

TOTAL MAXIMUM DAILY LOAD (TMDL) DEVELOPMENT

For NUTRIENT ENRICHMENT in

LAKE WEISS

(HUC 03150105)

Cherokee County, Coosa River Basin, Alabama



Under the authority of Section 303(d) of the Clean Water Act, 33 U.S. Code §1251 et seq., as amended by the Water Quality Act of 1987 (PL 100-4), the U.S. Environmental Protection Agency is hereby establishing a TMDL for nutrients in Lake Weiss.

 /s/
James D. Giattina, Director
Water Management Division

 11/01/04
Date

Table of Contents

Introduction.....	1
Problem Definition.....	1
Target Identification	1
Background.....	2
Available Monitoring Data	4
Numeric Targets and Sources	6
Model Development.....	6
Modeling Assumptions	7
Total Maximum Daily Load (TMDL)	7
Critical Condition Determination	7
Seasonal Variation and Margin of Safety	10
TMDL Determination	10
Allocation of Responsibility and Recommendations.....	12
REFERENCES	13

Table of Figures

Figure 1: Lake Weiss Location Map..... 3

Figure 2: Lake Weiss Lake Wide Chl a Measurements..... 4

Figure 3: Lake Weiss Coosa River @ State Line Flow and TP..... 5

Figure 4: Lake Weiss Coosa River @ State Line TP Loading 6

Table of Tables

Table 1: Years 1991 to 2000 Existing Conditions 9

Introduction

Section 303(d) of the Clean Water Act (CWA) as Amended by the Water Quality Act of 1987, Public Law 100-4, and the United States Environmental Protection Agency's (USEPA/EPA) Water Quality Planning and Management require each State to identify those waters within its boundaries not meeting water quality standards. Total maximum daily loads (TMDLs) for all pollutants violating or 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 consideration given to seasonal variations and margins of safety. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a water body, 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 nonpoint sources and restore and maintain the quality of their water resources (USEPA, 1991).

Problem Definition

Alabama's Section 303(d) lists identified forty miles of Lake Weiss in the Coosa River Basin between the Alabama-Georgia state line to the Lake Weiss powerhouse dampool as not supporting its designated use as a fishing water, with the pollutant of concern being nutrient enrichment. The Specific Lakes water quality criteria and antidegradation narrative criteria from the Code of Alabama rules and regulations (335-6-10.11 and 335-6-10.06 (c), 2001) applies. This listing decision was based on historical routine monitoring data that was collected in Lake Weiss and the data available in the Lake Weiss Phase 1 Diagnostic/Feasibility Study for water years 1991 and 1992 (Bayne 1993).

Target Identification

The chlorophyll-a target is based on Alabama Water Quality Criteria Applicable to Specific Lakes (335-6-10-.11 (2) (b) (1)) for Lake Weiss in the Coosa River Basin. chlorophyll-a: the mean of photic-zone composite of chlorophyll-a samples collected monthly April through October shall not exceed 20 ug/l, as measured at the deepest point, main river channel, power dam forebay; or 20 ug/l,

as measured at the deepest point, main river channel, immediately upstream of the causeway (Alabama Highway 9) at Cedar Bluff. This water quality criterion was approved by USEPA in August 2002. The target level for the development of the nutrient enrichment TMDL in Lake Weiss are these specific lake criteria of 20 ug/l chlorophyll-a. The TMDL will be represented by the average nutrient loads that are allowable so that the reservoir achieves an average growing season (May-October) reservoir-wide chlorophyll-a concentration of 20 ug/l. This target will allow for sufficient productivity in the reservoir to maintain the fisheries, but on the other hand, reduce the risk of nuisance blooms of algae and reduce the hypolimnetic oxygen deficit, thereby improving fish habitat.

Background

Lake Weiss is a major impoundment with significant recreational fishing value to the public in both northeast Alabama and northwest Georgia. In addition, the reservoir serves as a source of water supply for the town of Cedar Bluff in Alabama. Alabama Power Company constructed the reservoir and manages hydroelectric operation with a generating capacity of 87,750 kilowatts.

Lake Weiss was formed when Alabama Power impounded the Coosa River in 1961 for the purpose of hydroelectric power generation. Other major tributaries to Lake Weiss include the Chattooga and Little Rivers. Lake Weiss drains approximately 13,657 square kilometers, most of which is located in northwest Georgia. The dam is a gravity concrete and earth-fill type with a maximum height of 26 meters. The reservoir is located in Cherokee County in northeastern Alabama near the Alabama-Georgia state line. (See Figure 1) The headwaters of the reservoir extend into Floyd County, Georgia. The Alabama towns of Centre, Leesburg, and Cedar Bluff are located in the immediate proximity of Lake Weiss, and the City of Rome, Georgia is located approximately 27 river miles upstream from the reservoir's headwaters. The reservoir lies in the Coosa Basin in the valley and ridge physiographic province of Northern Alabama. The reservoir at full pool encompasses over 12,000 hectares of surface area and a volume of almost 38,000 hectare-meters.

Full pool elevation is 172 meters above mean sea level and average depth of the reservoir is 3.1 meters. Drawdown of approximately 2 meters occurs from September until December, and the reservoir is allowed to reach full pool again by May. Average hydraulic retention time in the

reservoir is approximately 18 days. Lake Weiss typically does not become thermally stratified due to its high flushing rate and relatively shallow average depth. Lake Weiss is chemically well mixed, but vertical gradients in dissolved oxygen are present during the spring, summer, and fall growing seasons.

Alabama Department of Environmental Management water-use classifications for Lake Weiss are:

- **Weiss Dam Powerhouse to Spring Creek** – Public Water Supply/Swimming/Fish and Wildlife
- **Spring Creek to state line** – Swimming/Fish and Wildlife

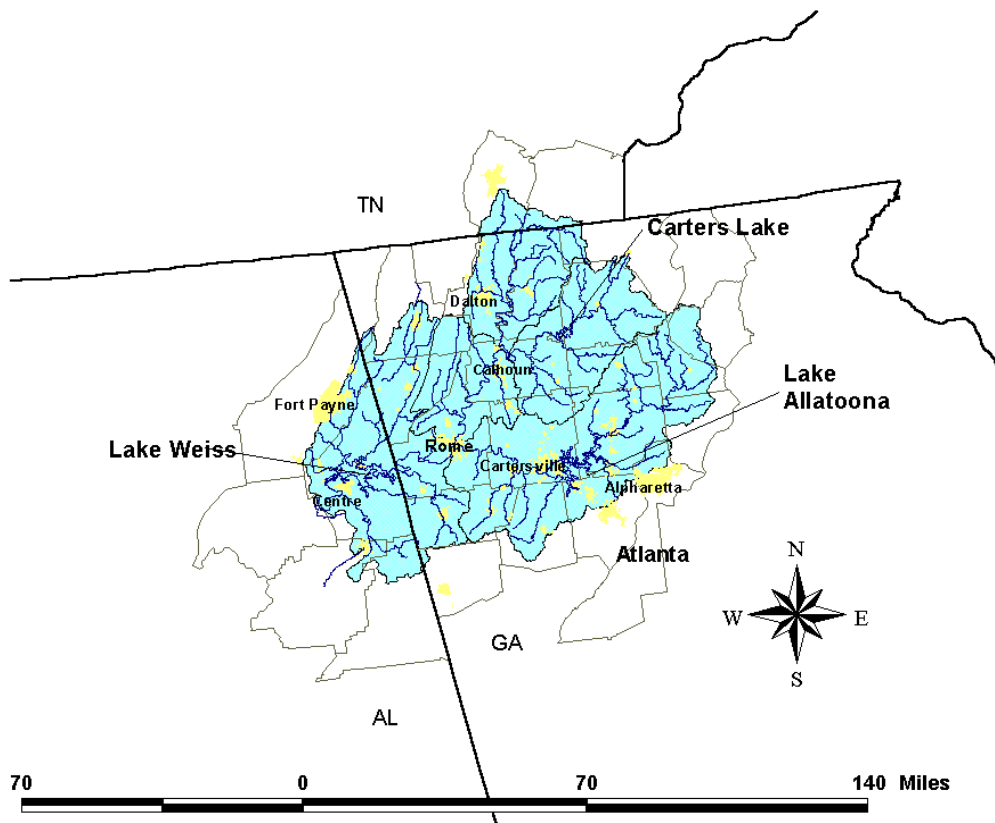


Figure 1: Lake Weiss Location Map

Available Monitoring Data

EPA Region 4 compiled the available monitoring data in the report “Summary of Water Quality Data and Information Developed Pursuant to Lake Weiss TMDL Study” (EPA, 2000). These data included reservoir vertical and longitudinal profiles for nutrients, algae, dissolved oxygen, and temperature. Other available data included meteorological, sediment oxygen demand, and algal growth potential test data and additional tributary monitoring conducted by Alabama Department of Environmental Quality (ADEM), Georgia Environmental Protection Division (GaEPD), and the United States Geologic Survey (USGS).

Figures 2, 3 and 4 indicate the levels of chlorophyll-a in Lake Weiss along with the flow and phosphorus concentrations and loadings to the lake. From 1991 to 2000 there has been a downward trend in the phosphorus loads to the lake.

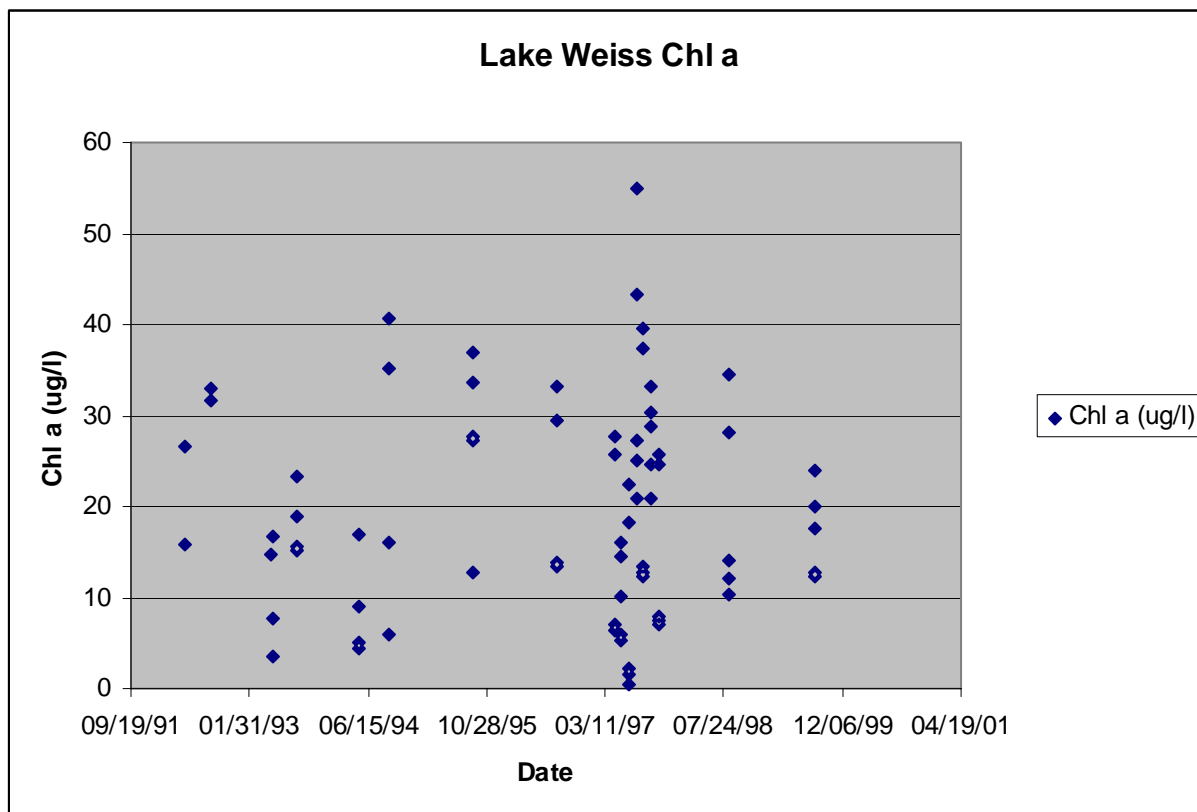


Figure 2: Lake Weiss Lake Wide Chl a Measurements

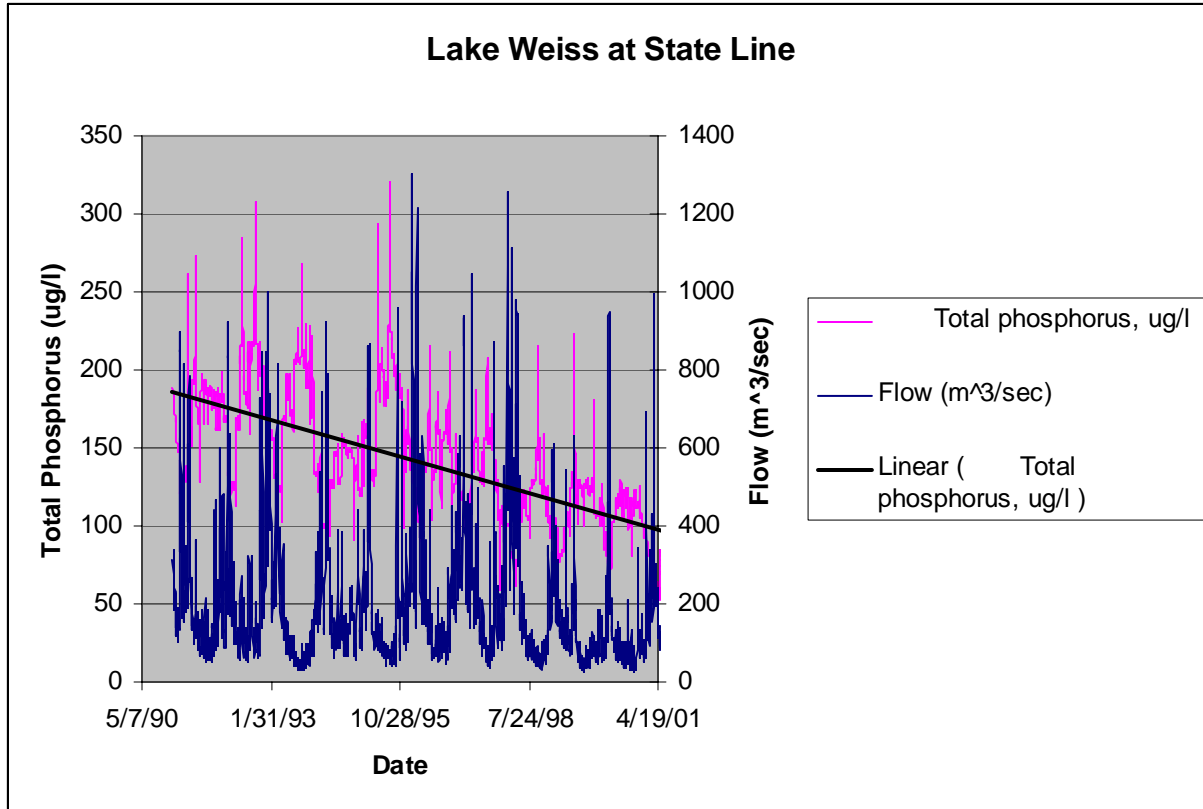


Figure 3: Lake Weiss Coosa River @ State Line Flow and TP

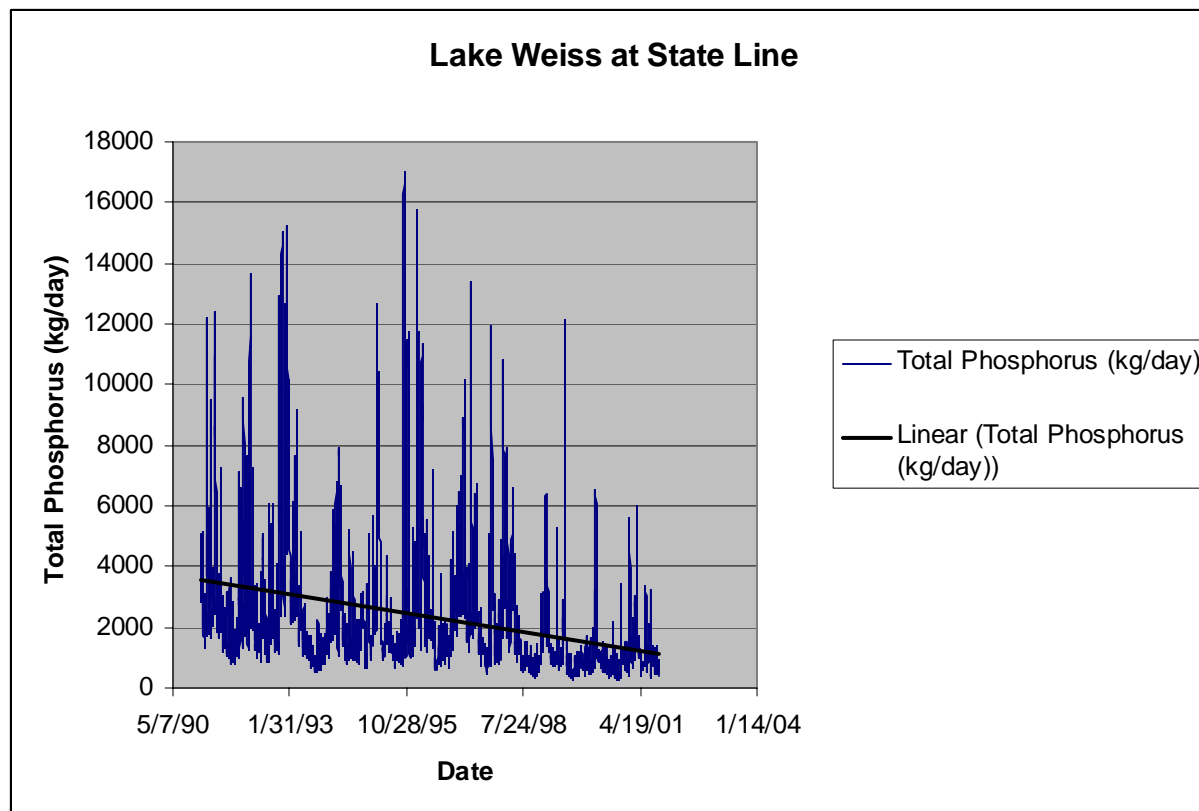


Figure 4: Lake Weiss Coosa River @ State Line TP Loading

Numeric Targets and Sources

Model Development

Weiss Lake was originally modeled with CE-QUAL-W2 by J. E. Edinger Associates, Inc. (JEEAI) in 1986 in support of thermal licensing issues at Plant Hammond on the Coosa River, just upstream of Weiss Lake (Edinger and Buchak, 1987a and 1987b). The Waterways Experiment Station made the definitive water quality application of CE-QUAL-W2 to Weiss Lake (Tilman, et.al., 1999). There have been several updates to the datasets since the WES modeling effort. The model was recalibrated for 1991 by EPA Region 4 to enhance comparison of predicted and observed algae concentrations and phosphorus concentrations. Details on the model development are contained in the EPA Lake Weiss Calibration Report (EPA 2000). An additional 2002 model study “CE-QUAL-W2 Model Recalibration and Simulations in Support of TMDL Activities for Weiss Lake, Alabama” by J. E. Edinger Associates, Inc. was funded by EPA. The three objectives of the study were:

- Develop boundary conditions and set up Version 3 of CE-QUAL-W2 to run long term simulations for 10 years from 1991 to 2000,
- Calibrate the model using data for all 10 years, and
- Provide assistance in application of the model to (Total Maximum Daily Load) TMDL development.

The study was carried out in close technical collaboration with EPA.

The calendar year 1991 to 2000 model runs were evaluated and used to determine what nutrient loads can be received by the Lake and still meet the numeric target of a 20-ug/l chlorophyll-a value. This target is based on Alabama Water Quality Standards and the Lake Weiss Phase 1 Diagnostic/Feasibility Study for water years 1991 and 1992 (Bayne 1993) and evaluation of chlorophyll-a data collected by Alabama from 1991 through 2000. The target will allow for sufficient productivity in the reservoir to maintain the fisheries, but on the other hand, reduce the risk of nuisance blooms of algae and reduce the hypolimnetic oxygen deficit, thereby improving fish habitat.

Modeling Assumptions

The Lake Weiss modeling assumptions are reported in the 2002 model study “CE-QUAL-W2 Model Recalibration and Simulations in Support of TMDL Activities for Weiss Lake, Alabama” by J. E. Edinger Associates, Inc.

Total Maximum Daily Load (TMDL)

Critical Condition Determination

Due to Lake Weiss’s relatively short retention time, the concept of phosphorus loading is not as important to productivity levels in the reservoir as phosphorus concentrations. High loads associated with high flows tend to flush more rapidly through the reservoir. Sensitivity analyses as well as review of historic data both suggest that Lake Weiss chlorophyll-a levels peak when reservoir

hydraulic retention is relatively long. These conditions occur during average and low flow years when inflows and outflows are less and Alabama Power operates the reservoir to maintain pool volume. Nutrient concentrations in the reservoir are conducive to a very productive reservoir, and light limitations, as well as hydraulic retention are major controls regarding ultimate productivity in the reservoir.

Lake Weiss is a relatively shallow impoundment with a relatively high surface area to volume ratio. Wet years tend to introduce much higher nutrient loads to the reservoir, but in turn, these high loads are driven rapidly through the reservoir with springtime average hydraulic retention on the order of a week to ten days. Wet years also introduce higher suspended solids to the reservoir, further limiting productivity as the higher velocities help to maintain suspended solids concentrations.

Table 1 provides the measured 1991 to 2000 yearly Coosa River average flows, phosphorus concentrations and phosphorus loads, along with the model predicted Lake Weiss Growing Season Average Chlorophyll-a values. There is no single discernable critical condition or critical year to serve as the basis for the Lake Weiss phosphorus TMDL. Therefore, the average growing season Chlorophyll-a for the 10 year period from 1991 through 2000 was used develop the TMDL because it includes low, average and high flow periods which experience algal bloom events. Figures 5 and 6 provide a graphical display of flow and phosphorus load distribution.

Table 1: Years 1991 to 2000 Existing Conditions

Year	Flow m ³ /sec	TP ug/l	TP kg/d	Reservoir Wide Growing Season Average Chla (ug/l)
1991	353	175	5289	28
1992	453	174	6723	21
1993	365	168	5292	16
1994	144	144	1804	21
1995	166	142	2090	26
1996	135	146	1664	23
1997	223	120	2308	23
1998	238	107	2205	22
1999	150	103	1321	28
2000	90	103	799	27
10 Year Average	232	138	2949	23
High Flow Year Average	390	172	5768	22
Medium Flow Year Average	184	123	1946	24
Low Flow Year Average	113	124	1232	25

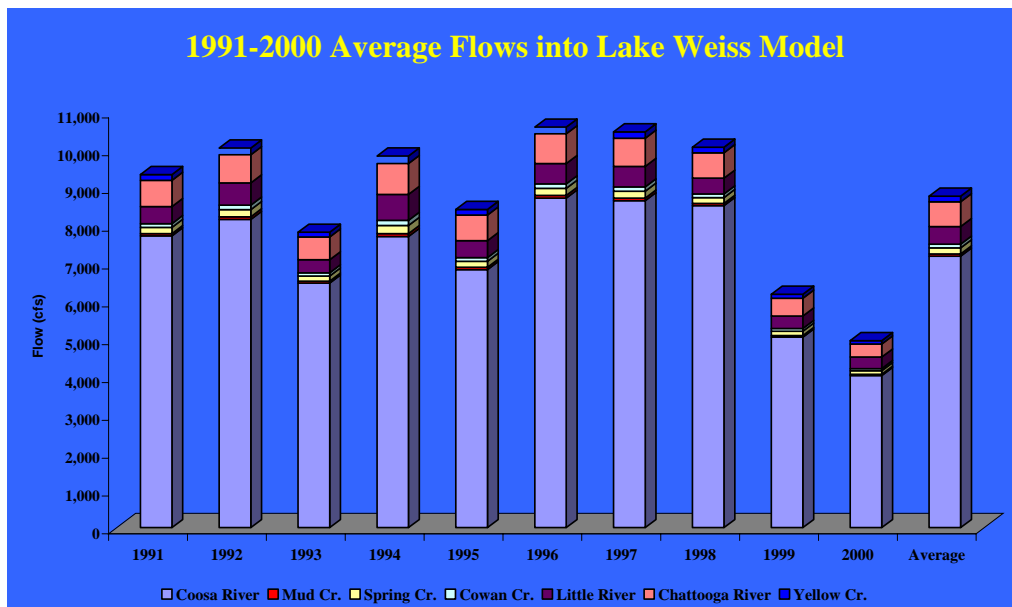


Figure 5: Average Annual Flows into Lake Weiss Model

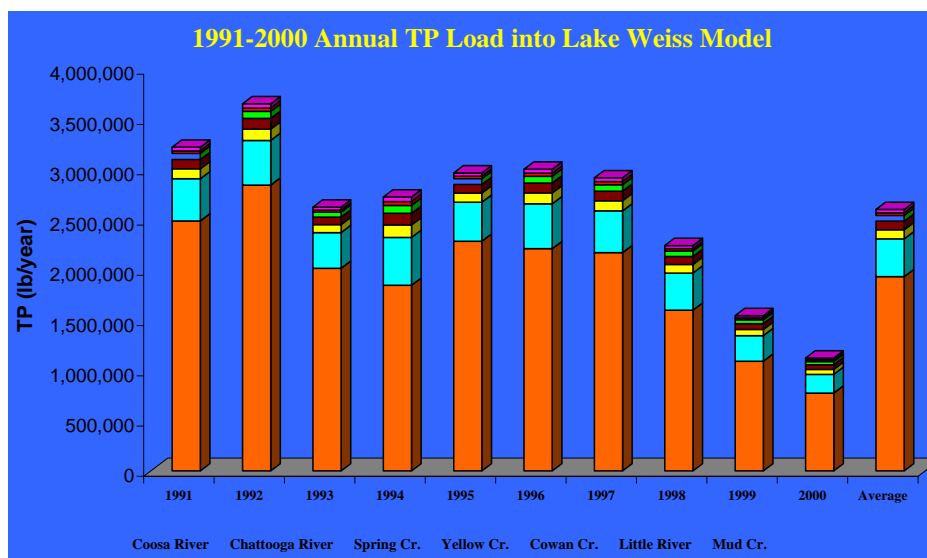


Figure 6: Total Phosphorus Annual Loads into Lake Weiss

Seasonal Variation and Margin of Safety

Seasonal variation and margin of safety were taken in to account by examining and evaluating the lake data for the years 1991 to 2000, a ten year timeframe, which contained low, average and high flow periods. Because of these data, the water quality model was able to simulate the complex interactions of flow rates, phosphorus loads and concentrations, and light penetration to algae productivity. The ten years of data indicated that Lake Weiss algal productivity is better correlated with annual average phosphorus concentration than the short-term mass loading of phosphorus into the Lake.

TMDL Determination

The objective of the Lake Weiss TMDL is to meet the 20 ug/l Chla targets at the two defined monitoring points. The annual seasonal averaged Chla at these monitoring points can be represented by the modeled lake wide growing season average Chla of 20 ug/l chlorophyll-a, based on the 1991 through 2000 historic flow and meteorological conditions. The water quality modeling indicates that algae productivity in Lake Weiss is dependent on the annual average phosphorus concentration observed in the Lake and in the retention time of the Lake. The model indicates that a ten year 70

$\mu\text{g/l}$ phosphorus annual average concentration will effectively control spring and summer algal blooms, while ensuring that there is sufficient nutrients in the Lake to maintain the desired fishery. This annual average phosphorus concentration in conjunction with the annual measured flows can be used to calculate the acceptable annual average phosphorus load for the Lake. A ten year average phosphorus load of 1475 kg/day or an annual average load of 540,000 kg/year is necessary to meet the growing season average 20 $\mu\text{g/l}$ chlorophyll-a target conditions during this ten year period of record. Since this period of record includes severe drought conditions, the use of a multi-year averaging period is considered protective for all but the most extreme conditions. Model simulations were run to determine the impacts of reducing the phosphorus annual average load necessary to meet the chlorophyll-a criterion under the most extreme observed conditions. Such stringent phosphorus load reductions would result in excessive reductions in algal productivity in average flow years, sufficient to jeopardize the Lake Weiss fishery.

The sources of phosphorus in Lake Weiss originate in two states, Alabama and Georgia. This TMDL allocates an aggregate allowable pollutant load, which includes both the point and nonpoint source contributions, to Georgia sources from the Coosa River and Chattooga River at the state line. Therefore, the TMDL for Lake Weiss allocates annual average phosphorus loads for Alabama's nonpoint sources and provides a gross allocation for all phosphorus loads from Georgia. Initial allocations of the TMDL of 540,000 kg/yr phosphorus equal 100,000 kg/yr Load Allocation in Alabama plus 440,000 kg/yr Aggregate Load allocation from Georgia at the state line, see Figure 6. These allocations are based upon the relative existing load contributions from the two states over the 1991-2000 ten-year period of record. These load allocations will be revisited and revised based on the addition monitoring and modeling activities that are occurring in the Coosa Basin.

The past ten years of phosphorus loading data indicate a downward trend as indicated in Figures 3 and 4. However, it is apparent that that additional load reduction from what occurred during the 1991 to 2000 time period are needed to fully achieve the water quality criterion of 20 $\mu\text{g/l}$ chlorophyll-a in Lake Weiss.

Allocation of Responsibility and Recommendations

EPA, ADEM, and Georgia EPD are planning to integrate three TMDL efforts in the Coosa River Basin. The Georgia EPD in cooperation with EPA is conducting a watershed and river modeling project that will be used to modify and link the dissolved oxygen TMDL for the upstream segment of the Coosa River with a revised EPA model for Lake Weiss. This revised model will be compatible with the WASP/EFDC model developed by ADEM for the lower Coosa River Basin reservoirs' TMDLs. Linking all three models in a compatible format will facilitate the development of load allocation scenarios necessary to achieve the water quality standards and ensure all portions of the Coosa River will be protected.

The 2003 ADEM nutrient TMDLs required a 30 percent reduction in total phosphorus from Lake Weiss to meet the water quality standards in the downstream reservoirs. This 30 percent reduction in total phosphorus is consistent with the Lake Weiss TMDL approach of targeting a 70 ppb total phosphorus annual average concentration to ensure the growing season chlorophyll-a average concentrations achieve the 20 ppb water quality criterion. (Current state-line average total phosphorus concentration is 100 ppb, so a 30 percent reduction would achieve the 70 ppb target value.) The three parties are cooperating on developing a monitoring and modeling effort to further refine all three TMDLs.

REFERENCES

- Bayne, et al. Weiss Lake Phase I Diagnostic and Feasibility Study, Department of Fisheries and Applied Aquacultures, Auburn University. 1993.
- Carlson, R.E. 1977. A Trophic State Index. *Limnology and Oceanography* 22(2): 361-369.
- Cole, T.M., and Buchak, E.M. (1995). "CE-QUAL-w2: A two-dimensional, laterally averaged, hydrodynamic and water quality model, Version 2.0," Instruction Report EL-95-, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- EPA Region 4. Lake Weiss Two-Dimensional Eutrophication Model Revision Report. EPA R4 Water Quality Assessment Section Weiss Reservoir TMDL Supplementary Report. July 2000.
- EPA Region 4. Summary of Water Quality Data and Information Developed Pursuant to Lake Weiss TMDL Study. EPA R4 Water Quality Assessment Section Weiss Reservoir TMDL Supplementary Report. May 2000.
- Martin, J.M. and Hesterlee, C. Detailed Reservoir Water Quality Modeling to Support Environmental Impact Statements for the Evaluation of ACT and ACF River Basins Water Allocation. 1998.
- Tillman, D., Cole, T., & Bunch, B. Detailed Reservoir Water Quality Modeling (CE-QUAL-CE-QUAL-W2), Alabama-Coosa-Tallapoosa/Apalachicola-Chattahoochee-Flint (ACT-ACF) Comprehensive Water Resource Study, Technical Report EL-99-XXX, USACE-WES, Vicksburg, MS (Contains companion compact data disk)
- Walker, W.W. (1996). "Simplified procedures for eutrophication assessment and prediction: User manual".
- Instruction Report W-96-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- J. E. Edinger Associates, Inc (2002) "CE-QUAL-W2 Model Recalibration and Simulations in Support of TMDL Activities for Weiss Lake, Alabama"