Alabama Department of Environmental Management

Final TMDL Development for
Cole Spring Branch, AL/06030002-070_01
Low Dissolved Oxygen/Organic Loading

Water Quality Branch
Water Division
February 2002

Cole Spring Branch Basin

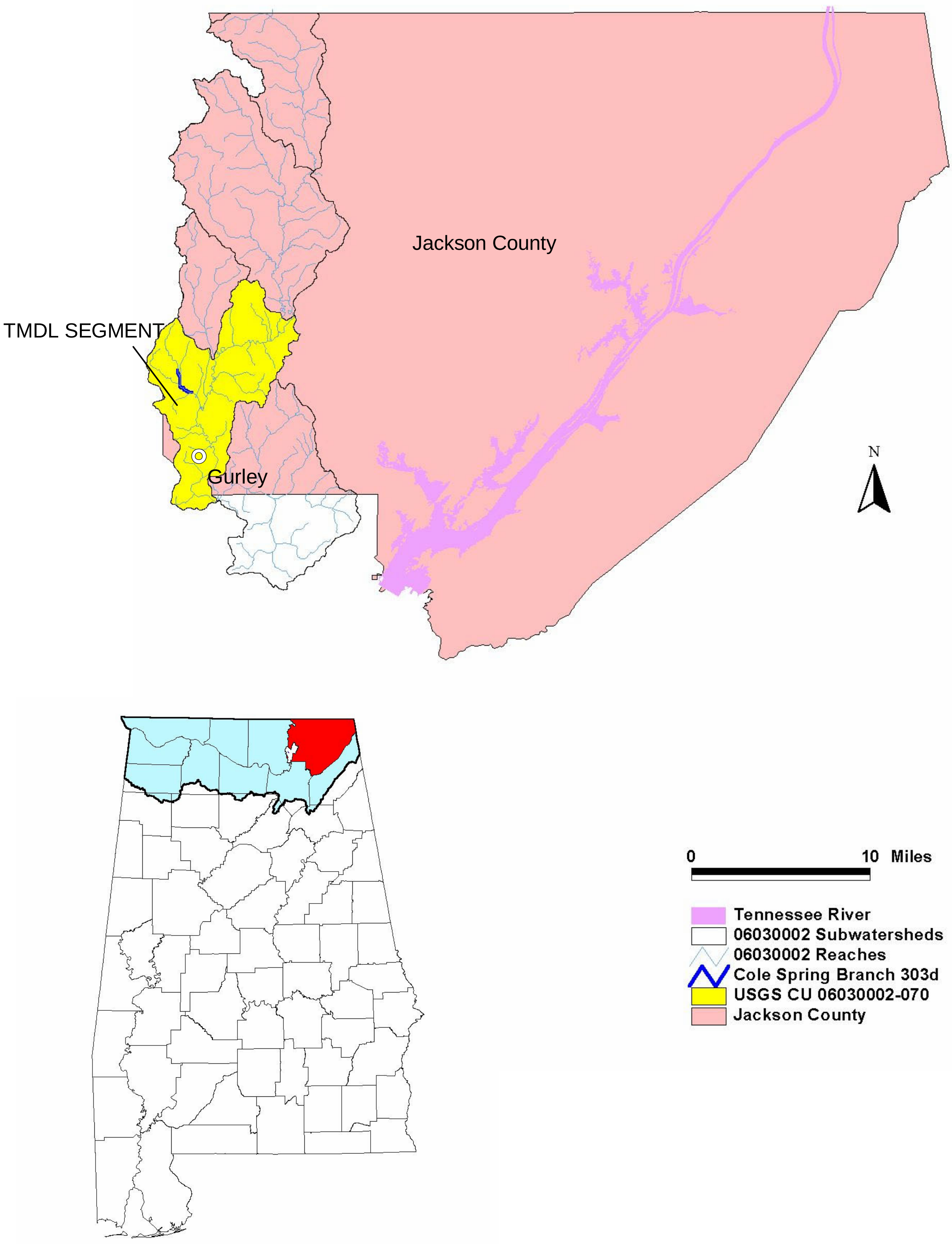


Table of Contents *Page*

1. Executive Summary 4

2. Basis for §303(d) Listing 5

   2.1. Introduction 5
   2.2. Problem Definition 6

3. Technical Basis for TMDL Development 8

   3.1. Water Quality Target Identification 8
   3.2. Source Assessment 8
   3.3. Loading Capacity - Linking Water Quality Numeric Targets and Pollutant Sources 12
   3.4. Data Availability and Analysis 12
   3.5. Critical Conditions 16
   3.6. Margin of Safety 16

4. Water Quality Model Development 17
   4.1. Water Quality Model Selection and Setup 17
   4.2. Water Quality Model Summary 18
   4.3. Critical Model Predictions and Graphics 21
   4.4. Loading Reduction Analysis 22
   4.5. Seasonal Variation 27

5. Conclusions 28

6. TMDL Implementation 29

   6.1. Non-Point Source Approach 29
   6.2. Point Source Approach 30

7. Follow Up Monitoring 31

8. Public Participation 31

9. Appendices

   9.1. References 9.1.1
   9.2. Water Quality Data 9.2.1
   9.3. Water Quality Model Input and Output Files 9.3.1
   9.4. Spreadsheet Water Quality Model (SWQM) User Guide 9.4.1

1.0 Executive Summary

This report contains one or more Total Maximum Daily Loads (TMDLs) for waterbody segments found on Alabama's 1996 and/or 1998 Section 303(d) List(s) of Impaired Waterbodies. Because of the accelerated schedule required by the consent decree, many of these TMDLs have been prepared out of sequence with the State's rotating basin approach. The implementation of the TMDLs contained herein will be prioritized within Alabama's rotating basin approach.

The amount and quality of data on which this report is based are limited. As additional information becomes available, the TMDLs may be updated. Such additional information may include water quality and quantity data, changes in pollutant loadings, or changes in land use within the watershed. In some cases, additional water quality data may indicate that no impairment exists.

Cole Spring Branch, a part of the Tennessee River Basin, is located in Jackson County near Gurley, Alabama. It has been on the State of Alabama's §303(d) use impairment list since 1996 for organic enrichment/low dissolved oxygen (O.E./D.O.) and siltation. Its use classification is Fish & Wildlife (F&W).

Biological data collected by TVA in 1994 and 1995 indicated impaired macroinvertebrate and fish communities. The impairment was attributed to siltation and organic enrichment/low dissolved oxygen but water column sampling was not available at the time to support this assumption. Since D.O. impairments generally occur during the summer months when stream flows are low and water temperatures are high, a steady state modeling approach, using the stream's $7Q_{10}$ flow (the minimum 7-day flow that occurs on average, over a 10 year recurrence interval) was adopted as an appropriate for the TMDL analysis.

The following report addresses the results of the TMDL analysis for O.E./D.O. In accordance with ADEM water quality standards, the minimum dissolved oxygen concentration in a stream classified as Fish and Wildlife is 5.0 mg/l. For the purpose of this TMDL, a minimum dissolved oxygen level of 5.0 mg/l will be implemented allowing for an implicit margin of safety resulting from conservative assumptions used in the dissolved oxygen model.

A summary of the TMDL for the watershed is provided in Table 1-1. The pollutants shown in the table include ultimate carbonaceous biochemical oxygen demand ($CBOD_u$) and nitrogenous biochemical oxygen demand (NBOD), the principle causes for observed low dissolved oxygen concentrations. $CBOD_u$ is a measure of the total amount of oxygen required to degrade the carbonaceous portion of the organic matter present in the water. NBOD is the amount of oxygen utilized by bacteria as they convert ammonia to nitrate. Because organic nitrogen can be converted to ammonia, its potential oxygen demand is included in the NBOD component of the TMDL. The table lists allowable pollutant loadings by source (point and non-point sources) for the critical period (May through November).

Table 1-1. Maximum Allowable Pollutant Loads by Source – Critical Period (May-November)

Pollutant	Point Source Loads (lbs./day)	Non-point Source Loads (lbs./day)
$CBOD_u$	0.0	11.2
NBOD	0.0	35.6
Total	0.0	46.8

2.0 Basis for §303(d) Listing

2.1 Introduction

Section 303(d) of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987 and EPA's Water Quality Planning and Management Regulations [(Title 40 of the Code of Federal Regulations (CFR), Part 130)] require states to identify waterbodies which are not meeting water quality standards applicable to their designated use classifications. The identified waters are prioritized based on severity of pollution with respect to designated use classifications. Total maximum daily loads (TMDLs) for all pollutants causing violation of applicable water quality standards are established for each identified water. Such loads are established at levels necessary to implement the applicable water quality standards with seasonal variations and margins of safety. The TMDL process establishes the allowable loading of pollutants, or other quantifiable parameters for a waterbody, based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water-quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991).

The State of Alabama has identified Cole Spring Branch as being impaired by organic loading (i.e., $CBOD_u$ and NBOD) for a length of 2.1 miles, as reported on the 1996, 1998, and draft 2000 §303(d) list(s) of impaired waters. Cole Spring Branch is prioritized as "low" on the list(s). Cole Spring Branch is located in Jackson County and lies within the Upper Paint Rock River watershed of the Tennessee River Basin.

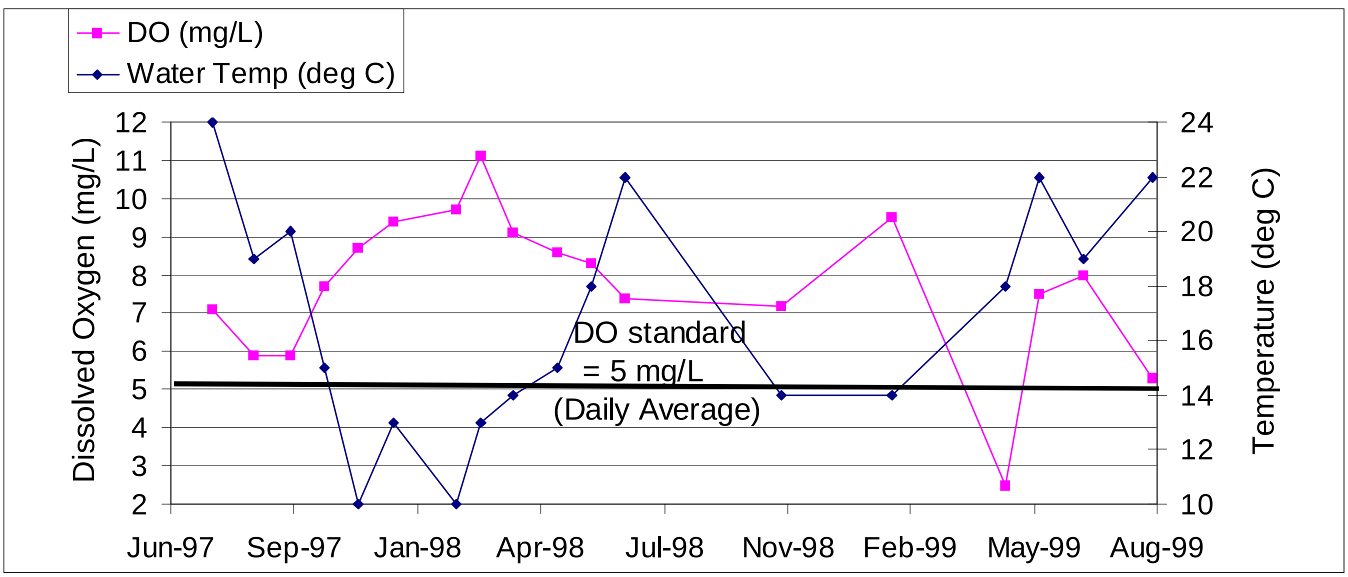
The TMDL developed for Cole Spring Branch illustrates the steps that can be taken to address a waterbody impaired by low dissolved oxygen levels. The TMDL is consistent with a phased-approach: estimates are made of needed pollutant reductions, load reduction controls are implemented, and water quality is monitored for plan effectiveness. Flexibility is built into the plan so that load reduction targets and control actions can be reviewed if monitoring indicates continuing water quality problems.

2.2 Problem Definition

Cole Spring Branch is a small, headwater stream with a relatively small drainage area of 11.5 square miles. Dry weather flows for the watershed are relatively low, or zero. Water quality data collected for the watershed during July 1997 through August 1999, indicates that dissolved oxygen impairments occurred primarily during stormwater events. The percentage of the dissolved oxygen data not meeting the minimum water quality standard is 5.3% during July 1997 through August 1999. Generally, depressed in-stream D.O. concentrations may be caused by several sources including the decay of oxygen demanding waste from both point and non-point sources, algal respiration, sediment oxygen demand or other sources. It is believed based on available data that the low dissolved oxygen concentrations observed in this watershed are due to nonpoint source impacts during stormwater runoff events and are not the result of algal dynamics.

Figure 2.1 below illustrates the dissolved oxygen versus temperature data available for Cole Spring Branch at station #CSPR-1.

Figure 2.1 Dissolved Oxygen vs. Temperature Data



<u>Waterbody Impaired:</u>	Cole Spring Branch-from Jeep Trail Crossing to Bridge at Jones' Farm.
<u>Water Quality Standard Violation:</u>	Dissolved Oxygen
<u>Pollutant of Concern:</u>	Organic Enrichment ($CBOD_u$/NBOD)
<u>Water Use Classification:</u>	Fish and Wildlife

The impaired stream segment, Cole Spring Branch, is classified as Fish and Wildlife. Usage of waters in this classification is described in ADEM Admin. Code R. 335-6-10-.09(5)(a), (b), (c), and (d).

(a) Best usage of waters:

Fishing, propagation of fish, aquatic life, and wildlife, and any other usage except for swimming and water-contact sports or as a source of water supply for drinking or food processing purposes.

(b) Conditions related to best usage:

The waters will be suitable for fish, aquatic life and wildlife propagation. The quality of salt and estuarine waters to which this classification is assigned will also be suitable for the propagation of shrimp and crabs.

(c) Other usage of waters:

It is recognized that the waters may be used for incidental water contact and recreation during June through September, except that water contact is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health.

(d) Conditions related to other usage:

The waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports.

Low D.O./Organic Loading Criteria:

Alabama's water quality criteria document (ADEM Admin. Code R. 335-6-10-.09-(5)(e)(4.)) states that for a diversified warm water biota, including game fish, daily dissolved oxygen concentrations shall not be less than 5 mg/l at all times; except under extreme conditions due to natural causes, it may range between 5 mg/l and 4 mg/l, provided that the water quality is favorable in all other parameters. The normal seasonal and daily fluctuations shall be maintained above these levels. In no event shall the dissolved oxygen level be less than 4 mg/l due to discharges from existing hydroelectric generation impoundments. All new hydroelectric generation impoundments, including addition of new hydroelectric generation units to existing impoundments, shall be designed so that the discharge will contain at least 5 mg/l dissolved oxygen where practicable and technologically possible. The Environmental Protection Agency, in cooperation with the State of Alabama and parties responsible for impoundments, shall develop a program to improve the design of existing facilities.

3.0 Technical Basis for TMDL Development

3.1 Water Quality Target Identification

The minimum dissolved oxygen concentration in a stream classified as Fish and Wildlife is 5.0 mg/l. For the purpose of this TMDL, a minimum dissolved oxygen level of 5.0 mg/l will be implemented allowing for an implicit margin of safety resulting from conservative assumptions used in the dissolved oxygen model. The target $CBOD_u$ and NBOD concentrations are concentrations that, in concert with the nitrification of ammonia, will not deplete the dissolved oxygen concentration below this level as a result of the decaying process.

3.2 Source Assessment

3.2.1. General Sources of $CBOD_u$ and NBOD

Both point and non-point sources may contribute $CBOD_u$ and NBOD (i.e., organic loading) to a given waterbody. Potential sources of organic loading are numerous and often occur in combination. In rural areas, storm runoff from row crops, livestock pastures, animal waste application sites, and feedlots can transport significant loads of organic loading. Nationwide, poorly treated municipal sewage comprises a major source of organic compounds that are hydrolyzed to create additional organic loading. Urban storm water runoff, sanitary sewer overflows, and combined sewer overflows can be significant sources of organic loading.

All potential sources of organic loading in the watershed were identified based on an evaluation of current land use/cover information on watershed activities (e.g., agricultural management activities). The source assessment was used as the basis for development of the model and ultimate analysis of the TMDL allocations. The determination of organic loading within the watershed included assessment of both point and non-point sources.

3.2.2. Point Sources in the Cole Spring Branch Watershed

ADEM maintains a database of current NPDES permits and GIS files that locate each permitted outfall. This database includes municipal, semi-public/private, industrial, mining, industrial storm water, and concentrated animal feeding operations (CAFOs) permits. Table 3-1, shows the permitted point sources in the watershed that discharge into or upstream of the impaired segment. Table 3-2 contains the permit limitations for the significant point sources that were considered in the model development. There were no point sources indentified in the watershed as indicated in these tables.

Table 3-1. Contributing Point Sources in the Cole Spring Branch Watershed.

NPDES Permit	Type of Facility (e.g., CAFO, Industrial, Municipal, Semi-Public/Private, Mining, Industrial Storm Water)	Facility Name	Significant Contributor (Yes/No)
None			

<u>Note</u>: Storm water discharges if listed in the above table were marked as not being significant contributors since the discharge would not occur during low flow conditions. Construction storm water discharges are not listed as these discharges do not occur during low flow and generally do not contribute directly to the organic loading.

Table 3-2. NPDES Permit Limits for Significant Contributing Point Sources

NPDES Permit	Facility Name	Permit Limitations - Summer					Permit Limitations - Winter				
		$CBOD_5$ (MG/L)		NH_3-N (MG/L)		DO (MG/L)	$CBOD_5$ (MG/L)		NH_3-N (MG/L)		DO (MG/L)
		Max	Avg	Max	Avg	Min	Max	Avg	Max	Avg	Min
None											

Notes: n/a = not applicable

3.2.3. Non-Point Sources in the Cole Spring Branch Watershed

Shown in Table 3-3, below, is a detailed summary of land usage in the Cole Spring Branch watershed. A land use map of the watershed is presented in Figure 3-1. Shown in Figure 3-1 is a pie chart depicting principal land uses. The predominant land uses within the watershed are forest, pasture/hay, and row crops. Their respective percentages of the total watershed are 56%, 27%, and 17%. These percentages were calculated by combining the smaller insignificant land uses (i.e. emergent herbaceous wetlands, woody wetlands).

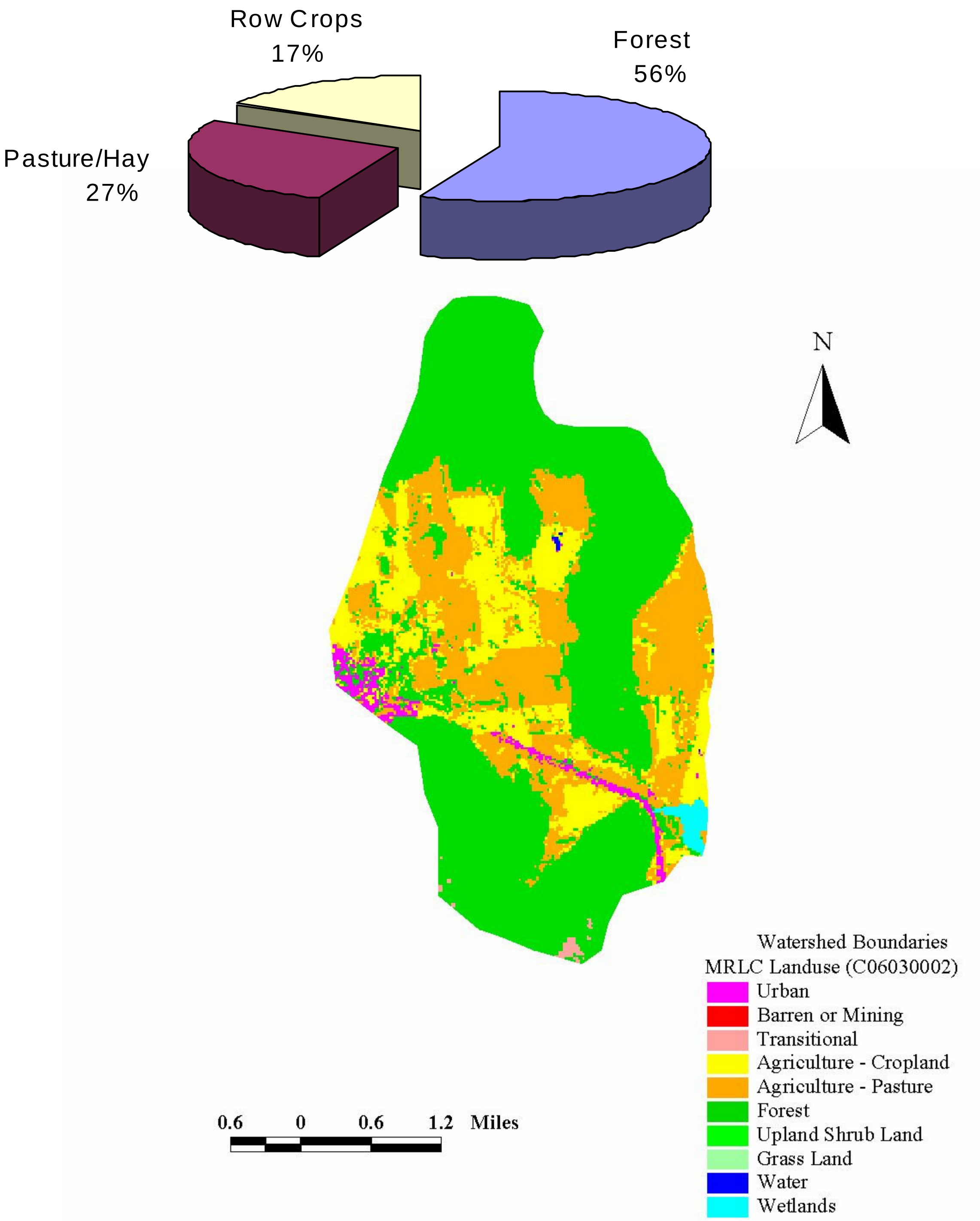
Table 3-3. Land Use in the Cole Spring Branch Watershed.

LAND USE	PERCENTAGE
Open Water	0.1%
Emergent Herbaceous Wetlands	0.1%
Woody Wetlands	0.7%
Low-Intensity Industrial Residential	0.6%
High-Intensity Industrial Residential	0.1%
Commercial/Industrial/Transport	1.1%
Transitional Barren	0.3%
Deciduous Forest	40.9%
Evergreen Forest	2.9%
Mixed Forest	11.4%
Other Grasses (Urban/recreational; e.g. parks)	0.2%
Pasture/Hay	25.6%
Row Crops	16.0%

The predominant land uses of forest, pasture/hay, and row crops make up 100% of the watershed. Each land use has the potential to contribute to the organic loading in the watershed due to organic material on the land surface that potentially can be washed off into the receiving waters of the watershed. Information on agricultural and management activities and watershed characteristics were obtained through coordination with the ADEM Mining and Non-Point Section, the Alabama Cooperative Extension System, and the USDA-Natural Resources Conservation Service (NRCS).

The major sources of organic enrichment from non-point sources within the Cole Spring Branch watershed are the forest, pasture/hay, and row crops land uses. Compared to other land uses organic enrichment from forested land is normally considered to be small. This is because forested land tends to serve as a filter of pollution originating within its drainage areas. However, organic loading can originate from forested areas due to the presence of wild animals such as deer, raccoons, turkeys, waterfowl, etc. Control of these sources is usually limited to land management best management practices (BMPs) and may be impracticable in most cases. In contrast to forested land, agricultural land can be a major source of organic loading. Runoff from pastures, animal operations, improper land application of animal wastes, and animals with access to streams are all mechanisms that can introduce organic loading to waterbodies.

Figure 3-1. Land Use Map for the Cole Spring Branch Watershed.



3.3 Loading Capacity – Linking Numeric Water Quality Targets and Pollutant Sources

EPA regulations define loading, or assimilative capacity, as the greatest amount of loading that a waterbody can receive without violating water quality standards (40 CFR Part 130.2(f)).

Alabama's water quality criteria document (ADEM Admin. Code R. 335-6-10-.09-(5)(e)(4.)) states that for a diversified warm water biota, including game fish, daily dissolved oxygen concentrations shall not be less than 5 mg/l at all times; except under extreme conditions due to natural causes, it may range between 5 mg/l and 4 mg/l, provided that the water quality is favorable in all other parameters. The normal seasonal and daily fluctuations shall be maintained above these levels.

Using the D.O. water quality criterion of 5.0 mg/l as the numerical target, a TMDL model analysis was performed at critical conditions (i.e., summer) to determine the loading capacity for the watershed. This was accomplished through a series of simulations aimed at meeting the dissolved oxygen target limit by varying source contributions. The final acceptable simulation represented the TMDL (and loading capacity of the waterbody). If point sources were identified in the watershed, an additional model analysis was performed for the winter to determine the loading capacity during higher flow conditions.

In the TMDL model analysis, the pollutant concentrations from forestland were assumed to be at normal background concentrations. Specific values for background pollutant concentrations are as follows: 2 mg/l $CBOD_u$, 0.5 mg/l ammonia oxygen demand (NH_3OD_u), and 1 mg/l total organic nitrogen oxygen demand ($TONOD_u$). Pollutant concentrations for the other land uses in the watershed were assigned in proportion to measured concentrations and were set in the TMDL model at levels necessary to maintain dissolved oxygen concentrations greater than, or equal to, 5 mg/l. The model predictions for in-stream pollutant concentrations were then compared to actual field data. The model velocities and reaeration coefficients were adjusted in those cases where the field data indicated significant discrepancies from the model predictions.

3.4 Data Availability and Analysis

3.4.1. Watershed Characteristics

A. General Description: Cole Spring Branch, located in Jackson County, is a tributary to the Paint Rock River. The Cole Spring Branch is a part of the Tennessee River basin. Cole Spring Branch is a part of the USGS (United States Geological Survey) 06030002 cataloging unit and the NRCS (Natural Resources Conservation Service) 070 sub-watershed. Cataloging unit 06030002 includes the Wheeler Lake. NRCS sub-watershed number 070 represents the Upper Paint Rock River watershed.

Cole Spring Branch begins approximately 2 miles northeast of Gurley, Alabama in NW1/4 Section 6, T4S, R4E. It has a linear distance of 4.96 miles and a total drainage area of 11.5 square miles. Cole Spring Branch has a use classification of Fish & Wildlife (F&W).

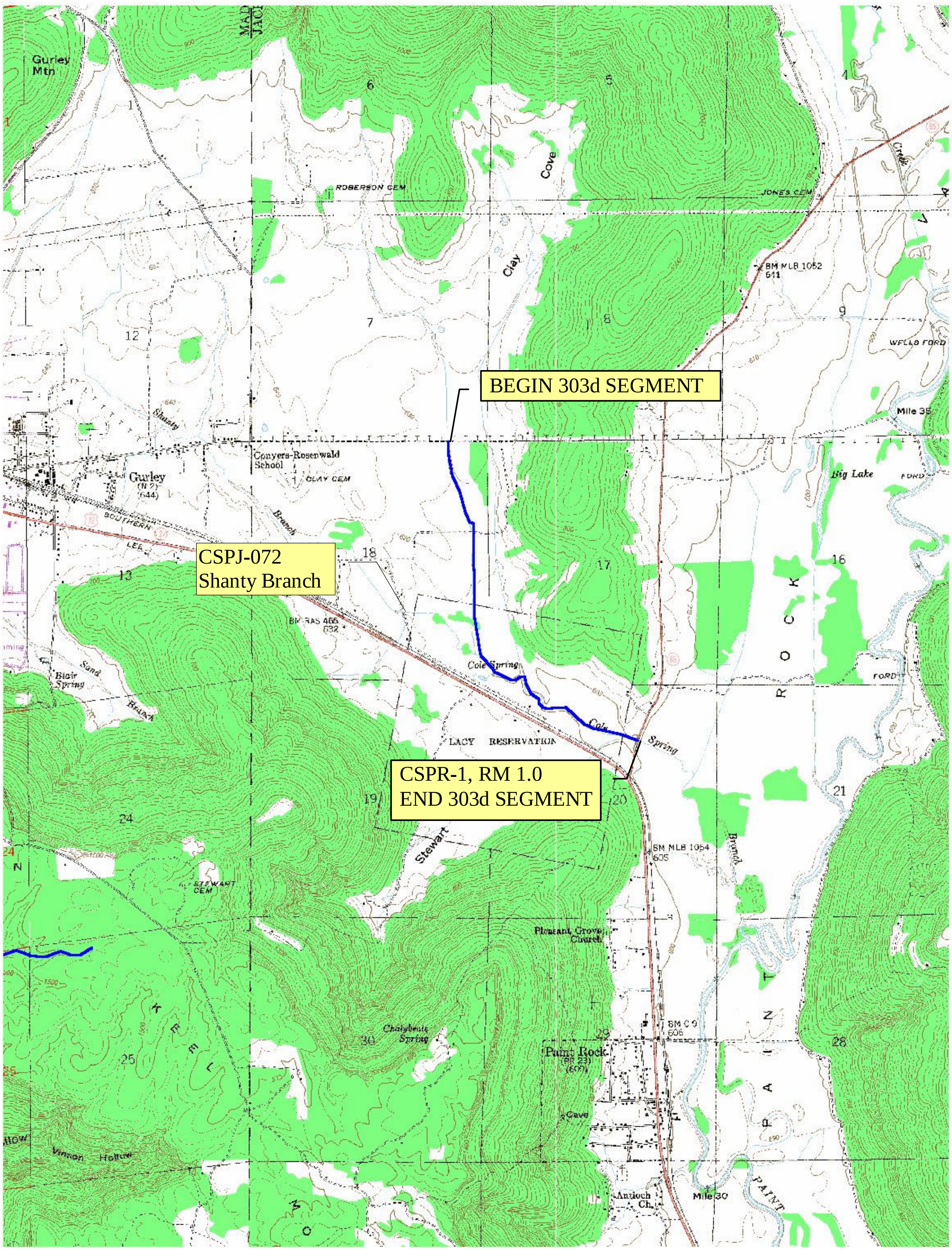
B. Eco-region Description: The Eastern Highland Rim has more level terrain and weaker dissection than the Western Highland Rim (71f), with flat to gently rolling landforms. Mississippian-age limestone, chert, shale, and dolomite predominate, and springs, sinks, and caves have formed by solution of the limestone. Cave and spring-associated fish fauna also typify the region. In the southern part of the region, streams flow down from the Pottsville Escarpment of ecoregion 68, cutting north across the Moulton Valley and through narrow valleys of Little Mountain (71j) to the impounded Tennessee River. Natural vegetation for the region is transitional between the oak-hickory type to the west and the mixed mesophytic forests of the Appalachian ecoregions to the east. Much of the original bottomland hardwood forest has been inundated by impoundments. The flatter areas in the east and on both sides of the Tennessee River have deep, well-drained, reddish, productive soils that are intensively farmed.

3.4.2 Available Water Quality and Biological Data

Water Quality and biological data collected by TVA for the Cole Spring Branch is available during 1994 and 1995. Data is also available for the period of July 1997 through August 1999. This data was collected by Alabama Department of Environmental Management. The data was collected from a single station, one mile from the mouth of the stream. A complete listing of the available data can be found in the appendix of this report.

A map indicating the location of sampling points relative to applicable point source discharges is presented in Figure 3-2.

Figure 3-2. Map of Sampling Locations and Point Source Discharges for the Cole Spring Branch Watershed.



3.4.3. Flow data

For the purpose of this TMDL, an annual $7Q_{10}$ stream flow for the summer season is employed. This flow represents a worst-case scenario for the critical model evaluations. The use of worst-case conditions, in turn, creates a margin of safety in the final results.

The $7Q_{10}$ flow represents the minimum 7-day flow that occurs, on average, over a 10-year recurrence interval.

The $7Q_{10}$ can be calculated for the model using gage data from the United States Geological Survey (USGS) or by using the Bingham Equation. The USGS continuous-record station (03574500) on Paint Rock River near Woodville, Alabama can be found on page 150 of a publication from the USGS entitled, **Low-Flow and Flow-Duration Characteristics of Alabama Streams, Report 93-4186.** The Bingham Equation can be found on page 3 of a publication from the Geological Survey of Alabama entitled, **Low-Flow Characteristics of Alabama Streams, Bulletin 117**.

The equation used to calculate the $7Q_{10}$ flow based on continuous USGS gaging records for the stream and any associated tributaries is as follows:

$$7Q_{10}\text{ (cfs)} = \frac{(7Q_{10}\text{ @ USGS Station (cfs)})}{(\text{Drainage Area @ USGS Station (mi}^2))} * (\text{Watershed Drainage Area (mi}^2))$$

$$7Q_{10} = \frac{(6.1)}{(320)} * (11.5)$$

$$7Q_{10} = 0.22\text{ cfs}$$

The calculated flow was distributed over Cole Spring Branch in the form of tributary flow or incremental inflow (identified on the modeled reach schematic as IF). The IF was distributed in proportion to the length of each segment.

3.5 Critical Conditions

Summer months (May – November) are generally considered critical conditions for dissolved oxygen in streams. This can be explained by the nature of storm events in the summer versus the winter. Periods of low precipitation allow for slower in-stream velocity, which increases the organic loading residence time and decreases stream re-aeration rates. This increased time permits more decay to occur which depletes the stream's dissolved oxygen supply. Reaction rates for $CBOD_u$ and NBOD (i.e., organic loading) are temperature dependent and high summertime temperatures increase the decay process, which depletes the dissolved oxygen even further.

In winter, frequent low intensity rain events are more typical and do not allow for the build-up of organic loading on the land surface, resulting in a more uniform loading rate. Higher flows and lower temperatures create less residence time and lower decay rates.

3.6 Margin of Safety (MOS)

There are two basic methods of incorporating the MOS (USEPA, 1991): 1) implicitly, using conservative model assumptions, or 2) explicitly, specifying a portion of the TMDL as the MOS.

The MOS is implicit in this TMDL process through the use of conservative model input parameters (**temperature, flow and D.O. concentrations**). Conservative temperature values are employed through the use of the highest average maximum temperature that would normally occur under critical stream flow conditions. The $7Q_{10}$ stream flow employed for summer, reflects the lowest flows that would normally occur under critical conditions. Finally, the D.O. concentration for incremental flow was set at 70% of the saturation concentration at the given temperature, which is 15% lower than the 85% normally assumed in a typical waste load allocation. Water depths are shallow, generally less than one foot, which aggravates the effect of sediment oxygen demand (SOD). Water velocities are sluggish, generally 0.5 fps or less, which intensifies the effect of BOD decay.

4.0 Water Quality Model Development

4.1 Water Quality Model Selection and Setup

Since the impairment noted by the available data is expected to occur during periods of low flow, a steady-state modeling approach was adopted as appropriate to represent the relevant conditions in the impaired waterbody. The steady state TMDL spreadsheet water quality model (SWQM) developed by the ADEM was selected for the following reasons:

- It is a simplified approach without unnecessary complexity.
- It conforms to ADEM standard practices for developing wasteload allocations.
- It lends itself to being developed with limited data, which is the present situation for this waterbody.
- It has the ability to handle tributary inputs and both point and non-point source inputs.

The TMDL spreadsheet model also provides a complete spatial view of a stream, upstream to downstream, giving differences in stream behavior at various locations along the model reach. The model computes dissolved oxygen using a modified form of the Streeter-Phelps equation. The modified Streeter-Phelps equation takes into account the oxygen demand due to carbonaceous decay plus the oxygen demand generated from the nitrification process (ammonia decay). Each stream reach is divided into twenty elements, with each element assumed to be the functional equivalent of a completely mixed reactor.

The following assumptions were used in the spreadsheet TMDL model***:***

- D.O. concentrations for incremental flow were assumed @ 70% of the saturated value at the given temperature. **(MOS)**
- Incremental and tributary loading were apportioned to correlate with the land usage of the drainage basin.
- Ratios for $CBOD_U/NH_3OD_U$ and $CBOD_U/TONOD_U$ were calculated using water quality data for the waterbody. These ratios were assigned in the estimation of loading parameters for incremental flow and tributaries for all land uses, except forest and open water.
- $CBOD_5/BOD_5$ ratio used for nonpoint sources was 1.5.
- NH_3OD_u is equal to 4.57 times the ammonia nitrogen concentration.
- $TONOD_u$ is equal to 4.57 times the organic nitrogen concentration.
- Background conditions were assumed for forest incremental flow.
  Background conditions are typically the following ranges: 2-3 mg/l $CBOD_u$, 0.2-1 mg/l NH_3OD_u, 1-2 mg/l $TONOD_u$.

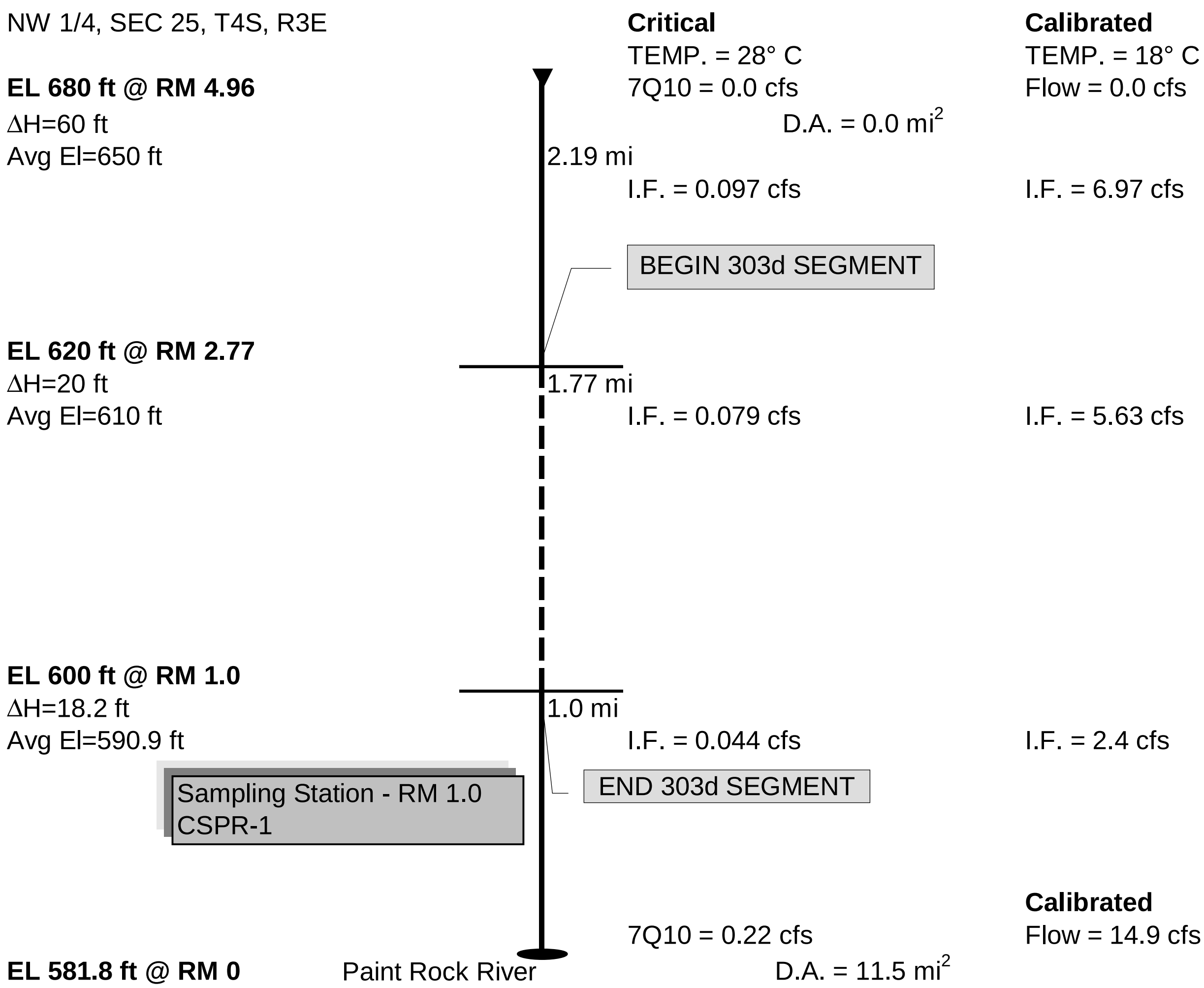
4.1.1. SOD Representation: Sediment oxygen demand (SOD) can be an important part of the oxygen demand budget in shallow streams. However, for shallow streams with steep slopes and rocky substrate, the SOD component is generally small. These hydrogeological conditions are representative of the Cole Spring Branch. It is believed, therefore, that the SOD for this stream is minimal. In the absence of available field SOD measurements for the waterbody, SOD data was obtained from EPA Region IV's SOD database. The EPA SOD database represents mixed land uses and varying degrees of point source activity. A SOD value of 0.05 gm-O_2/ft^2/day was applied in time model for Cole Spring Branch. The number was determined from the EPA SOD database for a stream with a sand and gravel bottom, which is similar to the characteristics in Cole Spring Branch.

4.1.2. Calibration Data: The model calibration period April 27, 1999 was determined from an examination of the available field data (ref: Appendix). The combination of the lowest, steady flow period with the lowest dissolved oxygen defined the critical modeling period. The stream conditions (i.e., D.O., temperature) during this period were incorporated into the calibrated model TMDL spreadsheet.

4.2 Water Quality Model Summary

The model reach used for critical period was longer than the impaired reach in order to ensure that predicted model pollutant concentrations were at, or near, normal background concentrations at the end of the modeled reach. The critical model reach consisted of three segments. The impaired portion of the critical model reach consists of segment two. The length of the impaired portion is 1.77 miles. Total distance of the critical model reach is 4.96 miles. A schematic diagram of the model is presented in Figure 4-1. Assumed in-stream seasonal temperatures are based on historical model development. A guide for use of ADEM's TMDL water quality model can be found in the appendix. The guide also explains the theoretical basis for the physical/chemical mechanisms and principles that form the foundation of the model.

Figure 4-1. Schematic of the Modeled Reach.



4.2.1. Critical (May – November) Model

Critical Stream Flow Parameters

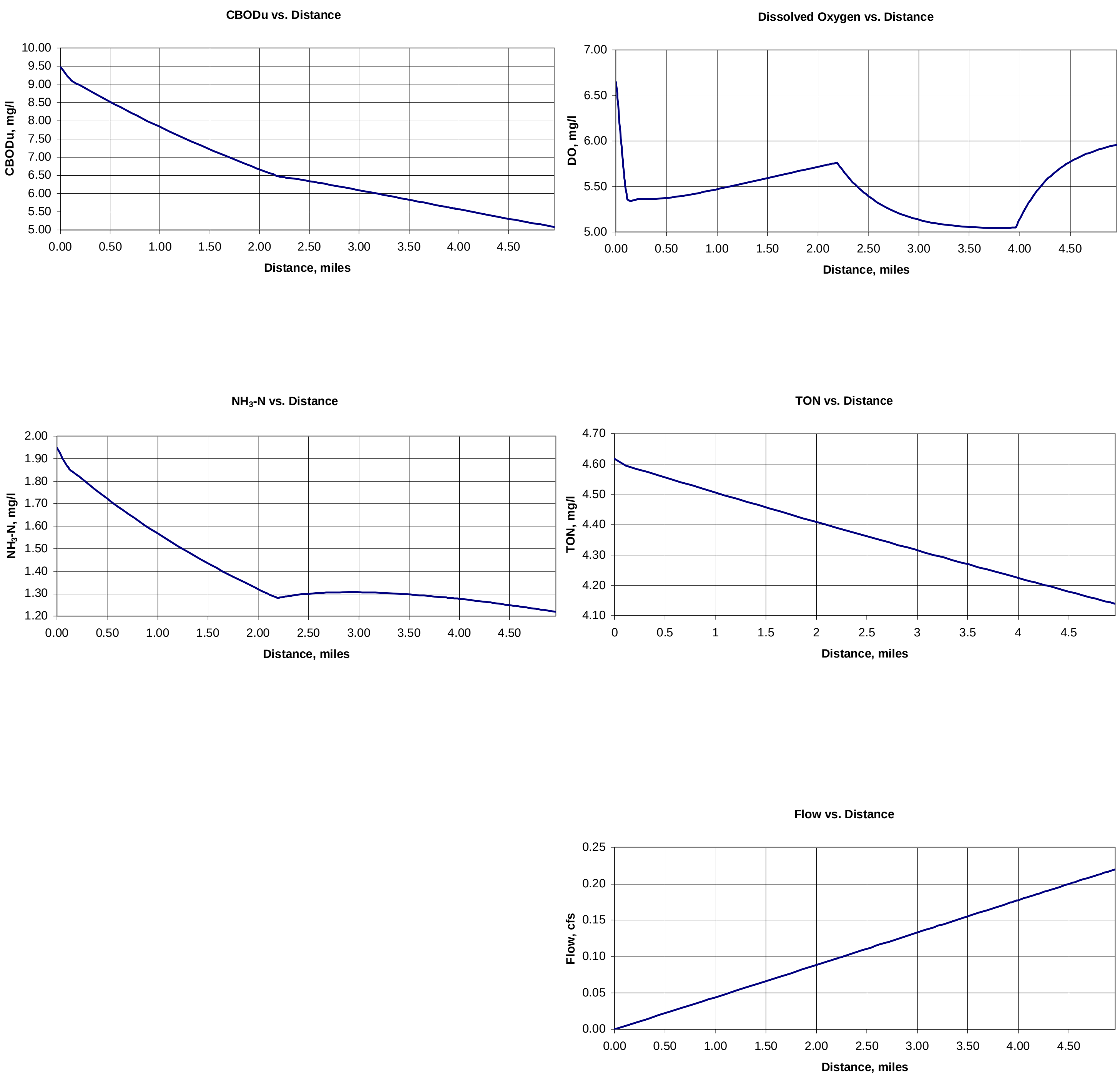
Description	**Flow (cfs)**	**DO (mg/l)**	**$CBOD_U$ (mg/l)**	**NH_3N (mg/l)**	**TON (mg/l)**	**Temp (^oC)**
Headwaters	0.0	6.65	9.4800	1.9484	4.6178	28.0
Conditions @ Lowest D.O.	0.1602	5.0469	5.6843	1.2867	4.2443	28.0
Flow @ End of Model	0.22	5.9597	5.0875	1.2195	4.1391	28.0

Critical Incremental Flow Parameters

Sections	**$CBOD_U$ (mg/l)**	**NH_3N (mg/l)**	**TON (mg/l)**	**DO (mg/l)**	**Total Flow (cfs)**	**Temp. (^oC)**
1	9.4800	1.9484	4.6178	5.4800	0.10	28.0
2	9.4800	1.9484	4.6178	5.4800	0.08	28.0
3	9.4800	1.9484	4.6178	5.4800	0.04	28.0

4.3 Critical Model Predictions and Graphics

Figure 4-2. Critical Model Predictions.



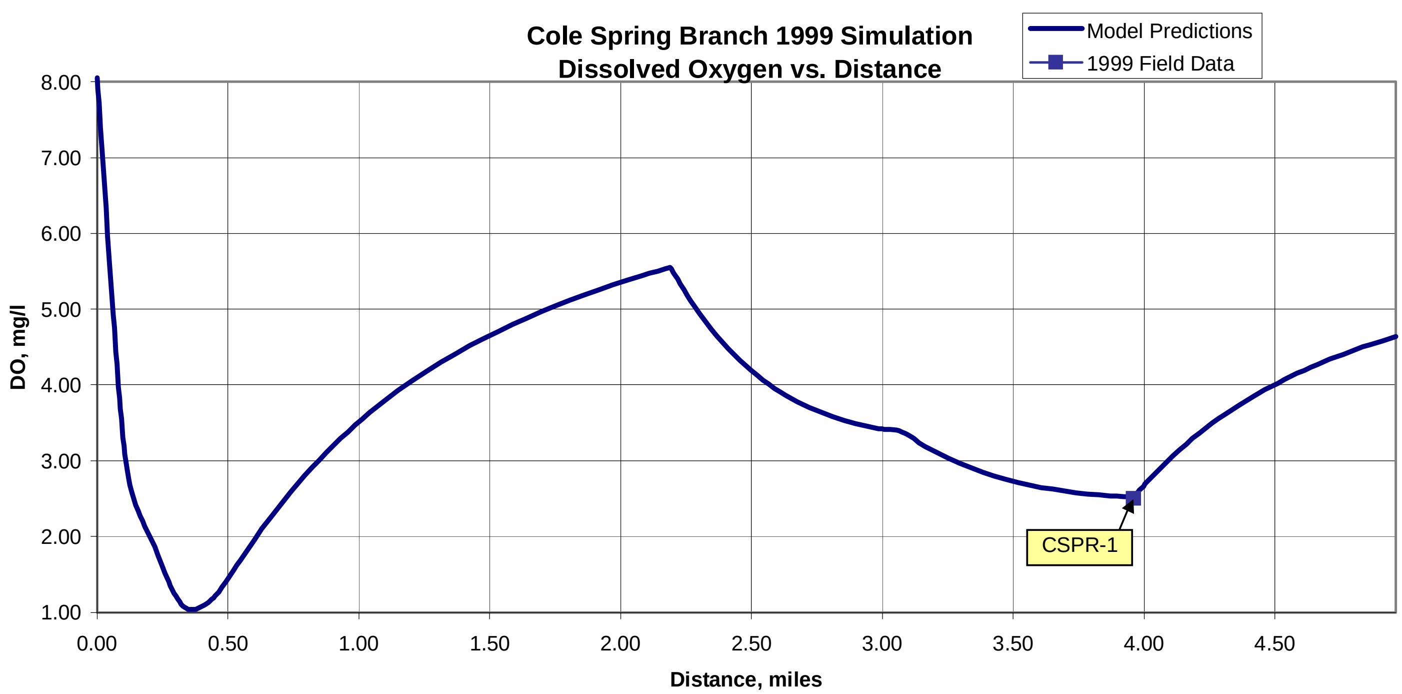
4.4 Loading Reduction Analysis

4.4.1. Calibrated Model

The only D.O. violation from available field data occurred at CSPR-1. The lowest observed D.O. value occurred during the April 27, 1999, sampling event. The measured concentration was 2.5 mg/l. Field data from the sampling event were used as input into the critical TMDL model to perform a second simulation referred to as the calibrated model (the first simulation is the critical model). The model predictions simulated the measured D.O. value as closely as possible at CSPR-1, while still providing a reasonable representation of water quality in the stream at the time of the sampling event.

Shown in Figure 4-3, below, is a plot of D.O. calibrated model predictions vs. actual D.O. field data.

Figure 4-3. Calibrated Model D.O. Predictions vs. Actual D.O. Field Data.



Calibrated Model Flow Parameters

Description	**Flow (cfs)**	**DO (mg/l)**	**$CBOD_U$ (mg/l)**	**NH_3N (mg/l)**	**TON (mg/l)**	**Temp (^oC)**
Headwaters	0	8.05	78.1200	17.4428	41.5210	18.0
Conditions @ Calibrated Point	12.6	2.4809	64.7174	16.4938	40.8474	18.0
Flow @ End of Model	15	4.5992	63.1763	16.4651	40.7593	18.0

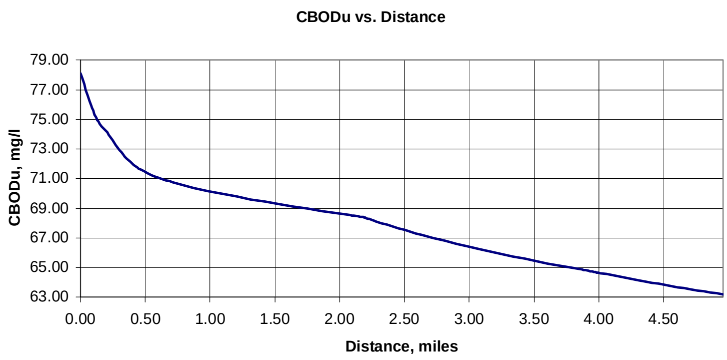
Calibrated Model Incremental Flow Parameters

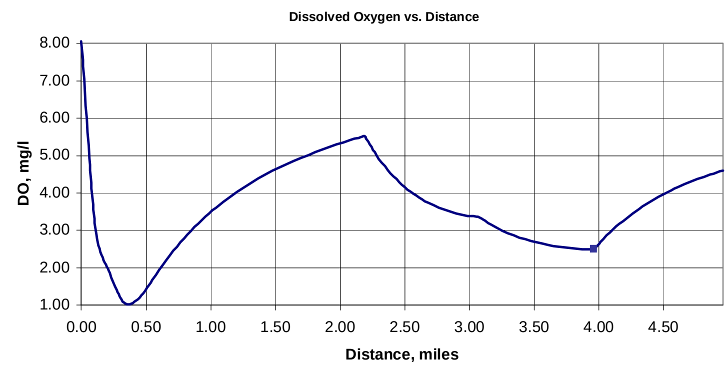
Sections	**$CBOD_U$ (mg/l)**	**NH_3N (mg/l)**	**TON (mg/l)**	**DO (mg/l)**	**Total Flow (cfs)**	**Temp. (^oC)**
1	78.1200	17.4428	41.5210	6.6300	6.97	18.0
2	78.1200	17.4428	41.5210	6.6300	5.63	18.0
3	78.1200	17.4428	41.5210	6.6300	2.40	18.0

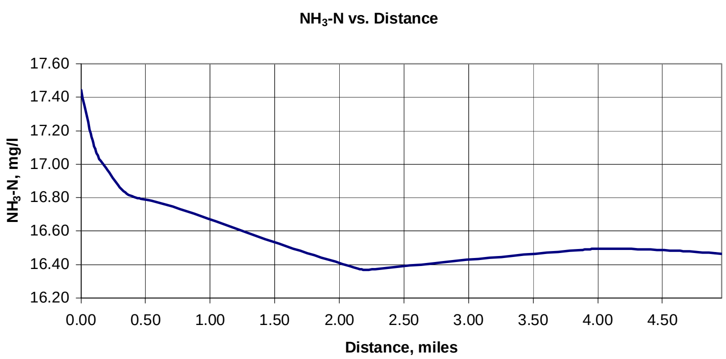
Comparison of Calibrated Model Flow Parameters to Actual Data

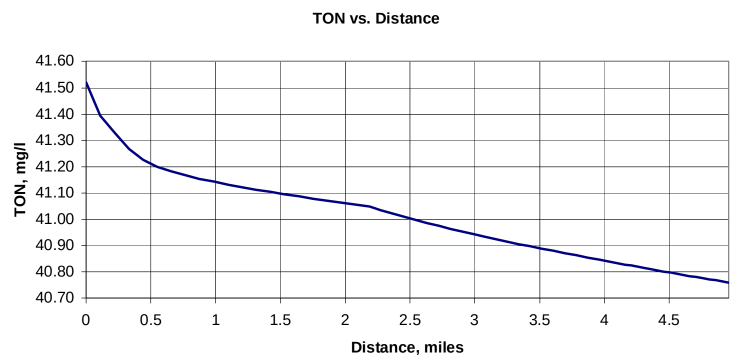
Description	**Flow (cfs)**	**DO (mg/l)**	**$CBOD_U$ (mg/l)**	**NH_3N (mg/l)**	**TON (mg/l)**	**Temp (^oC)**
Actual Conditions @ Low D.O.	12.6	2.5	>234	54.08	-	18.0
Cal. Conditions @ Low D.O.	12.6	2.4809	64.7174	16.4938	40.8474	18.0

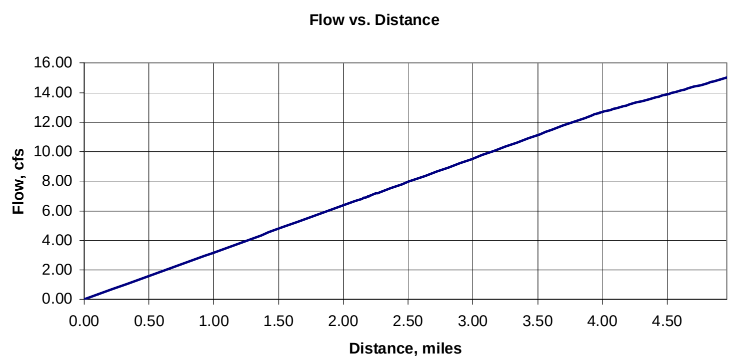
Figure 4-4. Calibrated Model Predictions and Graphics.











4.4.2. Load Reduction Model

The third simulation is referred to as the load reduction model. Since there are no point sources present in the watershed in this simulation, non-point sources in the calibrated model were adjusted to bring the waterbody into compliance with the 5 mg/l D.O. Fish & Wildlife water quality standard.

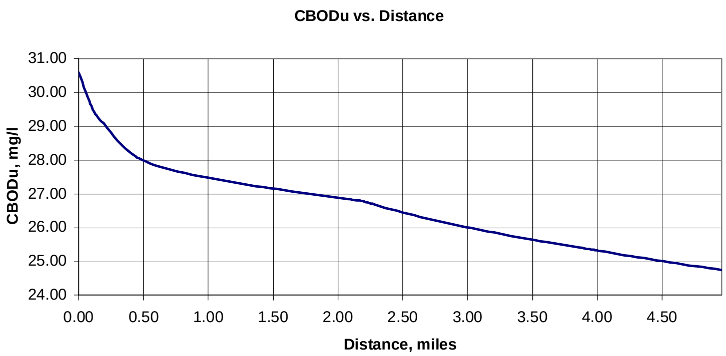
Load Reduction Model Flow Parameters

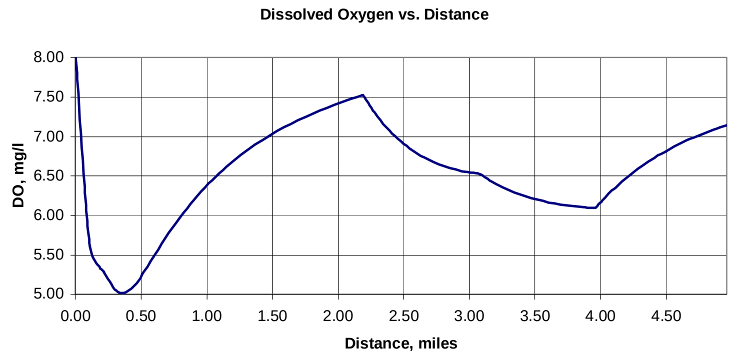
Description	Flow (cfs)	DO (mg/l)	$CBOD_U$ (mg/l)	NH_3N (mg/l)	TON (mg/l)	Temp (^oC)
Headwaters	0	8.05	30.6000	6.7159	15.9727	18.0
Conditions @ Calibrated Point	12.6	6.0718	25.3501	6.2646	15.7135	18.0
Flow @ End of Model	15	7.1275	24.7465	6.2474	15.6796	18.0

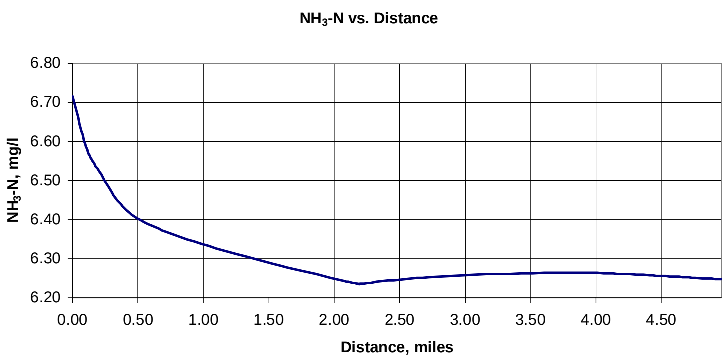
Load Reduction Model Incremental Flow Parameters

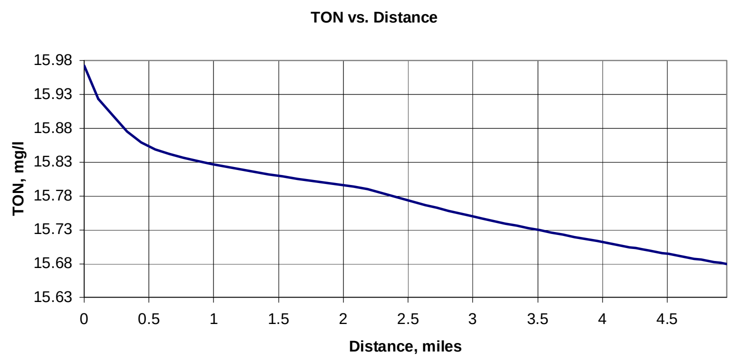
Sections	$CBOD_U$ (mg/l)	NH_3N (mg/l)	TON (mg/l)	DO (mg/l)	Total Flow (cfs)	Temp. (^oC)
1	30.6000	6.7159	15.9727	6.6300	6.97	18.0
2	30.6000	6.7159	15.9727	6.6300	5.63	18.0
3	30.6000	6.7159	15.9727	6.6300	2.40	18.0

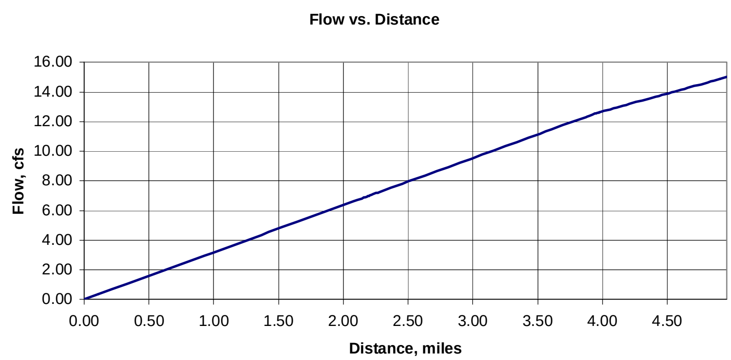
Figure 4-5. Load Reduction Model Predictions and Graphics.











4.4.3. Required Reductions

Total organic loading (i.e., $CBOD_u$ and NBOD) was calculated at CSPR-1 for both the calibrated model and the load reduction model. The total organic loading for the calibrated model was 28,108 lbs./day. For the load reduction model, the total organic loading loading was 10,860 lbs./day. This would require a theoretical total organic loading reduction of 0% for point source loads and 61.4% reduction for non-point source loads to bring Cole Spring Branch into compliance with the Fish & Wildlife D.O. water quality standard of 5.0 mg/l. Since there are no point sources in the watershed, the necessary reductions are being sought from existing non-point sources.

A summary of the required reductions for point and non-point source loads is presented in Table 4-1.

Table 4-1. Required Load Reductions for Point and Non-Point Sources.

Existing Point Source Load[1]	Existing Non-Point Source Load[1]	Total Existing Load [1]	Reduced Load[1]	% Reduction	% Reduction
(lbs./day)	(lbs./day)	(lbs./day)	(lbs./day)	Point Sources	Non-Point Sources
0	28,108	28,108	10,860	0%	61.4%

Notes: 1 = $CBOD_u$ + NBOD

The required reductions will be sought through TMDL implementation with follow up monitoring to determine the effectiveness of implementation. Follow up monitoring as discussed further in this document will be conducted according to basin rotation.

4.5 Seasonal Variation

The regulations require that a TMDL be established with consideration of seasonal variations. Since impairments for dissolved oxygen would typically be expected during the critical period and not during other times of the year, a seasonal variation in the TMDL was not necessary. Since there were no point source loads identified, only a critical TMDL was calculated .

5.0 Conclusions

A summary of the TMDL for the critical model is presented in Table 5-1.

Table 5-1. Critical TMDL Summary

	SIMULATION Critical
CBODU Loading (Lbs/Day)	11.2
NBOD Loading (Lbs/Day)	35.6
TOTAL Loading (Lbs/Day)	46.8

Within the impaired segment, the point source allocations if used in development of the critical TMDL will be addressed by the NPDES permit program during permit renewals and modifications. Based on the TMDL analysis, the revised NPDES permit limitations (presented in Table 5-2) are not applicable, since there are no point sources in the watershed.

Table 5-2. Suggested Revised NPDES Permit Limits for Significant Contributing Point Sources.

NPDES Permit	Facility Name	Permit Limitations - Summer					Permit Limitations - Winter				
		$CBOD_5$ (MG/L)		NH_3-N (MG/L)		DO (MG/L)	$CBOD_5$ (MG/L)		NH_3-N (MG/L)		DO (MG/L)
		Max	Avg	Max	Avg	Min	Max	Avg	Max	Avg	Min
None											

Notes: n/a = not applicable

6.0 TMDL Implementation

6.1 Non-Point Source Approach

Cole Spring Branch is impaired solely by nonpoint sources. For 303(d) listed waters impaired solely or primarily by nonpoint source (NPS) pollutants, necessary reductions will be sought during TMDL implementation using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired water. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. Therefore, TMDL implementation activities will be coordinated through interaction with local entities in conjunction with Clean Water Partnership efforts.

The primary TMDL implementation mechanism used will employ concurrent education and outreach, training, technology transfer, and technical assistance with incentive-based pollutant management measures. The ADEM Office of Education and Outreach (OEO) will assist in the implementation of TMDLs in cooperation with public and private stakeholders. Planning and oversight will be provided by or coordinated with the Alabama Department of Environmental Management's (ADEM) Section 319 nonpoint source grant program in conjunction with other local, state, and federal resource management and protection programs and authorities. The CWA Section 319 grant program may provide limited funding to specifically ascertain NPS pollution sources and causes, identify and coordinate management programs and resources, present education and outreach opportunities, promote pollution prevention, and implement needed management measures to restore impaired waters.

Depending on the pollutant of concern, resources for corrective actions may be provided, as applicable, by the Alabama Cooperative Extension System (education and outreach); the USDA-Natural Resources Conservation Service (NRCS) (technical assistance) and Farm Services Agency (FSA) (federal cost-share funding); and the Alabama Soil and Water Conservation Committee (state agricultural cost share funding and management measure implementation assistance) through local Soil and Water Conservation Districts, or Resource Conservation and Development Councils (funding, project implementation, and coordination). Additional assistance from such agencies as the Alabama Department of Public Health (septic systems), Alabama Department of Agriculture and Industries (pesticides), and the Alabama Department of Industrial Relations and Dept of Interior - Office of Surface Mining (abandoned minelands), Natural Heritage Program and US Fish and Wildlife Service (threatened and endangered species), may also provide practical TMDL implementation delivery systems, programs, and information. Land use and urban sprawl issues will be addressed through the Nonpoint Source for Municipal

Officials (NEMO) education and outreach program. Memorandums of Agreements (MOAs) may be used as a tool to formally define roles and responsibilities.

Additional public/private assistance is available through the Alabama Clean Water Partnership (CWP) Program. The CWP program uses a local citizen-based environmental protection approach to coordinate efforts to restore and protect the state's resources in accordance with the goals of the Clean Water Act. Interaction with the state or river basin specific CWP will facilitate TMDL implementation by providing improved and timely communication and information exchange between community-based groups, units of government, industry, special interest groups, and individuals. The CWP can assist local entities to plan, develop, and coordinate restoration strategies that holistically meet multiple needs, eliminate duplication of efforts, and allow for effective and efficient use of available resources to restore the impaired waterbody or watershed.

Other mechanisms that are available and may be used during implementation of this TMDL include local regulations or ordinances related to zoning, land use, or storm water runoff controls. Local governments can provide funding assistance through general revenues, bond issuance, special taxes, utility fees, and impact fees. If applicable, reductions from point sources will be addressed by the NPDES permit program. The Alabama Water Pollution Control Act empowers ADEM to monitor water quality, issue permits, conduct inspections, and pursue enforcement of discharge activities and conditions that threaten water quality. In addition to traditional "end-of-pipe" discharges, the ADEM NPDES permit program addresses animal feeding operations and land application of animal wastes. For certain water quality improvement projects, the State Clean Water Revolving Fund (SRF) can provide low interest loans to local governments.

Long-term physical, chemical, and biological improvements in water quality will be used to measure TMDL implementation success. As may be indicated by further evaluation of stream water quality, the effectiveness of implemented management measures may necessitate revisions of this TMDL. The ADEM will continue to monitor water quality according to the rotational river basin monitoring schedule as allowed by resources. In addition, assessments may include local citizen-volunteer monitoring through the Alabama Water Watch Program and/or data collected by agencies, universities, or other entities using standardized monitoring and assessment methodologies. Core management measures will include, but not be limited to water quality improvements and designated use support, preserving and enhancing public health, enhancing ecosystems, pollution prevention and load reductions, implementation of NPS controls, and public awareness and attitude/behavior changes.

6.2 Point Source Approach

There were no point sources located within the Cole Spring Branch watershed.

7.0 Follow Up Monitoring

ADEM has adopted a basin approach to water quality management; an approach that divides Alabama's fourteen major river basins into five groups. Each year, the ADEM water quality monitoring resources are concentrated in one of the basin groups. One goal is to continue to monitor §303(d) listed waters. This monitoring will occur in each basin according to the following schedule:

River Basin Group	Schedule
Cahaba / Black Warrior	2002
Tennessee	2003
Choctawhatchee / Chipola / Perdido-Escambia / Chattahoochee	2004
Tallapoosa / Alabama / Coosa	2005
Escatawpa / Upper Tombigbee / Lower Tombigbee / Mobile	2006

Monitoring will help further characterize water quality conditions resulting from the implementation of best management practices in the watershed.

8.0 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.

9.0 Appendices

9.1 References

Adkins, J.B., Pearman, J.L.. 1994. Low-Flow and Flow-Duration Characteristics of Alabama Streams. Water-Resources Investigations Report 93-4186.

United States Environmental Protection Agency. 1991. Guidance for Water Quality-Based Decisions: The TMDL Process, Office of Water, EPA 440/4-91-001.

9.2 Water Quality Data

tation I.D.	2466-, Bridge at G.W. Jones' Farm, RM 1
tate-Alabama	Latitude 34°40'57"
ounty-Jackson	Longitude 86°19'46"
gency - TVA	NE1/4, Sec. 20, T4S, R3E RM 1.0

ource-Appendix F-4a. Physical / chemical data collected from July 1997 to August 1999 as part of the Paint Rock Nonpoint Source Monitoring Project in the Wheeler Lake Cataloging Unit (0603-0002) (ADEM 1999a).

Stream Name	Station	Date	Time	Air Temp.	Water Temp.	Dissolved Oxygen	pH	Conductivity	Stream Flow	BOD-5	TDS	TSS	NH3-N	NO2/ NO3-N	TKN	T-PO4	Total Alkalinity	Hardness
	#	*yymmdd*	*24hr*	*C*	*C*	*mg/l*	*s.u.*	*umhos @25c*	*cfs*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/l*	*mg/l*	*mg/l*
ole Spr. Br	CSPR-1	970723	1130	33	24	7.1	7.5	350	2.1	0.9	207	7	0.054	2.814	0.179	0.053	144	170
ole Spr. Br	CSPR-1	970825	0723	17	19	5.9	7.6	275	1.0	2.1	220	36	<0.005	2.581	0.046	0.075	144	180
ole Spr. Br	CSPR-1	970924	0730	22	20	5.9	7.2	354	1.4	3.6	189	15	0.066	2.100	0.376	0.107	135	174
ole Spr. Br	CSPR-1	971021	1115	12	15	7.7	7.4	345	1.5	0.8	196	4	0.072	2.231	0.499	0.156	145	172
ole Spr. Br	CSPR-1	971118	0955	2	10	8.7	6.9	185	1.5	1.1	195	32	<0.005	3.270	<0.05	<0.005	120	160
ole Spr. Br	CSPR-1	971216	1055	9	13	9.4	7.4	364	6.2	0.3	185	13	<0.005	2.039	<0.05	<0.005	125	160
ole Spr. Br	CSPR-1	980205	0800	4	10	9.7	7.6	252		1.6	144	14	<0.05	1.104	0.377	0.076	95	138
ole Spr. Br	CSPR-1	980225	1050	21	13	11.1	7.1	234	18.4	6.2	164	6	<0.005	1.554	<0.05	0.056	121	156
ole Spr. Br	CSPR-1	980324	1035	14	14	9.1	7.3	241	51.1	4.6	166	24	<0.005	1.200	1.334	0.192	92	124
ole Spr. Br	CSPR-1	980428	1105	18	15	8.6	7.5	303	13.7	0.7	172	3	<0.005	2.349	<0.005	0.034	130	164
ole Spr. Br	CSPR-1	980526	1055	29	18	8.3	7.4	330	4.5	0.6	196	7	<0.005	<0.005	<0.1	0.055	136	166
ole Spr. Br	CSPR-1	980622	1100	35	22	7.4	7.7	345	0.0	1.3	200	13	<0.005	2.164	0.125	<0.005	143	186
ole Spr. Br	CSPR-1	980818	1030	32		5.9	7.7	360		1.1	221	12	<0.005	2.537	0.127	0.084	154	182
ole Spr. Br	CSPR-1	981027	1125	26	14	7.2	6.9	371		0.5	215	31	<0.005	1.602	0.386	0.094	159	186
ole Spr. Br	CSPR-1	990125	1215	18	14	9.5	7.3	247	54.9	1.0	147	13	<0.005	2.193	0.295	<0.005	93.5	116
ole Spr. Br	CSPR-1	990427	1454	23	18	2.5	6.9	514	12.6	>156	452	204	11.834	0.863	39.4	4.584	158	207
ole Spr. Br	CSPR-1	990524	1210	24	22	7.5	8	322	4.3									
ole Spr. Br	CSPR-1	990629	1145	29	19	8	8	290	28.1									
ole Spr. Br	CSPR-1	990824	1125	28	22	5.3	7.4	351		2.8	204	79	<0.015	2.707	0.416	0.031	148	174

Water Quality Data

Station I.D.	2466-, Bridge at G.W. Jones' Farm, RM 1
State-Alabama	Latitude 34°40'57"
County-Jackson	Longitude 86°19'46"
Agency - TVA	NE1/4, Sec. 20, T4S, R3E RM 1.0

TVA Macroinvertebrate/EPT and Fish/IBI Biological Data for 1994-95

CU	Waterbody	Bug Health	EPT*	Fish Health	IBI*	Causes	Sources
Partially Supporting							
0607	Cole Spring Cr	VP/Poor	2	Poor	30	silt, org enrich	Ag NPS

Water Quality Data

Station I.D.	CSPJ-072, Off County Road #65, tributary to Cole Spring Branch
State-Alabama	Latitude 34°41'23"
County-Jackson	Longitude 86°20'47"
Agency - TVA	SE1/4, Sec. 18, T4S, R3E

Source-Appendix D-1. Physical / chemical data collected as part of the Paint Rock Nonpoint Source Monitoring Project in the Wheeler Lake Cataloging Unit (0603-0002).

Stream Name	Station	Date	Time	Air Temp.	Water Temp.	Dissolved Oxygen	pH	Conductivity	Stream Flow	BOD-5	TDS	TSS	NH3-N	NO2/ NO3-N	TKN	T-PO4	Total Alkalinity	Hardness
	#	*yymmdd*	*24hr*	*C*	*C*	*mg/l*	*s.u.*	*umhos @25c*	*cfs*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/l*	*mg/l*	*mg/l*
Shanty Br.	CSPJ-072	980512							0.0									
Shanty Br.	CSPJ-072	980707							0.0									
Shanty Br.	CSPJ-072	980818							0.0									

9.3 Water Quality Model Input and Output Files

9.4 Spreadsheet Water Quailty Model (SWQM) User Guide Guide