PHASE I CLEAN LAKES PROJECT

DIAGNOSTIC AND FEASIBILITY STUDY OF

LAKE CLAREMORE

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FINAL REPORT
April 1996

EXECUTIVE SUMMARY

Lake Claremore is a water supply reservoir located northeast of the City of Claremore, Oklahoma. Seasonal sampling by the Oklahoma Conservation Commission from 1987 to 1992 indicated that the lake was hypereutrophic. Impairment of the recreational and water supply uses were recognized as potential results of the high trophic state. Therefore, under §314-A of the Clean Water Act, a Phase I Clean Lakes Study was conducted on Lake Claremore from April 21, 1993 to March 23, 1994 to: assess the lake water quality, physical conditions, and trophic state; evaluate the watershed effects, such as sediment and nutrient loading, on the lake; and identify lake problems and their causes.

Problems in identified in the lake include hypereutrophication, excessive siltation, and elevated levels of toxic substances. These problems result from excessive sediment, nutrient, and metal loading from the tributaries. According to city officials, excessive sediment loading has reduced the depth of the lake substantially. Excessive phosphorous loading from the watershed has resulted in highly productive (hypereutrophic) conditions in the lake. The likely sources of the elevated phosphorous levels are leaking or improperly working septic systems or manure from livestock. The high productivity has contributed to hypolimnetic dissolved oxygen (D.O.) depletion which by late summer is so severe that one-fourth of the lake volume contained D.O. concentrations of less than 2 mg/l.

Another concern is the presence of toxic substances. Arsenic (in water), mercury (in water), chlordane (in fish and sediment), and total PCBs (in sediment) were present in excessive levels in the lake. Water from Dog Creek contained elevated levels of arsenic and selenium, while Little Dog Creek contained elevated levels of arsenic, selenium, lead, zinc, and copper. The source of the toxic metals is likely runoff and seepage from the coal mines. However, further study is needed to identify the source and evaluate the affects of these metals.

Hypereutrophication and an imbalance in the fish community have impacted the biological community. The lake was dominated by algae typically found in nutrient rich lakes. Due to the anaerobic conditions present at the sediment/water interface throughout much of the lake, the benthic macroinvertebrate community was dominated by low D.O. tolerant tubificids and chironomids. Small zooplankton were dominant indicating that insufficient numbers of predator fish may be present to suppress the planktivorous fish density. This was confirmed by the fish survey which found that planktivorous fish dominated the fish community.

Restoration options which were recommended include increasing the ratio of predator fish to prey fish, build fish attractors, implement best management practices in the watershed, upgrade sewage treatment in the watershed, reclaim strip mines, and treat mine drainage. In addition, it is suggested that water and fish from Lake Claremore be monitored regularly to determine long range trends of pollutants in the lake. Bioassessment of the tributaries should also be conducted to evaluate the impact of the metals on the fish and benthic macroinvertebrate communities.

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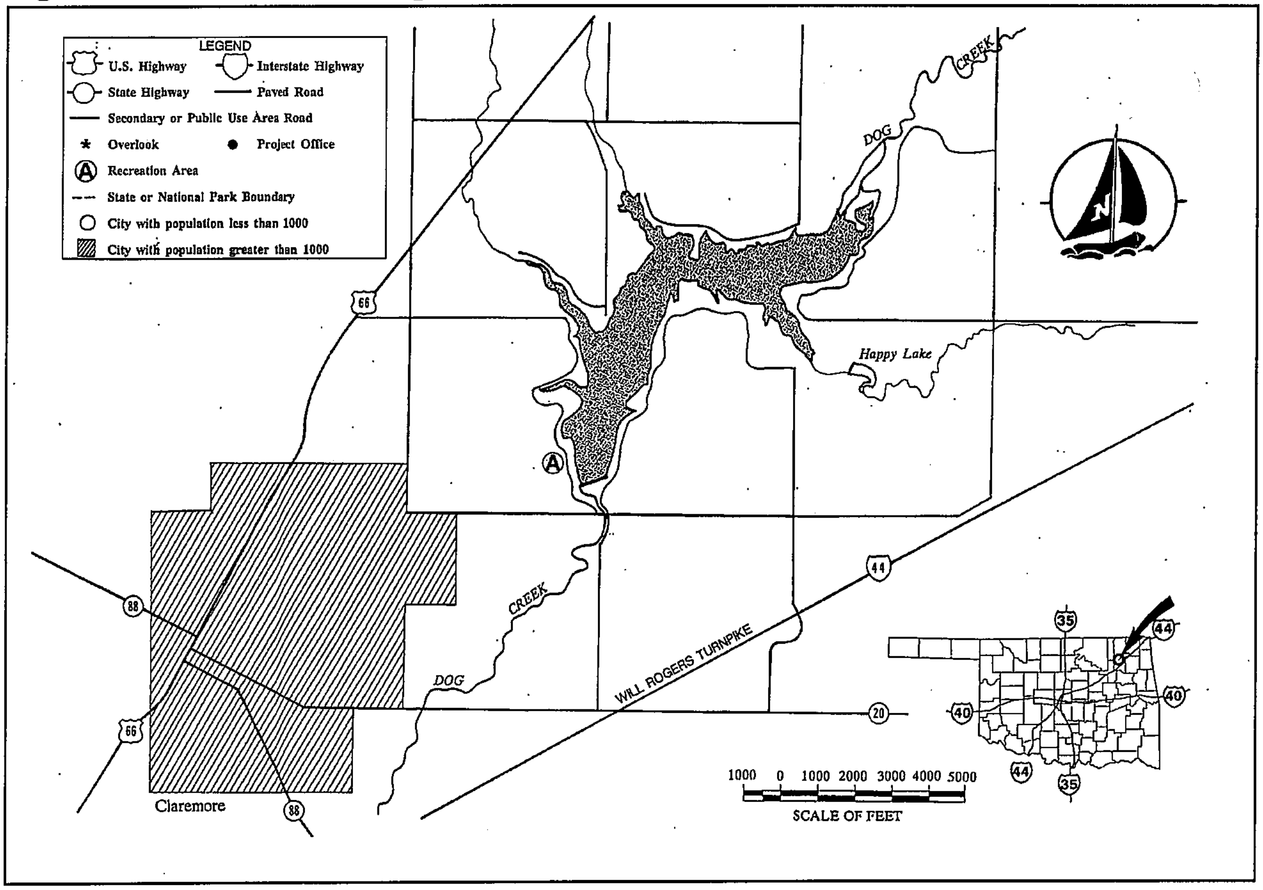
I.1 Lake Identification and Description

Lake Claremore is located in Rogers County, Oklahoma, northeast of the City of Claremore in the southeast quarter of Section 3, Range 16E, Township 21N (Figure 1). The lake was constructed in 1930 for the purpose of providing water for the City of Claremore. The lake covers 470 acres and has a storage capacity of 7,900 acre-feet (OWRB 1990). Its major tributaries are Dog Creek and Little Dog Creek. In 1967, the spillway height was raised 5 feet to 610 feet above mean sea level (CH_2M Hill 1986). In addition, a 12 inch pipeline transports water from near the Lake Oologah dam to the north end of Lake Claremore. However, water from Lake Oologah was not transported to Lake Claremore during the study period. The *Small Lakes Study* (OCC 1994) identified Lake Claremore as hypereutrophic. Siltation and turbidity are also major concerns of the citizens of the City of Claremore.

Figure 1. Location of and public access to Lake Claremore (OWRB 1990).



I.2 Geological Description of Drainage Basin

Lake Claremore and its watershed are located in the Central Irregular Plains Ecoregion. This ecoregion is generally composed of a mosaic of bluestem prairie (bluestem, panic, and indiangrass) and oak/hickory forest. The landuse in this ecoregion is predominately cropland and grazing land. The soils are primarily mollisols (Omernik 1987). The elevation in the watershed ranges from approximately 607 to 951 feet (185-290 m) above mean sea level.

The mean annual temperature is 60° F. Mean monthly temperatures range from 38° F in January to 82° F in July. Temperatures greater than 90°F occur on average 77 days a year and temperatures below freezing occur on average 82 days a year. The prevailing wind is south to southeasterly except during mid-winter when it is predominately northerly. Annual precipitation averages roughly 38 inches with the highest amount falling in the Spring. Snowfall averages about 7 inches annually. The estimated loss of water by evaporation annually ranges from 3-6 feet depending on temperature, humidity, and wind (SCS 1966).

Soil types found in the watershed and their susceptibility to erosion are listed in Table 1. Nearly half of the watershed contains soils of the Hector-Linker association. These well-drained, loamy soils are generally present under trees on gently sloping to very steep upland areas. The remaining upland areas contain soils of the Dennis-Choteau and Collinsville-Bates associations. Soils of the Dennis-Choteau association are formed under prairie grasses on nearly level to moderately sloping upland areas. Soils of the Collinsville-Bates association are loamy soils formed on gently sloping to steep sandstone uplands. The lowlands contain soils of the Verdigris-Osage association. These deep loamy to clayey soils are present on the nearly level bottomlands (SCS 1966).

Soils of the Dennis-Choteau association (Dennis, Choteau, Okemah, Parsons, and Woodson) are the most susceptible to erosion. These soils are present primarily along U.S. Highway 66 in the Dog Creek watershed and along the Will Rogers Turnpike. In addition, a small area of this association is also present in the Little Dog Creek watershed.

Strip mining for coal has significantly altered the geology of the upland areas of the Dog Creek and Little Dog Creek watersheds. These strip mines are bordered by mounds of shale, mixed with large sandstone and limestone boulders. The pits range in depth from 30-50 feet and are usually filled with water.

Table 1. Soil types in the Lake Claremore watershed, Rogers County, Oklahoma. Erodibility = Low (L), Moderate (M), or High (H).

Soil	Erodibility	Acres
Collinsville Stony Loam	L	435
Bates-Collinsville Complex	M	3,697
Dennis-Bates Complex, 2-5% Slopes	M-H	5,377
Bates and Dennis Soils, 3-5% Slopes, Eroded	M-H	613
Dennis Silt Loam, 1-3% Slopes	M-H	3,410
Dennis Silt Loam, 3-5% Slopes	M-H	524
Eroded Loamy Land (Dennis)	M-H	148
Breaks-Alluvial Land Complex (Dennis, Verdigris)	M-H	326
Verdigris Soils, Frequently Flooded	M	1,483
Verdigris Silt Loam	M	820
Verdigris Clay Loam	M	40
Newtonia Silt Loam, 1-3% Slopes (Lula)	M	10
Okemah Silty Clay Loam, 0-1 % Slopes	M-H	59
Okemah Silty Clay Loam, 1-3% Slopes	M-H	1,058
Woodson and Summit Soils, 0-1% Slopes	M-H	79
Parsons Silt Loam, 0-1% Slopes	H	237
Claremore Silt Loam, 0-3% Slopes	M	30
Hector Stony Sandy Loam	L	8,056
Hector-Linker Fine Sandy Loams, 1-5% Slopes	L-M	5,782
Rough Stony Land (Hector)	L	474
Linker Fine Sandy Loams, 1-3% Slopes	M	1,156
Linker Fine Sandy Loam, 3-5% Slopes	M	692
Choteau Silt Loam, 1-3% Slopes	M-H	10
Summit Silty Clay Loam, 1-3% Slopes	M	277
Summit Silty Clay Loam, 3-5% Slopes	M	129
Summit Silty Clay Loam, 1-5% Slopes, Eroded	M	49
Sogn Soils (Shidler)	M	49
Strip Mines (Kanima)	M	435
No Data		148
Borrow Pits		10
Fill Material-Dams and Highways, etc.		10
TOTAL		35,623

I.3 Historical Lake Uses and Trends in Use

The Oklahoma Water Quality Standards (OWQS) lists the designated beneficial uses of Lake Claremore and its watershed as public and private water supply, warm water aquatic community, agriculture, municipal and industrial process and cooling water, primary recreation, and aesthetics. The lake has also been designated a sensitive public and private water supply (SWS). Sensitive public and private water supplies are prohibited from having new point source discharges or increased loading from existing point sources without approval from the Oklahoma Water Resources Board. In addition, best management practices for control of nonpoint source discharges should be implemented in watersheds of waterbodies designated SWS (OWRB 1995). It is estimated that 150,000-200,000 people visit the lake each year. Fees collected by the City of Claremore for lake use (boating, fishing, and duck blinds) totaled $10,142.50 between July 1994 and July 1995.

Lake Claremore is the primary water supply for the City of Claremore and Rural Water Districts (RWD) 2, 8 and 9 in Rogers County, and is a standby (secondary) water source for Rural Water District 7. The rural water districts purchase treated water from the City of Claremore. The intakes for the City of Claremore water supply are located at the dam at depths of 10 and 19 feet. The city primarily uses the intake at 10 feet. The intake at 19 feet is used only during emergencies (Brown 1995).

The City of Claremore currently has rights to 4,580 acre-feet (4.1 mgd) of Lake Claremore/Dog Creek water and 3,360 acre-feet (3.0 mgd) of Lake Oologah water. Water right number 40-76 gives the city the rights to 1,459 acre-feet of Lake Claremore/Dog Creek water per year. Water right number 67-278 gives the city the rights to 1,419 acre-feet of Lake Claremore/Dog Creek water per year. However, the city has not fully utilized this water right. Based on usage, this water right (67-278) should be reduced to 729 acre-feet per year. Water right number 80-207 gives the City of Claremore the rights to 1,702 acre-feet of Lake Claremore/Dog Creek water per year. Water right number 77-162 gives the City of Claremore the rights to 3,360 acre-feet of Lake Oologah water per year. Water right numbers 80-207 and 77-162 have schedules of use, allowing the City of Claremore until 2030 to fully utilize these water rights. In the event that water is used at a lesser rate, the City may actually lose a portion of the water right based on the difference between the scheduled and actual use. In the event that water is used at a faster rate, the City will need to amend the schedules of use to ensure availability at the higher rate (CH_2M Hill 1986).

Use of the lake as a water supply will increase with the population, which is projected to grow to 19,200 residents by the year 2000 and 28,700 residents by the year 2030. However, current growth rates exceed those used for the projections mentioned above. Therefore, the population will likely exceed the projections referred to above.

The normal average daily demand is 135 gallons per capita per day, while the drought average daily demand is 160 gallons per capita per day. At this rate, average daily demand on the lake for water could reach 2.6 million gallons by the year 2000 and 3.9 million gallons per day by the year 2030, while maximum daily demands could reach 4.7 million gallons by the year 2000 and 7.0 million gallons during normal conditions. Provided that sufficient raw water storage is available, current water rights appear to be sufficient for future demands (CH_2M Hill 1986). Recreational use is also expected to increase as the population increases unless inhibited by further degradation of the lake.

Mean water usage for 1990-94 was approximately 3,000 acre-feet per year (2.7 mgd). This exceeds estimates made in the 1986 study (discussed in the previous paragraph). Currently, the only challenge with treating the water is eliminating the turbidity. Low alkalinity is also a problem at times. The City of Claremore is currently testing a microfiltration system as a means of treating water to replace the alum and lime treatment system currently used. Current water treatment costs range from $325-350 per million gallons of water treated.

The *Oologah Water Supply Study* found that the yield of Lake Claremore is approximately 18,000 acre-feet (16 mgd) in a normal year and approximately 2,200 to 2,800 acre-feet (2.0 to 2.5 mgd) in a drought year. The normal 16 mgd yield is significantly more than the average daily demands projected well into the the future. However, the 2.0 to 2.5 mgd available in a drought year can only marginally provide for the current average daily demands (CH_2M Hill 1986). Therefore, during drought conditions, daily demands can be met only with supplemental use of Lake Oologah water or by enlarging the storage capacity of Lake Claremore by dredging or raising the dam. Currently, the pipeline from Lake Oologah has the capacity to provide 1.5 mgd of water to Lake Claremore.

The small size of Lake Claremore relative to the size of its watershed accounts for large differences in normal and drought year yields. Estimates indicate that the storage volume provided by Lake Claremore is less than 25% of the storage volume that would be required to make maximum use of the runoff generated in the Lake Claremore watershed. As a result, most of the runoff generated in a normal year is discharged over the spillway with very little being stored in the lake for use in a subsequent drought year when runoff is much less. For more information on the Lake Claremore water supply and City of Claremore water use, see the *Oologah Water Supply Study* (CH_2M Hill 1986).

I.4 Public Access to Lake

Lake Claremore is easily accessible from the historic U.S. Highway 66, the Will Rogers Turnpike (Interstate Highway 44), and State Highway 20 via numerous paved county roads (Figure 1). A recreation area is located northwest of the dam. A boat ramp, boat dock, fishing dock, electrical hookups, picnic area, grills, restrooms, group shelters, and drinking water are available at the recreational area (OWRB 1990). In addition, numerous duck blinds are available for rent in areas surrounding the lake. The recreational area is managed by the City of Claremore Parks and Recreation Department, who collect fees for boating, fishing, duck blind use, and shelter use. Swimming is not allowed in Lake Claremore.

I.5 Lake User Population Impacted by Lake Degradation

The City of Claremore and RWD 2,7, 8, and 9, which depend upon the lake for their water, could be impacted by further degradation of the lake. Recreational users (i.e. fishermen, etc.) would also be impacted by degradation.

I.6 Size and Economic Structure of Population Using Lake

Lake Claremore is used primarily by residents of the City of Claremore and people residing in the rural areas of Rogers County in close proximity to the lake. The City of Claremore, which is the county seat of Rogers County, is the largest city in the county with an approximate population of 12,085. According to the 1990 census, the median age of Rogers County residents is 33.9 years and the median family income is $33,112 per year.

I.7 Comparison of Lake Use to Other Lakes within an 80 km Radius

Table 2 compares usage of lakes located within an 80 km (50 miles) radius of Lake Claremore.

Table 2. Comparison of lake uses to other lakes within an 80 km radius. (*Hydroelectric power)

Lake	Rec.	H_2O Supply	Wild-life	Flood Cntl.	Nav.	Area (acres)
Grand*	X	X	X	X		46,500
Oologah*	X	X	X	X	X	29,460
Keystone*	X	X	X	X	X	23,610
Ft. Gibson*	X	X	X	X		19,900
Webbers Falls*	X	X	X		X	11,600
Hudson*	X	X	X	X		10,900
Skiatook	X	X	X	X		10,190
Copan	X	X	X	X		4,850
Eucha	X	X	X			2,860
Spavinaw	X	X	X			1,584
Birch	X	X	X	X		1,137
Heyburn	X	X	X	X		880
W.R. Holway*	X	X	X			712
Shell	X	X	X			573
Claremore	**X**	**X**	**X**			**470**
Yahola	X	X	X			431
Sahoma	X	X	X			312
Hudson	X	X	X			250
Waxhoma	X	X	X			197
Hominy	X	X	X			165
Bixhoma	X	X	X			110

I.8 Inventory of Point Source Pollutant Discharges

Excluding backwash water from the water treatment facility, there are no permitted point sources in the Lake Claremore watershed.

I.9 Watershed Landuse

The landuse was determined using a Geographical Information System (GIS). The GIS used for this project was GRASS (Geographic Resources Analysis Support System). Data was input into GRASS by the Soil Conservation Service (now the Natural Resource Conservation Service). Landuse data for GRASS was obtained from 1985-89 using aerial photography interpretation and local knowledge of the area.

The landuse in Lake Claremore's watershed (Table 3) is primarily pasture (46%) and forest (30%). Oak and hickory forest is the predominant forest type in the watershed. Urban ranchettes also make up a substantial portion of the watershed (14%). These urban ranchettes rely primarily on septic systems to treat their sewage. In addition, urban ranchettes often have large animals on small plots of land which may contribute excessive amounts of soil and manure to area streams. The NRCS has BMPs (best management practices) for large animal maintenance on urban ranchettes which should be implemented. Other notable landuses are urban land, strip mines (coal), rangeland, and cropland. The unincorporated town of Foyil composes most of the urban land.

Table 3. Landuse in the Lake Claremore watershed, Rogers County, Oklahoma.

Landuse	Acres	Percent
Pastureland	16,368	46
Forest Land	10,596	30
Urban Ranchettes	5,209	14
Urban and Built-up Land	1,048	3
Rangeland	672	2
Strip Mines - Unreclaimed	633	2
Farmsteads	395	1
Cropland	336	1
Strip Mines - Reclaimed	198	1
Misc.	168	<1
TOTAL	35,623	100

As Table 3 indicates, 633 acres of strip mines remain unreclaimed. A majority of these mines lie in the Dog Creek watershed. However, two areas in the Little Dog Creek watershed have been mined. The strip mine located at Section 11, Range 17E, Township 22N was mined until 1976 and reclaimed in the early 1990s. The strip mine located in Sections 15 and 16, Range 17E, Township 22N, was abandoned in 1929 and remains unreclaimed. A tributary draining this area discharges into Little Dog Creek.

I.10 Lake Limnology

A. Investigative approach

Seasonal sampling by the Oklahoma Conservation Commission from 1987 to 1992 indicated that Lake Claremore was hypereutrophic based on the Carlson TSI-chlorophyll *a* (Carlson 1977). Impairment of the recreational and water supply uses were recognized as potential results of the high trophic state. While the lake is currently supporting a sports fishery, potential oxygen depletions resulting from massive algal blooms threaten the aquatic community. Based on these data, the limnological objectives of this investigation were to:

1) assess the lake water quality, physical conditions, and trophic state,
2) evaluate the watershed effects, such as sediment and nutrient loading, on the lake,
3) and identify lake problems and their causes.

B. Experimental Procedures

1. Lake Location and Sampling Sites

Lake Claremore is located approximately 1 mile northeast of the City of Claremore. Three representative sampling sites were established on Lake Claremore for assessment of the lake water quality. Lake sampling sites were located at the dam, the mid-point, and in the upper end of the lake. Additional sites were established on each of the two main tributaries (Dog and Little Dog Creeks) and on Dog Creek downstream of the reservoir. Dog Creek originates near Chelsea and flows into the Verdigris River approximately 8 miles south of Claremore. Little Dog Creek is a tributary to Dog Creek. The stream sites included single stage samplers for runoff collection, and staff and crest gauges for the purpose of aiding in the determination of lake hydrologic and nutrient budgets. Figure 2 identifies the location of the lake, the watershed, lake sampling stations, and sampling stations on the two streams.

2. Lake and Tributary Sampling

The lake and its two tributaries were first sampled in April, 1993 and were sampled at least monthly throughout the project. From May through September, the lake and two tributaries were sampled twice per month. All water quality sampling was carried out according to Standard Operating Procedures on file at the Oklahoma Conservation Commission or as written in the project workplan. A brief summary of these follows.

Water temperature, dissolved oxygen, conductivity, and pH profiles were taken *in situ* at all lake sites with the assistance of a Hydrolab Surveyer III - H_2O instrument. Profiles were established by taking readings at 1 m increments from the water surface to the lake bottom. Water transparency was measured with a 20 cm Secchi disk. Water temperature, dissolved oxygen, pH, and conductivity were determined *in situ* in the two tributaries.

Grab samples were collected from 0.1 m below the surface at the two tributaries. At lake locations, water was collected at 0.1 m, mid-depth, and 0.5 m above bottom, and then composited into a single sample. When stratification was evident, discrete samples were taken from 0.1 m and from 0.5 m above the lake bottom. Routine water quality samples were analyzed for total Kjeldahl nitrogen (TKN), nitrate (NO_3), nitrite (NO_2), total phoshporous (TP), total alkalinity, total hardness, total dissolved solids (TDS), total suspended solids (TSS), sulfate (SO_4), and chloride (Cl). In lake water samples, chlorophyll was analyzed. Twice throughout the project, additional water samples were analyzed for metals and pesticides.

Samples were collected from the tributaries during four high flow events throughout the course of the study. High flow samples were collected using single stage samplers. Composites of each runoff event were analyzed for nutrients, metals, and pesticides.

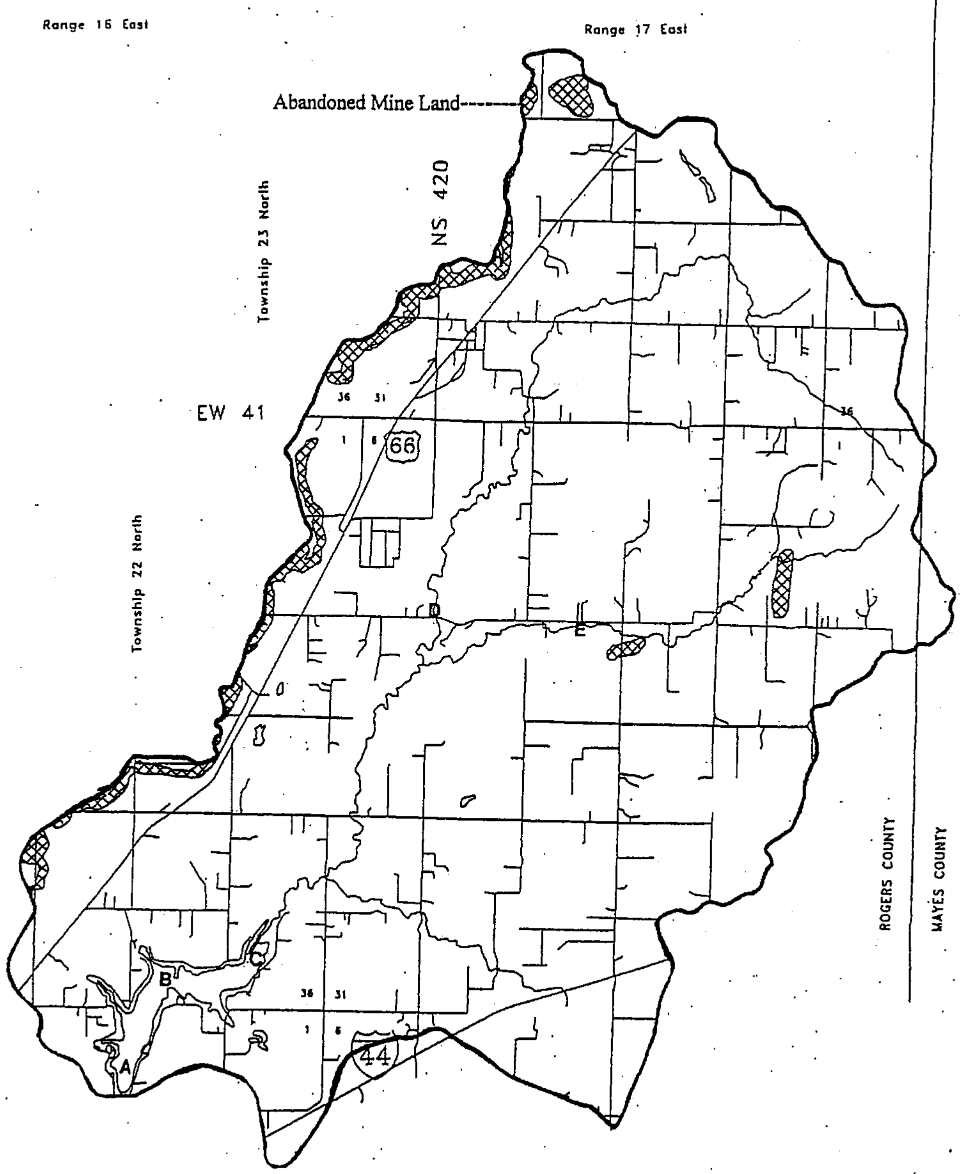
Sediment samples were collected from the dam and mid-point sites using a Ponar Dredge on September 15, 1993 for analyses of nutrients, metals, and pesticides.

Benthic macroinvertebrates were collected at 30 sites in the lake along 3 transects using a ponar dredge. The transects were located in the lacustrine, transition, and riverine zones. These zones were identified using secchi depth. The samples were washed in a #30 mesh sieve, preserved in ethanol, and delivered to City-County Health Department Laboratory of Oklahoma City for enumeration and identification.

Fish were collected by the Oklahoma Department of Wildlife Conservation (ODWC) under contract to the OCC from the three zones of the lake using electroshocking and gill nets. Fish flesh was analyzed for metals and pesticides once.

Zooplankton and phytoplankton were collected 3 times during the study (April 21, June 15, and September 28, 1993). A 500 ml composite sample from the dam was collected three times for analysis of phytoplankton. A single, bottom to surface vertical tow with a Wisconsin net was taken to collect zooplankton from the dam. These samples were preserved in the field and sent immediately to the lab for taxonomic identification and community analysis.

Figure 2. Location of sampling sites for Lake Claremore Clean Lakes Project, 1993-94.



LEGEND

A Lake Claremore Dam
B Lake Claremore Mid-point
C Lake Claremore Upper End
D Dog Creek near Sequoyah
E Little Dog Creek near Sequoyah

C. Morphological and Hydrological Characteristics of the Lake

1. Lake Morphology

A bathymetric survey was conducted on Lake Claremore by the City of Claremore Engineering Department (Figure 3) in 1988. Estimates of the surface area and volume from this survey agreed with the values reported by the OWRB. The morphological characteristics of Lake Claremore are listed in Table 4 (OWRB 1990). Lake Claremore is a relatively shallow lake. Shallow lakes are generally more susceptible to eutrophication due to their having higher depth-averaged light intensities to support photosynthesis and greater sediment/water contact, which can encourage nutrient recycling (EPA 1990).

Table 4. Morphological characteristics of Lake Claremore (OWRB 1990).

Parameter	Value
Surface Area	470 acres
Storage Capacity	7,900 acre-feet
Normal Pool Elevation	610 feet above MSL
Maximum Depth	25 feet
Mean Depth	16.8 feet
Shoreline Length	9 miles
Shoreline Development	3.0

According to city officials, siltation has substantially reduced the lake's volume (Brown 1995). Siltation is a natural process in lakes and reservoirs. In fact, reservoirs are usually designed and constructed with finite life spans due to siltation. However, the extent of the siltation should be verified by further study. In addition, reasonable actions should be taken to reduce siltation to extend the life of the reservoir.

2. Lake Hydrology

Discharges in Dog Creek and Little Dog Creek were measured by fixed staff and crest gages at the routine sample sites. Staff gauges were monitored by Rogers County Conservation District staff. Crest gauges were read following storm events. Flows were measured five times during the study in each stream. However, due to problems with beavers and lack of flow data, this information could not be used. Therefore, an alternate method of determining the discharge was used. Average annual runoff was determined from USGS data for nearby streams by dividing their total annual discharge by their watershed area. From this it was found that annual runoff averages 0.26 m/yr (m^3/m^2-yr) in this area. This compares closely with USGS estimations of annual runoff ranging from 5-10 inches (0.13-0.25 m/yr) for this area (Linsley et al. 1975). Table 5 displays Lake Claremore's hydrologic budget.

Figure 3. Bathymetric map of Lake Claremore, 1988.

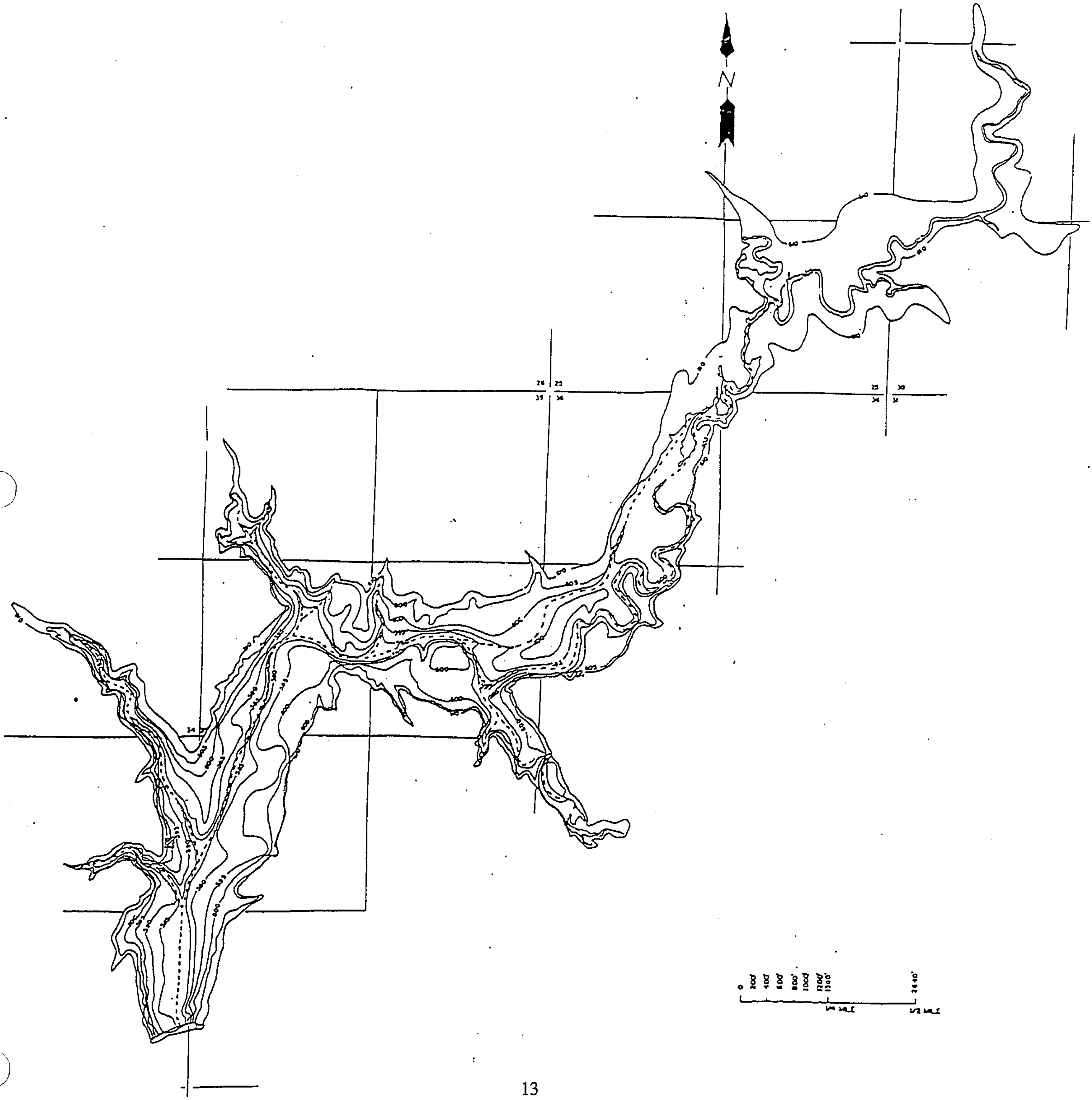
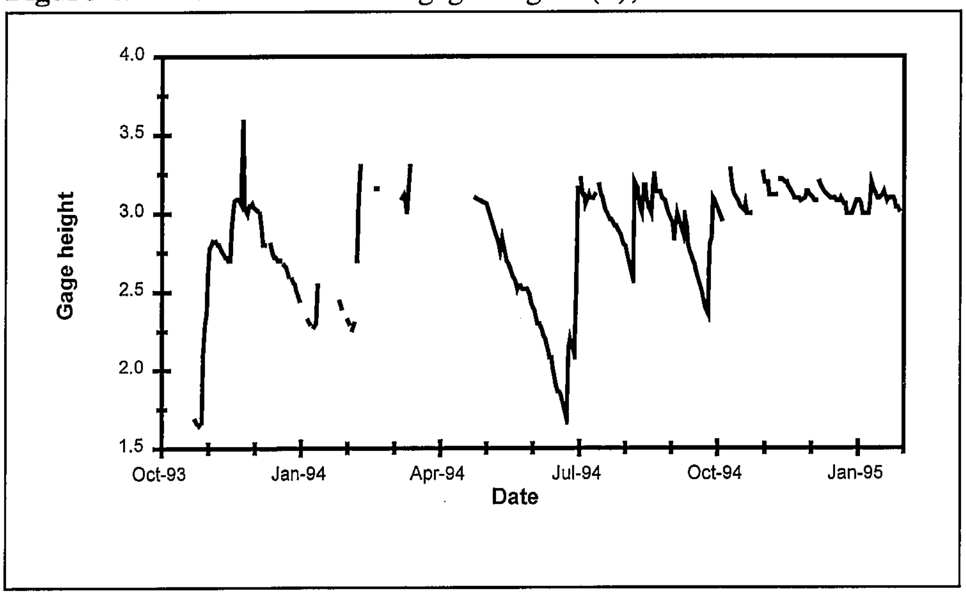


Table 5. Hydrologic budget for Lake Claremore estimated to the nearest 1,000 m^3/yr (ac-ft/yr).

Input	Volume
Inflow	38,050,000 m^3/yr (31,000 ac-ft/yr)
Rainfall	1,834,000 m^3/yr (1,000 ac-ft/yr)
Output	
Lake Evaporation	2,365,000 m^3/yr (2,000 ac-ft/yr)
Water Supply	3,785,000 m^3/yr (3,000 ac-ft/yr)
Outflow	33,734,000 m^3/yr (27,000 ac-ft/yr)

Inflow was determined by multiplying the annual runoff (discussed above) by the watershed area. Because water was not transported to Lake Claremore from Lake Oologah during the study, it was not included in the hydrologic budget. Use of water from Lake Oologah varies year to year and may provide substantial input during some years. Rainfall onto the lake was determined by multiplying the average precipitation of 0.96 m/yr (SCS 1966) by the lake surface area. Lake evaporation was determined by multiplying the average annual lake evaporation for Rogers County of 1.24 m/yr (SCS 1966) by the lake surface area. The mean water usage for 1990-1994 was used to determine the output for water supply. The outflow was calculated by subtracting all outputs from inputs. Residence time, which was calculated by dividing storage capacity by the total annual input, was approximately three months. Lake levels (Figure 4) fluctuated very little (2 ft) during the study.

Figure 4. Lake Claremore gage heights (ft), 1993-95.



D. Water Quality of the Lake

Water quality in Lake Claremore and its tributaries was monitored from April 21, 1993 to March 23, 1994. This involved semimonthly sampling from May 12 to September 28, 1993 and monthly sampling during the remaining seven months. The two major tributaries were also sampled during four storm events. The outflow was sampled eight times between April and September 1993 and on March 9, 1994. The results of the sampling program are discussed in the following sections. Routine water quality data collected from the lake can be found in Appendix A.

1. Thermal Structure of the Lake

Surface temperature ranged from 4°C in late January to 30°C in late July (Figure 5). Lake Claremore is classified as a monomictic lake. Thermal stratification was evident at the dam and mid-point sites from mid-May through mid-August under normal weather conditions. However, the temperature difference between the top and bottom was small and resistance to mixing was low. The location of the thermocline at the dam ranged from a depth of 2.7 m to 5.9 m (Figure 6). Mixis occurred in September, and the lake remained well mixed from September through April. The site at the upper end of the lake experienced only short periods of stratification during relatively calm periods and remained unstratified throughout most of the year due to its shallowness and wind mixing action.

Figure 5. Surface temperature at Lake Claremore dam, 1993-94.

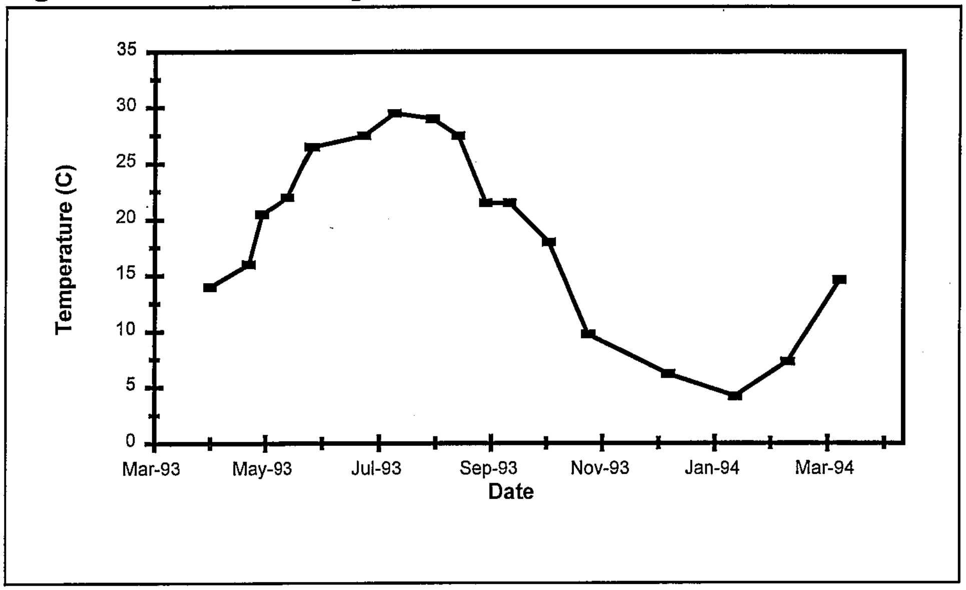
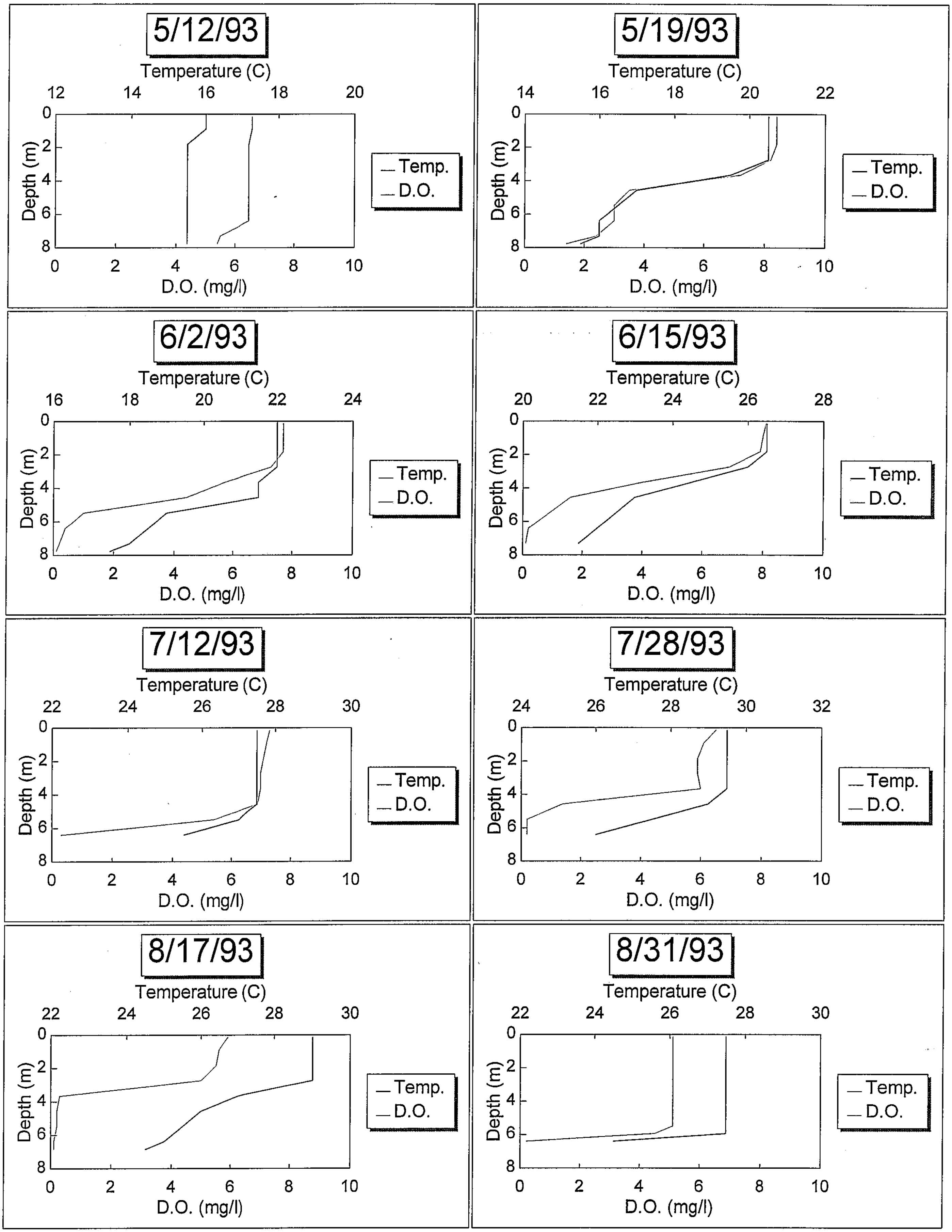


Figure 6. Temperature and D.O. profiles measured at the Lake Claremore dam, 1993.



2. Dissolved Oxygen (D.O.)

Dissolved oxygen (D.O.) concentrations were present at sufficient concentrations throughout the lake from September through April. However, clinograde oxygen profiles were present at the dam (Figure 6) and mid-point sites during thermal stratification. Decomposition of high levels of organic matter result in hypolimnetic D.O. depletion. At the site near Lake Claremore's dam, D.O. concentrations were less than 2 mg/l in the hypolimnion from mid-May through August. At the mid-point site, hypolimnetic D.O. concentrations were less than 2 mg/l on June 2 and from mid-July to mid-August, 1993. Excluding the June 15, 1993 bottom D.O. concentration (2.5 mg/l), the upper end site remained well oxygenated throughout most of the year. Hypolimnetic D.O. depletion impacts the benthic macroinvertebrate and fish communities by limiting the areas of the lake which can be inhabited. On August 17, 1993, when D.O. depletion was at its worst, approximately one-fourth of the lake volume had a D.O. concentration of less than 2 mg/l and could not be inhabited by fish. In addition, half the lake bottom had a D.O. concentration of less than 2 mg/l.

3. Chlorophyll-a and Secchi Depth

Chlorophyll *a* concentrations, corrected for pheophytin *a*, are listed in Appendix B. During the study (1993-94), mean chlorophyll concentrations were 19 mg/l at the dam, 22 mg/l at the upper end site, and 25 mg/l at the mid point site. Chlorophyll *a* concentrations were greatest in the mid-point of the lake. During the study, chlorophyll concentrations peaked during the early-fall (September). Chlorophyll *a* was also used as an indicator of trophic state. Trophic state will be discussed in Section I.10 M.

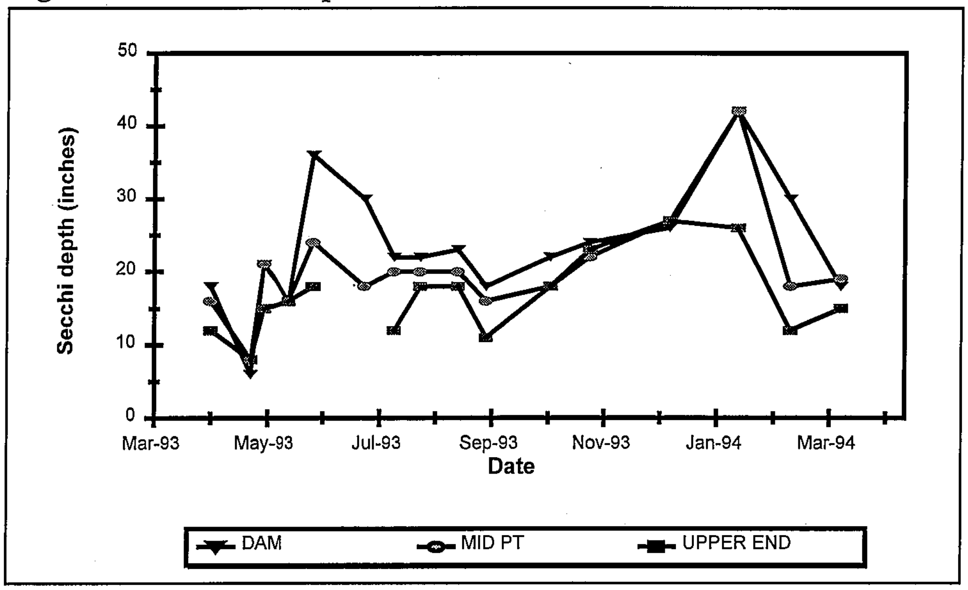
Surface chlorophyll concentrations at the dam were also analyzed on a quarterly basis from 1987-92 as a part of the OCC's Small Lakes Sampling Program. The statistical program WQStat was used to analyze the surface chlorophyll data from 1987-94. Results indicate that the chlorophyll concentrations do not express significant seasonality. In addition, no significant trend was detected in the chlorophyll data.

Secchi depth (Appendix C) is an indicator of water clarity. Secchi depth (Figure 7) ranged from 6 to 42 inches at the dam and averaged 23 inches (CV=36%). The secchi depth at the mid-point site ranged from 8 to 42 inches and averaged 20 inches (CV=35%). Secchi depth ranged from 8 to 27 inches at the upper end site and averaged 17 inches (CV=33%). As expected, a trend of increasing water clarity occurred between the upper end and dam. Highest secchi depth values occurred in mid-June 1993 and late-January 1994. These secchi depths correspond with extended periods with no runoff. Excluding the two peaks, secchi depth varied little.

Secchi depth and surface chlorophyll concentrations were significantly correlated (r=0.7) at the dam indicating that chlorophyll concentrations had a significant affect on the transparency of the water at the dam. Secchi depth and surface chlorophyll concentrations were slightly correlated (r=0.4) at the mid-point site. Not enough surface chlorophyll concentrations were measured at the upper end site to perform a correlation.

Secchi depth and surface turbidity were slightly correlated (r=0.5) at the dam indicating that turbidity affected the transparency of the water at the dam. Secchi depth and surface turbidity were not correlated (r=0.0) at the mid-point site. Not enough surface turbidities were measured at the upper end site to perform a correlation. At the dam, chlorophyll concentrations significantly influenced water clarity. Therefore, by decreasing algal production, water clarity should increase.

Figure 7. Secchi depth in Lake Claremore, 1993-94.



4. <u>Nitrogen and Phosphorous</u>

Total nitrogen concentrations ranged from 0.2 to 1.1 mg/l and averaged 0.6 mg/l at the dam. Total nitrogen concentrations ranged from 0.3 to 1.1 mg/l and averaged 1.0 mg/l at the mid-point site. Total nitrogen concentrations ranged from 0.4 to 0.8 mg/l and averaged 0.6 at the upper end site.

Total phosphorous concentrations ranged from 0.02 to 0.13 mg/l and averaged 0.06 mg/l at the dam. Total phosphorous concentrations ranged from 0.02 to 0.14 mg/l and averaged 0.06 mg/l at the mid-point site. Total phosphorous concentrations ranged from 0.02 to 0.12 mg/l and averaged 0.05 mg/l at the upper end site. Total phosphorous concentrations are present at levels known to cause hypereutrophication (EPA 1979).

Based on average total nitrogen and total phosphorous concentrations, the TN:TP was 11:1 at the dam, 17:1 at the mid-point site, and 10:1 at the upper end site. A TN:TP greater than 7:1 indicates phosphorous limitation (Wetzel 1983). Therefore, productivity in Lake Claremore is limited by phosphorous availability.

5. pH, Alkalinity, Hardness, TSS, Turbidity, TDS, Conductance, SO_4, and Cl

Means and ranges for pH, alkalinity, hardness, TSS, turbidity, TDS, sulfate (SO_4), chloride (Cl), and conductance calculated from data collected between April 1993 and March 1994 are listed in Table 6. All pH values measured in Lake Claremore complied with the Oklahoma Water Quality Standards (OWQS). Alkalinities were generally low; therefore, the water has a low pH buffering capacity. The hardness of the water ranged from soft to moderately hard. Softer waters have a lower capacity to mitigate toxicity. Total suspended solids (TSS) in Lake Claremore are comparable to other lakes in Oklahoma and Kansas. The turbidity in Lake Claremore exceeded Oklahoma's numerical turbidity criteria of 25 NTU (OWRB 1995) on numerous occassions. However, none of the exceedances are considered to be in violation of the OWQS, because the higher turbidities were associated with runoff events or hypolimnetic samples. Total dissolved solid (TDS) concentrations were within the recommended limits for drinking water supplies and near the worldwide average TDS concentration of 120 mg/l. TDS concentrations and conductivity were comparable to other waterbodies in northeastern Oklahoma. Sulfate and chloride concentrations were within the recommended limits for drinking water supplies.

Table 6. Means and ranges for pH, alkalinity, hardness, TSS, turbidity, SO_4, Cl, TDS, and conductance measured in Lake Claremore, April 1993 to March 1994.

Parameter	Units	Upper End		Mid-Point		Dam	
		Mean	Range	Mean	Range	Mean	Range
pH	Std Units	7.8	7.2-8.4	8	6.7-8.6	7.6	6.8-8.7
Alkalinity	mg/l	47	6-66	49	31-64	51	6-71
Hardness	mg/l	73	53-83	72	44-100	71	31-94
TSS	mg/l	21	4-34	18	3-82	19	4-56
Turbidity	NTU	27	1-99	18	1-67	23	3-100
TDS	mg/l	136	111-170	128	102-147	135	106-166
Conductance	uS/cm	197	154-223	190	124-214	188	89-262
Sulfate	mg/l	31	23-42	29	18-39	28	11-36
Chloride	mg/l	5	3-11	5	2-11	5	2-11

6. Heavy Metals

Zinc, cadmium, lead, and selenium were not detected in any of the lake water samples (Appendix D). However, calcium, sodium, potassium, manganese, iron, copper, chromium, nickel, arsenic, mercury, and barium were detected in lake water samples (Table 7). None of the detected metals exceeded the raw water numerical criteria in the OWQS. Hypolimnetic metal concentrations were generally greater than epilimnetic concentrations indicating that metals may be diffusing from the sediments. Calcium, magnesium, potassium, and sodium were not present at significant concentrations. Iron concentrations did not exceed EPA Goldbook (EPA 1986) biological criteria (1.0 mg/l).

Table 7. Metal concentrations in Lake Claremore, 1993.

SITE	DATE	Depth m	Na mg/l	K mg/l	Mn ug/l	Fe ug/l	Cu ug/l	Cr ug/l	Ni ug/l	As ug/l	Hg ug/l	Ba ug/l
Dam	07/28/93	0.2	6.9	1.9	230	220	ND	ND	2	2	ND	ND
Dam	07/28/93	5.5	6.9	2.1	4300	610	ND	ND	3	9	0.1	ND
Dam	09/28/93	0.2	6.6	2.2	290	550	ND	1	1	2	ND	ND
Dam	09/28/93	5.5	6.6	2.2	320	710	ND	ND	2	2	0.4	ND
Mid-point	07/28/93	0.2	7.0	2.0	260	400	1	ND	2	2	ND	100
Mid-point	07/28/93	3.7	7.0	1.9	240	290	ND	ND	2	2	0.1	ND
Mid-point	09/28/93	0.2	6.6		180	320	ND	ND	ND	1	ND	ND
Mid-point	09/28/93	2.7	6.7	2.2	200	340	ND	ND	ND	2	0.6	ND
Upper end	07/28/93	0.2	7.5	2.0	280	740	1	ND	3	2	ND	ND
Upper end	09/28/93	0.2	6.6	2.2	190	460	ND	ND	2	1	ND	ND
Upper end	09/28/93	0.9	6.6	2.2	220	560	ND	ND	1	1	1.5	ND

Quantities of copper, chromium, nickel, arsenic, mercury, and barium were compared to water quality criteria as listed in the OWQS (OWRB 1995). Concentrations of copper, chromium, nickel, and barium did not exceed OWQS criteria. On September 28, 1993, hypolimnetic mercury concentrations at the mid-point (0.6 ug/l) and upper-end (1.5 ug/l) lake sites exceeded the water column criteria (0.56 ug/l) to protect human health for the consumption of fish flesh and water. On September 28, 1993, the hypolimnetic mercury concentration at the upper-end lake site also exceeded the chronic numerical criteria for toxic substances (1.302 ug/l) for protection of fish and wildlife.

Arsenic concentrations in the lake, which ranged from 1-9 ug/l, exceeded the water column criteria (0.175 ug/l) to protect human health for the consumption of fish flesh and water. There may be some cause for concern if these samples represent a long-term trend in the lake and its watershed. Additional information is needed to fully evaluate the implications of this data set. Therefore, it is recommended that the City of Claremore sample the lake for metals regularly. It should be noted that finished public drinking water supplied from Lake Claremore, which is routinely tested by the Oklahoma Department of Environmental Quality (DEQ), has not exceeded any water quality standards for toxics.

E. Lake Sediment Quality

Sediment collected from the dam and mid-point sites on September 15, 1993 was analyzed for pesticides and metals (Appendix E). Of the following 17 pesticides and organics, only chlordane, DDD, DDE, DDT, and PCB were detected in the lake sediments.

Aldrin	Chlordane	Lindane	Mirex
DDD	Dieldrin	Endosulfane	Endrin
DDE	Toxaphene	Heptachlor	Perthane
DDT	Methoxychlor	Heptachlor epoxide	
Polychlorinated Biphenyls (PCB)		Polychlorinated Napthalenes (PCN)	

Sediment samples contained chlordane concentrations of 1 ug/kg at the mid-point site and 2 ug/kg at the dam, DDD concentrations of 0.5 ug/kg at the mid-point site and 0.3 ug/kg at the dam, DDE (degradation product of DDT) concentrations of 1.7 ug/kg at the mid-point site and 1.2 ug/kg at the dam, DDT concentrations of 0.1 ug/kg at the dam, and total PCBs concentrations of 4 ug/kg at the mid-point site and 3 ug/kg at the dam. Sediment Screening Values developed by EPA (1995) were used to assess the chemical concentrations found in Lake Claremore's sediments. Sedimentary concentrations of DDD, DDE, and DDT did not exceed EPA Sediment Screening Values. The chlordane concentration at the dam exceeded the EPA Sediment Screening Value (1.5 ug/kg). In addition, the total PCBs concentrations at both the mid-point and dam exceeded the EPA Sediment Screening Value (0.14 ug/kg). However, chlordane, DDT, and PCBs are banned or restricted in the United States; therefore, their concentrations, as well as the DDE concentrations, likely result from past activities and should decrease with time.

Metal concentrations in Lake Claremore sediments were compared to EPA Sediment Screening Values in Table 8 to determine their significance. None of the metal concentrations found in Lake Claremore's sediments exceeded the EPA Sediment Screening Values.

Table 8. Detected quantities of metals in Lake Claremore sediment as compared to EPA Sediment Screening Values (EPA 1995).

Metal	Dam	Mid-pt.	Screening Value
Mg (ug/g)	2400	1500	N/A
Na (ug/g)	200	60	N/A
K (ug/g)	240	170	N/A
As (ug/g)	14	10	85
Cd (ug/g)	1	1	9
Cr (ug/g)	20	20	145
Cu (ug/g)	20	10	390
Pb (ug/g)	30	20	110
Fe (ug/g)	41,000	20,000	N/A
Mn (ug/g)	2,400	810	N/A
Ni (ug/g)	30	20	50
Zn (ug/g)	140	60	270
Hg (ug/g)	0.05	0.05	1.3

F. Lake Biological Resources

1. Algae

The algal community is presented in detail in Appendix F. Taxonomy was carried out to genus in the samples collected on April 21, June 15, and September 28, 1993. Lake Claremore is dominated by algae typically found in nutrient enriched lakes. The diatom *Melosira* was dominant throughout the growing season.

Although algae are extremely diverse and capable of tolerating a wide range of environmental conditions, certain characteristic algal associations have been found repeatedly in lakes of increasing nutrient enrichment. For example, nutrient enriched (eutrophic), alkaline lakes are commonly dominated by diatoms much of the year, especially *Asterionella spp.*, *Fragilaria crotonensis*, *Synedra*, *Stephanodiscus*, and *Melosira granulata*. Blue-green algae are also common during warmer months of the year (Wetzel 1983).

The algal association found in Lake Claremore is similar to algal associations found in other eutrophic lakes. Besides being dominated by the diatom *Melosira*, blue-green algae also became increasingly abundant during the warmer months. The eutrophic classification indicated here is consistent with other findings of this study.

2. Zooplankton

Zooplankton collections were made on April 21, June 15, and September 28, 1993. Zooplankton abundance and length are listed in Appendix G. At least nine zooplankton species were identified in the lake. Copepods were consistently more abundant than cladocerans.

The size of zooplankton is closely related to fish community structure (Mills and Schiavone 1982). Most zooplankton collected in Lake Claremore were small (length < 0.8 mm) indicating that a predator:prey ratio of 0.2 or less may exist in the fish community (Mills et al. 1987). The dominance of small zooplankton strongly implies that insufficient numbers of predator fish are present to suppress the planktivorous fish (gizzard shad and sunfish) density (Mills and Schiavone 1982). In addition, the reduction in *Daphnia* length from 0.97 mm in June to 0.68 mm in September may result from predation impact of young fish indicating that the lake may contain a strong year class of young fish which potentially supply food for piscivorous gamefish (Mills et al. 1987). Thus, stocking and/or restrictive harvest of top predators (flathead catfish, saugeye, and largemouth bass) may provide an acceptable means to restoring the predator-prey balance. With the restoration of the predator-prey balance and the resulting larger zooplankton, it can be expected that clearer water will result from intense grazing of zooplankton on algae (Mills and Schiavone 1982). Filtering rates of zooplankton have been found to increase exponentially with increasing body length (Wetzel 1983).

The planktonic insect *Chaoborus* (Order Diptera) was found in high numbers in the sediment. *Chaoborus* (the phantom midge) larvae is capable of migrating vertically through the water column. During the day they migrate to the sediments to escape fish predation, and at night they migrate to the water surface to feed. Their abundance was highest in the lacustrine zone (97.6 orgs./ft^2) and lowest in the riverine zone (15.9 orgs./ft^2). They were found in 97% of the sediment samples and had an average abundance of 55.5 organisms per square foot.

3. Benthic Macroinvertebrates

Thirty sediment samples were collected from Lake Claremore on August 11-12, 1993: 10 from the riverine zone, 10 from the transition zone, and 10 from the lacustrine zone. A map showing the locations of the riverine, transition, and lacustrine transects is included in Appendix H. The mean depth of the lacustrine zone was 5 meters with a mean bottom dissolved oxygen concentration of 0.6 mg/l. The mean depth of the transition zone was 3 meters with a mean bottom dissolved oxygen concentration of 4.7 mg/l. The mean depth of the riverine zone was 1 meter with a mean bottom dissolved oxygen concentration of 6.9 mg/l.

Benthic macroinvertebrates were present at all sample sites. The benthic macroinvertebrate community was diverse throughout the lake consisting of 4 Phyla, 5 Classes, 9 Families, and no less than 13 genera. The taxa and densities of the benthic organisms recovered from the lake are summarized in Appendix I. The benthic community was dominated by the tolerant tubificid oligochaetes and chironomids. However, several sensitive taxa were also present.

The most prevalent and abundant benthic macroinvertebrates were chironomids of the sub-family Tanypodinae (Class Insecta, Order Diptera) which were found in 97% of the samples and had an overall density of 71.7 organisms per square foot. Their abundance was highest in the riverine zone (near inflow) and lowest in the lacustrine zone (near dam).

The chironomids of the tribe Chironomini were also prevelant, being found in 60% of the samples; however, they were not as abundant as the Tanypodinae having an overall density of only 2 organisms per square foot. In contrast to the Tanypodinae, the Chironomini abundance was highest in the lacustrine zone and lowest in the riverine zone. Chironomids are considered tolerant according to Beck's Biotic Index (Terrell and Perfetti 1991) and Hilsenhoff's Family Biotic Index (Plafkin et al. 1989). However, according to the Hilsenhoff FBI the Chironomini are more tolerant than the Tanypodinae. Another dipteran family, the ceratopogonidae, was also identified. The ceratopogonids were present throughout the lake; however, their abundance increased with distance from the dam. Although the ceratopogonids are considered tolerant by Beck's Biotic Index and facultative by the Hilsenhoff FBI, they seem to prefer the less stressful conditions of the riverine zone.

The oligochaetes were also very abundant in Lake Claremore. Oligochaetes are classified as tolerant according to Beck's Biotic Index and Hilsenhoff's FBI, and are able to withstand low dissolved oxygen levels. Tubificid oligochaetes were found in 90% of the samples and were most abundant in the lacustrine zone. Four genera of tubificid worms (Family Tubificidae) were found in the lake (Limnodrilus, Branchiura, Aulodrilus, and Tubifex). Limnodrilus was the most abundant. Limnodrilus abundance was highest in the lacustrine zone and lowest in the riverine zone. The oligochaete Pristina (Family Naididae) was also found in the lacustrine zone. The dominance of the chironomids and oligochaetes results from the anaerobic conditions found at the sediment water interface present throughout much of the lake.

The very tolerant annelid Helobdella (Class Hirudinea, Family Glossiphoniidae) was found in three samples (one sample from each zone).

The ephemeropteran Hexagenia was the least abundant of the benthic macroinvertebrates identified, being recovered from only one sample (near shore of riverine zone). The megalopteran Sialis was found in 27% of the samples. Sialis were found in the littoral zone (near shore) throughout the lake; however, their abundance increased with distance from the dam. The ephemeropterans and megalopterans are intolerant of low dissolved oxygen. Thus, their absence from the deeper waters of the lake likely resulted from the anaerobic conditions found throughout the profundal zone of the lake.

The clam Psidium was found in three samples. The clam was generally found in the littoral areas; although, one was found in the profundal of the transition zone. The clam Psidium is considered tolerant by both Beck's Biotic Index and Hilsenhoff's FBI. However, its presence indicates that some oxygen was present at the sediment-water interface throughout the lifespan of the clam. It was most abundant in the riverine zone.

In a recent study (OCC 1995), benthic macroinvertebrate metrics were used to assess the biotic integrity of five small reservoirs in Oklahoma (Lakes Taylor, Pawhuska, Claremore, Bixhoma, Pauls Valley). Of the five, Lake Claremore scored third for benthic community integrity. The seven metrics used on Lake Claremore are discussed below. The metric *percent of samples with long lived taxa present* indicated that only 10% of Claremore's lake bottom had sufficient dissolved oxygen (and possibly no toxics) to support benthic macroinvertebrates over a long period of time (> 1 year). The average taxa richness per sample (family level) was 2.9. Thirty percent of the samples contained sensitive taxa. Forty percent of the samples contained only tubificids and/or chironomids indicating that 40% of the lake bottom will only support very tolerant organisms. Eighteen percent of the total organisms was composed of tubificids and chironominii. Only two percent of the total organisms were sensitive. As mentioned previously, all samples contained macroinvertebrates.

4. Fisheries

a. Past and Present Activities and Suitability of the Lake

The primary recreational use of Lake Claremore is sport fishing. The Oklahoma Department of Wildlife Conservation (ODWC) is responsible for monitoring and managing the fishery. Surveys are conducted on regular intervals. Collection methods include both spring and fall electrofishing and fall gillnetting. Seventeen species (Table 9) were collected in 1993, which compares favorably to other municipal reservoirs in the area of similar size that were sampled using similar gear type and collection methods. Eleven species are considered moderately tolerant, four species are tolerant, and two species are moderately intolerant (Jester et al. 1992). Thirty-five percent of the species (6) collected are piscivorous, thirty-five percent (6) are omnivorous and twenty-nine percent (5) are invertivores/insectivores. A total of 2,497 individuals were collected.

Largemouth Bass (Micropterus Salmoides)
Surveys conducted during the mid-1980's indicated that a large percentage of the population was smaller than the 14" minimum. As a result, a 13-16" slot limit was imposed in 1987. Since that time ODWC has allowed and encouraged the utilization of those smaller fish which has allowed more fish to reach larger sizes. Results of the 1993 survey are encouraging, as the population structure has shifted as desired. Pending the results of the 1995 survey, a 14" minimum may be reintroduced. Reproduction, recruitment, and growth rates are also good (Ambler 1995).

Table 9. Fish collected from Lake Claremore on October 20, 1993.

Species	Number	Tolerance
White Bass	57	Mod. Tolerant
Large Mouth Bass	93	Mod. Tolerant
Black Crappie	6	Mod. Tolerant
Bluegill Sunfish	336	Mod. Tolerant
Longear Sunfish	35	Mod. Tolerant
Redear Sunfish	34	Mod. Tolerant
Channel Catfish	56	Mod. Tolerant
Flathead Catfish	1	Mod. Tolerant
Gizzard Shad	1,745	Mod. Tolerant
Drum	26	Mod. Tolerant
Blackspotted top Minnow	1	Mod. Tolerant
White Crappie	22	Tolerant
Green Sunfish	10	Tolerant
Carp	35	Tolerant
Golden Shiner	1	Tolerant
Spotted Bass	33	Mod. Intolerant
Spotted Sucker	6	Mod. Intolerant

Crappie (Pomoxis Annularis/Nigromaculatus)
Surveys conducted during the mid and late-1980's indicated that the number of spawning adults was low. This was likely due to over harvest. A 10" minimum length limit was imposed in 1992. Surveys conducted in 1993 indicated a slight restructuring of the population. Both reproduction and recruitment are believed to be good as several strong year classes were evident (Ambler 1995). All indications suggest this fishery is improving.

Channel Catfish (Ictalurus Punctatus)
Reproduction, recruitment, and growth rates are good (Ambler 1995). Recent stockings include 9,042 in 1986 and 9,000 in 1987. Pending results of the 1995 survey, the creel limit may be reduced from 15 to 6 as this is an intensely utilized fishery.

White Bass (Morone Chrysops)
The white bass fishery is very dynamic and somewhat limited by the small size of the reservoir. Reproduction and recruitment range from very good to poor and is largely dependent upon flow (Ambler 1995). As a result, year class strength is hit and miss. By all indications this is not a high priority fishery, and therefore is not intensely managed.

Flathead Catfish (Pylodictis Olivaris)
The role of the flathead catfish as top predator in Lake Claremore is vital. It is the only piscivorous species capable of reaching sufficient size to consume the large gizzard shad.

Without predation to keep them in check, the bulk of the shad population would quickly become too large to be consumed by other top predators. Data from the most recent surveys suggest that their abundance is decreasing due to intense fishing pressure. Reproduction is poor, due to insufficient numbers of broodstock. Recruitment, however, is considered fair to good. Growth rates appear to be good (Ambler 1995). Recent stockings of flathead catfish include 4,410 in 1988 and 2,786 in 1989. If flathead catfish numbers do not improve, regulations restricting the use of trot lines, limb lines, jug lines, and yo yos may result.

Gizzard Shad (Dorosoma Cepedianum)
Its role as one of the primary forage fish in Lake Claremore is vital. Gizzard shad make up a large percentage of the diet of all the piscivorous species. As a result, biologists are monitoring its population closely. Reported catch per unit effort (CPUE) based on 1993 full electrofishing data was 865.9 with 1,472 individuals collected per 1.7 units effort. This is up substantially from the spring electrofishing of 1990 when CPUE was 140 with 175 individuals collected per 1.2 units effort. Reproduction is believed to be good. However, recruitment is considered poor to fair. Condition appears to be good (Ambler 1995). The structure of the population is a concern as approximately 25% of those collected were greater than 7.0" in length. This size is the upper limit of what is consumable by the average size adult bass. The bulk of this percentage of the shad population is utilized only by the larger flathead catfish.

Bluegill Sunfish (Lepomis Macrochirus)
Bluegill sunfish is the other primary forage fish of this fishery. It too makes up a large percentage of the diet of all piscivorous species. Unlike the shad, however, bluegills are actively pursued by anglers making their management even more challenging. Currently, the bluegill fishery is offering nearly trophy level status. Approximately 30% of those collected during the 1993 fall electrofishing survey were greater than 150 mm (quality length). The CPUE of 197.6 (336 individuals/1.7 effort) is up substantially from the spring electrofishing survey of 1990 when CPUE was 121.6 (152 individuals/1.25 effort). Both reproduction and recruitment are believed to be good. Condition appears to be good.

Redear Sunfish (Lepomis Microlophus)
This species makes up a principal part of the secondary forage base. Like the bluegill sunfish, it is heavilly utilized by anglers. The CPUE for the fall 1993 electrofishing survey was 20 (34 individuals/1.7 effort). This is down slightly from the spring electrofishing survey of 1990, when CPUE was 22.4 (28 individuals/1.25 effort). The structure of the population is a concern, as the proportion stock density (P.S.D.) was 0 with all those collected being less than stock length. Both reproduction and recruitment are believed to be good (Ambler 1995).

b. Wholesomeness of Fish Tissue

Zinc, iron, copper, cadmium, chromium, lead, arsenic, selenium, and mercury were measured in bass, drum, crappie, channel catfish, gizzard shad, and mussell. Lead and arsenic were the only metals detected. No numeric criteria for lead and arsenic in fish flesh are included in the OWQS or FDA Action Levels list.

Organochlorine pesticides and total PCBs were also measured in fish flesh (Table 10). DDD, methoxychlor, and PCBs were not detected in the fish flesh. Aldrin, DDT, dieldrin, endrin, heptachlor, and toxaphene did not exceed Oklahoma's alert or concern levels.

Table 10. Organochlorine pesticides measured in fish flesh collected from Lake Claremore in 1993 (ND=not detected).

Parameter (ug/kg)	Bass	Drum	Crappie	Channel Catfish	Gizzard Shad
Aldrin	ND	ND	23.4	ND	23.1
Alachlor	ND	47.9	ND	ND	93.5
Chlordane	170	ND	ND	ND	191
DDD	ND	ND	ND	ND	ND
DDE	20.1	ND	20.6	ND	38.4
DDT	ND	ND	ND	ND	47.4
Dieldrin	ND	ND	ND	ND	21.8
Endrin	ND	ND	ND	30.4	ND
Gamma BHC	39.3	79.3	ND	ND	29.9
Heptachlor	ND	47.2	28.8	ND	51.2
Heptachlor epoxide	ND	ND	21.5	ND	ND
Methoxychlor	ND	ND	ND	ND	ND
Toxaphene	78.6	207	122	199	ND
Total PCBs	ND	ND	ND	ND	ND

Chlordane concentrations in fish flesh collected from Lake Claremore exceeded the concern level of 0.15 mg/kg (OWRB 1995). A chlordane concentration of 0.170 mg/kg was detected in bass flesh, while a concentration of 0.191 mg/kg was detected in gizzard shad flesh collected October 20, 1993. However, chlordane does not exceed OWQS alert levels or FDA levels. In large reservoirs, elevated levels of chlordane are frequently found in fish tissue. While this is a continuing concern, a downward trend in these chlordane levels has been observed since its use has been banned. Exceedence of the concern level indicates the need for further study.

Alachlor, DDD, gamma BHC, and heptachlor epoxide fish flesh criteria are not addressed in the OWQS. Heptachlor-epoxide and DDE levels did not exceed the United States legal limits for organic priority pollutants and pesticides in fish. Gamma BHC (Lindane) also does not exceed legal limits (Nauen 1983). Therefore, DDD, gamma BHC, and heptachlor are not a threat to human health. No numeric criteria were found for alachlor.

G. Sanitary Quality of Lake and Tributaries

Appendix J presents bacteriological data for Lake Claremore during the summer of 1993. At no time during the study did the fecal coliform bacteria exceed the raw water criteria for public and private water supplies. To protect the use of *primary body contact,* the OWQS state that from May 1 to September 30, the monthly geometric mean of five samples over a 30 day period should not exceed 200/100ml and no more than 10% of the samples collected in a 30 day period should exceed 400/100ml (OWRB 1995). Unless the 10% of samples is interpreted to consist of less than 5 individual samples, a water quality standard violation could not be shown due to the insufficient number of samples collected. If it is interpreted in this way then the samples from Little Dog Creek, Dog Creek, and the mid-point site of Lake Claremore were in violation of the water quality standards on May 19, 1993, following a runoff event. The site in the upper end of the lake was also in violation on September 15, 1993, shortly after a runoff event. Because swimming is not allowed in the lake, the chances of body contact with elevated levels of bacteria are greatly reduced. It should be noted that both of the possible violations corresponded to runoff events and therefore may not be representative of typical conditions. However, because fecal coliforms are often associated with BOD and nutrients, and may indicate their transport to the lake, the source of the bacteria should be identified and remediated.

H. Problems Identified in Lake Claremore

Problems identified in Lake Claremore include excessive siltation, hypereutrophication, and elevated levels of toxic substances, which have impacted the lake's biotic community.

Siltation

According to city officials, siltation, which is a major concern of the citizens of Claremore, has substantially reduced the depth and storage capacity of the lake. Further study is needed to determine the extent of the siltation.

Eutrophication

Elevated total phosphorous concentrations have resulted in chlorophyll concentrations indicative of hypereutrophic conditions. Between 1987-94, chlorophyll concentrations did not change significantly. The surface chlorophyll concentrations have significantly affected secchi depth at the dam. In addition, high productivity has contributed to hypolimnetic D.O. depletion. During thermal stratification, hypolimnetic D.O. was depleted to the extent that by late summer one-fourth of the lake volume could not be inhabited by fish (D.O. < 2 mg/l).

Hypolimnetic mercury concentrations exceeded the numeric criteria to protect human health for consumption of fish flesh and water (2 out of 11 samples), and the chronic numeric criteria for the protection of fish and wildlife (1 out of 11 samples). Arsenic in the water column also exceeded the criteria to protect human health for the consumption of both fish flesh and water (11 out of 11 samples). There may be some cause for concern if these samples represent a long-term trend in the lake and its watershed. Further study is needed to fully evaluate the implications of this data set. Therefore, it is recommended that the City of Claremore sample the lake for metals regularly. It should be noted that finished public drinking water supplied from Lake Claremore, which is routinely tested by the Oklahoma Department of Environmental Quality (DEQ), has not exceeded any water quality standards for toxics. In addition, the water criteria related to consumption of fish and water have been determined by EPA to be technically and economically unfeasible to achieve at this time. There are a number of active and abandoned coal strip mines in the Lake Claremore watershed. Because of the absence of point source dischargers, these mines represent the most likely source of the metals detected in the water and sediment. In addition to the metals, chlordane in fish tissue (bass and shad) exceeded the concern level, which warrants further investigation. Chlordane and total PCBs in the sediments also exceeded EPA Sediment Screening Values.

Biotic integrity

Bacteria levels exceeded the criteria to protect primary body contact at the mid-point and upper end sites following runoff events. The lake was dominated by algae typically found in nutrient enriched lakes. The benthic macroinvertebrate community was dominated by low D.O. tolerant tubificid oligochaetes and chironomids, because of the anaerobic conditions present at the sediment/water interface present throughout much of the lake. Small zooplankton were dominant possibly indicating that insufficient numbers of predator fish were present to suppress the planktivorous fish density. This was confirmed by the fish survey results which found that planktivorous fish dominated the fish community.

I. Characteristics of Lake Tributaries

Field, nutrient, and inorganic data for each stream are included in Appendix K.

1. Base Flow Quality Chemical Characteristics

Base flow concentrations of parameters measured in Little Dog Creek and Dog Creek are listed in Table 11. Base flow in Little Dog Creek is generally less than 1 cfs, while base flow in Dog Creek is generally between 2 and 4 cfs. Dissolved oxygen criteria for warm water aquatic communities was violated numerous times during the summer of 1993 in the streams. In Little Dog Creek near Sequoyah, the dissolved oxygen criteria (5.0 mg/l) was violated on July 28 and August 17, 1993. In Dog Creek near Sequoyah, the dissolved oxygen criteria was exceeded on June 15, July 12, July 28, and August 31, 1993. In Dog Creek near Claremore, the dissolved oxygen criteria was violated on June 2, June 15, July 12, and July 28, 1993. Percent saturation (D.O.) averaged 78% in Little Dog Creek and 70% in Dog Creek. In August, both Little Dog and Dog Creeks near Sequoyah experienced their most severe D.O. depletions when percent saturation values of 12% and 29%, respectively, were observed.

Total dissolved solid (TDS) concentrations were within all recommended limits for drinking water supplies and agricultural use. Conductivity and TDS concentrations in the streams were comparable to those found in other waterbodies in northeast Oklahoma. Chloride, sulfate, and flouride concentrations in the streams were also within recommended limits for drinking water and agricultural use.

The pH of all stream samples were compliant with the OWQS. However, alkalinity was low to moderate; therefore, the water has moderate buffering capacity at best. The hardness of the stream water was classified as soft to moderately hard. Soft water has a lower capacity to mitigate metal toxicity than harder waters. Hardness was primarily controlled by calcium.

The OWQS numerical criteria for turbidity (50 NTU) was exceeded only once (in Dog Creek near Sequoyah on August 31, 1993). Turbidity was 25 NTU or less in 86% of Little Dog Creek samples, 79% of Dog Creek near Sequoyah samples, and 50% of Dog Creek near Claremore samples. In addition, TSS concentrations were relatively high in the streams.

Total nitrogen concentrations in the stream base flow samples were relatively low. Total nitrogen concentrations were significantly lower in Little Dog Creek than in Dog Creek. Mean total phosphorous (TP) concentrations averaged 0.06 mg/l in the tributaries. The EPA suggests that TP concentrations not exceed 0.05 mg/l in any stream at the point where it enters a reservoir, and should not exceed 0.10 mg/l in streams not discharging directly into a lake (EPA 1986). Dog Creek exceeds this suggested criteria.

Table 11. Means and ranges of parameters measured in the tributaries (Little Dog Creek and Dog Creek near Sequoyah) and outflow (Dog Creek near Claremore) of Lake Claremore, April 1993 to March 1994.

Parameter	Little Dog Creek nr Sequoyah		Dog Creek nr Sequoyah		Dog Creek @ Claremore	
	Mean	Range	Mean	Range	Mean	Range
D.O. (mg/l)	8.1	1-12.5	7.3	2.5-11.9	6.6	3.5-10.6
% Sat. (DO)	78%	12-104%	70%	29-103%	70%	44-104%
Cond. (uS/cm)	239	139-333	207	145-366	194	92-310
pH	7.4	6.7-8	7.4	6.8-8.4	7.5	7-7.8
Alk. (mg/l)	46	6-111	59	36-131	53	26-105
Turb. (NTU)	12	4.3-29	23	1-51	26	14-46
Hard. (mg/l)	82	46-110	76	55-120	70	32-120
Cl (mg/l)	7.2	2.7-12	7	2.4-11	4.1	1.8-6.9
TDS (mg/l)	171	128-214	163	120-254	148	118-184
TSS (mg/l)	11	ND-25	30	4.3-133	25	8-52
SO_4 (mg/l)	50	10-82	26	9.2-67.4	28	12-34
TP (mg/l)	0.06	ND-0.25	0.06	ND-0.11	0.05	0.02-0.11
TN (mg/l)	0.2	ND-0.5	0.5	ND-1.4	0.6	0.4-1
F (mg/l)	0.2	ND-0.3	0.2	ND-0.3	0.1	ND-0.3
Ca (mg/l)	18	2-28	19	13-31	18	8-33
Mg (mg/l)	7.8	4.4-10	6.9	5.4-9.9	6.3	2.8-10

2. Runoff Quality Chemical Characteristics

Runoff concentrations of parameters measured in Little Dog Creek and Dog Creek are listed in Table 12. On September 13, 1993, TDS and TSS concentrations in Little Dog Creek runoff were extremely high (5220 and 3340 mg/l, respectively). The TDS concentration (5220 mg/l) greatly exceeded the sample standard statistical mean of the historic data (403 mg/l) for its waterbody segment (121500) and the criteria for the beneficial use of Agriculture: livestock and irrigation stated in 785:45-5-13(d) of the OWQS (OWRB 1995). This may have resulted from a discharge from a strip pit or an anthropogenic disturbance. All runoff samples from Dog Creek contained TDS concentrations which were compliant with the OWQS.

Nutrient concentrations in runoff samples from Dog and Little Dog Creeks were relatively high. Nutrient concentrations in Dog Creek runoff samples were at levels which are known to cause eutrophication in lakes. The total phosphorous concentrations in runoff from Little Dog Creek were substantially higher than total phosphorous concentrations in Dog Creek runoff.

Table 12. Parameters measured in storm water samples from Dog and Little Dog Creeks near Sequoyah, 1993-94 (ND=not detected).

Parameter	Little Dog Creek near Sequoyah		Dog Creek near Sequoyah	
	Mean	Range	Mean	Range
TDS (mg/l)	1835	114-5220	135	126-143
TSS (mg/l)	1172	21-3340	113	62-155
TP (mg/l)	0.21	0.07-0.33	0.14	0.05-0.24
TN (mg/l)	2.0	0.6-3.7	2.0	0.4-3.3
Cl (mg/l)	6.4	4-9	9.4	5-12
SO_4 (mg/l)	24	ND-55	26	10-46
Hard (mg/l)	63	50-75	78	62-88
Ca (mg/l)	14.3	12-16.5	16.5	15.2-18.3
Mg (mg/l)	7.3	7.2-7.4	7.1	6.2-7.9
Na (mg/l)	7.8	4.6-10.6	9.9	8.2-12.6
K (mg/l)	4.5	2.1-5.9	3.7	1.7-5

Chloride and sulfate concentrations in runoff samples were within recommended limits for drinking water and agricultural use. The hardness of runoff samples from Little Dog and Dog Creeks ranged from soft to moderately hard. Hardness in the tributaries was primarily controlled by calcium concentrations. Sodium and potassium concentrations in runoff samples were well below levels which are detrimental to human health or crops.

3. Toxics in Tributaries

Pesticides and metals were measured in runoff samples from Dog Creek on November 17, 1993, January 27, 1994, and February 22, 1994 and from Little Dog Creek on September 13, 1993, January 27, 1994, and February 22, 1994 . No pesticides were detected. Metal levels (Table 13) found in Dog and Little Dog Creek (Appendix D) were evaluated using the 1995 Oklahoma Water Quality Standards (OWRB 1995). Cadmium was not detected in Dog or Little Dog Creek. Mercury, barium, nickel, and chromium concentrations in Dog and Little Dog Creek did not exceed any of the criteria listed in the OWQS. Arsenic concentrations in Dog Creek (36 ug/l on 1/27/94 and 67 ug/l on 4/22/94) and Little Dog Creek (22 ug/l on 1/27/94) exceeded the water column criteria (0.175 ug/l) to protect human health for the consumption of fish flesh and water. The lead concentration in Little Dog Creek (35 ug/l) on September 13, 1993 exceeded the water column criteria to protect human health for the consumption of fish flesh and water (5.0 ug/l) and the chronic numerical criteria (2.1 ug/l) for toxic substances for protection of fish and wildlife. Zinc concentrations in Little Dog Creek on September 13, 1993 (210 ug/l) and February 22, 1994 (150 ug/l) exceeded acute and chronic numerical criteria for toxic substances for protection of fish and wildlife.

Table 13. Metals measured in storm water samples from Dog and Little Dog Creeks near Sequoyah collected between September 1993 and March 1994 (ND=not detected).

Parameter	Little Dog Creek near Sequoyah		Dog Creek near Sequoyah	
	Mean	Range	Mean	Range
Fe (mg/l)	24.6	2.3-51	6.8	2.5-12.4
Mn (ug/l)	1563	80-3700	320	160-400
Zn (ug/l)	120	ND-210	50	ND-80
Cu (ug/l)	11	ND-33	ND	ND
Cd (ug/l)	ND	ND	ND	ND
Cr (ug/l)	22	ND-44	5	ND-15
Ni (ug/l)	37	ND-110	ND	ND
Pb (ug/l)	12	ND-35	ND	ND
As (ug/l)	8	ND-22	34	ND-67
Se (ug/l)	12	ND-35	8	ND-23
Hg (ug/l)	ND	ND-0.1	ND	ND
Ba (ug/l)	270	ND-600	93	ND-150

The copper concentration (33 ug/l) in Little Dog Creek on September 13, 1993 exceeded the acute (9.7 ug/l) and chronic (14.1 ug/l) numerical criteria for toxic substances for protection of fish and wildlife. Selenium concentrations in Dog Creek (0.023 mg/l) and Little Dog Creek (0.035 mg/l) on February 22, 1994 exceeded the raw water numerical criteria for public and private water supplies (0.010 mg/l), as well as the acute (0.020 mg/l) and chronic (0.005 mg/l) numerical criteria for toxic substances for protection of fish and wildlife.

Because metals were measured in runoff only, it is impossible to determine if chronic exposure occurs. Regardless, acutely toxic levels of copper, zinc, and selenium is a concern. Further study is needed to determine the sources and actual impacts of the metals levels which exceeded the OWQS acute and/or chronic criteria for toxic substances for the protection of fish and wildlife propagation. Additional sampling for metals is definitely needed. This would aid in determining if chronic exposure occurs and if the elevated metal levels occur only in runoff.

In addition, the National Primary Drinking Water Standard [see 40 CFR § 141.11(b) and OAC 252:630-1-3(a)] for selenium was recently changed from 0.01 mg/l to 0.05 mg/l, which is well above the levels found in the samples. Although the two referenced samples would technically constitute OWQS violations, it is believed that in this specific case, the National Primary Drinking Water Standard may be a more appropriate number to use to evaluate the potential impact of selenium on drinking water supplies.

4. Problems Identified in Tributaries

Problems identified in the tributaries include dissolved oxygen depletion, excessive sediment and nutrient loading, and elevated levels of heavy metals.

Dissolved Oxygen

Dissolved oxygen criteria for warm water aquatic communities were violated numerous times during the summer of 1993 in the streams.

Sediment

The numerical criteria for turbidity was violated only once (Dog Creek near Sequoyah). TSS concentrations were relatively high in the streams indicating possible anthropogenic disturbance. On September 13, 1993, the TSS concentration in the Little Dog Creek runoff sample was extremely high, indicating a potential anthropogenic disturbance in its watershed or possibly intense beaver activity in the stream.

Nutrients

Mean base flow total phosphorous (TP) concentrations averaged 0.06 mg/l in the tributaries. The EPA suggests that TP concentrations not exceed 0.05 mg/l in any stream at the point where it enters a reservoir, and should not exceed 0.10 mg/l in streams not discharging directly into a lake (EPA 1986). Dog Creek exceeds this suggested criteria. Nutrient concentrations in runoff samples from Dog and Little Dog Creeks were relatively high. Nutrient concentrations in Dog Creek runoff samples were at levels which are known to cause eutrophication in lakes. The TP concentrations in runoff from Little Dog Creek were substantially higher than TP concentrations in Dog Creek runoff. Nonpoint sources, such as septic systems and livestock manure, are most likely the source of the elevated nutrients, due to the absence of point sources and cropland in the watershed.

Toxic Substances

Arsenic concentrations in Dog Creek and Little Dog Creek exceeded the water column criteria to protect human health for the consumption of fish flesh and water (in 4 of 6 samples). Selenium concentrations in Dog Creek and Little Dog Creek exceeded the raw water numerical criteria for public and private water supplies as well as the acute and chronic numerical criteria for toxic substances for protection of fish and wildlife (in 2 of 6 samples). Lead concentrations in Little Dog Creek exceeded the water column criteria to protect human health for the consumption of fish flesh and water (in 1 of 3 samples) and the chronic numerical criteria for toxic substances for protection of fish and wildlife (in 1 of 3 samples). Zinc (in 2 of 3 samples) and copper (in 1 of 3 samples) concentrations in Little Dog Creek exceeded the acute and chronic numerical criteria for toxic substances for protection of fish and wildlife.

Elevated lead, zinc, and copper concentrations were found in Little Dog Creek on September 13, 1993. In addition, extremely high levels of TSS and TDS were found in Little Dog Creek on September 13, 1993. The TDS concentration (5220 mg/l) in Little Dog Creek on September 13, 1993 greatly exceeded the sample standard statistical mean of the historic data (403 mg/l) for its waterbody segment (121500). The TDS also exceeded the criteria to protect the beneficial use of Agriculture: livestock and irrigation. Due to the absence of point sources, it is likely that the elevated metals, TSS, and TDS resulted from discharges from strip pits and/or other runoff from the strip mines. More study is needed to further investigate the sources and possible impacts of these metals.

J. Phosphorous Load and Lake Response

The average total phosphorous concentration (P_1) observed in the streams was 0.08 mg/l. The total annual phosphorous load to the lake is approximately 3000 kg/yr. Phosphorous loading from Lake Oologah water was not used in the calculation of the total annual phosphorous load to Lake Claremore, because Lake Oologah water was not used during the study. However, water from Lake Oologah could potentially provide substantial amounts of phosphorous during years when Lake Oologah water input is significant. The mean hydraulic residence time (T) is approximately 0.24 years in Lake Claremore. The following model was used to predict the lake phosphorous (P) concentration (EPA 1990):

$$P \text{ (ppb)} = P_1/(1+T^{0.5})$$

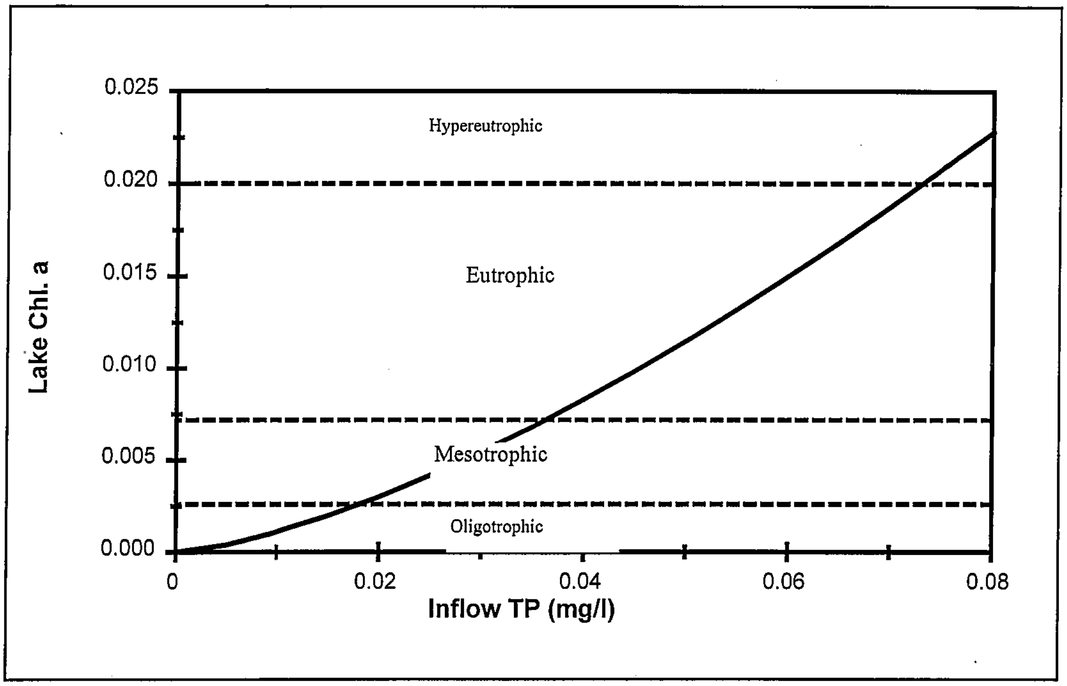
This model predicts that the lake phosphorous concentration will be 0.054 mg/l. This estimate is nearly identical to the observed average lake phosphorous concentration of 0.057 mg/l. The following model was used to predict the chlorophyll *a* response to the predicted in lake phosphorous concentration (EPA 1990):

$$\text{Chl. } a \text{ (ppb)} = 0.068\, P^{1.46}$$

This model predicts that the lake chlorophyll *a* concentration will be 0.023 mg/l. This estimate is nearly identical to the observed lake average chlorophyll *a* concentration of 0.022 mg/l. These phosphorous and chlorophyll *a* concentrations indicate that the lake is currently hypereutrophic (see following section).

As the lake response model indicates (Figure 8), average stream phosphorous concentrations would have to be reduced to 0.07 mg/l to achieve a trophic state of eutrophic, 0.03 mg/l to achieve a trophic state of mesotrophic, and 0.01 mg/l to achieve a trophic state of oligotrophic.

Figure 8. Lake chlorophyll response to varying instream phosphorous concentrations.



K. Current Trophic State

Carlson's (1977) trophic state indices (TSI) were used to assign a trophic state classification. The following scale was used to assign trophic state:

Carlson TSI	Trophic State
0-39	Oligotrophic
40-49	Mesotrophic
50-59	Eutrophic
>60	Hypereutrophic

TSI values, which were calculated from observed and estimated chlorophyll *a* concentrations, secchi depths, and total phosphorous concentrations are as follows:

	TSI	Trophic State
chlorophyll *a*	61	Hypereutrophic
est. chlorophyll *a*	61	Hypereutrophic
secchi	70	Hypereutrophic
observed TP	62	Hypereutrophic
estimated TP	62	Hypereutrophic

Obviously, Lake Claremore is hypereutrophic. The TSI values for observed and estimated chlorophyll *a* and total phosphorous agreed very well. Mineral turbidity's influence on Secchi depth resulted in the higher TSI-Secchi.

L. Conclusion

Problems identified in Lake Claremore include siltation, hypereutrophication, and elevated levels of toxic substances which have impacted the biotic integrity of the lake. These problems result from excessive sediment, nutrient, and metal loading from the tributaries. According to city officials, excessive sediment loading has substantially reduced the depth of the lake. Excessive phosphorous loading has resulted in chlorophyll concentrations indicative of hypereutrophic conditions. High productivity has contributed to hypolimnetic dissolved oxygen (D.O.) depletion. The OWQS state that lake D.O. concentrations should not fall below 5 mg/l. During thermal stratification, hypolimnetic D.O. was depleted to the extent that by late summer D.O. in one-fourth of the lake volume was less than 2 mg/l. The lake response model indicated that average stream phosphorous concentrations would have to be reduced to 0.07 mg/l to achieve a trophic state of eutrophic, 0.03 mg/l to achieve a trophic state of mesotrophic, and 0.01 mg/l to achieve a trophic state of oligotrophic. The likely sources of the elevated phosphorous levels are from leaking or improperly functioning septic systems or manure from livestock on hobby farms (urban ranchettes). However, this should be confirmed. The presence of bacteria levels, which exceeded the criteria to protect primary body contact following two runoff events, may also indicate the possibility of improperly treated sewage or animal waste.

Another concern is the presence of toxic substances. Arsenic (in water), mercury (in water), chlordane (in fish and sediment), and total PCBs (in sediment) were present at noticeable levels in the lake. Water from Dog Creek contained notable levels of arsenic and selenium, while Little Dog Creek contained significant levels of arsenic, selenium, lead, zinc, and copper. The source of these metals is likely runoff and seepage from the coal mines; however, this should be confirmed. Further study is needed to assess the sources and affects of the metals.

The combination nutrient enrichment and an imbalance in the fish community is reflected by the biological community. The lake was dominated by algae typical of nutrient enriched lakes. The benthic macroinvertebrate community was dominated by low D.O. tolerant tubificid oligochaetes and chironomids, because of the anaerobic conditions present at the sediment/ water interface throughout much of the lake. Small zooplankton were dominant indicating that insufficient numbers of predator fish may be present to suppress the planktivorous fish density. This was confirmed by the fish survey results which found that planktivorous fish dominated the fish community.

Like most reservoirs, Lake Claremore is not without problems. However, with continued monitoring and management, the reservoir's needs can be met, allowing it to continue to meet the needs of the public for generations to come.

II.1 Lake Restoration and Maintenance Goals

Based on the data presented and discussed in the previous report sections, there appear to be four major goals that should be addressed in order to best protect and maintain good water quality at Lake Claremore.

1) Reduce siltation.
2) Reduce phosphorous and nitrogen loading.
3) Reduce biologically available phosphorous in the lake.
4) Reduce metal concentrations to levels protective of human health and the environment.

II.2 Lake Restoration and/or Pollution Control Alternatives

A. No Action

On a short term basis this alternative would be the least expensive. Continued siltation would result in the continued loss of aquatic habitat as well as loss of valuable storage capacity. The trophic state of Lake Claremore would remain hypereutrophic or advance even further over time, as more nutrients enter the lake. Algae blooms would become more frequent. Eventually, phytoplankton levels would severely jeopardize the water supply, as well as the aesthetic quality of the lake for fisherman and other recreational interests. Large populations of algae which cause taste and odor problems could develop which would foul the water supply making the water nearly undrinkable as well as difficult and costly to treat. Development of large populations of filter clogging algae could also increase water treatment costs substantially.

Increasing eutrophication would result in the decreased use of the lake as a quality fishery in years to come. Heavy algae blooms concurrent with heavy cloud cover and little wind during the summer would result in massive fish kills. Potential for massive fish kills currently exists and increased eutrophication increases the potential. Restocking of game fish would prolong the collapse of fish communities; however, population fitness (fecundity, longevity) would certainly be diminished. Eventually, restocking costs and fisherman dissatisfaction would be high enough to consider some type of restoration. By this time, the problem would be more severe and difficult to fix, cost share funding will probably not be available, and contractual costs would increase with inflation. In the long term, this would be the most expensive alternative.

B. Algae Control (Herbicides)

Algae control with copper sulfate ($CuSO_4$) is a common practice, especially in the control of odor and taste algae. However, $CuSO_4$ is an expensive treatment with only temporary benefits. Effective control could only be achieved with frequent applications. In addition, resistant algal strains have been shown to develop with long term use at several water supply reservoirs. The disadvantages of $CuSO_4$ use would not justify its use in Lake Claremore.

C. Algae Control (Food Web Manipulation)

Another form of algal control would be biological manipulation by means of fish population control. This could be achieved by regulating the ratio of predator to prey species. By increasing predation pressure on selected zooplankton grazers (gizzard shad, blue-gill, shiners, etc.), it is possible to increase grazing pressure on phytoplankton. Although this would not have a significant impact on nutrient levels, it could certainly decrease turbidity attributable to algal production. This could be accomplished by stocking of adult flathead catfish and/or saugeyes to eat the large gizzard shad. The importance of flathead catfish to the overall health of the fishery has already been established. Recent data suggest that flathead catfish abundance is declining due to over harvest. As a result, regulations should be implemented restricting the use of trot lines, jug lines, limb lines, and yo yos. Periodic restocking of adult flatheads should continue to supplement weak or missing year classes. This alternative would not be expensive but would require some long term cooperation on the part of the ODWC.

D. Dredging

Dredging has been demonstrated as an effective method to improve the quality of fisheries and recreational values in eutrophic lakes (Randtke and DeNoyelles 1985; Cooke et al. 1986). With Lake Claremore, dredging would facilitate the removal of accumulated nutrients, sediments, and metals. In addition, storage capacity would be increased. Selected sites could also be deepened to enhance fish habitat. However, before dredging, it is important to initiate improved land management practices or risk jeopardizing the long term effectiveness of sediment removal.

Problems associated with dredging are numerous. The cost of this alternative can range from $1.00 to $10.00 per cubic meter of sediment removed. This would probably cost in excess of $1,000,000.00 for Lake Claremore in order to effectively remove sediment over a 300 acre area, 1 meter deep. Because the sediments are polluted with heavy metals, disposal costs would significantly increase the cost of this option.

Dredging activities could potentially release excessive amounts of toxic metals and nutrients into the water, fouling the water supply, and killing fish. Thus an alternative water supply must be developed prior to initiating dredging activities.

An important concern would be distress placed on aquatic populations from benthic macroinvertebrates to game fish. Loss of year classes of catfish and bass as a result of resuspension of sediments would severely impact the long term health of the fishery. It would be very detrimental to the biota of the lake to initiate this alternative during times of hard stratification. Care should be taken to administer the timing and scope of the dredging operation with consultation from ODWC fisheries biologists.

Lastly, a plan for the disposal of dredge material must be developed. Due to the high concentrations of metals found in the sediments, it is imperative that the sediments are properly disposed of. Land application may not be a viable alternative. Improper disposal or storage can result in the discharge of metal or nutrient rich runoff water to the lake or watershed which could result in algal blooms, dissolved oxygen depletion of receiving waters, and toxicity. It is not recommended that this method be used.

E. Sediment Covering/Phosphorous Inactivation

If dredging is considered too expensive, phosphorous inactivation has been found to be an effective method for reducing algal biomass. Aluminum sulfate or alum, can effectively bind inorganic phosphorous in the water column, precipitate it to the bottom of the lake, and prevent internal release of phosphorous from nutrient rich sediment. This could result in the limitation of algal growth by sharply depleting this nutrient. This method is generally effective in reducing algal biomass only in lakes which receive low external phosphorous loads and have high levels of internal phosphorous release from nutrient rich sediments. However, nutrient loading from the sediment was not significant compared to the inflow. Costs involved with an application of alum sufficient to produce long term phosphorous inactivation (~6 years) would be approximately $82,250, assuming the entire area under the hypolimnion (235 acres) was treated at a cost of $350 per acre.

The EPA suggests that impoundments are poor candidates for this type of phosphorous removal because of their inherent inability to limit nutrient income (EPA 1990). Therefore, should this method be utilized, it would be of the utmost importance that land practices which limit nutrient loading be successfully implemented before this treatment is initiated.

Negative impacts caused by alum application include direct toxicity to fish, pH changes, smothering of the benthic community, and higher sulfide production in the hypolimnion. When alum is introduced into the aquatic system, the buffering capacity (alkalinity) of the water is compromised. In soft water lakes this could cause exhaustion of this capacity, sending the pH below 6 which would result in the release of $Al(OH)_2$ and dissolved elemental Al^{+++}, as well as other toxic metals. These can be toxic to lake species. Well buffered, hard water lakes are good candidates. Because the buffering capacity in Lake Claremore is moderate at best, sediment recirculation of phosphorous is insignificant compared to inflow levels, and the low residence time of the lake, this would not provide a viable alternative. Therefore, it is not recommended that this method be used.

F. Fish Stocking, Regulation, etc.

As previously stated, it is believed the 10" minimum length limit imposed on crappie is helping to improve that fishery. This effort could be enhanced by supplemental stocking of threadfin shad (*Dorosoma petenese*). This species does not attain the extreme size of the gizzard shad, and is therefore more suitable prey for crappie. Threadfin shad, however, are fairly intolerant of cold temperatures. Therefore, periodic restocking may be necessary.

The importance of flathead catfish to the overall health of this fishery has already been established. Recent data suggest that flathead catfish abundance is on the decline. Officials believe this is due to over harvest. As a result, regulations should be implemented restricting the use of trot lines, jug lines, limb lines, and yo yos. Periodic restocking of adult flathead catfish should continue to supplement weak or missing year classes.

As this reservoir has aged, vital habitat has been lost due primarily to siltation and deterioration. The ODWC has attempted to counter this natural process by constructing fish attractors (brush piles). This activity should continue on a larger scale. Lake associations and local bass clubs should be involved.

G. Artificial circulation

Artificial circulation eliminates thermal stratification or prevents its formation, through the injection of compressed air into lake water from a pipe or ceramic diffuser at the lake's bottom. The rising column of bubbles, if sufficiently powered, produce lakewide mixing at a rate that eliminates temperature differences between top and bottom waters. However, results have varied greatly from case to case. When properly used, algal blooms have been reduced and problems with iron and manganese have been eliminated. Project failure may be caused by lake chemistry or inadequate equipment. To adequately mix a lake, an air flow of approximately 1.3 cubic feet per minute per acre of lake surface area is required. The system should be designed by a professional who is experienced in artificial circulation. Installation costs are relatively low and are primarily for the compressor and installation of pipes and diffusers (EPA 1990).

H. Implementation of best management practices (BMP)

Land use in the Dog and Little Dog Creek watersheds was dominated by pasture (46%), forest (30%), and urban ranchettes (14%). Best management practices should be implemented throughout the watershed to reduce sediment and nutrient runoff from these land uses.
Best management practices recommended for controlling nutrients and sediment include: stream bank stabilization; livestock exclusion from streams, eroding land, and water supplies; nutrient management; proper grazing use; establish vegetation on mined areas; install filter strips; and hard surfacing or grading roads. Section 319 grants provide cost-share money for implementation of BMP's to control NPS pollution.

Livestock exclusion (fencing of riparian areas) will provide streambank and shoreline protection as well as aid in stream channel stabilization by allowing the establishment of vegetation. Federal money is available for fencing of riparian areas and developing alternative water supplies. In addition, §319 funding can be used to purchase a conservation easement for a stream corridor. Nutrient management through soil testing and proper fertilizer application rates will prevent runoff of excessive nutrients. Proper grazing use will prevent over stocking and over grazing of both pasture land and urban ranchettes. This will reduce both sediment and nutrient loading to streams. Establishment of vegetation on strip mines should significantly reduce sediment loading to the lake. The strip mines are a major source of sediment loading to the streams. All BMP selection and implementation should occur through the cooperation and coordination of the Rogers County Conservation District, Natural Resource Conservation Service, and the Oklahoma Conservation Commission. Special effort will be needed to educate owners of urban ranchettes on BMP implementation. If voluntary BMP implementation is not effective, BMPs could be enforced through the rural water districts, county zoning, or by the City of Claremore annexing and zoning these areas.

I. Upgrade sewage treatment system

Upgrading current sewage treatment in the Lake Claremore watershed should substantially reduce nutrient loading to Dog and Little Dog Creek. Options include: ensuring that the septic systems throughout the watershed are working properly; connecting the Community of Foyil to the City of Claremore sewer system, constructing a waste water treatment facility in Foyil, or a combination of the three. The State Revolving Fund could provide funding for connecting Foyil to or constructing Foyil a waste water treatment facility. Section 319 grants provide cost-share money for installation of septic systems to rural residences.

In general, properly working septic systems are more efficient at removing nutrients from sewage than waste treatment facilities. Therefore, upgrading and inspecting the septic systems throughout the watershed woud be the best choice because it is less costly and more efficient at removing nutrients. The next best choice would be to connect the Community of Foyil and nearby rural areas to the City of Claremore sewer system. Because the City of Claremore discharges its treated sewage below the lake, this would decrease the nutrient load to Lake Claremore. However, this solution would be very costly and would only move the problem further downstream. The last choice would be to construct a waste water treatment facility in Foyil, because it is likely that this would increase the nutrient loading to Lake Claremore.

J. Strip mine reclamation

Methods of controlling mine drainage include prevention at the source by remediating the mines and treating the drainage directly to remove acidity, metals, and sulphur (discussed in next section). Reclamation of strip mines in the watershed should eliminate metal concentrations and siltation associated with runoff from abandoned strip mines. Reclamation activities for strip mine areas generally involves: spoil ridge reduction, high wall reduction, final pit elimination, final grading, topsoil handling, and revegetation.

Earth-moving is the costliest aspect of strip mine reclamation. The mine should be sealed with materials with low permeability, such as clay, to decrease or prevent infiltration of water into the filled strip pit. This should reduce or eliminate contamination of groundwater. In addition, blanketing with pulverized limestone before top soiling and revegetating may increase the pH of the infiltrate, which inhibits the growth of *Ferrobacillus-Thiobacillus* organisms, thereby greatly reducing acid formation. The current rate for strip mine reclamation is approximately $5,400/acre. At this rate, it would cost approximately $3,400,000 to reclaim all remaining strip mines in the Lake Claremore watershed.

K. Mine drainage remediation (Chemical Treatment)

Acid or other toxic mine drainage water can be treated and neutralized by adding alkaline material to the mine drainage. Many metals can be removed during neutralization as insoluble hydroxides. Alkaline material, such as hydrated lime (CaOH), caustic soda (NaOH), and limestone are generally used as neutralizing agents. Mine drainages having relatively high pH (>6.5) and containing predominately iron can be successfully treated by aeration or addition of hydrogen peroxide. After neutralization, water should enter a sludge settling basin before being discharged to a stream. The long term nature of chemical treatment, as well as the excessive operation and maintenance costs, makes this measure undesirable.

L. Mine drainage remediation (Wetlands)

Toxic mine drainage can also be treated using wetlands. Aerobic wetland systems encourage the oxidation process and as a result are relatively shallow (~0.3 m deep), vegetated (with reeds, etc.), and with surface flow predominating. This results in the precipitation of iron. However, it is necessary to add alkalinity to the mine water to prevent the pH from falling and to ensure that the removal rate of iron remains optimal. Alkalinity can be added to this system by using organic matter as a growth substrate for the wetland plants or by using anoxic limestone drains. Disadvantages of using aerobic wetlands are: mine water loading rates must be kept low to avoid overwhelming the wetland's ability to absorb metals and metals are introduced into the food chain through plant uptake. In anaerobic wetland systems, which require the mine water to flow through organic material (i.e. spent mushroom compost, manure, saw dust) under anaerobic conditions, high levels of sulfate and metals are removed from the mine drainage by sulphur reducing microorganisms which reduce sulfate to sulfide and precipitate metals. The major disadvantages of using anaerobic wetlands are: mine water loading rates must be kept low to avoid exceeding the rate of sulfate reduction and reactions are temperature dependent and must be kept warm in winter (Amacher et al. 1993, Robb and Robinson 1995). Remediation of mine drainage using wetlands is recommended over chemical treatment.

M. Upstream reservoir construction

Sediment retention structures could be constructed on strategic sites of the watershed to trap silt transported from strip mines, pasture, cropland, urban ranchettes, and streambank erosion. This has been proven to be successful in highly erodible lands of western and central Oklahoma. The cost of a typical 2000 cubic yard pond with a 90 foot discharge pipe is \$2800.00 (\$0.72 per cubic yard + \$15.00 per foot for discharge pipe). At this cost, 3 structures could be constructed for under \$9,000.00. However, several studies have shown that these structures contribute to entrenchment of streams which leads to severe bank erosion and excessive sedimentation. The cause is modification of the hydrograph, with the resulting adjustment in stream channel morphology to accomodate the new flow regime.

N. Water Conservation

Reducing water usage reduces waste water discharges. Water-saving devices such as flow-reducing shower heads and water-saving toilets can cut household waste water by 25%. Additional water conservation procedures are listed on page 104 of *The Lake and Reservoir Restoration Guidance Manual, Second Edition* (EPA 1990) or can be obtained from local County Extension offices. Water conservation in the watershed will reduce the amount of waste water entering the lake. In addition, water conservation by the City of Claremore will reduce draw down of the lake during summer and drought conditions.

II.3 Benefits versus Problems of Each Alternative

A. No Action

Benefits - Low to no cost of implementation

Problems - Eutrophication, siltation, and toxic metal loading unchecked
Eventual loss of water supply and recreational facility

B. Algae Control (Herbicides)

Benefits - Temporary elimination of algal blooms
Temporarily decreases odor and improves taste of drinking water

Problems - Requires repeated treatment with $CuSO_4$
Treats only the symptoms of eutrophication
Introduces potentially high concentrations of Cu which can be toxic
High cost
Does not address siltation

C. Algae Control (Food Web Manipulation)

Benefits - Low cost (Unless stocking is required)
May result in improved fisheries
No adverse environmental impact

Problems - Results may not be immediately observable
Effectiveness not proven
May provide only short term benefits

D. Dredging

Benefits - Removes accumulated nutrients and other contaminants bound to sediment
Increases depth, extending the potential life of the lake and increasing capacity
Improvement of fishery

Problems- Expensive
Does not address nutrient or silt inputs
Temporary unless linked to watershed measures
Costly disposal of polluted sediments contaminated with metals and nutrients

E. Sediment Covering/Phosphorous Inactivation

Benefits - Less expensive nutrient removal than dredging
Traps sediment bound nutrients preventing internal loading

Problems - Contributes to lost lake volume
Implementation could create adverse water quality conditions detrimental to fish
Ineffective unless nutrient loading from watershed is limited

F. Fish Stocking, Regulation, etc.

Benefits - Improve fish community structure

Problems - Cost
Public support not guaranteed

G. Artificial circulation

Benefits - Prevents release of metals and nutrients from sediments
Improve benthic and fish community health

Problems - Treats only the symptoms
Eutrophication, siltation, and toxic metal loading left unchecked
Effectiveness varies

H. Implementation of best management practices (BMP)

Benefits - Provides valuable soil and water conservation practices to all land uses
Provide significant reductions of nutrient loading and siltation

Problems - No guarantee of land owner cooperation unless zoned by city or county
No guarantee of maintenance of the BMPs installed unless zoned

I. Upgrade sewage treatment system

Benefits - Proper treatment of sewage
Properly working septic systems would reduce nutrient loading to lake
Reduce fecal coliform bacteria

Problems - Construction of treatment facilities and installing sewer system is expensive
Potential increased sedimentation during construction of treatment facility
Treatment facility in watershed could increase nutrient loading

J. Strip mine reclamation

Benefits - Eliminate discharge of contaminated water
Reduce siltation
Restore land to productive use
Eliminate unsafe areas
Controls problem at its source

Problems - Costly
Auto-oxidation of pyrite cycle hard to stop

K. Mine drainage remediation (Chemical Treatment)

Benefits - Raises pH
Removes metals

Problems - Requires continual treatment (costly)
Does not control problem at its source

L. Mine drainage remediation (Wetlands)

Benefits - Raises pH
Removes metals

Problems - Does not control problem at its source
Loading rates must be kept low to prevent overloading the system
Temperature dependent reactions (anaerobic wetland)
Metals introduced into food chain (aerobic wetland)
High initial cost

M. Upstream reservoir construction

Benefits - Water storage
Settling Basin
Control Flooding
May reduce sediment loading

Problems - May not substantially reduce nutrients
May increase stream bank erosion down-stream of structure

N. Water conservation

Benefits- Reduce amount of waste water
Reduce lake draw down
Low cost of implementation

Problems- No guarantee of public cooperation

II.4 Description of Phase II Monitoring Program

The following water quality monitoring program was designed to evaluate the success or failure of the restoration project. Monitoring will not occur during restoration activities. However, Phase III monitoring should be initiated no less than 5 years after the completion of lake restoration activities (both lake and watershed). Ideally, this should be carried out indefinitely, limited only when data indicate maximum improvement has been achieved.

Lake and tributary monitoring should include monthly sampling. Parameters from lake sampling should include temperature, dissolved oxygen, conductivity, and pH profiles, alkalinity, fecal coliform bacteria, turbidity, Secchi depth, total dissolved solids, total suspended solids, sulfate, chloride, complete nutrient analysis, metals, chlorophyll *a*, zooplankton dynamics, and phytoplankton dynamics. Parameters from inflow sampling should include temperature, dissolved oxygen, conductivity, pH, alkalinity, fecal coliform bacteria, turbidity, total dissolved solids, total suspended solids, sulfate, chloride, complete nutrient analysis, and metals. Water samples submitted for laboratory analysis will be collected from surface water and hypolimnion when stratification exists. Runoff sampling from the inflows should be performed for at least two significant events per year. Parameters measured in runoff should include TSS, nutrients, turbidity, basic chemistries, metals, and pesticides. Sediments should be sampled once and analyzed for pesticides, metals, and nutrients. Fish tissue should be collected once per year for metals and pesticide analysis. The fishery should be monitored on at least an alternate year schedule. In addition, it is suggested that the City of Claremore analyze lake and streams samples for metals on a regular basis, as well as their treated water.

II.5 Lake Restoration and Pollution Control Work Plan

Currently, no Phase II Work Plan exists for a Lake Claremore restoration project. Before this can be developed, officials from the City of Claremore, the Rogers County Commissioners, and land owners from the watershed will have to agree on a cooperative agreement which would include the commitment of funding for cost shared implementation. It would not be possible to draft any Work Plan without total commitment of resources from these parties.

II.6 Sources of Funding

Funding for this restoration project could be a cooperative effort between the following entities: City of Claremore, Rogers County Commissioners, Oklahoma Conservation Commission (OCC) Water Quality Division, OCC Abandoned Mine Lands Program, Oklahoma Department of Agriculture, Rogers County Cooperative Extension Service, Rogers County Conservation District, United States Department of Agriculture (USDA), USDA Natural Resource Conservation Service (NRCS), Office of the Secretary of the Environment, USDA Farm Services Agency (FSA), City-County Health Department of Oklahoma County, Oklahoma Department of Environmental Quality (DEQ), Oklahoma Water Resources Board (OWRB), and the Dog Creek Watershed Conservation Association. Section 319 non-point source pollution funds may be sought to implement watershed measures at a 60/40 cost share, 40% state and 60% federal. The State Revolving Fund could be used to provide funding for installation of a sewer system and waste water treatment facility (WWTF) for the Community of Foyil and surrounding rural areas. The OWRB has oversight of the State Revolving Fund. The DEQ would also have to be involved if a WWTF is built.

II.7 Relationship of Project to Other Pollution Control Programs

A §319 grant for Lake Claremore could be used to facilitate watershed BMP implementation and upstream reservoir construction. A §319 grant would serve to coordinate all of the watershed's stakeholders and would petition a cooperative effort among state and federal agencies to provide technical assistance and cost-share programs for landowners and livestock producers in the watershed.

A Phased TMDL (Total Maximum Daily Load) project has been initiated in the Dog Creek watershed. INCOG (Indian Nations Council of Governments) has recently received 104(b)(3) funding to conduct Phase I of the TMDL which addresses land use characterization and identification of potential NPS pollution. A §319 grant has been submitted by the OCC, INCOG, and the OWRB to conduct Phase II of the TMDL, which consists of characterizing the chemical and biological conditions in the Dog and Cat Creek (tributary to Dog Creek located downstream of Lake Claremore) watersheds relating to NPS pollution and paired BMP implementation conditions, assessing any limitations in stream channel hydraulics that could be corrected to improve reoxygenation and aquatic community habitat, refining the original INCOG waste load allocation model to account for NPS pollution and physical limitations in stream hydraulics, and developing education programs for facilitating TMDL goals. The Phase II work plan is included in Appendix L. Future phases will address implementation of demonstration projects to control nonpoint sources and stream channel modifications to improve aquatic community habitat.

The FSA ensures the compliance of agreements between landowners and the U.S. government. Compliance enables landowners to receive federal funds for a designated land use. The NRCS manages activities in the watershed designed to control pollution to rivers and streams. The NRCS encourages farmers to practice good land management practices over a period of time. Development of a watershed management plan would involve cooperation between the OCC, NRCS, and FSA.

Conservation education programs are currently administered by the Rogers County Conservation District. However, no pollution control structures have been constructed in the Lake Claremore watershed. The Dog Creek Watershed Conservation Association performs volunteer monitoring on a regular basis.

Reclamation of an abandoned strip mine in the Little Dog Creek watershed is scheduled to begin in the near future. Completion of this project will leave only one more site in the Little Dog Creek watershed unreclaimed. In addition, the Abandoned Mine Land Program plans to begin a strip mine reclamation project in early 1996 for Sections 27 and 28, Range 16E, Township 22N. Runoff from this area drains directly to the lake; therefore, sediment control on the reclamation site is a must.

II.8 Summary of Public Participation Activities

Public participation in the Phase I project occurred through meetings with lake users, city officials, and lake association members. OCC staff communicated with Jim Bickford, President of the Dog Creek Watershed Conservation Association on a regular basis. The Rogers County Commissioners, City of Claremore, and its citizens are committed to the long term restoration of Lake Claremore and its watershed.

To date, 2 public meetings have been held. The initial meeting was conducted by the Oklahoma Conservation Commission and the Rogers County Conservation District on June 30, 1993 and summarized how these studies were performed and the goals of the Lake Claremore Clean Lakes Phase I study. Initial results of the study were presented on February 13, 1995 to the Dog Creek Watershed Conservation Association and Claremore City Council at the request of Jim Bickford, President of the Dog Creek Watershed Conservation Association. Further meetings are anticipated to present the final results and develop the Phase II plan.

II.9 Necessary Permits

Upon selection of restoration methods for Lake Claremore, all permits necessary for the execution of those methods shall be secured. Corps of Engineers 404 permits will be obtained for any dredging, should that alternative be elected. Permits (401 certification, etc.) will be obtained from the Oklahoma Department of Environmental Quality (ODEQ) for any in-lake alterations that should occur.

PROJECT ENVIRONMENTAL EVALUATION

III.1 Displacement of People

None.

III.2 Defacement of Residences and Residential Areas

None.

III.3 Changes in Land Use Patterns

Yes. The implementation of BMP's will require a slight change in land use patterns. However, the project will improve the land through the installation of BMP's. In addition, reclamation of strip mines will restore the land to a more natural condition.

III.4 Impact on Prime Agricultural Land

Implementation of BMP's and strip mine reclamation should provide beneficial impacts such as decreased top soil loss, increased fertility, and restoration and/or preservation of site productivity.

III.5 Impact on Park Land, Public Land, and Scenic Value Lands

Restoration activities will enhance recreational uses of the lake and adjacent parkland. Successful riparian revegetation should provide visual aesthetic improvements and the increased utilization by native wildlife. Establishment of riparian corridors will increase the movement of both game and non-game species between woodlands dissected by managed pasture and cropland. The quality of upland game hunting should increase over time.

III.6 Impact on Lands or Structures of Historic, Architectural, Archeological, or Cultural Value

Prior to any construction activities, a survey of the area will be completed to determine if any sites of cultrural value are present. If such sites are found, all necessary precautions will be taken to prevent disturbance or destruction of the site.

III.7 Long Term Energy Impacts

None.

III.8 Short and Long Term Ambient Air Quality and Noise Level Impacts

Short term effects are possible due to construction activities. However, once construction activities are complete, no long term ambient air quality and/or noise level impacts will be incurred.

III.9 Short and Long Term Impacts of In-Lake Chemical Treatment

In-lake chemical treatment is not recommended. However, if alum is applied, extreme care must be taken. Improper application could temporarily cause acidic conditions and fish kills. Proper application would temporarily decrease nutrient levels which would result in a temporary decrease in productivity.

III.10 Flood Plain Impacts

Construction of upstream reservoirs should aid in controlling flood waters. However, riparian revegetation could slow drainage of flood waters as result of increased obstruction of the stream bed.

III.11 Impacts of Dredging Activities

Due to the high levels of metals in the sediment, dredging is not recommended. However, if this alternative is elected, implementation would certainly have temporary adverse impacts on human health and the fishery due to sediment disruption and the resultant release of toxic metals into the water column. In addition, it would be difficult and costly to dispose of the contaminated dredge material. If dredge material is improperly disposed of, long term toxic effects could be realized.

III.12 Impacts to Wetlands

None.

III.13 Feasible Alternatives to Project

Increasing the dam height is the only other feasible alternative. Obviously, this would provide a substantial increase in depth, storage capacity, retention time, and fish habitat. However, dam heightening is generally not considered a feasible alternative for restoring lakes. In addition, unless implementation of BMP's, upgrading sewage treatment systems, and reclaiming strip mines are successfully completed, then this would only result in a bigger problem.

III.14 Other Measures and Impacts Not Previously Discussed

Public education on eliminating and preventing NPS pollution would also be beneficial.

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APPENDIX A

ROUTINE WATER QUALITY DATA

LAKE CLAREMORE

1993-94

LAKE CLAREMORE, DAM

Date	Depth m	Temp C.	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
21-Apr-93	0.2	14	10.1	190	7.9	35	25	62	4.9	141	10	33	0.04	<0.01	0.46	<0.1	15	6.0
21-Apr-93	0.9	14	10.1	192	7.9													
21-Apr-93	1.8	14	10.1	192	7.9													
21-Apr-93	2.7	14	10.0	193	7.9													
21-Apr-93	3.7	14	10.1	193	7.9													
21-Apr-93	4.6	14	10.1	194	7.8													
21-Apr-93	5.5	14	10.1	194	7.8													
21-Apr-93	6.4	14	10.1	191	7.8													
21-Apr-93	7.3	14	10.0	195	7.8													
12-May-93	0.2	16	6.6	89	7.7	25	100	31	1.6	146	36	11	0.09	0.02	0.82	<0.1	8	2.7
12-May-93	0.9	16	6.6	89	7.7													
12-May-93	1.8	16	6.5	89	7.6													
12-May-93	2.7	17	6.5	90	7.6													
12-May-93	3.7	16	6.5	90	7.6													
12-May-93	4.6	16	6.5	90	7.6													
12-May-93	5.5	16	6.5	90	7.5													
12-May-93	6.4	16	6.5	90	7.5													
12-May-93	7.3	16	5.5	92	7.5													
12-May-93	7.8	16	5.4	93	7.5													
19-May-93	0.2	21	8.4	147	7.5	33	25	49	2.4	119	16	23	0.05	<0.01	0.62	0.1	12	4.6
19-May-93	0.9	21	8.4	147	7.5													
19-May-93	1.8	21	8.4	147	7.5													
19-May-93	2.7	21	8.2	147	7.5													
19-May-93	3.7	20	7.2	145	7.4													
19-May-93	4.6	17	3.5	145	7.3													
19-May-93	5.5	17	3.0	146	7.2													
19-May-93	6.4	16	3.0	143	7.1													
19-May-93	7.3	16	2.4	145	7.1	37	59	49	2.3	150	40	21	0.08	0.02	0.99	0.1	12	4.5
19-May-93	7.8	16	1.4	152	7.0													

LAKE CLAREMORE, DAM

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
02-Jun-93	0.2	22	7.7	174	8.0			66	3.2	137	19	31	0.06	<0.01	0.77	0.1	16	6.3
02-Jun-93	0.9	22	7.7	174	8.0													
02-Jun-93	1.8	22	7.7	174	7.9													
02-Jun-93	2.7	22	7.3	174	7.9													
02-Jun-93	3.7	22	5.7	174	7.8													
02-Jun-93	4.6	22	4.4	174	7.7													
02-Jun-93	5.5	19	1.0	174	7.5													
02-Jun-93	6.4	19	0.4	171	7.4	46	32	62	2.9	150	28	28	0.10	<0.01	1.10	0.1	15	6.0
02-Jun-93	7.3	18	0.2	174	7.4													
02-Jun-93	7.8	18	0.1	174	7.3													
15-Jun-93	0.2	27	8.1	190	8.2	43	10	67	3.3	117	4	33	0.05	0.02	0.50	0.2	16	6.6
15-Jun-93	0.9	27	8.0	190	8.2													
15-Jun-93	1.8	27	7.9	190	8.2													
15-Jun-93	2.7	26	6.9	190	8.0													
15-Jun-93	3.7	25	4.0	190	7.9													
15-Jun-93	4.6	23	1.6	194	7.6													
15-Jun-93	5.5	23	0.9	197	7.5													
15-Jun-93	6.4	22	0.2	202	7.4	60	39	71	3.5	166	56	30	0.04	<0.01	0.40	0.2	17	7.0
15-Jun-93	7.3	22	0.1	209	7.4													
12-Jul-93	0.2	28	7.3	196	8.0	48	11	74	3.9	132	12	31	0.03	<0.01	0.40	<0.1	18	7.0
12-Jul-93	0.9	28	7.2	196	8.0													
12-Jul-93	1.8	28	7.1	196	8.0													
12-Jul-93	2.7	28	7.0	196	8.0													
12-Jul-93	3.7	28	7.0	196	8.0													
12-Jul-93	4.6	28	6.9	196	7.9													
12-Jul-93	5.5	27	5.4	198	7.9													
12-Jul-93	6.4	26	0.3	209	7.9	57	20	74	3.8	158	17	31	0.05	0.01	0.70	<0.1	18	7.0
28-Jul-93	0.2	30	6.5	202	7.5	52	10	75	4.1	128	8	31	0.03	<0.01	0.40	0.1	18	7.2
28-Jul-93	0.9	30	6.1	203	7.4													
28-Jul-93	1.8	30	5.9	202	7.3													
28-Jul-93	2.7	30	5.9	203	7.3													
28-Jul-93	3.7	30	6.0	203	7.3													
28-Jul-93	4.6	29	1.4	204	6.8													
28-Jul-93	5.5	28	0.2	220	6.8	68	18	78	4.1	154	31	28	0.05	0.02	0.80	0.1	19	7.3
28-Jul-93	6.4	26	0.2	231	6.8													

LAKE CLAREMORE, DAM

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
17-Aug-93	0.2	29	5.9	208	7.7	60	8	78	4.6	136	6	29	0.04	<0.01	0.70	0.2	19	7.4
17-Aug-93	0.9	29	5.6		7.7													
17-Aug-93	1.8	29	5.5		7.6													
17-Aug-93	2.7	29	5.0		7.5													
17-Aug-93	3.7	27	0.3	209	6.8													
17-Aug-93	4.6	26	0.2	215	6.8													
17-Aug-93	5.5	26	0.2	220	6.9													
17-Aug-93	6.4	25	0.1	228	7.8	71	37	80	3.9	132	22	25				0.2	20	7.3
17-Aug-93	6.9	25	0.1	240	7.0													
31-Aug-93	0.2	28	5.1	213	7.4	62	13	80	4.8	133	8	26				0.2	20	7.2
31-Aug-93	0.9	28		214														
31-Aug-93	1.8	28		213														
31-Aug-93	3.7	28	5.1	213	7.4													
31-Aug-93	4.6	28	5.1	213	7.4													
31-Aug-93	5.5	28	5.1	213	7.4													
31-Aug-93	5.9	28	4.5	215	7.4													
31-Aug-93	6.4	25	0.2	262	7.0	59	13	77	4.7	133	7	27				0.2	19	7.1
15-Sep-93																		
15-Sep-93	0.2	22	6.8	207	7.3	66	16	70	4.5	122	21	26	0.05	<0.01	0.63	0.2	18	6.0
15-Sep-93	0.9	22	6.7	208	7.4													
15-Sep-93	1.8	22	6.0	207	7.5													
15-Sep-93	2.7	22	6.6	207	7.5													
15-Sep-93	3.7	22	6.6	207	7.5													
15-Sep-93	4.6	22	6.6	207	7.5													
15-Sep-93	5.5	22	6.8	207	7.5													
15-Sep-93	6.4	22	6.9	207	7.6													
15-Sep-93	6.9	22	6.8	207	7.6													
28-Sep-93	0.2	22	6.1	207	7.2	61	3	78	4.6	128	14	26	0.02	<0.01	0.47	0.2	19	7.3
28-Sep-93	0.9	22	6.0	207	7.2													
28-Sep-93	1.8	22	5.9	205	7.2													
28-Sep-93	2.7	22	5.9	207	7.2													
28-Sep-93	3.7	22	5.9	207	7.2													
28-Sep-93	4.6	22	5.9	207	7.2													
28-Sep-93	5.5	22	5.8	207	7.2	57	21	78	6.8	106	15	26	0.02	<0.01	0.55	0.2	19	7.3
28-Sep-93	6.4	22	5.8	207	7.2													

LAKE CLAREMORE, DAM

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
19-Oct-93	0.1	18	7.3	209	7.5													
19-Oct-93	1.0	18	7.3	209	7.5													
19-Oct-93	2.0	18	7.3	209	7.5													
19-Oct-93	3.0	18	7.3	209	7.5													
19-Oct-93	4.0	18	7.3	209	7.5													
19-Oct-93	5.0	18	7.3	209	7.6													
19-Oct-93	6.0	18	7.3	209	7.6													
19-Oct-93	7.0	18	7.3	209	7.6													
19-Oct-93	7.5	18	7.3	209	7.2													
19-Oct-93						64	16	94	6.0	136	14	30	0.08	<0.01	0.86			
09-Nov-93	0.1	10	11.0	208	8.1													
09-Nov-93	1.0	9	11.0	208	8.2													
09-Nov-93	2.0	9	10.8	208	8.1													
09-Nov-93	3.0	9	10.6	208	8.1													
09-Nov-93	4.0	9	10.2	208	8.0													
09-Nov-93	5.0	9	10.1	208	7.9													
09-Nov-93	6.0	9	10.1	208	7.9													
09-Nov-93	7.0	9	10.0	208	7.9													
09-Nov-93	7.5	9	9.9	208	7.8													
09-Nov-93						64	11	69	3.5	117	9	27	0.06	<0.01	0.65			
22-Dec-93	0.1	6	10.7	200	7.3													
22-Dec-93	1.0	6	10.7	200	7.3													
22-Dec-93	2.0	6	10.7	200	7.4													
22-Dec-93	3.0	6	10.5	201	7.4													
22-Dec-93	4.0	6	10.4	200	7.4													
22-Dec-93	5.0	6	10.4	200	7.4													
22-Dec-93	6.0	6	10.4	200	7.4													
22-Dec-93	7.0	6	10.4	200	7.4													
22-Dec-93						6	13	76	7.0	120	14	35	0.03	<0.01	0.60			

LAKE CLAREMORE, DAM

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
27-Jan-94	0.1	4	10.8	201	7.7													
27-Jan-94	1.0	4	10.7	201	7.7													
27-Jan-94	2.0	4	10.7	201	7.7													
27-Jan-94	3.0	4	10.7	203	7.7													
27-Jan-94	4.0	4	10.7	203	7.7													
27-Jan-94	5.0	4	10.7	203	7.7													
27-Jan-94	6.0	4	10.7	203	7.7													
27-Jan-94	7.0	4	10.7	203	7.7													
27-Jan-94						54		78	9.0	146	23	36	0.07	0.01	0.50			
24-Feb-94	0.1	7	11.3	213	8.7	51	11											
24-Feb-94	1.0	7	9.7	209	7.9													
24-Feb-94	2.0	7	9.7	207	7.9													
24-Feb-94	3.0	7	9.6	211	7.9													
24-Feb-94	4.0	7	9.7	210	8.0													
24-Feb-94	5.0	7	9.6	209	8.0													
24-Feb-94	6.0	7	9.6	206	8.0													
24-Feb-94	7.0	7	9.6	207	8.0													
24-Feb-94	7.5	7	9.6	215	8.0													
24-Feb-94								78	11.0		14	36	0.08	<0.01	0.20			
23-Mar-94	0.1	15	9.6	145	7.7	41	23											
23-Mar-94	1.0	15	9.6	145	7.6													
23-Mar-94	2.0	15	9.5	147	7.7													
23-Mar-94	3.0	15	9.5	148	7.7													
23-Mar-94	4.0	15	9.3	150	7.7													
23-Mar-94	5.0	14	9.2	151	7.7													
23-Mar-94	6.0	14	9.2	151	7.7													
23-Mar-94	6.5	14	9.0	152	7.7													
23-Mar-94								72	6.8		33	31	0.13	0.01	0.79			
AVERAGE				188	7.6	51	23	71	4.7	135	19	28	0.06	<0.01	0.63	0.1	17	6.4
MINIMUM				89	6.8	6	3	31	1.6	106	4	11	0.02	<0.01	0.20	<0.1	8	2.7
MAXIMUM				262	8.7	71	100	94	11.0	166	56	36	0.13	0.02	1.10	0.2	20	7.4

LAKE CLAREMORE, MID POINT

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
21-Apr-93	0.2	14.0	9.9	178	7.8	37	29	58	4.6	131	14	31	0.08	<0.01	0.79	<0.1	14	5.6
21-Apr-93	0.9	14.0	9.8	179	7.8													
21-Apr-93	1.8	14.0	9.8	180	7.7													
21-Apr-93	2.7	14.0	9.8	180	7.7													
21-Apr-93	3.7	14.0	9.8	180	7.7													
21-Apr-93	4.6	14.0	9.7	181	7.7													
21-Apr-93	5.5	13.5	9.5	183	7.7													
12-May-93	0.2	15.5	7.3	125	7.3	31	67	44	2.2	135	23	18	0.08	0.01	0.62	<0.1	11	4.0
12-May-93	0.9	15.5	7.2	124	7.3													
12-May-93	1.8	15.5	7.2	124	7.2													
12-May-93	2.7	15.5	7.1	128	7.2													
12-May-93	3.7	15.0	7.3	152	7.2													
12-May-93	4.1	15.0	7.3	150	7.2													
19-May-93	0.2	20.5	8.4	181	7.4	39	23	62	3.0	128	12	31	0.03	<0.01	0.51	0.1	15	6.0
19-May-93	2.7	19.5	7.1	153	7.4													
19-May-93	3.7	18.0	4.1	157	7.2	37	44	51	2.4	134	82	23				0.1	13	4.6
19-May-93	4.1	17.0	3.2	146	7.2													
02-Jun-93	0.2	23.0	8.9	177	8.1	41	18	67	3.1	138	17	32	0.06	<0.01	0.70	0.1	16	6.5
02-Jun-93	0.9	23.0	8.5	177	8.0													
02-Jun-93	1.8	22.5	8.5	177	8.0													
02-Jun-93	2.7	22.5	7.9	177	7.9													
02-Jun-93	3.7	22.5	7.6	177	7.9													
02-Jun-93	4.6	22.0	6.1	177	7.7	42	19	67	3.0	147	22	31	0.07	0.01	0.60	0.1	16	6.5
02-Jun-93	5.0	21.0	1.1	177	7.5													
15-Jun-93	0.2	27.0	7.7	191	7.9	44	8	71	3.4	112	3	34	0.07	<0.01	0.60	0.2	17	6.9
15-Jun-93	0.9	26.5	7.8	190	7.9													
15-Jun-93	1.8	26.0	7.6	188	7.9													
15-Jun-93	2.7	25.5	5.8	180	7.8													
15-Jun-93	3.7	24.0	3.1	192	7.5			100	3.4	138	24	33	0.08	0.01	0.60	0.1	27	8.2

LAKE CLAREMORE, MID POINT

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
12-Jul-93	0.2	28.0	8.1	195	8.3	48	17	73	3.9	112	10	31	0.08	<0.01	0.60	<0.1	18	6.9
12-Jul-93	0.9	28.0	8.0	195	8.3													
12-Jul-93	1.8	28.0	6.7	195	8.1													
12-Jul-93	2.7	27.5	5.0	197	8.0													
12-Jul-93	3.7	27.0	0.6	202	7.7			74	3.9	146	27	31	0.04	<0.01	0.40	<0.1	18	7.0
28-Jul-93	0.2	31.0	8.4	200	8.3	55	11		4.2	130	6	31	0.03	<0.01	0.40	0.1		
28-Jul-93	0.9	30.0	6.9	200	7.7													
28-Jul-93	1.8	30.0	6.4	203	7.6													
28-Jul-93	2.7	30.0	6.0	202	7.5													
28-Jul-93	3.7	29.5	3.6	205	7.1	52	12	75	4.7	128	12	31	0.03	<0.01	0.50	0.1	18	7.2
28-Jul-93	4.6	29.0	0.5	212	6.7													
17-Aug-93	0.2	30.0	7.5	208	8.6	59	9	80	4.2	134	4	29	0.05	<0.01	0.60	0.2	20	7.3
17-Aug-93	0.9	30.0	7.3	209	8.5													
17-Aug-93	1.8	30.0	6.1	209	8.3													
17-Aug-93	2.7	28.5	1.5	208	7.1													
17-Aug-93	3.7	27.5	0.3	210	6.9	59	9	78	4.2	124	4	29	0.04	<0.01	0.60	0.2	19	7.4
31-Aug-93	0.2	28.0	5.9	214	7.6	64	19	78	4.6	125	9	27				0.2	19	7.3
31-Aug-93	0.9	28.0	5.7	214	7.6													
31-Aug-93	1.8	28.0	5.7	214	7.6													
31-Aug-93	2.7	28.0	5.7	214	7.6													
31-Aug-93	3.2	28.0	5.6	214	7.6													
15-Sep-93																		
15-Sep-93	0.9	21.5	7.6	205	7.7			74	4.4	130	6	27	0.06	0.01	0.71	0.1	19	6.4
15-Sep-93	1.8	21.5	7.5	206	7.7													
15-Sep-93	2.7	21.5	7.3	207	7.7													
15-Sep-93	3.2	21.5	7.3	207	7.7													
28-Sep-93	0.2	21.5	9.6	205	8.1	53	12	78	4.9	108	7	26	0.02	<0.01	0.30	0.2	19	7.5
28-Sep-93	0.9	21.5	9.5	207	8.1													
28-Sep-93	1.8	21.5	9.4	207	8.0													
28-Sep-93	2.7	21.5	9.3	207	8.0	59	12	80	4.9	124	12	26	0.02	<0.01	0.40	0.2	20	7.4
28-Sep-93	3.2	21.5	8.9	207	7.9													

LAKE CLAREMORE, MID POINT

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
19-Oct-93	0.1	18.0	7.8	209	7.6													
19-Oct-93	1.0	18.0	7.7	209	7.6													
19-Oct-93	2.0	18.0	7.6	209	7.6													
19-Oct-93	3.0	18.0	7.6	209	7.5													
19-Oct-93						54	15	78	5.0	143	17	23	0.11	<0.01	0.72			
09-Nov-93	0.1	9.8	11.4	212	8.5													
09-Nov-93	1.0	9.1	11.1	212	8.3													
09-Nov-93	2.0	9.0	10.8	210	8.2													
09-Nov-93	2.5	9.0	10.4	210	8.1													
09-Nov-93						62	1	66	6.0	110	10	27	0.05	<0.01	0.60			
22-Dec-93	0.1	6.3	11.8	202	7.7													
22-Dec-93	1.0	5.9	11.7	202	7.7													
22-Dec-93	2.0	5.6	11.7	202	7.7													
22-Dec-93	3.0	5.5	11.6	202	7.7													
22-Dec-93	3.5	5.5	11.4	202	7.7													
22-Dec-93						54	2	77	10.0				0.02	<0.01	0.58			
26-Jan-94	0.1	5.3	11.0	203	7.8													
26-Jan-94	1.0	5.2	11.0	204	7.8													
26-Jan-94	2.0	5.2	10.9	202	7.8													
26-Jan-94	3.0	5.2	10.9	205	7.8													
26-Jan-94	3.5	5.2	10.9	206	7.8													
26-Jan-94						46		78	8.5	102	11	39	0.09	<0.01	0.80			
24-Feb-94	0.1	7.2	10.2	212	7.7	52	24											
24-Feb-94	1.0	7.2	10.1	212	7.7													
24-Feb-94	2.0	7.2	9.8	212	7.8													
24-Feb-94	3.0	7.2	9.7	212	7.8													
24-Feb-94	3.5	7.2	9.7	212	7.9													
24-Feb-94								86	11.0		29	29	0.08	<0.01	1.13			

LAKE CLAREMORE, MID POINT

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
23-Mar-94	0.1	16.0	10.5	152	7.9	42	25											
23-Mar-94	1.0	15.7	10.3	152	7.9													
23-Mar-94	2.0	15.1	9.9	149	7.9													
23-Mar-94	3.0	15.1	9.4	151	7.9													
23-Mar-94	4.0	15.0	9.2	152	7.8													
23-Mar-94	4.5	15.0	9.1	152	7.8													
23-Mar-94								72	6.1		42	37	0.14	<0.01	0.77			
AVERAGE				190	7.7	49	19	72	4.8	128	18	29	0.06	<0.01	0.62	0.1	18	6.6
MINIMUM				124	6.7	31	1	44	2.2	102	3	18	0.02	<0.01	0.30	<0.1	11	4.0
MAXIMUM				214	8.6	64	67	100	11.0	147	82	39	0.14	0.01	1.13	0.2	27	8.2

LAKE CLAREMORE, UPPER END

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
21-Apr-93	0.2	15.0	9.4	166	7.7	36	44	53	4.3	142	26	26	0.05	<0.01	0.50	<0.1	13	5.1
21-Apr-93	0.9	15.0	9.3	166	7.7													
21-Apr-93	1.8	14.5	9.2	166	7.6													
21-Apr-93	2.3	14.5	9.2	166	7.6													
12-May-93	0.2	15.5	7.9	167	7.2	40	46	61	3.1	111	19	29	0.07	<0.01	0.61	0.1	15	5.8
12-May-93	0.9	15.0	7.7	169	7.2													
12-May-93	1.8	15.0	7.6	173	7.2													
21-May-93	0.2	20.0	6.8	215	7.2	45	36	77	3.6	170	21	41	0.08	<0.01	0.73	0.1	18	7.7
21-May-93	0.9	18.0	6.7	209	7.2													
21-May-93	1.8	19.0	6.0	223	7.2													
02-Jun-93	0.2	23.0	8.9	177	8.1	38	16	72	3.4	152	22	34	0.03	<0.01	0.40	0.1	17	7.1
02-Jun-93	0.9	23.0	9.0	190	8.0													
02-Jun-93	1.4	23.0	8.8	190	8.0													
15-Jun-93	0.2	26.5	5.9	201	7.6	46	13	71	3.8	130	32	34	0.07	<0.01	0.60	0.2	17	7.0
15-Jun-93	0.9	26.5	5.9	201	7.6													
15-Jun-93	1.8	25.0	2.5	200	7.5	49	12	73	3.7	148	24	34	0.02	<0.01	0.35	0.2	18	6.9
28-Jul-93	0.2	31.5	7.5	203	8.3		14	65	4.2	152	18	31	0.04	<0.01	0.40	0.1	16	6.1
28-Jul-93	0.9	30.0	7.0	205	7.8													
28-Jul-93	1.8	29.5	5.6	205	7.4													
17-Aug-93	0.2	30.5	7.0	209	8.4	52	20	81	4.2	138	13	29	0.06	<0.01	0.80	0.2	20	7.5
17-Aug-93	0.9	30.5	6.6	209	8.3		99											
17-Aug-93	1.4	30.0	6.1	213	8.1													
31-Aug-93	0.2	28.0	5.1	216	7.4	57	22	83	4.7	139	17	27				0.2	21	7.3
15-Sep-93	0.2	20.0	6.2	194	7.7	66	30	67	4.3	152	31	26	0.05	<0.01	0.60	0.1	17	6.0
15-Sep-93	0.9	20.0	5.5	190	7.6													
15-Sep-93	1.4	20.0	4.7	185	7.4													

LAKE CLAREMORE, UPPER END

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
28-Sep-93	0.2	21.5	9.9	204	8.1	53	20	77	5.8	114	14	28	0.02	<0.01	0.40	0.2	19	7.2
28-Sep-93	0.9	21.5	9.4	204	8.1	61	20	77	5.2	126	19	27	0.02	<0.01	0.40	0.2	19	7.1
28-Sep-93	1.4	21.5	9.2	204	8.0													
19-Oct-93	0.1	17.9	7.6	210	7.5													
19-Oct-93	1.0	17.8	7.3	210	7.5													
19-Oct-93	1.5	17.8	7.1	210	7.5													
19-Oct-93						6	19	80	6.0	125	21	23	0.10	<0.01	0.78			
09-Nov-93	0.1	9.9	11.6	209	8.4													
09-Nov-93	1.0	8.9	11.0	210	8.2													
09-Nov-93	1.5	8.7	10.8	210	8.1													
09-Nov-93						62	1	69	5.0	117	23	28	0.05	<0.01	0.50			
22-Dec-93	0.1	5.8	12.4	204	8.0													
22-Dec-93	1.0	5.7	12.2	204	8.0													
22-Dec-93	2.0	5.7	12.1	204	8.0													
22-Dec-93						53	1	78	6.0	127	10	33	0.02	<0.01	0.51			
27-Jan-94	0.1	6.9	10.9	210	7.9													
27-Jan-94	1.0	6.9	10.8	209	7.9													
27-Jan-94	2.0	6.7	10.8	208	7.9													
27-Jan-94						46		79	10.0	125	4	36	0.07	<0.01	0.60			
24-Feb-94	0.1	6.8	9.5	218	7.7	55	44											
24-Feb-94	1.0	6.8	9.5	217	7.8													
24-Feb-94	1.5	6.8	9.2	217	7.8													
24-Feb-94								80	11.0		31	34	0.05	0.01	0.60			
23-Mar-94	0.1	16.8	11.1	154	8.1	41	22											
23-Mar-94	1.0	16.5	11.0	159	8.2													
23-Mar-94	2.0	16.0	10.7	156	8.3													
23-Mar-94								68	7.4		35	43	0.12	<0.01	0.74			

LAKE CLAREMORE, UPPER END

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.	Alk mg/l	Turb NTU	Hard mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	PO4 mg/l	TN mg/l	F mg/l	Diss Ca mg/l	Diss Mg mg/l
AVERAGE				197	7.8	47	27	73	5.3	136	21	31	0.05	<0.01	0.56	0.1	18	6.7
MINIMUM				154	7.2	6	1	53	3.1	111	4	23	0.02	<0.01	0.35	0.0	13	5.1
MAXIMUM				223	8.4	66	99	83	11.0	170	35	43	0.12	0.01	0.80	0.2	21	7.7

LAKE CLAREMORE, WEST ARM

Date	Depth m	Temp C	D.O. mg/l	Cond uS/cm	pH S.U.
19-Oct-93	0.10	18.1	7.0	210	7.5
19-Oct-93	1.00	18.0	6.7	210	7.4
19-Oct-93	2.00	18.0	6.5	210	7.4
19-Oct-93	3.00	18.0	6.3	210	7.4
19-Oct-93	4.00	18.0	6.1	210	7.3
22-Dec-93	0.10	6.7	11.7	200	7.9
22-Dec-93	1.00	6.1	11.4	200	7.8
22-Dec-93	2.00	6.0	11.3	200	7.8
22-Dec-93	3.00	5.7	11.2	200	7.8
22-Dec-93	4.00	5.4	10.8	208	7.8

APPENDIX B

CHLOROPHYLL DATA

CLAREMORE LAKE CHLOROPHYLL - DAM SITE

Date	Top Chl. a	Bottom Chl. a	Comp/Mean Chl. a
07/01/87	37.6		
10/01/87	2.1		
01/01/88	4.9		
04/01/88	12.2		
07/01/88	52.6		
10/01/88	15.0		
01/01/89	19.2		
04/01/89	18.3		
07/01/89	19.0		
10/01/89	20.2		
01/01/90	29.9		
04/01/90	23.6		
07/01/90	31.3		
10/01/90	33.1		
02/01/91	17.1		
05/01/91	4.0		
08/28/91	28.2		
11/25/91	28.4		
03/10/92	22.8		
05/29/92	28.7		
08/12/92	20.2		
04/21/93			21.2
05/12/93			1.4
05/19/93	34.5	2.6	18.6
06/02/93		13.2	
06/15/93	8.1	12.3	10.2
07/12/93	15.1	10.8	13.0
07/29/93	16.4	1.6	9.0
08/17/93	12.7	7.5	10.1
08/31/93	30.3	29.2	29.7
09/15/93			35.5
09/28/93	25.3	27.8	26.5
10/19/93			32.6
12/21/93			21.5
01/28/94			18.4
02/24/94	16.4		
03/23/94	22.4		
Average	21.6	13.1	19.1

CLAREMORE LAKE CHLOROPHYLL - MID-POINT SITE

Date	Top Chl. a	Bottom Chl. a	Comp/Mean Chl. a
04/21/93			14.1
05/12/93			2.2
05/19/93	27.6		
06/02/93	21.4	25.8	23.6
06/15/93	9.4		
07/12/93	59.9	14.6	37.2
07/29/93	13.1	14.3	13.7
08/17/93	29.5	12.8	21.2
08/31/93			34.0
09/15/93			43.7
09/28/93	44.1	28.0	36.1
10/19/93			36.2
12/21/93			21.4
01/28/94			15.9
02/24/94	15.2		
03/23/94	32.7		
Average	28.1	19.1	24.9

CLAREMORE LAKE CHLOROPHYLL - UPPER SITE

Date	Top Chl. a	Bottom Chl. a	Comp/Mean Chl. a
04/21/93			11.9
05/12/93			2.1
05/19/93			3.5
06/02/93			16.3
06/15/93	12.1		
07/12/93			
07/29/93			26.7
08/17/93			26.9
08/31/93			32.3
09/15/93			36.9
09/28/93	41.4	37.6	39.5
10/19/93			33.1
12/21/93			19.1
01/28/94			15.9
02/24/94	11.6		
03/23/94			
Average	21.7	37.6	22.0

APPENDIX C

SECCHI DEPTH DATA

LAKE CLAREMORE SECCHI (inches)

Date	Dam	Mid Pt	Upper End	W. Arm
21-Apr-93	18	16	12	24
12-May-93	6	8	8	
19-May-93	21	21	15	
02-Jun-93	16	16	16	
15-Jun-93	36	24	18	
12-Jul-93	30	18		24
28-Jul-93	22	20	12	
11-Aug-93	22	20	18	
31-Aug-93	23	20	18	20
15-Sep-93	18	16	11	
19-Oct-93	22	18	18	18
09-Nov-93	24	22	23	
22-Dec-93	26	27	27	26
27-Jan-94	42	42	26	
24-Feb-94	30	18	12	
23-Mar-94	18	19	15	
AVERAGE	23	20	17	22
MINIMUM	6	8	8	18
MAXIMUM	42	42	27	26
s	8	7	5	3
CV	36	35	33	15

APPENDIX D

HEAVY METALS DATA

LAKE CLAREMORE METALS

SITE	DATE	DEPTH m	Na mg/1	Ca mg/1	Mg mg/1	Mn ug/l	K mg/1	Zn ug/l	Fe ug/l	Cu ug/l	Cd ug/l	Cr ug/l	Ni ug/l	Pb ug/l	As ug/l	Se ug/l	Hg ug/l	Ba ug/l	Depth m	Hardness mg/l
Claremore Lake, Dam	19930728	0.2	6.9			230	1.9	<10	220	<1	<1	<1	2	<1	2	<1	<0.1	<100	0.2	75
Claremore Lake, Dam	19930728	5.5	6.9			4300	2.1	<10	610	<1	<1	<1	3	<1	9	<1	0.1	<100	5.5	78
Claremore Lake, Dam	19930928	0.2	6.6			290	2.2	<10	550	<1	<1	1	1	<1	2	<2	<0.1	<100	0.2	78
Claremore Lake, Dam	19930928	5.5	6.6			320	2.2	<10	710	<1	<1	<1	2	<1	2	<2	0.4	<100	5.5	78
		AVG	6.8			1285	2.1	0	523	0	0	0	2	0	4	0	0.1	0		
		MIN	6.6			230	1.9	0	220	0	0	0	1	0	2	0	0.0	0		
		MAX	6.8			1285	2.1	0	523	0	0	0	2	0	4	0	0.1	0		
Claremore Lake, mid pt	19930728	0.2	7.0			260	2.0	<10	400	1	<1	<1	2	<1	2	<1	<0.1	100	0.2	
Claremore Lake, mid pt	19930728	3.7	7.0			240	1.9	<10	290	<1	<1	<1	2	<1	2	<1	0.1	<100	3.7	75
Claremore Lake, mid pt	19930928	0.2	6.6			180		<10	320	<1	<1	<1	<1	<1	1	<2	<0.1	<100	0.2	78
Claremore Lake, mid pt	19930928	2.7	6.7			200	2.2	<10	340	<1	<1	<1	<1	<1	2	<2	0.6	<100	2.7	80
		AVG	6.8			220	2.0	0	338	0	0	0	1	0	2	0	0.2	25		
		MIN	6.6			180	1.9	0	290	0	0	0	0	0	1	0	0.0	0		
		MAX	7.0			260	2.2	0	400	1	0	0	2	0	2	0	0.6	100		
Claremore Lake, upper end	19930728	0.2	7.5			280	2.0	<10	740	1	<1	<1	3	<1	2	<1	<0.1	<100	0.2	65
Claremore Lake, upper end	19930928	0.2	6.6			190	2.2	<10	460	<1	<1	<1	2	<1	1	<2	<0.1	<100	0.2	77
Claremore Lake, upper end	19930928	0.9	6.6			220	2.2	<10	560	<1	<1	<1	1	<10	1	<2	1.5	<100	0.9	77
		AVG	6.9			230	2.1	0	587	0	0	0	2	0	1	0	0.5	0		
		MIN	6.6			190	2.0	0	460	0	0	0	1	0	1	0	0.0	0		
		MAX	7.5			280	2.2	0	740	1	0	0	3	0	2	0	1.5	0		
Dog Cr nr Seq., Storm	19931117		9.0	16.1	6.2	400	5.0	70	5727	<40	<10	<50	<100	<100	<10	<10	<1	<100		88
Dog Cr nr Seq., Storm	19940127		12.6	18.3	7.1	160	1.7	<10	2470	<40	<10	<10	<100	<100	36	<10	<1	130		75
Dog Cr nr Seq., Storm	19940222		8.2	15.2	7.9	400	4.3	80	12350	<40	<10	15	<100	<100	67	23	<1	150		86
		AVG	9.9	16.5	7.1	320	3.7	50	6849	0	0	5	0	0	34	8	0.0	93		
		MIN	8.2	15.2	6.2	160	1.7	0	2470	0	0	0	0	0	0	0	0.0	0		
		MAX	12.6	18.3	7.9	400	5.0	80	12350	0	0	15	0	0	67	23	0.0	150		
Little Dog Creek Storm	19930913		8.2			3700	5.4	210	51000	33	<1	44	110	35	1	<2	0.1	600		72
Little Dog Creek Storm	19940127		10.6	16.5	7.4	80	2.1	<10	2330	<40	<10	<10	<100	<100	22	<10	<1	<100		75
Little Dog Creek Storm	19940222		4.6	12.0	7.2	910	5.9	150	20320	<40	<10	23	<100	<100	<10	35	<1	210		56
		AVG	7.8	14.3	7.3	1563	4.5	120	24550	11	0	22	37	12	8	12	0.0	270		
		MIN	4.6	12.0	7.2	80	2.1	0	2330	0	0	0	0	0	0	0	0.0	0		
		MAX	10.6	16.5	7.4	3700	5.9	210	51000	33	0	44	110	35	22	35	0.1	600		

APPENDIX E

LAKE SEDIMENT QUALITY DATA

LAKE CLAREMORE SEDIMENT QUALITY

DATES	SITES	NH3-N mg/kg	NO2+NO3 mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	K mg/kg	As ug/g	Cd ug/g	Cr ug/g	Cu ug/g	Pb ug/g	Mn ug/g	Ni ug/g	Zn ug/g	Fe ug/g	Hg ug/g
19930915	Lake Claremore dam	65	25	<10	2400	200	240	14	1	20	20	30	2400	30	140	41000	0.05
19930915	Lake Claremore mid pt	31	15	<10	1500	60	170	10	1	20	10	20	810	20	60	20000	0.05

DATES	SITES	PCN ug/kg	Aldrin ug/kg	Lindane ug/kg	Chlordane ug/kg	DDD ug/kg	DDE ug/kg	DDT ug/kg	Dieldrin ug/kg	Endosulfane ug/kg	Endrin ug/kg	Toxaphene ug/kg	Heptachlor ug/kg	Hept Epox ug/kg	Methoxychlor ug/kg	PCB ug/kg	Mirex ug/kg	Perthane ug/kg
19930915	Lake Claremore dam	<1	<0.1	<0.1	2	0.3	1.2	0.1	<0.3	<0.1	<0.1	<10	<0.1	<0.1	<0.2	3	<0.1	<1
19930915	Lake Claremore mid pt	<1	<0.1	<0.1	1	0.5	1.7	<0.1	<0.3	<0.1	<0.1	<10	<0.1	<0.1	<0.2	4	<0.1	<1

APPENDIX F

ALGAL DATA

ALGAL SAMPLE ANALYSIS
Lake Claremore
Date: 04/21/93
Tow Volume (ml): n/a
Depth: Epilimnion
Calc. Type: Phyto-Grab

Taxa	Division	GALD (μm)	Conc. Unit/ml	Rel% Conc.	Biov. (μM^3/U)	Rel% Biov.
Cyclotella sp	Diatom	9.5	1441.1	8.4	238.1	15.3
Dinobryon sp.	Chryso	33.0	17.4	0.1	189.0	0.1
Fragilaria sp.	Diatom	11.0	17.4	0.1	62.1	TR
Melosira sp.	Diatom	133.8	538.2	3.1	1829.6	43.8
Nitzschia sp	Diatom	66.0	17.4	0.1	165.5	0.1
Stephanodiscus sp.	Diatom	22.0	17.4	0.1	2842.0	2.2
Synedra sp.	Diatom	127.6	86.8	0.5	1036.7	4.0
Synura sp.	Chryso	16.9	191.0	1.1	422.8	3.6
Chrysococcus sp.	Chryso	4.0	225.7	1.3	34.3	0.3
Ankistrodesmus sp.	Chloro	26.1	295.2	1.7	25.0	0.3
Carteria sp.	Chloro	13.8	34.7	0.2	483.4	0.7
Chlamydomonas sp.	Chloro	8.4	52.1	0.3	100.2	0.2
Gonium sp.	Chloro	27.5	17.4	0.1	1392.2	1.1
Scenedesmus sp.	Chloro	11.0	17.4	0.1	100.3	0.1
Selenastrum sp. (?)	Chloro	8.8	17.4	0.1	44.6	TR
Stigeoclonium sp.	Chloro	11.0	17.4	0.1	112.8	0.1
Non-motile chlorococcales	Chloro	4.4	34.7	0.2	44.6	0.1
Lagerheimia sp.	Chloro	13.8	34.7	0.2	13.1	TR
Cryptomonas sp.	Crypto	23.8	486.1	2.8	1145.9	24.8
Rhodomonas sp.	Crypto	8.8	416.7	2.4	55.8	1.0
Non-motile blue-greens	Cyano	1.1	11459.1	66.7	0.7	0.4
Gymnodinium sp.	Dinofl	13.9	52.1	0.3	503.0	1.2
Misc. micros, 1 flagellum	Misc.	2.2	34.7	0.2	5.6	TR
Misc. micros, 2 flagella	Misc.	2.2	1666.8	9.7	5.6	0.4

ALGAL SAMPLE ANALYSIS
Lake Claremore
Date: 06/15/93
Tow Volume (ml): n/a
Depth: Epilimnion
Calc. Type: Phyto-Grab

Taxa	Division	GALD (μm)	Conc. Unit/ml	Rel% Conc.	Biov. (μM³/U)	Rel% Biov.
Cyclotella sp.	Diatom	5.5	1284.8	5.0	45.7	2.4
Melosira sp.	Diatom	148.5	1024.4	4.0	2222.1	91.7
Stephanodiscus sp.	Diatom	16.5	17.4	0.1	1198.9	0.8
Chrysococcus sp.	Chryso	3.3	17.4	0.1	18.8	TR
Ankistrodesmus sp.	Chloro	28.9	260.4	1.0	23.2	0.2
Crucigenia sp.	Chloro	11.0	34.7	0.1	91.4	0.1
Oocystis sp.	Chloro	11.0	34.7	0.1	100.2	0.1
Scenedesmus sp.	Chloro	6.6	34.7	0.1	50.2	0.1
Selenastrum sp. (?)	Chloro	4.4	34.7	0.1	12.5	TR
Stigeoclonium sp.	Chloro	16.5	17.4	0.1	112.8	0.1
Colonial chlorophyta - type	Chloro	33.0	17.4	0.1	1202.9	0.8
Non-motile chlorococcales	Chloro	4.4	34.7	0.1	44.6	0.1
Lagerheimia sp.	Chloro	22.0	17.4	0.1	89.1	0.1
Anabaena sp.	Cyano	92.7	69.4	0.3	924.4	2.6
Oscillatoria sp.	Cyano	46.6	69.4	0.3	48.8	0.1
Non-motile blue-greens	Cyano	1.1	21876.5	85.7	0.7	0.6
Misc. micros, 2 flagella	Misc.	2.2	677.1	2.7	5.6	0.2

ALGAL SAMPLE ANALYSIS
Lake Claremore
Date: 09/28/93
Tow Volume (ml): 232
Depth: Pooled Epilimnion
Calc. Type: Phyco-Net

Taxa	Division	GALD (μm)	Conc. Unit/ml	Rel% Conc.	Biov. (μM^3/U)	Rel% Biov.
Cyclotella sp.	Diatom	8.6	5625.4	10.5	175.8	4.0
Melosira sp.	Diatom	134.8	5625.4	10.5	3261.5	73.4
Nitzschia sp.	Diatom	66.0	833.4	1.6	196.5	0.7
Stephanodiscus sp.	Diatom	19.8	312.5	0.6	2071.8	2.6
Synedra sp.	Diatom	99.0	104.2	0.2	993.0	0.4
Actinastrum sp.	Chloro	28.6	104.2	0.2	340.7	0.1
Coelastrum sp.	Chloro	11.0	104.2	0.2	44.6	TR
Dictyosphaerium sp.	Chloro	22.0	208.3	0.4	445.5	0.4
Scenedesmus sp.	Chloro	13.8	312.5	0.6	167.2	0.2
Anabaena sp.	Cyano	33.4	1145.9	2.1	857.9	3.9
Anabaenopsis sp.	Cyano	29.3	312.5	0.6	831.6	1.0
Chroococcus sp.	Cyano	11.0	104.2	0.2	75.2	TR
Lyngbya sp.	Cyano	33.0	625.0	1.2	47.0	0.1
Merismopedia sp.	Cyano	18.3	520.9	1.0	133.7	0.3
Oscillatoria sp.	Cyano	99.0	5417.0	10.1	336.7	7.3
Gomphosphaeria sp.	Cyano	17.6	1145.9	2.1	91.9	0.4
Non-motile blue-green	Cyano	1.1	30731.2	57.2	0.7	0.1
Trachelomonas sp.	Euglen	19.8	312.5	0.6	4059.7	5.1
Misc. micros, 2 flagella	Misc.	2.2	208.3	0.4	5.6	TR

APPENDIX G

ZOOPLANKTON DATA

Zooplankton Abundance (organisms/liter) in Lake Claremore

Zooplankton	04/21/93	06/15/93	09/28/93
Copepoda			
Calanoids*	4.7	4.8	15.0
Cyclopoids	18.0	7.9	14.0
nauplius larvae	36.0	30.0	65.0
Cladoceran			
Bosmina	6.8		
Daphnia	16.0	7.2	2.3
Chydorids	0.3		
Diaphanosoma			2.7
Leptodora			<0.4
Rotifers	common	common	common

Zooplankton Length (mm) in Lake Claremore

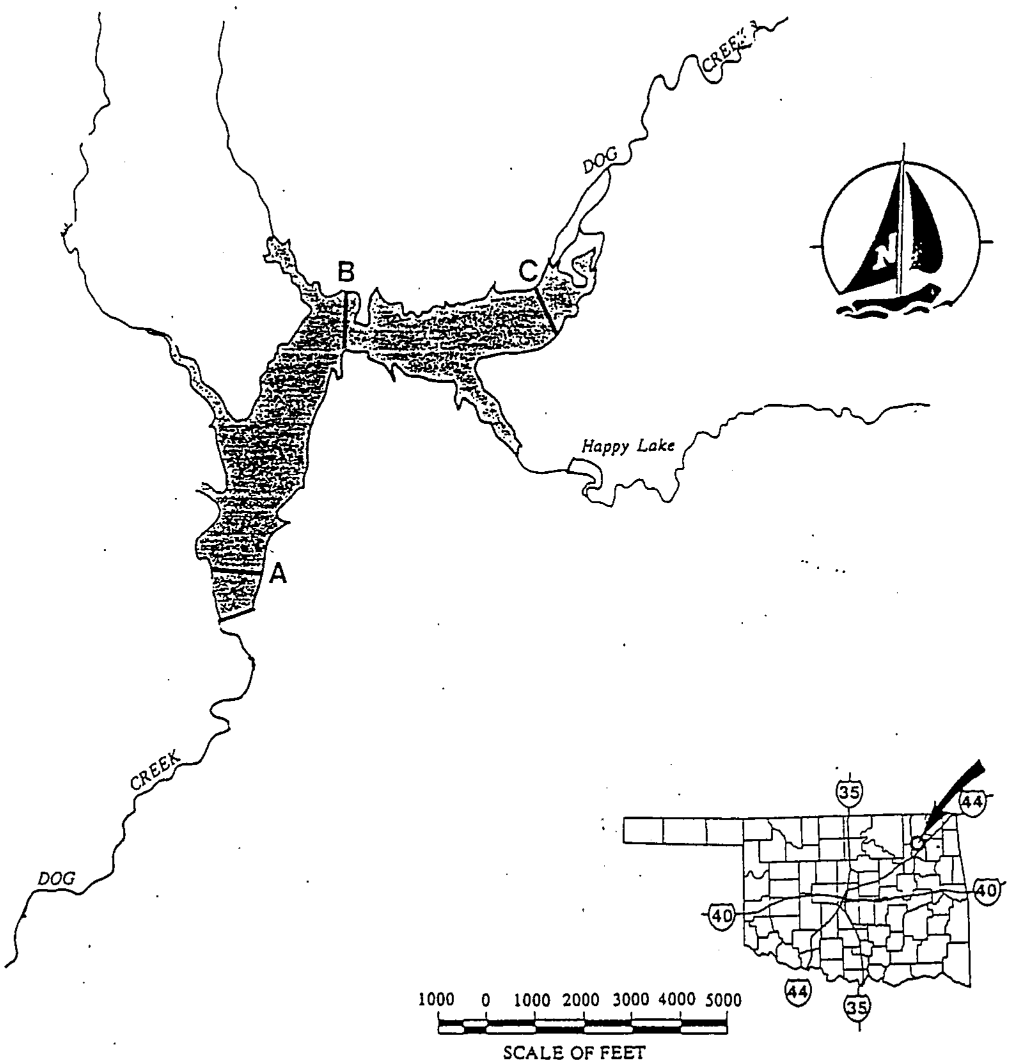
Zooplankton	06/15/93 Mean	06/15/93 Std. Dev.	09/28/93 Mean	09/28/93 Std. Dev.
Copepoda				
Calanoids*	0.61	0.23	0.77	0.32
Cyclopoids	0.57	0.29	0.61	0.22
Cladoceran				
Daphnia	0.97	0.45	0.68	0.21
Diaphanosoma			0.73	0.24
Leptodora			1.90	N/A

* *Probably Diaptomus*

APPENDIX H

MAP SHOWING LOCATIONS OF
BENTHIC MACROINVERTEBRATE
COLLECTIONS

CLAREMORE LAKE



APPENDIX I

BENTHIC MACROINVERTEBRATE DATA

Benthics Collected at Lake Claremore

Phyllum	Class	Order	Family	Subfam/Tribe/Genus	Tolerance*
Aschelminthes	Nematoda				
Annelida	Oligochaeta		Tubificidae	Tubifex	T
				Limnodrilus	T
				Branchiura	T
				Aulodrilus	T
			Naididae	Pristina	T
	Hirudinea		Glossiphoniidae	Helobdella	T
Mollusca	Pelecypoda		Sphaeriidae	Pisidium	T
Arthropoda	Insecta	Ephemeroptera	Ephemeridae	Hexagenia	I
		Megaloptera	Sialidae	Sialis	I
		Diptera	Ceratopogonidae		T
			Chironomidae	Tanypodinae	T
				Chironomini	T

* *Tolerance classifications of T (tolerant) and I (intolerant) are from Hilsenhoff's FBI and Beck's Biotic Index.*

Benthic Abundance (orgs./sq. ft.) and Frequency in Lake Claremore

Fam/Subfam/ Tribe/Genus	Lacustrine Zone	Transition Zone	Riverine Zone	Average Abundance	Frequency**
Tubifex	0.0	0.4	0.4	0.3	13%
Limnodrilus	30.4	2.0	0.5	11.0	50%
Branchiura	2.1	1.2	2.6	2.0	60%
Aulodrilus	1.1	1.8	1.3	1.4	37%
Pristina	0.2	0.0	0.0	0.1	7%
Helobdella	0.3	0.1	0.3	0.2	10%
Pisidium	0.1	0.1	0.5	0.2	10%
Hexagenia	0.0	0.0	0.2	0.1	3%
Sialis	0.1	1.0	2.2	1.1	27%
Ceratopogonidae	0.1	1.7	2.8	1.5	40%
Tanypodinae	18.3	51.5	145.3	71.7	97%
Chironomini	3.7	1.5	0.7	2.0	60%

** *Frequency indicates the percent of samples where each organism was found.*

APPENDIX J

BACTERIOLOGICAL DATA

CLAREMORE LAKE BACTERIOLOGICAL DATA

SITE	DATE	FECAL	STREP
Dog Cr Below Dam	15-Jun-93	50	
Dog Cr Below Dam	12-Jul-93	<600	
Dog Cr Below Dam	27-Jul-93	50	
Claremore Dam	19-May-93	280	640
Claremore Dam	15-Jun-93	<100	
Claremore Dam	12-Jul-93	<10	
Claremore Dam	27-Jul-93	<10	
Claremore Dam	17-Aug-93	<10	
Claremore Dam	31-Aug-93	30	
Claremore Dam	15-Sep-93	<10	
Claremore Mid Pt	19-May-93	450	620
Claremore Mid Pt	12-Jul-93	<10	
Claremore Mid Pt	27-Jul-93	<10	
Claremore Mid Pt	17-Aug-93	10	
Claremore Mid Pt	31-Aug-93	50	
Claremore Mid Pt	15-Sep-93	10	
Claremore Upper End	19-May-93	220	670
Claremore Upper End	15-Jun-93	100	
Claremore Upper End	27-Jul-93	<10	
Claremore Upper End	17-Aug-93	<10	
Claremore Upper End	31-Aug-93	<10	
Claremore Upper End	15-Sep-93	470	
Dog Cr	19-May-93	1600	650
Dog Cr	15-Jun-93	<100	
Dog Cr	12-Jul-93	110	
Dog Cr	27-Jul-93	50	
Dog Cr	17-Aug-93	30	
Dog Cr	31-Aug-93	330	
Dog Cr	15-Sep-93	<600	
Little Dog Cr	19-May-93	470	570
Little Dog Cr	15-Jun-93	100	
Little Dog Cr	12-Jul-93	260	
Little Dog Cr	27-Jul-93	20	
Little Dog Cr	15-Sep-93	<600	

APPENDIX K

STREAM DATA

Base flow concentrations in Little Dog Creek near Sequoyah, 1993-94

Date	Temp. C	D.O. mg/l	Cond. uS/cm	pH S.U.	Alk mg/l	Turb. NTU	Hard. mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	TN mg/l
04/21/93	15.5	9.7	194	7.8	37	17	64	5.2	149	7	42	0.03	0.20
05/12/93	13.5	9.6	139	7.7			46	2.7	153	22	27	0.04	0.37
05/19/93	14.5	8.7	184	7.2	35	24	61	3.1	141	9	28	0.02	0.41
06/02/93	18.5	7.7	264	8.0	44	5	92	6.7	182	4	60	<0.01	<0.2
06/15/93	22.0	6.7	278	7.7	46	7	96	7.1	152	<1	61	<0.01	<0.2
07/12/93	24.0	5.3	291	7.7	54	7	46	7.5	190	<1	63	0.02	0.08
07/28/93	23.5	4.5	311	7.3	64	9	110	8.2	211	20	62	0.01	<0.2
08/17/93	25.5	1.0	250	6.9	111	15	110	8.1	214	25	10		
09/15/93	15.5	9.3	193	6.7	32	29	65	4.5	128	24	50	0.05	0.44
09/28/93	17.0	8.3	252	7.0	46	6	95	6.8	144	1	58	0.01	0.09
10/19/93	16.0	6.9	273	6.9	56	5	102	8.0	174	11	44	0.09	0.10
11/09/93	9.3	7.3	333	7.1	6	5			208	2	82	0.06	0.20
12/22/93	4.0	12.5	265	7.5	46	4	103	10.5	176	<2	62	<0.01	0.21
01/27/94	7.1	9.8	209	7.7	38		74	9.0	167	15	54	0.25	0.50
02/24/94	5.6	11.7	195	7.7	35	26	68	12.0		12	42	0.08	0.21
03/23/94	14.8	10.5	193	7.7	33	9	94	8.5		16	59	0.15	0.11
Average	15.4	8.1	239	7.4	46	12	82	7.2	171	10	50	0.06	0.21

Storm flow concentrations in Little Dog Creek near Sequoyah, 1993-94

Date	Temp. C	D.O. mg/l	Cond. uS/cm	pH S.U.	Alk mg/l	Turb. NTU	Hard. mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	TN mg/l
09/13/93							72	5.4	5220	3340	38	0.33	1.40
01/26/94							75	9.0	172	21	55	0.17	0.60
02/22/94							56	7.0			<5	0.07	3.65
03/09/94							50	4.0	114	155	<5	0.28	2.26
Average							63	6.4	1835	1172	21	0.21	1.98

Base flow concentrations in Dog Creek near Sequoyah, 1993-94

Date	Temp. C	D.O. mg/l	Cond. uS/cm	pH S.U.	Alk. mg/l	Turb. NTU	Hard. mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	TN mg/l
04/21/93	14.0	10.6	179	7.8	44	15	61	4.0	145	7	27	0.05	0.37
05/12/93	14.0	8.3	171	7.5	40	39	62	2.4	169	31	31	0.05	0.52
05/19/93	15.5	8.5	176	7.2	44	23	63	3.9	129	16	37	0.04	0.58
06/02/93	18.0	6.8	234	7.9	59	15	90	5.1	172	17	39	0.04	0.30
06/15/93	22.0	5.2	203	7.5	58	16	71	5.1	154	24	23	<0.01	<0.2
07/12/93	24.5	4.0	205	7.3	71	25	76	6.3	166	36	15	0.05	0.57
07/28/93	23.5	4.5	211	7.3		9	95	8.1	177	19	17	0.03	0.57
08/31/93	22.5	2.5	366	7.1	131	51	120	11.0	254	56	9		
09/15/93	17.0	7.7	145	6.8	49	50	55	5.0	152	38	18	0.07	0.65
10/19/93	15.9	5.0	201	6.9	68	23	76	8.0	138	33	10	0.07	0.41
11/09/93	9.4	6.0	207	7.2	68	21	66	5.0	120	9	11	0.10	0.34
12/22/93	3.7	11.0	201	7.5	53	1	73	10.0	137	4	29	0.02	0.27
01/27/94	8.4	8.3	261	7.6	53		90	11.0	205	133	67	0.10	1.40
02/24/94	4.2	11.9	183	7.8	36	25	70	11.0		15	29	0.09	0.68
03/23/94	14.3	9.9	158	8.4	52	11	74	8.4		19	30	0.11	0.06
Average	15.1	7.3	207	7.5	59	23	76	7.0	163	30	26	0.06	0.49

Storm flow concentrations in Dog Creek near Sequoyah, 1993-94

Date	Temp. C	D.O. mg/l	Cond. uS/cm	pH S.U.	Alk. mg/l	Turb. NTU	Hard. mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	TN mg/l
11/17/93			205				88	11.8	126	155	11	0.08	3.30
01/26/94							75	12.0	143	62	27	0.19	0.40
02/22/94							86	9.0			21	0.05	3.18
03/09/94							62	5.0	136	123	46	0.24	1.19
Average			205				78	9.5	135	113	26	0.14	2.02

Outflow concentrations (Dog Creek at Claremore), 1993

Date	Temp. C	D.O. mg/l	Cond. uS/cm	pH S.U.	Alk. mg/l	Turb. NTU	Hard. mg/l	Cl mg/l	TDS mg/l	TSS mg/l	SO4 mg/l	TP mg/l	TN mg/l
04/21/93	14.5	10.6	195	7.8	46	22	63	5.1	136	12	34	0.04	0.52
05/12/93	15.5	9.4	92	7.5	26	46	32	1.8		52	12	0.09	0.72
05/19/93	19.0	8.3	146	7.7	35	28	49	2.5	118	8	23	0.03	0.52
06/02/93	18.5	4.2	175	7.8	47	36	65	3.1	162	32	26	0.11	1.00
06/15/93	23.5	4.7	201	7.6	52	14	73	3.5	158	35	34	0.06	0.40
07/12/93	25.0	4.8	221	7.8	57	17	80	4.4	156	21	34	0.05	0.82
07/28/93	27.0	3.5	310	7.1	105	15	120	5.5	184	18	30	0.02	0.40
09/28/93	17.0	6.9	208	7.0	53	28	79	6.9	120	20	31	0.03	0.40
Average	20.0	6.6	194	7.5	53	26	70	4.1	148	25	28	0.05	0.60

APPENDIX L

DRAFT WORKPLAN FOR PHASE 2 OF TMDL FOR DOG CREEK AND CAT CREEK WATERSHEDS

Agency: Oklahoma Conservation Commission

In Cooperation With:

Office of the Secretary of Environment(OSE)
Oklahoma Water Resources Board (OWRB)
Indian Nations Council of Governments (INCOG)
Natural Resources Conservation Service (NRCS)
Rogers County Cooperative Extension
Rogers County Conservation District
City of Claremore
Dog Creek Watershed Conservation Association, Inc. (DCWCAI)
Department of Environmental Quality(DEQ)

Title: Phase 2 of TMDL for Dog Creek and Cat Creek Watersheds

Introduction:

Wasteload allocation studies conducted by the Indian Nations Council of Governments (INCOG) in 1988 and 1992 resulted in placement of Dog Creek on the State's 303(d) list as a high priority TMDL watershed. Severe dissolved oxygen stress within the lower segments of Dog Creek and Cat Creek indicate the need for non-point source controls and possible physical stream channel modification, in conjunction with advanced treatment improvements at the Claremore wastewater treatment plant (WWTP). INCOG has recently received 104(b)(3) funding to conduct Phase I of the TMDL which addresses land use characterization and identification of potential non-point sources. The Oklahoma Conservation Commission is completing a Phase I Clean lakes project on Claremore lake located in the middle of the watershed. Numerous nonpoint source contributions to the lake water quality problems have been identified. these problems include excessive nutrients from home septic system and animal waste, sediments, and metals from abandoned coal strip mines . This project will bring together in the TMDL an integrated watershed based approach to solve the water quality problems in Dog Creek and Claremore Lake. A partnership will be formed with INCOG, the Oklahoma Conservation Commission (OCC) and the Oklahoma Water Resources Board (OWRB) for Phase II of the TMDL. Phase II, to be funded under this grant, will consist of chemical and biological characterization of the Dog Creek and Cat Creek watersheds relating to non-point sources and pre-BMP implementation conditions, assessing any limitations in stream channel hydraulics that could be corrected to improve reoxygenation and aquatic community habitat, refinement of the original INCOG wasteload allocation model to account for non-point sources and physical limitations in stream hydraulics, and development of education programs for facilitating TMDL goals. Future phases will address implementation of demonstration projects to control non-point sources and stream channel modifications to improve aquatic community habitat.

Project Objectives:

There are four project objectives for this Phase II TMDL. The first objective will be to establish a biological and chemical sampling program, using the land use data gathered in Phase I, that will characterize non-point source loadings within the Dog Creek and Cat Creek watersheds. The sampling program will also establish the environmental conditions that exist prior to implementation of Best Management Practices (BMPs). This data will be used in Phase III to assess the effectiveness of BMP implementation and aquatic community habitat improvements.

The second objective will be to determine the physical channel hydraulic condition to assess the effects of NPS loads on the reaeration of the water column and limitations to aquatic community habitat diversity. This assessment will examine alternatives for stream channel improvements which will result in improved dissolved oxygen conditions and increased aquatic community diversity.

The third objective will be to use the information from the first two tasks to re-examine the original wasteload allocation model. The model will be re-calibrated using newly identified non-point source stressors and project future wasteload allocations based upon assumed improvements in non-point source reductions through BMP implementation and improved stream reaeration resulting from stream channel improvements.

The fourth objective will involve implementing education and citizen monitoring programs. Volunteer monitoring will be a valuable asset to accomplishing the first objective, while the education program will be most useful towards the end of the Phase II by smoothing the transition into Phase III, BMP implementation. The OWRB will use mail-outs accompanying items such as water bills, and newspaper / newsletter articles will be used to generate interest. These will be followed by training sessions and seminars on proper watershed management.

The Oklahoma Conservation Commission will be responsible for the first two objectives, INCOG will be responsible for the third objective, and the OWRB will be responsible for the fourth. These objectives address the 303(d) listed water quality problems of nutrient enrichment, D.O. and habitat alteration.

Completion of the Phase II TMDL under this grant will result in collection of quantitative chemical, biological, aquatic habitat and hydrological data. The third objective, the wasteload re-modeling, will result in the development of quantitative NPDES permit limits for the City of Claremore. There will be no BMP implementation funded with this grant. BMP implementation is planned for Phase III which will be funded under a future grant.

The OCC, as lead agency, will develop the overall project management plan. The results of the chemical, biological, habitat and hydrologic data collection will be analyzed by OCC, with assistance established through cooperative agreements with INCOG, OWRB, the

Rogers County Conservation District and the Rogers County Extension Service . The evaluation will be consistent with the goals of the overall Phased TMDL for the watersheds. The education programs implemented by the OWRB will improve the success of implementing BMPs under Phase III of the TMDL.

Project Area Description:

The Dog Creek watershed is located almost entirely in Rogers County of northeastern Oklahoma. The watershed is part of the Central Irregular Plains Ecoregion. The land use in this ecoregion is predominately as cropland and grazing land (Omernik 1987). Major waterbodies within the watershed include Dog Creek, Little Dog Creek, Lake Claremore, Cat Creek, Panther Creek, and Otter Creek. Lake Claremore is located near the mid-point of the watershed on Dog Creek (downstream of Little Dog Creek confluence). The area above the dam is approximately 36,760 acres. Land use in the Lake Claremore's watershed is primarily pasture, oak/hickory forest, and urban ranchettes. A portion of the upper watershed has been strip mined. Two major highways, historic U.S. Highway 66 and the Will Rogers Turnpike (Interstate Highway 44) traverse the watershed.

Most of the 1992 INCOG study area on lower Dog Creek is characterized by dense woods and thick underbrush. Dog Creek itself is fairly uniform throughout the INCOG study reach with silted sandy clay sediments, occasional log jams, numerous fallen trees, thick over story of tree canopy along its banks, and extensive shallow pooling with only an occasional short riffle. The lower Cat Creek study segment is very similar to the middle reaches of Dog Creek. The effluent tributary begins at the Claremore treatment plant as an open channel with no tree canopy. From its crossing at the turnpike to a small pond, stream flows become more shallow and slow through thick forest and dense tree canopy. Stream bed sediments are mostly silt with large accumulations of detritus.

The land use patterns along the lower portion of Doc Creek are characterized by mostly agricultural cultivation (mostly grains, hay and soybeans) and cattle ranching. There are scattered rural residences along the study reach and a single small subdivision . Lower Dog Creek is characterized by dense riparian tree canopy and long meandering pools with no noticeable flow during dry summer conditions.

A map or the project area is attached.

Project Activities:

The first activity of this project is to formalize the commitments of INCOG, OWRB and the OCC to accomplish the following tasks. This project is intended to be a cooperative effort between INCOG , OWRB and the OCC. The cooperative agreement will establish the roles and responsibilities of each agency , a frame work for interagency coordination and billing procedures for the work performed. Agency responsibilities are still general in nature with

OCC providing project management for the work program and field work. INCOG will be the technical lead for this project for the stream model and TMDL waste load and load allocations. OWRB is responsible for coordinating education activities within the watershed, volunteer monitoring and public participation developing an watershed based resource conservation plan.

The major activity required of this project is to characterize non-point source loadings within the Dog Creek and Cat Creek watersheds. The sampling program will also establish the environmental conditions that exist prior to implementation of Best Management Practices (BMPs). This data will be used in Phase III to assess the effectiveness of BMP implementation and aquatic community habitat improvements. The OCC will conduct a stream riparian area and instream habitat assessment for selected reaches. This survey will also help to identify problem areas within the watershed. All riparian and instream habitat data will be entered in the OCC GIS. These data in GIS will facilitate targeting areas for BMP implementation. Two years of monthly low flow samples and at least two high flow events will be collected at four core sites. Quarterly samples will be taken at several additional sites on Dog and Cat Creeks and a reference stream. On each sampling event field parameters will be assessed and samples will be analyzed at contract laboratory for CBOD 5, 20, ammonia -N, Nitrate- N, Nitrite - N, Total P, Ortho P, Fecal Coliform, Chlorophyll a, TSS, Sulfate, periphyton Chlorophyll a, hardness and alkalinity. Two years biological monitoring consisting of annual fish collections and quarterly benthic macroinvertebrate collections to assess attainment of beneficial uses and improvements in water quality will be conducted at the core sites and reference stream. Periphytometers will be set at the core sites to monitor stream productivity. Diurnal dissolved oxygen profiles will be monitored over two 24 hour periods at four sites each summer at the core sites and reference stream. To characterize the hydrological condition of the stream , a time of travel study will be conducted. A Quality Assurance Project Plan (QAPP) will be written as is customary for all environmental monitoring activities. With development of Data Quality Objectives the aforementioned sampling plan will be further defined.

The TMDL model developed for this study will be a modification of the 1992 INCOG wasteload allocation model for the Claremore wastewater treatment plant (WWTP). This model addressed the lower segments of Cat Creek and Dog Creek. These areas are the only significant portions of the watershed that have flow during hot and dry seasons (critical conditions). The purpose of the TMDL model is to develop final wasteload allocations for the City of Claremore's WWTP which will be incorporated into their NPDES discharge permit.

The TMDL model will use data from Phase I and Phase II of the TMDL study concerning non-point source nutrient and oxygen-demand loadings. INCOG will use the non-point source data to re-calibrate the 1992 INCOG model by imputing non-point oxygen-demand loads into the appropriate model segments. Setting final wasteload allocations for future conditions will be performed by assuming a significant reduction in non-point source loads due to successful education programs and implementation of best management practices

(BMPs). If stream channel improvements are recommended for improving aeration, then the positive impacts of these improvements can be quantified and incorporated into the TMDL model.

The Oklahoma Water Resources Board will perform activities related to the development of a Natural Resource Management Plan (NRMP) for the *Dog Creek Basin* and will utilize volunteer monitoring procedures to supplement data collection activities conducted by the Conservation Commission. The Natural Resource Management Plan for the *Dog Creek Basin* will involve cooperative efforts between the resource stakeholders in the basin, the public and local/state governmental entities. Local "buy in" within the basin is essential for successful implementation of Best Management Practices (BMPs). Through the NRMP process the public can provide input into the management process. Numerous educational projects for teachers and volunteer monitoring training sessions will be implemented as part of the proposed project.

Project Management:

This proposal is a joint venture between the Oklahoma Conservation Commission (OCC), the Oklahoma Water Resources Board (OWRB) and the Indian Nations Council of Governments (INCOG). The OCC will act as lead agency, and OCC and INCOG will together receive $100,000 for conducting their portion of the Phase II. The OWRB will receive $50,000 for implementing the education and citizen monitoring programs to support the TMDL. Lead and supporting agency roles are defined below:

OCC
The OCC will act as Lead Agency and provide overall project management. The OCC will prepare a QA Project Plan and field activities scope needed to achieve project objectives. The OCC will conduct field activities and prepare project reports in conjunction with OWRB and INCOG. The OCC will complete the Phase I Clean Lakes project for Claremore Lake. Data from this report will be useful in developing the TMDL Phase II activities. The OCC will receive 319(h) federal funds and state funds for match.

INCOG
INCOG will assist the OCC and other participants, as needed, with QAPP, field and data activities. INCOG will provide to OCC their Phase I TMDL data to assist with developing sampling plans. INCOG will receive 319(h) federal funds and provide in-kind services as match. INCOG will develop the TMDL using an existing QUALTX model of the system from a 1992 INCOG wasteload allocation study.

OWRB
The OWRB will implement an educational and citizen monitoring program via the Oklahoma Water Watch Program to support the TMDL. The OWRB will assist the OCC in preparing the QAPP, and will administer the NRMPC. The OWRB will receive 319(h) funds.

DCWCAI

The Dog Creek Watershed Conservation Association, Inc. (DCWCAI) will provide information about the watershed, as needed, and provide local community support and involvement.

DEQ

The Oklahoma Department of Environmental Quality as the state regulatory agency will take part in this project in this capacity. The DEQ will review the final waste load allocations developed by INCOG and the data and models used to derive the TMDL. The DEQ will also participate in the development and review of the Data Quality Objectives of this project.

Measures of Success:

One measure of success will be the approval of the final TMDL modeling report which will provide final wasteload allocations for the Claremore WWTP. This report will form the basis of setting NPDES permit limits for this facility. Another measure of success will be the improved dissolved oxygen conditions in lower Cat Creek and lower Dog Creek. The purpose of the TMDL is to implement programs that will result in full attainment of dissolved oxygen water quality standards within the two watersheds. Another measure of success will be the successful integration of water quality educational programs within the Claremore area community. Measures of success for the educational and volunteer programs follow:

- 250 individuals will be educated by the OWRB
- 50 monitors will be trained to collect water quality data, verify land-use patterns, and perform routine monitoring in the basin
- 25 workshops/meetings will be conducted
- A Natural Resource Management Plan will be developed
- Surveys as well as follow-up meetings will be conducted to determine the effectiveness of the OWRB educational program

Project Milestones:

Cooperative Agreement. The first task of this project is to formalize the commitments of INCOG OWRB and the OCC to accomplish the following tasks.	September 1996
Quality Assurance Quality Control Project Plan will be written as is customary for all environmental monitoring activities.	October 1996
Stream habitat assessment completed	August 1997
Stream biological assessments completed	November 1998
Stream Water Quality Monitoring completed	November 1998
Stream hydrological Assessment completed	September 1997
Development of TMDL Model and Report by INCOG.	May 1999
Contact basin stakeholders for inclusion in the NRMP Working Group	September 1996
Initial NRMP Working Group meeting to discuss basin priority needs with stakeholders	June 1997
NRMP Working Group meeting to discuss priorities and determine format for document	November 1997
300 individuals trained/educated as part of Education/Volunteer Monitoring programs	October 1998
NRMP Working Group meeting to discuss BMPs for Phase III implementation procedures	June 1998
NRMP Working Group meeting to initiate work on the NRMP draft document -	October 1998
Review of the NRMP draft document	February 1999
Presentation of final NRMP document	May 1999

Project Tasks:

	Task:	Total Resource Allocation:
1.	**Cooperative agreement and interagency coordination.** The first task of this project is to formalize the commitments of INCOG OWRB and the OCC to accomplish the following tasks. This project is intended to be a cooperative effort between INCOG and the OCC. The cooperative agreement will establish the roles and responsibilities of each agency. Interagency coordination will be an ongoing task throughout the life of the project.	$ 11,000
2.	**Quality Assurance Project Plan,** to be written for all data collection activities.	$ 1,000
3.	**Nonpoint source load characterization and stream monitoring.**	
	Stream riparian area and instream habitat assessment	$ 8,000
	Biological monitoring (fish and benthic macroinvertebrate collections)	$ 12,000
	Water quality monitoring	$ 82,000
	Time of travel study	$ 4,666
	Data entry and reporting	$ 15,000
4.	Development of TMDL Model and Report by INCOG.	$ 33,000
5.	**NRMP**	
	Contact resource user groups, municipal authorities and state resource management agencies from the area inviting their participation in the NRMP Working Group	$ 2,500
	Convene NRMP Working Group and begin Problem Solving Process	$ 2,500
	Identify and select problems to be addressed by NRMP Working Group	$ 3,500
	Analyze/Refine problem statement and collect information for NRMP Working Group	$ 8,500

Generate potential solutions for inclusion in Management Plan -	$ 10,200
Utilize "Natural Resource Management Evaluation Matrix" to determine viable management solutions	$ 9,100
Evaluate solutions by the NRMP Working Group	$6,700
Convene meeting of working group to select solutions to be included in the draft NRMP	$2,400
Write draft NRMP document and seek review by all concerned parties	$12,000
Conduct public meeting to discuss NRMP	$1,600
Write Final NRMP document	$7,600

6. **OWRB Volunteer Monitoring/Educational Program**

Solicit groups for participation in education program and volunteer monitoring training/education program	$2,100
Conduct Phase I training of Volunteer Monitors to collect supplemental water quality data for OCC monitoring program	$2,600
Conduct Phase II training of Volunteer Monitors under field conditions to verify understanding of sampling procedures	$2,600
Conduct Phase III Volunteer Monitor training at volunteers sample site. Sample sites will be determined through consultation with OCC personnel. Sampling will occur at least once a month through the life of the project.	$3,100
Conduct Education program for area teachers and other interested parties	$2,116
Conduct second educational session for teachers/public	$2,116
Generate or acquire educational material to distribute to the public	$901
Conduct Quality Control Assessments as needed to assure collection of high quality data	$1,200

Outputs:

1.	Quarterly reports	
2.	Annual reports	
3.	Cooperative Agreement	September, 1996
4.	QAPP	October, 1996
5.	Nonpoint source characterization and water quality summary report	February, 1999
6.	TMDL model report	May, 1999
7.	Final Natural Resource Management Plan document	May, 1999

Project Duration:

Three years

Resource Allocation:

Federal	$ 150,000
State	100,000
Total	250,000

Supply List for the Phase 2 of TMDL for Dog Creek and Cat Creek Watersheds

Sharpie Waterproof Pens 6 Boxes	$71
Log Books (K & E Water Resistant 10 Books)	$146
Ice Chests (5)	$100
Chain of Custody Forms	$229
Seine Net	$50
alkalinity kit	$150
Dip net	$40
vacuum pump	$701
Fluorescent dye	$100
Benthic Kick Net	$95
Ethyl Alcohol (30 Gal)	$244
Formaldehyde (5 Gal)	$146
Conductivity Solution 8 Qts.	$64
Ph Solution (10.0) 8 Qts.	$64
pH Solution (7.0) 8 Qts	$64
Bromcresol Green-Methyl Red Indicator	$68
pH meter	$700
turbidity meter	$1,050
DO meter	$1,200
Conductivity Probes - 3	$190
pH Probes - 3	$245
Dissolved Oxygen Probe	$621
Electrode Storage Solution 6 Liters	$43

Standards for Spikes: Chloride 6 Pack	$114
Nitrogen (150 Mg/L) 6 Pack	$117
Nitrogen (500 Mg/L) 6 Pack	$117
Sulfate (2500 Mg/L) 6 Pack	$117
Phosphate (250 Mg/L) 6 Pack	$117
Sulfuric Acid	$397
Assorted Bottles and Caps:	$640
Total supplies	$8,000

Staffing List for the Phase 2 of Tmdl for Dog Creek and Cat Creek Watersheds

Position	Person Years	Resource Allocation
Wq Program Director	.06	$2,930
Wq Programs Assistant Director	.12	$5,200
Senior Biologist	.25	$10,400
Engineer/Modeler	.075	$3,111
Field Water Quality Specialist	1.5	$36,438
Technical Writer/Qa Officer	.25	$8,965
Water Quality Specialist	.125	$3,398
		$70,442

Contract expense	
INCOG Task 4	33000
OWRB Tasks 5 and 6	83333
Contract laboratory water sample analysis	23667
Total Contract	140000