CLEARWATER LAKE WATER QUALITY MODEL STUDY

Final Report

Red Lake Watershed District

December 2003

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1.0 Acknowledgements

The Red Lake Watershed District Staff included Ryan Odenbach (grant application, project management, Sampling and Analysis Plan, sampling), Corey Hanson (project management and coordination, sampling, flow measurement, FLUX/PROFILE/BATHTUB modeling, semi-annual reporting, author of final report, GIS, and data analysis) Stephanie Hanson (GIS, sampling, flow measurement, data entry/analysis, assisted with creation of final report), Zebulen Lamp (GIS, sampling, and flow measurement), Gary Lane (surveying and flow measurement), Loren Sanderson (surveying and flow measurement), Chuck Fritz, and Harry Farris.

Many people in addition to Red Lake Watershed Staff participated in this project. Eric Pearson and Melanie Johnson of the Beltrami Soil and Water Conservation District, along with John Cucci, Bob Widerski, and Roger Holm of the Clearwater Lake Area Association all assisted with sampling. Bob Widerski also collected daily evaporation pan and rainfall data for the project. Doug Thompson of the Clearwater Soil and Water Conservation Service helped with the planning process and provided technical expertise. The Board of Water and Soil Resources project managers for this project were Jeff Hrubes and Bill Best.

2.0 Introduction

During the summer of 2002, the Red Lake Watershed District (RLWD), along with the Beltrami Soil and Water Conservation District (SWCD), and the Clearwater Lake Area Association (CLAA) collected water samples from within the Clearwater Lake watershed for the Clearwater Lake Water Quality Study. A Challenge Grant from the Minnesota Board of Water and Soil Resources funded this project.

3.0 Background Information

According to the pre-settlement vegetation map from the Minnesota Department of Natural Resources, Clearwater Lake was considered a water or lake area before settlement. The surrounding local watershed was predominantly forested. The dam on Clearwater Lake raised the amount of storage in the lake. The Minnesota Department of Game and Fish constructed the dam at the outlet of Clearwater Lake in 1931. Normal lake elevation is considered 1273 feet Mean Sea Level, where the surface area at this height is 988 acres. The dam is designed so that 2-foot stop logs may be installed above the concrete crest. There is also a 4-foot wide slot in the dam where stop logs could be removed to draw the level down about three feet below the crest. Information on dam design and the rating curve is on file at the Red Lake Watershed District office.

Since the construction of the dam, development around the lake has increased to include approximately 127 cabins and lake homes. The recreation and economic value of the Clearwater Lake area has greatly increased. Due to this fact, maintaining and improving the water quality of Clearwater Lake has been a top priority of local and state government agencies. This has spurred the effort of developing a management plan for the lake as well as a water quality model study for the lake.

4.0 Previously Collected Water Quality Data and Information

There has been considerable data collected on Clearwater Lake in the past by state agencies and volunteers. This section summarizes the data collected to this point and some findings.

4.1 Clearwater River Nonpoint Study (RLWD)

During this diagnostic study, data was collected over approximately one year in 1992 and 1993. The study found that during 1992, the lake was mesotrophic with a mean total phosphorus concentration of 29 ug/L and a mean Secchi disk reading of 3.3 m (10.8 ft.). The lake was found to be moderately efficient at retaining phosphorus (approximately 37% of inlet load) as well as the retention of nitrogen (approximately 31% of inlet load). According to the study, solids retention generally does not occur, although there is not a differentiation between dissolved and suspended solids.

The difference in mass loads between nitrogen and phosphorus determined by the Nonpoint Study suggests that Clearwater Lake is phosphorus limited.

4.2 Long-term Monitoring Program (RLWD)

The Red Lake Watershed District has collected baseline water quality data on a periodic basis (mainly quarter annually) since 1984 at the outlet of Clearwater Lake. The Red River Watershed Assessment Protocol Project currently being conducted by the Red Lake Watershed District will perform a statistical analysis of this data. This will be done to compare this site to others within the RLWD and determine the long-term range of water quality parameters.

4.3 Lake Assessment (MPCA)

In 1996, the Minnesota Pollution Control Agency collected intensive in-pool measurements of several water quality parameters. A report of this study was not generated at this point.

4.4 General Lake Monitoring (Beltrami and Clearwater Counties, Clearwater Area Lake Association)

The Beltrami and Clearwater County Soil and Water Conservation Districts in cooperation with the Clearwater Area Lake Association have collected in-pool measurements of total phosphorus, chlorophyll-a, and Secchi disk. The information from the years 2000 and 2001 show that on average the trophic status of Clearwater Lake is bordering between mesotrophic and eutrophic.

5.0 Problem Description

The intensive set of water quality information gathered in 1996 for the Clearwater Lake Assessment used in-pool monitoring to display the trophic status of Clearwater Lake. Though, the study did not use collected data to determine hydrologic, nutrient and sediment budgets for Clearwater Lake. Furthermore, the information available at the time about Clearwater Lake did not identify the sources or provide any recommendations or solutions to lake water quality problems.

Concerns about water quality on Clearwater Lake include increases in the growth of problem algae and aquatic vegetation and the nutrient and/or sediment loading to the lake from the contributing drainage area. Concerns from the contributing drainage area include urban and rural land use.

6.0 Study Purpose and Goals

The purpose of this study is to provide feasible and economic solutions to maintaining and improving water quality in Clearwater Lake. The information from this study will be used to develop lake management goals and action steps in the Clearwater Lake Management Plan. The specific technical goals of this project include:

- Develop loading estimates from sites in question in the upper portion of the Clearwater Lake watershed (i.e. above and below the City of Bagley and Walker Brook)
- Develop an estimate of the hydrologic budget by measuring or estimating the amount of precipitation, surface inflow, surface outflow, evaporation, groundwater inflow/outflow and change in storage.
- Develop a statistical analysis of the flow and water quality data with graphical and tabular displays (i.e. boxplots, DO/water temp. area graphs), which will include a comparison of the trophic state of Clearwater Lake to other lake data. This information can also be compared to MPCA's Lake Assessment data.
- Develop an annual mass balance for total phosphorus, total nitrogen, total solids, and total suspended solids and chloride.
- Develop a water quality model of Clearwater Lake using the collected data (hydrologic and nutrient balances). The BATHTUB program from the Army Corps of Engineers will be used to develop the water quality model. The model will be used to evaluate effects of nutrient load reductions on in-lake water quality.
- Use the water quality model to estimate arbitrary load reductions in Clearwater Lake (i.e. reducing nutrient loads by 10%, 20%, etc.) and its predicted effect on lake water quality.
- Develop a technical report/memorandum to be used as a guide for the Clearwater Lake Management Plan.

7.0 Period of Study

The BWSR Local Water Planning Challenge Grant project implementation period began July 1, 2001 and ends June 30, 2003. The period of data collection for the mass balances and the water quality model will proceed from November 2001 to November 2002. Assessment of the data, model development and report development will occur from November 2002 to April 2002, with the report due April 2002 (See project workplan).

8.0 Methods

Samples were collected according to the Clearwater Lake Water Quality Model Sampling and Analysis Plan and the Standard Operating Procedures for Water Quality Monitoring in the Red River Watershed. The samples were collected at six sites along the Clearwater River, and two in-pool sites within Clearwater Lake. Samples were collected monthly during the ice-on period of the year and bi-weekly during the ice-off period. Nineteen samples were collected at each site over the course of the study, with the exception of the Buzzle Lake outlet, for which fifteen samples were collected. At times, two hydrolabs (SWCD's and RLWD's) were used during the lake monitoring in order to compare results and check for errors. In most cases, the two readings were averaged for summarization and graphical analysis purposes. The following is a description of the stream and lake monitoring sites:

- #52 - Clearwater Dam, (Clearwater Lake outlet)-located on Clearwater County Road # 4, in section 12 of Sinclair Township.

- #131 - Clearwater River (Clearwater Lake inlet)-located on Beltrami County Road #24, in section 31 of Buzzle Township and section 32 of Roosevelt Township.

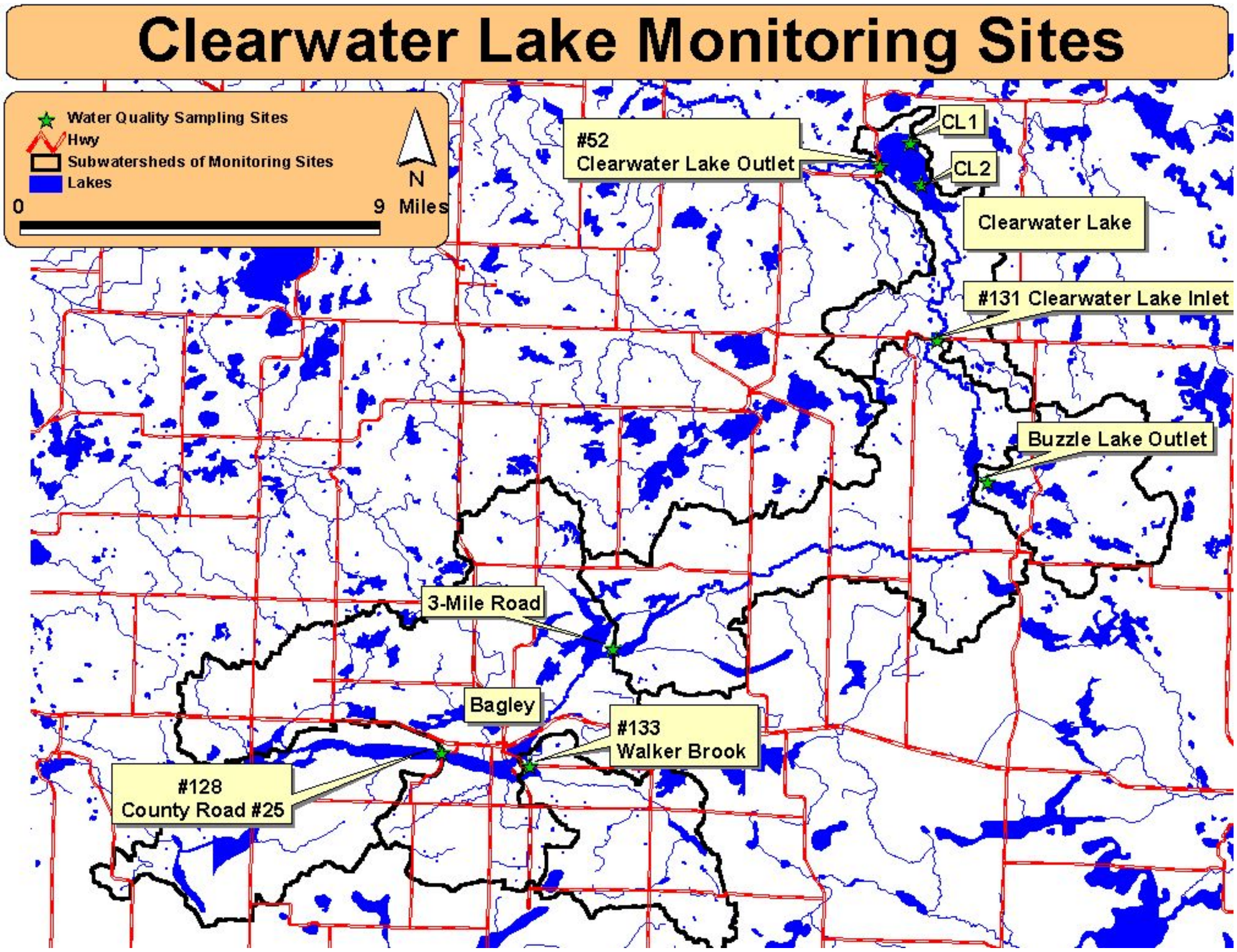
- Buzzle Lake outlet (tributary of the Clearwater River) located on a gravel township road northwest of Beltrami County Road # 5, north of Pinewood 2 miles, in section 20 & 21 of Buzzle Township.

- 3-mile road - Clearwater River - located on a gravel township road, 1 mile north of Clearwater County Road #91, in section 10 & 11 of Copley Township.

- #133 - Clearwater River (tributary of the Walker Brook)-located on Clearwater County Road #19 southeast of Bagley, in section 29 & 32 of Copley Township.

- #128 - Clearwater River-located on Clearwater County Road #25 southwest of Bagley, in section 25 of Popple Township.

- Two lake monitoring sites were sampled in Clearwater Lake and were named CL1 and CL2. CL1 was located in the deepest part of the lake, towards the northwest end of the lake, and CL2 was the shallower site located toward the southeast end of the lake. The sites were located in section 12 of Sinclair Township and section 7 of Roosevelt Township, respectively.



RMB Environmental Laboratories in Detroit Lakes performed the water quality sample analysis for the project. Stream samples were analyzed for: total phosphorus (TP), orthophosphorus (OP), total suspended solids (TSS), total dissolved solids (TDS), ammonia (NH_3), nitrates/nitrites ($NO_2 + NO_3$), chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), and fecal coliform. Field measurements were taken for water temperature, dissolved oxygen (DO), conductivity, and pH at each site. Total phosphorus and chlorophyll-a samples were collected at the Clearwater Lake in-pool sites along with Secchi disk readings. Descriptions of parameters and some other terms that will be used in this report are listed on the following pages.

- **Chemical Oxygen Demand (COD)** is a measure of the amount of oxygen required to degrade organic compounds in water. This is the equivalent of the organic matter content in a sample that is susceptible to oxidation by a strong chemical oxidant. Elevated levels of COD may reduce the amount of dissolved oxygen in the water.

- **Chlorophyll-a** is a molecule that absorbs sunlight, and is an important part of photosynthesis. Chlorophyll-a samples taken from a lake are used as a measure of the amount of algae present in the water. Chlorophyll-a test results are used along with total phosphorus levels and Secchi disk readings to calculate the trophic state of a lake.

- **Conductivity** is the measurement of the water's capacity for conveying electrical current and is directly related to the concentrations of ionized substances in the water. The conductivity of water increases with an increase in the level of dissolved solids in the water. Elevated levels of conductivity may be related to geology, flow conditions, groundwater sources, urban runoff, and runoff from fields.

- **Dissolved Oxygen (DO)** is the amount of oxygen freely present in water. Dissolved oxygen is important for reproduction of aquatic life, natural degradation of pollutants in the water, and photosynthesis in plants. Decaying organic matter, warmer water temperatures, sediment in the river, and bacterial respiration are all potential causes of depleted dissolved oxygen levels. An average level of 5 mg/L, with levels not dropping below 4 mg/L is necessary for the survival of fish in a waterbody.

- **Fecal coliform bacteria** are microorganisms that are present inside the intestines of animals and humans. The presence of fecal coliform bacteria can indicate the presence of other disease-causing organisms. Sources of fecal coliform bacteria include animal waste (domestic animals and wildlife), sewage, and untreated urban stormwater runoff.

- **Hypolimnetic Oxygen Depletion (HOD)** The rate at which dissolved oxygen is decreased in the bottom layer (hypolimnion) of a water body when it is being consumed faster than it can be replaced. There are two ways of measuring it, volumetric hypolimnetic oxygen depletion rate (VHOD – g O_2/m^3/day) and aerial hypolimnetic oxygen depletion rate (AHOD – g O_2/m^2/day). VHOD is used in this study. The oxygen depletion rate can be used as a measure of the productivity within a water body.

- **Load** is the mass of a particular water quality parameter such as suspended solids or phosphorus being carried past a point in a stream.

- **Metalimnetic Oxygen Depletion (MOD)** The rate at which dissolved oxygen is decreased in the middle layer (metalimnion) of a water body when it is being consumed faster than it can be replaced. The volumetric metalimnetic oxygen depletion rate (VMOD - g O_2/m^3/day) was used in this study. Warmer temperatures within the metalimnion and the subsequent higher rates respiration of zooplankton and heterotrophic bacteria may contribute to MOD. The metalimnion can also be a density barrier to sinking particles of organic matter, which are then be decomposed by bacteria, thus reducing oxygen levels.

- **Nitrogen - Ammonia Nitrogen (NH_3)** is a form of nitrogen that exists as a colorless gas with a strong odor mainly from fertilizers. Death can occur from large doses. Ammonia nitrogen is available as a nitrogen source for living organisms. In a lake, these organisms would include aquatic macrophytes and algae. Ammonia nitrogen is produced in rivers by decaying organisms, industrial waste, and fertilizer.

- **Nitrogen - Nitrates/Nitrites (NO_2 and NO_3)** are forms of nitrogen that are abundant in the environment, while nitrate is one of the primary forms of nitrogen for plant uptake, it is a major concern in water quality because of hemoglobonemia, or blue baby syndrome, that occurs when high nitrate concentrations in drinking water that cut off blood supply to the body. Nitrogen levels greater than .5 mg/L (milligrams per Liter, or ppm - parts per million) are toxic to rainbow trout. The standard for nitrates in drinking water is 10 mg/L. Nitrate levels that fall between 0 and .40 mg/L indicate a low level of impact from agriculture and other human activities. Nitrate levels that fall between 0 and 4.5 mg/L show a medium impact, and levels that are between 0 and 30 mg/L show a high degree of impact. Increased nitrogen concentrations can be caused by wastewater, low flow, failing septic systems, animal waste, atmospheric deposition, natural sources (dependant upon geology and soils of the area), and fertilizers applied to crops, lawns, and golf courses. Since nitrogen is often present in lower concentrations than phosphorus, it is often the limiting nutrient for algae growth in lakes.

- **Nitrogen - Total Kjeldahl Nitrogen (TKN)** is the amount of organic nitrogen and ammonia nitrogen together in water. Total Kjeldahl nitrogen can come from decaying plant matter, decaying animal waste, industrial waste and fertilizer.

- **Peak discharge** is the volume of runoff during a storm event per inch of rain per mile.

- **Peak runoff** is the peak amount of overland flow that enters the river during a 5-year 24-hour storm event. For the Clearwater Lake watershed, this is equal to 2.69 inches of rain in 24 hours.

- **pH** is the negative log of the activity of hydrogen ions in a liquid. It is used to determine whether water is acid or alkaline. A pH of 7 is neutral. A pH of less than 7 is acid and a pH of greater than 7 is alkaline. Organic acids produced by decaying organic matter in wetlands and bogs can cause a decrease in pH (an increase in acidity). Algae introduce Carbon Dioxide to the water column, which in turn, lowers pH and increases the acidity of the water. Water with a low pH (high acidity) can have an increased availability and toxicity of metals and toxins such as mercury and ammonia.

- **Phosphorus – Ortho Phosphorus (OP)** is the inorganic soluble (dissolved) reactive form of phosphorus that is readily used by algae and other plants.

- **Phosphorus – Total Phosphorus (TP)** is the total amount of organic phosphorus (living materials such as algae) and inorganic phosphorus in a water sample. Elevated levels of TP in lakes cause eutrophication and algae blooms. If phosphorus is the limiting nutrient within a lake (the nutrient in shortest supply), even a small increase in the amount of phosphorus can cause a large increase in the growth of aquatic vegetation. Keeping the inflow of TP at acceptable levels will help maintain the health of a lake. Reducing the levels of TP flowing into a lake will help improve the water quality within the lake. TP levels are adversely affected by wastewater effluent, failing septic systems, urban stormwater runoff (especially from lawns and streets), industrial wastewater, plant material, and agricultural runoff. Phosphorus readily attaches to sediment particles. An increase in the level of total suspended solids may increase the level of total phosphorus.

- **Secchi Disk** readings are taken using a round disk approximately 8 inches in diameter that is either marked with alternating black and white quadrants or is completely white. The disk, attached to an incrementally marked rope, is lowered to the deepest point at which the disk is still visible, in other words, the point just before it disappears. The depth to this point is then measured using markings on the rope to obtain the reading.

- **Total Dissolved Solids (TDS)** is the amount of material that is dissolved in the water (either organic or inorganic). In large amounts this can affect drinking water and corrode metals. Sources of dissolved solids include natural causes, erosion, sewage, urban runoff, and industrial wastewater.

- **Total Suspended Solids (TSS)** is a measure of the amount of material suspended in the water (either organic or inorganic materials). High levels of suspended solids can impair aquatic life and plant life by blocking sunlight. Suspended solids can enter waterways by means of erosion from cropland, roadways, ditches, building sites, stream banks, livestock grazing or confinement areas, urban areas, and forested lands. A portion of the suspended solids carried by a river comes from natural sources, but the level of total suspended solids in the river can be minimized by reducing the amount of human impact through the use of Best Management Practices (BMPs) such as vegetative cover, buffer strips and conservation tillage.

- **Water Temperature** is the warmth of the body of water. Temperature can exert great control over aquatic communities, lake stratification and water chemistry.

9.0 Stream Monitoring Results

There are two reaches within the Clearwater Lake watershed that are on the MPCA 2002 and 2004 303(d) impaired waters lists. These two reaches are Walker Brook from Walker Brook Lake to the Clearwater River, and the trout stream portion of the Clearwater River. Walker Brook is listed for low dissolved oxygen, which impairs the ability of the stream to support aquatic life. The trout stream portion of the Clearwater River, which begins at the Beltrami County line and ends at Clearwater Lake, is impaired for fecal coliform. This impairs the river for the designated use of swimming. The impairments are based upon Environmental Protection Agency standards for the State of Minnesota. The standard for dissolved oxygen is 5 mg/L and the standard for fecal coliform is 200 coliforms/100 ml.

During the RLWD's 2002 monitoring program in the Clearwater Lake watershed, only two potential impairments were found based upon the EPA standards. The Walker Brook sampling site and the 3-mile road sampling site were both impaired for aquatic life based on low dissolved oxygen levels. 3-mile road would be considered partially supporting (>10% of samples exceed the standard), but Walker Brook would be considered not supporting (>25% of the samples exceed the standard). Fecal coliform exceedances were also recorded, including a high spike at County Road #25. However, the frequency of exceedance of the fecal coliform standard at County Road #25 over the last ten years is only 6.52% based on RLWD district monitoring and the monitoring conducted for this study. Based on this information, the site would still pass as fully supporting in the first step of the process of determination of an impairment. Also, according to RLWD district monitoring data, the monitoring site at the Highway 2 crossing on the Clearwater River (S.G. #O-6) is impaired for dissolved oxygen because it has failed to meet the EPA standards in 22.9% of the samples taken there over the last ten years. That site would not be considered impaired in respect to fecal coliform because it has failed to meet the fecal coliform standards in just 6.1% of the samples. S.G. #O-6 is not yet listed on the 303(d) list because the data from the site was not in the EPA STORET database at the time of the assessment for the 2004 list. It is currently in the process of being entered. The MPCA only uses data from the STORET database to assess bodies of water.

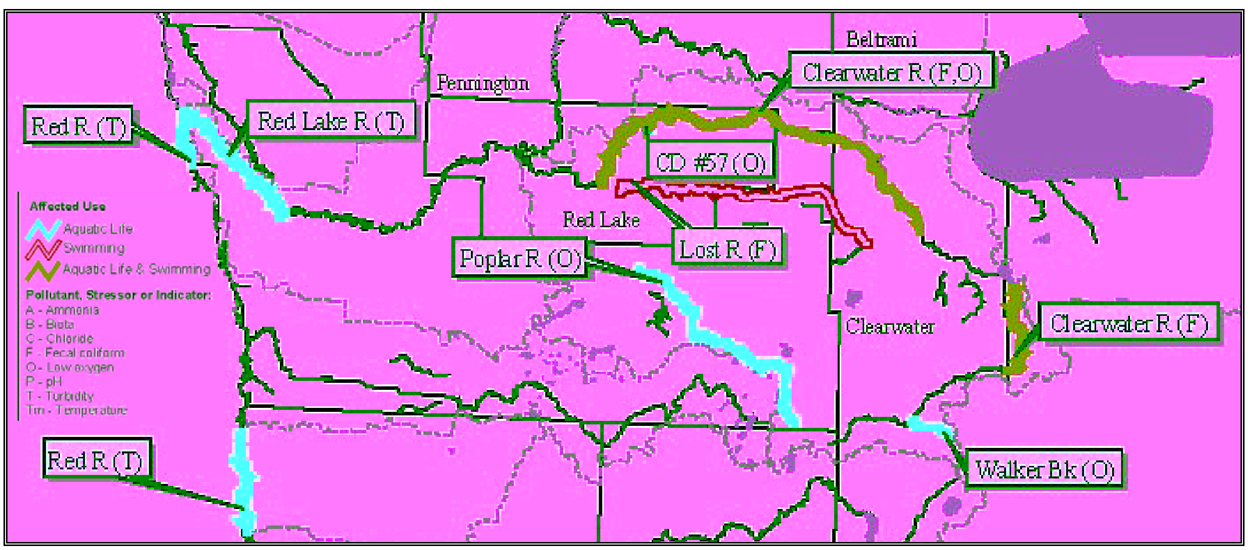
Exceedances occurred at other sites and for other parameters during the Clearwater Lake Water Quality Model Study, but at a lower frequency. These are noted in the following table.

Percentage of 2002 Samples Not Meeting EPA Standards					
Site	**DO**	**Fecal Coliform**	**Conductivity**	**TSS**	**TDS**
Standard	5 mg/L	200 col./100 ml	1,000 mg/L	25 mg/L	500 mg/L
Co. Rd. 25	5.3%	7.1%	0.0%	0.0%	0.0%
Walker Brook	26.3%	7.1%	0.0%	0.0%	0.0%
3-Mile Road	15.8%	0.0%	0.0%	5.3%	0.0%
Buzzle Lake	0.0%	0.0%	0.0%	0.0%	0.0%
CL Inlet	0.0%	0.0%	0.0%	5.3%	0.0%
CL Outlet	0.0%	0.0%	0.0%	0.0%	0.0%

The Minnesota Pollution Control Agency also has a list of standards for minimally impacted streams for each ecoregion within the state. These standards are not currently used in the 305(b) report assessment process or for placing water bodies on the 303(d) list of impaired waters. For the Clearwater Lake watershed, most of these standards are tougher since the water quality within the Northern Lakes and Forests ecoregion is expected to be better than the water quality within the Red River Valley based upon land use, geology, and position within the overall watershed. The ecoregion standards are listed and exceedances during the Clearwater Lake Water Quality Model Study are highlighted in the table below.

Percentage of 2002 Samples Exceeding Ecoregion Standards for Minimally Impacted Streams							
Site	**TSS**	**Fecal Coliform**	**Conductivity**	**Ammonia**	**TP**	**Nitrates and Nitrites**	**Water Temp.**
Northern Lakes and Forests							
Standard	**6.4 ppm**	**20 col./100 ml**	**270 ppm**	**.20 ppm**	**.052 ppm**	**.09 ppm**	**17.6 ºC**
Co. Rd. 25	10.5%	26.3%	100.0%	15.8%	21.1%	0.0%	47.4%
Walker Brook	0.0%	57.9%	94.7%	21.1%	57.9%	0.0%	47.4%
Buzzle Lake	0.0%	5.3%	68.4%	0.0%	0.0%	0.0%	47.4%
CL Inlet	42.1%	31.6%	100.0%	15.8%	47.4%	42.1%	42.1%
North Central Hardwood Forests							
Standard	**16.1 ppm**	**330 col./100 ml**	**340 ppm**	**.22 ppm**	**.170 ppm**	**.29 ppm**	**20.0 ºC**
CL Outlet	0.0%	0.0%	94.7%	5.3%	0.0%	0.0%	26.3%
3-Mile Road	5.3%	0.0%	100.0%	10.5%	0.0%	0.0%	36.8%

When compared to EPA standards (single values applied to the whole state), the Clearwater River does well for most parameters, but when compared with ecoregion standards, it is evident that there is room for improvement. Although natural causes contribute to some of the impairments on the river, human activities often have a direct affect on water quality. Below is a map reaches within the RLWD that are listed on the 2002 Impaired Waters List.



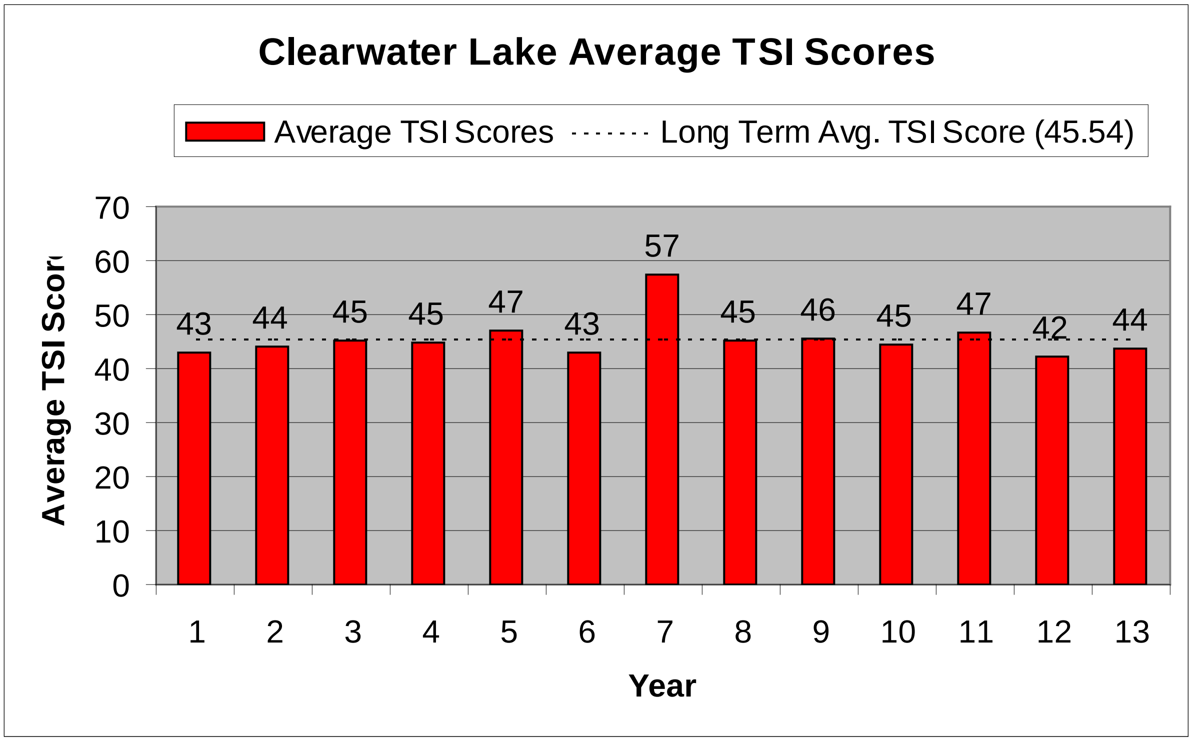
10.0 Lake Monitoring Results

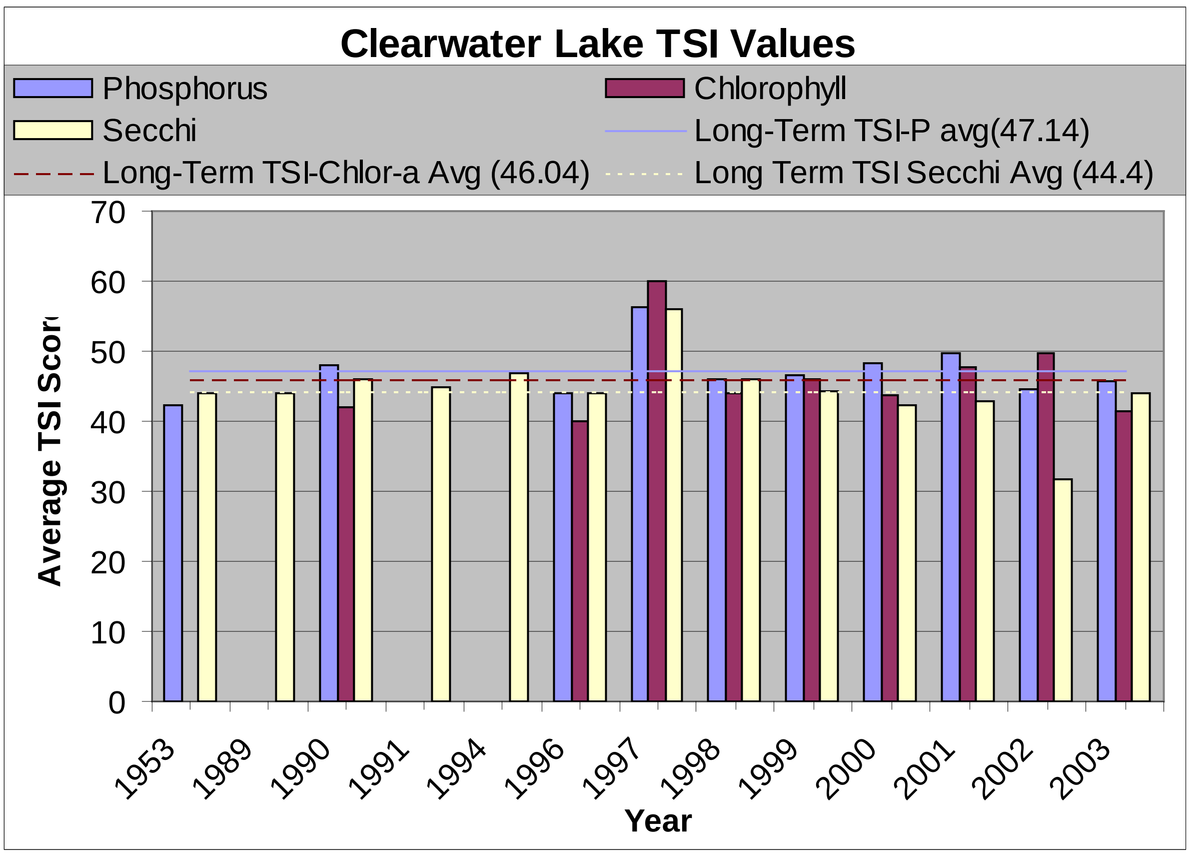
The monitoring site used to determine the trophic state of the Clearwater Lake is CL1 (also called site #204 by the MPCA), which is located at the deepest point of the lake. This site was monitored prior to this study and continues to be monitored by the RLWD and the Clearwater Lake Area Association.

The trophic state index (TSI) is a score based upon total phosphorus, Secchi disk, and chlorophyll-a readings. It is used to classify the growth and productivity of a lake. Lakes may be oligotrophic (<30), mesotrophic (40-50), eutrophic (50-60), or hypereutrophic (>70). The average trophic state index score for Clearwater Lake in 2002 was 42.18. This score is on the lower end of the mesotrophic range and is an improvement from previous years. The average trophic state of the lake is normally around the middle of the mesotrophic range. This means that the lake has enough nutrients to support aquatic life but does not have an excessive amount of nutrients. This is a desirable condition for the lake. The lake is unable to support salmonids (trout), but supports a predominant walleye population.

The charts below show yearly average trophic state scores for all the years in which data was collected. Although the average score of the lake is in the low-to-mid-40’s, there is a great range in scores throughout the year. During the summer of 2002, the TSI scores ranged from 31 to 47. In 2003, the TSI scores ranged from 40-54.

The water in Clearwater Lake can be very clear at times. The lake had average Secchi disk readings of 7.54 in 2002 and 9.5 in 2003. On June 9, 2003, the Secchi disk reading was 16.5 feet. Although the water quality in the lake is relatively good, Clearwater Lake is still listed on the MPCA’s 2004 303(d) list of impaired waters. Due to mercury content, the use of aquatic consumption is impaired and the lake has a fish consumption advisory. A lake is considered impaired for mercury content if fish consumption for a species of fish is limited to one meal or less per week. According to the *Minnesota Department of Health Fish Consumption Guidelines for the General Population*, northern pike longer than 15 inches should be limited to one meal per week. Walleye longer than 15 inches should be limited to one meal per week and walleye longer than 20 inches should be limited to one meal per month. Bluegill sunfish, white sucker, and yellow bullhead are listed as unlimited.


Clearwater Lake Average TSI Scores
Average TSI Scores
Long Term Avg. TSI Score (45.54)
Average TSI Score
Year
43 44 45 45 47 43 57 45 46 45 47 42 44
1 2 3 4 5 6 7 8 9 10 11 12 13
0 10 20 30 40 50 60 70


Clearwater Lake TSI Values
Phosphorus
Chlorophyll
Secchi
Long-Term TSI-P avg(47.14)
Long-Term TSI-Chlor-a Avg (46.04)
Long Term TSI Secchi Avg (44.4)
Average TSI Score
Year
1953 1989 1990 1991 1994 1996 1997 1998 1999 2000 2001 2002 2003
0 10 20 30 40 50 60 70

How does the lake compare to other lakes within the same ecoregion? Based on the 1994 Minnesota Lake Water Quality Data Base Summary, Clearwater Lake has ranked at about the 18th percentile for area, at the 25th percentile for depth, between the 50th and 75th percentiles for TSI-phosphorus, between the 50th and 80th percentiles for TSI-chlorophyll-a, between the 50th and the 100th percentiles for TSI-Secchi, and between the 50th and the 60th percentiles for TSI-mean. The table below is a comparison of 2002 monitoring results at CL-1 with average values for all lakes within the Northern Lakes and Forests ecoregion. Also listed below are the MPCA thresholds for determination of use support (swimming) for lakes. All values below the threshold values listed are fully supporting and those above the threshold values are listed as impaired and would fall under the category of partially supporting or potentially non-supporting in the 305(b) assessment process. If a lake is listed as partially supporting or potentially non-supporting, it is either reviewed or listed as impaired on the 303(d) list, based on the degree of impairment. Clearwater Lake meets all of the MPCA standards so it would be determined to be fully supporting for swimming use based on the data collected for this study.

Parameter	MPCA Thresholds	Northern Lakes and Forests Ecoregion	Clearwater Lake 2002	Clearwater Lake 2003
Total Phosphorus (ppb)	30	14-27	30	22.4
Chlorophyll-a Maximum (ppb)		<15	16	21
Chlorophyll-a Mean (ppb)	10	<10	8.45	7.57
Secchi Disk (ft)	5.25	8-15	7.54	9.5
Total Kjeldahl Nitrogen (ppm)		<0.75	.44	.42*
Nitrates and Nitrites (ppm)		<0.01	.006*	.057*
pH		7.2-8.3	8.35	8.39
Total Suspended Solids (ppm)		<1-2	2.06	2*
Conductivity		50-250	409.46	383.80
TN:TP ratio		25:1 – 35:1	14.8	21.28

*Concentrations are based on results from the Clearwater Lake outlet since no analysis for this parameter was conducted on lake samples.
*ppb = parts per billion, or micrograms per Liter (µg/L)

The lake is mixed in the spring, stratified throughout the summer, and then mixed again in the fall. When a lake is stratified, it has three layers, the epilimnion (top layer), metalimnion or thermocline (middle, transitional layer), and the hypolimnion (bottom layer). The lake experiences its highest trophic state levels when it is mixed as nutrients are brought up from the bottom of the lake and mixed with the rest of the water column. Clearwater Lake experiences anoxia (no dissolved oxygen) in the hypolimnion during late summer. Hypoxia (low dissolved oxygen) occurs in the hypolimnion of Clearwater Lake throughout the year, with the exception of when the lake was mixed. During anoxia, there is not enough oxygen for fish to survive, plus, phosphorus can be released from the sediment on the bottom of the lake by bacteria. This phosphorus is relatively isolated in the hypolimnion until the lake mixes or “turns over.”

Phosphorus may then be mixed into the rest of the water column and increases the levels of phosphorus in the upper water column where water quality samples are taken.

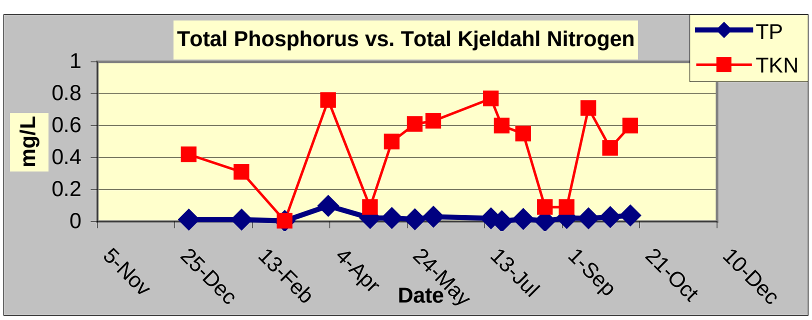
The conductivity levels in the lake are high relative to the ecoregion values; this is possibly due to the geology of the area and suggests a strong interaction between the lake and ancient ground water that contains a high amount of dissolved solids. Ground water with high TDS levels entering the lake would increase the electrical conductivity of the lake.

The lake exhibits a clinograde oxygen profile throughout the year. This means that dissolved oxygen levels decrease from the epilimnion to the hypolimnion. This may be due to decomposition of organic matter on the lake bottom, lack of circulation of water (oxygen levels dramatically decrease in the hypolimnion during stratification in Clearwater lake), lack of sunlight penetration into the hypolimnion for photosynthesis, water temperature, the volume of the hypolimnion, and/or chemical oxidation of dissolved organic matter.

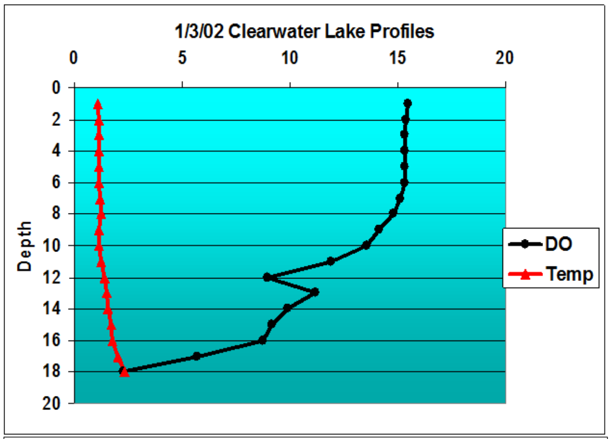
A series of profiles are included in this report, starting on page 17. Lines that are relatively straight indicate periods of mixed conditions. The kinked lines that are vertical near the surface and vertical near the bottom, but sloping in the middle indicate stratified conditions. The vertical section near the surface is the epilimnion, the sloping section is the metalimnion, and the vertical section near the bottom is the hypolimnion. Clearwater Lake is dimictic, meaning it mixes twice per year, once in the spring and once in the fall.

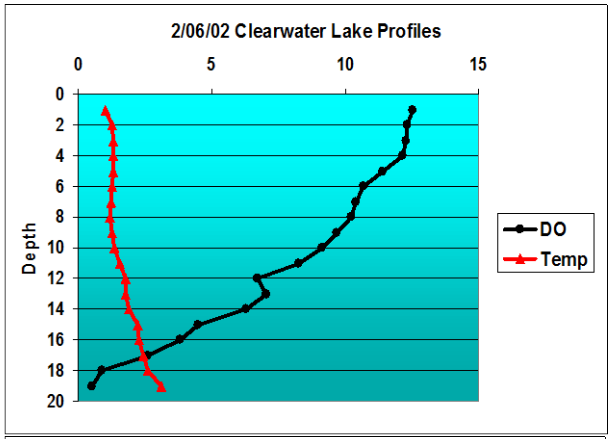
Through the monitoring of two sites on the lake, a gradient between two different zones of the lake became apparent. The shallower, more nutrient rich zone in the southeast end of the lake represents a transitional zone (CL2) between the riverine and the lacustrine (CL1) zones of the lake. The riverine zone is the relatively narrow area of the lake immediately down-stream of the river inflow where current velocities decrease and significant sediment transport still occurs. The EPA defines the lacustrine zone of the lake as that area of a reservoir that is most lake-like. Current velocities are much slower in this zone than for riverine or transitional zones. Little sediment deposition normally occurs since most sediment load has been deposited in the riverine or transitional zones. This explains the thick vegetation on that end of the lake that makes navigation difficult. This gradient and zone of sediment deposition are common on lakes and reservoirs that are located on rivers.

As was determined by the Clearwater Nonpoint Study, the lake appears to be phosphorus limited. The total nitrogen concentrations are nearly always higher than the total phosphorus concentrations as evidenced by the following graph.



The lake has recovered from extreme eutrophication and resulting TSI levels that neared 60 during the summer of 1997. The eutrophication that occurred during that summer was due a flooding related influx of nutrients that included overflows from the sewage treatment facility of the City of Bagley. Since 1997, Bagley's sewage treatment plant has been upgraded to prevent future sewage bypass. The city has also recently constructed stormwater treatment ponds to reduce the amount of sediment and nutrients entering the river.


1/3/02 Clearwater Lake Profiles
0 5 10 15 20
0 2 4 6 8 10 12 14 16 18 20
Depth
DO
Temp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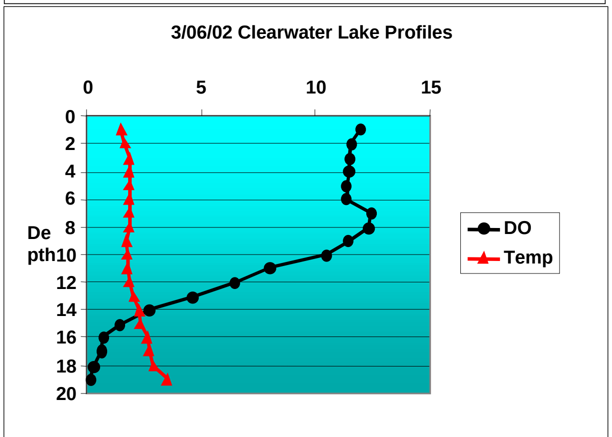
0 2 4 6 8 10 12 14 16 18 20
Depth
DO
Temp


3/06/02 Clearwater Lake Profiles
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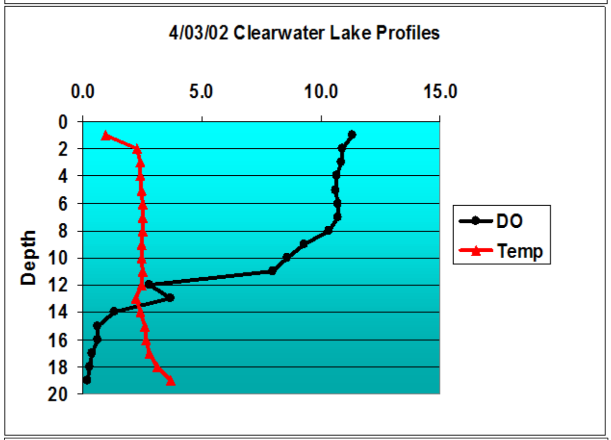
0 2 4 6 8 10 12 14 16 18 20
Depth
DO
Temp


4/03/02 Clearwater Lake Profiles
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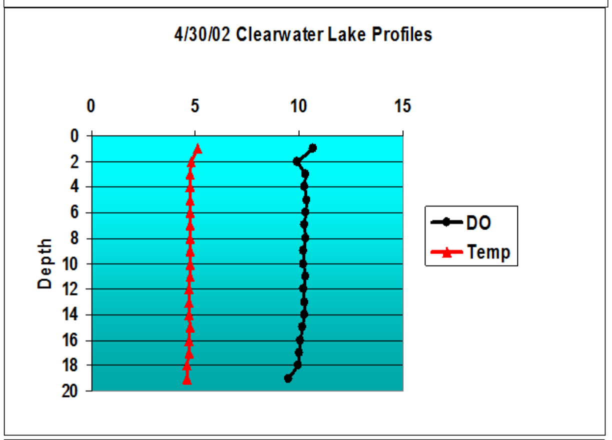
0 2 4 6 8 10 12 14 16 18 20
Depth
DO
Temp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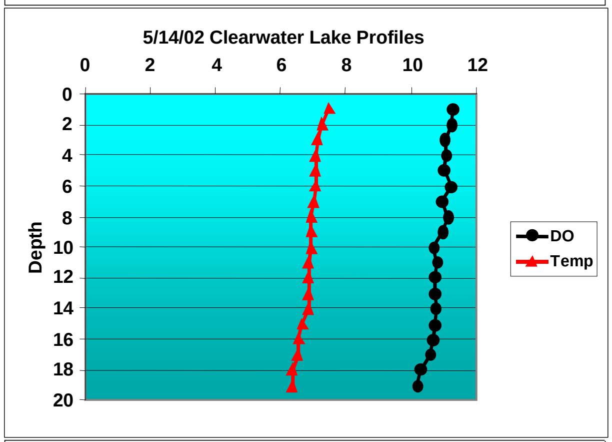
Depth
DO
Temp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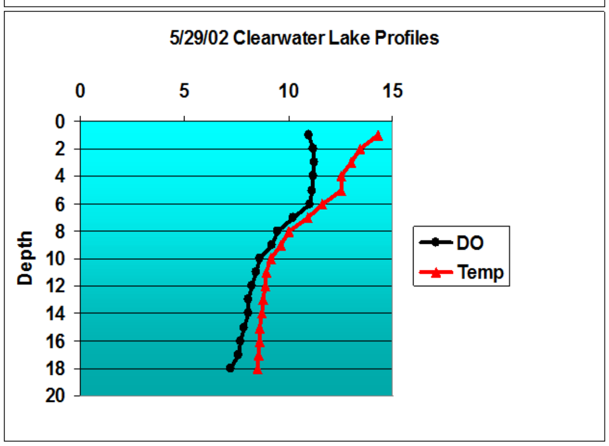
0 2 4 6 8 10 12 14 16 18 20
Depth
DO
Temp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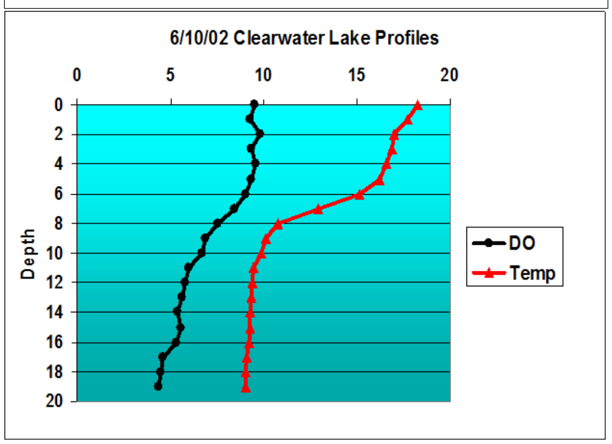
0 2 4 6 8 10 12 14 16 18 20
Depth
DO
Temp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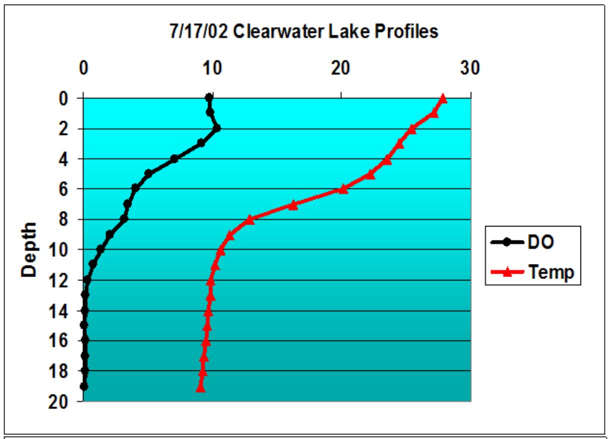
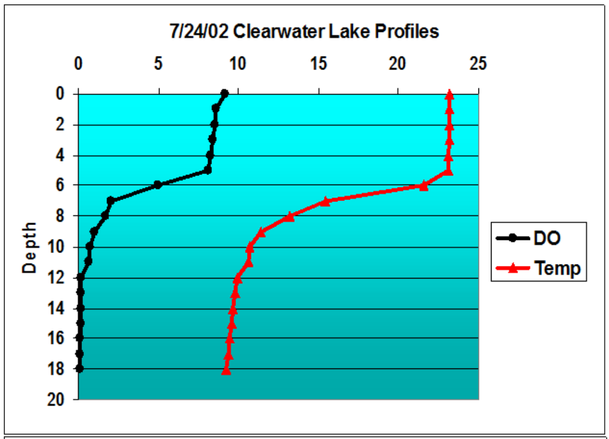
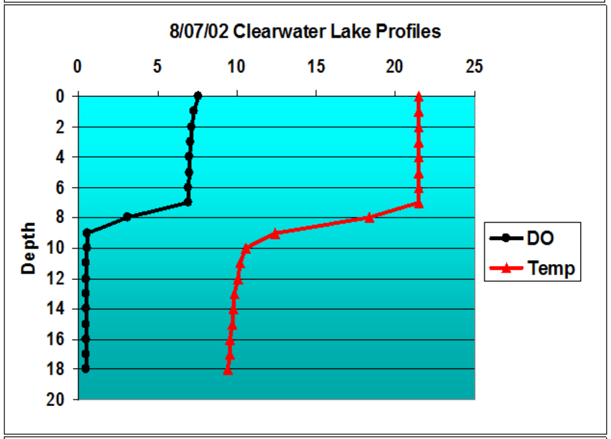
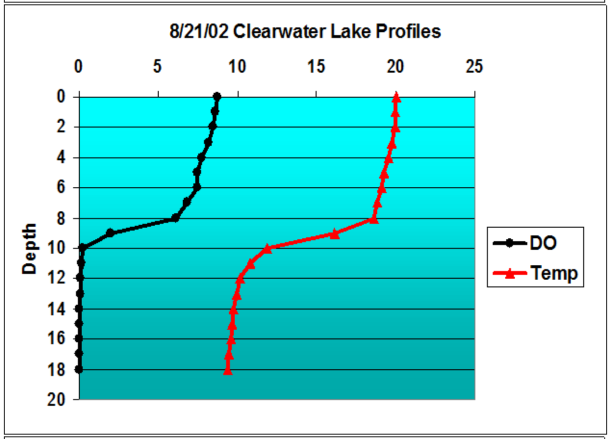
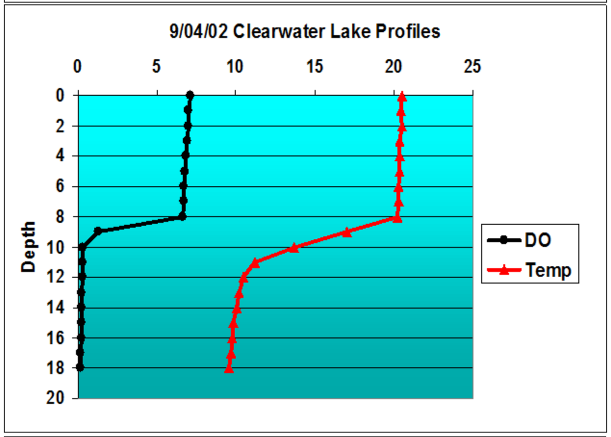
0 2 4 6 8 10 12 14 16 18 20
Depth
DO
Temp

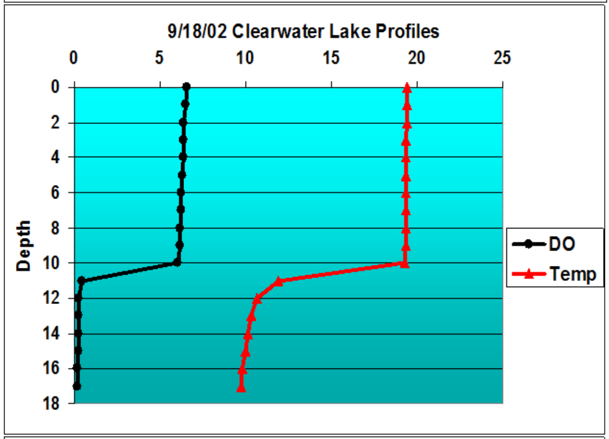

7/17/02 Clearwater Lake Profiles
Depth
DO
Temp

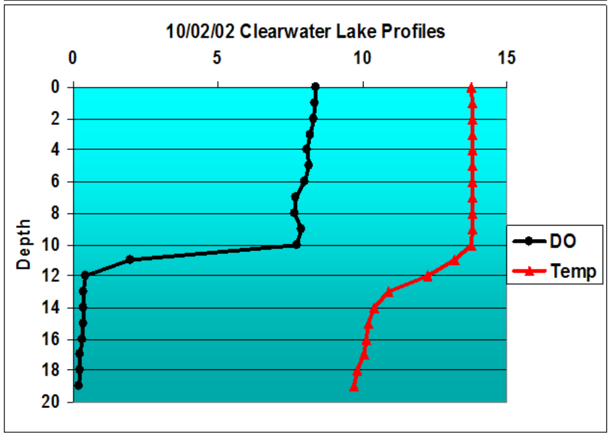

7/24/02 Clearwater Lake Profiles
Depth
DO
Temp

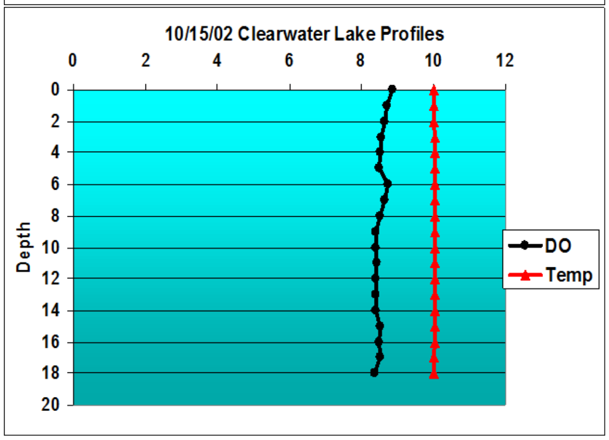

8/07/02 Clearwater Lake Profiles
Depth
DO
Temp

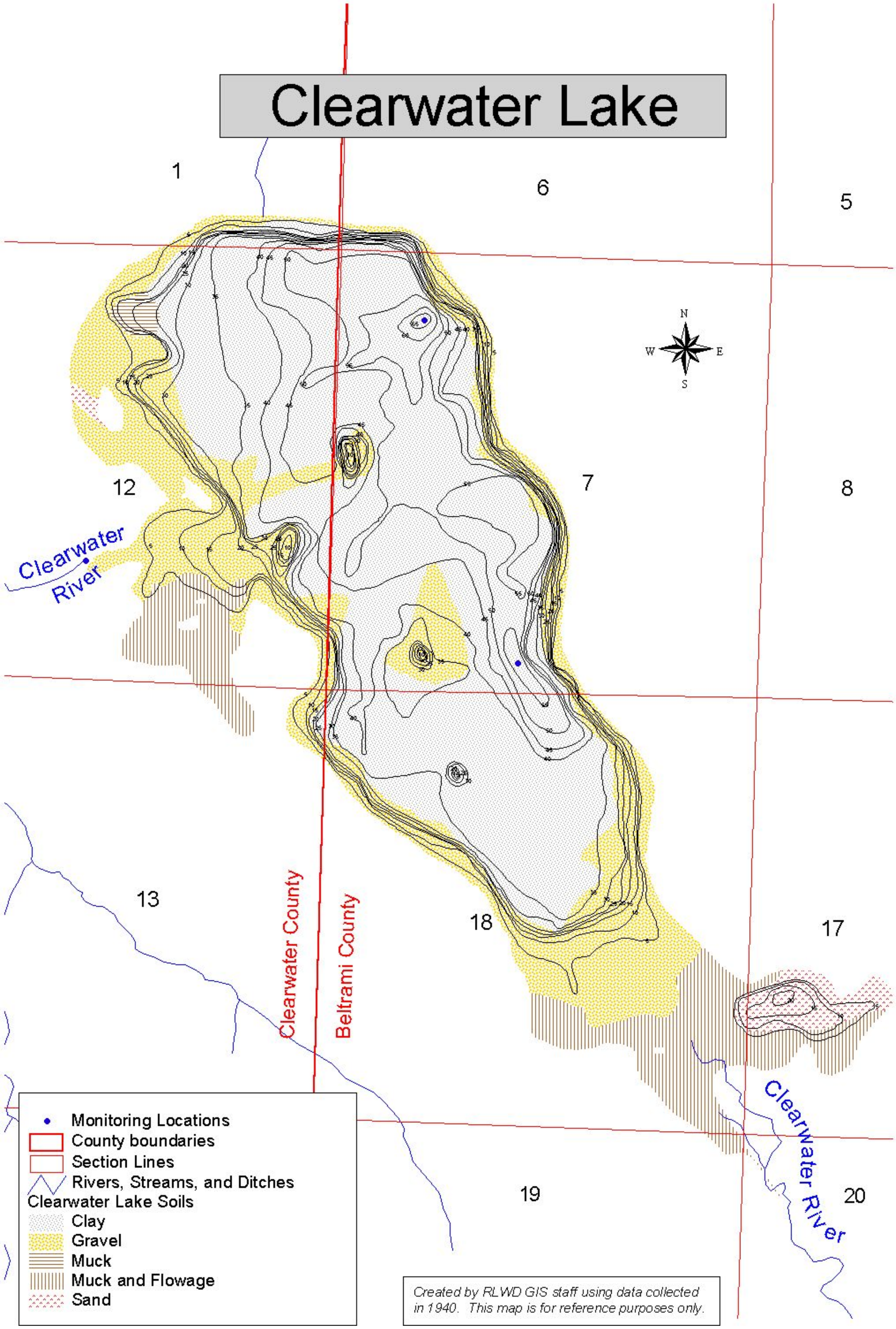

8/21/02 Clearwater Lake Profiles
Depth
DO
Temp


9/04/02 Clearwater Lake Profiles
Depth
DO
Temp


9/18/02 Clearwater Lake Profiles
Depth
DO
Temp


10/02/02 Clearwater Lake Profiles
Depth
DO
Temp


10/15/02 Clearwater Lake Profiles
Depth
DO
Temp



Clearwater Lake Bathymetric Map

11.0 FLUX Modeling Results

The water quality modeling program FLUX was used to calculate total annual flow volume in cubic hectometers, total annual loads for water quality parameters, as well as flow-weighted means for all stream monitoring sites. This program uses continuous flow data and available sampling data to determine yearly totals and averages for water quality parameters. The modeling completed for the Clearwater Lake watershed shows that, during the study period, the most water quality degradation on the Clearwater River came from two of the six subwatersheds that were monitored. The first is the watershed of the reach of the Clearwater River that lies between Clearwater County Road 25 (Site #128) and 3-mile road (excluding the Walker Brook subwatershed). The other is the watershed of the Clearwater River reach between 3-mile road and the Clearwater Lake inlet (excluding the Buzzle Lake outlet and everything upstream of 3-mile road). Other subwatersheds either minimally contribute to the degradation of water quality in the Clearwater River or actually help improve the water quality (a diluting effect) in the river in some cases. There are some of the subwatersheds that do not greatly contribute to sediment and nutrient loadings due to their low flows, but they still, in some cases, have their own water quality problems.

Water from Walker Brook enters the Clearwater River on the southeast edge of the city of Bagley. When comparing the flow weighted means before and after this confluence (at the #128 and 3-mile road water quality monitoring sites, respectively), water quality is degraded for TSS, TP, OP, TDS, Nitrates and Nitrites, and DO after the confluence and Walker Brook may appear to be the source. However, when loads (tons/year) from the Walker Brook watershed and the 3-mile road watershed are compared, the 3-mile road subwatershed is more likely to be the primary source of the degradation. It contributes higher loads than Walker Brook. Some parameters that appeared to be improved from #128 to 3-mile road include COD, TKN, Ammonia, and Fecal Coliform.

How do the watersheds of Walker Brook and #128 compare? Walker Brook has a slightly higher weighted average curve number, which means that a higher percentage of water will run off of the landscape during a storm. Walker Brook has higher TP levels but has lower TSS concentrations, which says that much of the phosphorus at this site may be dissolved in the water. Monitoring data reinforces this observation. The ratio of soluble reactive phosphorus (OP) to total phosphorus was twice as high at the Walker Brook monitoring site as it was at #128. Walker Brook is worse in terms of orthophosphorus concentrations, total dissolved solids concentrations, and peak discharge when compared to the #128 monitoring site on the Clearwater River. Walker Brook has lower concentrations of TSS, ammonia, fecal coliform, and a lower amount of peak runoff. Ammonia was not very high at either location when compared to the minimally impacted stream levels for the ecoregion.

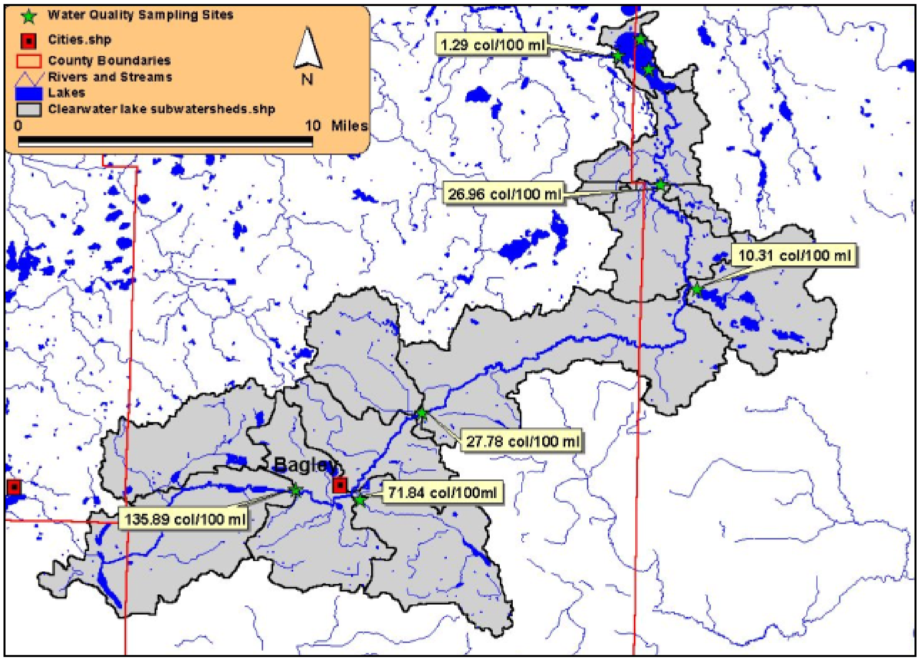
The reason Walker Brook had higher average levels of phosphorus when compared to #128 may be attributed to a period of elevated concentrations in July and August of 2002 at the Walker Brook monitoring site. When examining sample results for individual dates, Walker Brook sometimes had lower concentrations of TP than #128. The lower values may be a result of the settling of sediment when the combination of the landscape and beaver dams cause water in the stream to pool and decrease the velocity of the water. When there is a storm event, higher levels of flow, or beaver dam removal, sediment and nutrients that are settled out may be swept downstream, causing a rise in concentrations.

A high spike in fecal coliform of 1584 col./100ml was recorded at the #128 monitoring site. This accounts for the higher average levels of fecal coliform for that watershed. This spike came during relatively high flows and there was precipitation occurring at the time the sample was collected. Walker Brook also experienced some spikes, although not quite as dramatic. Both sites experienced spikes that greatly exceeded the EPA standard of 200 col./100 ml.

The channel of the Clearwater River has a relatively low slope in the upper reaches from the headwaters downstream to the confluence with water coming from the Buzzle Lake subwatershed. After this point, the channel grade increases significantly. The geology of the area, restricted flow through the culvert at 3-mile road, beaver dams, and beaver dam remnants are all factors that may be acting to keep the river in a relatively flooded state in the upper watershed of the Clearwater River. This flooded state helps to increase the temperature of the water, increase the depth of the water, and reduce the velocity of the water. A beaver dam was present just downstream of the #128 monitoring site in late summer and throughout the fall. During pre-study reconnaissance, beaver dam remnants were found by RLWD and Clearwater SWCD staff downstream of the 3-mile road site. Relatively high stage levels and relatively low flows showed that water was “backed-up” at the Walker Brook monitoring site in early June and in middle to late August of 2002, most likely because of downstream beaver dams.

Fecal coliform bacteria grow better in warmer temperatures and in deeper, more stagnant water. Although they grow better in warm-water temperatures versus cold-water temperatures, fecal coliform bacteria do not survive when exposed to too much sunlight. The deeper the water, the lower the amount of sun that can penetrate it. The shallower the water, the more sun can penetrate it. Prior to 3-mile road (upstream of the trout-stream reach), the Clearwater River and Walker Brook are both very deep and ponded when compared to the trout stream portion of the Clearwater River, even though there is a lower volume of flow in the upper watershed. It is impossible to wade far from shore in the upper watershed of the Clearwater River due to ponded water and a mucky bottom. Most of the lower watershed (trout-stream reach) is easily wadeable and has a firmer, sandier bottom. The fine sediment deposited in the upper watershed, of which the mucky bottom is composed, is most likely another factor contributing to the high growth rate of fecal coliform as well as the depletion of dissolved oxygen in the #128 watershed.

Monitoring data supports the theory that the suitability for fecal coliform bacteria growth in the river decreases from the headwaters downstream to the trout stream reach. The weighted average mean concentrations decrease in the Clearwater River from the headwaters to the Clearwater Lake inlet. This is shown in the following map.



Another reason for the decrease in fecal coliform concentrations from the headwaters to Clearwater Lake could be time of travel. Fecal coliform only has a life span of 12 hours to 5 days. So, not all the fecal coliform traveling through the #128 monitoring site will make it downstream to Clearwater Lake. The shallower water (more sunlight) and time of travel within trout stream portion of the river would help minimize the fecal coliform concentrations at that monitoring site. According to the Clearwater River Time of Travel Study of April 1991, dye traveled at an average rate of about 1 mile per hour between the Clearwater Lake outlet and the beginning of the channelized portion of the Clearwater River. The flow during that study was similar to the flow recorded at the Clearwater Lake Inlet during the Clearwater lake Water Quality Model Study. However, the flow during the study was as much as 3 times as high as the flows in the upper watershed of the Clearwater at sites such as Walker Brook and #128. The limited life span of fecal coliform can explain the fluctuation of fecal coliform levels within the #128 and Walker Brook subwatersheds. The low flow from these two watersheds would minimize the amount of fecal coliform being swept downstream. So, much of the life cycles of the fecal coliform bacteria in these two watersheds would be carried out before they get carried past 3-mile road. The life cycle of fecal coliform, including its decomposition would also consume DO. This could be one more factor contributing to the low dissolved oxygen levels in these two subwatersheds.

Construction activity within the Walker Brook watershed during the study period may have an exacerbating effect on the increase of sediment and nutrient levels during storm events. The TP levels within the Walker Brook watershed exceeded the ecoregion value for minimally impacted streams in 57.9% of the samples taken during the study. There is also a relatively high level of

COD in Walker Brook, which consumes oxygen, which, in turn, leads to low dissolved oxygen levels, which then can lead to anoxia and the release of phosphorus from sediment. Walker Brook also has a low DO problem due to organic soils, low flow and stagnant water, geologic factors such as the inflow of ancient oxygen depleted groundwater, and the highest COD levels of all the monitoring sites.

Nitrates and nitrites were rarely detectable at most of the sites in the Clearwater Lake watershed with the exception of the Clearwater Lake Inlet site. The concentrations at the Clearwater Lake inlet monitoring site exceeded the standards for minimally impacted streams within the Northern Lakes and Forests ecoregion for 42.1% of the samples taken while the all of the other sampling sites did not once exceed the minimally impacted levels for their respective ecoregions. This site had a significantly higher loading of nitrates and nitrites from its subwatershed. Since agricultural runoff is one of the sources of this pollutant, a buffer strip program and the implementation of other conservation practices should be implemented to help alleviate this problem.

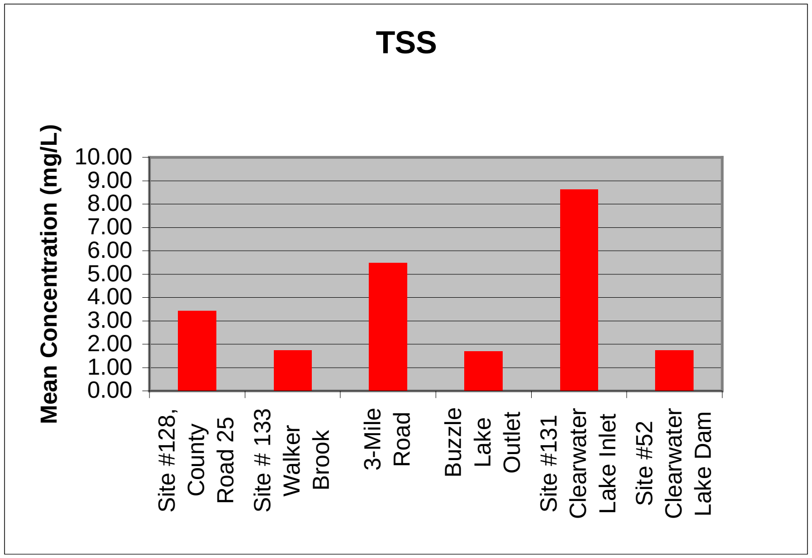
The 3-mile road subwatershed had the highest amount of peak runoff of all the subwatersheds. The development around the City of Bagley may be a contributing factor to this runoff. Stormwater ponds have recently been constructed to capture the rapid runoff from the city and remove sediment and other pollutants from the water before it enters the river. Now that the stormwater runoff from Bagley will be treated with stormwater retention ponds, the runoff from this subwatershed should have less of an impact upon the water quality of the Clearwater River.

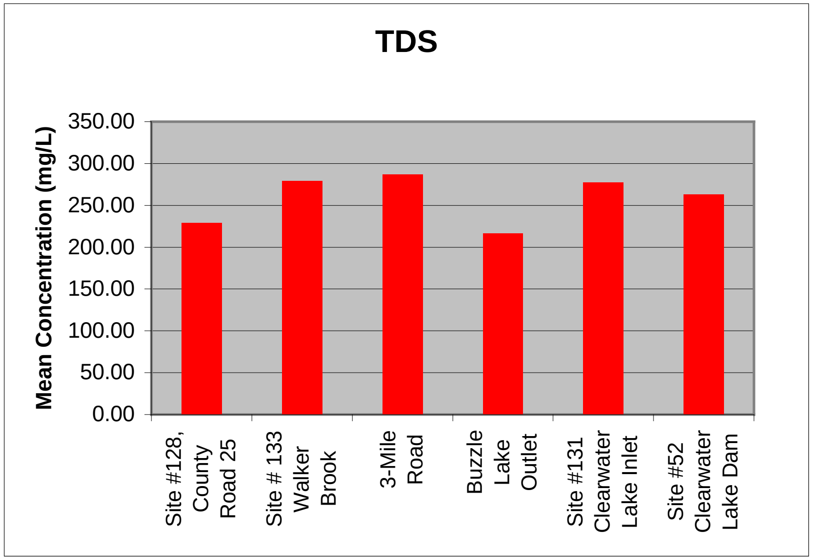
The Buzzle Lake watershed had the least amount of peak runoff, which helps explain the good water quality coming from this subwatershed, along with the lack of development or agricultural activity within the subwatershed. Much of the watershed is well vegetated and wooded so there is minimal runoff of nutrients and sediments. Plus, part of what does run off the landscape is retained in Buzzle Lake. When spatially examining the average concentrations, Buzzle Lake appears to improve water quality in the Clearwater River for total suspended solids, total phosphorus, total dissolved solids, chemical oxygen demand, total Kjeldahl nitrogen, and dissolved oxygen concentrations. It has a high peak discharge when compared to the 3-mile subwatershed and the Clearwater Lake inlet subwatershed, but has the lowest peak runoff rate of all the subwatersheds. This indicates that, although a large amount of water may flow from this subwatershed during a storm event, there is not a lot of overland flow or erosion, so there is a lower amount of sediment and nutrients being carried to the stream from the land. This results in lower concentrations of sediment and nutrients within the stream. The flow of this high quality water into the Clearwater River in between 3-mile road and the Clearwater Lake inlet may help explain the observed improvement in concentrations of certain water quality parameters in this reach of the river.

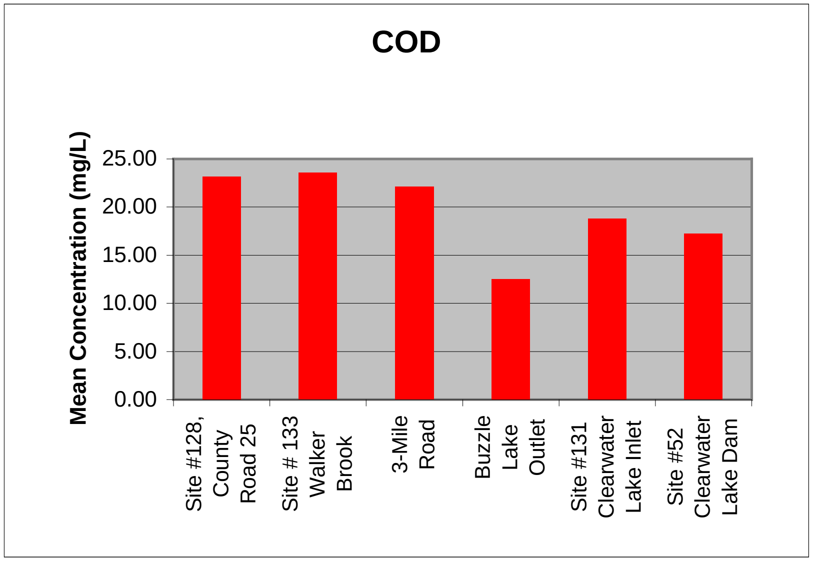
A comparison of modeling results for the Clearwater Lake inlet and the Clearwater Lake outlet shows that about 260 tons of sediment and over a ton of phosphorus are deposited in the lake each year. Determining how much phosphorus and suspended sediment is coming from the immediate watershed of the lake can not be directly measured from monitoring data, but was estimated by the BATHTUB modeling program based upon monitoring data from the Clearwater Lake Inlet monitoring site and land use data from the lake's immediate watershed. One interesting fact, however, is that the amount of total dissolved solids increases from the inlet to the outlet. Dissolved solids entering the lake are less likely to be deposited in the lake than suspended solids. The annual dissolved solids load at the outlet exceeded the load at the inlet by 17,444 tons in 2002, even thought the concentration decreased. Some potential sources of dissolved solids on Clearwater Lake are sewage, wetlands, erosion and runoff from lake lots. Another possible explanation for the increase may be the fact that the continuous stage (water surface elevation) recording device at the Clearwater Lake outlet retrieved more data during the heavy storm events in June of 2002 because it was safe and dry while the stage recorder at the inlet was flooded and damaged. The data at the outlet includes some of the high flows recorded during this time period. The loads of Ammonia and Total Kjeldahl Nitrogen also increase from the inlet of the lake to the outlet of the lake. The most likely source of these two constituents in Clearwater Lake is decaying plant matter and animal waste. The following pages show the results from the FLUX modeling in table and graphical form.

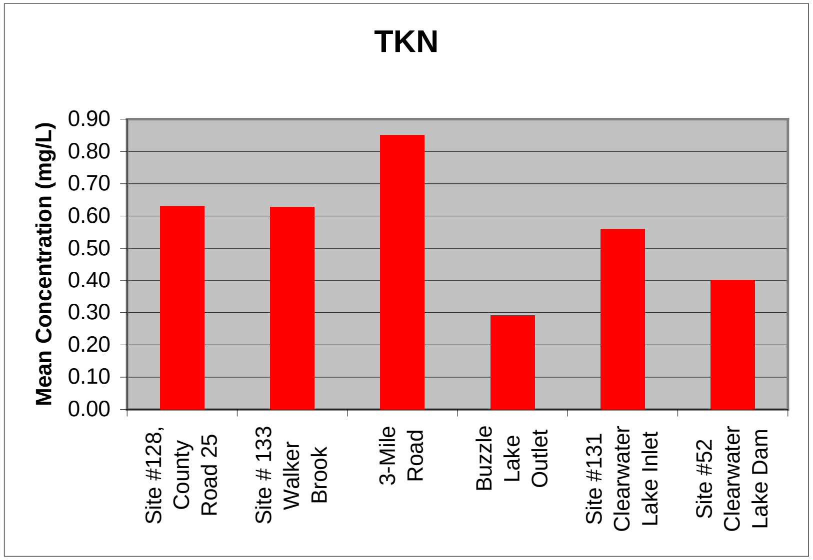
	TSS mg/L	TDS mg/L	COD mg/L	TKN mg/L	AMMONIA mg/L	OP mg/L	TP mg/L	Fecal Coliform col./100ml	DO mg/L	Nitrates and Nitrites mg/L
Minimally Impacted	6.40				0.20		0.05	20.00		0.09
EPA Standards	25.00	500.00						200.00	5.00	
Site #128, County Road 25										
Total annual flow	11.76	11.76	11.76	11.76	11.76	11.76	11.76	11.76	11.76	11.76
Total annual loads (tons)	44.28	2967.84	300.46	8.17	1.59	0.12	0.45	17615.24	121.40	0.31
Mean Conc	3.42	228.94	23.18	0.63	0.12	0.01	0.04	135.89	9.37	0.02
Site # 133 Walker Brook										
Total annual flow	9.23	9.23	9.23	9.23	9.23	9.23	9.23	9.23	9.23	9.23
Total annual loads (tons)	17.79	2842.64	239.93	6.40	0.87	0.34	0.71	7309.09	64.30	0.21
Mean Conc (mg/L)	1.75	279.39	23.58	0.63	0.09	0.03	0.07	71.84	6.32	0.02
3 Mile Road										
Total annual flow	38.51	38.51	38.51	38.51	38.51	38.51	38.51	38.51	38.51	38.51
Total annual loads (tons)	232.88	12184.07	938.89	36.14	4.05	1.86	2.77	11794.47	318.65	1.46
Mean Conc (mg/L)	5.49	287.02	22.12	0.85	0.10	0.04	0.07	27.78	7.51	0.03
Buzzle Lake Outlet										
Total annual flow	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76	5.76
Total annual loads (tons)	10.80	1377.10	79.74	1.85	0.49	0.04	0.07	655.03	63.28	0.13
Mean Conc (mg/L)	1.70	216.74	12.55	0.29	0.08	0.01	0.01	10.31	9.96	0.02
Site #131 Clearwater Lake Inlet										
Total annual flow	46.20	46.20	46.20	46.20	46.20	46.20	46.20	46.20	46.20	46.20
Total annual loads (tons)	356.69	14163.01	882.98	19.93	5.74	0.75	2.73	13811.18	517.92	2.88
Mean Conc (mg/L)	7.00	278.11	17.34	0.39	0.11	0.01	0.05	27.12	10.17	0.06
Site #52 Clearwater Lake Dam										
Total annual flow	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34	109.34
Total annual loads (tons)	201.88	31607.29	2091.64	47.89	14.44	0.86	3.43	1554.91	1262.17	4.40
Mean Conc (mg/L)	1.67	262.24	17.35	0.40	0.12	0.01	0.03	1.29	10.47	0.04

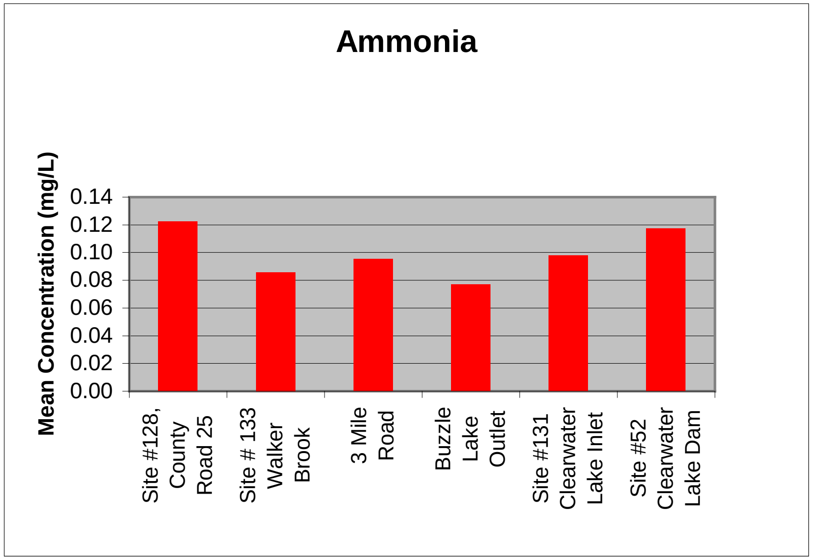
FLUX Modeling Results

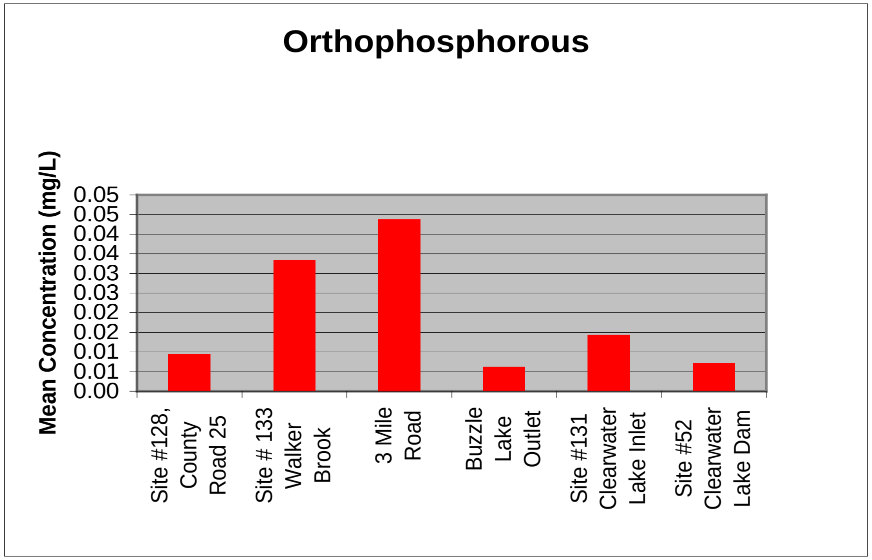

TSS
Mean Concentration (mg/L)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Site #128, County Road 25
Site # 133 Walker Brook
3-Mile Road
Buzzle Lake Outlet
Site #131 Clearwater Lake Inlet
Site #52 Clearwater Lake Dam

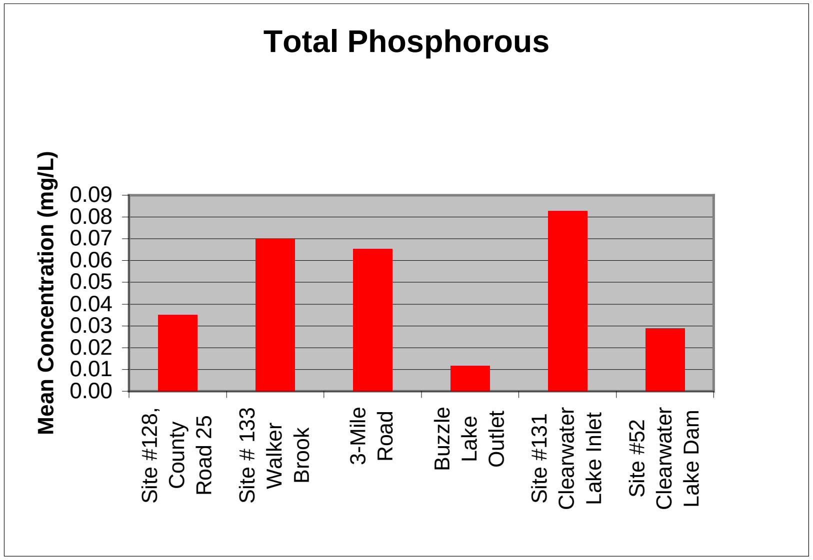

TDS
Mean Concentration (mg/L)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Site #128, County Road 25
Site # 133 Walker Brook
3-Mile Road
Buzzle Lake Outlet
Site #131 Clearwater Lake Inlet
Site #52 Clearwater Lake Dam

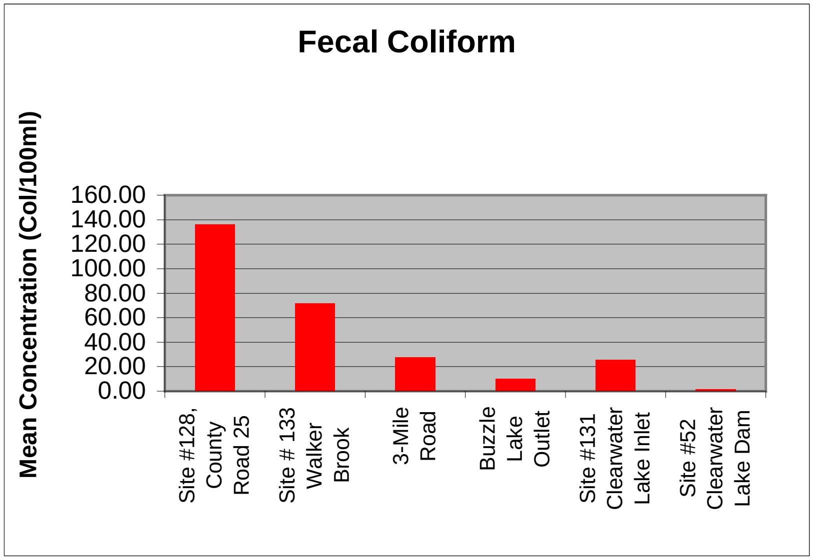

COD
Mean Concentration (mg/L)
25.00
20.00
15.00
10.00
5.00
0.00
Site #128, County Road 25
Site # 133 Walker Brook
3-Mile Road
Buzzle Lake Outlet
Site #131 Clearwater Lake Inlet
Site #52 Clearwater Lake Dam

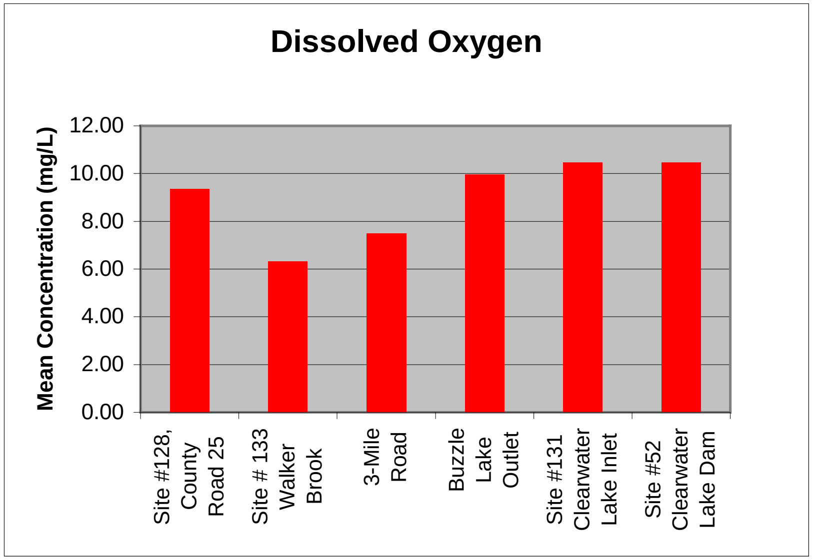

TKN
Mean Concentration (mg/L)
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Site #128, County Road 25
Site # 133 Walker Brook
3-Mile Road
Buzzle Lake Outlet
Site #131 Clearwater Lake Inlet
Site #52 Clearwater Lake Dam

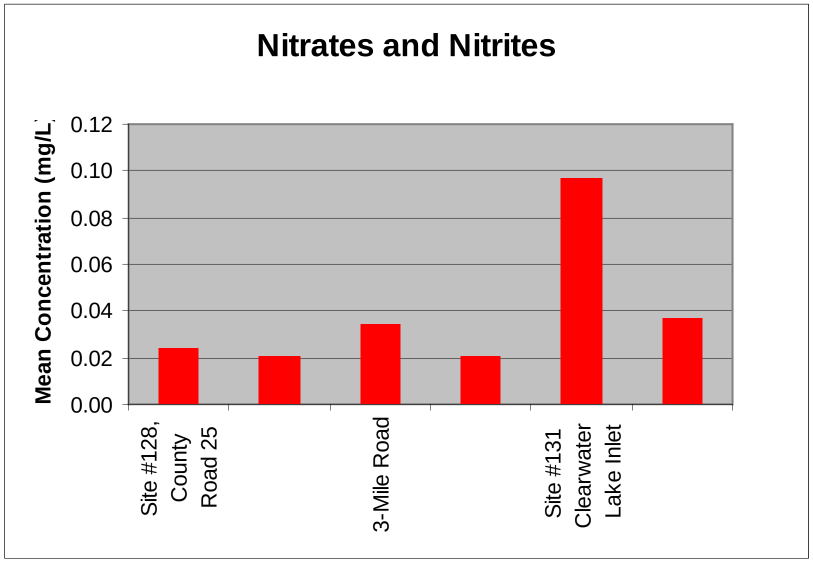

Ammonia
Mean Concentration (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Site #128, County Road 25
Site # 133 Walker Brook
3 Mile Road
Buzzle Lake Outlet
Site #131 Clearwater Lake Inlet
Site #52 Clearwater Lake Dam


Orthophosphorous
Mean Concentration (mg/L)
0.05
0.05
0.04
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
Site #128, County Road 25
Site # 133 Walker Brook
3 Mile Road
Buzzle Lake Outlet
Site #131 Clearwater Lake Inlet
Site #52 Clearwater Lake Dam


Total Phosphorous
Mean Concentration (mg/L)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Site #128, County Road 25
Site # 133 Walker Brook
3-Mile Road
Buzzle Lake Outlet
Site #131 Clearwater Lake Inlet
Site #52 Clearwater Lake Dam


Fecal Coliform
Mean Concentration (Col/100ml)
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Site #128, County Road 25
Site # 133 Walker Brook
3-Mile Road
Buzzle Lake Outlet
Site #131 Clearwater Lake Inlet
Site #52 Clearwater Lake Dam


Dissolved Oxygen
Mean Concentration (mg/L)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Site #128, County Road 25
Site # 133 Walker Brook
3-Mile Road
Buzzle Lake Outlet
Site #131 Clearwater Lake Inlet
Site #52 Clearwater Lake Dam


Nitrates and Nitrites
Mean Concentration (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Site #128, County Road 25
3-Mile Road
Site #131 Clearwater Lake Inlet

12.0 PROFILE and BATHTUB Modeling Results

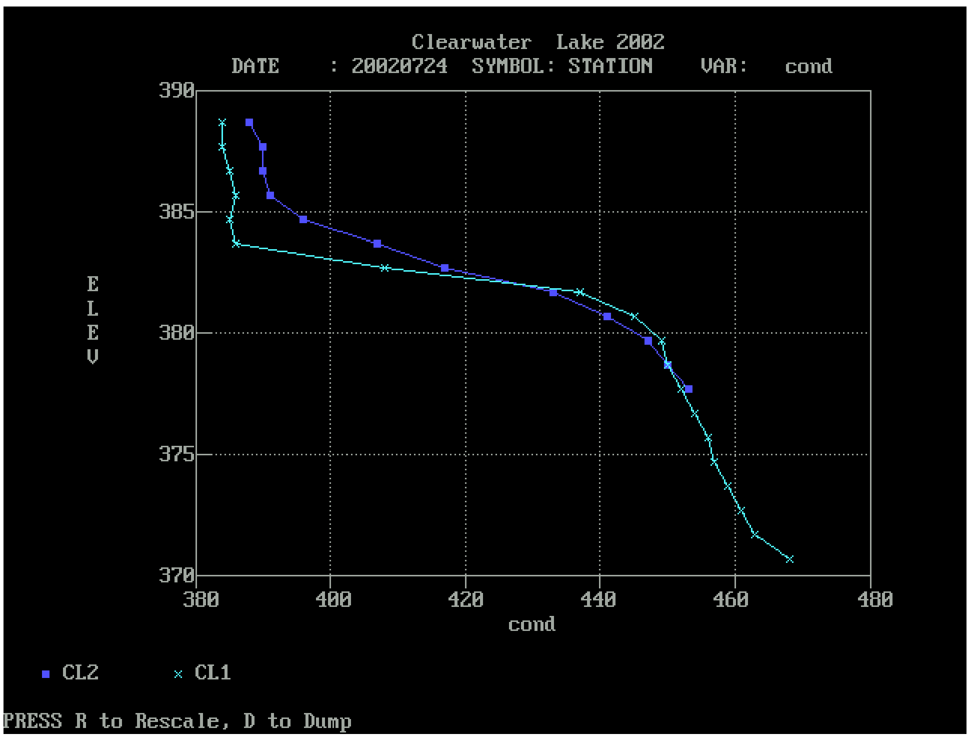
Water quality modeling with the PROFILE program was conducted using the data collected at sites CL1 and CL2. In addition to the generation of graphs and box plots, this program calculated areal and volumetric oxygen depletion rates for the hypolimnion and the metalimnion layers. The mean and maximum depths for these layers were also determined. The mean depths for the hypolimnion and metalimnion, respectively, were 2.02 m and 2.17 m. The maximum depths were 5.01 m and 3.00 m, respectively. The program also predicted mean concentrations of all input parameters based upon observed data and provided error mean coefficients of variance for these predictions. The coefficients of variance equal “the standard error of the estimate expressed as a fraction of the predicted value.” In other words, the higher the coefficient of variance (CV), the greater the possibility of error. Below is a table of the water quality statistics generated by PROFILE for each monitoring site.

CL1 - Deep Site					
Parameter	***Number Of Samples***	***Min***	***Max***	***Mean***	***Coefficient Variance***
Water Temperature	311	0.7	27.3	9.70	0.671
Dissolved Oxygen	311	0.0	16.4	6.80	0.659
Total Phosphorus	76	3.0	609.0	48.9	1.948
Chlorophyll-A	41	0.0	16.0	6.10	0.880
Secchi	232	1.0	5.0	2.40	0.398
Conductivity	311	299.8	589.0	427.2	0.113
Total Kjeldahl Nitrogen	48	5.0	770.0	444.4	0.585
Total Suspended Solids	48	1.0	7.0	2.30	0.862
Total Dissolved Solids	48	140.0	312.0	251.6	0.179
CL2 - Shallow Site					
Parameter	***Number Of Samples***	***Min***	***Max***	***Mean***	***Coefficient Variance***
Water Temperature	192	0.20	28.3	10.20	0.712
Dissolved Oxygen	192	0.20	15.3	8.20	0.459
Total Phosphorus	75	5.0	203.0	30.70	0.870
Chlorophyll-A	32	0.0	18.0	9.80	0.612
Secchi	140	2.0	3.0	2.20	0.179
Conductivity	192	303.7	653.7	430.1	0.120
Total Kjeldahl Nitrogen	44	5.0	750.0	427.3	0.512
Total Suspended Solids	44	0.0	7.0	2.30	0.784
Total Dissolved Solids	44	164.0	320.0	258.7	0.150

Several observations were made possible by the PROFILE modeling process. Profile graphs aided in determining when the lake was stratified and when it was mixed. The extent of hypolimnetic hypoxia was also calculated. Dissolved oxygen levels in the hypolimnion were below the 5 mg/L level (EPA standard for the minimum amount of dissolved oxygen necessary for aquatic life to thrive) for most of the sampling dates. The only sampling dates that did not have hypolimnetic hypoxia or anoxia were those from April 30th through May 29th and the final October 15th sampling date. The lake was mixed on these sampling dates.

Total phosphorus profiles for the lake showed that, during periods of stratification, phosphorus levels were generally highest in the hypolimnion. During stratification, there was a gradual decrease in phosphorus levels in the metalimnion and the lowest levels were found in the epilimnion. When the lake mixed in the spring, however, total phosphorus levels seemed to be highest in the metalimnion. During the fall mixing, phosphorus levels were relatively similar throughout the water column, differing by only 3 ppb.

Conductivity profiles showed that, during stratification, there was normally a gradual increase in conductivity levels within the epilimnion, a sharp increase in conductivity in the metalimnion, and then another gradual increase in the hypolimnion. No pattern was evident in conductivity levels throughout the water column while the lake was mixed. The following graphic is an example of a conductivity profile that was recorded while the lake was stratified.



When the time series plot of conductivity is compared to that of TDS, there appears to be a positive relationship between the two parameters. This makes sense, since the two parameters are related. The more dissolved solids in the water, the better it will conduct electricity. Temperature has a definite inverse relationship with dissolved oxygen as can be expected since warmer water holds less oxygen and colder water holds more. Total Kjeldahl nitrogen levels varied little with depth and time. Total phosphorus and chlorophyll-a fluctuations appeared to correlate until the month of June, where they suddenly diverge into an inverse relationship until the fall mixing. Zooplankton activity may be the cause of another observation. Chlorophyll-a measurements correlate with temperature in the spring and then suddenly have an inverse relationship beginning with the month of June. The two preceding observations may be due to zooplankton activity that normally peaks around the month of June. The increased zooplankton activity would mean increased consumption of algae and reduced Chlorophyll-a levels.

Several load reduction scenarios were run using the BATHTUB program. The first scenario tested the effect of the sediment reduction within the City of Bagley. The estimated amount of sediment reduction from the stormwater treatment ponds is 82%. The amount of total phosphorus reduction from the project was estimated at 47%. The watershed of the City of Bagley was analyzed for land use and total runoff volume. The amount of runoff volume was then compared to the total amount of runoff volume for the 3-mile road subwatershed and the amounts of TSS and TP load reduction were quantified in Kg/yr and then subtracted from the loads at the Clearwater Lake inlet monitoring site. The new concentrations for TSS and TP were then entered into BATHTUB.

The other type of load reduction scenarios modeled the reductions in sediment and nutrient concentrations in runoff for the entire watershed of the lake. These scenarios essentially predicted how the water quality within the lake would be affected by the implementation of best management practices. The concentrations for each parameter were reduced incrementally. Sediment and nutrient concentrations in nonpoint runoff entering the river and in runoff from the lake's immediate watershed were reduced by 10%, 20%, 30%, and 40%. The results of this modeling are listed in the table on the next page.

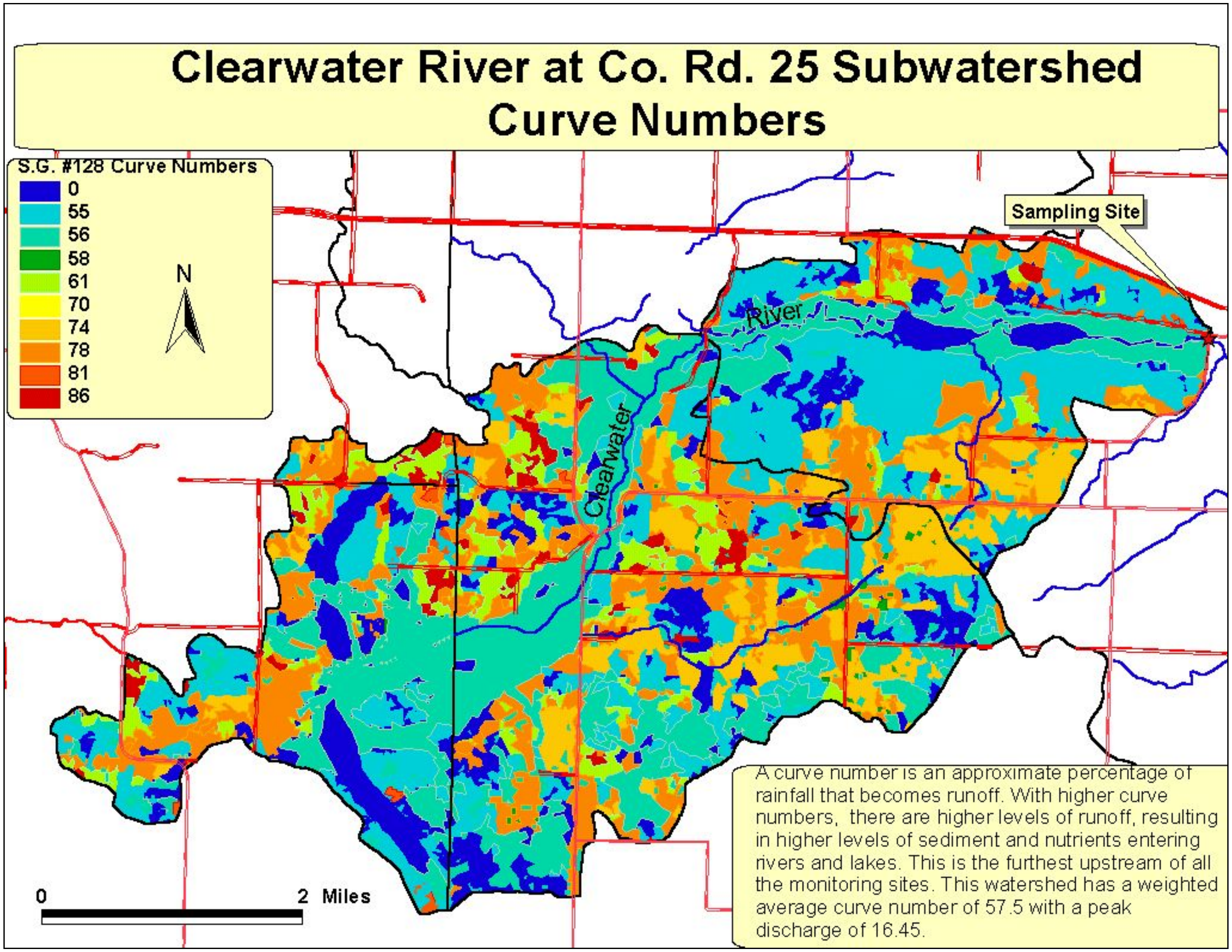
Load Reductions:	Original Data (0%)		80% from Bagley	10% Load Reduction	20% Load Reduction	30% Load Reduction	40% Load Reduction
	Observed	Estimated	Estimated	Estimated	Estimated	Estimated	Estimated
Segment 1 - Shallow Site (CL2)							
TSS (ppm)	2.3	8.1	7.86	7.3	6.49	5.68	4.88
Total P (ppb)	30.7	32.74	31.77	30.61	28.39	26.03	23.53
Total N (ppb)	427.3	218.21	218.21	200.5	182.17	163.21	143.41
Chlorophyll-a (ppb)	9.8	1.68	8.55	8.34	7.9	7.4	6.82
Secchi Disk (m)	2.2	1.26	4.16	5.24	7.46	15.03	18.72
Organic N (ppb)	304.67	211.15	367.76	362.84	352.85	341.45	328.38
Ortho P (ppb)	23.3	3.86	16.09	15.7	14.92	14.03	13.01
HOD-V (ppb/day)	46.15	25.04	56.51	55.79	54.31	52.57	50.5
MOD-V (ppb/day)	14.56	25.92	58.48	57.74	56.2	54.4	52.26
TSI-P	53.53	54.46	54.02	53.49	52.40	51.15	49.69
TSI-Chl-a	52.99	35.69	51.65	51.41	50.88	50.23	49.43
TSI-Secchi	48.64	56.67	39.46	36.13	31.04	20.95	17.78
TSI-Average	**51.72**	**48.94**	**48.38**	**47.01**	**44.77**	**40.78**	**38.97**
TSI Improvement			**1.15%**	**3.94%**	**8.51%**	**16.68%**	**20.37%**
Segment 2 - Deep Site (CL1)							
TSS	2.3	8.1	7.86	7.29	6.49	5.68	4.88
Total P	48.9	31.5	30.6	29.52	27.45	25.24	22.87
Total N	756.9	215.8	215.8	198.44	180.44	161.8	142.29
Chlorophyll-a	6.1	1.53	7.79	7.6	7.2	6.75	6.24
Secchi Disk	2.4	1.29	4.28	5.42	7.79	16.43	18.72
Organic N	444.4	211.67	354.6	350.14	341.13	330.85	319.05
Ortho P	39.4	4.88	16.03	15.69	14.98	14.18	13.26
HOD-V	46.15	25.04	56.51	55.79	54.31	52.57	50.5
MOD-V	14.56	25.92	58.48	57.74	56.2	54.4	52.26
TSI-P	60.24	53.90	53.48	52.96	51.91	50.70	49.28
TSI-Chl-a	48.34	34.77	50.74	50.50	49.97	49.33	48.56
TSI-Secchi	47.38	56.33	39.05	35.65	30.42	19.66	17.78
TSI-Average	**51.99**	**48.33**	**47.76**	**46.37**	**44.10**	**39.90**	**38.54**
TSI Improvement			**1.20%**	**4.07%**	**8.76%**	**17.45%**	**20.26%**
Area Weighted Mean							
TSS	2.3	8.1	7.86	7.3	6.49	5.68	4.88
Total P	37.92	32.25	31.31	30.18	28.02	25.72	23.27
Total N	558.05	217.25	217.25	199.68	181.48	162.65	142.96
Chlorophyll-a	8.33	1.62	8.25	8.04	7.62	7.14	6.59
Secchi Disk	2.28	1.27	4.2	5.31	7.59	15.58	18.72
Organic N	360.1	211.36	362.54	357.8	348.2	337.25	324.68
Ortho P	29.69	4.26	16.07	15.7	14.95	14.09	13.11
HOD-V	46.15	25.04	56.51	55.79	54.31	52.57	50.5
MOD-V	14.56	25.92	58.48	57.74	56.2	54.4	52.26
TSI-P	56.57	54.24	53.81	53.28	52.21	50.98	49.53
TSI-Chl-a	51.40	35.33	51.30	51.05	50.52	49.88	49.10
TSI-Secchi	48.12	56.56	39.32	35.94	30.79	20.43	17.78
TSI-Average	**52.03**	**48.71**	**48.14**	**46.76**	**44.51**	**40.43**	**38.80**
TSI Improvement			**1.16%**	**4.01%**	**8.62%**	**17.00%**	**20.33%**

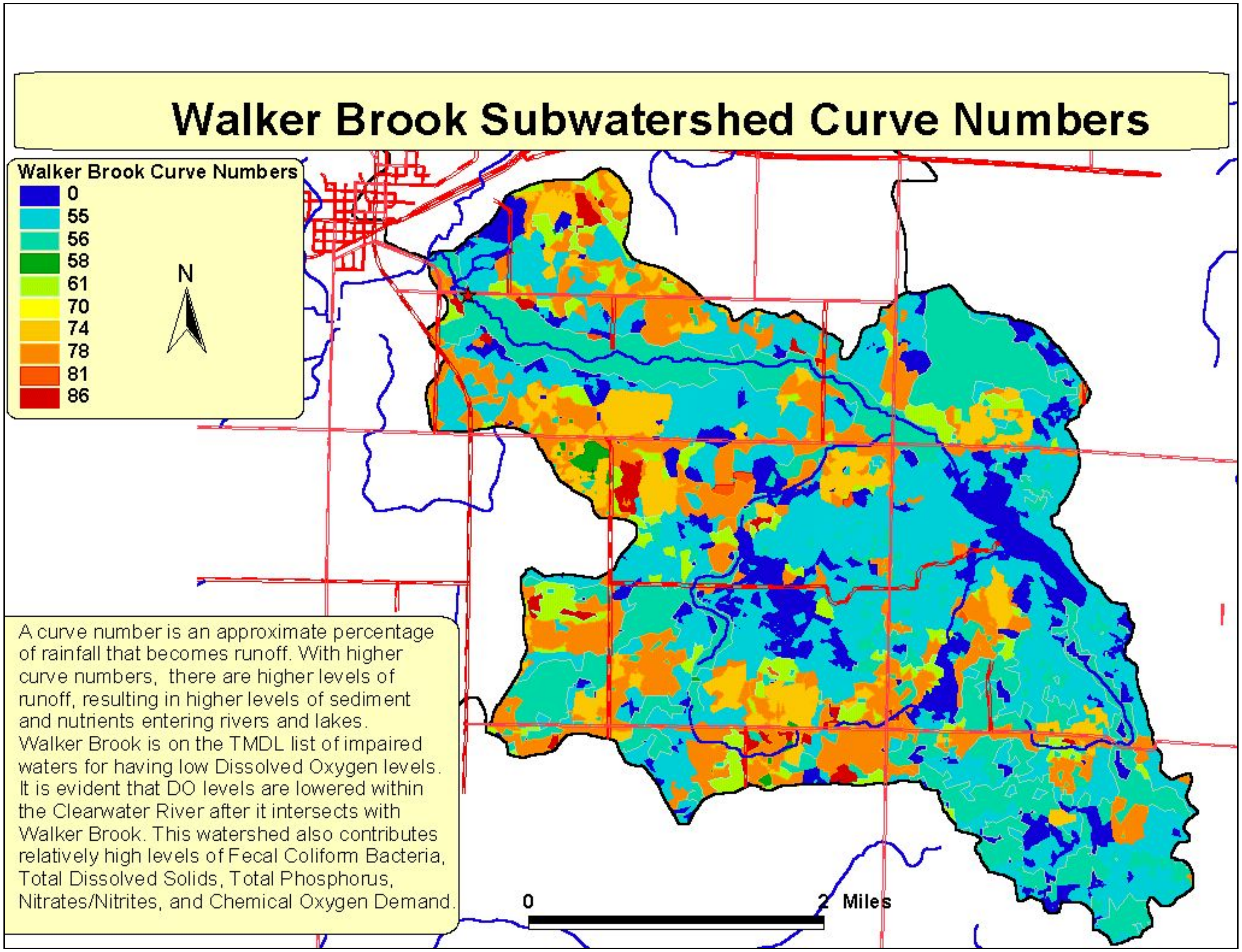
13.0 Conclusions

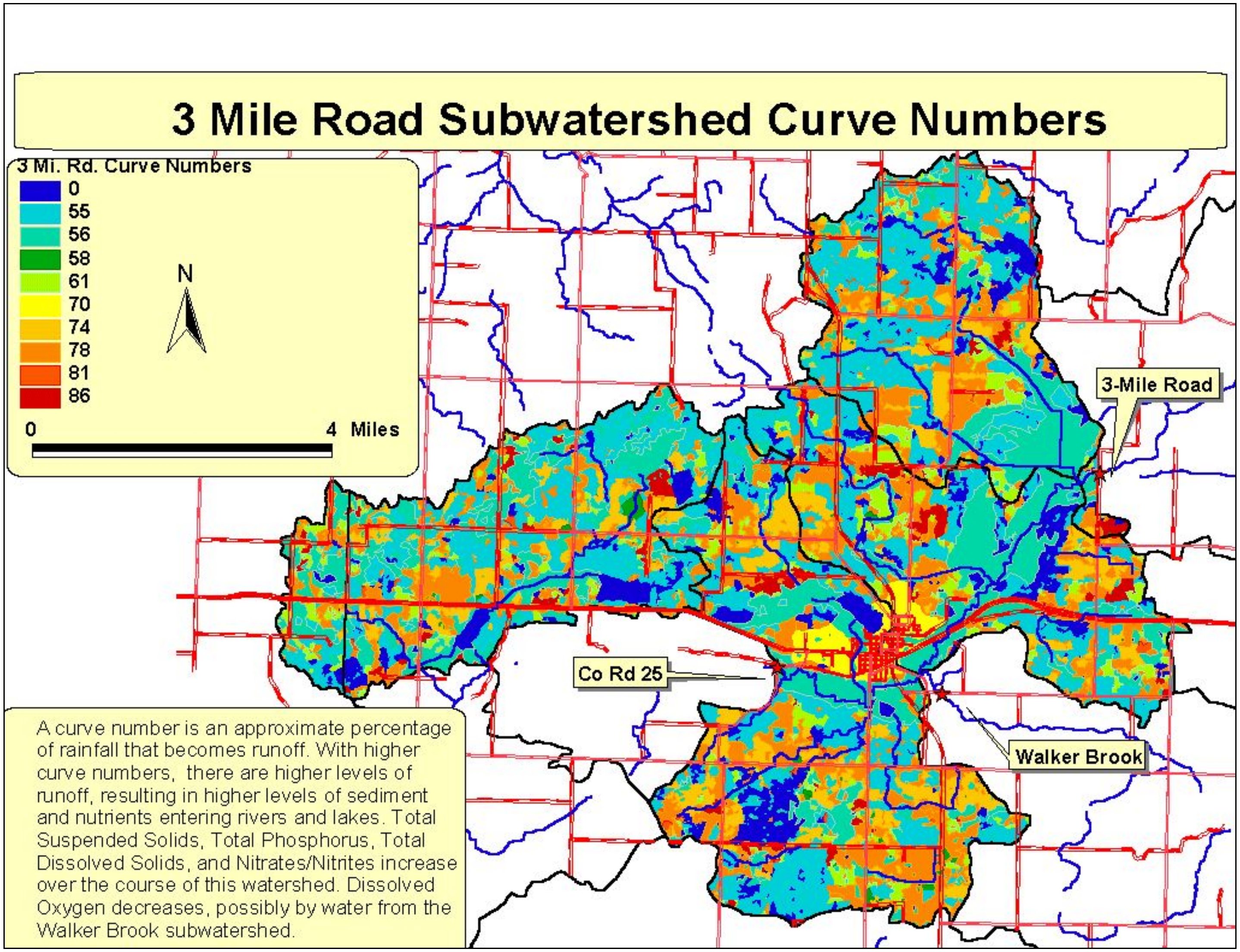
One goal of the Clearwater Lake Water Quality Model Study was to determine focus watersheds for water quality improvements. Total phosphorus loading was highest from the subwatersheds of the 3-mile road, Clearwater Lake inlet, and Clearwater Lake outlet monitoring sites. Something within the watershed between 3-mile road and the Clearwater Lake inlet is causing an increase in fecal coliform loads, even though the concentration decreases between these two sites. Dissolved oxygen levels are not of concern to the lake because the weighted averages were quite high for the inlet and outlet sites. However, the low levels in the upper reaches of the Clearwater River may have a negative impact upon aquatic life and water quality in the river.

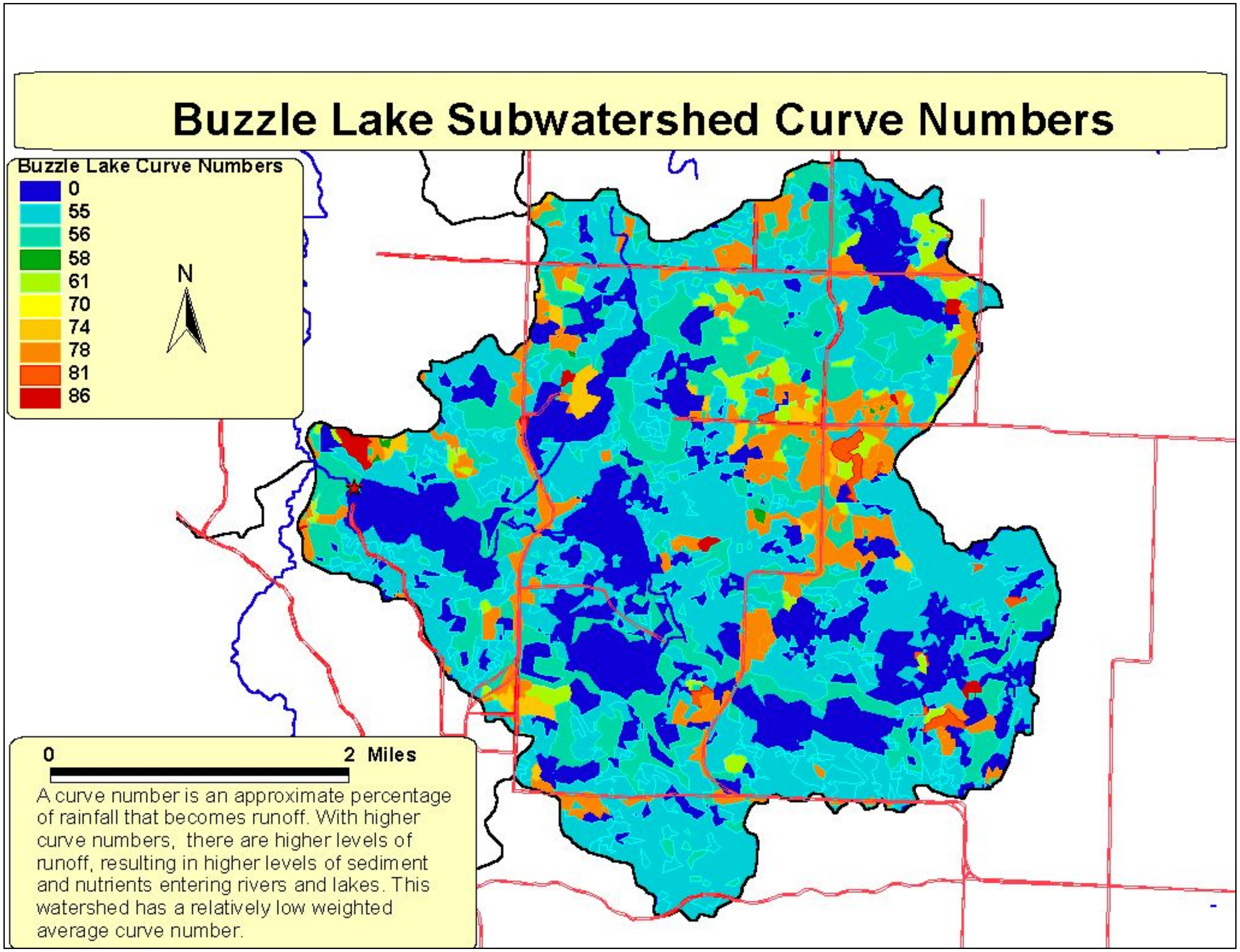
The Clearwater River does not violate EPA standards for total suspended solids at any of the sites, but is minimally impacted according to the ecoregion standards at the monitoring site near the inlet. Much of this sediment is deposited in the lake. This explains the shallower lake levels near the higher prevalence of weeds, higher levels of total phosphorus near the inlet. Making sure all septic systems are in compliance should be a priority for maintaining the water quality of the lake. This should help minimize the increase in dissolved solids and total Kjeldahl nitrogen from the lake’s immediate watershed. Public education about lakeshore restoration and other methods for minimizing the contribution of sediment and nutrients from individual lake lots should be implemented.

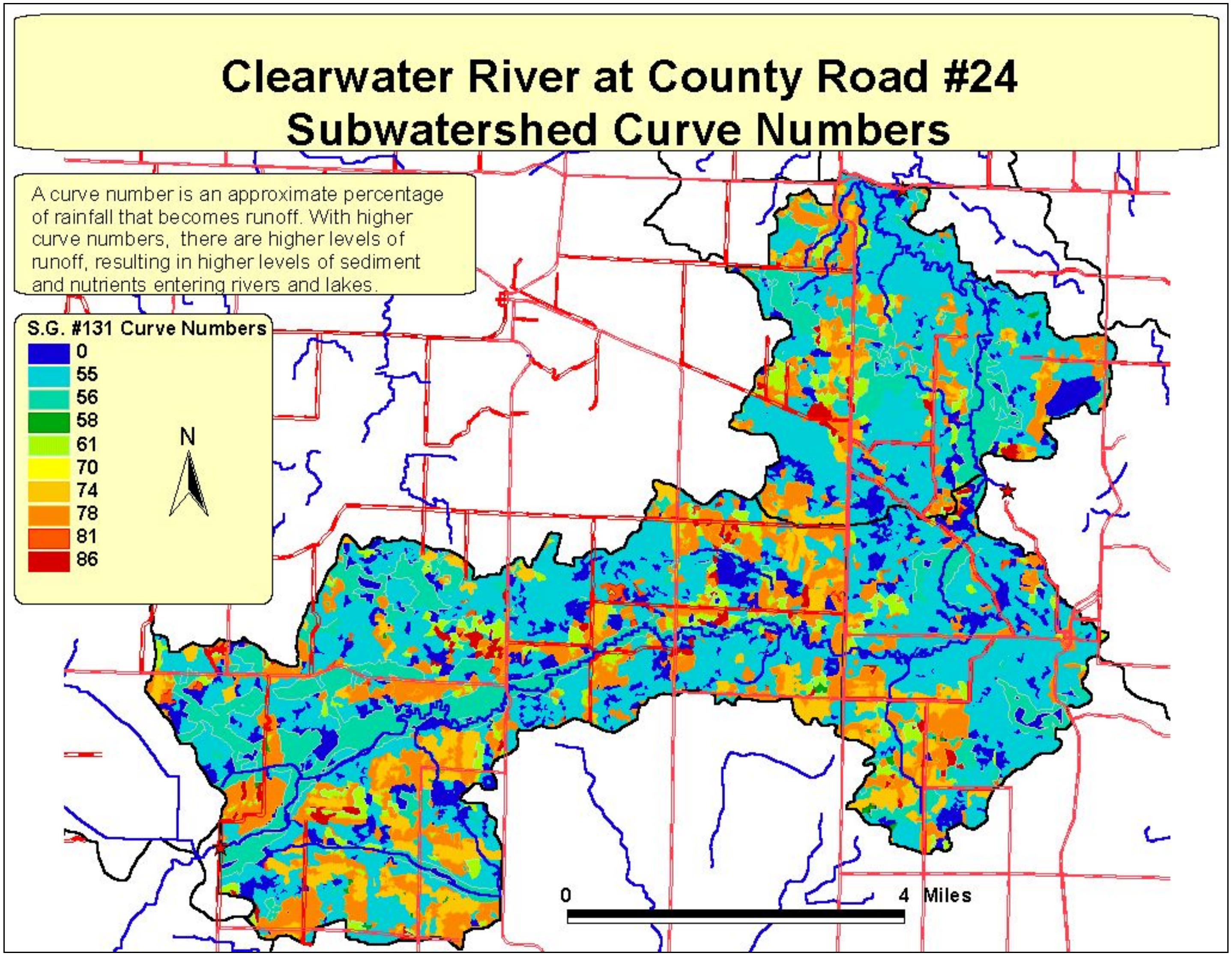
In order to reduce the amount of sediment and nutrients flowing into Clearwater Lake, the amount of sediment and nutrients that are being carried into the stream via runoff should be reduced. The two subwatersheds with the highest contributions to the sediment and nutrient loads in the river are the 3-mile road subwatershed (Bagley) and the Clearwater Lake inlet subwatershed (excluding the Buzzle Lake watershed and everything upstream of 3-mile road). See the map of sites and their corresponding subwatersheds on page 6. The sediment loads coming from the 3-mile road subwatershed should be decreased by the Bagley Urban Runoff Reduction Project, for which three stormwater treatment ponds have been constructed. This project was designed to reduce the amount of sediment entering the river from the watershed of the city of Bagley by up to 80%. In the Clearwater Lake inlet subwatershed, it appears that the areas with the highest runoff potential are located next to streams and ditches. This subwatershed should be targeted for the implementation of best management practices (BMPs) such as buffer strips. Buffer strips consist of land along rivers, streams, and lakes that is vegetated with grass and trees in order to filter sediment (soil particles and pollutants) from runoff before it enters the water. The vegetation in buffer strips also helps to reduce erosion from the stream channel by holding soil in place. The implementation of best management practices has been included in the goals for implementing the Clearwater Lake Management plan. Areas with high runoff potential can be targeted for BMP implementation. The following pages contain runoff potential maps for each of the monitoring site subwatersheds. Following the maps is a list of BMPs from the Clearwater River Nonpoint Study that may be considered for implementation within this subwatershed.

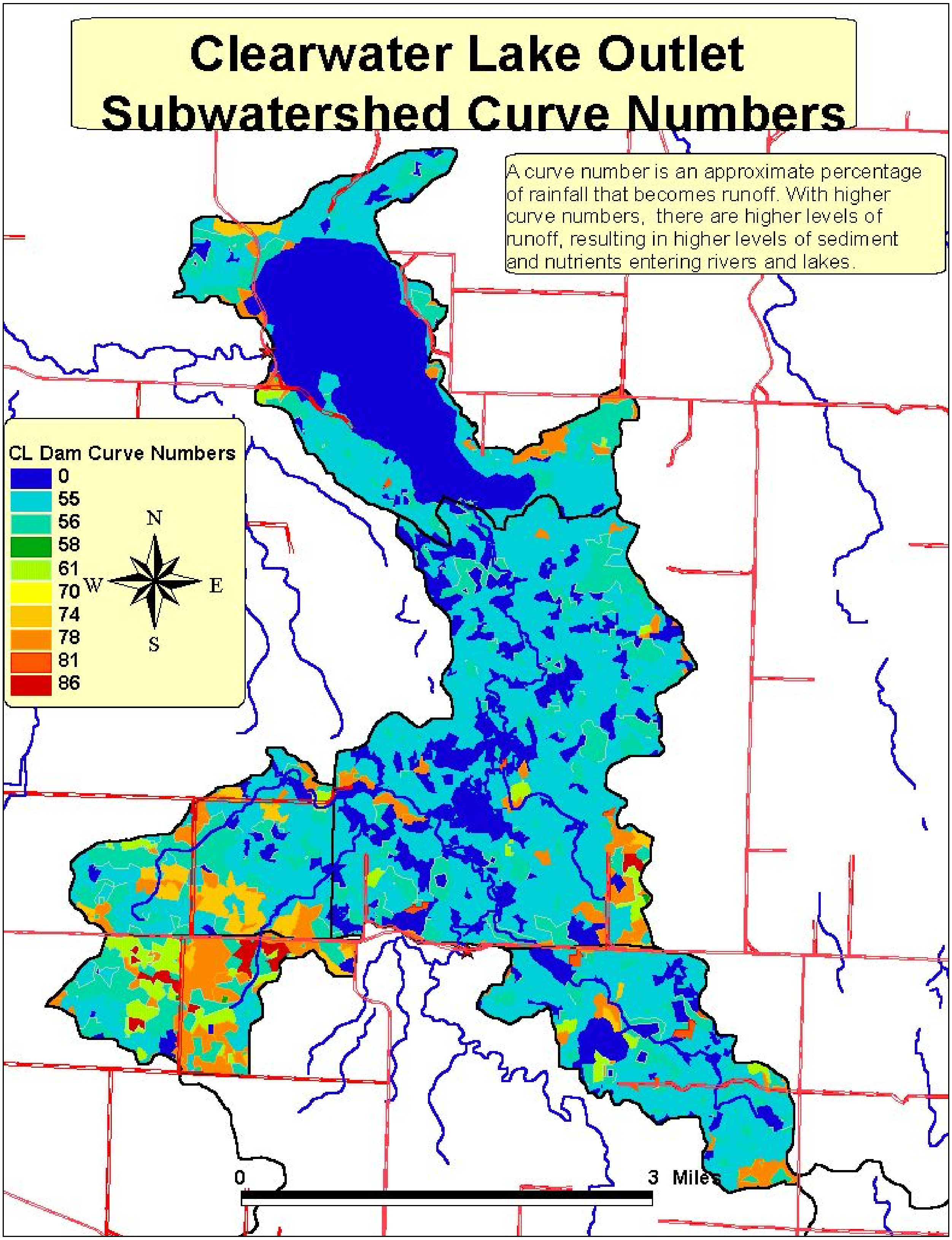

Clearwater River at Co. Rd. 25 Subwatershed
Curve Numbers
S.G. #128 Curve Numbers
0
55
56
58
61
70
74
78
81
86
N
Sampling Site
River
Clearwater
0
2 Miles
A curve number is an approximate percentage of rainfall that becomes runoff. With higher curve numbers, there are higher levels of runoff, resulting in higher levels of sediment and nutrients entering rivers and lakes. This is the furthest upstream of all the monitoring sites. This watershed has a weighted average curve number of 57.5 with a peak discharge of 16.45.


Walker Brook Subwatershed Curve Numbers
Walker Brook Curve Numbers
0
55
56
58
61
70
74
78
81
86
N
A curve number is an approximate percentage of rainfall that becomes runoff. With higher curve numbers, there are higher levels of runoff, resulting in higher levels of sediment and nutrients entering rivers and lakes. Walker Brook is on the TMDL list of impaired waters for having low Dissolved Oxygen levels. It is evident that DO levels are lowered within the Clearwater River after it intersects with Walker Brook. This watershed also contributes relatively high levels of Fecal Coliform Bacteria, Total Dissolved Solids, Total Phosphorus, Nitrates/Nitrites, and Chemical Oxygen Demand.
0
2 Miles


3 Mile Road Subwatershed Curve Numbers
3 Mi. Rd. Curve Numbers
0
55
56
58
61
70
74
78
81
86
N
0
4 Miles
3-Mile Road
Co Rd 25
Walker Brook
A curve number is an approximate percentage of rainfall that becomes runoff. With higher curve numbers, there are higher levels of runoff, resulting in higher levels of sediment and nutrients entering rivers and lakes. Total Suspended Solids, Total Phosphorus, Total Dissolved Solids, and Nitrates/Nitrites increase over the course of this watershed. Dissolved Oxygen decreases, possibly by water from the Walker Brook subwatershed.


Buzzle Lake Subwatershed Curve Numbers
Buzzle Lake Curve Numbers
0
55
56
58
61
70
74
78
81
86
N
0
2 Miles
A curve number is an approximate percentage of rainfall that becomes runoff. With higher curve numbers, there are higher levels of runoff, resulting in higher levels of sediment and nutrients entering rivers and lakes. This watershed has a relatively low weighted average curve number.

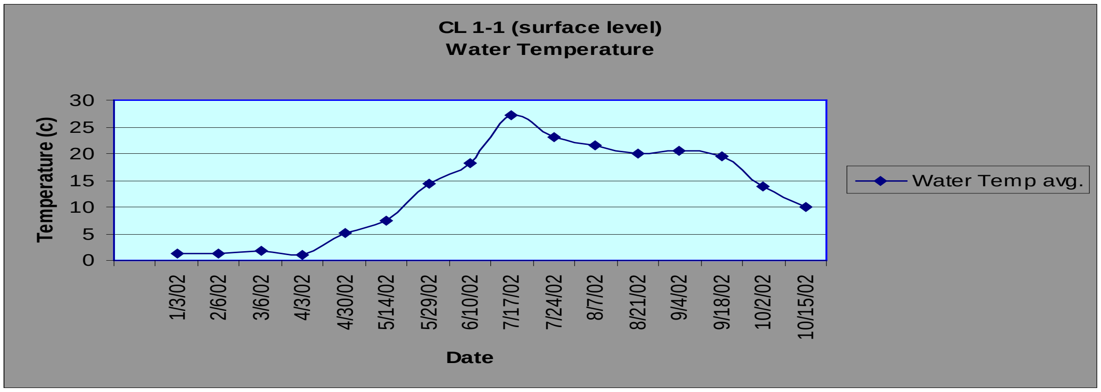

Clearwater River at County Road #24
Subwatershed Curve Numbers
A curve number is an approximate percentage of rainfall that becomes runoff. With higher curve numbers, there are higher levels of runoff, resulting in higher levels of sediment and nutrients entering rivers and lakes.
S.G. #131 Curve Numbers
0
55
56
58
61
70
74
78
81
86
N
0
4 Miles

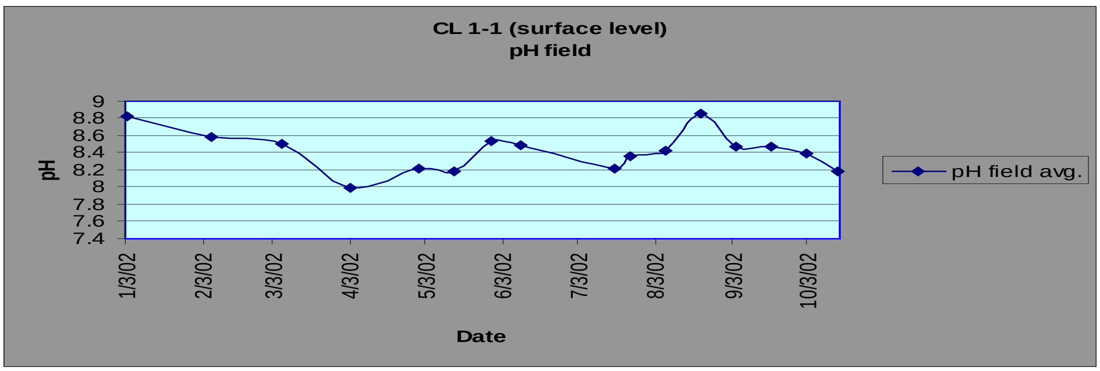

Clearwater Lake Outlet
Subwatershed Curve Numbers
A curve number is an approximate percentage of rainfall that becomes runoff. With higher curve numbers, there are higher levels of runoff, resulting in higher levels of sediment and nutrients entering rivers and lakes.
CL Dam Curve Numbers
0
55
56
58
61
70
74
78
81
86
N
W
E
S
0
3 Miles

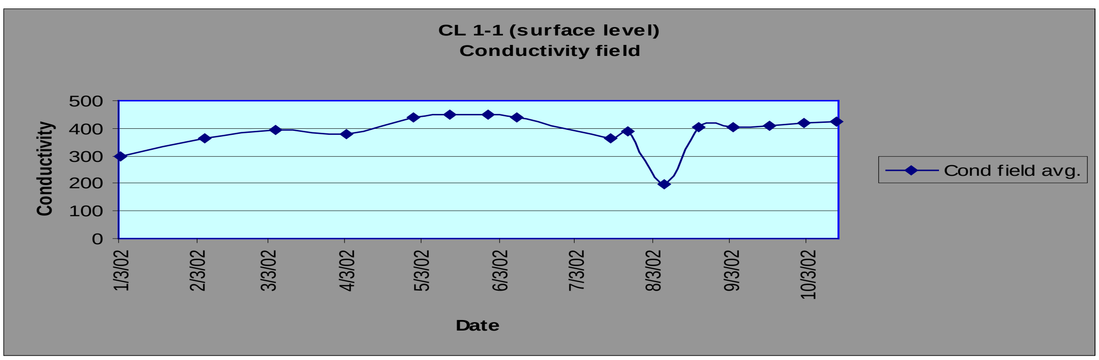
Best Management Practices	
Conservation Cover	Establishing and maintaining perennial vegetative cover to protect soil and water recourses on land retired from agricultural production.
Conservation Tillage	Conservation tillage includes a number of different planting, tilling, and cultivating methods designed to leave a vegetative residue on the soil.
Contour Farming	Farming around the slopes, which reduces erosion and increases infiltration. Erosion rates can be reduced up to 50% using this practice.
Cover and Green Manure Crop	A crop of close-growing grasses, legumes, or small grain grown primarily for seasonal protection and soil improvement.
Critical Area Planting	Planting vegetation, such as trees, shrubs, grasses, or legumes on highly erodible or critically eroding areas.
Crop Residue Use	Using plant residues to protect cultivated fields during critical erosion periods.
Diversion	A channel constructed across a slope to collect water and prevent damage to the area below the diversion.
Field Border	A strip of perennial vegetation established at the edge of a field by planting or converting it from trees to herbaceous vegetation of shrubs.
Filter (Buffer) Strip	A strip or area of vegetation intended to remove sediment, organic matter, and other pollutants from runoff and wastewater.
Grade Stabilization Structure	Grade stabilization structures involve pipe outlets or drop spillways and are used to allow water to drop to a lower elevation while protecting the soil from gully erosion or scouring.
Grassed Waterway	A natural or constructed channel that is planted with suitable vegetation to protect the soil from erosion by concentrated storm event flows.

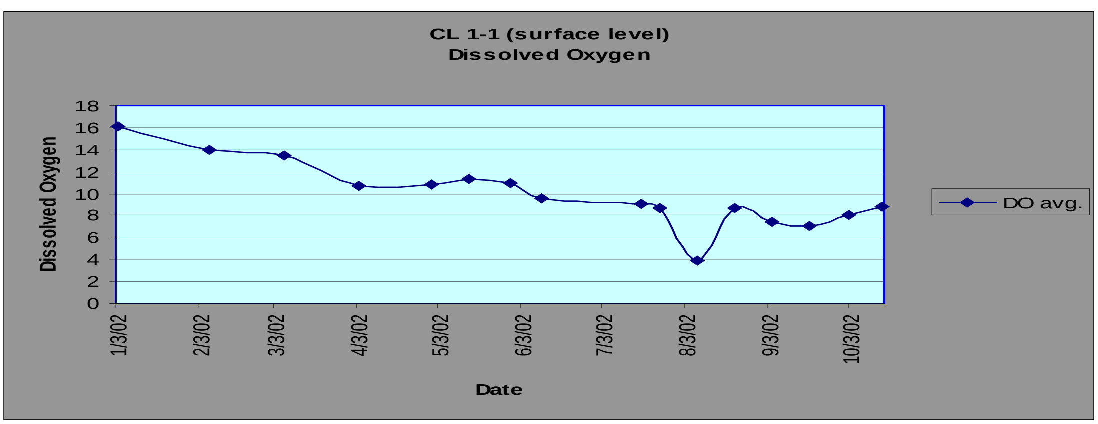
Best Management Practices (continued)	
Grasses and Legumes in Rotation	Establishing grasses and legumes or a mixture of them and maintaining the stand for a definite number of years as part of a conservation cropping system.
Sediment Basin	Basins constructed to collect and store debris or sediment.
Contour Strip-Cropping	Growing crops in a systematic arrangement of strips or bands on the contour to reduce water erosion.
Field Strip-Cropping	Growing crops in a systematic arrangement of strips or bands across the general slope (not contour) to reduce water erosion.
Terrace	An earthen embankment, a channel, or combination ridge and channel constructed across the slope to intercept runoff.
Tile Intake Buffers	Tile intake buffers are intended to filter sediment and nutrients from cropland runoff prior to being discharged to ditches and streams.
Water and Sediment Control Basin	An earthen embankment or a combination ridge and channel constructed across gullies and watercourses with underground outlets. Effective for preventing gully erosion, trapping sediment, and reducing downstream peak flows.
Wetland Development/Restoration	Wetland Development involves creating an artificial wetland or restoring a previously drained wetland. Wetlands act as sediment and nutrient traps, and can also reduce peak flows.
Agricultural Waste/Feedlot Management	An agricultural waste management system is a combination of practices used to properly store manure and other wastes from feedlots until they can be properly applied to cropland. A runoff management system is designed to control polluted runoff from a feedlot.
Pasture Management/Livestock Exclusion	Livestock exclusion involves the fencing off of areas where grazing would cause erosion of stream banks or allow water quality to be lowered by livestock activity. The quality of pastureland can also be maintained.
Nutrient Management	Using proper rates, placement, and timing of fertilizer applications to reduce nitrogen and phosphorus losses from cropland.

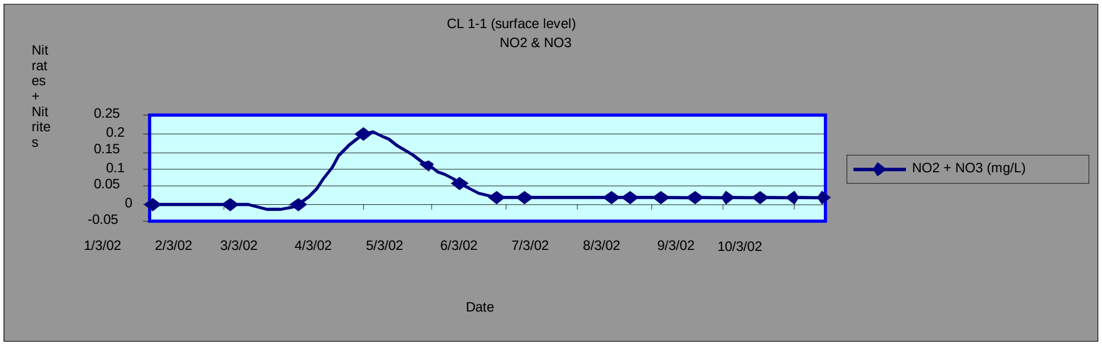
Appendix A. Lake Water Quality Charts.

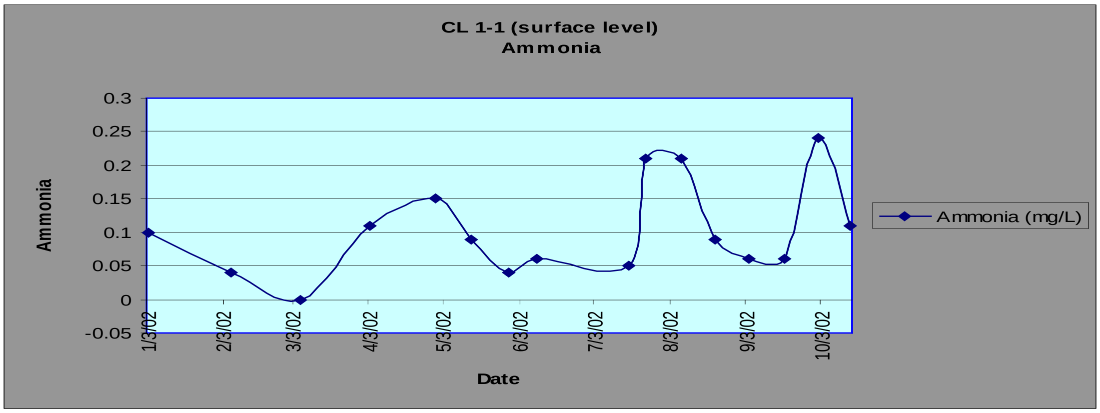


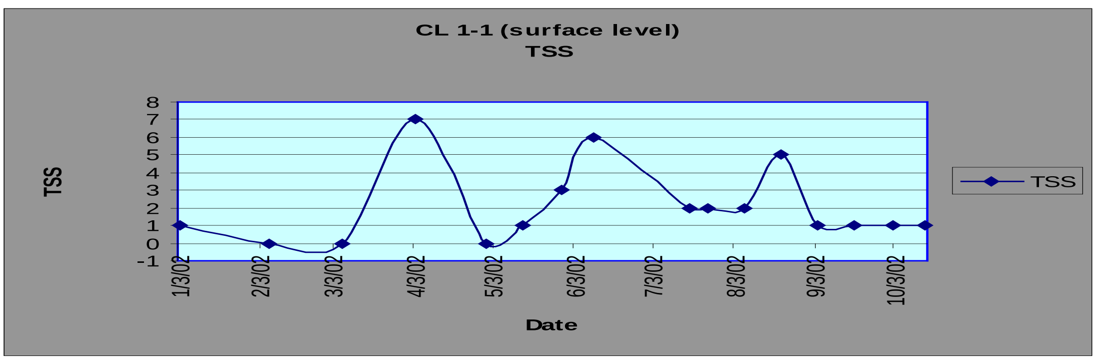


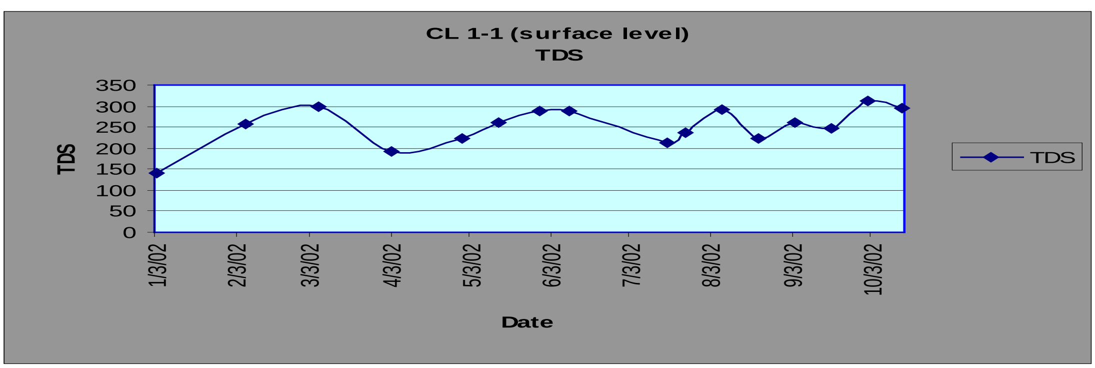


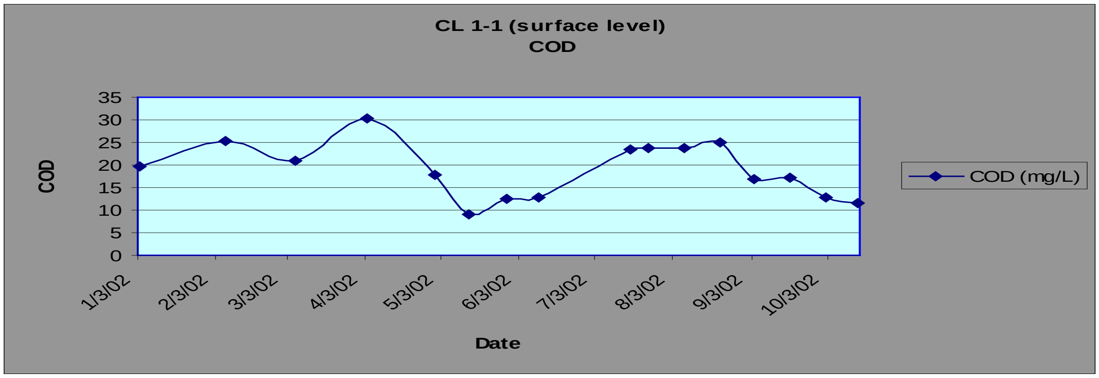


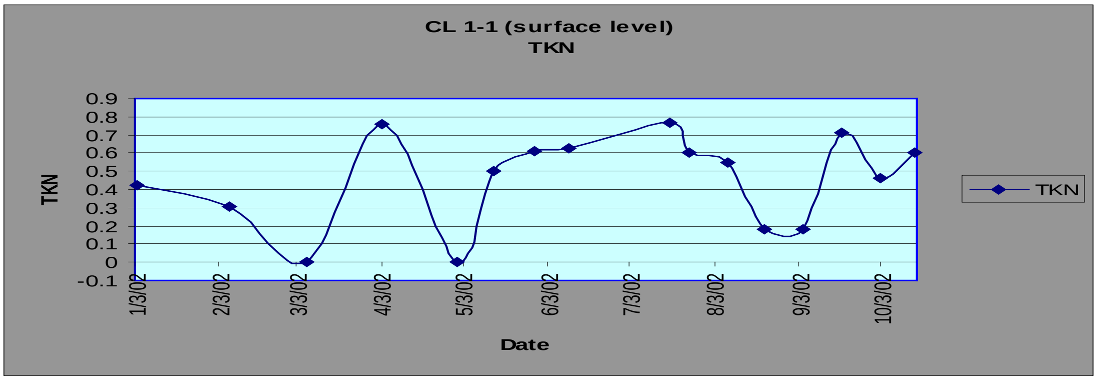

CL 1-1 (surface level)
NO2 & NO3
Nitrates + Nitrites
0.25
0.2
0.15
0.1
0.05
0
-0.05
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
NO2 + NO3 (mg/L)

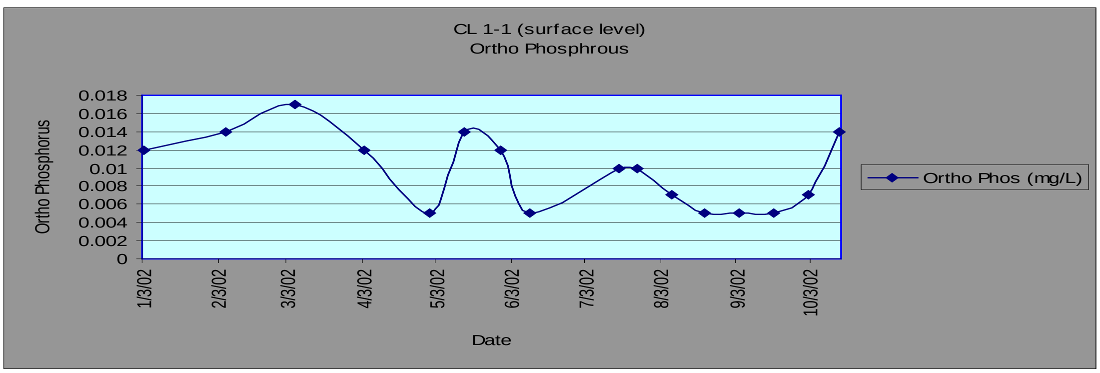

CL 1-1 (surface level)
Ammonia
Ammonia
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
Ammonia (mg/L)

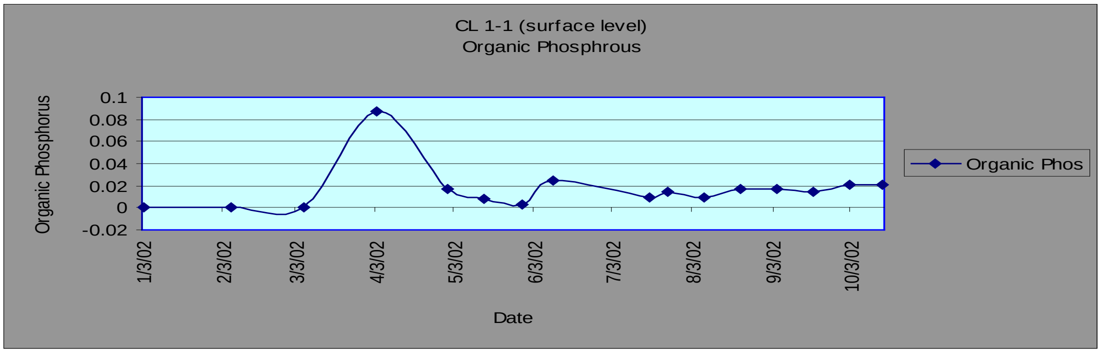

CL 1-1 (surface level)
TSS
TSS
8
7
6
5
4
3
2
1
0
-1
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
TSS

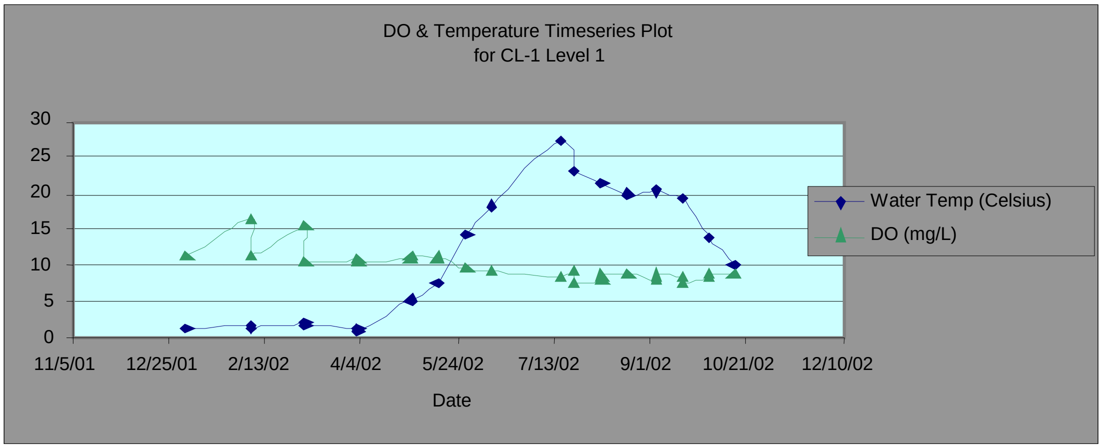

CL 1-1 (surface level)
TDS
TDS
350
300
250
200
150
100
50
0
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
TDS

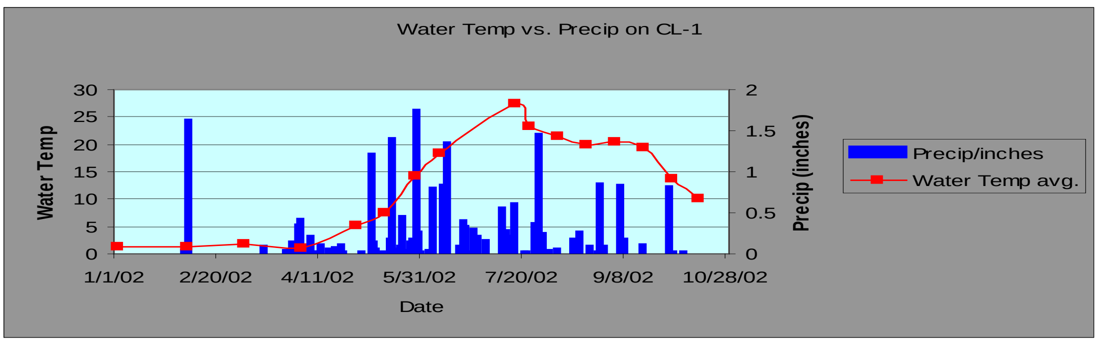

CL 1-1 (surface level)
COD
COD
35
30
25
20
15
10
5
0
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
COD (mg/L)

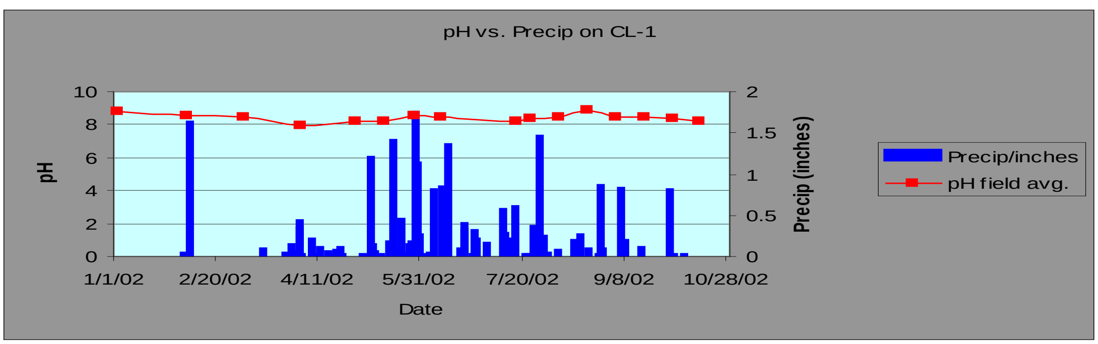

CL 1-1 (surface level)
TKN
TKN
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
TKN

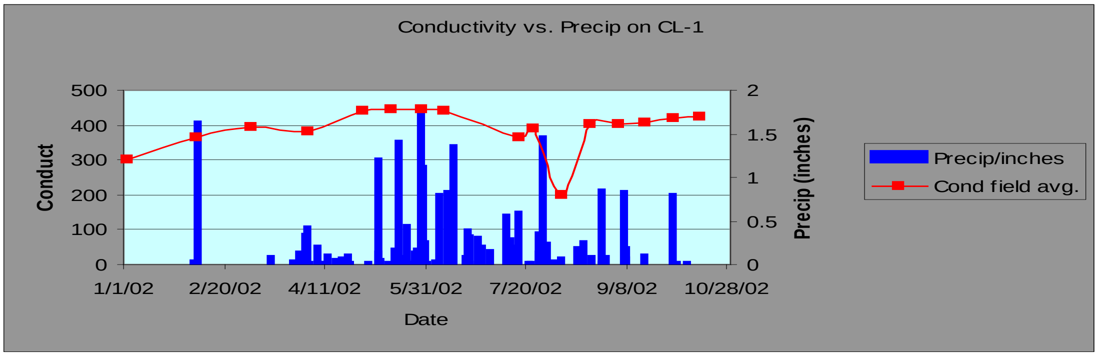

CL 1-1 (surface level)
Ortho Phosphrous
Ortho Phosphorus
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
Ortho Phos (mg/L)

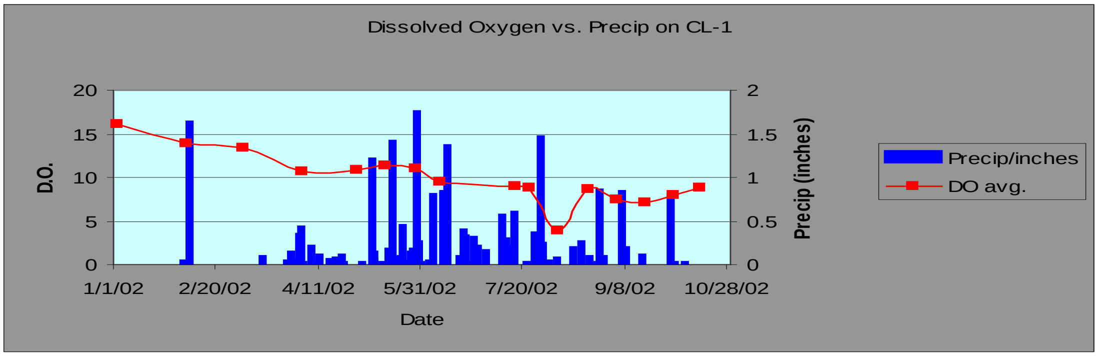

CL 1-1 (surface level)
Organic Phosphrous
Organic Phosphorus
0.1
0.08
0.06
0.04
0.02
0
-0.02
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
Organic Phos

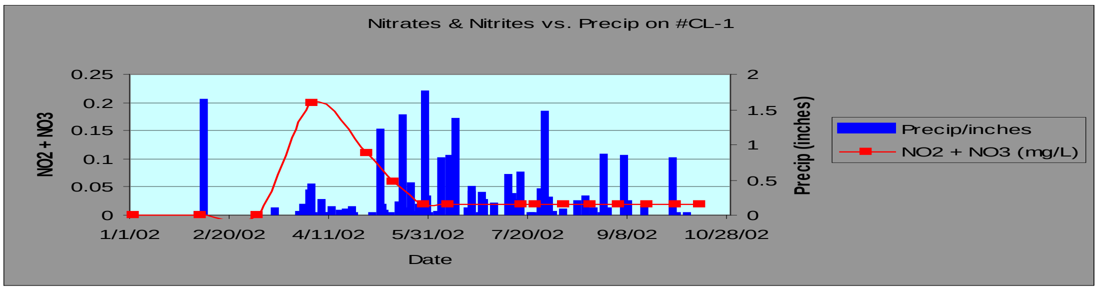

DO & Temperature Timeseries Plot
for CL-1 Level 1
30
25
20
15
10
5
0
11/5/01
12/25/01
2/13/02
4/4/02
5/24/02
7/13/02
9/1/02
10/21/02
12/10/02
Date
Water Temp (Celsius)
DO (mg/L)

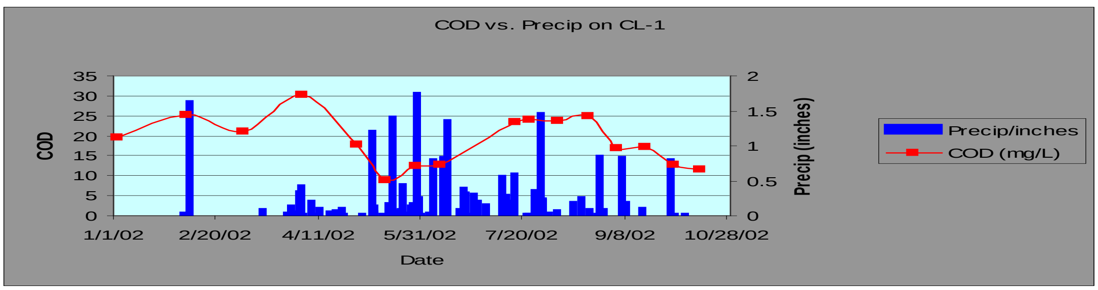

Water Temp vs. Precip on CL-1
Water Temp
30
25
20
15
10
5
0
2
1.5
1
0.5
0
Precip (inches)
1/1/02
2/20/02
4/11/02
5/31/02
7/20/02
9/8/02
10/28/02
Date
Precip/inches
Water Temp avg.

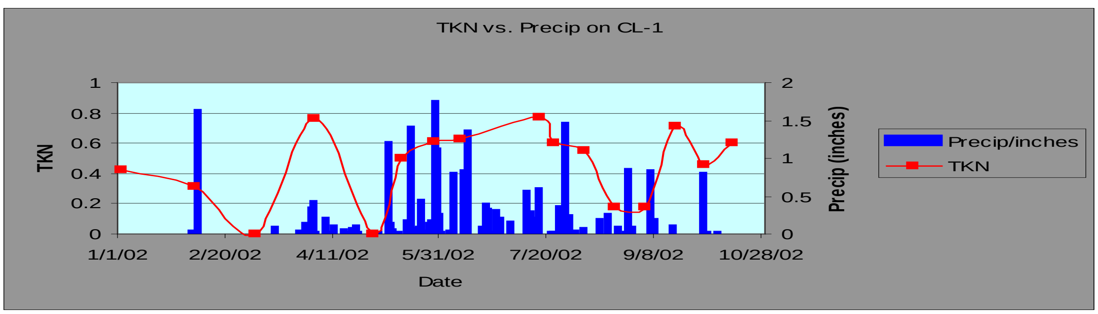

pH vs. Precip on CL-1
pH
10
8
6
4
2
0
2
1.5
1
0.5
0
Precip (inches)
1/1/02
2/20/02
4/11/02
5/31/02
7/20/02
9/8/02
10/28/02
Date
Precip/inches
pH field avg.

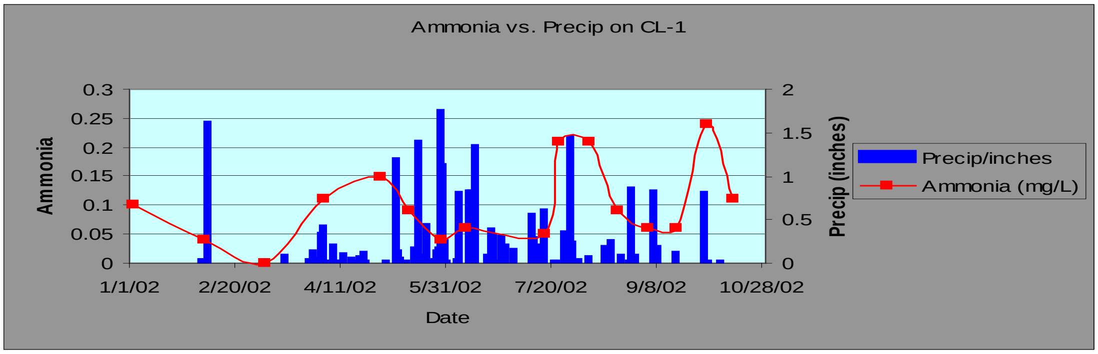

Conductivity vs. Precip on CL-1
Conduct
Precip (inches)
Date
1/1/02
2/20/02
4/11/02
5/31/02
7/20/02
9/8/02
10/28/02
Precip/inches
Cond field avg.

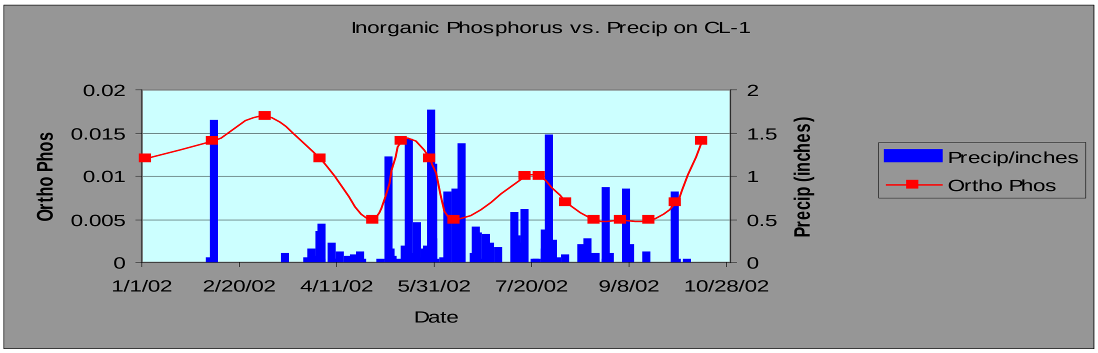

Dissolved Oxygen vs. Precip on CL-1
D.O.
Precip (inches)
Date
1/1/02
2/20/02
4/11/02
5/31/02
7/20/02
9/8/02
10/28/02
Precip/inches
DO avg.

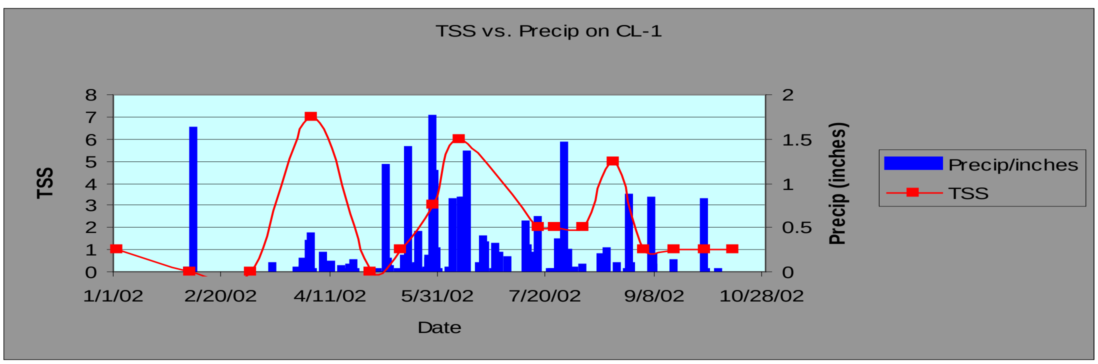

Nitrates & Nitrites vs. Precip on #CL-1
NO2 + NO3
Precip (inches)
Date
1/1/02
2/20/02
4/11/02
5/31/02
7/20/02
9/8/02
10/28/02
Precip/inches
NO2 + NO3 (mg/L)

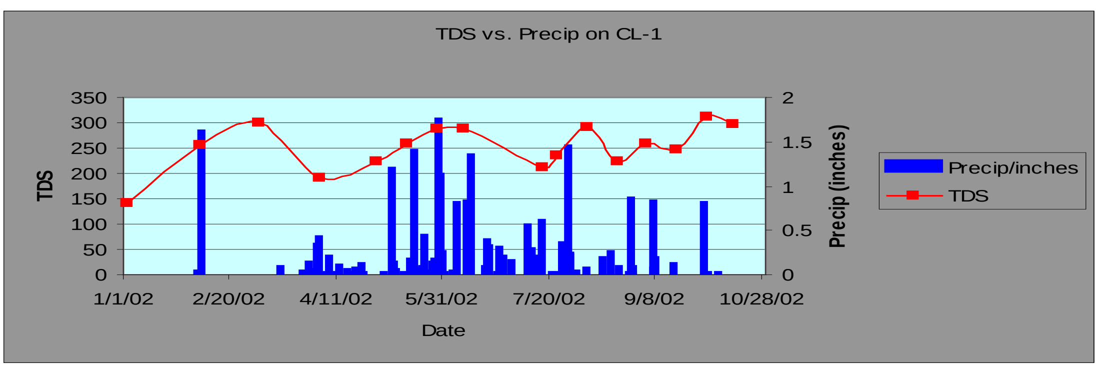

COD vs. Precip on CL-1
COD
Precip (inches)
Date
1/1/02
2/20/02
4/11/02
5/31/02
7/20/02
9/8/02
10/28/02
Precip/inches
COD (mg/L)

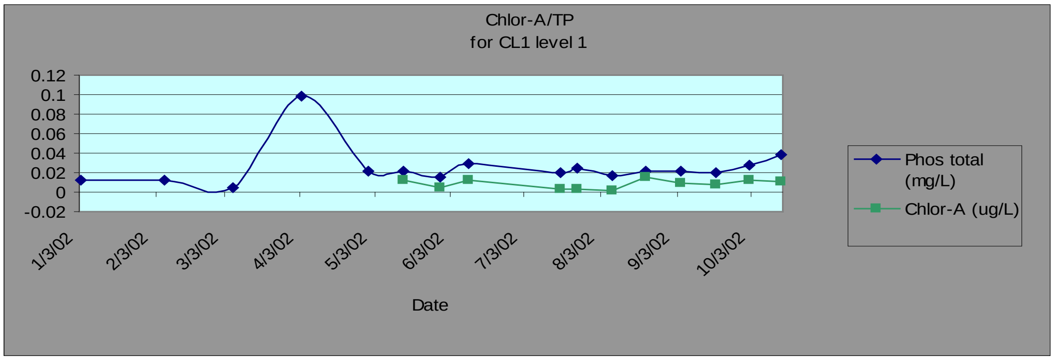

TKN vs. Precip on CL-1
TKN
Precip (inches)
Date
1/1/02
2/20/02
4/11/02
5/31/02
7/20/02
9/8/02
10/28/02
Precip/inches
TKN

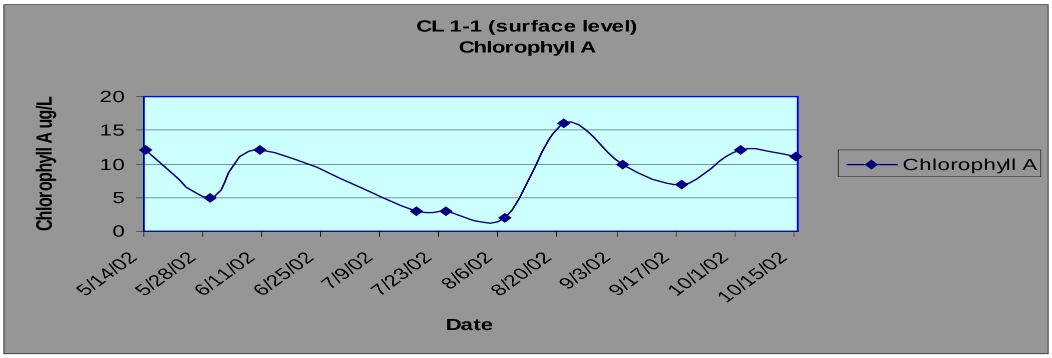

Ammonia vs. Precip on CL-1
Ammonia
Precip (inches)
Date
Precip/inches
Ammonia (mg/L)
1/1/02
2/20/02
4/11/02
5/31/02
7/20/02
9/8/02
10/28/02


Inorganic Phosphorus vs. Precip on CL-1
Ortho Phos
Precip (inches)
Date
Precip/inches
Ortho Phos

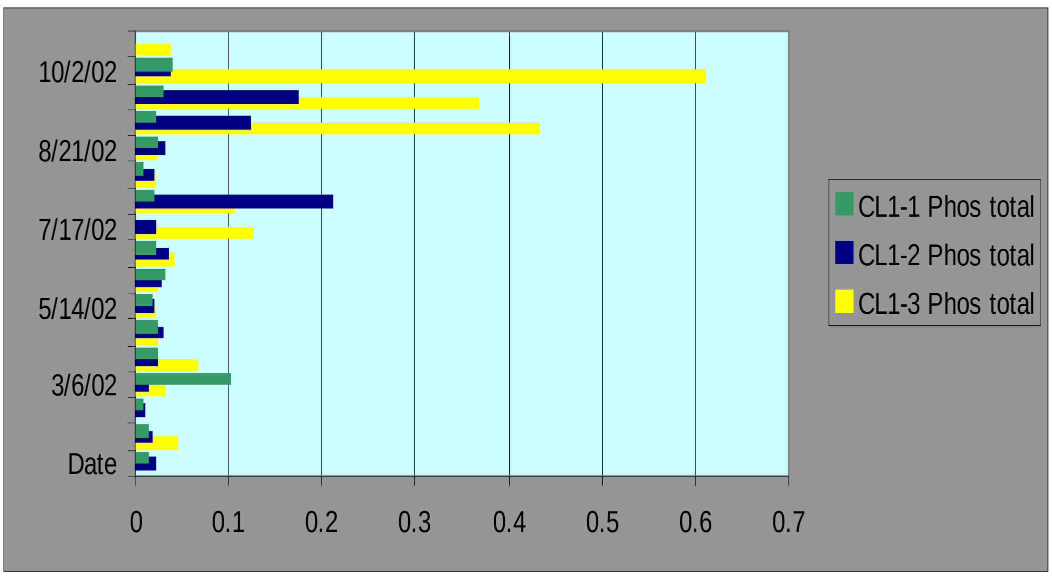

TSS vs. Precip on CL-1
TSS
Precip (inches)
Date
Precip/inches
TSS

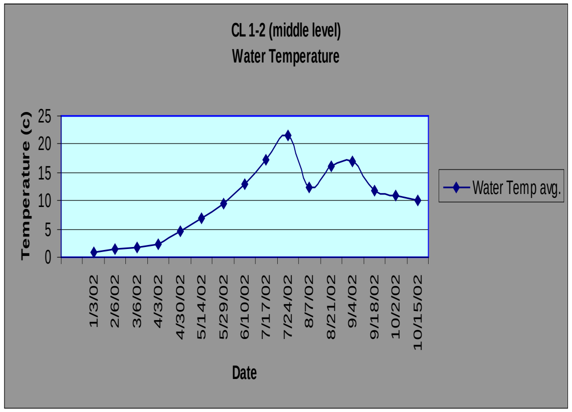

TDS vs. Precip on CL-1
TDS
Precip (inches)
Date
Precip/inches
TDS

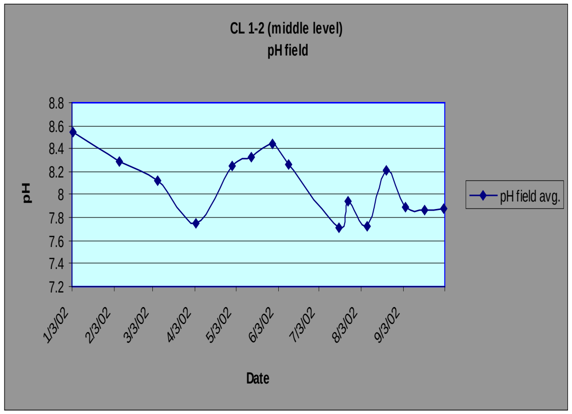

Chlor-A/TP
for CL1 level 1
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
Phos total (mg/L)
Chlor-A (ug/L)

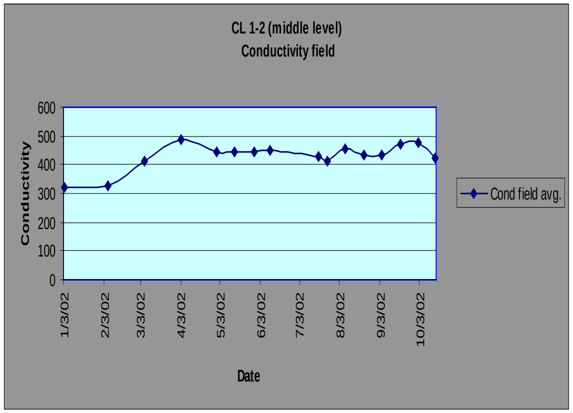

CL 1-1 (surface level)
Chlorophyll A
Chlorophyll A ug/L
20
15
10
5
0
5/14/02
5/28/02
6/11/02
6/25/02
7/9/02
7/23/02
8/6/02
8/20/02
9/3/02
9/17/02
10/1/02
10/15/02
Date
Chlorophyll A

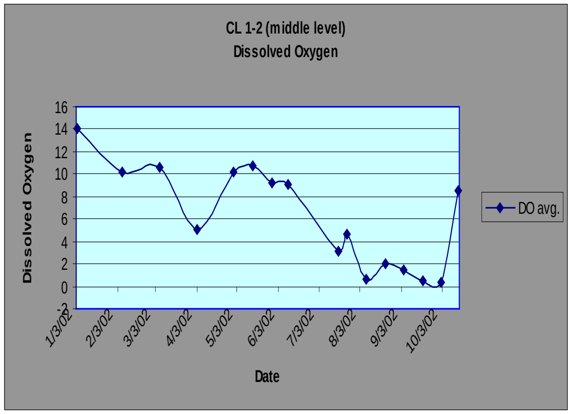
0

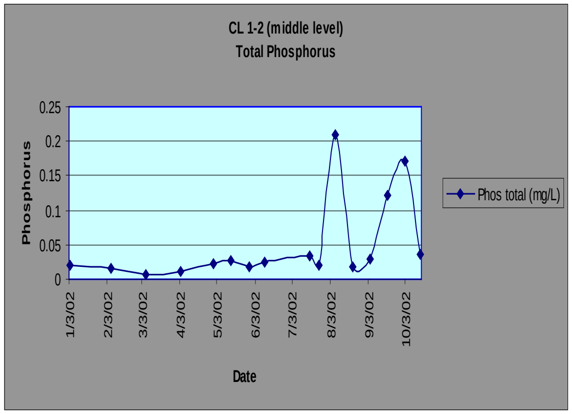

10/2/02
8/21/02
7/17/02
5/14/02
3/6/02
Date
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
CL1-1 Phos total
CL1-2 Phos total
CL1-3 Phos total

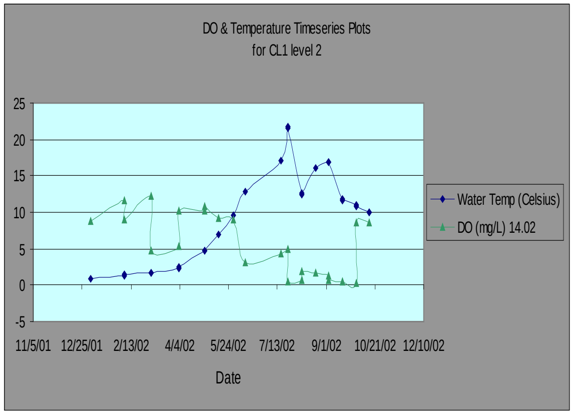

CL 1-2 (middle level)
Water Temperature
Temperature (c)
Date
Water Temp avg.

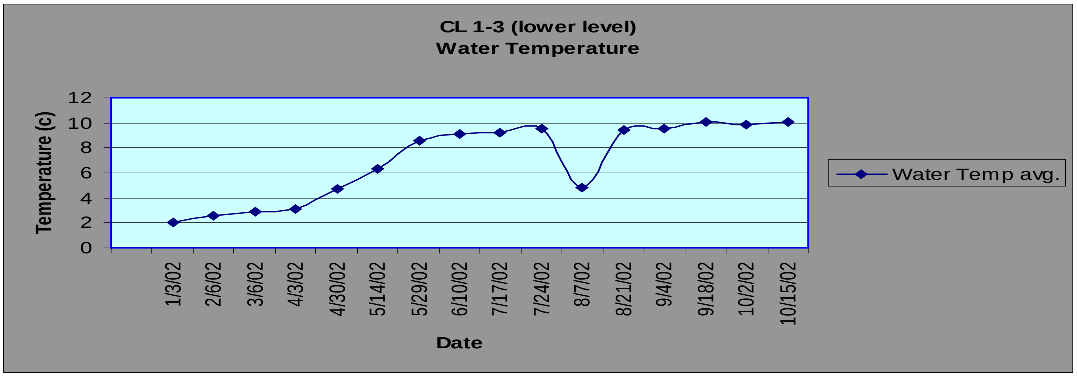

CL 1-2 (middle level)
pH field
pH
Date
pH field avg.

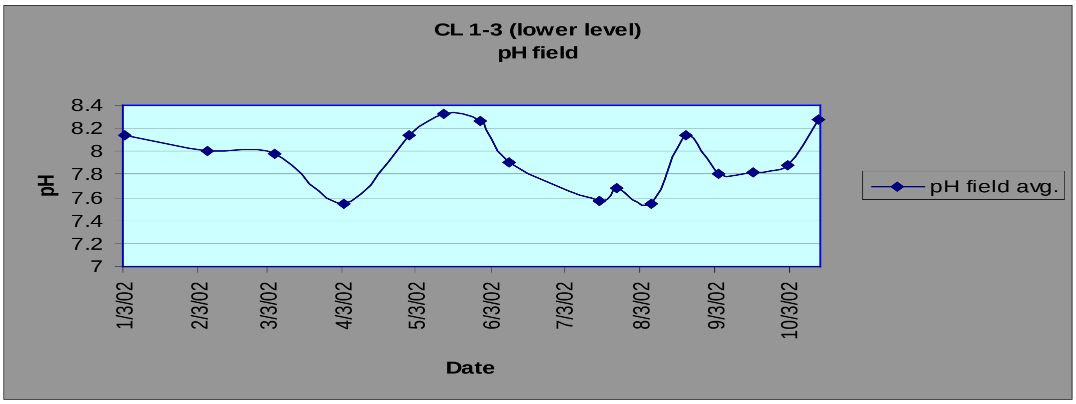

CL 1-2 (middle level)
Conductivity field
Conductivity
Date
Cond field avg.

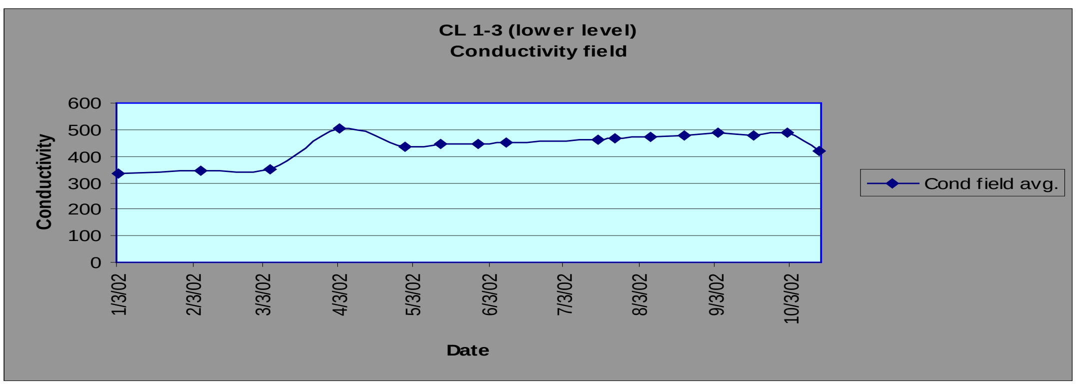

CL 1-2 (middle level)
Dissolved Oxygen
Dissolved Oxygen
Date
DO avg.

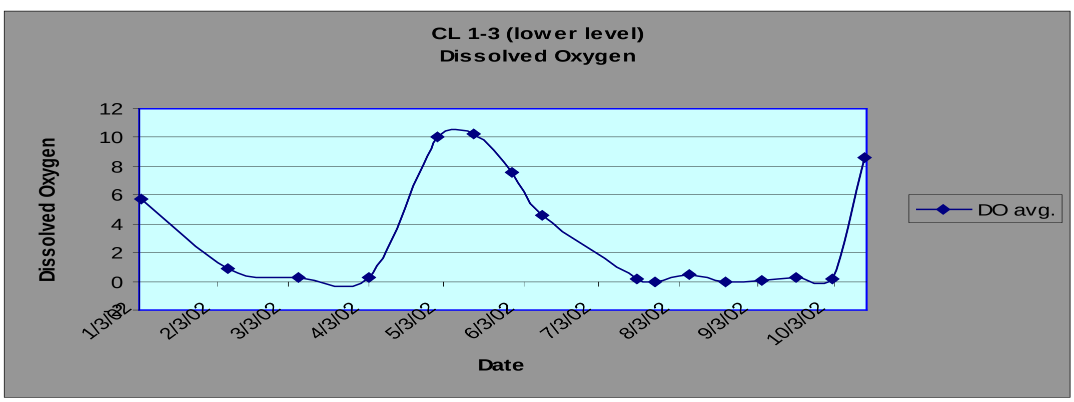

CL 1-2 (middle level)
Total Phosphorus
Phosphorus
Date
Phos total (mg/L)

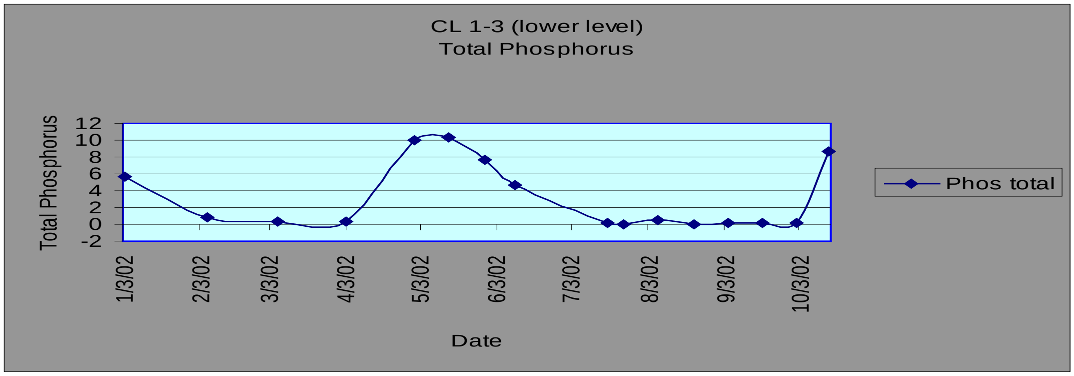

DO & Temperature Timeseries Plots
for CL1 level 2
Date
Water Temp (Celsius)
DO (mg/L) 14.02

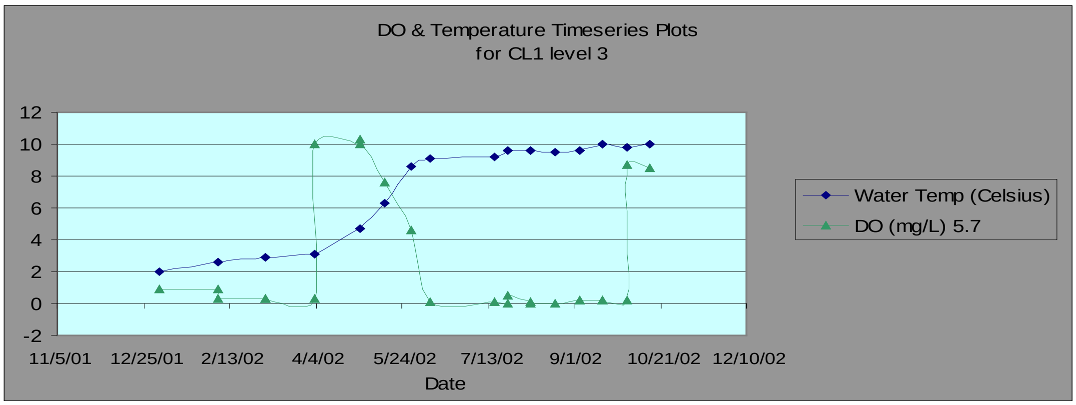

CL 1-3 (lower level)
Water Temperature
Temperature (c)
12
10
8
6
4
2
0
1/3/02
2/6/02
3/6/02
4/3/02
4/30/02
5/14/02
5/29/02
6/10/02
7/17/02
7/24/02
8/7/02
8/21/02
9/4/02
9/18/02
10/2/02
10/15/02
Date
Water Temp avg.


CL 1-3 (lower level)
pH field
pH
8.4
8.2
8
7.8
7.6
7.4
7.2
7
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
pH field avg.


CL 1-3 (lower level)
Conductivity field
Conductivity
600
500
400
300
200
100
0
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
Cond field avg.


CL 1-3 (lower level)
Dissolved Oxygen
Dissolved Oxygen
12
10
8
6
4
2
0
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
DO avg.


CL 1-3 (lower level)
Total Phosphorus
Total Phosphorus
12
10
8
6
4
2
0
-2
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
Date
Phos total


DO & Temperature Timeseries Plots
for CL1 level 3
12
10
8
6
4
2
0
-2
11/5/01
12/25/01
2/13/02
4/4/02
5/24/02
7/13/02
9/1/02
10/21/02
12/10/02
Date
Water Temp (Celsius)
DO (mg/L) 5.7

Appendix B. Lake Water Quality Sampling Data.

CL1 Water Quality Samples Summary

Date	Epilimnion Phos total (mg/L)	Metalimnion Phos total (mg/L)	Hypolimnion Phos total (mg/L)	Secchi Disk (ft)	Level 1 Chlorophyll-A (ug/L)
1/3/02	0.012	0.02	0.043		
2/6/02	0.012	0.015	0		
3/6/02	0.005	0.007	0.03		
4/3/02	0.099	0.012	0.065		
4/30/02	0.022	0.022	0.022	15	
5/14/02	0.022	0.028	0.020	8.5	12
5/29/02	0.015	0.017	0.022	8.5	5
6/10/02	0.030	0.025	0.040	6.0	12
7/17/02	0.02	0.033	0.124	5.5	3
7/24/02	0.025	0.020	0.104	6.5	3
8/7/02	0.017	0.209	0.019	7.5	2
8/21/02	0.022	0.017	0.366	4.0	16
9/4/02	0.022	0.030	0.431	6.0	10
9/18/02	0.02	0.122	0.366	9.0	7
10/2/02	0.028	0.172	0.609	6.0	12
10/15/02	0.038	0.035	0.035	8.0	11

CL2 Water Quality Samples Summary

Date	Epilimnion Phos total (mg/L)	Metalimnion Phos total (mg/L)	Hypolimnion Phos total (mg/L)	Secchi Disk (ft)	Chlorophyll A (ug/L)
01/03/02	0.015	0.012	0.028		
02/06/02	0.015	0.01	0.02		
03/06/02	0.012	0.007	0.005		
04/03/02	0.084	0.012	0.017		
04/30/02	0.028	0.025	0.022	11	
05/14/02	0.033	0.025	0.012	6.5	13
05/29/02	0.025	0.022	0.022	6.5	9
06/10/02	0.025	0.025	0.03	5.51	14
07/17/02	0.028	0.035	0.058	7.5	3
07/24/02	0.028	0.015	0.043	7.5	3
08/07/02	0.022	0.022	0.017	8.5	2
08/21/02	0.022	0.017	0.111	5.0	15
09/04/02	0.038	0.022	0.203	5.5	14
10/02/02	0.035	0.033	0.038	5.5	18
10/15/02	0.038	0.038	0.038	7.5	13

Trophic State Index Data for Both Lake Monitoring Sites									
Date	Secchi Depth TSI Score		TP TSI Score		Chlorophyll-a TSI Score		Average TSI Score		Mixed or Stratified
	CL1	CL2	CL1	CL2	CL1	CL2	CL1	CL2	
1/3/2002			39.98	43.20			39.98	43.20	Mixed
2/6/2002			39.98	43.20			39.98	43.20	Mixed
3/6/2002			27.36	39.98			27.36	39.98	Mixed
4/3/2002			70.41	68.04			70.41	68.04	Mixed
4/30/2002	20.98	25.45	48.72	52.20			34.85	38.82	Mixed
5/14/2002	29.16	33.03	48.72	54.57	54.98	55.76	44.29	47.79	Mixed
5/29/2002	29.16	33.03	43.20	50.57	46.39	52.15	39.58	45.25	Stratified
6/10/2002	34.18	35.41	53.20	50.57	54.98	56.49	47.45	47.49	Stratified
7/17/2002	35.43	30.97	47.35	52.20	41.38	41.38	41.39	41.51	Stratified
7/24/2002	33.03	30.97	17.36	52.20	41.38	41.38	30.59	41.51	Stratified
8/7/2002	30.97	29.16	45.00	48.72	37.40	37.40	37.79	38.43	Stratified
8/21/2002	40.02	36.81	27.36	48.72	57.80	57.17	41.73	47.57	Stratified
9/4/2002	34.18	35.43	48.72	56.60	53.19	56.49	45.36	49.51	Stratified
9/18/2002	28.34		47.35		49.69		41.79		Stratified
10/2/2002	34.18	35.43	52.20	55.42	54.98	58.95	47.12	49.94	Stratified
10/15/2002	30.04	30.97	56.60	56.60	54.12	55.76	46.92	47.78	Mixed
Averages	**31.64**	**32.42**	**44.60**	**51.52**	**49.66**	**51.29**	**42.29**	**46.00**	

Laboratory Analysis Results for Surface Water Quality Samples												
	COD		TKN		Ammonia		TSS		TDS		Chlorophyll-a	
Date	CL1	CL2	CL1	CL2	CL1	CL2	CL1	CL2	CL1	CL2	CL1	CL2
1/3/2002	19.70	20.00	0.42	0.38	0.10	0.05	1.00	1.00	140.00	164.00		
2/6/2002	25.30	27.60	0.31	0.24	0.04	0.05	<1	3.00	256.00	286.00		
3/6/2002	21.00	21.00	<.01	<.01	0.00	0.11	<1	1.00	300.00	296.00		
4/3/2002	30.20	26.60	0.76	0.63	0.11	0.10	7.00	2.00	192.00	223.00		
4/30/2002	17.70	13.50	<.18	0.19	0.15	0.09	<1	<1	224.00	272.00		
5/14/2002	8.94	9.92	0.50	0.46	0.09	0.04	<1	1.00	260.00	268.00	0.012	0.013
5/29/2002	12.50	15.80	0.61	0.51	0.04	0.00	3.00	<1	288.00	280.00	0.005	0.009
6/10/2002	12.90	15.80	0.63	0.53	0.06	0.05	6.00	7.00	288.00	296.00	0.012	0.014
7/17/2002	23.30	21.00	0.77	0.57	0.05	0.04	2.00	3.00	212.00	216.00	0.003	0.003
7/24/2002	23.90	24.20	0.60	0.60	0.21	0.19	2.00	2.00	236.00	248.00	0.003	0.003
8/7/2002	23.60	20.00	0.55	0.53	0.21	0.24	2.00	3.00	292.00	272.00	0.002	0.002
8/21/2002	24.90	20.70	<.18	0.53	0.09	0.07	5.00	3.00	224.00	224.00	0.016	0.015
9/4/2002	16.80	19.00	<.18	<.18	0.06	0.05	1.00	5.00	260.00	244.00	0.010	0.014
9/18/2002	17.10		0.71		0.06		<1		246.00		0.007	
10/2/2002	12.80	13.50	0.46	0.50	0.24	0.16	<1	<1	312.00	320.00	0.012	0.018
10/15/2002	11.50	12.20	0.60	0.75	0.11	0.11	1.00	1.00	296.00	292.00	0.011	0.013

Water Temperature Profiles at Both Lake Monitoring Sites

Date:	1/3/2002		2/6/2002		3/6/2002		4/3/2002		4/30/2002		5/14/2002		5/29/2002		6/10/2002	
Depth	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**
Surface															18.26	18.34
1 Meter	1.22	1.00	1.39	0.72	2.03	0.99	1.04	0.84	5.12	5.58	7.47	8.11	14.28	13.93	17.75	17.28
2 Meters	1.17	1.06	1.39	1.11	2.01	1.27	2.50	1.99	4.80	4.97	7.28	7.61	13.42	12.06	17.03	16.72
3 Meters	1.17	1.06	1.39	1.22	2.01	1.73	2.71	2.07	4.75	4.88	7.14	7.10	13.00	11.76	16.90	16.43
4 Meters	1.17	1.06	1.39	1.22	2.01	1.68	2.71	2.11	4.73	4.85	7.06	6.94	12.54	11.57	16.60	16.32
5 Meters	1.17	1.06	1.39	1.22	2.01	1.68	2.73	2.17	4.72	4.82	7.05	6.82	12.54	11.45	16.24	15.67
6 Meters	1.17	1.11	1.33	1.20	2.01	1.68	2.75	2.24	4.73	4.79	7.06	6.50	11.61	11.15	15.17	15.44
7 Meters	1.22	1.17	1.22	1.20	2.03	1.68	2.76	2.25	4.72	4.70	7.03	6.48	10.95	10.60	12.93	14.18
8 Meters	1.28	1.22	1.17	1.14	2.01	1.68	2.81	2.17	4.72	4.66	6.94	6.48	10.01	10.18	10.80	11.28
9 Meters	1.06	1.22	1.17	1.22	1.74	1.81	2.67	2.21	4.72	4.64	6.92	6.48	9.62	9.64	10.10	9.88
10 Meters	0.94	1.33	1.33	1.34	1.70	1.95	2.70	2.18	4.72	4.63	6.91	6.49	9.18	9.56	9.87	9.71
11 Meters	1.06	1.40	1.44	1.64	1.73	1.88	2.82	2.20	4.72	4.60	6.87	6.49	8.97	9.28	9.44	9.69
12 Meters	1.22	1.61	1.56	1.95	1.85	1.84	2.44	2.50	4.71	4.60	6.86	6.47	8.89	8.94	9.43	9.52
13 Meters	1.50		1.67		2.06		2.20		4.71		6.85		8.78		9.35	
14 Meters	1.55		1.83		2.30		2.41		4.70		6.84		8.72		9.31	
15 Meters	1.72		2.17		2.36		2.59		4.72		6.66		8.65		9.29	
16 Meters	1.78		2.28		2.62		2.64		4.70		6.56		8.62		9.21	
17 Meters	2.00		2.44		2.72		2.78		4.69		6.53		8.59		9.10	
18 Meters	2.33		2.61		2.94		3.09		4.59		6.35		8.50		9.07	
19 Meters			3.11		3.52		3.70		4.59		6.33				9.05	

Water Temperature Profiles for Both Lake Monitoring Sites (Continued)

Date:	7/17/2002		7/24/2002		8/7/2002		8/21/2002		9/4/2002		9/18/2002		10/2/2002		10/15/2002	
Depth	CL1	CL2	CL1	CL2	CL1	CL2	CL1	CL2	CL1	CL2	CL1	CL2	CL1	CL2	CL1	CL2
Surface	27.30	28.30	23.16	22.78	21.45	21.03	20.04	19.77	20.49	20.51	19.42		13.78	13.96	10.02	9.72
1 Meter	26.16	28.21	23.16	22.77	21.45	21.03	19.99	19.56	20.47	20.48	19.40		13.79	13.97	10.02	9.72
2 Meters	25.00	25.92	23.16	22.72	21.45	21.02	19.93	19.51	20.50	20.42	19.38		13.79	13.97	10.02	9.72
3 Meters	23.89	25.12	23.15	22.69	21.44	21.02	19.76	19.36	20.40	20.38	19.37		13.79	13.97	10.05	9.70
4 Meters	23.14	23.84	23.13	22.53	21.45	20.95	19.54	19.14	20.36	20.25	19.37		13.79	13.97	10.05	9.70
5 Meters	22.00	22.40	23.11	20.89	21.45	20.54	19.28	19.07	20.35	19.96	19.37		13.79	13.98	10.05	9.70
6 Meters	20.28	20.00	21.59	18.89	21.44	19.45	19.14	19.02	20.32	18.97	19.36		13.79	13.98	10.05	9.70
7 Meters	17.14	15.29	15.45	16.37	21.43	16.58	18.85	18.96	20.28	18.05	19.36		13.79	13.98	10.05	9.68
8 Meters	13.26	12.53	13.18	14.99	18.36	12.00	18.59	18.44	20.25	17.35	19.34		13.79	13.96	10.05	9.61
9 Meters	11.50	11.23	11.40	12.40	12.36	11.04	16.13	13.03	16.99	14.45	19.32		13.79	13.90	10.04	9.60
10 Meters	10.68	10.63	10.68	11.29	10.56	10.35	11.87	10.88	13.65	12.25	19.25		13.78	13.75	10.04	9.56
11 Meters	10.25	10.16	10.62	10.54	10.23	9.95	10.76	10.10	11.15	10.77	11.89		13.19	13.65	10.05	9.51
12 Meters	10.03	9.72	9.89		10.05	9.79	10.14		10.49	10.34	10.67		12.27	12.93	10.05	
13 Meters	9.88		9.77		9.84		9.93		10.21		10.33		10.91		10.05	
14 Meters	9.72		9.65		9.78		9.76		10.01		10.13		10.39		10.04	
15 Meters	9.60		9.56		9.70		9.67		9.86		10.03		10.20		10.04	
16 Meters	9.50		9.45		9.58		9.56		9.74		9.80		10.11		10.04	
17 Meters	9.36		9.37		9.53		9.46		9.66		9.71		10.04		10.03	
18 Meters	9.23		9.25		9.41		9.35		9.56				9.83		10.03	
19 Meters	9.09												9.72			

Dissolved Oxygen Profiles at Both Lake Monitoring Sites

Date:	1/3/2002		2/6/2002		3/6/2002		4/3/2002		4/30/2002		5/14/2002		5/29/2002		6/10/2002	
Depth	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**
Surface															9.54	10.00
1 Meter	16.15	14.81	14.15	13.02	11.40	12.48	10.78	11.84	10.65	10.45	11.28	10.65	10.99	10.77	9.28	10.16
2 Meters	16.17	14.65	13.97	12.42	11.15	11.97	11.23	10.60	9.92	10.43	11.26	10.75	11.20	11.04	9.81	9.89
3 Meters	16.07	14.64	13.92	12.62	11.10	11.93	11.30	10.38	10.30	10.37	11.04	10.64	11.25	10.87	9.37	9.80
4 Meters	16.08	14.62	13.80	12.54	11.15	11.74	11.37	9.96	10.24	10.37	11.09	10.82	11.20	10.85	9.59	9.73
5 Meters	16.06	14.64	13.29	11.52	11.00	11.73	11.37	9.87	10.36	10.25	11.01	10.67	11.15	10.65	9.37	9.53
6 Meters	16.06	14.60	12.09	11.01	11.00	11.71	11.40	10.00	10.29	10.26	11.21	10.64	11.06	10.63	9.04	9.39
7 Meters	15.82	14.39	11.65	10.80	13.06	11.74	11.43	9.99	10.26	10.22	10.94	10.49	10.23	10.18	8.44	8.51
8 Meters	15.57	14.05	11.51	10.56	12.95	11.68	11.42	9.21	10.31	10.17	11.14	10.52	9.47	9.49	7.53	7.96
9 Meters	14.71	13.61	10.84	10.08	11.55	11.25	10.99	7.61	10.22	10.15	10.96	10.55	9.21	9.19	6.90	6.54
10 Meters	14.02	13.10	10.17	9.11	10.62	10.35	10.73	6.42	10.23	10.15	10.71	10.60	8.65	8.89	6.68	5.84
11 Meters	13.02	10.82	9.08	7.90	7.88	8.11	10.58	5.33	10.30	10.12	10.80	10.57	8.44	8.09	6.01	5.75
12 Meters	12.41	5.53	7.98	5.42	5.99	6.94	5.05	0.55	10.23	9.90	10.73	10.63	8.26	6.83	5.82	5.25
13 Meters	11.17		7.06		4.63		3.68		10.27		10.72		8.11		5.65	
14 Meters	9.90		6.30		2.75		1.34		10.27		10.75		8.11		5.40	
15 Meters	9.15		4.48		1.45		0.63		10.18		10.73		7.85		5.55	
16 Meters	8.76		3.82		0.73		0.62		10.04		10.67		7.73		5.31	
17 Meters	5.70		2.60		0.63		0.39		10.02		10.58		7.61		4.63	
18 Meters	2.30		0.90		0.29		0.28		9.94		10.28		7.21		4.48	
19 Meters			0.49		0.18		0.21		9.49		10.17				4.35	

Dissolved Oxygen Profiles for Both Lake Monitoring Sites (Continued)

Date:	7/17/2002		7/24/2002		8/7/2002		8/21/2002		9/4/2002		9/18/2002		10/2/2002		10/15/2002	
Depth	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**
Surface	9.05	10.49	9.14	7.80	7.58	7.00	8.71	8.46	7.12	7.36	6.60		8.39	8.92	8.88	8.78
1 Meter	9.69	10.10	8.61	7.65	7.32	6.63	8.59	8.45	6.98	7.12	6.52		8.36	8.90	8.71	8.76
2 Meters	9.17	11.50	8.49	7.26	7.16	6.46	8.43	8.28	7.00	6.96	6.40		8.30	8.90	8.64	8.64
3 Meters	7.61	10.69	8.40	6.88	7.07	6.37	8.17	8.07	6.89	6.79	6.35		8.19	8.70	8.57	8.56
4 Meters	6.71	7.44	8.23	6.57	7.03	6.08	7.73	7.32	6.82	6.47	6.36		8.07	8.55	8.53	8.62
5 Meters	4.50	5.77	8.12	3.20	6.99	4.80	7.45	7.25	6.77	5.56	6.31		8.17	8.75	8.51	8.66
6 Meters	4.20	3.86	4.97	1.88	6.97	3.15	7.47	6.86	6.73	3.60	6.28		7.99	8.64	8.73	8.70
7 Meters	3.12	3.77	2.05	2.02	6.91	0.57	6.79	7.04	6.68	2.14	6.24		7.68	8.51	8.64	8.67
8 Meters	3.36	3.03	1.70	1.95	3.13	0.48	6.08	6.75	6.65	1.39	6.18		7.64	8.59	8.52	8.60
9 Meters	2.49	1.65	1.00	1.41	0.54	0.43	1.99	0.42	1.25	0.17	6.21		7.90	8.29	8.41	8.60
10 Meters	1.72	1.00	0.71	0.68	0.58	0.45	0.22	0.24	0.30	0.15	6.07		7.73	8.06	8.41	8.62
11 Meters	1.32	0.29	0.62	0.23	0.53	0.41	0.14	0.18	0.27	0.15	0.43		1.99	7.91	8.43	8.64
12 Meters	0.59	0.18	0.16		0.51	0.41	0.10		0.25	0.15	0.28		0.44	7.43	8.40	
13 Meters	0.17		0.15		0.51		0.05		0.21		0.28		0.33		8.41	
14 Meters	0.13		0.12		0.53		0.03		0.20		0.25		0.33		8.41	
15 Meters	0.11		0.11		0.50		0.00		0.18		0.24		0.33		8.52	
16 Meters	0.15		0.10		0.48		0.00		0.18		0.23		0.30		8.49	
17 Meters	0.16		0.09		0.51		0.00		0.17		0.22		0.23		8.54	
18 Meters	0.13		0.10		0.48		0.00		0.16				0.22		8.37	
19 Meters	0.12												0.21			

pH Profiles at Both Lake Monitoring Sites

Date:	1/3/2002		2/6/2002		3/6/2002		4/3/2002		4/30/2002		5/14/2002		5/29/2002		6/10/2002	
Depth	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**
Surface															8.48	8.59
1 Meter	8.83	8.85	8.58	8.50	8.67	8.19	7.99	8.09	8.30	8.42	8.22	8.44	8.54	8.61	8.48	8.58
2 Meters	8.84	8.86	8.60	8.50	8.63	8.31	8.14	8.01	8.34	8.42	8.26	8.44	8.55	8.64	8.48	8.54
3 Meters	8.84	8.86	8.61	8.52	8.63	8.29	8.16	7.99	8.36	8.42	8.29	8.45	8.55	8.63	8.47	8.52
4 Meters	8.85	8.86	8.63	8.55	8.63	8.32	8.16	7.97	8.36	8.43	8.30	8.45	8.53	8.63	8.46	8.52
5 Meters	8.86	8.87	8.61	8.47	8.63	8.33	8.16	7.97	8.37	8.42	8.31	8.44	8.52	8.61	8.43	8.48
6 Meters	8.86	8.86	8.46	8.42	8.63	8.34	8.17	7.99	8.37	8.42	8.32	8.43	8.50	8.61	8.36	8.47
7 Meters	8.84	8.86	8.41	8.41	8.64	8.34	8.17	7.98	8.37	8.41	8.33	8.43	8.55	8.57	8.26	8.38
8 Meters	8.83	8.82	8.39	8.37	8.38	8.35	8.18	7.90	8.37	8.40	8.33	8.42	8.48	8.51	8.12	8.24
9 Meters	8.66	8.78	8.34	8.33	8.22	8.34	8.11	7.82	8.35	8.40	8.33	8.42	8.44	8.46	8.05	8.08
10 Meters	8.54	8.74	8.29	8.27	8.13	8.26	8.10	7.73	8.36	8.40	8.33	8.42	8.37	8.44	8.03	8.03
11 Meters	8.49	8.42	8.22	8.21	7.99	8.07	8.11	7.70	8.36	8.40	8.34	8.42	8.34	8.34	7.97	8.02
12 Meters	8.47	8.11	8.15	8.01	7.90	7.95	7.75	7.55	8.36	8.38	8.35	8.43	8.33	8.24	7.97	7.94
13 Meters	8.41		8.11		7.86		7.63		8.37		8.35		8.32		7.95	
14 Meters	8.31		8.06		7.82		7.56		8.36		8.35		8.30		7.95	
15 Meters	8.27		8.01		7.80		7.54		8.38		8.35		8.28		7.95	
16 Meters	8.24		7.98		7.98		7.53		8.15		8.33		8.27		7.95	
17 Meters	8.14		8.04		7.98		7.53		8.14		8.35		8.26		7.92	
18 Meters	8.03		8.00		7.98		7.55		8.14		8.33		8.22		7.90	
19 Meters			8.15		8.17		7.33		8.12		8.33				7.88	

pH Profiles for Both Lake Monitoring Sites (Continued)

Date:	7/17/2002		7/24/2002		8/7/2002		8/21/2002		9/4/2002		9/18/2002		10/2/2002		10/15/2002	
Depth	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**
Surface	8.21	8.25	8.15	7.96	8.15	8.11	8.85	8.87	8.20	8.22	8.25		8.24	8.36	8.35	8.38
1 Meter	8.21	8.26	8.15	7.95	8.15	8.11	8.85	8.85	8.22	8.26	8.25		8.26	8.36	8.33	8.38
2 Meters	8.13	8.23	8.15	7.95	8.15	8.09	8.84	8.85	8.23	8.26	8.25		8.27	8.37	8.15	8.39
3 Meters	7.97	8.19	8.14	7.94	8.16	8.09	8.82	8.83	8.23	8.26	8.25		8.28	8.37	8.34	8.39
4 Meters	7.85	7.91	8.14	7.90	8.16	8.06	8.78	8.75	8.23	8.24	8.25		8.28	8.38	8.35	8.40
5 Meters	7.68	7.74	8.14	7.56	8.16	8.03	8.74	8.74	8.23	8.15	8.26		8.28	8.38	8.35	8.40
6 Meters	7.67	7.68	7.75	7.50	8.16	7.74	8.74	8.73	8.23	7.80	8.26		8.28	8.38	8.35	8.39
7 Meters	7.71	7.72	7.57	7.56	8.16	7.54	8.69	8.75	8.23	7.81	8.26		8.28	8.38	8.36	8.40
8 Meters	7.70	7.67	7.54	7.56	7.72	7.53	8.62	8.66	8.23	7.74	8.26		8.29	8.37	8.36	8.40
9 Meters	7.64	7.60	7.50	7.52	7.52	7.53	8.21	8.12	7.72	7.63	8.26		8.29	8.37	8.36	8.40
10 Meters	7.59	7.57	7.49	7.49	7.54	7.54	8.06	8.10	7.63	7.62	8.25		8.29	8.34	8.36	8.40
11 Meters	7.57	7.55	7.49	7.49	7.54	7.55	8.06	8.10	7.61	7.61	7.71		7.89	8.33	8.36	8.40
12 Meters	7.54	7.58	7.50		7.54	7.54	8.08		7.61	7.60	7.68		7.80	8.18	8.36	
13 Meters	7.52		7.51		7.54		8.11		7.60		7.67		7.73		8.36	
14 Meters	7.51		7.51		7.54		8.13		7.59		7.66		7.73		8.37	
15 Meters	7.51		7.53		7.54		8.12		7.59		7.66		7.73		8.37	
16 Meters	7.51		7.53		7.54		8.14		7.58		7.64		7.72		8.37	
17 Meters	7.53		7.55		7.54		8.14		7.58		7.62		7.72		8.37	
18 Meters	7.57		7.57		7.54		8.15		7.58				7.72		8.37	
19 Meters	7.63												7.71			

Conductivity Profiles at Both Lake Monitoring Sites

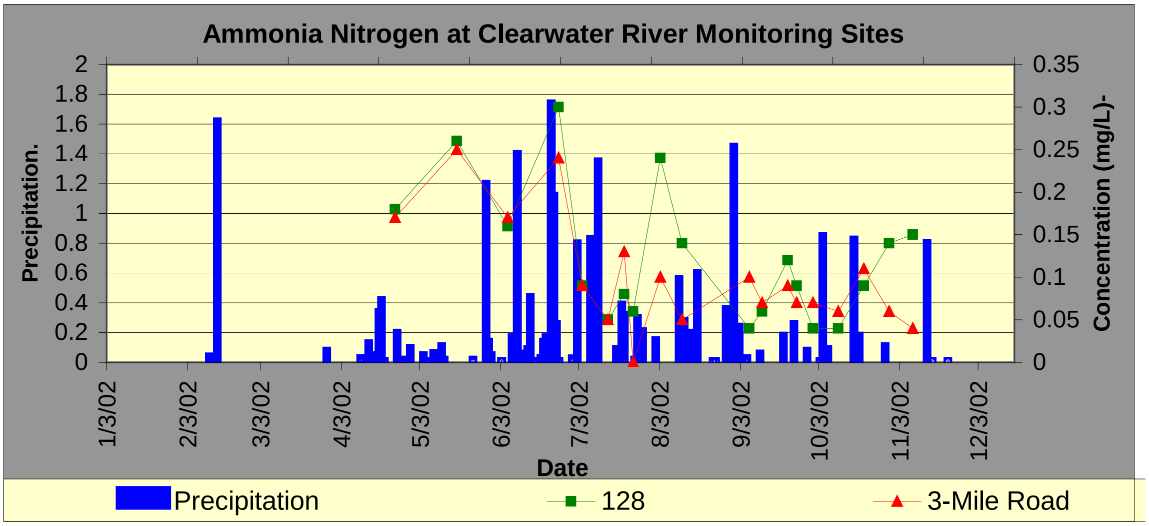
Date:	1/3/2002		2/6/2002		3/6/2002		4/3/2002		4/30/2002		5/14/2002		5/29/2002		6/10/2002	
Depth	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**
Surface															440.00	440.00
1 Meter	299.80	305.20	366.00	440.85	466.00	408.00	377.00	409.00	446.00	447.00	447.10	450.30	447.00	445.00	440.00	439.00
2 Meters	300.60	304.90	352.00	400.55	466.00	402.50	468.50	481.00	446.00	447.00	446.90	447.10	447.00	441.00	440.00	441.00
3 Meters	300.70	304.90	343.95	380.50	466.00	403.50	467.50	482.50	446.00	447.00	446.30	448.00	446.00	441.00	441.00	442.00
4 Meters	300.90	305.10	343.95	382.60	466.00	405.50	468.00	482.50	447.00	447.00	446.70	447.30	446.00	441.00	441.00	443.00
5 Meters	300.80	304.80	343.80	402.10	466.00	406.00	468.00	481.50	447.00	448.00	446.70	447.30	447.00	442.00	442.00	446.00
6 Meters	301.10	303.80	321.00	463.15	467.00	406.00	468.00	480.50	447.00	448.00	446.20	447.70	447.00	442.00	446.00	445.00
7 Meters	300.70	303.70	323.80	517.40	395.00	406.00	468.00	480.50	447.00	448.00	446.50	447.80	442.00	442.40	450.00	441.00
8 Meters	300.90	305.50	325.80	557.45	397.50	406.00	467.50	484.50	447.00	448.00	446.70	446.60	442.00	443.00	448.00	449.00
9 Meters	313.90	307.00	325.40	627.40	412.50	404.50	471.00	485.50	447.00	448.00	446.80	447.70	442.00	443.00	449.00	449.00
10 Meters	322.10	308.50	327.60	605.05	414.00	404.00	471.00	489.50	447.00	448.00	446.70	447.40	443.00	444.00	449.00	452.00
11 Meters	323.00	325.50	334.60	624.85	396.00	423.50	471.00	493.00	447.00	448.00	446.80	447.30	443.00	445.00	450.00	451.00
12 Meters	323.50	353.20	337.70	653.70	419.00	456.00	486.50	519.50	447.00	448.00	447.00	447.40	444.00	447.00	450.00	453.00
13 Meters	325.30		342.10		422.00		496.50		447.00		446.90		444.00		451.00	
14 Meters	332.50		345.50		424.00		499.50		447.00		446.60		444.00		450.00	
15 Meters	334.80		344.20		424.00		500.50		447.00		446.60		445.00		450.00	
16 Meters	337.10		346.90		348.00		499.00		439.00		447.10		445.00		451.00	
17 Meters	334.80		347.10		348.00		500.00		438.00		446.90		445.00		452.00	
18 Meters	333.40		347.20		350.00		507.00		438.00		446.80		446.00		452.00	
19 Meters			370.60		385.00		589.00		440.00		447.30				452.00	

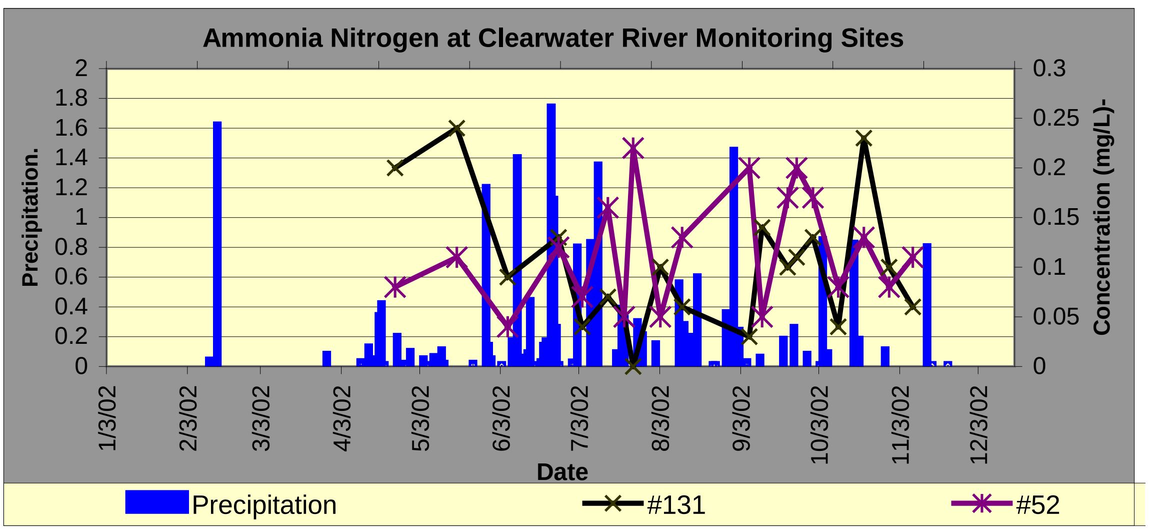
Conductivity Profiles for Both Lake Monitoring Sites (Continued)

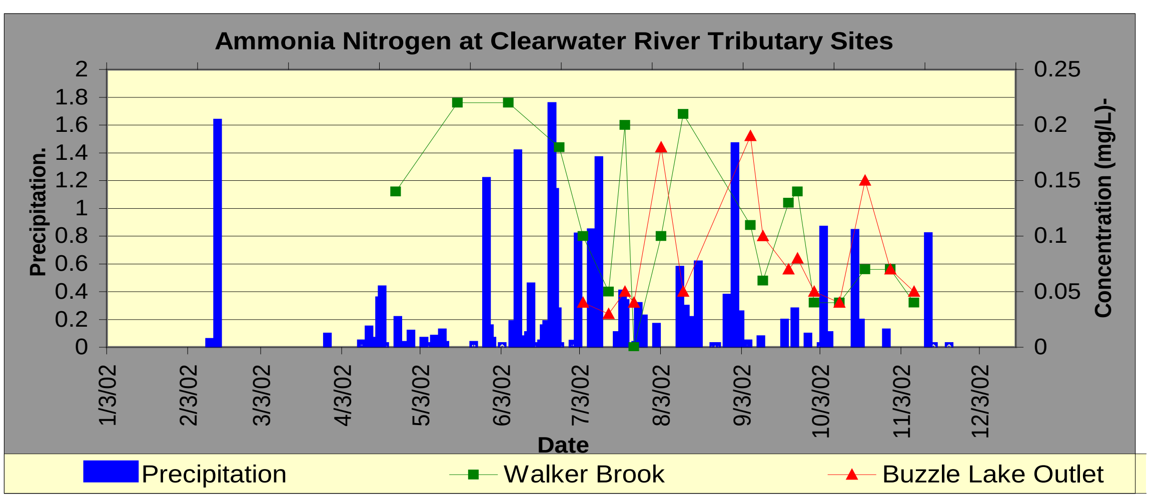
Date:	7/17/2002		7/24/2002		8/7/2002		8/21/2002		9/4/2002		9/18/2002		10/2/2002		10/15/2002	
Depth	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**	**CL1**	**CL2**
Surface	366.00	378.00	384.00	388.00	399.60	405.90	402.00	401.00	409.50	411.10	410.30		419.00	423.60	424.80	427.30
1 Meter	370.00	378.00	384.00	390.00	400.20	405.20	402.00	401.00	410.00	412.10	411.00		417.30	424.40	425.20	427.90
2 Meters	380.00	376.00	385.00	390.00	401.10	405.90	401.00	401.00	410.50	411.70	411.20		417.80	424.00	419.80	428.00
3 Meters	385.00	377.00	386.00	391.00	401.50	406.10	401.90	402.00	410.90	412.20	411.00		417.70	424.90	425.50	428.50
4 Meters	390.00	399.00	385.00	396.00	401.70	408.50	403.00	405.00	411.20	413.50	410.20		418.80	423.40	425.40	428.90
5 Meters	397.00	391.00	386.00	407.00	401.50	409.50	405.00	405.00	411.40	417.30	411.20		419.50	422.90	425.50	429.00
6 Meters	406.00	409.00	408.00	417.00	401.90	422.80	404.00	405.00	411.70	427.20	411.50		418.60	425.30	427.00	429.60
7 Meters	431.00	438.00	437.00	433.00	401.90	440.20	407.00	406.00	412.00	435.20	411.00		419.40	424.60	426.70	429.30
8 Meters	445.00	446.00	445.00	441.00	431.60	459.10	410.00	427.00	412.10	440.00	412.00		419.50	422.10	426.70	429.40
9 Meters	448.00	450.00	449.00	447.00	458.40	463.00	436.00	455.00	442.00	465.60	412.00		418.00	422.70	426.60	430.00
10 Meters	450.00	451.00	450.00	450.00	466.30	467.50	460.00	465.00	472.20	479.30	413.10		420.90	425.70	426.70	430.10
11 Meters	451.00	454.00	452.00	453.00	466.40	473.40	462.00	470.00	484.20	488.20	475.00		450.70	428.40	426.50	431.10
12 Meters	453.00	466.00	454.00		467.80	481.80	466.00		487.30	491.00	480.50		463.10	436.20	426.90	
13 Meters	454.00		456.00		469.70		468.00		488.80		482.30		481.60		426.30	
14 Meters	455.00		457.00		470.90		470.00		490.10		483.20		485.80		427.50	
15 Meters	456.00		459.00		471.00		471.00		491.50		484.00		486.30		429.10	
16 Meters	457.00		461.00		473.90		473.00		493.30		486.90		486.50		427.80	
17 Meters	462.00		463.00		475.30		476.00		494.40		489.60		489.40		428.20	
18 Meters	468.00		468.00		478.80		479.00		469.80				494.30		427.70	
19 Meters	482.00												499.90			

Appendix C. Stream Water Quality Charts

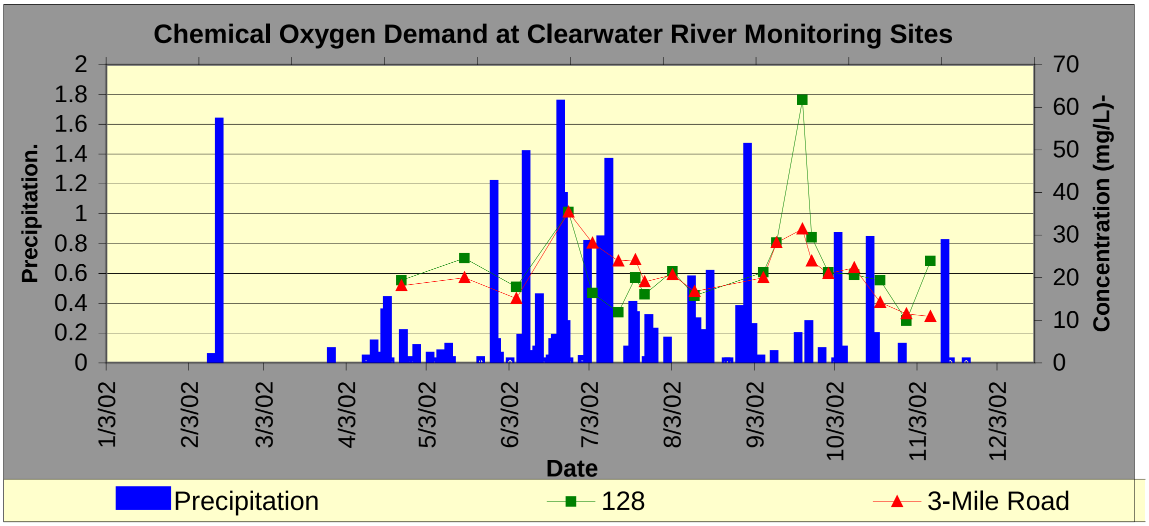
Ammonia

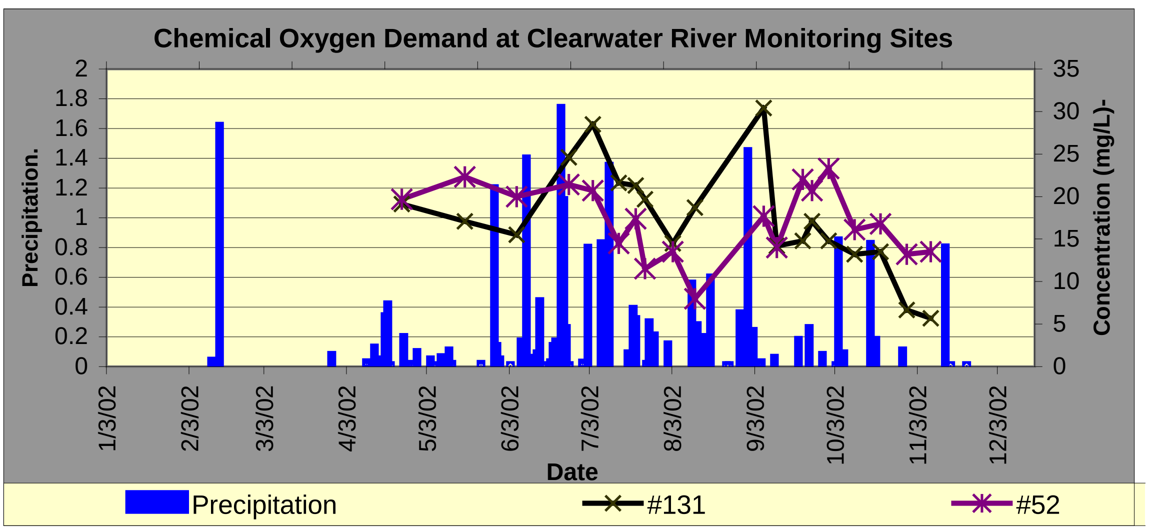


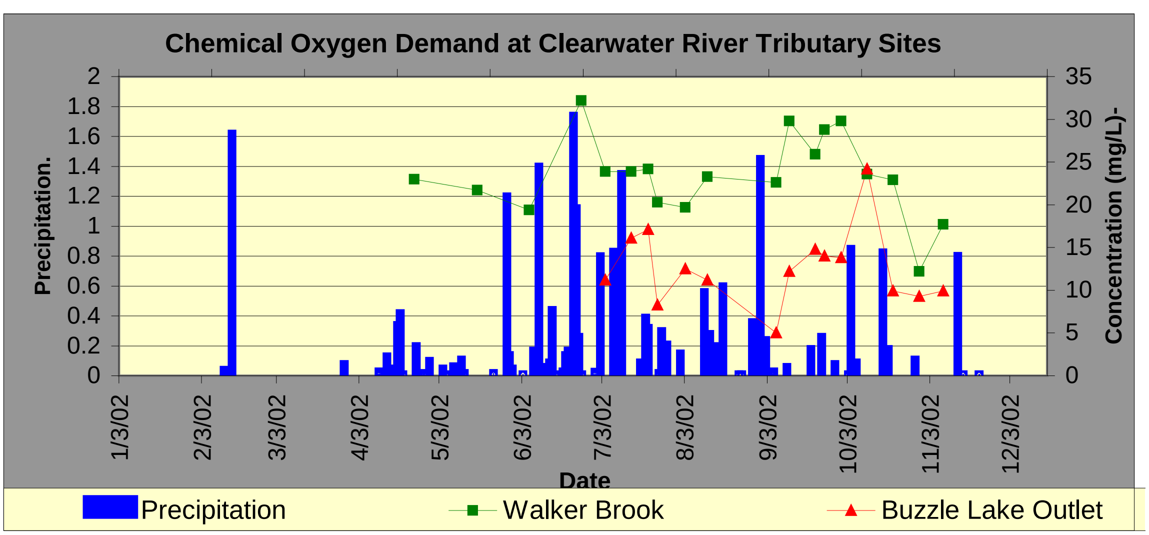




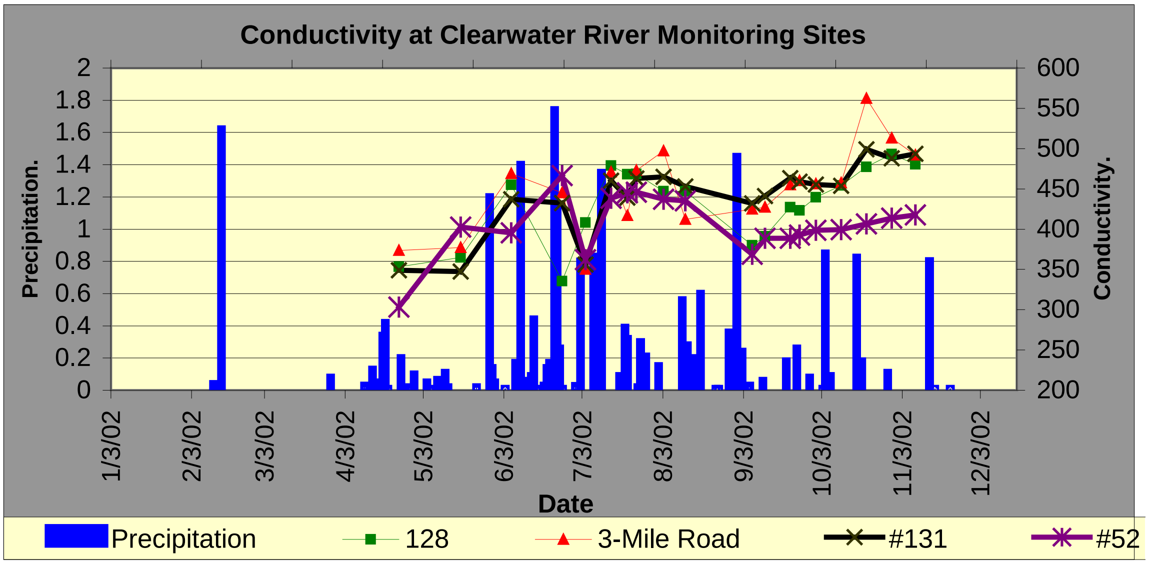
Chemical Oxygen Demand

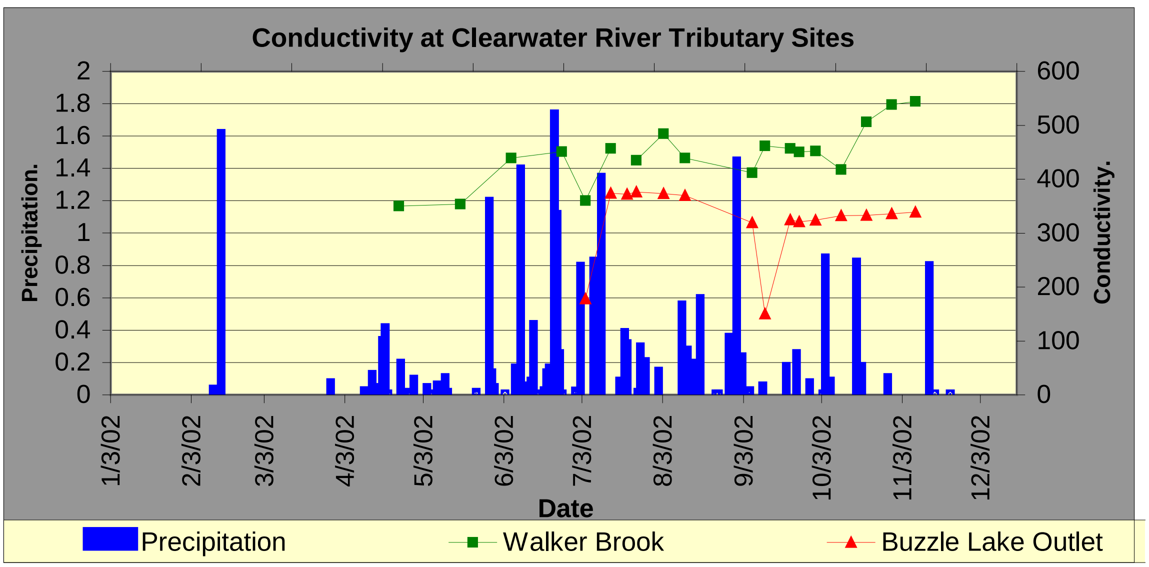




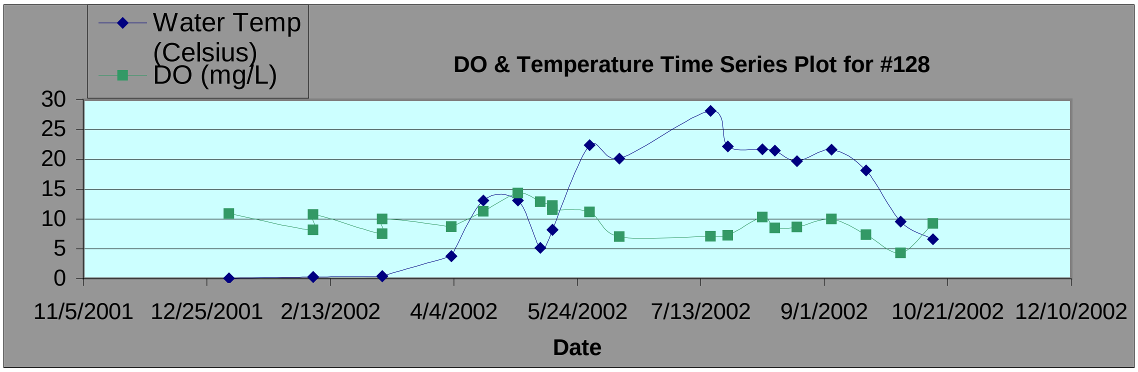


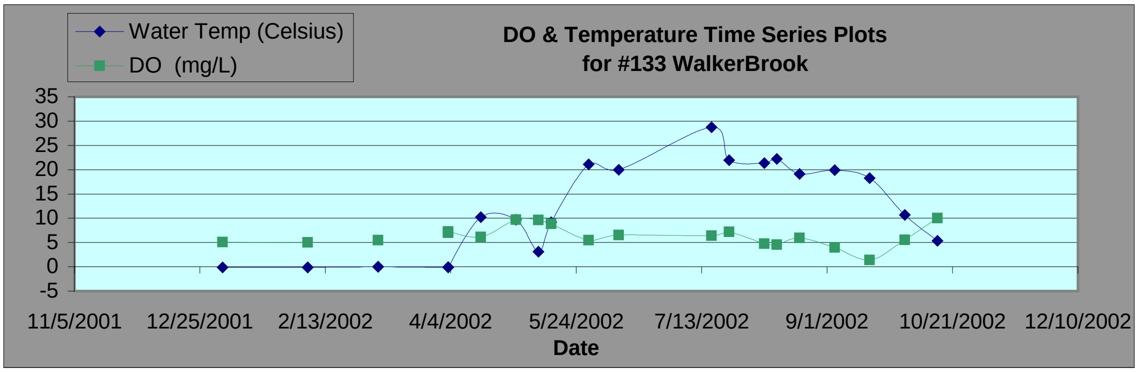
Conductivity

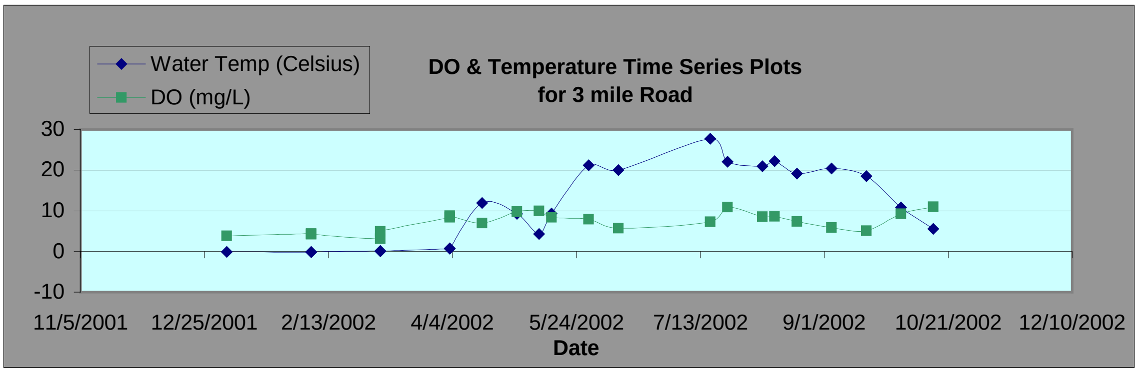


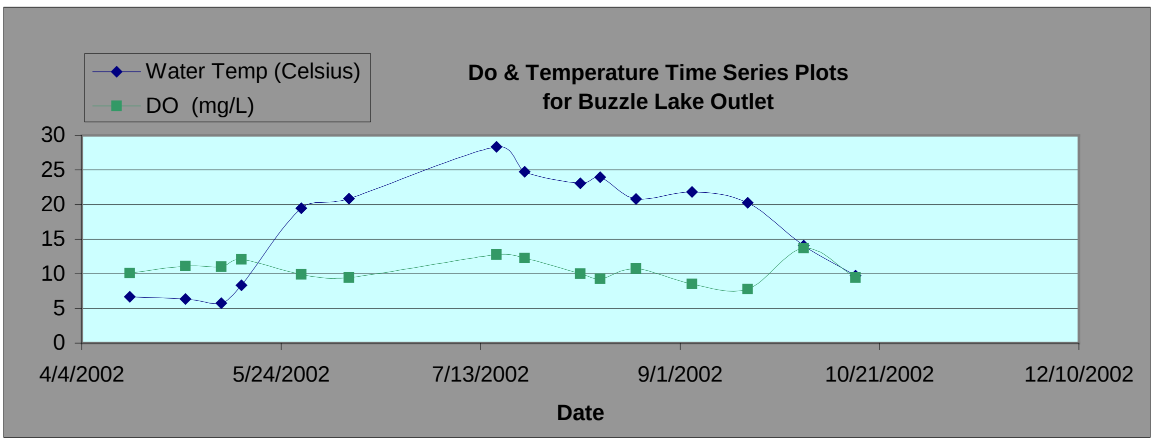


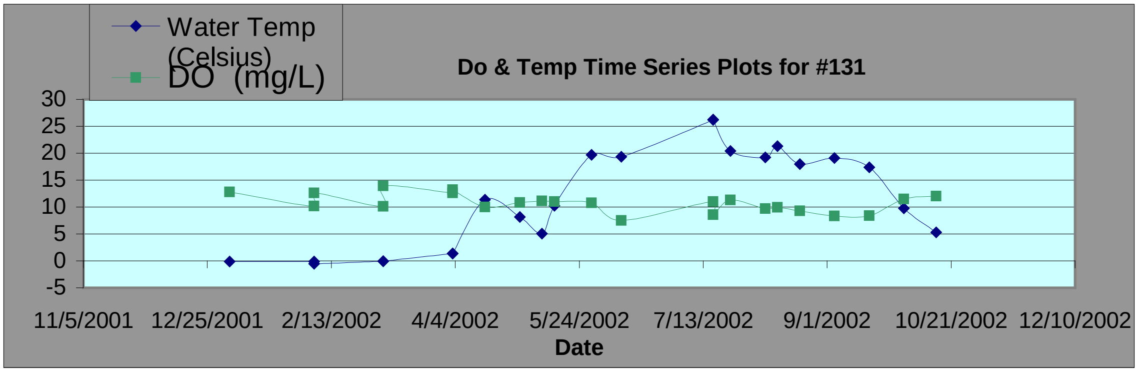
Dissolved Oxygen and Temperature

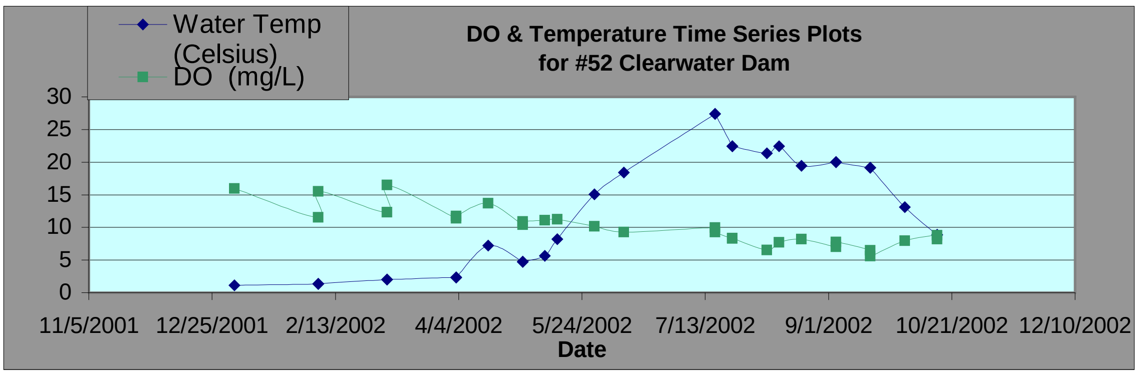




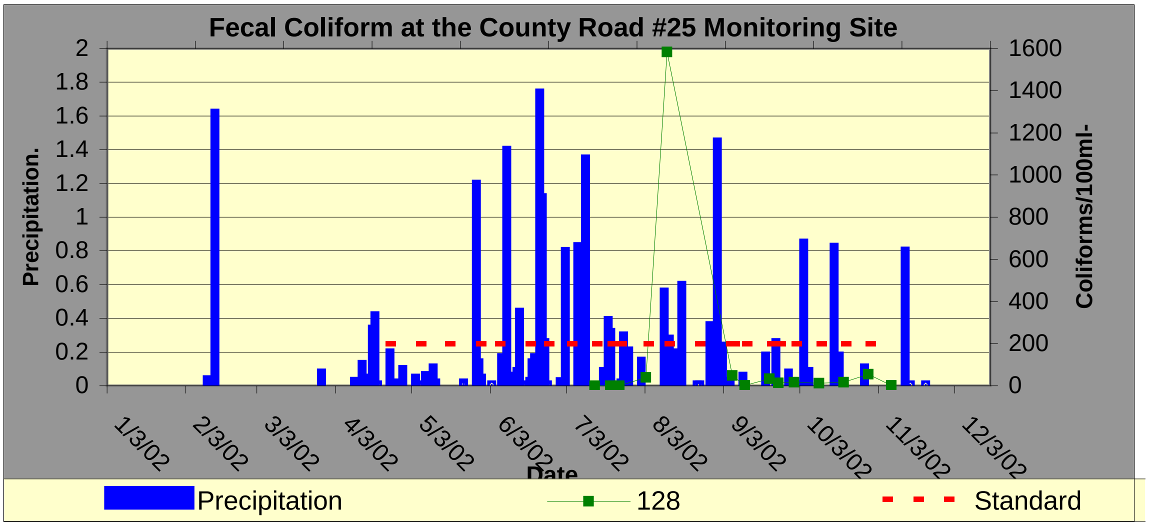


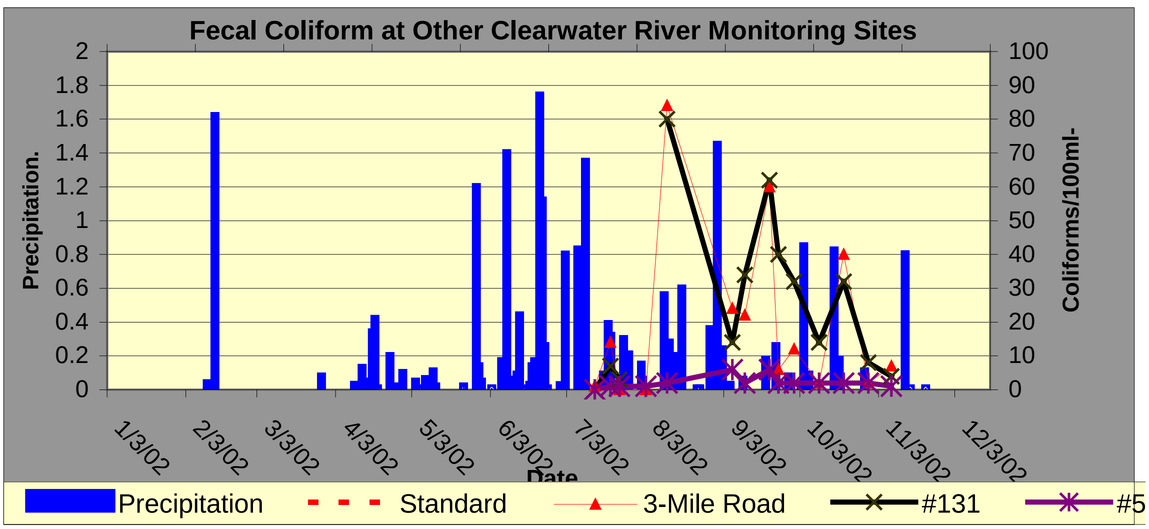


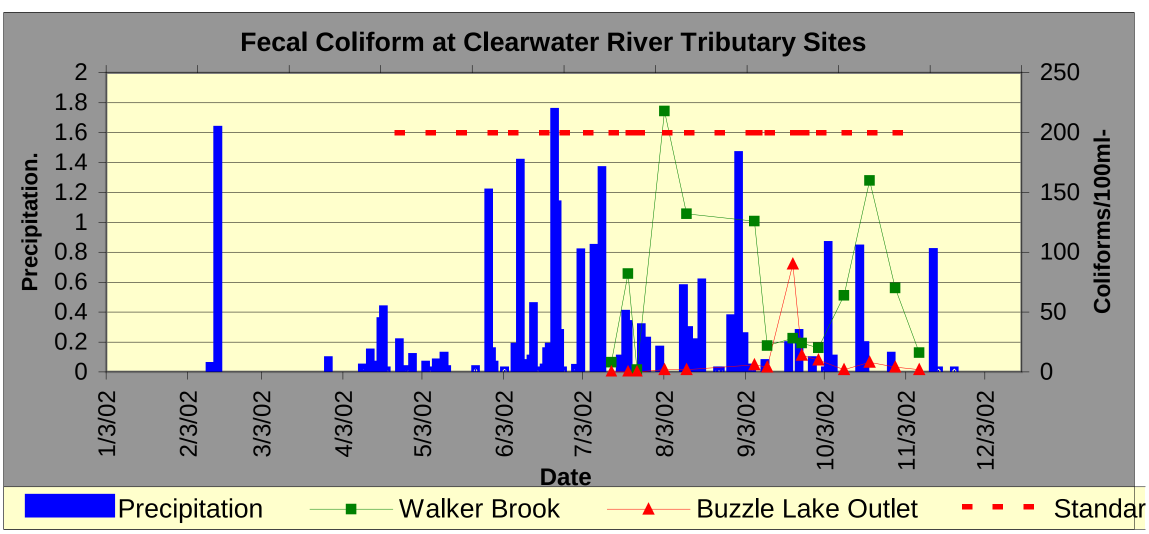

Water Temp (Celsius)
DO (mg/L)
Do & Temp Time Series Plots for #131
30
25
20
15
10
5
0
-5
11/5/2001
12/25/2001
2/13/2002
4/4/2002
5/24/2002
7/13/2002
9/1/2002
10/21/2002
12/10/2002
Date


Water Temp (Celsius)
DO (mg/L)
DO & Temperature Time Series Plots for #52 Clearwater Dam
30
25
20
15
10
5
0
11/5/2001
12/25/2001
2/13/2002
4/4/2002
5/24/2002
7/13/2002
9/1/2002
10/21/2002
12/10/2002
Date

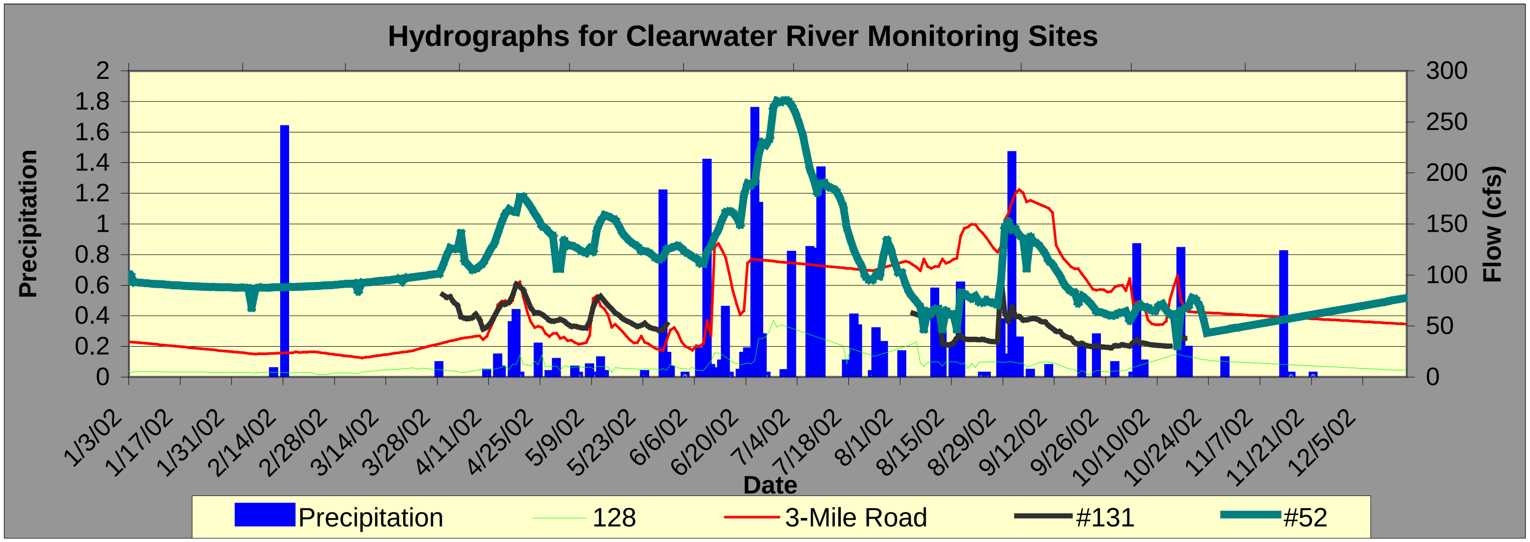
Fecal Coliform

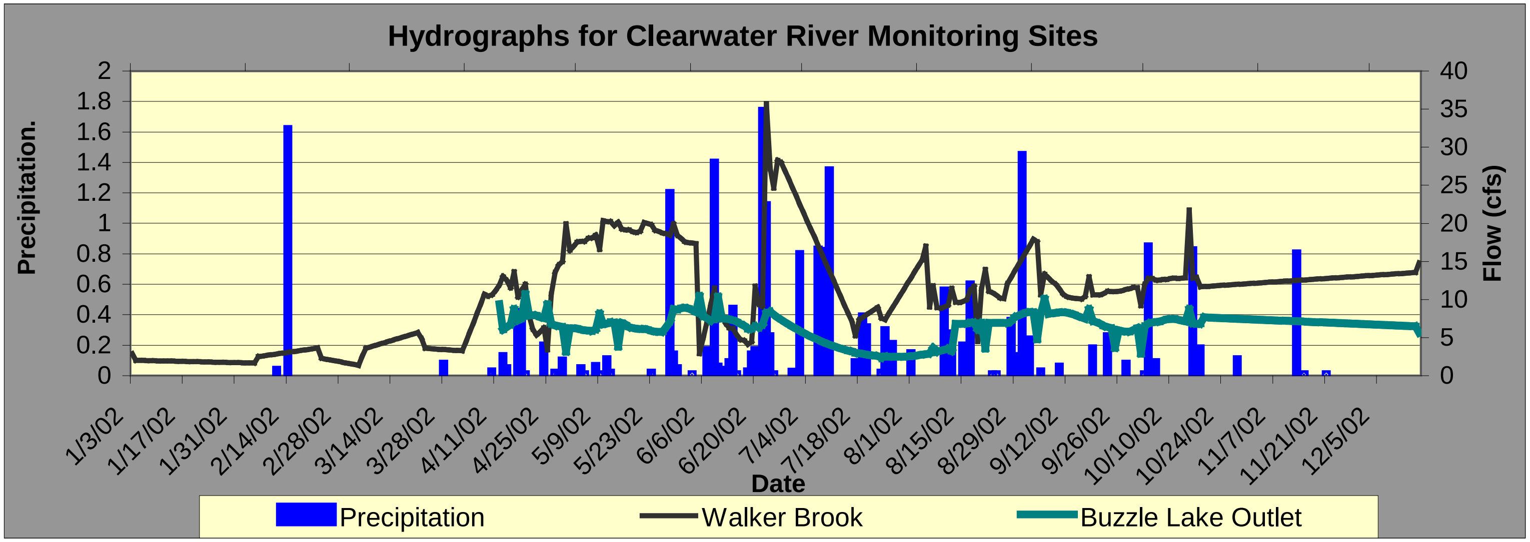




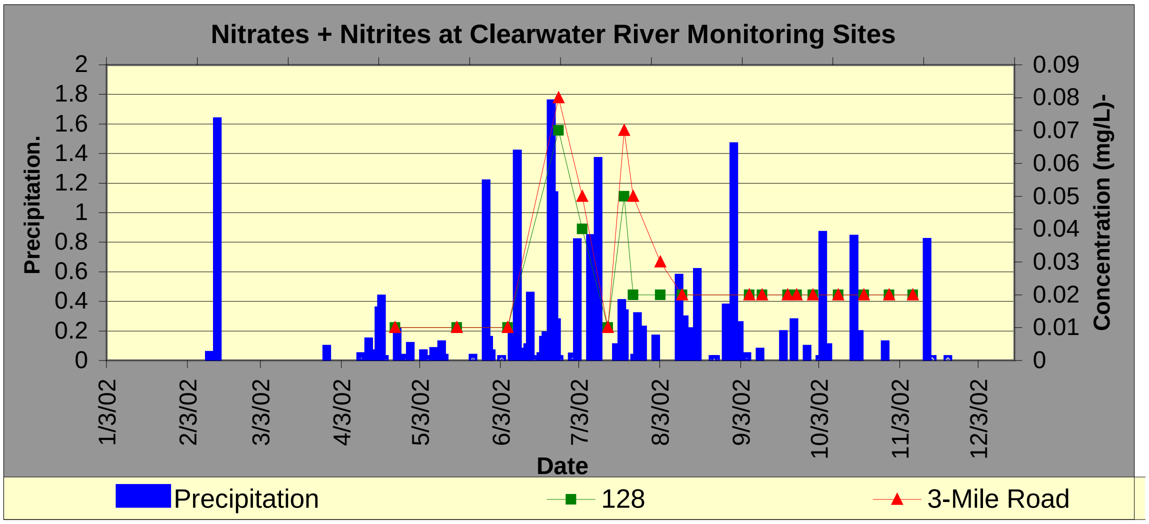


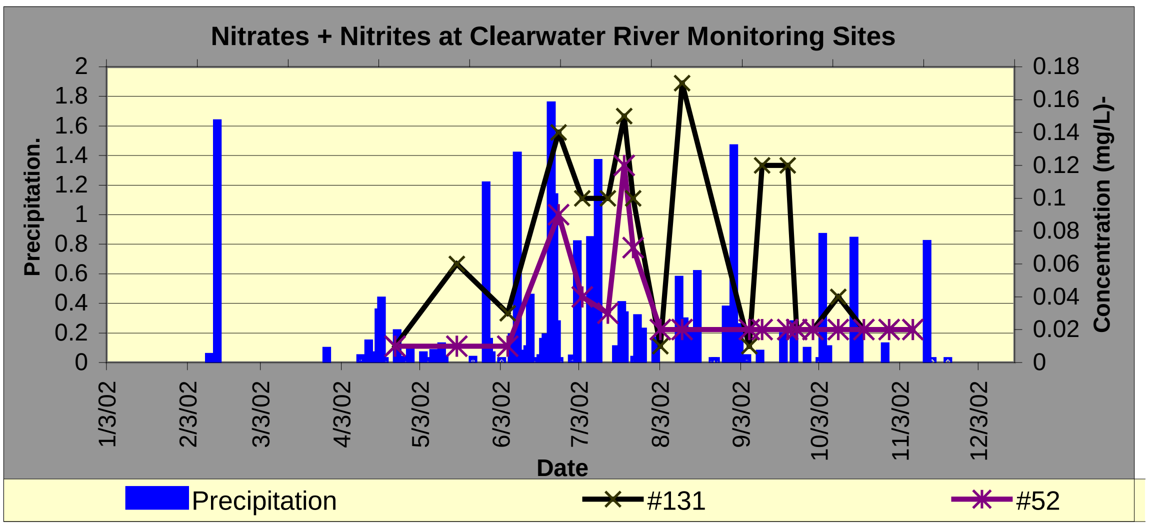
Hydrographs

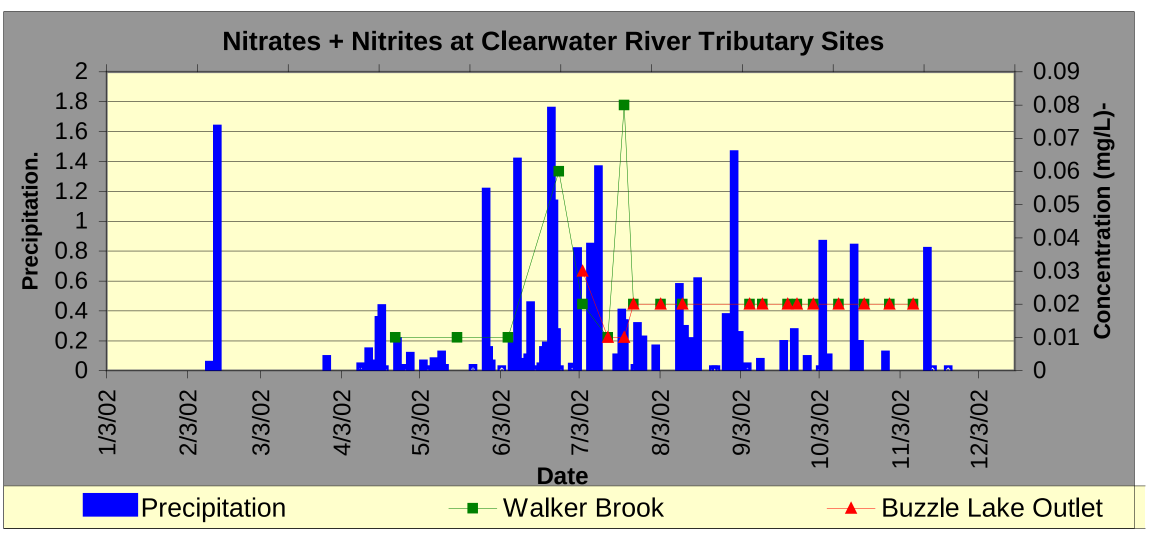




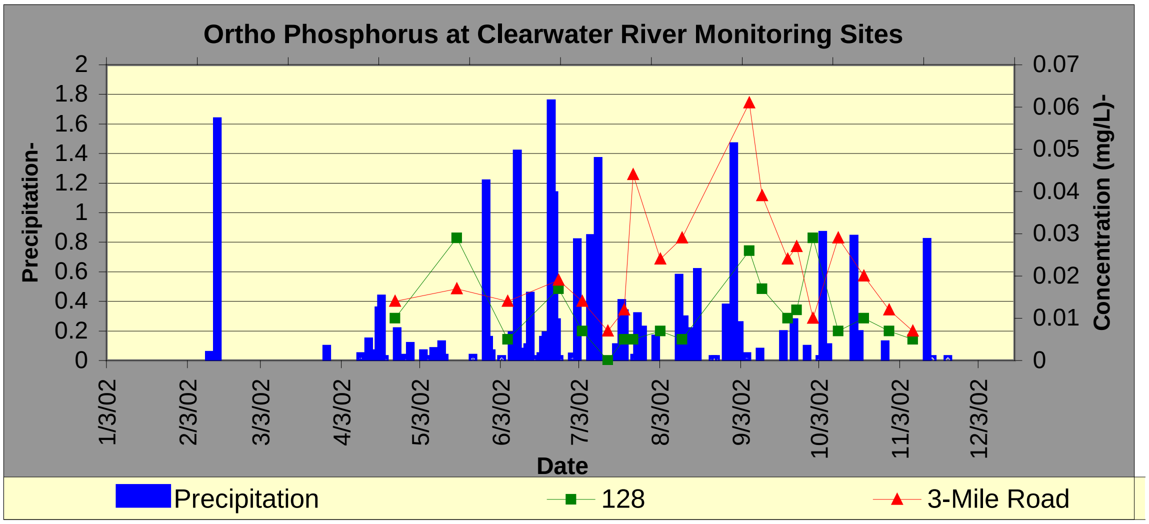
Nitrates and Nitrites

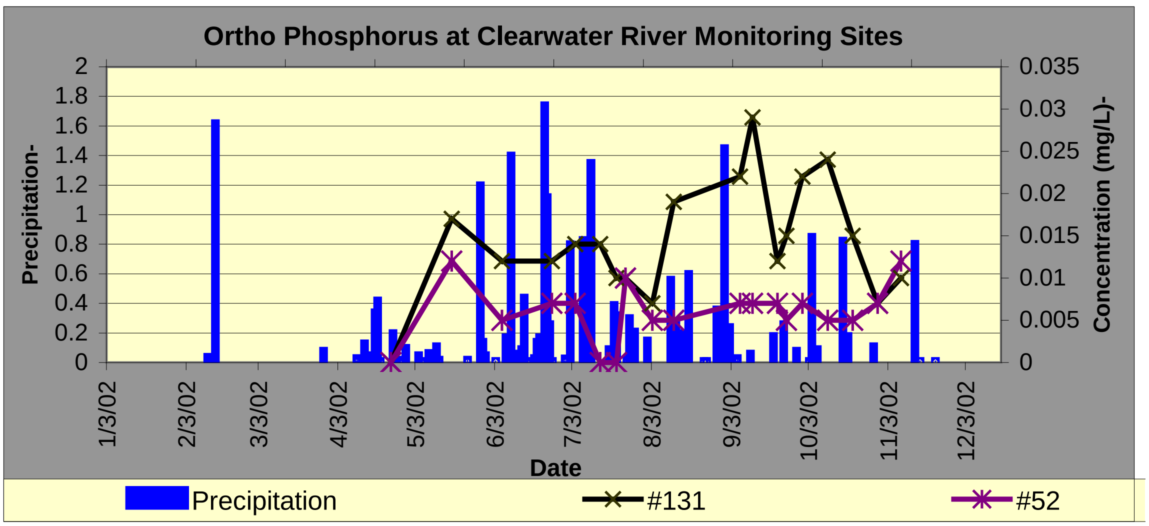


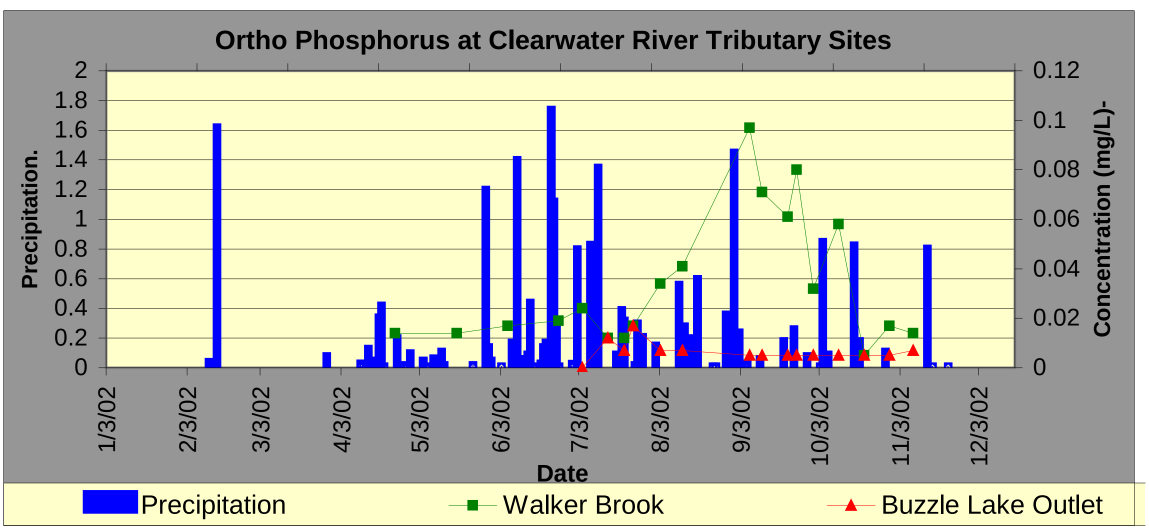




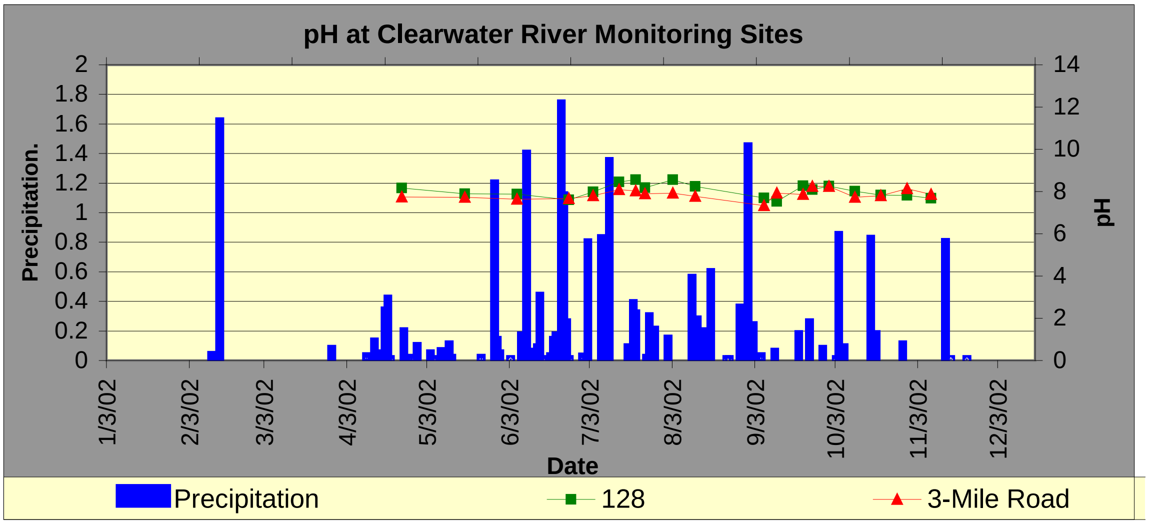
Ortho Phosphorus

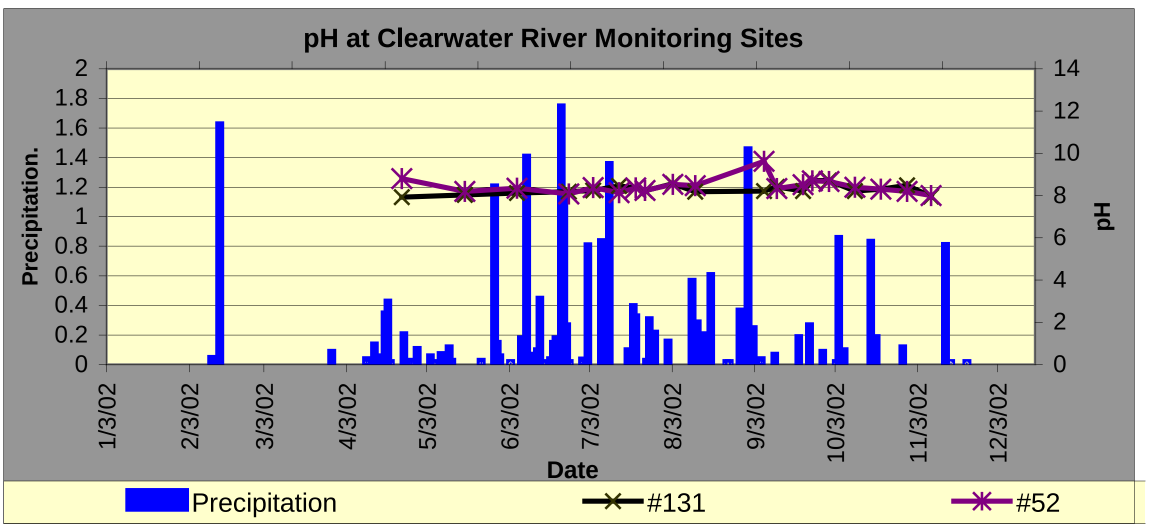


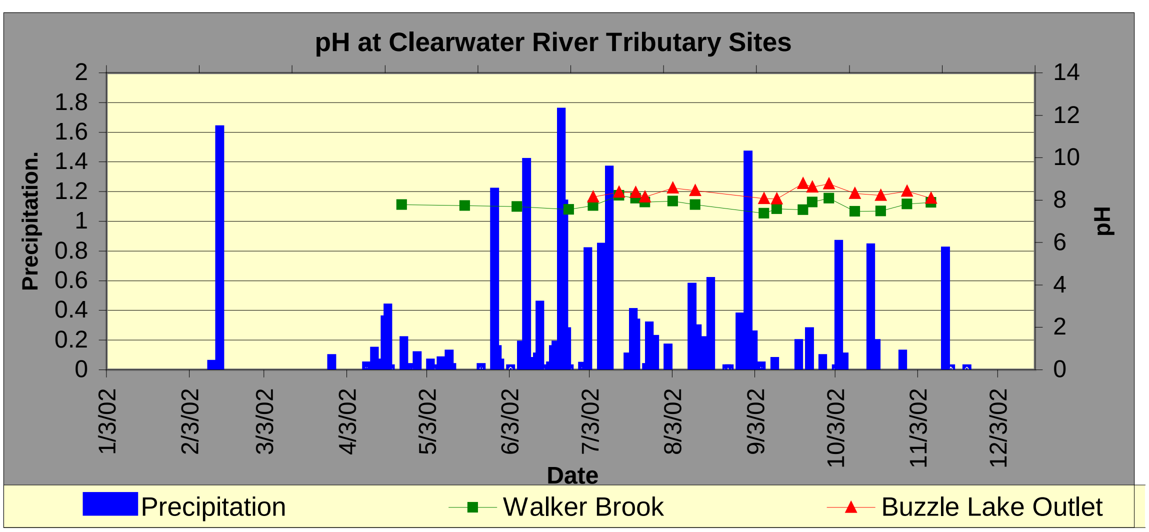




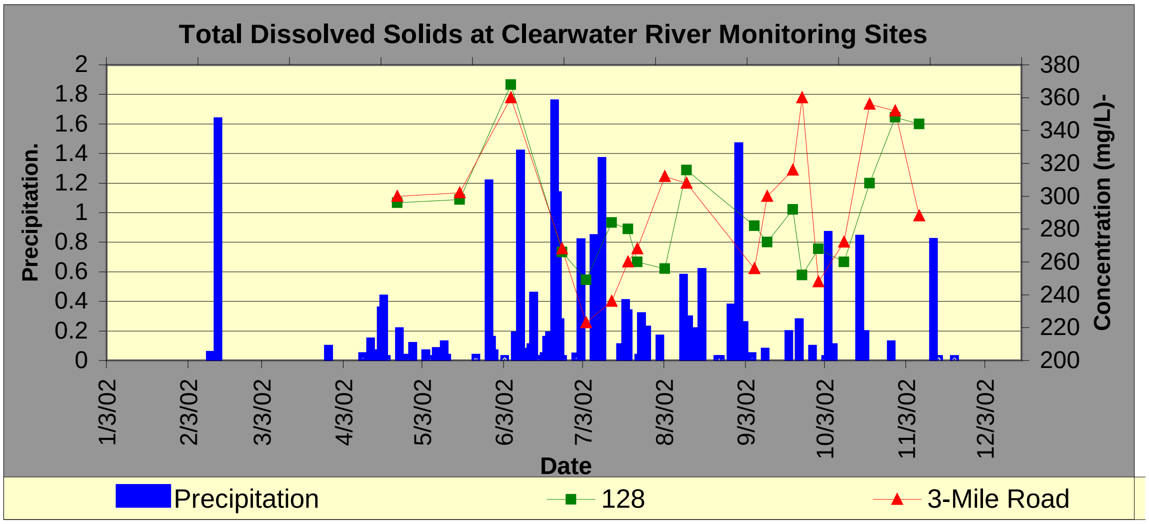
pH

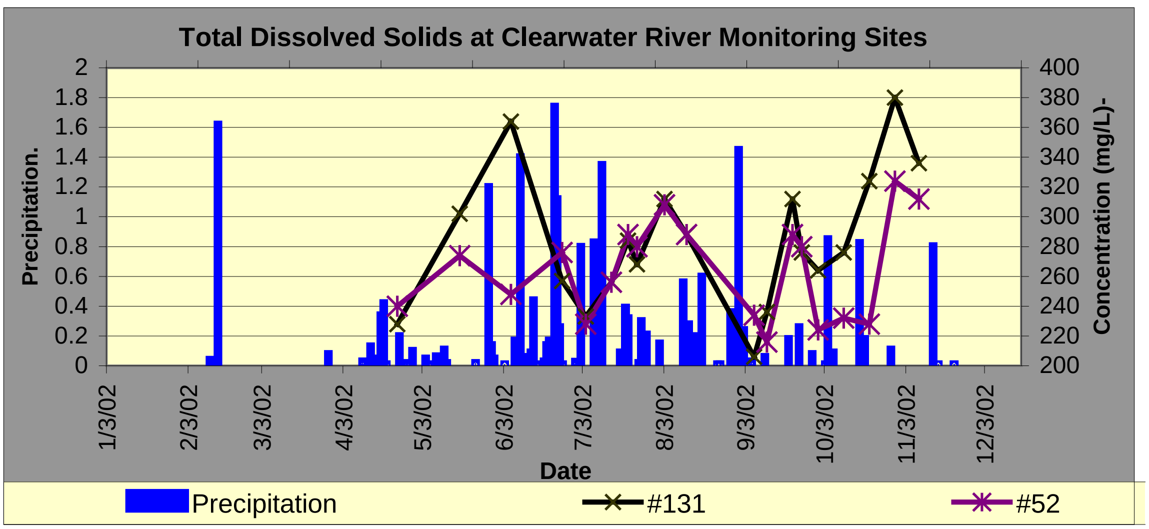

pH at Clearwater River Monitoring Sites
Precipitation.
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
14
12
10
8
6
4
2
0
pH
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
11/3/02
12/3/02
Date
Precipitation
128
3-Mile Road

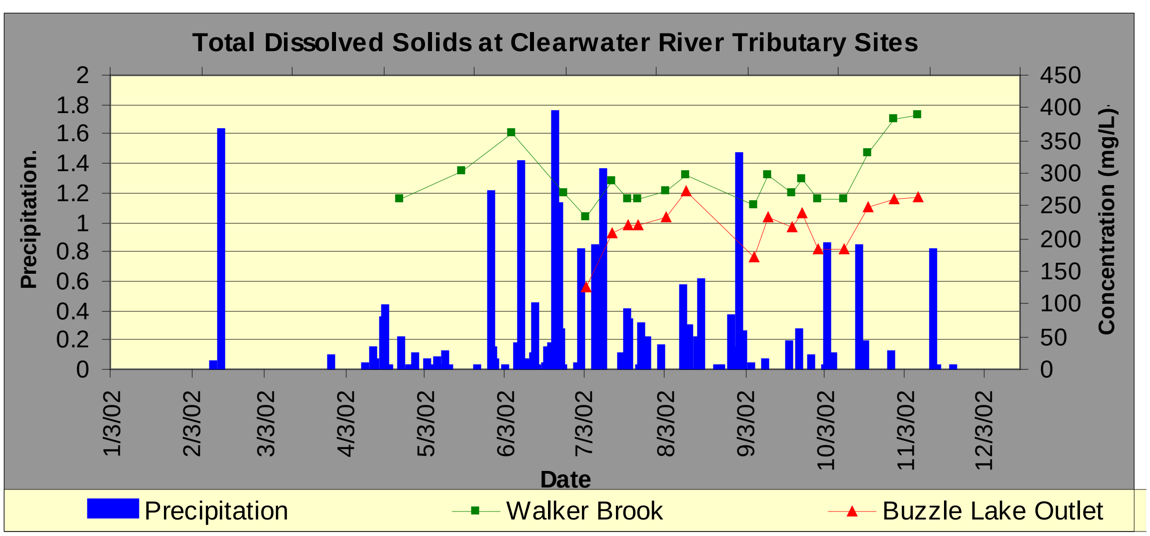

pH at Clearwater River Monitoring Sites
Precipitation.
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
14
12
10
8
6
4
2
0
pH
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
11/3/02
12/3/02
Date
Precipitation
#131
#52


pH at Clearwater River Tributary Sites
Precipitation.
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
14
12
10
8
6
4
2
0
pH
1/3/02
2/3/02
3/3/02
4/3/02
5/3/02
6/3/02
7/3/02
8/3/02
9/3/02
10/3/02
11/3/02
12/3/02
Date
Precipitation
Walker Brook
Buzzle Lake Outlet

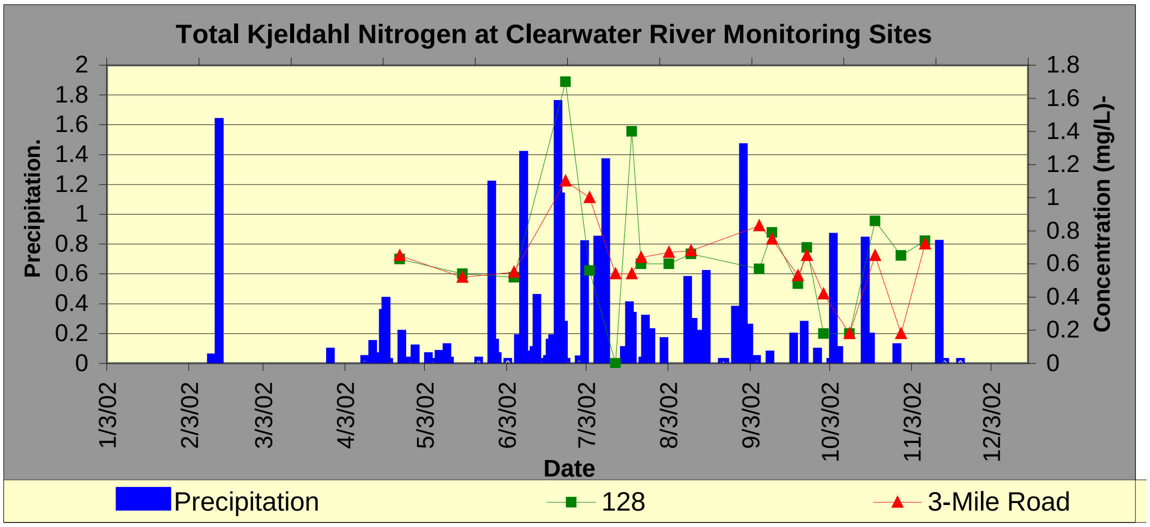
Total Dissolved Solids

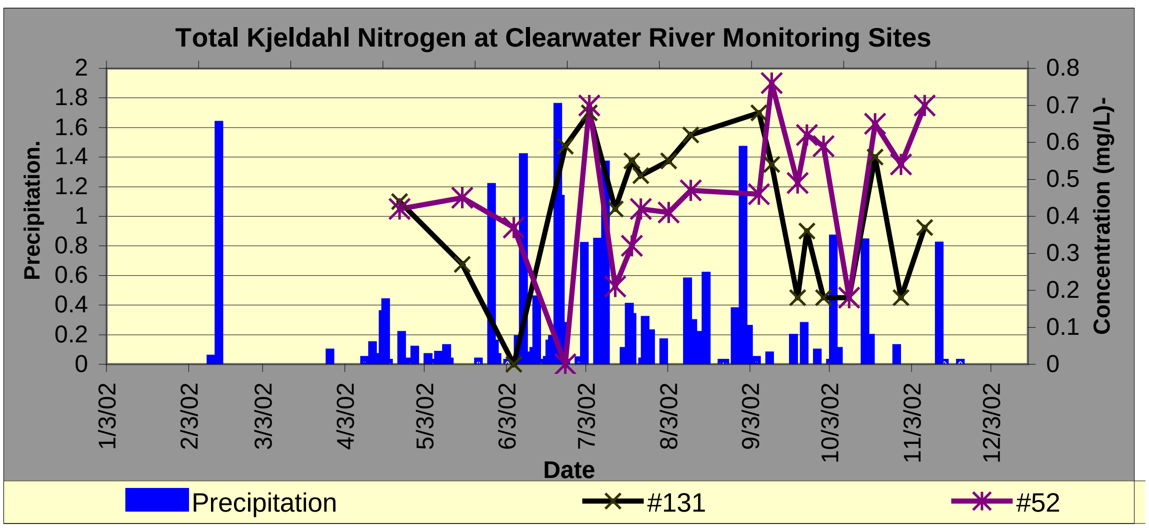


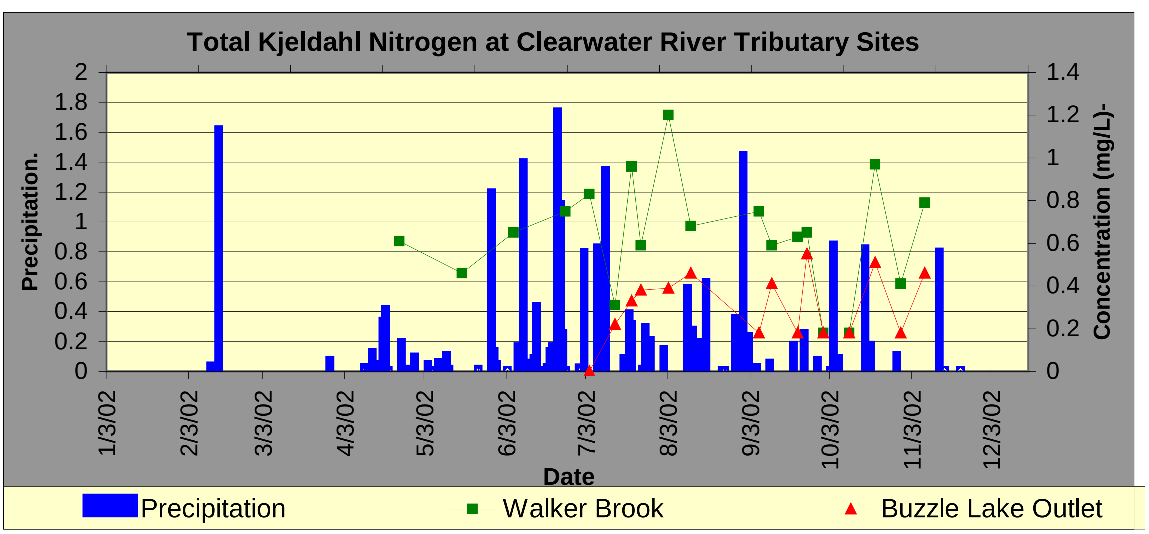




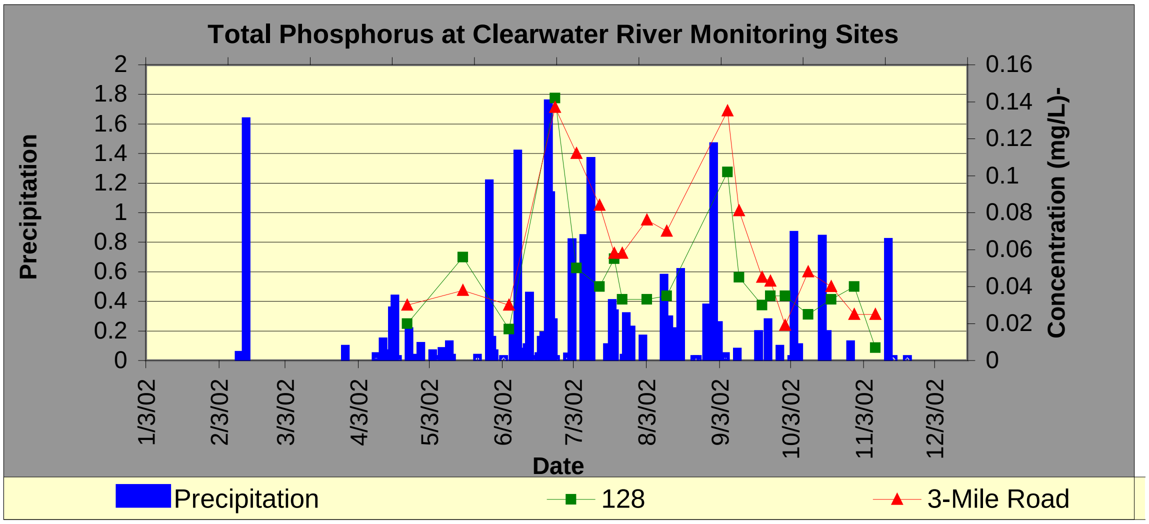
Total Kjeldahl Nitrogen

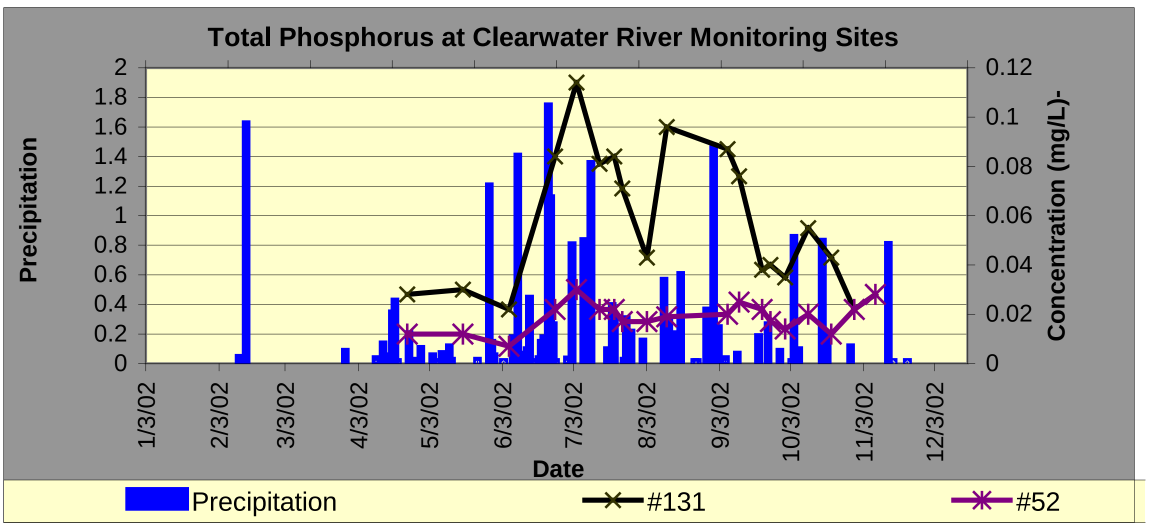


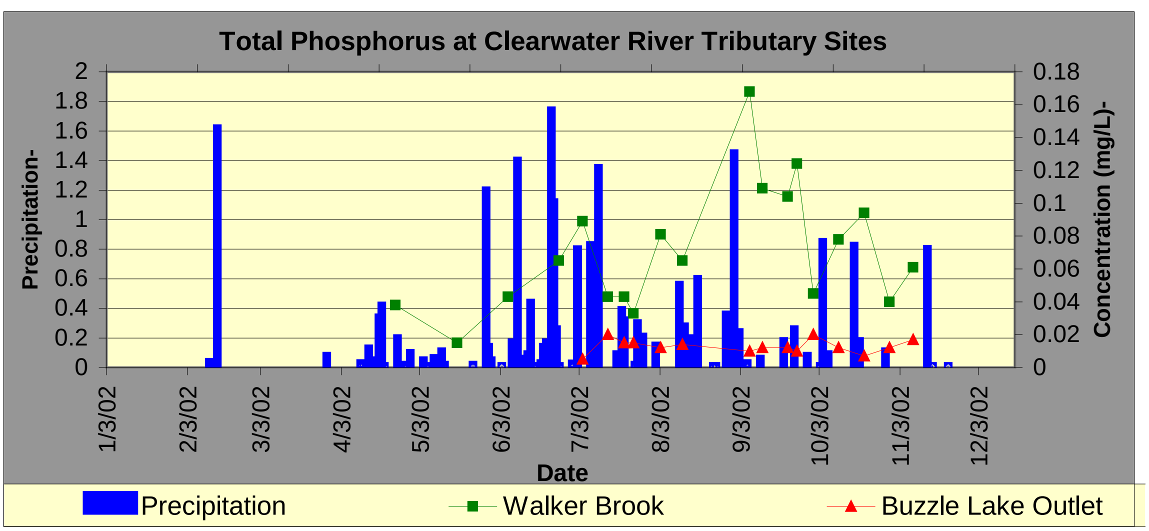




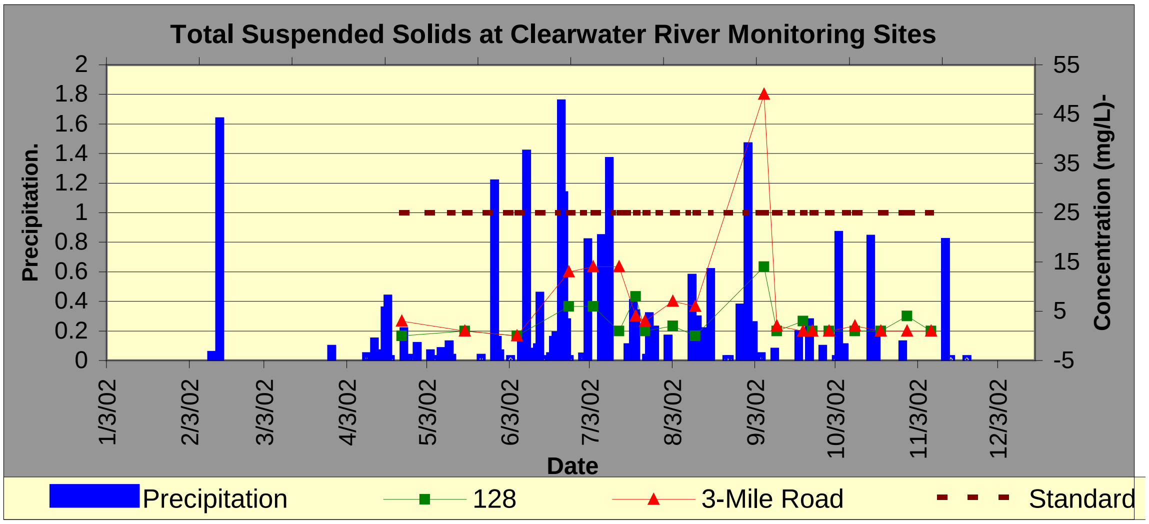
Total Phosphorus

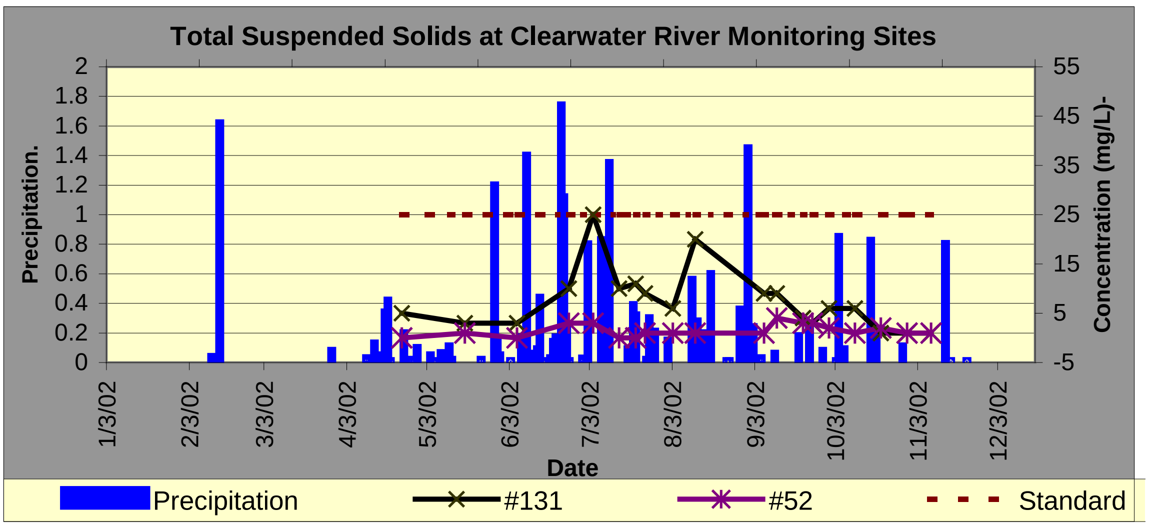


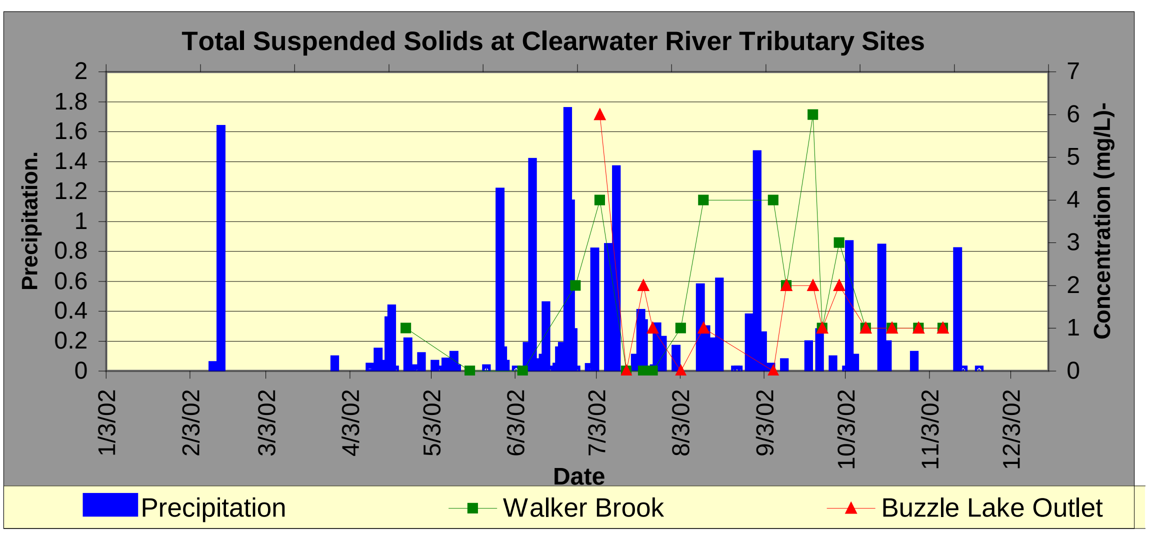




Total Suspended Solids







Appendix D. Stream Water Quality Monitoring Data

Site # 128 - Clearwater River at County Road #25

Date	TSS	TDS	NH3 (mg/L)	TKN	COD (mg/L)	Fecals	Ortho Phos (mg/L)	Org Phos (mg/L)	Total Phos (mg/L)	NO2 + NO3 (mg/L)	Cond Avg	pH Avg	H2O Temp Avg	DO Avg
01/03/02	0	296	0.18	0.63	19.4		0.01	0.01	0.02	0	353.2	8.16	0.056	10.91
02/06/02	1	298	0.26	0.54	24.6		0.029	0.027	0.056	0	365	7.895	0.28	7.895
03/06/02	0	368	0.16	0.52	17.8		0.005	0.012	0.017	0	455	7.88	0.385	7.88
04/03/02	6	266	0.3	1.7	35.4		0.017	0.125	0.142	0.07	335.5	7.6	3.76	8.68
04/16/02	6	249	0.09	0.56	16.4		0.007	0.043	0.05	0.04	408	7.98	13.08	11.25
04/30/02	1	284	0.05	0	11.9	0	BDL	0.04	0.04	0	479	8.46	13.08	14.31
05/09/02	8	280	0.08	1.4	20	0	0.005	0.05	0.055	0.05	468	8.56	5.17	12.87
05/14/02	1	260	0.06	0.60	16.1	0	0.005	0.028	0.033	0.02	468.5	8.18	11.78	8.18
05/29/02	2	256	0.24	0.60	21.5	40	0.007	0.026	0.033	0.02	447	8.56	22.39	11.17
06/10/02	0	316	0.14	0.66	15.8	1584	0.005	0.03	0.035	0.02	447	8.24	20.14	7.01
07/17/02	14	282	0.04	0.57	21.3	48	0.026	0.076	0.102	0.02	380	7.69	28.14	7.1
07/24/02	1	272	0.06	0.79	28.2	2	0.017	0.062	0.045	0.02	391.2	7.53	22.17	7.27
08/07/02	3	292	0.12	0.48	61.7	34	0.010	0.020	0.030	0.02	427.4	8.28	21.68	10.31
08/12/02	1	252	0.09	0.70	29.5	14	0.012	0.023	0.035	0.02	423.3	8.09	21.45	8.47
08/21/02	1	268	0.04	0.18	21.3	16	0.029	0.006	0.035	0.02	439.7	8.26	19.68	8.64
09/04/02	1	260	0.04	0.18	20.7	12	0.007	0.019	0.025	0.02	454.2	8.01	21.65	9.99
09/18/02	1	308	0.09	0.86	19.4	16	0.010	0.023	0.033	0.02	477.1	7.84	18.15	7.34
10/02/02	4	348	0.14	0.65	9.92	54	0.007	0.033	0.040	0.02	493.1	7.82	9.56	4.3
10/15/02	1	344	0.15	0.74	23.9	2	0.005	0.007	0.007	0.02	480.4	7.68	6.58	9.24

Site #133 - Walker Brook at Count Road 19

Date	TSS	TDS	NH3	TKN	COD (mg/L)	Fecals	Ortho Phos (mg/L)	Org Phos (mg/L)	Total Phos (mg/L)	NO2 + NO3 (mg/L)	Cond Avg	pH Avg	H2O Temp Avg	DO Avg
01/03/02	1	260	0.14	0.61	23		0.014	0.024	0.038	0	350	7.78	-0.11	5.1
02/06/02	0	304	0.22	0.46	21.7		0.014	0.001	0.015	0	354	7.75	-0.11	5
03/06/02	0	360	0.22	0.65	19.4		0.017	0.026	0.043	0	439	7.7	-0.12	5.5
04/03/02	2	270	0.18	0.75	32.2		0.019	0.046	0.065	0.06	451	7.56	-0.1	7.135
04/16/02	4	232	0.1	0.83	23.9		0.024	0.065	0.089	0.02	360	7.74	10.25	6.14
04/30/02	0	288	0.05	0.31	23.9	8	0.012	0.031	0.043	0	457	8.22	9.72	9.67
05/09/02	0	260	0.2	0.96	24.2	82	0.012	0.031	0.043	0.08	0	8.09	3.1	9.64
05/14/02	0	260	0	0.59	20.3	2	0.017	0.016	0.033	0.02	435	7.9	9.2	8.83
05/29/02	1	272	0.10	1.2	19.7	218	0.034	0.047	0.081	0.02	484	7.95	21.08	5.48
06/10/02	4	296	0.21	0.68	23.3	132	0.041	0.024	0.065	0.02	439	7.78	19.97	6.51
07/17/02	4	252	0.11	0.75	22.6	126	0.097	0.071	0.168	0.02	412	7.37	28.75	6.43
07/24/02	2	296	0.06	0.59	29.8	22	0.071	0.038	0.109	0.02	462	7.59	21.98	7.21
08/07/02	6	268	0.13	0.63	25.9	28	0.061	0.043	0.104	0.02	457	7.54	21.37	4.76
08/12/02	1	292	0.14	0.65	28.8	24	0.080	0.044	0.124	0.02	450	7.91	22.23	4.57
08/21/02	3	260	0.04	0.18	29.8	20	0.032	0.013	0.045	0.02	453	8.08	19.15	5.93
09/04/02	1	260	0.04	0.18	23.6	64	0.058	0.020	0.078	0.02	418	7.47	19.91	3.97
09/18/02	1	332	0.07	0.97	22.9	160	0.005	0.089	0.094	0.02	506	7.48	18.25	1.37
10/02/02	1	384	0.07	0.41	12.2	70	0.017	0.023	0.040	0.02	538	7.82	10.69	5.56
10/15/02	1	388	0.04	0.79	17.7	16	0.014	0.047	0.061	0.02	544	7.89	5.34	10.01

3-Mile Road Summary of Parameters

Date	H2O Temp Avg	pH Avg	Cond Avg	DO Avg	NO2 + NO3	Ortho Phos (mg/L)	Org Phos (mg/L)	Total Phos (mg/L)	Fecals	COD (mg/L)	TKN	NH3 (mg/L)	TSS	TDS
01/03/02	-0.11	7.75	373.7	3.8	0	0.014	0.016	0.03		18.1	0.65	0.17	3	300
02/06/02	-0.11	7.73	377	4.3	0	0.017	0.021	0.038		20	0.52	0.25	1	302
03/06/02	-0.167	7.635	468.9	4.01	0	0.014	0.016	0.03		15.1	0.55	0.17	0	360
04/03/02	0.74	7.66	445.15	8.56	0.08	0.019	0.118	0.137		35.4	1.1	0.24	13	268
04/16/02	11.89	7.8	350	7	0.05	0.014	0.098	0.112		28.1	1	0.09	14	223
04/30/02	9.23	8.09	471	9.77	0	0.007	0.077	0.084	1	23.9	0.54	0.05	14	236
05/09/02	4.28	8.03	417	10	0.07	0.012	0.046	0.058	14	24.2	0.54	0.13	4	260
05/14/02	9.33	7.89	473	8.4	0.05	0.044	0.014	0.058	0	19.0	0.64	0	3	268
05/29/02	21.21	7.93	497	7.93	0.03	0.024	0.052	0.076	0	20.7	0.67	0.10	7	312
06/10/02	20.05	7.78	412	5.7	0.02	0.029	0.041	0.070	84	16.8	0.68	0.05	6	308
07/17/02	27.75	7.34	425	7.32	0.02	0.061	0.074	0.135	24	20.0	0.83	0.1	49	256
07/24/02	22.03	7.92	427.2	10.94	0.02	0.039	0.042	0.081	22	28.2	0.75	0.07	2	300
08/07/02	20.95	7.86	455.1	8.54	0.02	0.024	0.021	0.045	60	31.4	0.53	0.09	1	316
08/12/02	22.24	8.25	460.1	8.61	0.02	0.027	0.016	0.043	6	23.9	0.65	0.07	1	360
08/21/02	19.12	8.24	456.2	7.4	0.02	0.010	0.009	0.019	12	21	0.42	0.07	1	248
09/04/02	20.45	7.73	457.3	5.84	0.02	0.029	0.019	0.048	2	22.3	0.18	0.06	2	272
09/18/02	18.52	7.8	562.4	5.09	0.02	0.020	0.020	0.040	40	14.2	0.65	0.11	1	356
10/02/02	10.79	8.14	512.9	9.29	0.02	0.012	0.013	0.025	2	11.5	0.18	0.06	1	352
10/15/02	5.54	7.87	491.9	10.97	0.02	0.007	0.018	0.025	7	10.9	0.72	0.04	1	288

Buzzle Lake Summary of Parameters

Date	TSS	TDS	NH3 (mg/L)	TKN	COD (mg/L)	Fecals	Ortho Phos (mg/L)	Org Phos (mg/L)	Total Phos (mg/L)	NO2 + NO3 (mg/L)	Cond	pH	H2O Temp	DO
04/16/02	6	124	0.04	0	11.2		0	0.005	0.005	0.03	178	8.14	6.7	10.09
04/30/02	0	208	0.03	0.22	16.1	0	0.012	0.008	0.02	0	374	8.38	6.38	11.11
05/09/02	2	220	0.05	0.33	17.1	0	0.007	0.008	0.015	0	372	8.36	5.76	11.03
05/14/02	1	220	0.04	0.38	8.29	0	0.017	0.008	0.015	0.02	376	8.15	8.36	12.1
05/29/02	0	232	0.18	0.39	12.5	2	0.007	0.005	0.012	0.02	373.1	8.57	19.46	9.91
06/10/02	1	272	0.05	0.46	11.2	2	0.007	0.007	0.014	0.02	370	8.45	20.84	9.44
07/17/02	0	170	0.19	0.18	5.0	6	0.005	0.005	0.010	0.02	319	8.07	28.36	12.77
07/24/02	2	232	0.1	0.41	12.2	4	0.005	0.007	0.012	0.02	150	8.05	24.75	12.26
08/07/02	2	216	0.07	0.18	14.8	90	0.005	0.007	0.012	0.02	324.4	8.78	23.06	10.01
08/12/02	1	240	0.08	0.55	14	14	0.005	0.005	0.010	0.02	321	8.62	23.95	9.26
08/21/02	2	184	0.05	0.18	13.8	10	0.005	0.015	0.020	0.02	323.8	8.76	20.83	10.77
09/04/02	1	184	0.04	0.18	24.2	2	0.005	0.007	0.012	0.02	332.5	8.32	21.81	8.55
09/18/02	1	248	0.15	0.51	9.92	8	0.005	0.002	0.007	0.02	333.1	8.22	20.26	7.82
10/02/02	1	260	0.07	0.18	9.27	4	0.005	0.007	0.012	0.02	335.9	8.42	14.07	13.72
10/15/02	1	264	0.05	0.46	9.92	2	0.007	0.010	0.017	0.02	338.6	8.09	9.74	9.48

Site #131 - Clearwater Lake Inlet Site at County Road #24

Date	TSS	TDS	NH3 (mg/L)	TKN (mg/L)	COD (mg/L)	Fecals	Ortho Phos (mg/L)	Org Phos (mg/L)	TP (mg/L)	NO2+NO3 (mg/L)	Cond Avg	pH Avg	H2O Temp Avg	DO Avg
01/03/02	5	228	0.2	0.44	19.1		0		0.028	0	349	7.93	-0.11	12.81
02/06/02	3	302	0.24	0.27	17.1		0.017	0.013	0.03	0.06	347.5	8.03	-0.56	11.38
03/06/02	3	364	0.09	0	15.5		0.012	0.01	0.022	0.03	437.15	8.13	-0.111	12
04/03/02	10	257	0.13	0.59	24.6		0.012	0.072	0.084	0.14	432.5	8.18	1.375	13.12
04/16/02	25	233	0.04	0.68	28.5		0.014	0.1	0.114	0.1	356	8.25	11.34	10.01
04/30/02	10	256	0.07	0.42	21.6	0	0.014	0.067	0.081	0.1	460	8.45	8.16	10.81
05/09/02	11	284	0.05	0.55	21.3	7	0.01	0.074	0.084	0.15	439	8.36	5.08	11.12
05/14/02	9	268	0	0.51	19.7	3	0.010	0.061	0.071	0.10	462.8	8.22	10.22	11.02
05/29/02	6	312	0.10	0.55	14.5		0.007	0.036	0.043	0	465	8.56	19.72	10.76
06/10/02	20	288	0.06	0.62	18.7	80	0.019	0.077	0.096	0.17	453	8.18	19.32	7.51
07/17/02	9	206	0.03	0.68	30.4	14	0.022	0.065	0.087	0	432	8.2	23.225	9.8
07/24/02	9	236	0.14	0.54	14.2	34	0.029	0.047	0.076	0.12	441	8.41	20.4	11.3
08/07/02	4	312	0.10	0.18	14.8	62	0.012	0.026	0.038	0.12	463.2	8.21	19.22	9.71
08/12/02	3	276	0.11	0.36	17.1	40	0.015	0.025	0.040	0.02	459.1	8.71	21.29	9.97
08/21/02	6	264	0.13	0.18	14.8	32	0.022	0.013	0.035	0.02	455.3	8.71	18	9.26
09/04/02	6	276	0.04	0.18	13.2	14	0.024	0.031	0.055	0.04	453.7	8.21	19.08	8.34
09/18/02	1	324	0.23	0.56	13.5	32	0.015	0.028	0.043	0.02	499.3	8.31	17.38	8.37
10/02/02	1	380	0.10	0.18	6.66	8	0.007	0.015	0.022	0.02	487.9	8.48	9.77	11.5
10/15/02	1	336	0.06	0.37	5.68	4	0.01	0.018	0.028	0.02	493.7	7.96	5.31	12.01

Clearwater Lake Outlet Summary of Parameters

Date	H2O Temp Avg	pH Avg	Cond Avg	DO Avg	NO2 + NO3 (mg/L)	Ortho Phos (mg/L)	Org Phos (mg/L)	Total Phos (mg/L)	Fecals	COD (mg/L)	TKN	NH3 (mg/L)	TSS	TDS
01/03/02	1.11	8.8	303.4	15.95	0	0	0.012	0.012		19.7	0.42	0.08	0	240
02/06/02	1.31	8.2	402.5	13.525	0	0.012	0	0.012		22.3	0.45	0.11	1	274
03/06/02	2.01	8.345	395.5	14.4	0	0.005	0.002	0.007		20	0.37	0.04	0	248
04/03/02	2.33	8.07	466.5	11.565	0.09	0.007	0.015	0.022		21.4	0	0.12	3	276
04/16/02	7.22	8.38	362	13.68	0.04	0.007	0.023	0.03		20.7	0.7	0.07	3	228
04/30/02	4.72	8.135	438.45	10.675	0.03	0	0.022	0.022	0	14.5	0.21	0.16	0	256
05/09/02	5.65	8.37	445	11.1	0.12	0	0.022	0.022	1	17.4	0.32	0.05	0	288
05/14/02	8.2	8.24	446	11.25	0.07	0.010	0.007	0.017	1	11.5	0.42	0.22	1	280
05/29/02	15.06	8.53	437	10.17	0.02	0.005	0.012	0.017	1	13.5	0.41	0.05	1	308
06/10/02	18.4	8.47	435	9.28	0.02	0.005	0.014	0.019	2	7.97	0.47	0.13	1	288
07/17/02	27.41	9.615	369	9.615	0.02	0.007	0.013	0.02	6	17.7	0.46	0.20	1	234
07/24/02	22.43	8.33	388.6	8.33	0.02	0.007	0.018	0.025	2	14	0.76	0.05	4	216
08/07/02	21.34	8.52	388.8	6.51	0.02	0.007	0.015	0.022	6	22	0.49	0.17	3	288
08/12/02	22.44	8.7	392.8	7.73	0.02	0.005	0.012	0.017	2	20.7	0.62	0.2	3	280
08/21/02	19.42	8.66	398.5	8.2	0.02	0.007	0.007	0.014	2	23.3	0.59	0.17	2	224
09/04/02	20	8.395	399.5	7.375	0.02	0.005	0.015	0.020	2	16.1	0.18	0.08	1	232
09/18/02	19.135	8.305	406.5	6.095	0.02	0.005	0.007	0.012	2	16.8	0.65	0.13	2	228
10/02/02	13.09	8.2	413.7	7.97	0.02	0.007	0.015	0.022	2	13.2	0.54	0.08	1	324
10/15/02	8.87	7.995	417.6	8.5	0.02	0.012	0.016	0.028	1	13.5	0.70	0.11	1	312

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