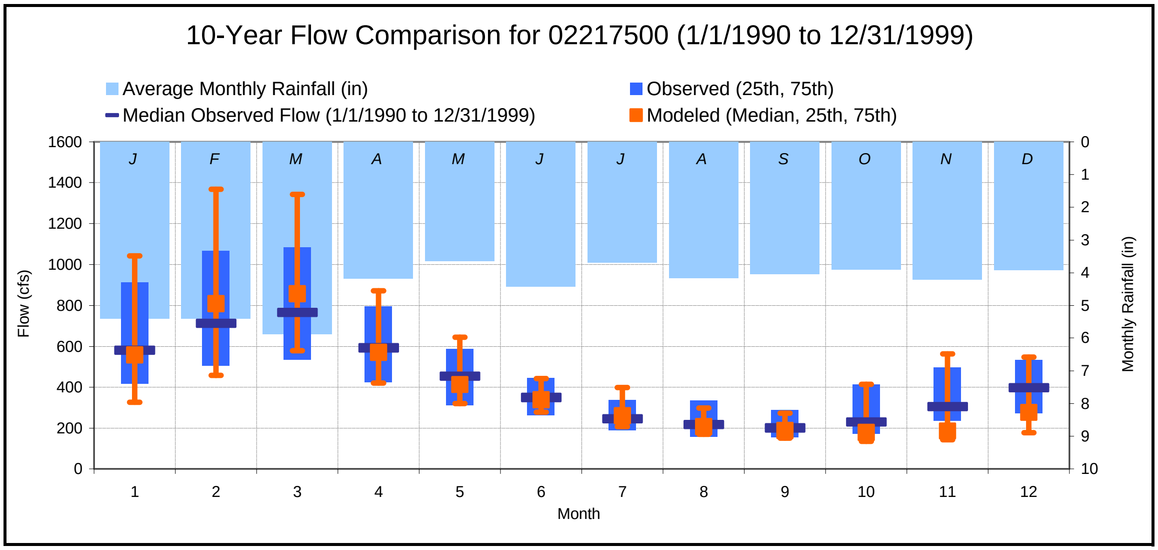


Figure A.15. 10-Year Validation (Monthly Medians) at 02217500 – Middle Oconee River near Athens, GA.

Simulation Name:	02217500	**Simulation Period:**	
		Watershed Area (ac):	252006
Period for Flow Analysis			
Begin Date:	**01/01/90**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/99**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**216.24**	Total Observed In-stream Flow:	**204.71**
Total of highest 10% flows:	**86.28**	Total of Observed highest 10% flows:	**78.78**
Total of lowest 50% flows:	**38.25**	Total of Observed Lowest 50% flows:	**41.80**
Simulated Summer Flow Volume (months 7-9):	**28.67**	Observed Summer Flow Volume (7-9):	**27.55**
Simulated Fall Flow Volume (months 10-12):	**41.92**	Observed Fall Flow Volume (10-12):	**42.23**
Simulated Winter Flow Volume (months 1-3):	**91.48**	Observed Winter Flow Volume (1-3):	**86.27**
Simulated Spring Flow Volume (months 4-6):	**54.17**	Observed Spring Flow Volume (4-6):	**48.65**
Total Simulated Storm Volume:	**175.96**	Total Observed Storm Volume:	**167.18**
Simulated Summer Storm Volume (7-9):	**18.50**	Observed Summer Storm Volume (7-9):	**18.39**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**5.33**	10	
Error in 50% lowest flows:	**-9.30**	10	
Error in 10% highest flows:	**8.69**	15	
Seasonal volume error - Summer:	**3.89**	30	
Seasonal volume error - Fall:	**-0.74**	30	
Seasonal volume error - Winter:	**5.69**	30	
Seasonal volume error - Spring:	**10.19**	30	
Error in storm volumes:	**4.99**	20	
Error in summer storm volumes:	**0.61**	50	

Figure A.16. 10-Year Validation Statistics at 02217500 – Middle Oconee River near Athens, GA.

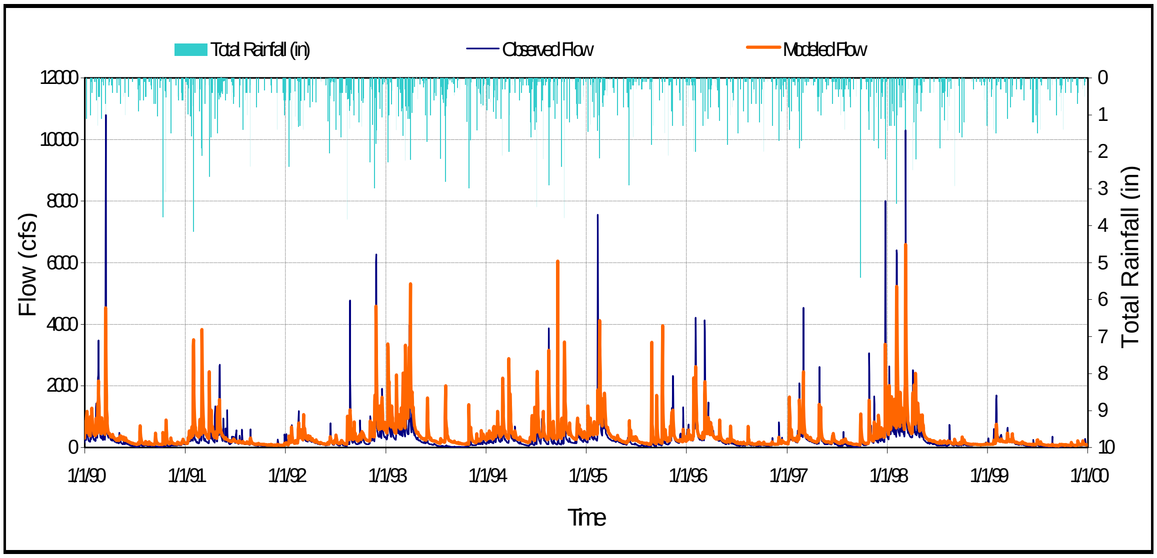


Figure A.17. 10-Year Validation (Daily Flow) at 02220900 – Little River near Eatonton, GA.

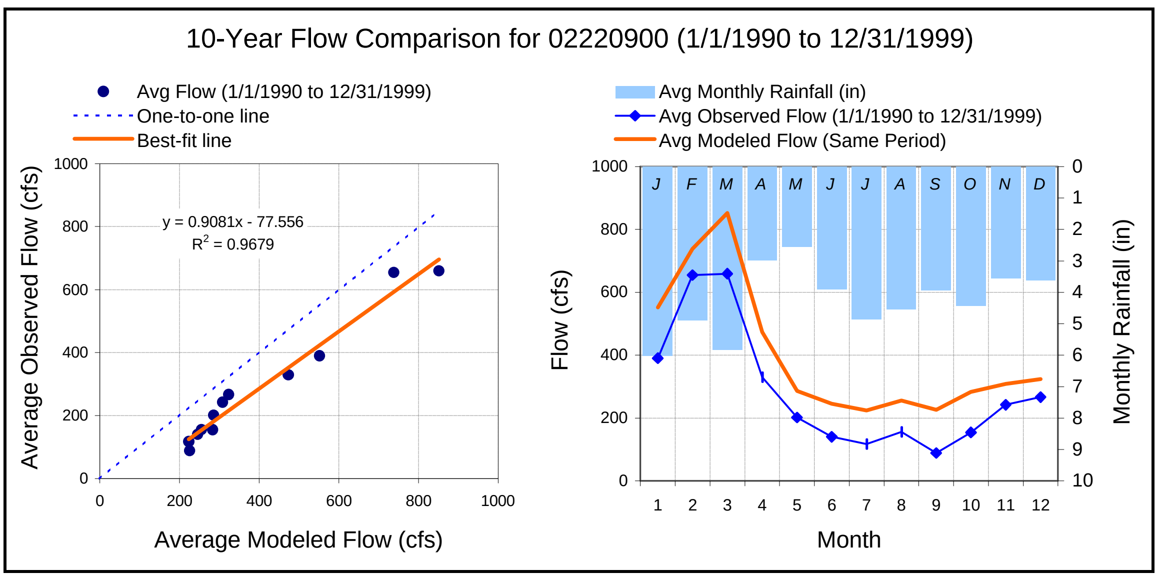


Figure A.18. 10-Year Validation (Monthly Average) at 02220900 – Little River near Eatonton, GA.

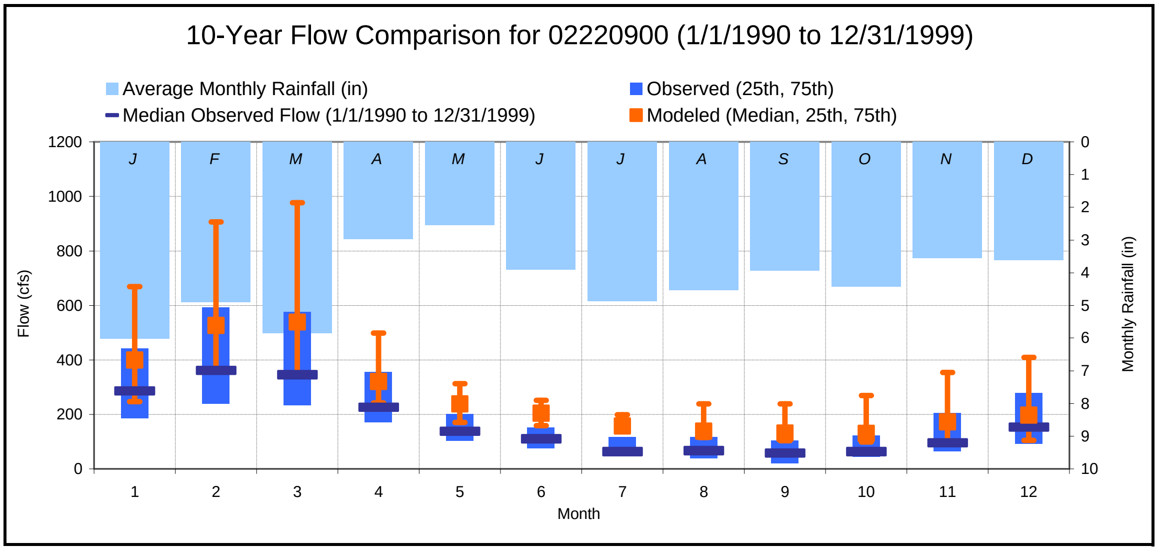


Figure A.19. 10-Year Validation (Monthly Medians) at 02220900 – Little River near Eatonton, GA.

Simulation Name:	02220900	**Simulation Period:**	
		Watershed Area (ac):	174445
Period for Flow Analysis			
Begin Date:	**01/01/90**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/99**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**197.17**	Total Observed In-stream Flow:	**140.21**
Total of highest 10% flows:	**77.93**	Total of Observed highest 10% flows:	**67.14**
Total of lowest 50% flows:	**34.87**	Total of Observed Lowest 50% flows:	**18.88**
Simulated Summer Flow Volume (months 7-9):	**29.53**	Observed Summer Flow Volume (7-9):	**15.17**
Simulated Fall Flow Volume (months 10-12):	**38.32**	Observed Fall Flow Volume (10-12):	**27.72**
Simulated Winter Flow Volume (months 1-3):	**87.78**	Observed Winter Flow Volume (1-3):	**69.58**
Simulated Spring Flow Volume (months 4-6):	**41.54**	Observed Spring Flow Volume (4-6):	**27.75**
Total Simulated Storm Volume:	**162.94**	Total Observed Storm Volume:	**131.80**
Simulated Summer Storm Volume (7-9):	**20.93**	Observed Summer Storm Volume (7-9):	**13.08**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**28.89**	10	
Error in 50% lowest flows:	**45.86**	10	
Error in 10% highest flows:	**13.84**	15	
Seasonal volume error - Summer:	**48.64**	30	
Seasonal volume error - Fall:	**27.66**	30	
Seasonal volume error - Winter:	**20.74**	30	
Seasonal volume error - Spring:	**33.20**	30	
Error in storm volumes:	**19.11**	20	
Error in summer storm volumes:	**37.52**	50	

Figure A.20. 10-Year Validation Statistics at 02220900 – Little River near Eatonton, GA.

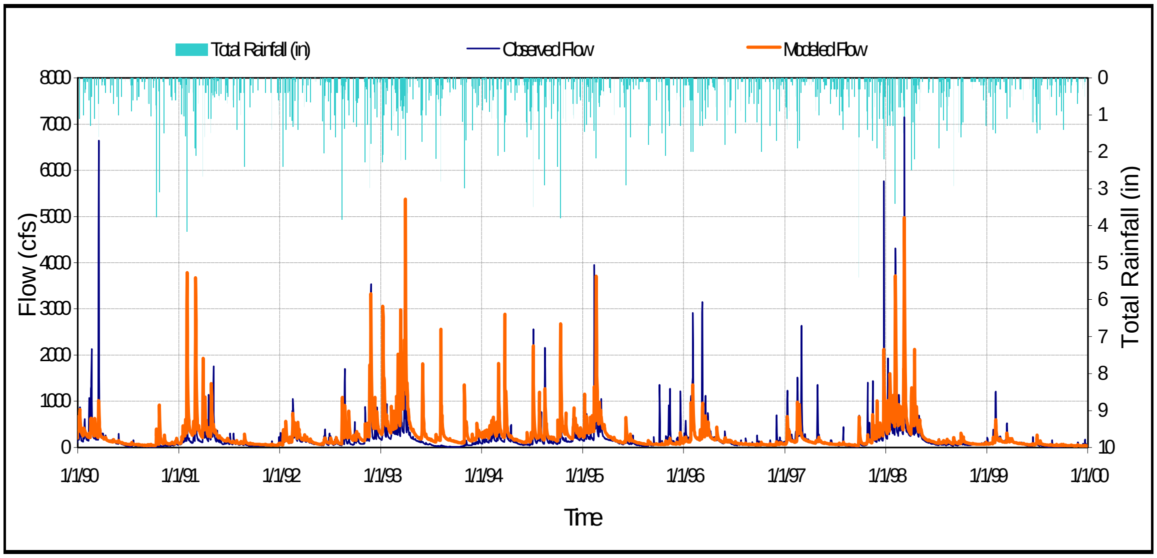


Figure A.21. 10-Year Validation (Daily Flow) at 02221525 – Murder Creek below Eatonton, GA.

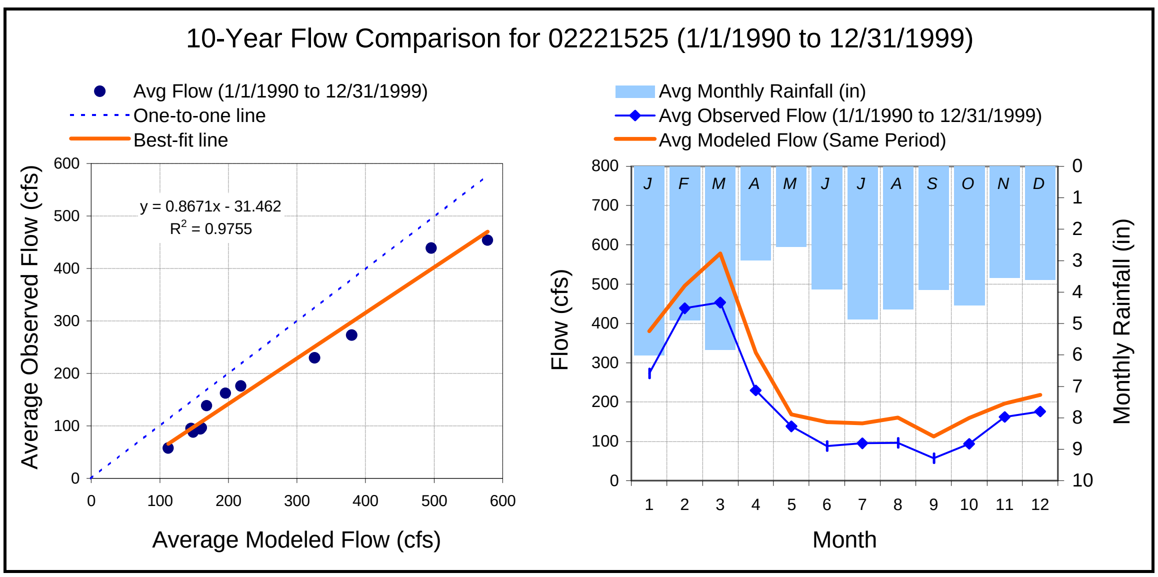


Figure A.22. 10-Year Validation (Monthly Average) at 02221525 – Murder Creek below Eatonton, GA.

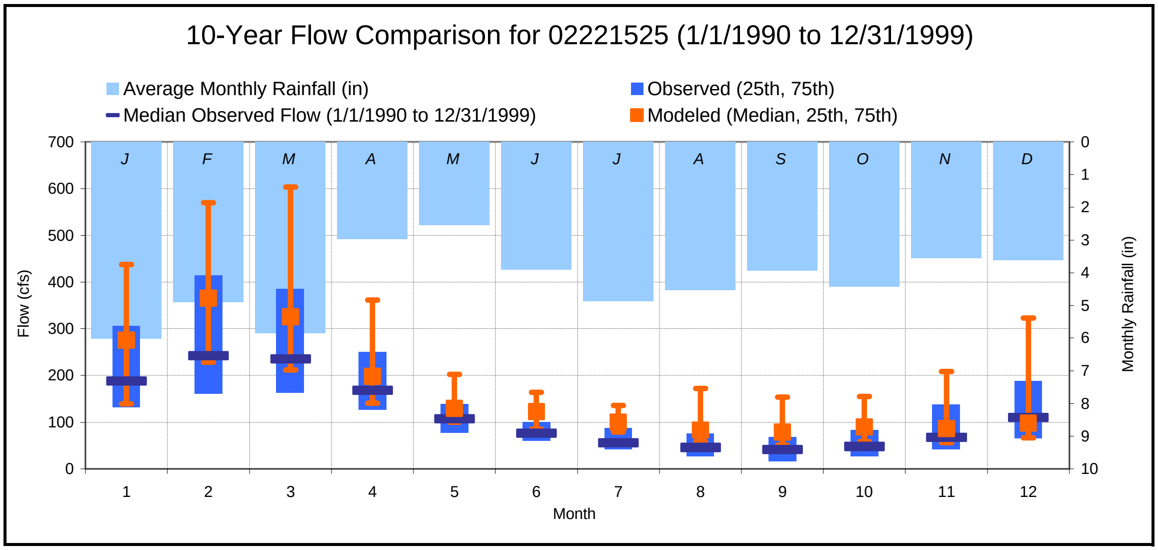


Figure A.23. 10-Year Validation (Monthly Medians) at 02221525 – Murder Creek below Eatonton, GA.

Simulation Name:	02221525	**Simulation Period:**	
		Watershed Area (ac):	121690
Period for Flow Analysis			
Begin Date:	**01/01/90**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/99**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**183.13**	Total Observed In-stream Flow:	**136.13**
Total of highest 10% flows:	**77.13**	Total of Observed highest 10% flows:	**65.23**
Total of lowest 50% flows:	**29.68**	Total of Observed Lowest 50% flows:	**19.42**
Simulated Summer Flow Volume (months 7-9):	**25.17**	Observed Summer Flow Volume (7-9):	**14.98**
Simulated Fall Flow Volume (months 10-12):	**34.40**	Observed Fall Flow Volume (10-12):	**25.89**
Simulated Winter Flow Volume (months 1-3):	**85.48**	Observed Winter Flow Volume (1-3):	**68.24**
Simulated Spring Flow Volume (months 4-6):	**38.09**	Observed Spring Flow Volume (4-6):	**27.02**
Total Simulated Storm Volume:	**154.89**	Total Observed Storm Volume:	**126.19**
Simulated Summer Storm Volume (7-9):	**18.04**	Observed Summer Storm Volume (7-9):	**12.51**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**25.67**	10	
Error in 50% lowest flows:	**34.59**	10	
Error in 10% highest flows:	**15.43**	15	
Seasonal volume error - Summer:	**40.47**	30	
Seasonal volume error - Fall:	**24.73**	30	
Seasonal volume error - Winter:	**20.17**	30	
Seasonal volume error - Spring:	**29.06**	30	
Error in storm volumes:	**18.52**	20	
Error in summer storm volumes:	**30.66**	50	

Figure A.24. 10-Year Validation Statistics at 02221525 – Murder Creek below Eatonton, GA.

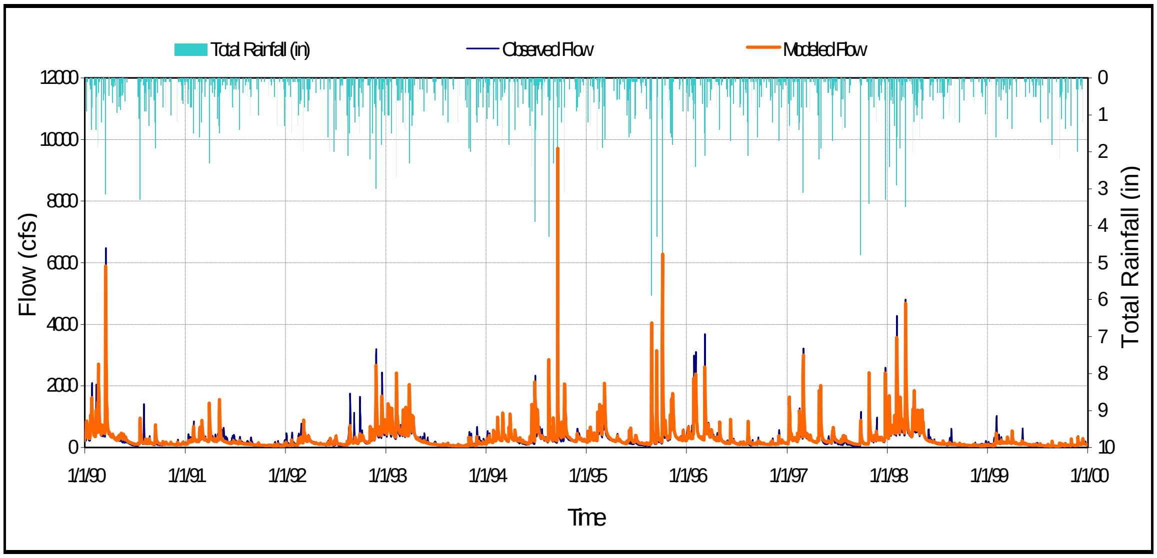


Figure A.25. 10-Year Validation (Daily Flow) at 02208450 – Alcovy River above Covington, GA.

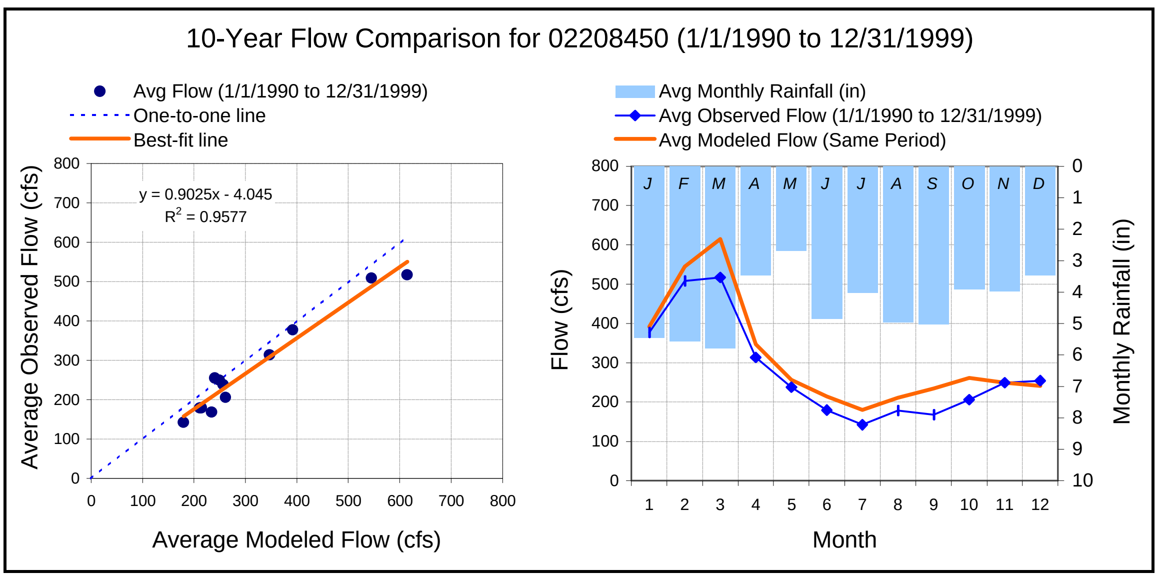


Figure A.26. 10-Year Validation (Monthly Average) at 02208450 – Alcovy River above Covington, GA.

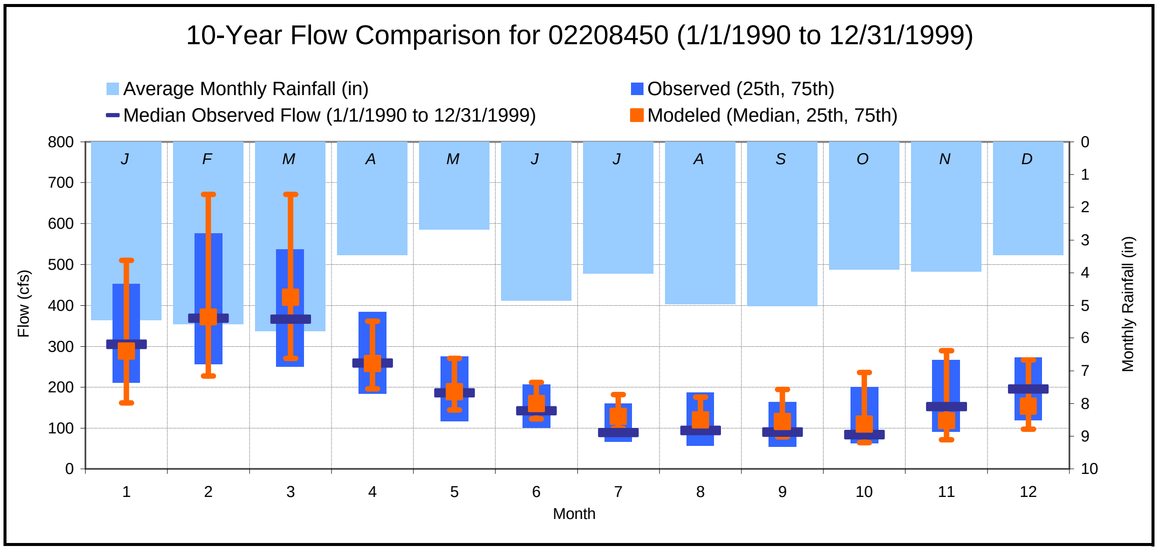


Figure A.27. 10-Year Validation (Monthly Medians) at 02208450 – Alcovy River above Covington, GA.

Simulation Name:	02208450	**Simulation Period:**	
		Watershed Area (ac):	122720
Period for Flow Analysis			
Begin Date:	**01/01/90**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/99**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**220.25**	Total Observed In-stream Flow:	**195.82**
Total of highest 10% flows:	**89.19**	Total of Observed highest 10% flows:	**72.34**
Total of lowest 50% flows:	**38.46**	Total of Observed Lowest 50% flows:	**35.50**
Simulated Summer Flow Volume (months 7-9):	**37.13**	Observed Summer Flow Volume (7-9):	**29.05**
Simulated Fall Flow Volume (months 10-12):	**44.68**	Observed Fall Flow Volume (10-12):	**42.19**
Simulated Winter Flow Volume (months 1-3):	**90.33**	Observed Winter Flow Volume (1-3):	**81.59**
Simulated Spring Flow Volume (months 4-6):	**48.11**	Observed Spring Flow Volume (4-6):	**42.99**
Total Simulated Storm Volume:	**184.55**	Total Observed Storm Volume:	**171.05**
Simulated Summer Storm Volume (7-9):	**28.18**	Observed Summer Storm Volume (7-9):	**22.97**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**11.09**	10	
Error in 50% lowest flows:	**7.69**	10	
Error in 10% highest flows:	**18.90**	15	
Seasonal volume error - Summer:	**21.75**	30	
Seasonal volume error - Fall:	**5.57**	30	
Seasonal volume error - Winter:	**9.68**	30	
Seasonal volume error - Spring:	**10.64**	30	
Error in storm volumes:	**7.31**	20	
Error in summer storm volumes:	**18.49**	50	

Figure A.28. 10-Year Validation Statistics at 02208450 – Alcovy River above Covington, GA.

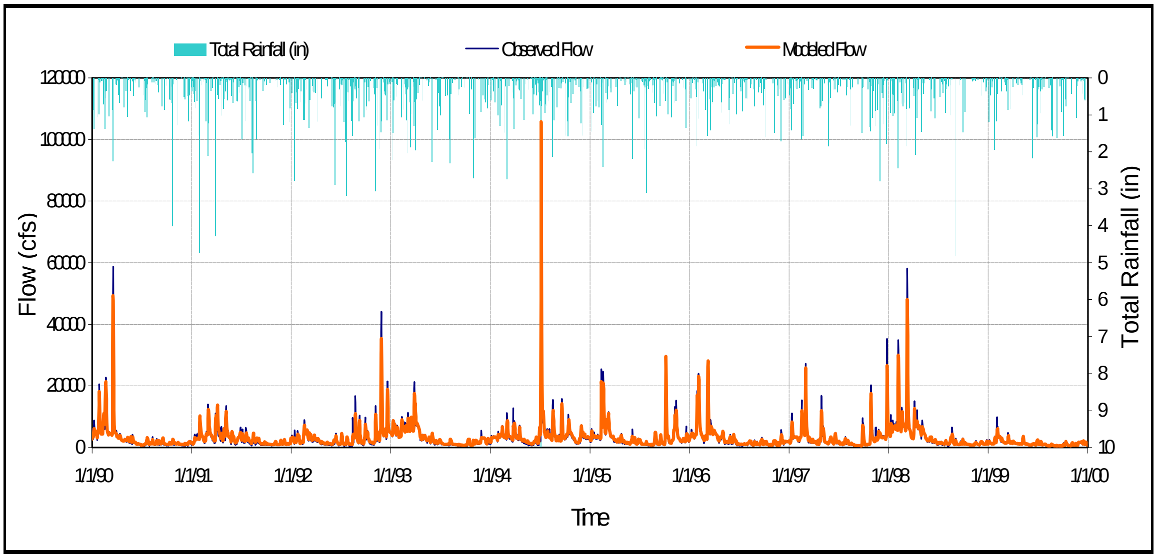


Figure A.29. 10-Year Validation (Daily Flow) at 02213000 – Ocmulgee River at Macon, GA.

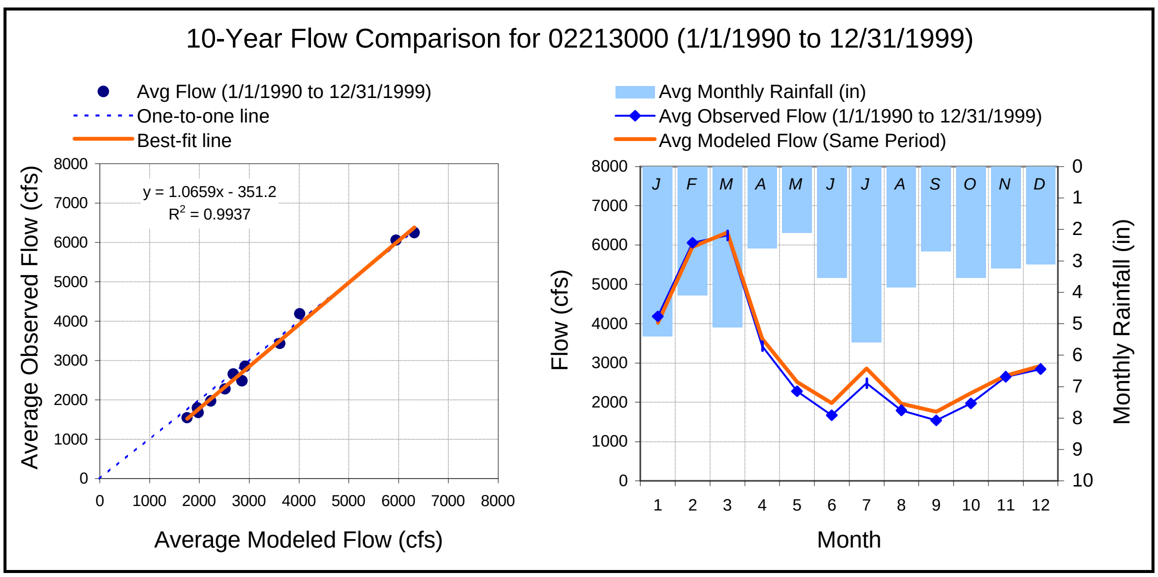


Figure A.30. 10-Year Validation (Monthly Average) at 02213000 – Ocmulgee River at Macon, GA.

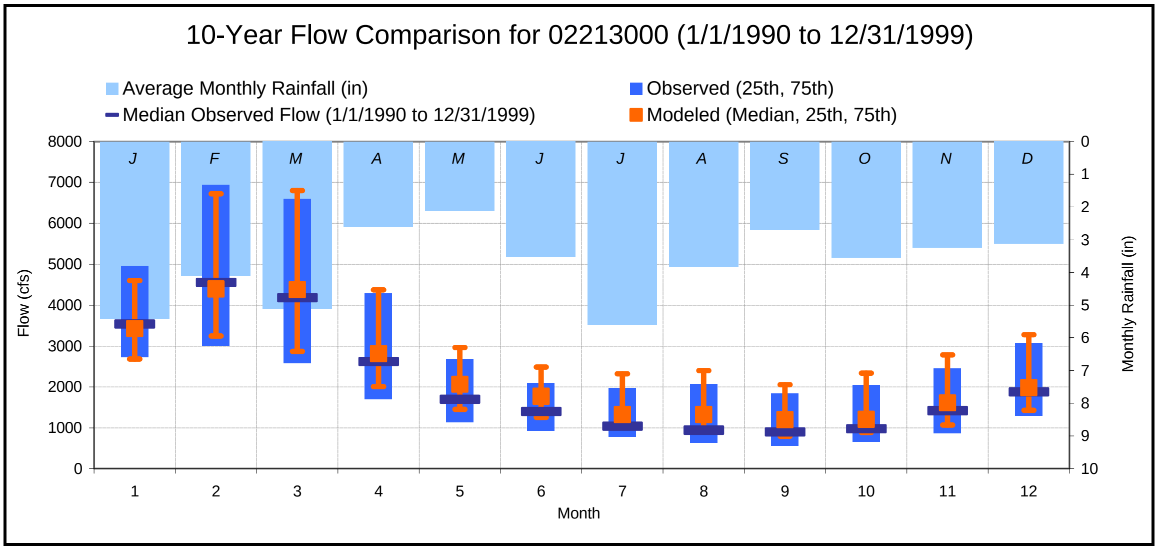


Figure A.31. 10-Year Validation (Monthly Medians) at 02213000 – Ocmulgee River at Macon, GA.

Simulation Name:	02213000	**Simulation Period:**	
		Watershed Area (ac):	1450880
Period for Flow Analysis			
Begin Date:	**01/01/90**	**Baseflow PERCENTILE:**	2.5
End Date:	**12/31/99**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**193.01**	Total Observed In-stream Flow:	**184.66**
Total of highest 10% flows:	**69.82**	Total of Observed highest 10% flows:	**72.06**
Total of lowest 50% flows:	**38.75**	Total of Observed Lowest 50% flows:	**31.13**
Simulated Summer Flow Volume (months 7-9):	**33.16**	Observed Summer Flow Volume (7-9):	**29.35**
Simulated Fall Flow Volume (months 10-12):	**39.39**	Observed Fall Flow Volume (10-12):	**37.54**
Simulated Winter Flow Volume (months 1-3):	**80.11**	Observed Winter Flow Volume (1-3):	**81.07**
Simulated Spring Flow Volume (months 4-6):	**40.35**	Observed Spring Flow Volume (4-6):	**36.70**
Total Simulated Storm Volume:	**154.66**	Total Observed Storm Volume:	**157.23**
Simulated Summer Storm Volume (7-9):	**23.59**	Observed Summer Storm Volume (7-9):	**22.55**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**4.33**	10	
Error in 50% lowest flows:	**19.67**	10	
Error in 10% highest flows:	**-3.21**	15	
Seasonal volume error - Summer:	**11.50**	30	
Seasonal volume error - Fall:	**4.71**	30	
Seasonal volume error - Winter:	**-1.20**	30	
Seasonal volume error - Spring:	**9.03**	30	
Error in storm volumes:	**-1.66**	20	
Error in summer storm volumes:	**4.41**	50	

Figure A.32. 10-Year Validation Statistics at 02213000 – Ocmulgee River at Macon, GA.

APPENDIX B:

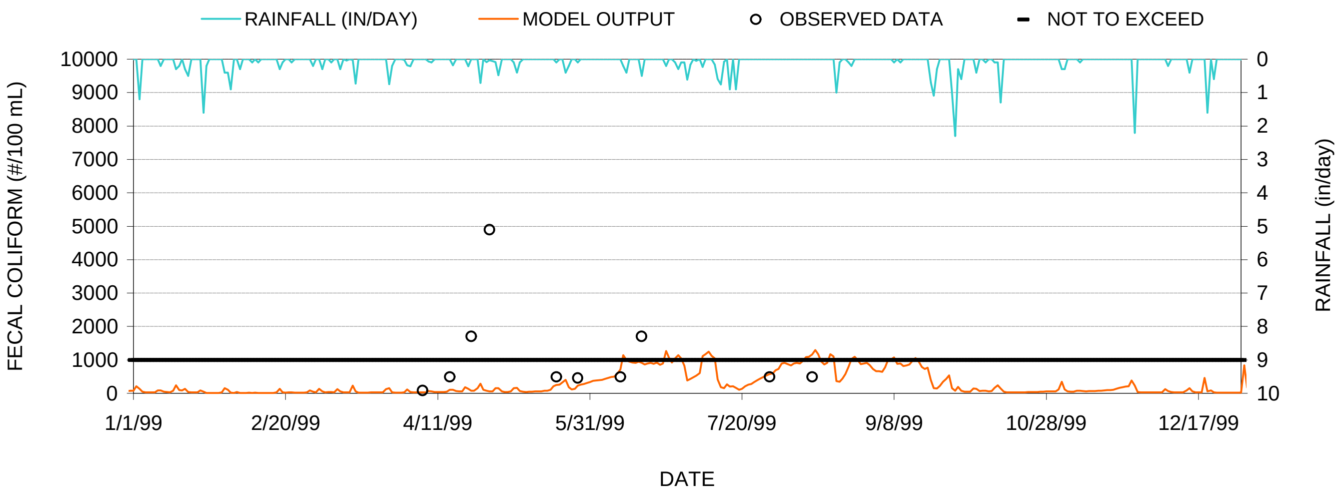
WATER QUALITY MODEL CALIBRATION

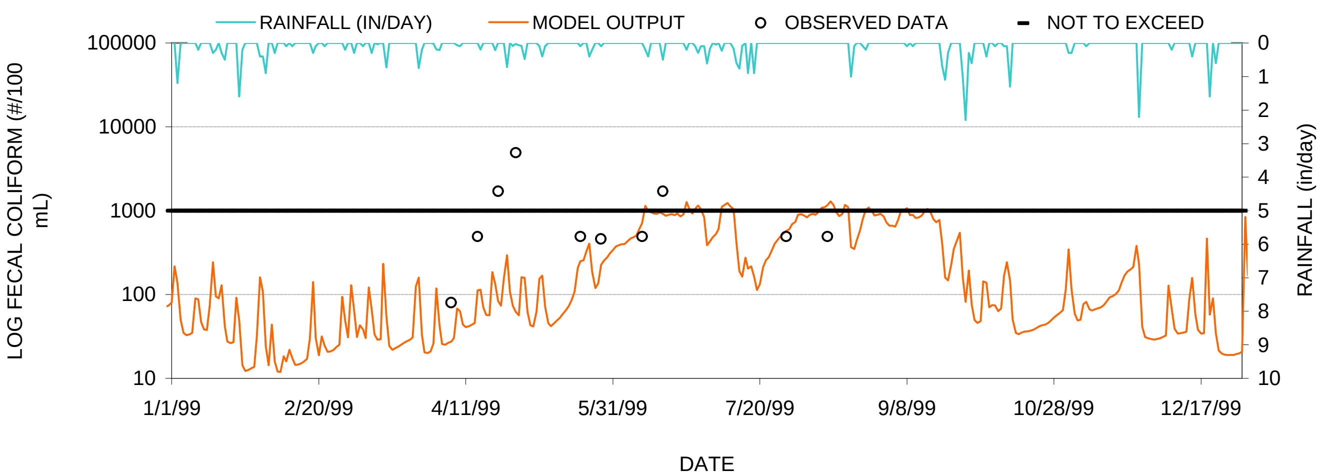
MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Alligator**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



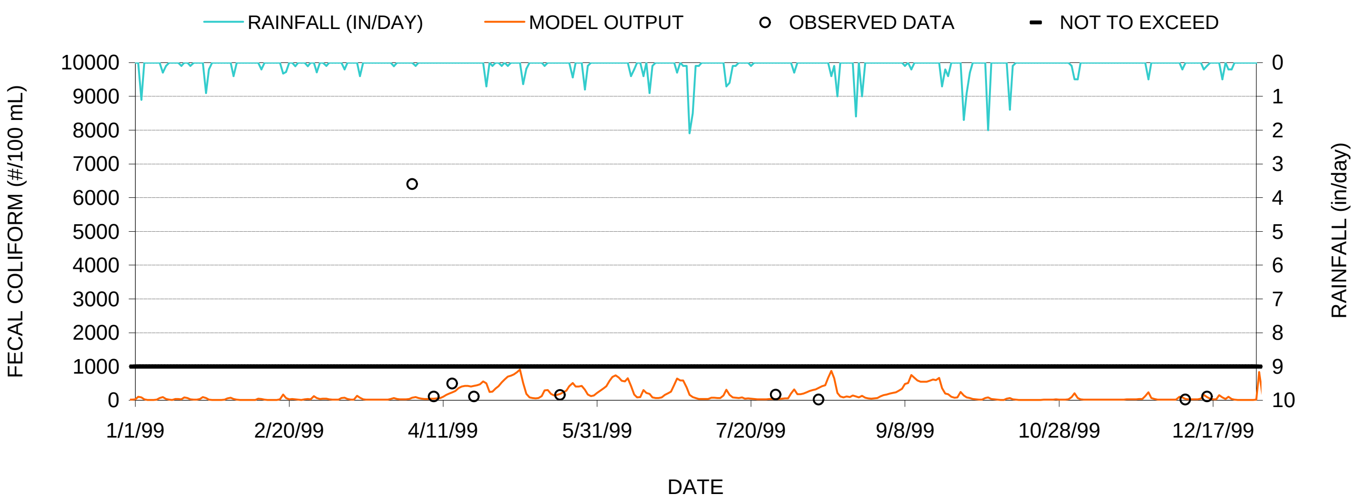


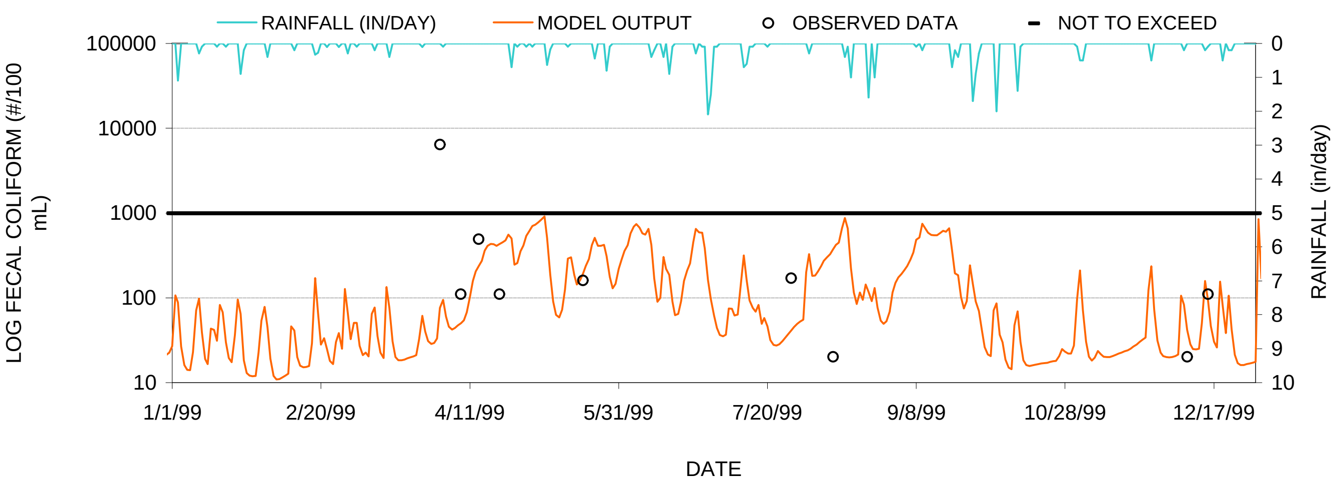
MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Turnpike**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2



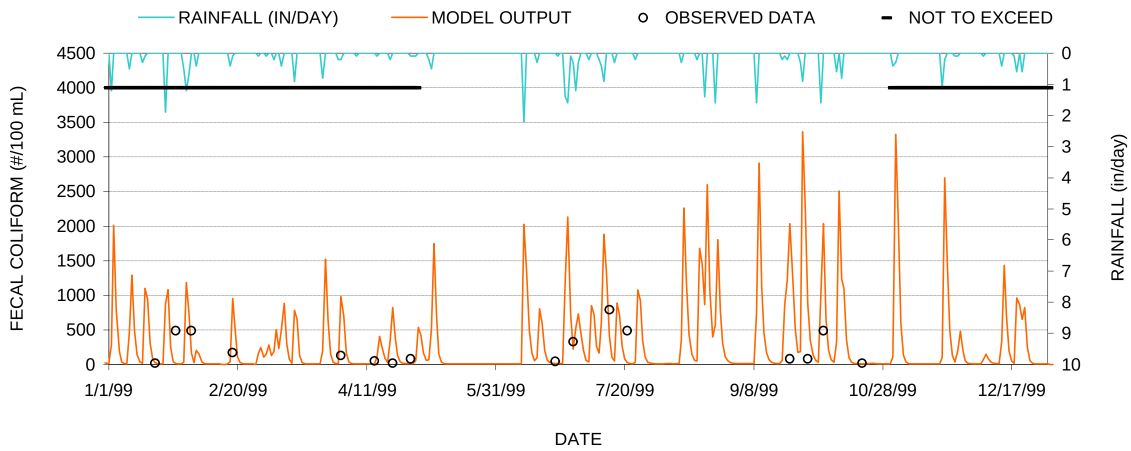


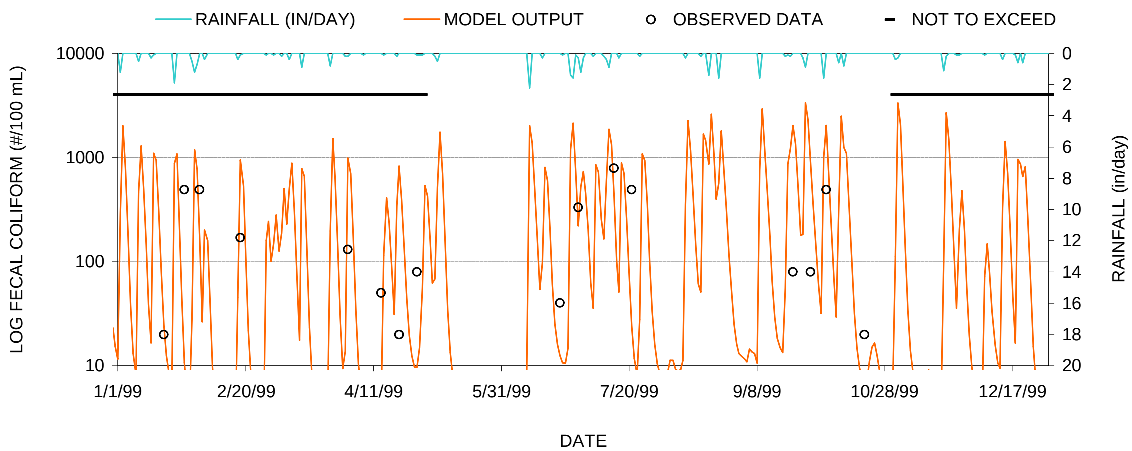
MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: MODEL RUN: 1

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2

Ocmulgee River, Sandy Run Creek to Big Indian Creek; Lower Ocmulgee Basin



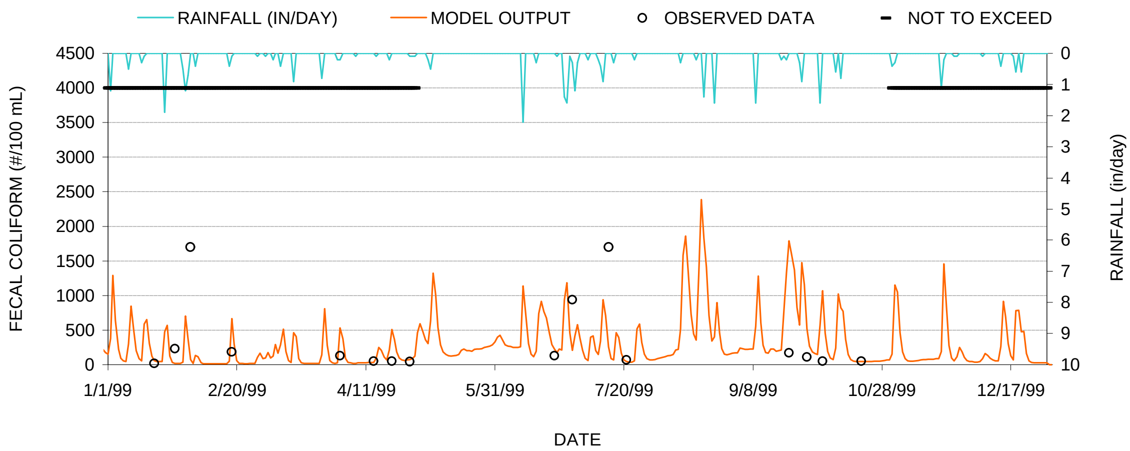


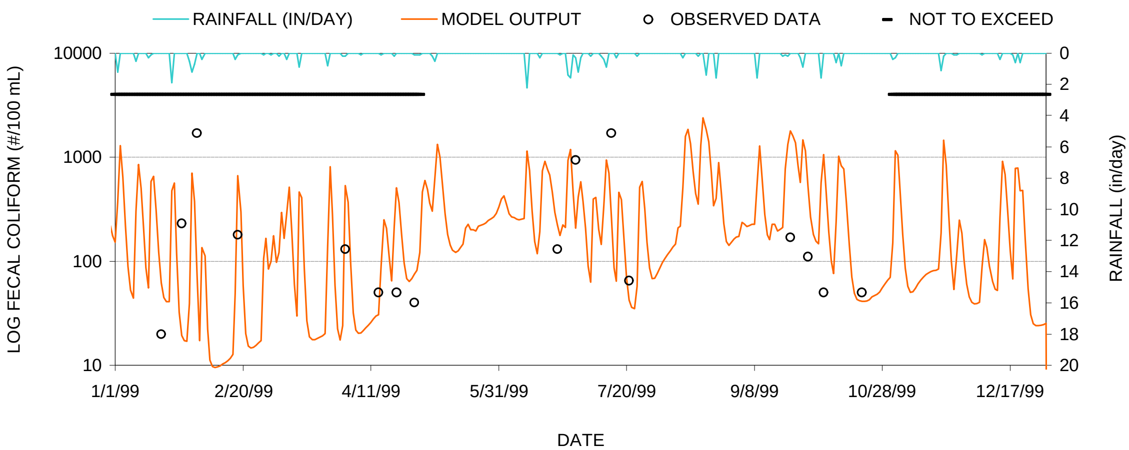
MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: MODEL RUN: 1

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2

Big Indian Creek, Mossy Creek to Ocmulgee River; Lower Ocmulgee Basin



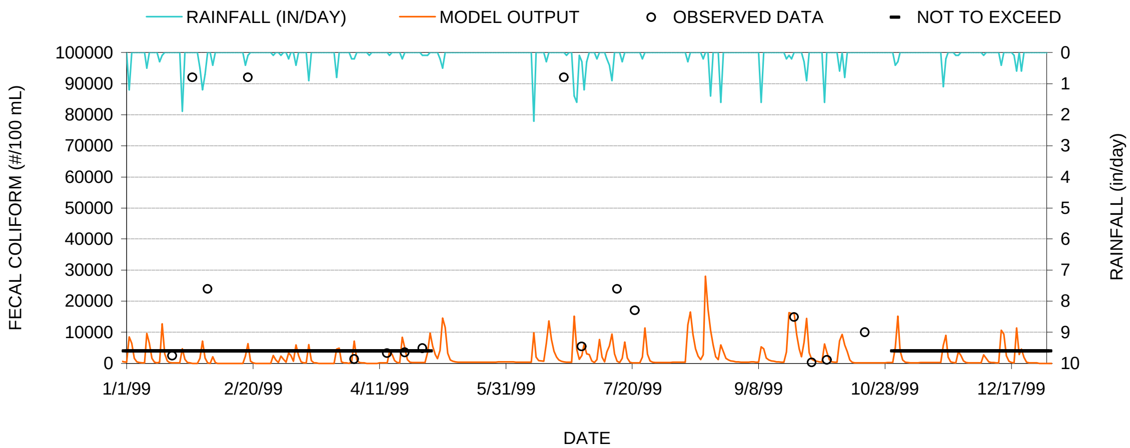


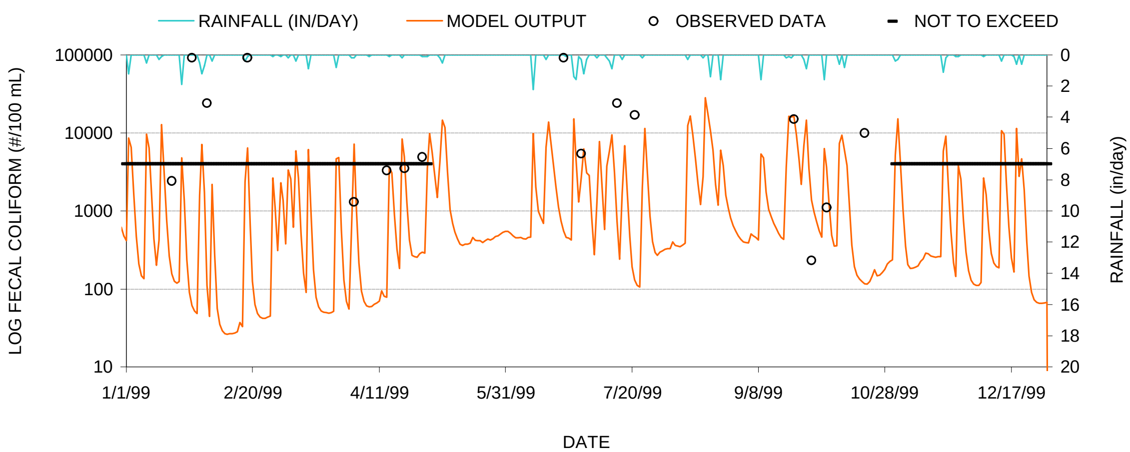
MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **Bay Creek, Headwaters to Beaver Creek; Upper Ocmulgee Basin**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2





MULTI-YEAR TIMESERIES MODEL VS DATA

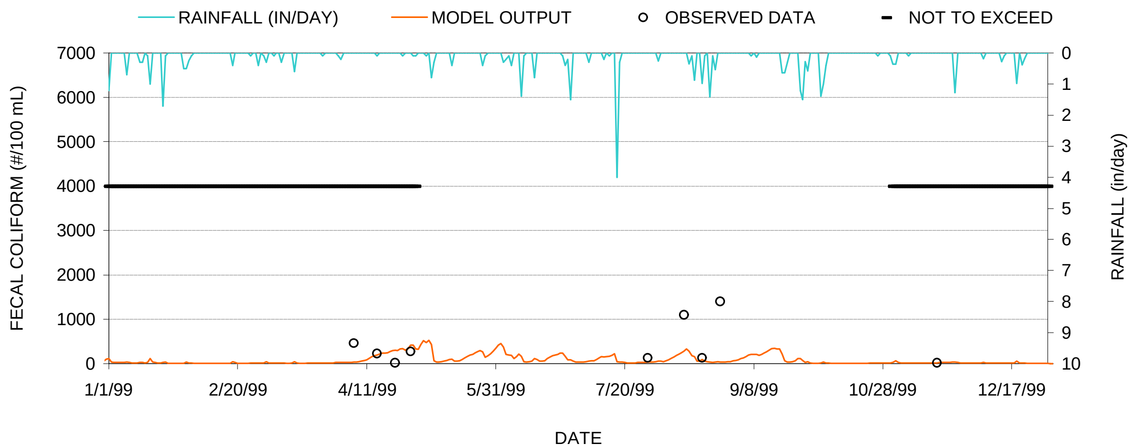
STATION: **House Creek, Ball Creek to Little House Creek; Lower Ocmulgee Basin**

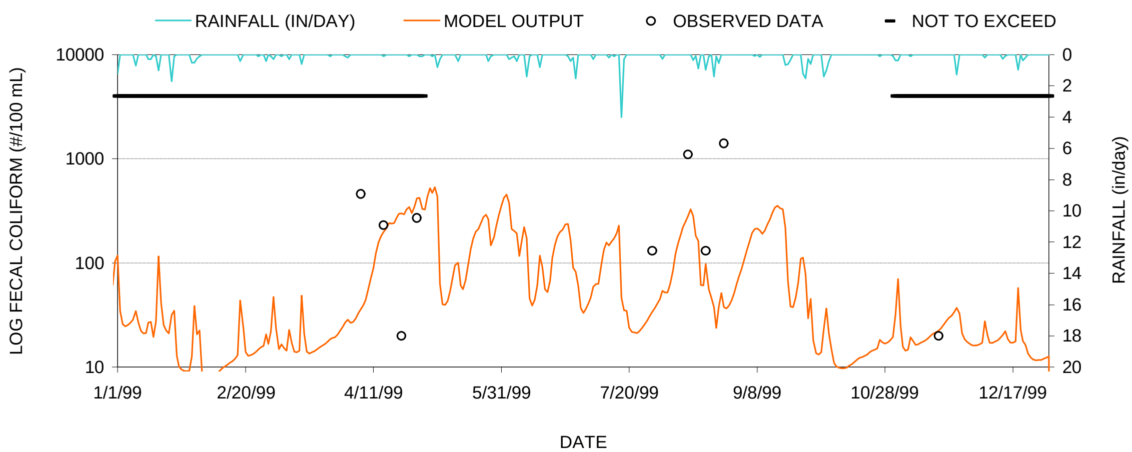
MODEL RUN: **1**

1 = EXISTING

2 = ALLOCATION 1

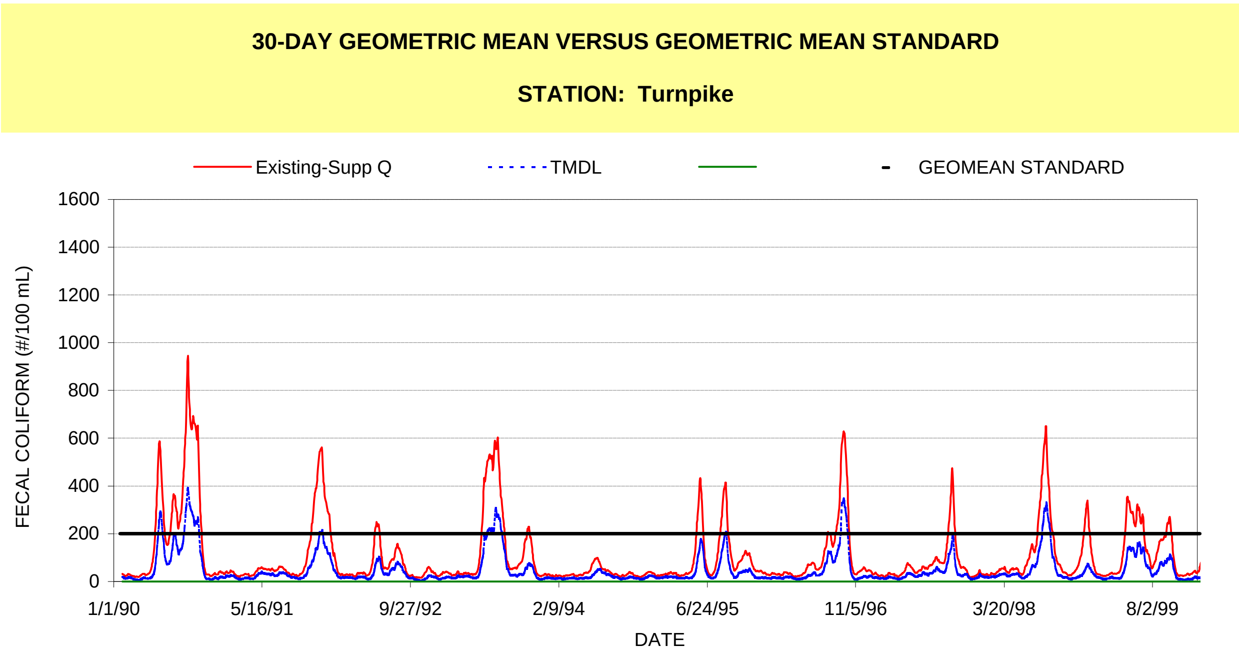
3 = ALLOCATION 2

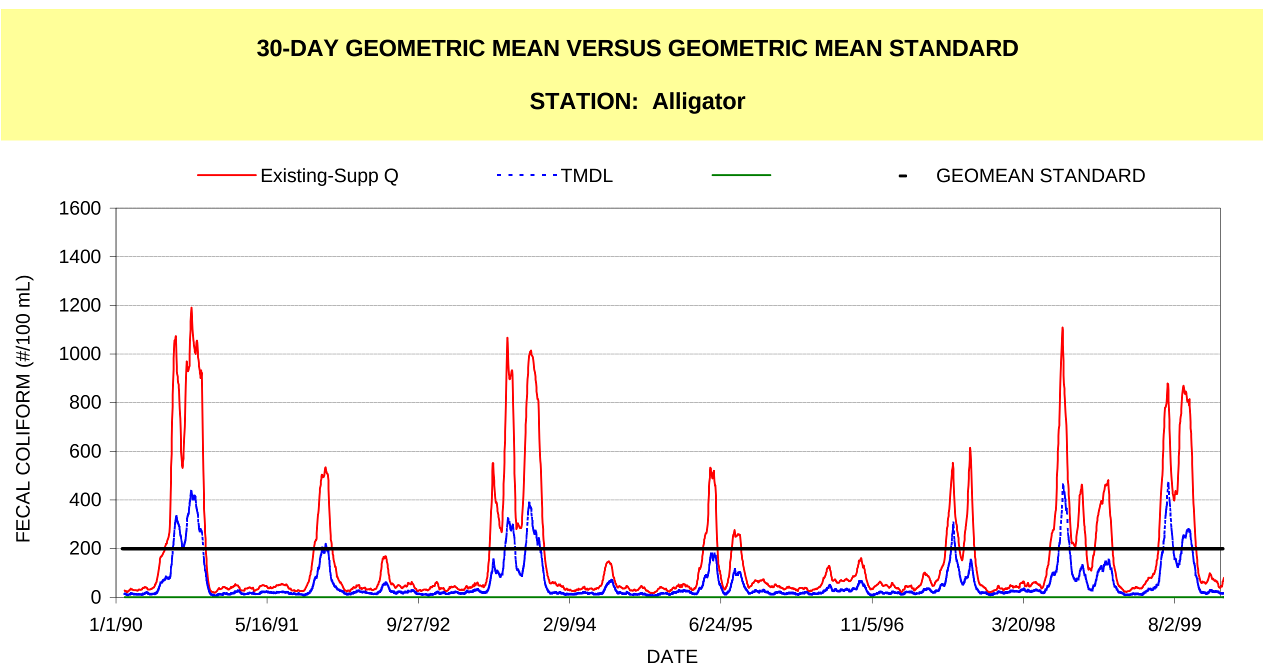


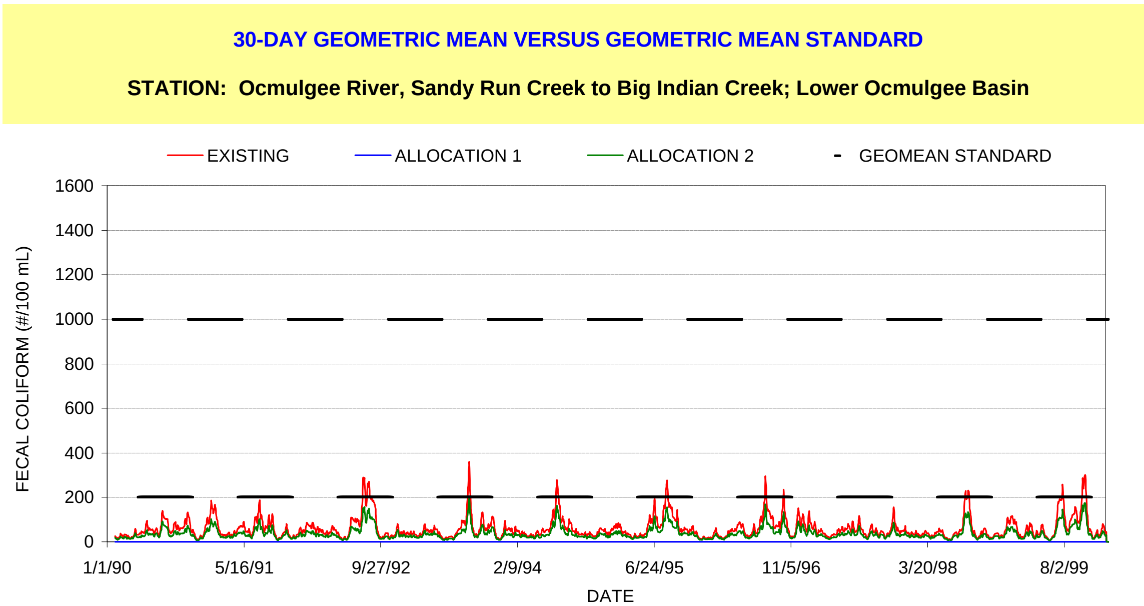


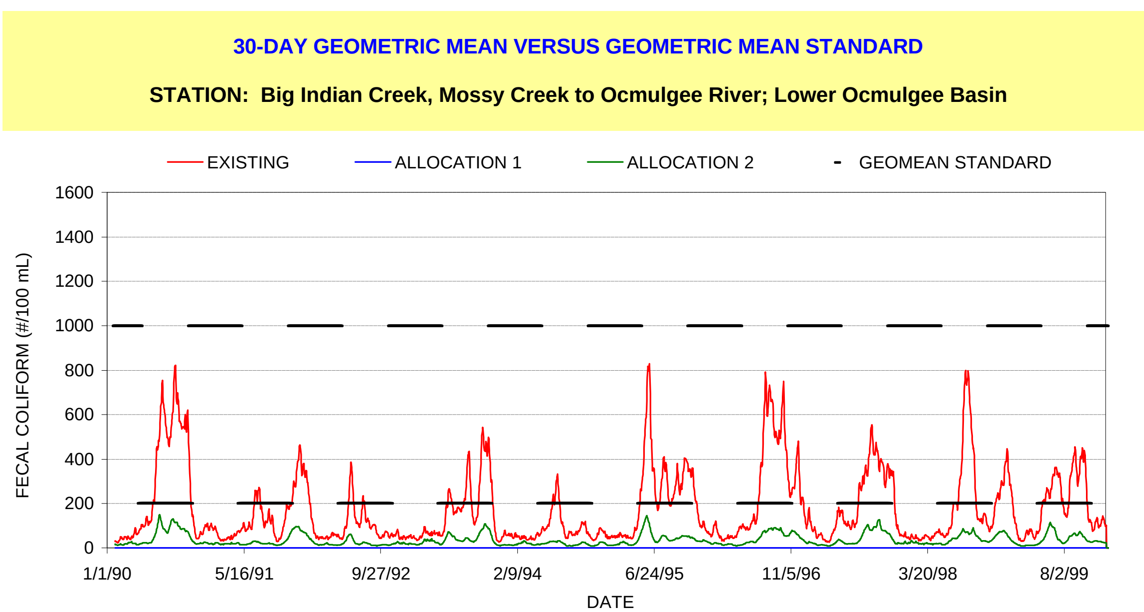
APPENDIX C:

Simulated Fecal Coliform Concentrations
(30-dayGeometric Mean for Existing and TMDL Conditions)


30-DAY GEOMETRIC MEAN VERSUS GEOMETRIC MEAN STANDARD
STATION: Turnpike
Existing-Supp Q
TMDL
GEOMEAN STANDARD
FECAL COLIFORM (#/100 mL)
1600
1400
1200
1000
800
600
400
200
0
1/1/90
5/16/91
9/27/92
2/9/94
6/24/95
11/5/96
3/20/98
8/2/99
DATE

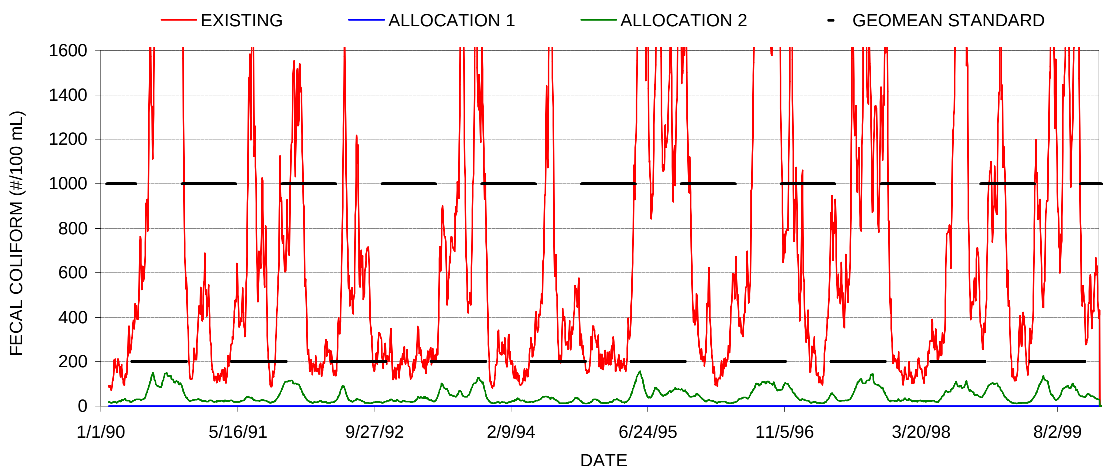

30-DAY GEOMETRIC MEAN VERSUS GEOMETRIC MEAN STANDARD
STATION: Alligator
Existing-Supp Q
TMDL
GEOMEAN STANDARD
FECAL COLIFORM (#/100 mL)
1600
1400
1200
1000
800
600
400
200
0
1/1/90
5/16/91
9/27/92
2/9/94
6/24/95
11/5/96
3/20/98
8/2/99
DATE


30-DAY GEOMETRIC MEAN VERSUS GEOMETRIC MEAN STANDARD
STATION: Ocmulgee River, Sandy Run Creek to Big Indian Creek; Lower Ocmulgee Basin
EXISTING
ALLOCATION 1
ALLOCATION 2
GEOMEAN STANDARD
FECAL COLIFORM (#/100 mL)
0
200
400
600
800
1000
1200
1400
1600
1/1/90
5/16/91
9/27/92
2/9/94
6/24/95
11/5/96
3/20/98
8/2/99
DATE


30-DAY GEOMETRIC MEAN VERSUS GEOMETRIC MEAN STANDARD
STATION: Big Indian Creek, Mossy Creek to Ocmulgee River; Lower Ocmulgee Basin
EXISTING
ALLOCATION 1
ALLOCATION 2
GEOMEAN STANDARD
FECAL COLIFORM (#/100 mL)
0
200
400
600
800
1000
1200
1400
1600
1/1/90
5/16/91
9/27/92
2/9/94
6/24/95
11/5/96
3/20/98
8/2/99
DATE

30-DAY GEOMETRIC MEAN VERSUS GEOMETRIC MEAN STANDARD

STATION: Bay Creek, Headwaters to Beaver Creek; Upper Ocmulgee Basin



30-DAY GEOMETRIC MEAN VERSUS GEOMETRIC MEAN STANDARD

STATION: House Creek, Ball Creek to Little House Creek; Lower Ocmulgee Basin