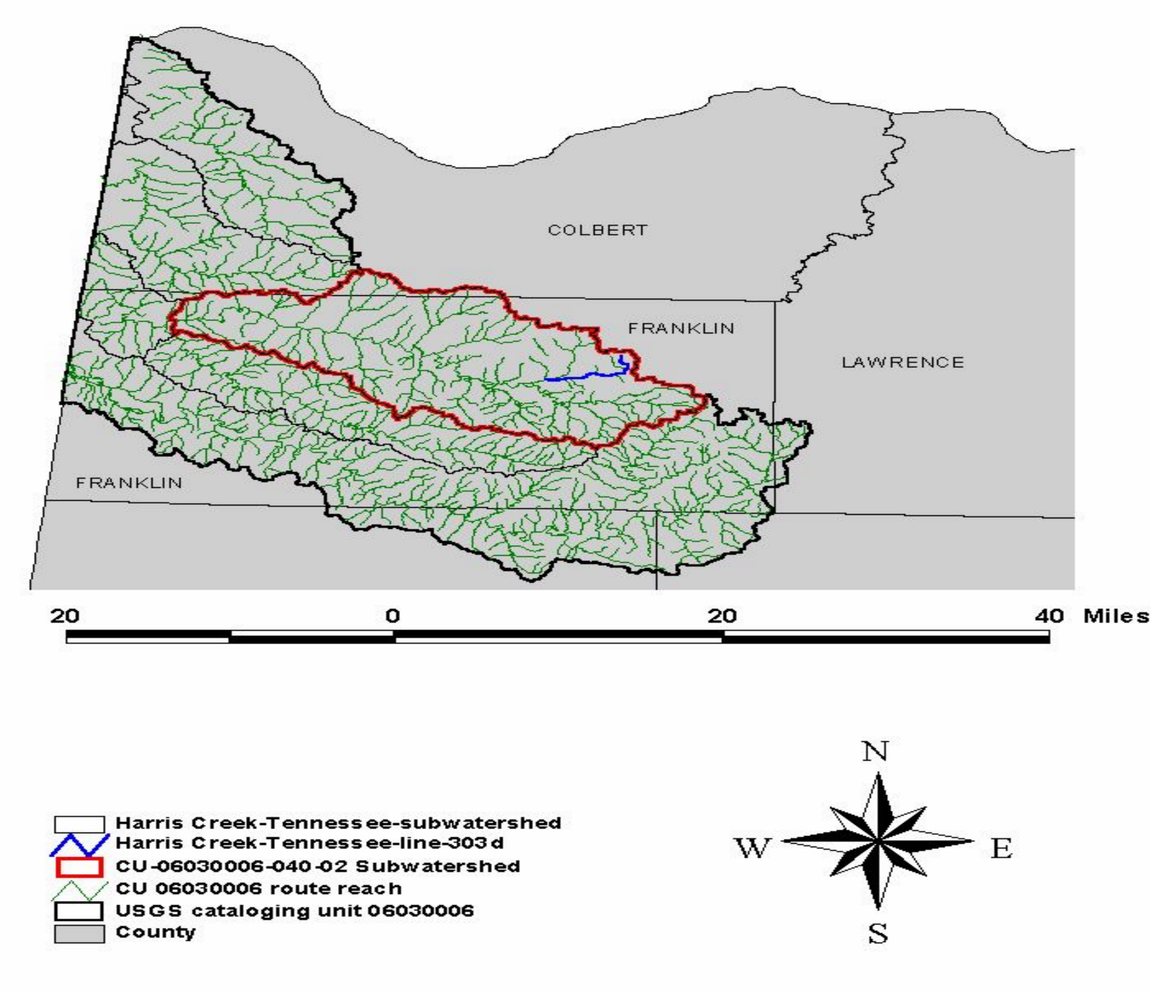
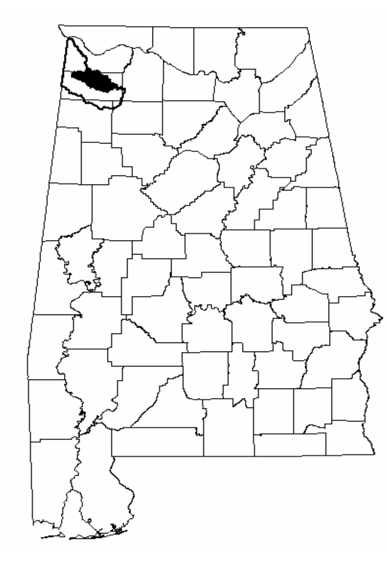
Alabama Department of Environmental Management

Final TMDL Development for
Harris Creek AL/06030006-040_02
Low Dissolved Oxygen/Organic Loading

Water Quality Branch
Water Division
February 2002

Harris Creek Watershed in the Tennessee River Basin





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1.0 Executive Summary

This report contains one or more Total Maximum Daily Loads (TMDLs) for waterbody segments found within Alabama's 1996 and/or 1998 Section 303(d) List(s) of Impaired Waterbodies. In view 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. 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, certain 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.

Harris Creek, a part of the Tennessee River basin, is located in Franklin County near the City of Russellville, Alabama. It has remained on the State of Alabama's §303(d) use impairment list since 1998 for organic enrichment/low dissolved oxygen (O.E./D.O.). Its current stream use classification is that of Fish & Wildlife.

Water quality data collected September 19 – 21, 1995, identified dissolved oxygen impairments for Harris Creek. Stream flows occurring during periods of impairment were typically at, or below, the established $7Q_{10}$ (the minimum 7-day average flow which occurs on average of once in 10 years). Since D.O. impairments were clearly attributable to low flows and high temperatures, evidenced during summer months, a steady state modeling approach was assumed appropriate for this particular TMDL analysis.

The following report addresses the results of TMDL analysis for O.E./D.O. In accordance with ADEM water quality standards, the minimum required dissolved oxygen concentration for a stream classified as Fish and Wildlife is 5.0 mg/l. For the purpose of this TMDL, a minimum instream dissolved oxygen level of 5.0 mg/l will be maintained as a conservative assumption, effectively yielding an implicit margin of safety.

A summary of the watershed TMDL is presented on the following page. Pollutants evaluated include ultimate carbonaceous biochemical oxygen demand ($CBOD_u$) and nitrogenous biochemical oxygen demand (NBOD), the principle causes of observed low dissolved oxygen concentrations. $CBOD_u$ is a measure of total oxygen required to degrade the carbonaceous portion of organic matter within the stream. NBOD is the amount of oxygen utilized by bacteria in converting ammonia to nitrate. In that organic nitrogen can be converted to ammonia, its potential oxygen demand is included within the NBOD component. Table 1.1 lists pollutant loadings by source (point and non-point sources) for the critical period (May through November) which was developed from the water quality field data collected September 19 – 21, 1995, which initially indicated D.O. impairment.

Table 1-1. Pollutant Loads by Source – Critical (May through November)

Pollutant	Point Source Loads (lbs./day)	Non-point Source Loads (lbs./day)
$CBOD_u$	0	7.6
NBOD	0	5.6
Total	0	13.2

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)] requires states to identify waterbodies which are not currently meeting water quality standards applicable to their designated use classifications. Identified waters are prioritized according to the severity of pollution with respect to their classifications. Total maximum daily loads (TMDLs) for all pollutants resulting in violations of applicable water quality standards are established for each identified steam segment. Such loads are established at levels necessary to implement applicable water quality standards with seasonal variations and margins of safety. The TMDL process establishes the allowable loading of pollutants, or other quantifiable parameters of a waterbody, based on the relationship between pollution sources and in-stream water quality conditions. States can then establish water-quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (USEPA, 1991).

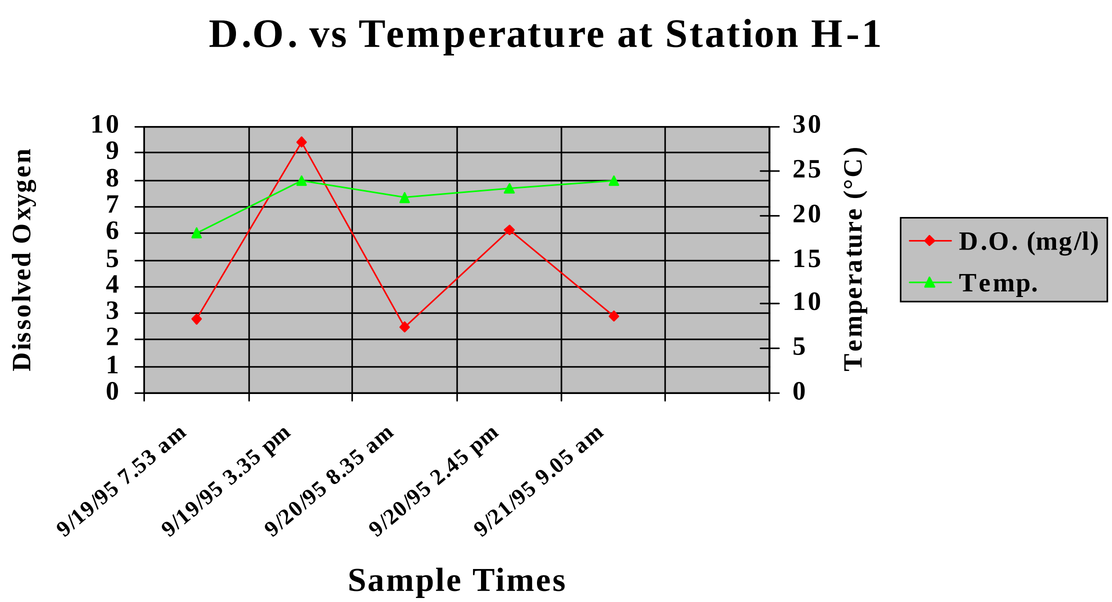
The State of Alabama identifies Harris Creek as impaired by organic loading (i.e., $CBOD_u$ and NBOD) for a length of 5.89 miles (0.12 miles of which consists of the initial section of Mud Creek), as set forth in the 1998 §303(d) list of impaired waters. Harris Creek is prioritized as "high" on the list and is located in Franklin County and lies within the Bear Creek watershed of the Tennessee River basin.

The TMDL developed for Harris Creek illustrates steps which can be employed to restore a waterbody which has become impaired by low dissolved oxygen levels. This TMDL is representative of a multi-phased-approach in which estimates are made as to needed pollutant reductions, load reduction controls are afterwards implemented, and water quality then monitored for restorative strategy effectiveness. Certain flexibility must allow re-evaluation of load reduction targets and control actions should monitoring results indicate continuing water quality impairment.

2.2 Problem Definition

Harris Creek is a small, headwater stream with a relatively small drainage area of 9.3 square miles. During periods of dry weather, the watershed experiences relatively little or no flow. Water quality data collected during September 1995, indicates dissolved oxygen impairments which occurred during the summer months (May through November). Generally, depressed in-stream D.O. concentrations are the result of various causes including the decay of oxygen demanding waste from both point and non-point sources, algal respiration, and/or sediment oxygen demand. According to available data, the high-low, diurnal fluctuations in observed dissolved oxygen concentrations within the watershed are believed the result of algal activity. Figure 2-1 illustrates the variations in temperature and dissolved oxygen recorded at Station H-1 located near the mouth of Harris Creek.

Figure 2-1. Dissolved Oxygen vs. Temperature at Station H-1



Waterbody Impaired:	Harris Creek - its mouth/ its source
Water Quality Standard Violation:	Dissolved Oxygen
Pollutant of Concern:	Organic Enrichment ($CBOD_u$/NBOD)
Water Use Classification:	Fish & Wildlife

The impaired stream segment of Harris Creek, is currently classified as Fish & Wildlife. Usage of waters in this classification is described in ADEM Administrative 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 swimming and water-contact sports or as a water supply for drinking or food processing purposes.

(b) Conditions related to best usage:

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 favorable to the propagation of shrimp and crabs.

(c) Other usage of waters:

Such waters may additionally be used for incidental water contact and recreation during June through September. Water contact, however, 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:

Waters, under proper sanitary supervision of controlling health authorities, shall satisfy accepted standards of water quality for outdoor swimming places and 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 any given time; except under extreme naturally occurring conditions when it may range between 4 and 5 mg/l, provided that all other water quality parameters remain favorable. Normal seasonal and daily fluctuations shall, nonetheless, be maintained above such levels. In no event shall the dissolved oxygen level be less than 4 mg/l as a result of discharges from existing hydroelectric generation impoundments. All new hydroelectric generation impoundments, including the addition of new hydroelectric generation units to existing impoundments, shall be designed to insure discharges with a minimum 5 mg/l dissolved oxygen wherever practicably and technically obtainable. The Environmental Protection Agency, in cooperation with the State of Alabama and responsible parties, shall jointly develop efforts to enhance the overall design and functioning of existing impoundment facilities.

3.0 Technical Basis for TMDL Development

3.1 Water Quality Target Identification

The minimum dissolved oxygen concentration of a stream classified as Fish and Wildlife is 5.0 mg/l. As is with this TMDL, a minimum instream dissolved oxygen level of 5.0 mg/l will be maintained as a conservative assumption, effectively resulting an implicit margin of safety. Target $CBOD_u$ and NBOD concentrations, in combination with ammonia nitrification, will not deplete dissolved oxygen concentrations below this level as a result of the decay 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 concurrently. In rural areas, storm runoff from row crops, livestock pastures, animal waste application sites, and feedlots can potentially transport considerable amounts of organic loading. Nationwide, poorly treated municipal sewage comprises a major source of organic compounds which when hydrolyzed create additional loading. Urban storm water runoff and sanitary sewer overflows, as well as, combined sewer overflows equally result in significant organic loading.

All potential load sources within the watershed were identified by principal land use/cover activities (e.g., agricultural management activities). Source assessment was used in development and analysis of TMDL allocations. Organic loadings within this particular watershed were restricted to non-point sources, as no point sources were present.

3.2.2. Point Sources within the Harris Creek Watershed

ADEM maintains a database of current NPDES permits and GIS files which identify the locations of every permitted outfall within the state. This database includes municipal, semi-public/private, industrial, mining, industrial storm water, and concentrated animal feeding operations (CAFOs) permits. Table 3-1, summarizes the permitted point sources within the watershed which either discharge into or upstream of the impaired segment. None of the listed facilities, however, were considered significant contributors relative to the impaired segment.

Table 3-1. Contributing Point Sources in the Harris Creek Watershed.

NPDES Permit	Type of Facility (e.g., CAFO, Industrial, Municipal, Semi-Public/Private, Mining, Industrial Storm Water)	Facility Name	Significant Contributor (Yes/No)
AL0023710	Industrial Storm Water	Wabash Alloys, LLC.	No
AL0060470	Industrial Land Application	Gold Kist Poultry Processing Plant	No
N/A	CAFO	Daniel Mills Farms	No
N/A	CAFO	Wayne West Farm	No
N/A	CAFO	Lazy T Farms	No

Note: Storm water discharges listed above were regarded as insignificant contributors since such discharges would neither precipitate nor contribute any water quality violation. These discharges would additionally not occur during low flow conditions. Storm water contributions were, however, taken into account through the SOD component. Construction storm water discharges similarly would not occur during low flows nor collectively contribute any discernable organic loading. CAFO and land application discharges were likewise considered insignificant contributors since their permits expressly prohibit stream discharges.

3.2.3. Non-Point Sources within the Harris Creek Watershed

Table 3-2, details principal land usage within the Harris Creek watershed. A land use map is presented in Figure 3-1. Predominant land uses within the watershed consist of forest, pasture/hay, and row crop related activities at 53.02, 25.60, and 11.14% respectively.

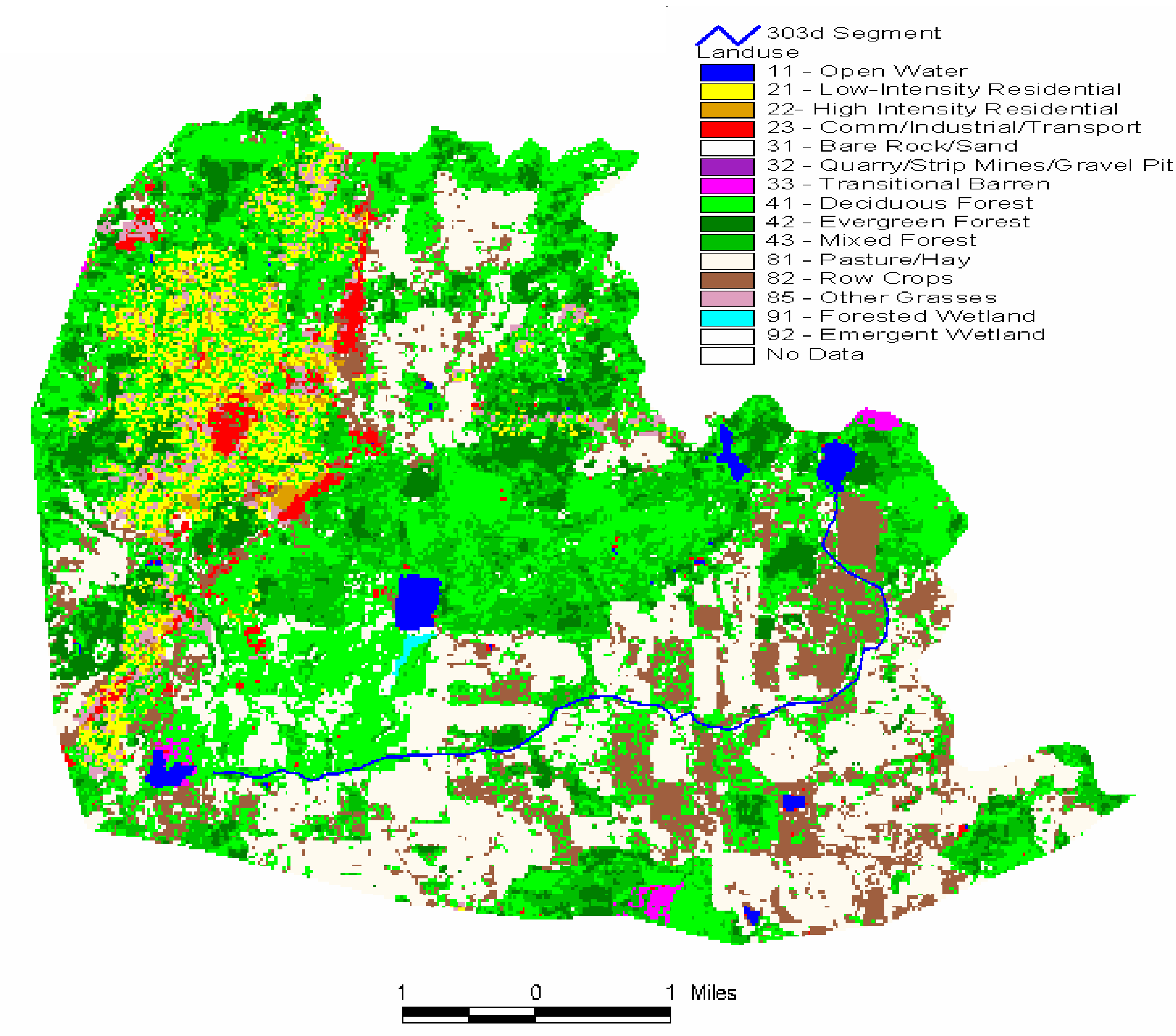
Table 3-2. Land Use in the Harris Creek Watershed.

LAND USE	PERCENTAGE
Open Water	1.03%
Low-Intensity Industrial Residential	4.27%
High-Intensity Residential	0.88%
Commercial/Industrial/Transport	1.55%
Bare Rock/Sand	
Quarry/Strip Mine/Gravel Pits	
Transitional Barren	0.35%
Deciduous Forest	28.49%
Evergreen Forest	7.39%
Mixed Forest	17.14%
Pasture/Hay	25.60%
Row Crops	11.14%
Other Grasses	2.00%
Forested Wetland	0.08%
Emergent Wetland	0.07%

Combined predominant land uses of forest, pasture/hay, and row crops comprise 89.8% of the overall watershed. All remaining 10.2% land uses, with the exception of residential, barren, and open water, were incorporated into one category (other) for modeling application. Each land use has the potential of contributing to the organic loading of the watershed due to wash off of land surface organic material. Information concerning agricultural and management activities and other similar watershed characteristics were obtained from the ADEM Mining and Non-Point Section, Alabama Cooperative Extension System, and USDA-Natural Resources Conservation Service (NRCS).

Major sources of organic enrichment from non-point sources within the Harris Creek watershed were associated with forest, pasture/hay, and row crop land use activities. Organic enrichment from forested land when compared to other land uses is normally considered insignificant, given that forested lands tend to filter out any naturally occurring pollution originating within their own drainage areas. Some organic loading can, however, be derived from forested areas owing to the presence of wild animals such as deer, raccoons, turkeys, waterfowl, etc. Control of such sources is usually limited to best management practices (BMPs) of land management which are often regarded as impracticable. By contrast, agricultural lands can be major sources of organic loading. Runoff from pastures, animal operations, improper land application of animal wastes, and animals with access to streams are all mechanisms by which organic loading can be introduced to streams.

Figure 3-1. Land Use Map for the Harris Creek Watershed.



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

EPA regulations define loading, or assimilative capacity, as the maximum loading that a waterbody can receive without violating existing 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 any given time; except under naturally occurring extreme conditions, when it may range between 4 and 5 mg/l, provided that all other water quality parameters remain favorable. Normal seasonal and daily fluctuations shall, nonetheless, be maintained above such levels.

Setting the D.O. water quality criterion of 5.0 mg/l as the numerical target, a TMDL model analysis was performed for critical conditions to determine the watershed's total loading capacity. This was accomplished through simulation aimed at meeting the dissolved oxygen target limit by varying the different source contributions. The final acceptable simulation represents the TMDL (and loading capacity of the waterbody). Had significant contributing point sources been identified, additional model analyses would have been required.

Pollutant concentrations from forestland were taken as normal background concentrations of 2 mg/l $CBOD_u$, 0.11 mg/l ammonia nitrogen (NH_3-N), and 0.22 mg/l total organic nitrogen (TON). Pollutant concentrations for other land uses were assigned in proportion to measured concentrations and set at levels necessary to maintain dissolved oxygen concentrations greater than, or equal to, 5 mg/l. End result parameter concentrations also had to be equivalent to or better than beginning headwater conditions previously used in the 1996 Wasteload Allocation performed for Russellville WWTP. Model predictions for in-stream pollutant concentrations were then compared to available field data. Model velocities and reaeration coefficients were adjusted in those cases where the field data varied from the model predictions.

3.4 Data Availability and Analysis

3.4.1. Watershed Characteristics

A. General Description: Harris Creek, located in Franklin County, is a tributary to the Bear Creek watershed, which in turn is part of the Tennessee River basin. Harris Creek is a part of the USGS (United States Geological Survey) AL/06030006 cataloging unit and NRCS (Natural Resources Conservation Service) 040 sub-watershed, with cataloging unit 02 indicating the Tennessee River basin and NRCS sub-watershed number 040 signifying the Bear Creek watershed.

Harris Creek begins approximately 3 miles east of Russellville, Alabama in Sec. 26, R11W, T6S. It has a linear distance of roughly 5.8 miles and total drainage area of nearly 9.3 square miles. Harris Creek holds a current stream use classification of Fish & Wildlife (F&W).

B. Geological Description: The Harris Creek watershed consists primarily of two major rock types composed of limestone and of sand, gravel, and clay. Some shalestone, sandstone, mudstone, limestone and coal formations are also sparsely distributed along the watershed's southeastern edge.

C. Eco-region Description: The watershed lies within what is classified as the Transition Hills (65j), which encompasses characteristics from both the Southeastern Plains (65) and Interior Plateau (71) ecoregions. Numerous streams within this transition area have scoured through Mississippian, Devonian, and Silurian-age rocks often appearing similar to streams of the Interior Plateau. Cretaceous-age coastal plain deposits of silt, sand, clay, and gravel overlie older depositions of limestone, shale, and chert. It is predominately a forested region of oak-hickory-pine, with small areas of cropland and pasture in narrow valley bottoms and along gently sloping ridges. Elevations range between 420 and 980 feet, representing some of the highest contained in ecoregion 65.

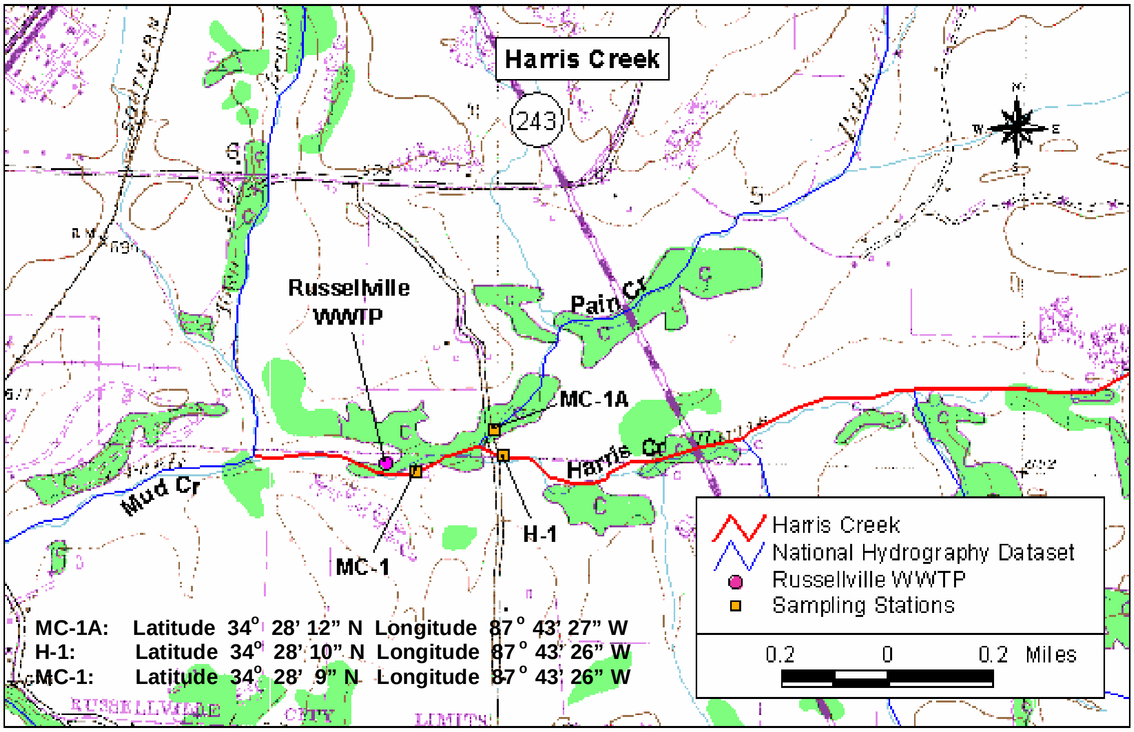
D. Other Notable Characteristics: None

3.4.2 Available Water Quality and Biological Data

Water Quality data for Harris Creek was collected by the Alabama Department of Environmental Management during September 1995 as part of an intensive water quality study in developing of a wasteload allocation for Russellville WWTP on Mud Creek. Data was collected from several locations along Mud Creek, as well as, from two samplings stations located immediately upstream of Mud Creek along both Harris Creek and Pain Creek which join together in forming Mud Creek.

A map indicating the locations of sampling stations along Pain and Harris Creeks and on Mud Creek immediately upstream of the Russellville WWTP discharge appear on the following page in Figure 3-2. A summary of accompanying field data is referenced within the appendix.

Figure 3-2. Map of Sampling Locations for the Harris Creek Watershed.



3.4.3. Flow data

For the purpose of this TMDL, annual calculated $7Q_{10}$ summer stream flows for Harris Creek at both its headwaters and mouth were compared to flows measured during the September 1995 intensive study. Both calculated and observable $7Q_{10}$ flows at the stream's headwaters were determined to be 0.0 cfs. The calculated $7Q_{10}$ flow at Harris Creek's mouth was 0.31 cfs while the field measured flow was only 0.13 cfs. This measured flow was considered more representative of worst-case conditions in providing the necessary margin of safety.

A $7Q_{10}$ flow represents the minimum 7-day flow which occurs, on average, over a 10-year recurrence interval. Likewise, the $7Q_2$, utilized here, represents the minimum 7-day flow that occurs, on average, over a 2-year period.

Both flows (i.e., $7Q_{10}$ and $7Q_2$) can be determined either from available United States Geological Survey (USGS) gauge data or by using the Bingham Equation. The Bingham Equation can be found on page 3 of the Geological Survey of Alabama's, **Low-Flow Characteristics of Alabama Streams, Bulletin 117**.

Equations used in calculating $7Q_{10}$ and $7Q_2$ flows are based on continuous USGS gauging records for streams and associated tributaries as follows:

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

$$7Q_2\ (\text{cfs}) = \frac{(7Q_2\ @\ \text{USGS Station (cfs)})}{(\text{Drainage Area @ USGS Station (mi}^2))} * (\text{Watershed Drainage Area (mi}^2))$$

Low flow estimates employing the Bingham Equation are based upon the stream's recession index (G, no units), drainage area (A, mi^2), and mean annual precipitation (P, inches):

$$7Q_{10}\ (\text{cfs}) = 0.15\text{x}10^{-5}(G-30)^{1.35}(A)^{1.05}(P-30)^{1.64}$$

$$7Q_2\ (\text{cfs}) = 0.24\text{x}10^{-4}(G-30)^{1.07}(A)^{0.94}(P-30)^{1.51}$$

For Harris Creek, headwater $7Q_{10}$ and $7Q_2$ flows were 0 cfs and 0 cfs, respectively due to the absence of source drainage area. The Bingham Equation was applied in determining end-of-stream $7Q_{10}$ and $7Q_2$ flows for Harris Creek of 0.31 cfs and 0.54 cfs. End-of-stream $7Q_{10}$ and $7Q_2$ flows for Pain Creek were also computed at 0.48 cfs and 1.12 cfs accordingly, along with $7Q_{10}$ and $7Q_2$ flows for Mud Creek, just upstream of Russellville WWTP, calculated at 0.80cfs and 1.67 cfs.

Even though an end-of-stream $7Q_{10}$ could be calculated for Harris Creek by using the Bingham Equation, observations from repeated site visits to the stream revealed virtually no flow during critical summer conditions. This consequently precluded any practical development of a summer TMDL using $7Q_{10}$ flows. No winter TMDL was likewise attempted since it would not be representative of critical stream flow conditions.

Flows utilized within the critical TMDL were taken directly from the September 19-21, 1995 field study and distributed over Harris Creek as tributary flow or incremental inflow (identified on the modeled reach schematic as IF), with IF distributed proportionally according to each segment length.

3.5 Critical Conditions

Summer months (May – November) are generally considered critical conditions for dissolved oxygen in streams as the result of lower precipitation rates which lead to slower stream velocities, increased organic loading residence time and decreased stream re-aeration rates. Increased residence time allows for additional decay which in turn further depletes the stream's dissolved oxygen supply. Reaction rates for $CBOD_u$ and NBOD (i.e., organic loading) are temperature dependent with higher summertime temperatures increasing the decay process, and depleting the dissolved oxygen even further.

Frequent low intensity rain events are more typical of winter months without the build-up of organic loading on land surfaces, resulting in more uniform loading rates. Higher flows with lower temperatures effectively result in less residence time and lower decay rates. This pattern is confirmed by model output data with the highest allowable loading occurring during winter flow conditions.

3.6 Margin of Safety (MOS)

Two basic methods exist for incorporating a MOS (USEPA, 1991): 1) implicitly, using conservative model assumptions, or 2) explicitly by specifying a portion of the TMDL as the MOS.

The MOS chosen for this TMDL is implicit by use of conservative model input parameters (**temperature, flow and D.O. concentrations**). Conservative temperature values were the highest average maximum temperature that would normally occur under critical stream flow conditions. Stream flows likewise reflect low flow critical conditions. Finally, D.O. concentration for incremental flow was set at 70% of saturation concentration, 15% lower than the 85% normally assumed in typical waste load allocations. Additionally, stream depths were quite shallow, at less than a foot, thus intensifying the effects of Sediment Oxygen Demand (SOD). Velocities were relatively sluggish, at 0.5 fps or less, which further amplified CBOD decay.

4.0 Water Quality Model Development

4.1 Water Quality Model Selection and Setup

Since the impairment noted by the available data occurred during periods of low flow, a steady-state modeling approach was appropriately adopted in representing all relevant conditions of impairment. This steady state TMDL spreadsheet water quality model (SWQM) was developed by ADEM and selected for the following reasons:

- It represents a simplified approach absent of unnecessary or undue complexity.
- It conforms to ADEM standards for developing wasteload allocations.
- It lends itself to development with only limited data, which at present is the case for this particular waterbody.
- It has the capability of handling tributary inputs along with both point and non-point source inputs.

The TMDL spreadsheet model also provides complete spatial view of a stream in its entirety, accounting for differences in stream behavior throughout the model reach. The model computes dissolved oxygen using a modified Streeter-Phelps equation which considers oxygen demand due to carbonaceous decay, as well as, from nitrification or ammonia decay. Each stream reach segment is divided into twenty-one computational elements, with each element recognized as the functioning equivalent of a complete mixed reaction.

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

- D.O. concentrations for incremental flow were assumed @ 70% of the saturated value at given temperature. **(MOS)**
- Incremental and tributary loadings were apportioned according to principal land use patterns.
- $CBOD_u$/ $CBOD_5$ ratios for non-point sources were 1.29 for Harris Creek and 1.71 for Pain Creek.
- NH_3OD_u was set equal to 4.57 times the ammonia nitrogen concentration.
- $TONOD_u$ was set equal to 4.57 times the organic nitrogen concentration.
- Background conditions were assumed for forest incremental flow which are typically 2-3 mg/l $CBOD_u$, 0.11-0.22 mg/l NH_3-N, 0.22-0.44 mg/l TON.

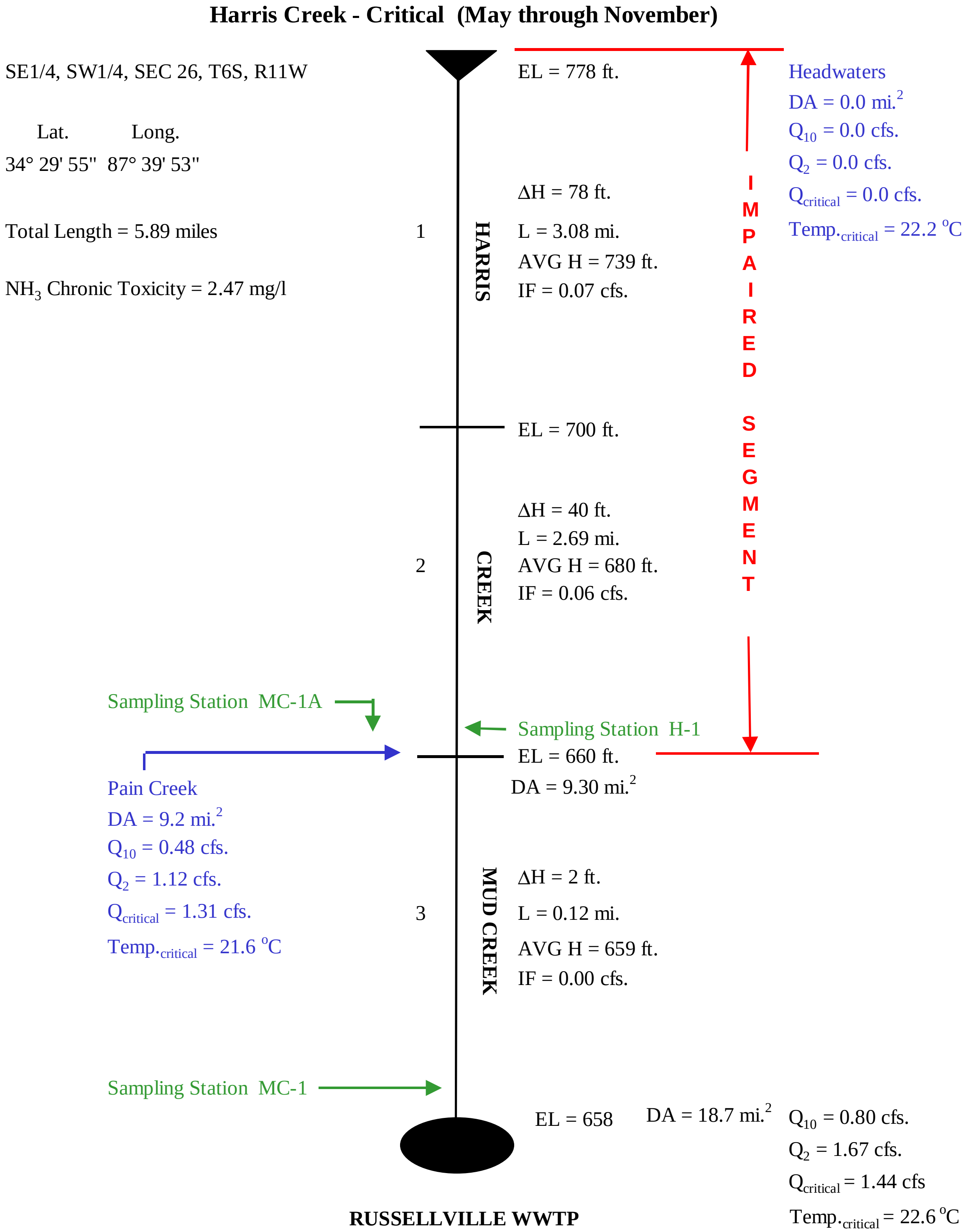
4.1.1. SOD Representation: Sediment oxygen demand (SOD) can represent a significant portion of the overall oxygen demand budget of shallow streams. In that no field SOD measurements were available for this waterbody, SOD data was obtained from EPA Region IV's SOD database, which represents mixed land uses and varying degrees of point source activity. SOD values of similar hydrogeological conditions were chosen and applied. A value of 0.068 O_2/ft^2/day was applied to both segments of Harris Creek while 0.080 O_2/ft^2/day was determined for the third segment or beginning portion of Mud Creek.

4.1.2. Calibration Data: Model calibration period was established from available field data (ref: Appendix) collected during September 19-21, 1995. Combination of lowest, steady flow and lowest dissolved oxygen defined the critical modeling period. Stream condition data (i.e., D.O., temperature) for this period was hence incorporated into the calibrated model TMDL spreadsheet.

4.2 Water Quality Model Summary

Critical model reach consisted of 3 segments with impaired portions consisting of the first two segments for a distance and overall impairment length of 5.77 miles. A schematic flow diagram of the model is presented as Figure 4-1. A user's guide to ADEM's TMDL water quality model has been incorporated within the appendix and explains much of the theoretical basis of physical/chemical mechanisms and principles upon which the model is created.

Figure 4-1. Schematic of the Modeled Reach.



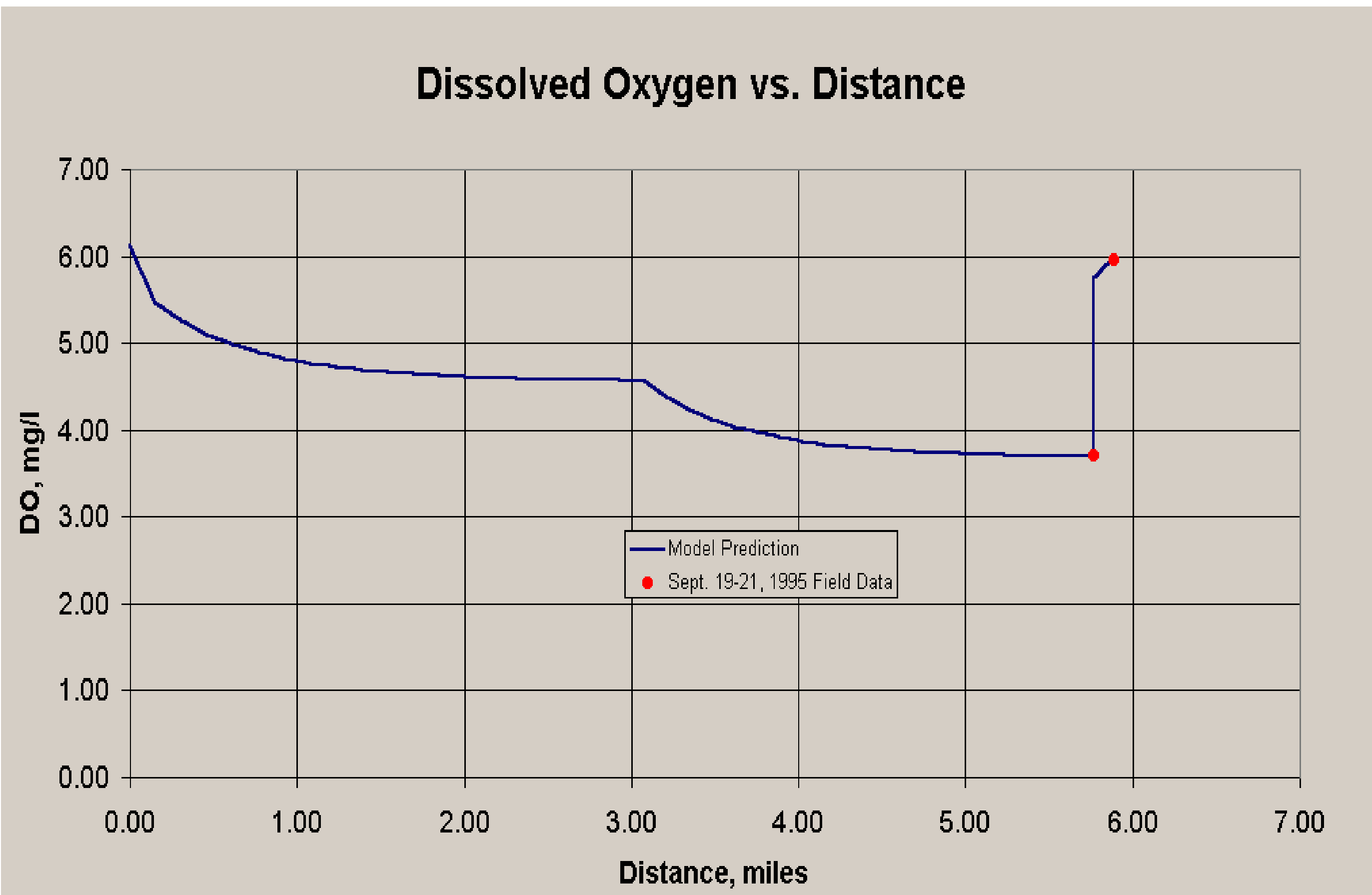
4.3 Loading Reduction Analysis

4.4.1. Calibrated Model

All D.O. violations indicated from available field data occurred at Sampling Station H-1, with lowest observed D.O. values occurring during the morning samplings of September 19-21, 1995, for an average morning measured concentration of 2.7 mg/l. Afternoon measured concentrations averaged at 7.8 mg/l. Morning deficits in D.O. saturation were compared to afternoon deficits to determine the degree of algal activity and to arrive at a D.O. value which would account for such variations. Field data from the sampling event was used as input in performing the calibrated simulation. Non-point source loading was adjusted in order to simulate measured D.O. values as close as possible to Sampling Station H-1 data, while still providing reasonable representation of stream water quality conditions during the recorded sampling event.

Figure 4-2, below, plots D.O. calibrated model predictions against actual D.O. field data.

Figure 4-2. 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_3-N (mg/l)**	**TON (mg/l)**	**Temp (^oC)**
Headwaters	0.00	6.13	2.99	0.14	0.40	22.2
Conditions @ Calibrated Point	0.13	3.69	1.82	0.09	0.31	22.2
Flow @ End of Model	1.44	5.98	0.87	0.01	0.13	21.7

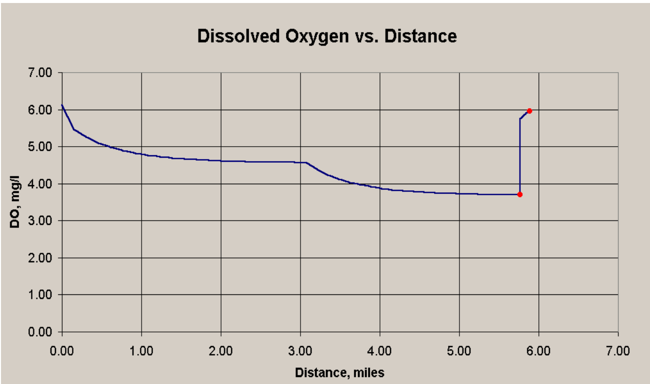
Calibrated Model Incremental Flow Parameters

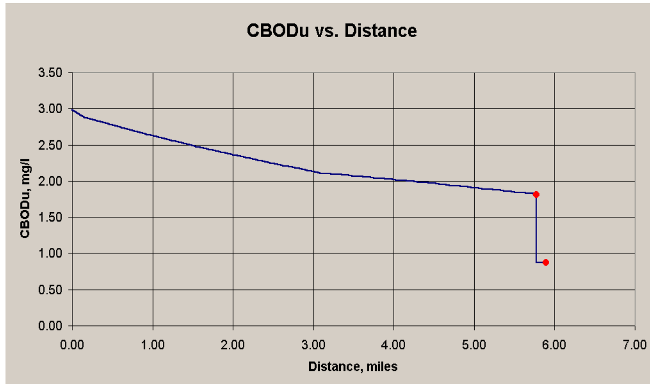
Sections	**$CBOD_u$ (mg/l)**	**NH_3-N (mg/l)**	**TON (mg/l)**	**DO (mg/l)**	**Total Flow (cfs)**	**Temp. (^oC)**
1	2.98	0.140	0.40	6.13	0.07	22.2
2	2.98	0.140	0.40	6.13	0.06	22.2
3	2.92	0.005	0.36	6.13	0.00	22.2

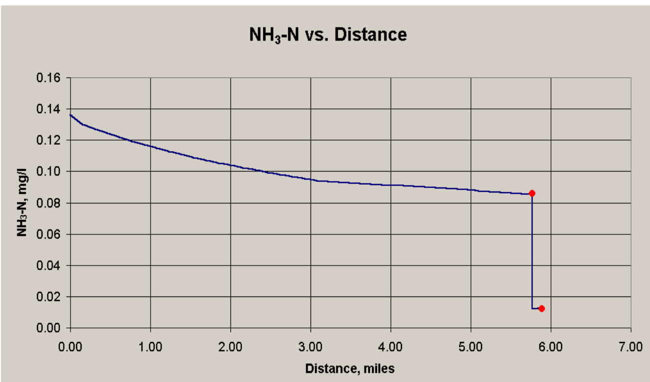
Comparison of Calibrated Model Flow Parameters to Actual Data

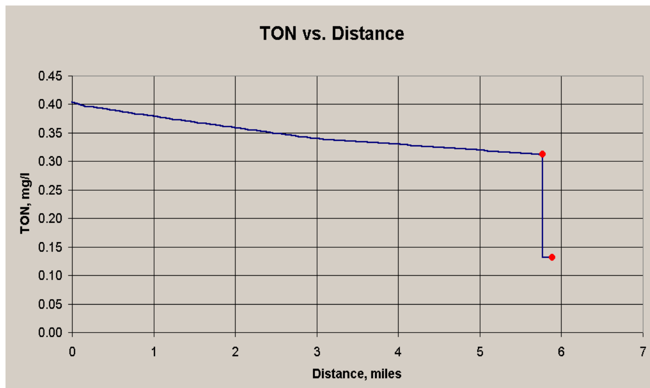
Description	**Flow (cfs)**	**DO (mg/l)**	**$CBOD_u$ (mg/l)**	**NH_3-N (mg/l)**	**TON (mg/l)**	**Temp (^oC)**
Actual Conditions @ Low D.O.	0.13	3.70	1.81	0.09	0.31	22.2
Cal. Conditions @ Low D.O.	0.13	3.69	1.82	0.09	0.31	22.2

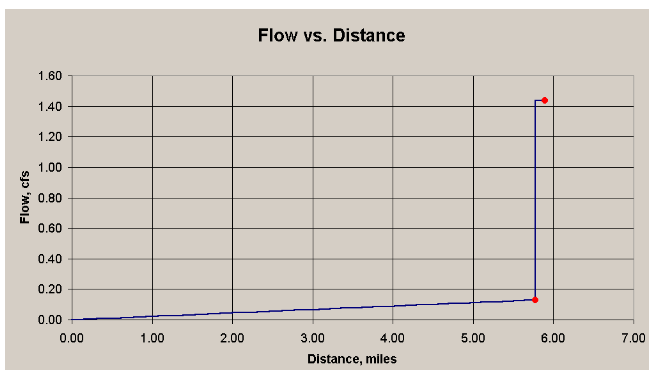
Figure 4-3. Calibrated Model Predictions and Graphics.











4.4.2. Load Reduction Model

The second simulation, hereto referred to as the load reduction model, adjusted non-point source loadings from the calibrated model to bring impaired waterbody segments into compliance with the 5 mg/l D.O. Fish & Wildlife water quality standard.

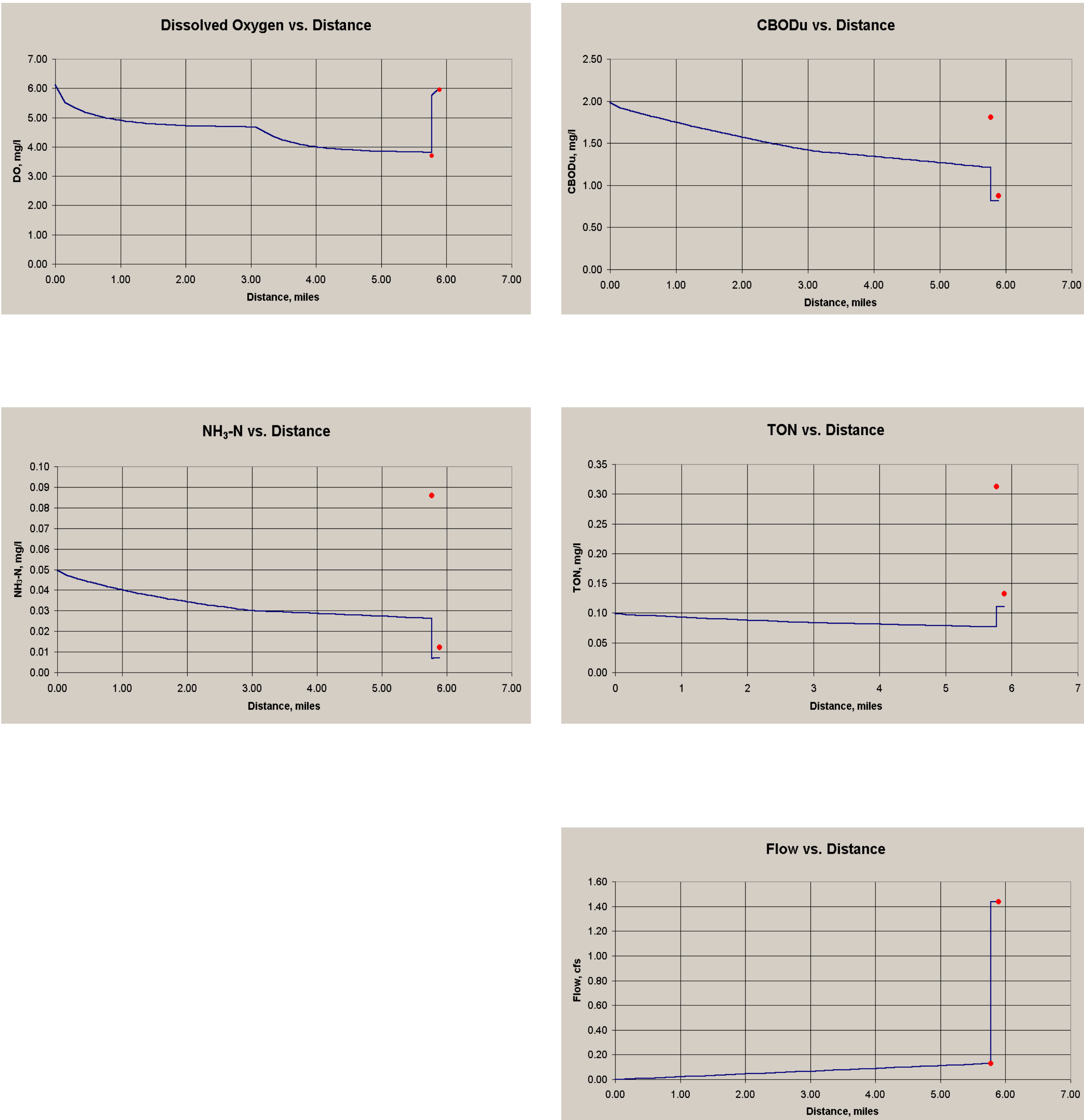
Load Reduction Model Flow Parameters

Description	**Flow (cfs)**	**DO (mg/l)**	**$CBOD_u$ (mg/l)**	**NH_3-N (mg/l)**	**TON (mg/l)**	**Temp (°C)**
Headwaters	0.000	6.13	1.99	0.050	0.10	22.2
Conditions @ Calibrated Point	0.13	3.82	1.21	0.026	0.08	22.2
Flow @ End of Model	1.44	5.99	0.81	0.007	0.11	21.7

Load Reduction Model Incremental Flow Parameters

Sections	**$CBOD_u$ (mg/l)**	**NH_3-N (mg/l)**	**TON (mg/l)**	**DO (mg/l)**	**Total Flow (cfs)**	**Temp. (°C)**
1	1.99	0.050	0.10	6.13	0.07	22.2
2	1.99	0.050	0.10	6.13	0.06	22.2
3	2.92	0.005	0.36	6.13	0.00	22.2

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



4.4.3. Required Reductions

Total organic loadings (i.e., $CBOD_u$ and NBOD) were calculated at Sampling Station H-1 for both calibrated and load reduction models. Total organic loading for the calibrated model was 13.2 lbs./day while total organic loading for the load reduction model was 11.2 lbs./day. This difference would require a 15.2 % reduction from non-point source loads in an attempt to bring Harris Creek into compliance with the Fish & Wildlife D.O. standard of 5.0 mg/l. In the process of determining the needed load reductions from the differing land uses, however, it became evident that no load reductions, regardless of their extent would have any sizeable effect on raising the D.O. concentration up to this minimum desired level. All land uses, except open water, were ultimately set to the same background conditions as for forest land. While this adjustment significantly lowered instream TON, NH_3-N, and $CBOD_u$ values, it unfortunately proved to have very little if any effect on raising the D.O.. Calibrated model flow conditions were at such exceptionally low levels (inclusive of incremental flow) that any changes made to land use would have minimal impact.

A summary of reductions to background conditions for all land uses is presented in Table 4-1., being reminded that these reductions would still not result in a D.O. of 5.0 mg/l. D.O. averages would still remain at about 4.8 mg/l within the first reach segment and at nearly 3.8 mg/l within the second segment.

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
N/A	13.2	13.2	11.2	N/A	15.2%

Notes: 1 = $CBOD_u$ + NBOD

Required reductions are usually sought through TMDL implementation with follow up monitoring to determine effectiveness of remediation strategies. Follow up monitoring as discussed further in this document will be conducted according to basin rotation.

4.4 Seasonal Variation

Regulations require that TMDLs be established with consideration of seasonal variations. Since impairments occurred only during the summer months and not during any other time of the year, seasonal variation was not necessary.

5.0 *Conclusions*

A summary of the Critical TMDL is presented in Table 5-1.

Table 5-1. Critical TMDL Summary

	TMDL
	Critical
$CBOD_u$ Loading (lbs./day)	7.6
NBOD Loading (lbs./day)	5.6
Total Loading (lbs./day)	13.2

It is recommended that additional study and investigation be made regarding Harris Creek's water quality. This TMDL was based on only one intensive study which occurred in the summer months. Additional summer measurements are needed in verifying the findings of the initial study and in justifying any recommended or proposed changes to land use. Measurements taken during the winter months would likewise prove beneficial in determining the need for seasonal variations.

6.0 *TMDL Implementation*

6.1 *Non-Point Source Approach*

Harris Creek is impaired exclusively 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.

6.3 Point Source Approach

In light of the fact that no point sources currently discharge to the impaired stream segments, no reduction of point source loading would be understandably proposed.

7.0 Follow Up Monitoring

ADEM has adopted a basin-by-basin approach to water quality management; an approach which divides Alabama's fourteen major river basins into five groups. Each year, ADEM water quality resources are allocated toward the intensive study of one of these basin groups. One primary goal is the continued monitoring of §303(d) listed waters according to the following projected 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 assist in the further assessment and evaluation of water quality conditions resulting from the application of corrective measures within each watershed.

8.0 Public Participation

A thirty-day public notice will be provided prior to the final execution of this TMDL, during which time, the TMDL will be made available, with copies of provided upon request, and the public invited to ask questions and/or provide and submit comments.

Appendix 9.1
References

References

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

Nelson, George H., Jr.. 1984. Maps to Estimate Average Streamflow and Headwater Limits for Streams in the U.S. Army Corps of Engineers, Mobile District, Alabama and Adjacent States. Water-Resources Investigations Report 84-4274.

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

Appendix 9.2
Water Quality Data

Mud Creek - Russellville, Alabama
Water Quality Data
September 19 - 21, 1995

tion	Date	Time	Flow (cfs)	$Temp_{air}$ (^oC)	$Temp_{water}$ (^oC)	D.O. (mg/l)	Cond. (mS/cm)	pH s.u.	Turb. NTU	BOD_5 (mg/l)	Computed $CBOD_u$ (mg/l)	TSS (mg/l)	Hardness $CaCO_3$ (mg/l)	Cl^- (mg/l)	NH_3-N (mg/l)	$NO_2 + NO_3$ (mg/l) N	TKN (mg/l)	Total PO_4-P (mg/l)
:-1A	9/19/95	7:58		14	18	6.5	425	7.3	1.4									
ıd	9/19/95	15:40		30	23	8.2	470	7.8	8.9									
:ek	9/20/95	8:40		23	21	6.2	445	7.6	1.9	0.8	0.78	3	208	46	<0.005	0.459	0.106	0.112
	9/20/95	14:50		25	22	7.3	460	7.7	2.2									
	9/21/95	9:10		24	24	5.95	460	7.6	2.5	0.7		5	212	46	<0.005	0.451	0.132	0.091
l	9/19/95	7:53		14	18	2.8	300	7.1	6.4									
:ris	9/19/95		0.13															
:ek	9/19/95	15:35		30	24	9.4	330	8.1	4.1									
	9/20/95	8:35		23	22	2.5	315	7.5	3.5	1.5	1.81	2	173	15	0.066	0.079	0.376	0.235
	9/20/95	14:45		25	23	6.15	325	7.7	6.4									
	9/21/95	9:05		24	24	2.9	320	7.5	6.3	1.2		6	183	11	0.106	0.103	0.420	0.112
:-1	9/19/95	7:40		14	20	5.95	420	7.2	3.6									
ıd	9/19/95	15:21	1.35															
:ek	9/19/95	15:25		29	24	7	465	7.7	5.6									
	9/20/95	8:23		22	21	6.25	440	7.7	4.9									
	9/20/95	9:45	1.23															
	9/20/95	14:35		23	22	7.45	455	7.8	2.5									
	9/20/95	14:53	1.41															
	9/21/95	8:40	1.76															
	9/21/95	8:52		24.5	26	6	440	7.7	3.2									

Appendix 9.3
Water Quality Model
Input and Output Files

CALIBRATED MODEL

LOAD REDUCTION MODEL

9.4
Spreadsheet Water Quality Model (SWQM) User Guide