Total Maximum Daily Load

Evaluation

for

Bear Creek

in the

Suwannee River Basin

(Fecal Coliform)

Submitted to:

The U.S. Environmental Protection Agency
Region 4
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EXECUTIVE SUMMARY

The State of Georgia assesses its water bodies for compliance with water quality standards criteria established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into three categories, supporting, partially supporting, or not supporting their designated uses depending on water quality assessment results. These water bodies are found on Georgia's 305(b) list as required by that section of the CWA that defines the assessment process, and are published in *Water Quality in Georgia* every two years.

Some of the 305(b) partially and not supporting water bodies are also assigned to Georgia's 303(d) list, also named after that section of the CWA. Water bodies on the 303(d) list are required to have a Total Maximum Daily Load (TMDL) evaluation for the water quality constituent(s) in violation of the water quality standard. The TMDL process establishes the allowable pollutant loadings or other quantifiable parameters for a water body based on the relationship between pollutant sources and in-stream water quality conditions. This allows water quality-based controls to be developed to reduce pollution and restore and maintain water quality.

The State of Georgia has identified Bear Creek in the Suwannee River basin as partially supporting the water quality standard criteria for fecal coliform bacteria. Bear Creek has a water use classification of fishing and a fecal coliform bacteria water quality standard as described below:

> For the months of May through October, fecal coliform 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. For the months of November through April, fecal coliform 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.

Sufficient fecal coliform bacteria data were collected at Bear Creek at County Road 32 near Adel, Georgia (GAEPD site 09027101) in 1998 to calculate four distinct geometric mean values. One geometric mean was in excess of water quality standards. As a result, four miles of Bear Creek from City of Adel Lake to the Withlacoochee River was added to the State's 303(d) list and scheduled for a TMDL evaluation.

The analysis performed to develop the TMDL for fecal coliform bacteria for Bear Creek used dynamic hydrologic and water quality modeling techniques that considered the characteristics of the watershed, meteorology, hydrology, and land use. The model used local meteorological data and local watershed and stream characteristics in the simulation. Land use in the watershed was characterized from Landsat Thematic Mapper digital images developed in 1995. Land use activities contributing fecal coliform bacteria simulated using the model included septic tanks, cattle grazing, poultry operations, manure management, urban development, and wildlife. Model parameterization for urban, agricultural, and forest land uses were provided by the USEPA. National Pollutant Discharge Elimination System (NPDES) permitted discharges were also included in the modeling analysis.

A simulation period of 10 years (1989 – 1998) was used to develop the fecal coliform bacteria TMDL. Load reductions were applied until the simulated 30-day geometric mean of the fecal coliform bacteria counts did not exceed the water quality geometric mean standard. Modeling assumptions were considered conservative to constitute an implied margin of safety.

Model results indicate that nonpoint sources related to agricultural practices have significant impact on the fecal coliform bacteria loadings in the watersheds. Leaking septic systems and sewer

collection lines and stormwater runoff from urban areas are considered secondary sources of fecal coliform. Reductions in these loading rates in the Bear Creek watershed reduce the in-stream fecal coliform bacteria levels.

A possible allocation scenario that would meet in-stream water quality standards in Bear Creek is an 35 percent reduction in nonpoint source fecal loads. Management practices that could be used to implement this TMDL include adoption of NRCS resource management practices including covering manure and poultry litter stacks exposed to the environment; reducing animal access to streams; and applying manure to croplands at agronomical rates. In addition, controlling leaking septic and sewer collection lines and urban runoff could also improve water quality. Best management practices (BMPs) should be developed to address urban and agricultural runoff during extreme storm events.

1.0 INTRODUCTION

1.1 Background

The State of Georgia assesses its water bodies for compliance with water quality standards criteria established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into three categories, supporting, partially supporting, or not supporting their designated uses depending on water quality assessment results. These water bodies are found on Georgia's 305(b) list as required by that section of the CWA that defines the assessment process, and are published in *Water Quality in Georgia* every two years.

Some of the 305(b) partially and not supporting water bodies are also assigned to Georgia's 303(d) list, also named after that section of the CWA. Water bodies on the 303(d) list are required to have a Total Maximum Daily Load (TMDL) evaluation for the water quality constituent(s) in violation of the water quality standard. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions. This allows water quality based controls to be developed to reduce pollution and restore and maintain water quality.

The State of Georgia has identified Bear Creek in the Suwannee River basis as violating the water quality standard criteria for fecal coliform bacteria. Fecal coliform bacteria data were collected in 1998 at Bear Creek at County Road 32 near Adel, Georgia (GAEPD site 09027101). Sufficient data were collected at this station to calculate four distinct geometric mean values. As a result the stream was listed as partially supporting its designated use as the summer geometric mean standard of 200 counts/100 ml was exceeded once. Four miles of Bear Creek in Cook County from the City of Adel Lake to the Withlacoochee River were added to the State's 303(d) list and scheduled for a TMDL evaluation.

1.2 Watershed Description

The Bear Creek watershed is located in the Suwannee River basin in southeastern Georgia, in Cook County (See Figure 1). Bear Creek is a tributary to the Withlacoochee River (see Figure 2). The total area of the Bear Creek watershed is approximately 21 square miles.

The land use characteristics of the Bear Creek watershed were determined using data from Georgia's Multiple Resolution Land Coverage (MRLC). This coverage is based on Landsat Thematic Mapper digital images developed in 1995. The classification is based on a modified Anderson level one and two system. Table 1 lists the land use distribution in the watershed. The data show that the watershed is predominately agriculture (pasture/hay and row crops) (47 percent) forested (64 percent) with the next predominate land use being forest (25 percent). Landuse coverage for the watershed is shown in Figure 3.

Table 1. Landuse Distribution by Subwatershed

Landuse	Bear Cr near Adel, GA	
	Area (ac)	Percent
Bare Rock/Sand/Clay	15	0.08
Deciduous Forest	1448	7.8
Emergent Herbaceous Wetlands	173	0.9
Evergreen Forest	2621	14.1
High Intensity Commercial/Industrial/ Transportation	448	2.4
High Intensity Residential	85	0.5
Low Intensity Residential	483	2.6
Mixed Forest	526	2.8
Open Water	66	0.4
Other Grasses (Urban/recreational; e.g. parks, lawns)	108	0.6
Pasture/Hay	1876	10.1
Quarries/Strip Mines/Gravel Pits	0	0.0
Row Crops	6805	36.7
Transitional	780	4.2
Woody Wetlands	3097	4.2
Total	13197	100.0

1.3 Water Quality Standard

The water use classification for Bear Creek is fishing. The fishing classification water quality standard for fecal coliform bacteria as stated in Georgia's Rules and Regulations for Water Quality Control Chapter 391-3-6-.03(6)(c) is:

(c) Fishing: Propagation of Fish, Shellfish, Game and Other Aquatic Life; secondary contact recreation in and on the water; or for any other use requiring water of a lower quality:

(iii) Bacteria: For the months of May through October, when water contact recreation activities are expected to occur, fecal coliform 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. The months of November through April, fecal coliform 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 State does not encourage swimming in surface waters since a number of factors, which are beyond the control of any State regulatory agency, contribute to elevated levels of fecal coliform. For waters designated as approved shellfish harvesting waters by the appropriate State agencies, the requirements will be consistent with those established by the State and Federal agencies responsible for the National Shellfish Sanitation Program. The requirements are found in the National Shellfish Sanitation Program Manual of Operation, Revised 1988, Interstate Shellfish Sanitation Conference, U.S. department of Health and Human Services (PHS/FDA), and the Center for Food Safety and

Applied Nutrition. Streams designated as generally supporting shellfish are listed in Paragraph 391-3-6-.03(14).

2.0 WATER QUALITY ASSESSMENT

Water quality monitoring data were collected during 1998 at Bear Creek at County Road 32 near Adel, Georgia. Table 2 lists the fecal coliform bacteria data results at this station as well as computed geometric mean values. The data collected were four instantaneous samples obtained within a 30 day period. These data results were compared with the fecal coliform bacteria water quality standard to assess compliance.

Table 2: Fecal Coliform Bacteria Data

Date	Bear Creek at CR 32 Fecal Coliform Bacteria (MPN/100 ml)	Geometric Mean
01/21/98	200	
02/04/98	220	
02/11/98	110	
02/18/98	330	200
06/4/98	460	
06/10/98	70	
06/17/98	20	
06/30/98	220	109
07/30/98	490	
08/12/98	230	
08/20/98	130	
08/27/98	330	263
11/02/98	170	
11/09/98	490	
11/23/98	330	
11/30/98	<20	153

The data show that sufficient data were collected to calculate four distinct geometric mean values. Bear Creek was listed as partially supporting the designated use as the geometric mean standard of 200 counts/100 ml (May – October) was exceeded in the July/August sampling period.

3.0 SOURCE ASSESSMENT

A source assessment is used to characterize the known and suspected sources of fecal coliform bacteria in the watershed for use in the water quality model, and the development of the TMDL. The general sources of fecal coliform bacteria are point and non-point sources. National Pollutant Discharge Elimination System (NPDES) permittees discharging treated domestic waste are the primary point sources of fecal coliform bacteria.

Nonpoint sources of fecal coliform bacteria are diffuse sources that cannot be identified as entering the water body at a single location. These sources generally involve land activities that contribute fecal coliform bacteria to streams during a rainfall runoff event. Nonpoint sources of fecal coliform bacteria considered in the analysis include:

- Wildlife,
- Land application of agricultural manure,
- Grazing animals,
- Leaking septic systems,
- Urban development, and
- Leaking sewer collection lines.

For nonpoint sources involving agricultural activities, the Natural Resources Conservation Service (NRCS) was consulted for information and parameters to be used to characterized agricultural activities represented in the water quality model.

3.1 Point Source Assessment

There are two permitted NPDES discharges identified in the Bear Creek watershed upstream of the listed segment**.** These facilities are the Adel Water Pollution Control Plant (WPCP, NPDES GA0024911) and the Sparks WPCP (NPDES GA0021563). The facilities have permitted flow rates of 2.5 million gallons per day (MGD) and 0.231 MGD, respectively. Both facilities discharge into Bear Creek.

3.2 Nonpoint Source Assessment

3.2.1 Wildlife

Wildlife deposit fecal coliform bacteria with their feces onto the land where it can be transported during a rainfall runoff event to nearby streams. In the water quality model, the wildlife fecal coliform contribution is accounted for in the deer population. The deer population is estimated to be 30 to 45 animals per square mile in this area (personal communication, NRCS and Georgia WRD State Deer Biologist, Nov. 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.

3.2.2 Land Application of Agricultural Manure

Processed agricultural manure from confined hog, dairy cattle, and poultry operations is generally collected in lagoons and applied to land surfaces during the months April through October. Hog manure is applied only to cropland. NRCS estimates that 75 percent of cattle manure and poultry

litter is applied to cropland and 25 percent is applied to pasture land. Manure application rates are included in Appendix A.

Data sources for confined feeding operations include the 1997 Census of Agriculture. Table 3 shows animal distribution in the watershed. The livestock data are also based on the 1997 Census of Agriculture and is reported by county. The county data are distributed to the watersheds based on the percentage of agricultural area in each subwatershed classified as pasture/hay. Cattle numbers reported in the census data also represent other breeds of cattle and calves besides dairy and beef.

Table 3. Livestock Distribution

Livestock	Hog Creek at Nicholls (animals)
Beef Cow	417
Milk Cow	0
Cattle	696
Chickens	0
Chickens Sold	0
Hogs	330
Sheep	0

Hog farms in the watershed 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 evenly to available cropland. Application rates of hog manure to cropland vary monthly according to management practices.

As shown in Table 3, cattle operations in the watershed are exclusively beef cattle. There are no dairy or chicken farms operating in the watershed.

3.2.3 Grazing Animals

Cattle, including beef and hogs, spend time grazing on pasture land and depositing manure onto the land. During a rainfall runoff event, a portion of this manure containing fecal coliform bacteria is transported to streams.

In south Georgia, animal access to pasture land varies monthly, resulting in varying fecal coliform loading rates throughout the year. Beef cattle spend all their time in pasture, while dairy cattle and hogs are confined periodically. The percentage of manure deposited during grazing time is used to estimate the fecal coliform loading rates from pasture land.

In addition, cattle and other unconfined animals often have direct access to streams that pass through pastures. Manure deposited in these streams by grazing animals is included in the water quality model as a point source having constant flow and concentration. To calculate the amount of bacteria introduced into streams by cattle, it is assumed that only beef cow population have access

to the streams and of those approximately 12 percent defecate in the stream (personal communication, EPA, NRCS, Univ. of GA, Georgia Agribusiness Council, and others).

3.2.4 Leaking Septic Systems

Table 4 shows estimates from county census data of people in the watershed on septic systems. In south Georgia, USEPA estimates that there are approximately 2.37 people per household on septic systems. Through the process of model development and calibration, it was determined that a septic failure rate of 45% was possible. Therefore, it is assumed that 45 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.

Table 4. Septic Systems

Watershed	Number of Septic Systems
Bear Creek	347

3.2.5 Urban Development

Fecal coliform bacteria from urban areas may originate from various sources including runoff through storm water sewers (e.g., residential, commercial, industrial, and road transportation), illicit discharges of sanitary waste, and runoff from improper disposal of waste materials. Overflowing sanitary sewers and leaking collection lines are considered a secondary source of fecal coliform bacteria in the Bear Creek watershed. To estimate the load of fecal coliform bacteria from leaking sewer collection lines, it is assumed that 5 percent of the permitted design flow of the Sparks municipal WPCP is lost through leaks. The average fecal coliform bacteria concentration in the Wastewater is 10,000 counts/100 ml (Horsley & Whitten, 1996).

4.0 MODELING APPROACH

Establishing the relationship between the in-stream water quality and the source loadings is an important component of TMDL development. It provides for both the identification of sources, and their relative contribution, as well as the examination of potential water quality changes resulting from varying management options to meet the water quality standard. This relationship can be developed using a variety of techniques ranging from qualitative assumptions based on scientific principles to numerical computer modeling techniques. In this section, the numerical modeling techniques developed to simulate fecal coliform bacteria fate and transport in the watershed are discussed.

4.1 Model Selection

A dynamic computer model was selected for the fecal coliform bacteria TMDL evaluation in order to satisfy a variety of objectives. The first objective is to simulate the time varying behavior of fecal coliform bacteria deposition on the land surface and transport to receiving water bodies. The second objective was to use a continuous simulation period to identify the critical condition and from which to develop the TMDL. Finally, the continuous simulation model provides the means to incorporate seasonal effects on the production and fate of fecal coliform bacteria. A series of computer-based tools were used to accomplish these objectives.

First, the Watershed Characterization System (WCS – developed by EPA and Tetra Tech), a geographic information system (GIS) tool, was used to display and analyze GIS information including land use, land type, point source discharges, soil types, population, and stream characteristics. The WCS was used to identify and summarize the sources of fecal coliform bacteria in the watershed, as well the other factors that affect its fate and transport.

Information collected using WCS was used in a series of spreadsheet applications designed to compute fecal coliform bacteria loading rates in the watershed from varying land uses including urban, agricultural, and forestry as described in Section 3.0. Computed loading rates were used in a hydrologic and water quality model, NPSM (Non-Point Source Model), to simulate the deposition and transport of fecal coliform bacteria, and the resulting water quality response. The NPSM program uses the Hydrologic Simulation Program Fortran (HSPF) to develop the TMDL. NPSM simulates nonpoint source runoff as well as the transport and flow of pollutants in stream reaches. A necessary feature of NPSM is its ability to integrate both point and nonpoint sources of fecal coliform bacteria and determine the in-stream water quality response.

4.2 Model Set Up

The Bear Creek watershed was delineated in order to characterize the relative fecal coliform bacteria contributions from the significant contributing area (see Figure 2). Watershed delineation was based on the RF3 stream coverage and elevation data. In addition, this discretization allows for management and load reduction alternatives to be varied by subwatershed.

A continuous simulation period from January 1, 1988 to December 31, 1998, was used in the analysis. The period from January 1, 1988 to December 31, 1988, was used to allow the model results to stabilize. The period from January 1, 1989 to December 31, 1998, was used to identify the critical condition period from which to develop the TMDL. Since field data were collected during the period January 1, 1998 to December 31, 1998, this period was used for model calibration.

An important factor driving 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. Data from the Valdosta, Georgia meteorological station were used in the simulation.

4.3 Fecal Coliform Bacteria Source Representation

Both point and nonpoint sources of fecal coliform bacteria are represented in the water quality model. Because of varying decay or die-off rates for fecal coliform bacteria, and varying transport assumptions, the fecal coliform bacteria loadings from these sources are computed separately. The following sections describe the assumptions used for the various sources described in Section 3.0. Appendix A contains the worksheets (developed by EPA and Tetra tech) used to compute the loading rates used in the model.

4.3.1 NPDES Discharge

There are two NPDES discharges in the Bear Creek watershed permitted for fecal coliform bacteria. NPDES discharges in the Bear Creek watershed was represented in the water quality model by a constant flow and fecal coliform bacteria concentration. A discharge flow rate equal to the facilities' permitted rate was used in the model. For the Adel WPCP this rate is 2.5 MGD and for the Sparks WPCP the rate is 0.231 MGD. The fecal coliform bacteria concentration equal to the water quality standard of 200 counts/100 ml was used to estimate the bacteria loading into the stream.

4.3.2 Wildlife

Fecal coliform contributions from wildlife are represented in the model based on deer population. In the model, deer are uniformly distributed to forest, pasture, cropland and wetland areas at a density of 45 deer per square mile. The assumed loading rate from wildlife is 5.0×10^8 counts/animal/day. This is based upon best professional judgment.

4.3.3 Land Application of Agricultural Manure

Fecal coliform accumulation and build-up rates resulting from the land application of hog and cattle manure and poultry litter are represented using monthly input values. For modeling purposes it is assumed that a typical poultry farmer produces 5.5 batches of chickens per year. Therefore, the number of chickens on a farm at any one time is about one-fifth the number shown in Table 3. The animal fecal loading rates are: 1.24×10^{10} counts/day/hog (NCSU, 1994); 1.06×10^{11} counts/day/cow (NCSU, 1994); and 1.38×10^8 counts/day/chicken (NCSU, 1994).

4.3.4 Grazing Animals

Beef cows and other cattle in the watershed contribute manure containing fecal coliform bacteria directly to pastures during grazing. Because there is no monthly variation in animal access to pastures in south Georgia, the fecal loading rates to pasture land does not vary significantly throughout the year. Contributions of fecal coliform from wildlife are included in the pasture loading rate.

4.3.5 Urban Development

Urban land use represented in the MRLC database includes areas classified as: high intensity commercial, industrial, transportation, low intensity residential, high intensity residential, and

transitional. A single, area-weighted loading rate from urban areas is used in the model and is based on the percentage of each urban land use type in the watershed and build-up and

accumulation rates referenced in Horner (1992). This rate is assumed constant throughout the year. Leaking sewer collection lines are estimated to contribute fecal coliform bacteria to Bear

Creek. In the model, leaking sewer lines are represented as a point source having constant flow and concentration. The design flow of the Sparks WPCP was used to estimate the bacteria loading from leaking sewer collection lines.

4.4 Model Calibration

The calibration of the watershed model involves both hydrology and water quality components. The hydrology calibration is performed first and involves comparing simulated streamflows to historic streamflow data from a U.S. Geological Survey (USGS) stream gaging station for the same period of time. Calibration of the hydrologic model involves adjusting model parameters (e.g., evapotranspiration, infiltration, upper and lower zone storage, groundwater storage and recession, and interflow discharge) used to represent the hydrologic cycle, until an acceptable agreement is achieved between simulated and observed streamflows. There is no streamflow gage in the Bear Creek watershed. The USGS gage 023177483 located on the Withlacoochee River was used to calibrate the flow model. Results of the hydrology calibration are included in Appendix B.

The only fecal coliform bacteria data available for Bear Creek were those data collected during 1998. These data were used to calibrate the water quality model. Model calibration results are shown in Appendix B. Results show that the model adequately simulates peaks in fecal coliform bacteria in response to rainfall events. Often a high observed value is not simulated in the model due to lack of rainfall at the meteorological station as compared to the rainfall occurring in the watershed, or an unknown source that is not included in the model. A comparison of simulated water quality concentrations and observed concentrations for sampling stations in the watershed are included in Appendix B.

4.5 Critical Conditions

The critical condition for fecal coliform impairment from nonpoint sources is a rainfall runoff event preceded by an extended period of dry weather. The dry weather allows a build-up of fecal coliform bacteria, which is then washed off the ground by rainfall. Critical conditions for point sources occur during low flow and corresponding reduced dilution. Both conditions are simulated in the NPSM model.

The ten-year simulation period from January 1, 1989 to December 31, 1998, was used to identify the critical conditions from which to base the fecal coliform bacteria TMDL. This ten-year period contained a range of hydrological conditions including low and high streamflows. The range of hydrological conditions provided an opportunity to identify the conditions critical to fecal coliform bacteria, as well as the amount of in-stream fecal coliform bacteria in the stream that can be used to develop the TMDL.

5.0 MODEL RESULTS

5.1 Existing Conditions

Model results indicate that the primary source of fecal coliform bacteria contamination in the Bear Creek watershed is from agricultural runoff and direct input of fecal coliform bacteria into the stream from various sources (e.g., illicit dischargers, cattle, and other animals having access to streams, wild hogs in wetlands, and leaking sewer collection lines). Leaking septic systems also contribute to fecal coliform bacteria contamination in the Bear Creek watershed. Nonpoint source loading rates representing existing model conditions are shown in Table 5.

Table 5. Nonpoint Source Loading Rates for Existing Conditions

Watershed ID	Runoff from all Lands (Counts / 30 day)	Septic Failure (Counts / 30 day)	Unknown Sources (Counts / 30 day)
Bear Creek	2.56×10^{12}	9.82×10^{09}	2.72×10^{10}

5.2 Critical Condition

Results of the ten-year simulation for existing conditions are shown in Figure 3. From this figure critical conditions can be determined. The 30-day critical period in the model is the time period preceding the largest simulated violation of the geometric mean standard (EPA, 1991). Achieving water quality standards during this time period ensures that water quality standards can be achieved for the ten-year period. For the listed segments in the Bear Creek watershed, the highest violation of the 30-day geometric mean occurred on September 19, 1993. The critical period is August 20, 1993 through September 18, 1993.

6.0 ALLOCATION

6.1 Total Maximum Daily Load

A TMDL is the sum of the individual waste load allocations (WLA) for point sources and load allocations (LA) for nonpoint sources and natural background (40 CFR 130.2). The sum of these components may not result in an exceedence of water quality standards for that water body. To protect against exceedences, the TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body. Conceptually, a TMDL can be expressed as follows:

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

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while maintaining water quality standards. TMDLs establish allowable pollutant loadings that are less than or equal to the TMDL, and thereby provide the basis to establish water quality based controls. For some pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds per day). For fecal coliform bacteria the TMDL are expressed as counts per 30 days. Therefore, the TMDL represents the maximum fecal coliform bacteria load that can be assimilated by the stream during the critical 30-day period while maintaining the fecal coliform bacteria water quality standard of 200 counts/100 ml.

The total maximum daily load of fecal coliform bacteria was determined by adding the WLA and the LA. The MOS (as described in Section 6.5) was implicitly included in the TMDL analysis and does not factor directly in the TMDL equation as shown above. Table 6 shows the computation of the total maximum daily load using the WLAs and the LAs for the critical condition. The TMDLs are summarized in Appendix C. The TMDL for fecal coliform bacteria in Bear Creek is 2.97×10^{12} counts per 30 days.

6.2 Waste Load Allocations

Two NPDES permitted discharges are identified in the Bear Creek watershed: Adel WPCP and Sparks WPCP. The WLA for these facilities were determined using the facilities' permitted flow rates and the water quality standard criteria of 200 counts/100 ml. Therefore, the WLA for the Adel facility is 6.69×10^{11} counts per 30 days, and 5.26×10^{10} counts per 30 days for the Sparks facility. Future facility permits will require end-of-pipe criteria equivalent to the water quality standard of 200 counts/100 ml.

6.3 Load Allocations

The nonpoint fecal coliform bacteria sources in the model have two transportation modes. First, animals in the stream, leaking septic systems, and leaking sewer collection lines are modeled as direct sources to the stream. The other nonpoint sources result from fecal coliform bacteria that are applied to land. 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 indicate that nonpoint sources related to agricultural practices have a significant impact on the fecal coliform bacteria loadings in the watersheds (see Appendix B). Leaking septic systems, leaking sewer collection lines and stormwater runoff from urban areas are considered

secondary sources of fecal coliform. Reductions in these loading rates in the Bear Creek watershed reduce the in-stream fecal coliform bacteria levels.

A possible allocation scenario that would meet in-stream water quality standards is a 35 percent reduction in runoff from nonpoint sources and a 70 percent reduction in direct input to the stream (e.g., animal access, failing septic systems, and leaking sewer collection lines). Fecal coliform loading rates for this allocation scenario are shown in Table 5. Fecal coliform loading from wildlife is represented in the model as background conditions. Management practices that could be used to implement this TMDL include adoption of NRCS resource management practices including covering manure and poultry litter stacks exposed to the environment; reducing animal access to streams; and applying manure to croplands at agronomical rates. Replacement of leaking septic systems and sewer collection lines and controlling stormwater runoff from urban areas could also improve water quality. Best management practices (BMPs) should be developed to address urban and agricultural runoff during extreme storm events. Additional monitoring and characterization of the watershed could be conducted to verify the various unknown sources of fecal coliform bacteria in the watershed.

Table 6. Load Allocations in the Hog Creek Watershed

Watershed ID	Existing Load (Counts / 30 days)	Allocated Load (Counts / 30 days)	Percent Reduction
Bear Creek	3.67×10^{12}	2.35×10^{12}	35

Table 7. TMDL Components (counts/30 days)

Watershed ID	WLA	LA	MOS	TMDL
Bear Creek	6.21×10^{11}	2.35×10^{12}	Implicit	2.97×10^{12}

6.4 Seasonal Variation

Seasonal variability was incorporated in the continuous simulation water quality model by using varying monthly loading rates and daily meteorological data. The combination of a continuous simulation with varying loading rates and meteorological conditions creates a condition of seasonal variation.

6.5 Margin of Safety

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

process by selecting a critical time period and critical default values for each of the summer and winter seasons based on the results of a 10-year simulation.

7.0 Recommendations

7.1 Monitoring

GAEPD has adopted the Basin Approach to Water Quality Management, a plan that divides Georgia's major river basins in to five groups. During each year-long cycle, GAEPD's water quality monitoring resources are concentrated in one of the basin groups. In watersheds identified as having both urban and agricultural activities, microbial source tracking may be used in the future to clarify the specific sources of fecal coliform bacteria. During the next phase of monitoring in the south Georgia river basins, water quality monitoring in the watershed will identify current water quality conditions resulting from the implementation of management practices. Additional characterization may be needed in the watershed to clarify the unknown sources of fecal coliform bacteria.

7.2 Point and Nonpoint Approaches

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

7.3 Public Participation

A thirty day public notice will be provided for this TMDL. During this time the availability of the TMDL will be public noticed, a copy of the TMDL will be provided as requested, and the public will be invited to provide comments on the TMDL.

REFERENCES

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Figure 1. Location Map

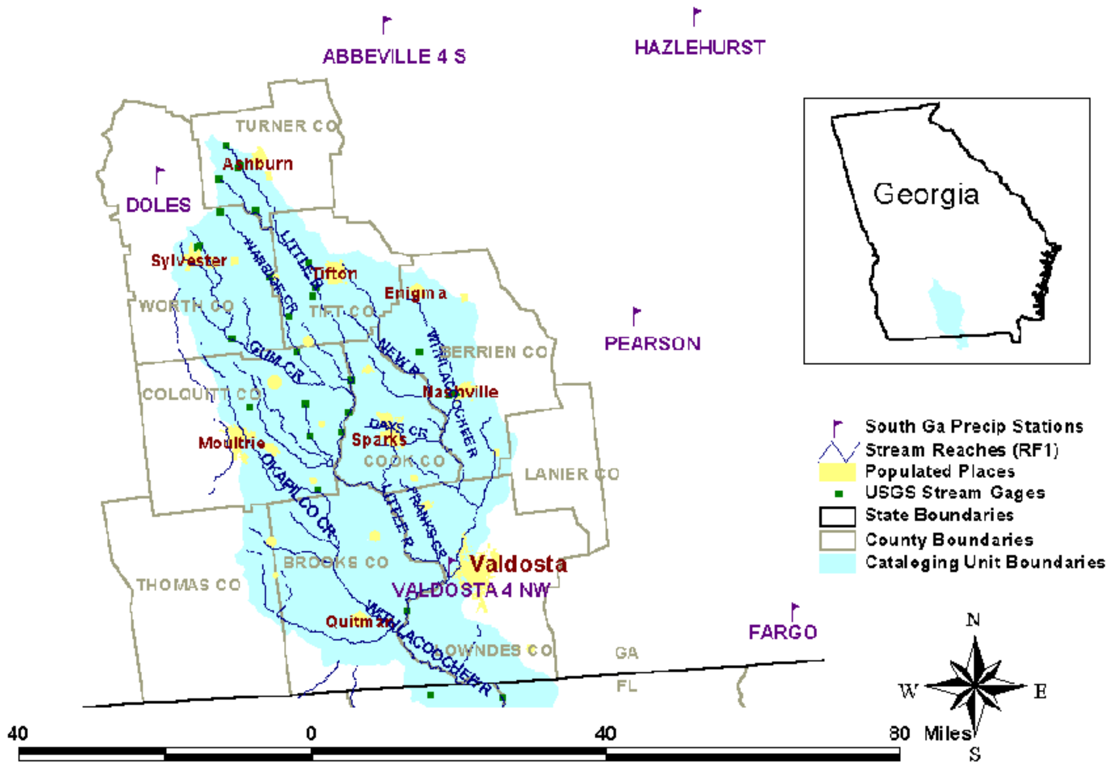
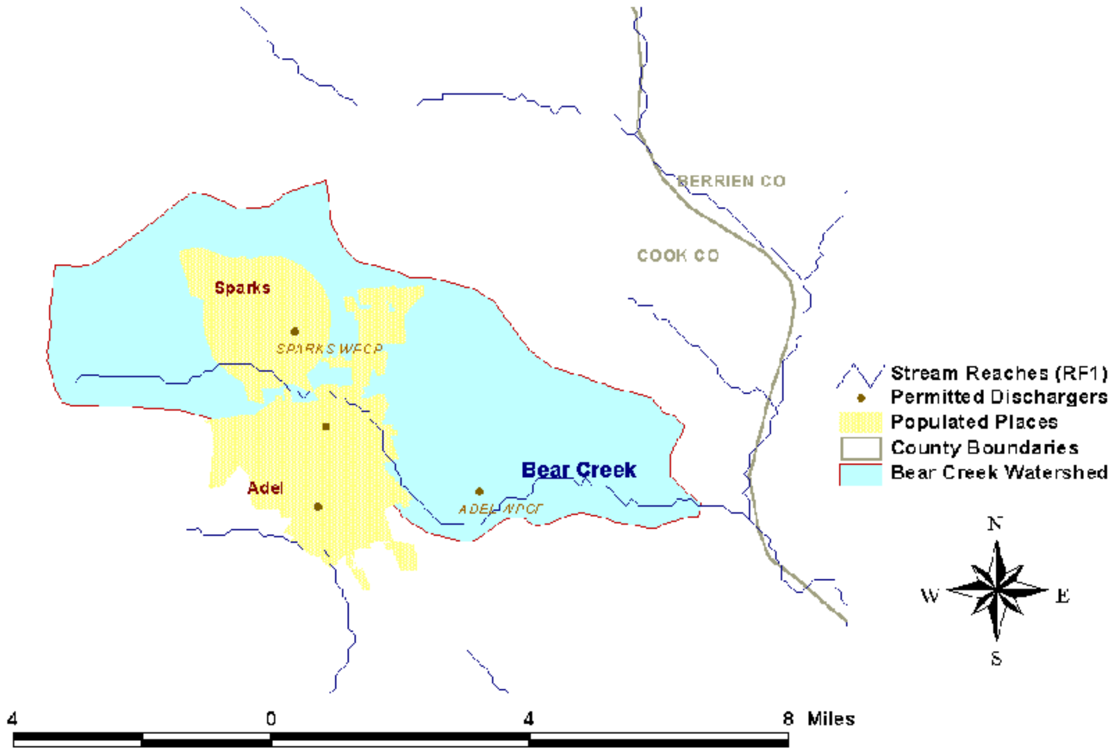


Figure 2. Bear Creek Watershed



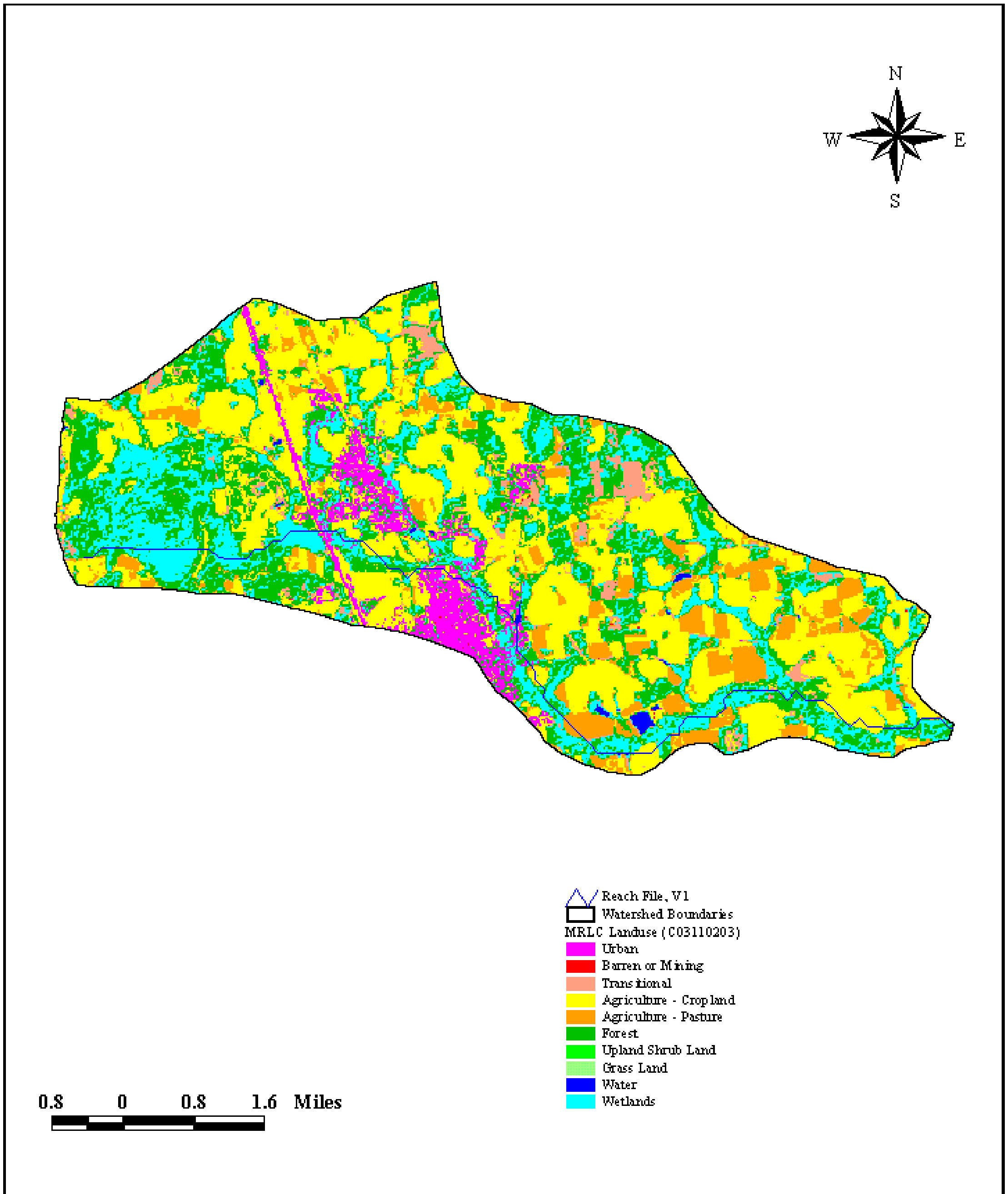
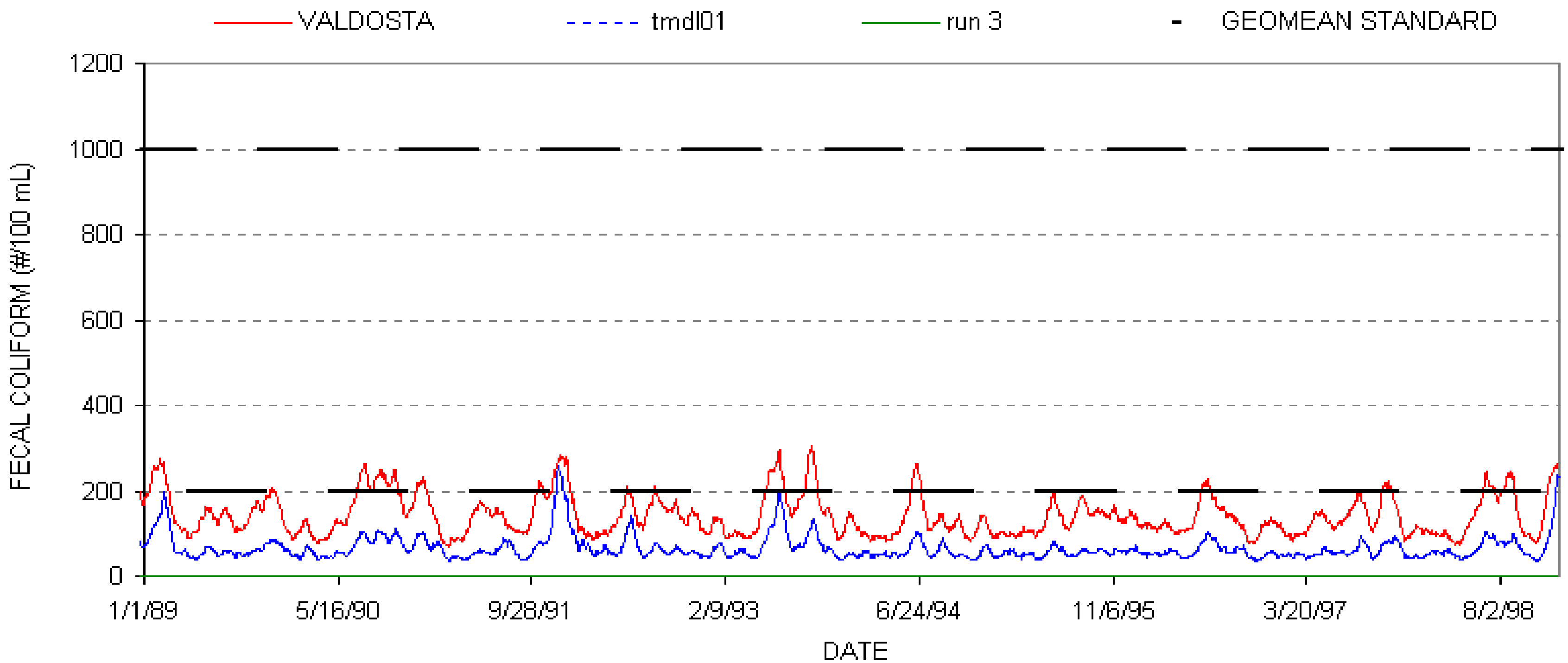


Figure 3. Land Use Map
Bear Creek Watershed

Map Projection: Albers Equal Area Conic
Datum: NAD83
Sphere: GRS 80
Data Sources USEPA; MRLC, 1994

Figure 4. Simulated Geometric Mean of Existing and Allocated Fecal Coliform Bacteria Levels

STATION: BEAR CR (09027101)



APPENDIX A

Water Quality Model Assumptions

This sheet contains information relevant to land application of waste produced by agricultural animals in the study area.

Application of hog manure, beef cattle manure, dairy cattle manure, horse manure, poultry litter, and manure from import are considered.
Manure generated by in-county animals is assumed to be applied fresh (thus fecal content from fresh manure is used in calculations).
Manure values can be varied using a multiplication factor, in order to consider die-off due to known treatment/storage methods.
Manure imported into the county is assigned a fecal coliform content based on known storage/treatment methods.
The information is presented based on monthly variability of waste application.
note: the fecal die-off rates (fecal content multiplier) are assumed values, adjust accordingly

Hog Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)
Manure fecal content multiplier 0.75 note: set to 1 for TMDL

This is the fraction of the annual manure application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December	
Fraction of manure applied each month	0	0	0.075	0.1575	0.1335	0.1335	0.1335	0.1335	0.1585	0.075	0	0	1

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.
Fraction incorporated into soil (assumed) 0.80 FRACTION AVAIL FOR RUNOFF = 0.6 = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5)
Fraction available for runoff 0.6000 For TMDL use NRCS RATE: 0.3354 (INCLUDES DIE OFF)

The following is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

COUNTY ID	January	February	March	April	May	June	July	August	September	October	November	December
13075	0	0	0.045	0.0945	0.0801	0.0801	0.0801	0.0801	0.0951	0.045	0	0

Beef Cattle Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)
Manure fecal content multiplier 1 (a value of 1 assumes fresh application) for calibration run and TMDL set to 1

This is the fraction of the annual manure application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December	
Fraction of manure applied each month	0.0833	0.0833	0.0833	0.0833	0.0833	0.0834	0.0834	0.0834	0.0834	0.0833	0.0833	0.0833	1

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.
Fraction incorporated into soil (assumed) 0.80 FRACTION AVAIL FOR RUNOFF = 0.6 = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5)
Fraction available for runoff 0.6000 For TMDL use NRCS RATE= 0.0098 (INCLUDES DIE OFF)

% Applied to Cropland:	0.00	% Applied to Pastureland:	1.00	1

The following is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

COUNTY ID	January	February	March	April	May	June	July	August	September	October	November	December
13075	0.04998	0.04998	0.04998	0.04998	0.04998	0.05004	0.05	0.05004	0.05004	0.04998	0.04998	0.04998

Poultry Litter Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)
Manure fecal content multiplier 0.5 (a value of 1 assumes fresh application) For TMDL set to 1

This is the fraction of the annual litter application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December	
Fraction of litter applied each month	0	0	0.075	0.1575	0.1335	0.1335	0.1335	0.1335	0.1585	0.075	0	0	1

The fraction of litter available for runoff is dependent on the method of litter application. The fraction available is computed below based on incorporation into soil. These are assumed values.
Fraction incorporated into soil (assumed) 0.96 FRACTION AVAILABLE FOR RUNOFF: 0.36 = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.33)
Fraction available for runoff 0.36000 NRCS VALUES : 0.2029 FOR LAYERS; 0.00496 FOR BROILERS **FOR TMDL USE 0.00496**

% Applied to Cropland:	0.40	% Applied to Pastureland:	0.60	1

The following is the resulting fraction of annual litter application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

COUNTY ID	January	February	March	April	May	June	July	August	September	October	November	December
13075	0	0	0.027	0.0567	0.04806	0.04806	0.0481	0.04806	0.05706	0.027	0	0

Dairy Cattle Manure Available for Wash-off

Storage/treatment of manure prior to application may affect the fecal coliform content in the manure.
The multiplier below can be used to increase or decrease the fecal content in manure that is applied (to consider storage/treatment)
Manure fecal content multiplier 1 (a value of 1 assumes fresh application) for TMDL set to 1

This is the fraction of the annual manure application that is applied each month.

	January	February	March	April	May	June	July	August	September	October	November	December	
Fraction of manure applied each month	0	0.0835	0.075	0.1585	0.05	0.1335	0.05	0.1335	0.075	0.1585	0	0.0825	1

The fraction of manure available for runoff is dependent on the method of manure application. The fraction available is computed below based on incorporation into soil. These are assumed values.
Fraction incorporated into soil (assumed) 0.80 FRACTION AVAILABLE FOR RUNOFF: 0.6 = (1 - [fraction incorporated]) + ([fraction incorporated] * 0.5)

Fraction available for runoff	0.6000	NRCS VALUES: 0.0965 GRAZING; 0.2048 CONFINED (FOR TMDL, ASSUME CONFINED CONDITIONS)

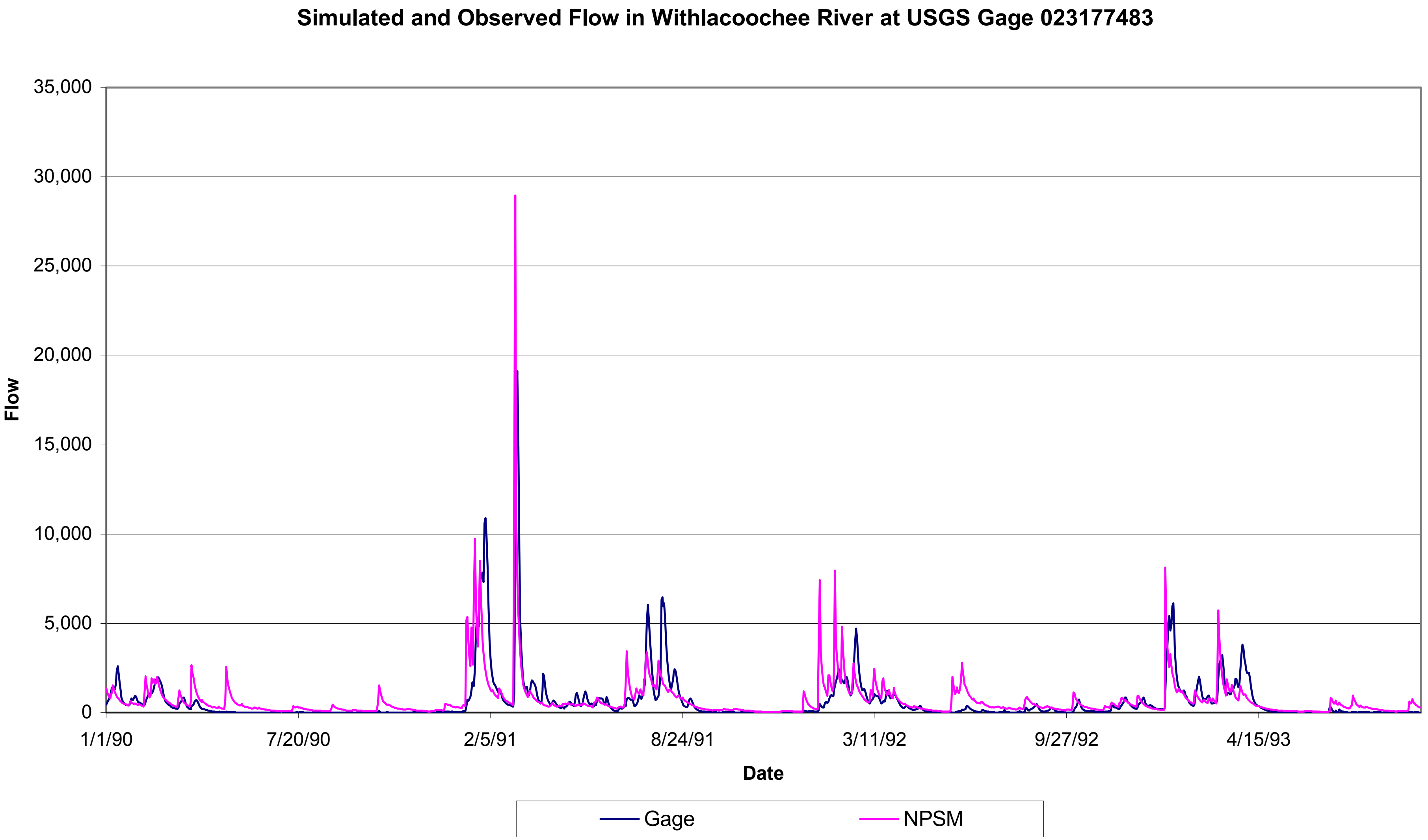
% Applied to Cropland:	0.75	% Applied to Pastureland:	0.25	1

The following is the resulting fraction of annual manure application available for runoff each month based on the monthly fraction applied and incorporation into the soil.

COUNTY ID	January	February	March	April	May	June	July	August	September	October	November	December
13075	0	0.0501	0.045	0.0951	0.03	0.0801	0.03	0.0801	0.045	0.0951	0	0.0495

APPENDIX B

Hydrodynamic and Water Quality Model

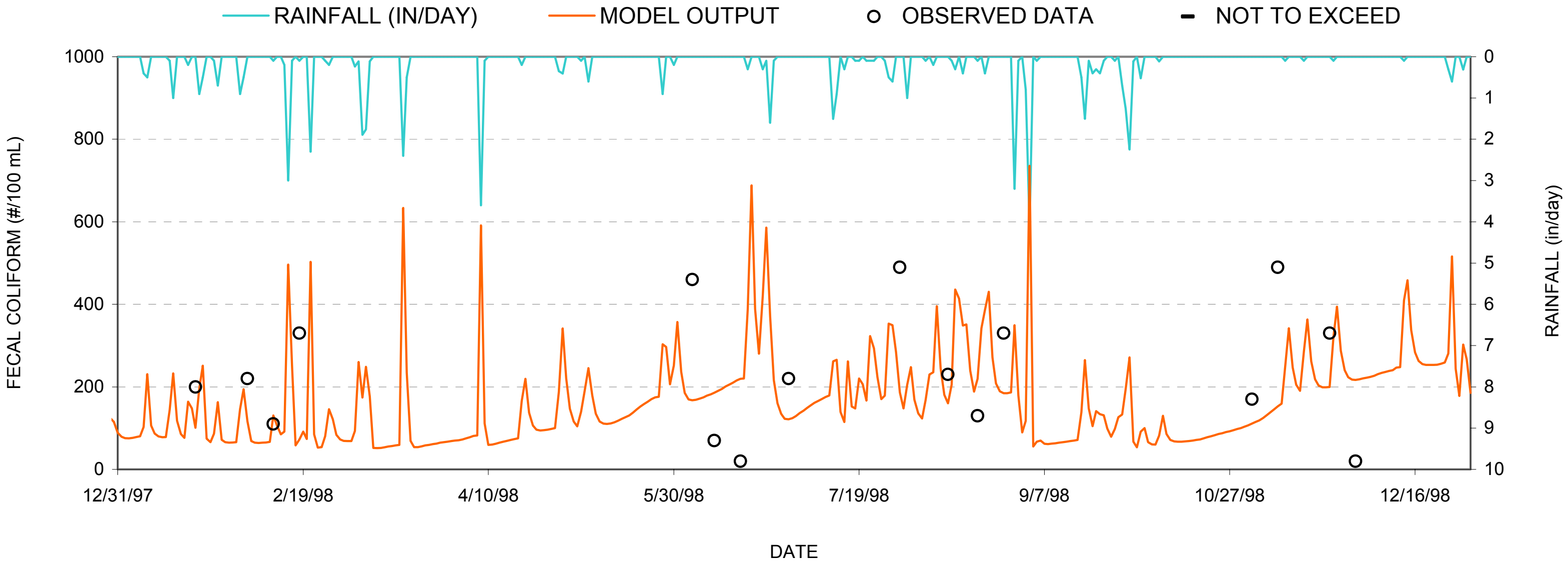

Simulated and Observed Flow in Withlacoochee River at USGS Gage 023177483
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Flow
1/1/90
7/20/90
2/5/91
8/24/91
3/11/92
9/27/92
4/15/93
Date
Gage
NPSM

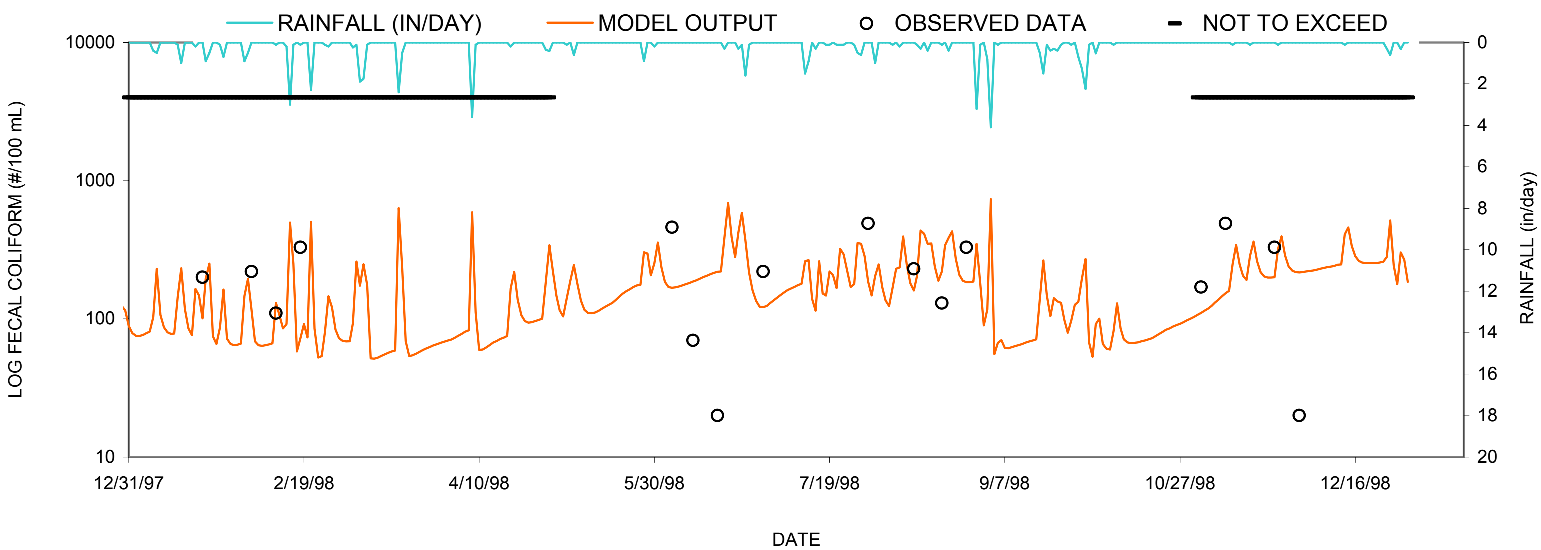
FECAL COLIFORM WATER QUALITY CALIBRATION
MULTI-YEAR TIMESERIES MODEL VS DATA

STATION: **BEAR CR (09027101)**

MODEL RUN: **1**

1 = EXISTING
2 = ALLOCATION 1
3 = ALLOCATION 2





APPENDIX C

Total Maximum Daily Load Summary Memorandum

SUMMARY MEMORANDUM
Total Maximum Daily Load (TMDL)
Bear Creek

1. 303(d) Listed Waterbody Information

State:	**Georgia**
County:	**Cook**
Major River Basin:	**Suwannee**
12-Digit Hydrologic Unit Code(s):	**030702020403**
Waterbody Name:	**Bear Creek**
Location:	**City of Adel Lake to Withlacoochee River**
Stream Length:	**4 mile**
Watershed Area:	**21 square miles**
Tributary to:	**Withlacoochee River**
Constituent(s) of Concern:	**Fecal Coliform Bacteria**
Designated Use:	**Fishing (partially supporting designated use)**

Applicable Water Quality Standard:

May through October fecal coliform 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. For the months of November through April, fecal coliform 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.

2. TMDL Development

Analysis/Modeling:

The Non-Point Source Model (NPSM)/Hydrologic Simulation Program Fortran (HSPF) was used to develop this TMDL. A daily time step was used to simulate hydrologic and water quality conditions. The model was developed for the entire watershed upstream from the 303(d) listed segment.

Critical Conditions:

A simulation period of 10 years was used to assess the water quality standards for this TMDL. This period represents a range of hydrologic and meteorologic conditions.

Seasonal Variation:

A simulation period of 10 years was used to assess the water quality standards for this TMDL. This period represents a range of hydrologic and meteorologic conditions including seasonal variations.

3. Allocation Watershed/Stream Reach:

Wasteload Allocations (WLA): 6.21 x 10^{11} counts/30 days
Note: All future permitted discharges shall meet the water quality standard for fecal coliform bacteria of 200/100 ml as a geometric mean.

Load Allocation (LA): 2.35 x 10^{12} counts/30 days

Margin of Safety (MOS): Implicit (conservative modeling assumptions)

Total Maximum Daily Load (TMDL): 2.97 x 10^{12} counts/30 days