PHASE I CLEAN LAKES PROJECT

DIAGNOSTIC AND FEASIBILITY STUDY OF

LAKE SKIPOUT

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EXECUTIVE SUMMARY

Lake Skipout is a heavily used recreational lake located in the Black Kettle National Grasslands of western Oklahoma. Because of documented hypereutrophic conditions and fish kills this §314 Clean Lakes Project was initiated. Excessive nutrient loading from the watershed has resulted in high nutrient concentrations in the lake and hypereutrophication. Landuse in the watershed is made up of range, pasture, and cropland. In addition, 12 homes and a dairy are located in the watershed. Therefore, the primary sources of nutrients are assumed to be from cattle manure, fertilizer, improperly treated sewage, and soil erosion. In addition, beaver, which inhabit portions of the stream, may be a minor source of nutrients.

Macrophytes encompass three quarters of the lake shoreline and pollution tolerant blue-green and euglenoid algae dominate the water column. The lake is relatively shallow and only stratifies during calm, hot periods. Although thermal stratification is generally weak and short lived, it has a considerable impact on the biotic integrity of the lake. During the short periods that the lake stratifies, the dissolved oxygen in the bottom 1-2 m of the water column is depleted to concentrations of less than 2 mg/l. This has severely impacted the benthic macroinvertebrate community.

Due to the high evaporation rate and low runoff rate in this region, the lake has a long retention time. This and the shallowness of the lake make it more susceptible to eutrophication. Because of the long retention time, the lake serves as a sink for nutrients. Because shallow lakes have greater sediment/water contact, nutrient recycling from the sediments occurs (EPA 1990). Because of this, reducing nutrient loading to the lake may not have a significant impact on its trophic state. Despite this, it is recommended that nutrient loading be reduced as much as possible. A lake response model used in the study predicted that the phosphorous loading would need to be reduced by 9% to achieve a eutrophic state, 55% to achieve a mesotrophic state, and 82% to achieve an oligotrophic state.

The introduction of gizzard shad has also impaired the quality of the lake. Analysis of the zooplankton community indicated an overabundance of these planktivorous fish. This has reduced the zooplankton's ability to efficiently filter algae from the lake. The gizzard shad have also replaced the bluegill, longear sunfish, and crappie as the primary forage base in the lake. Analysis of the fish community indicated that the bluegill, longear sunfish, crappie, gizzard shad, and saugeye populations were in poor condition. However, the conditions of the largemouth bass and channel catfish populations are good.

In order to improve and protect the water quality in Lake Skipout, algal productivity (trophic state) should be reduced and the gizzard shad population should be eradicated or actively managed. Reducing phosphorous loading to the lake through the implementation of best management practices provides the most feasible alternative for reducing the trophic state. It is also recommended that all septic systems within the watershed be inspected to determine if they are functioning properly, and those not functioning properly be repaired. Intensive management of the gizzard shad population through the stocking of predator fish and/or treatment with rotenone could provide numerous benefits such as an improved fishery and potentially less algae.

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LAKE SKIPOUT DIAGNOSTIC STUDY

I.1 Lake Identification and Description

Lake Skipout (OK 310840-02-0230) is a federally owned impoundment located within the Black Kettle National Grasslands at Section 5, Township 13N, Range 25W (Latitude 35º 38'15" and Longitude 99º 53'5"). It is situated approximately 13 miles west of Cheyenne, Oklahoma in Roger Mills County (Figure 1). The lake is managed and administered by the U.S.D.A. Forest Service. The lake (Floodwater Retarding Dam No. 53) was constructed in 1960 by the U.S. Soil Conservation Service [now the Natural Resources Conservation Service (NRCS)] in cooperation with the Upper Washita Soil Conservation District as part of the Upper Washita River Watershed Project to provide flood control. The Upper Washita Soil Conservation District maintains the facility in an effort to enhance soil conservation in the watershed. The lake covers 47 acres (OWRB 1990) and has a storage capacity of 570 acre-feet. Two unnamed tributaries to Rush Creek flow into the lake from the south. The *Small Lakes Trophic State Report* (OCC 1994) identified Lake Skipout as hypereutrophic. U.S. Forest Service and Oklahoma Department of Wildlife Conservation (ODWC) officials have been documented fish kills in Lake Skipout. These fish kills are likely related to the lake’s hypereutrophic environment. The ODWC oversees fish and wildlife concerns.

I.2 Geological Description of Drainage Basin

Lake Skipout and its watershed are located in the Central Great Plains Ecoregion. The vegetation in this ecoregion is generally composed of bluestem, grama, and buffalo grass prairie (Omernik 1987). The landscape of the watershed consists mostly of rolling plains. The elevation in the watershed ranges from approximately 2247 to 2526 feet (685-770 m) above mean sea level.

The soils are generally sandy, developed or modified by wind, highly erodible, and require special management such as protection from wind and crop rotation with soil improving crops (Table 1). However, only those soils located on highly sloping terrain are considered highly erodible by water.

There are two major soil associations within the Lake Skipout watershed (Table 1), the Nobscot-Brownfield association and the Miles-Springer association. These associations encompass 94% of the watershed. The Nobscot-Brownfield association is composed largely of Nobscot and Brownfield fine sands. The minor soils in the Nobscot-Brownfield association are Miles fine sandy loams, Springer loamy fine sands, eroded Nobscot and Brownfield soils, eroded sandy land, and Zavala fine sandy loam. In the Miles-Springer association, Miles and Springer soils are dominant, but small areas of eroded sandy land are included (SCS 1959).

Figure 1. Location of sampling sites for Lake Skipout Clean Lakes Project, 1993-94.

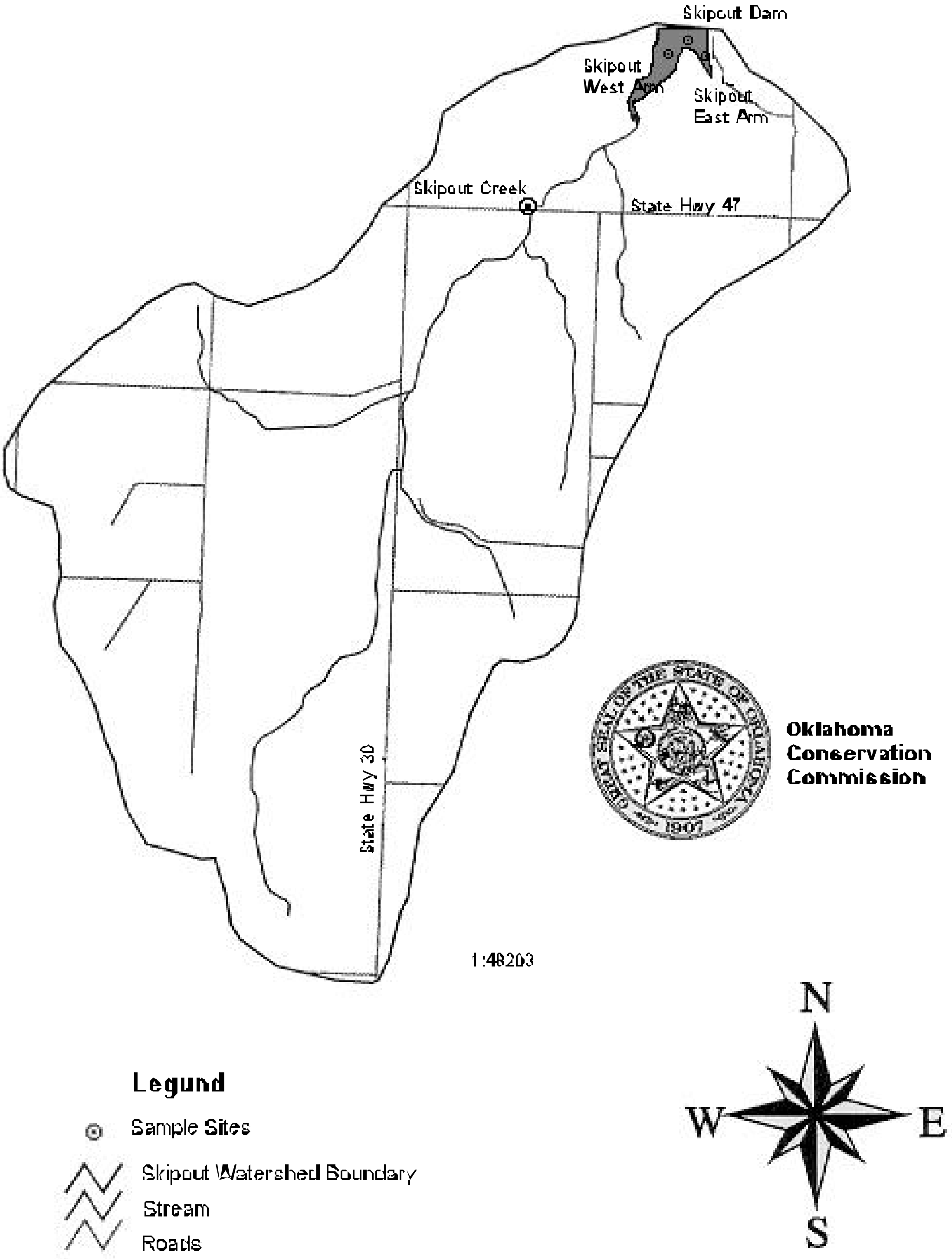


Table 1. Soils in Lake Skipout watershed.

Soil Name	Erodibility	Acres
Pratt Loamy Fine Sand, Undulating	H (wind)	148
Pratt Loamy Fine Sand, Hummocky	H (wind)	10
Nobscot Fine Sand, 0-4% Slopes	H (wind)	554
Nobscot and Brownfield Fine Sands, 0-4% Slopes	H (wind)	1829
Nobscot and Brownfield Fine Sands, 4-8% Slopes	H (wind)	1028
Nobscot and Brownfield Soils, Eroded	H (wind)	168
Eroded Sandy Land (Nobscot)	H (wind)	1018
Miles Fine Sandy Loam, 1-3% Slopes	H (wind)	178
Miles Fine Sandy Loam, 3-5% Slopes	H (wind)	168
Miles Fine Sandy Loam, 5-8% Slopes	H (wind)	445
Miles-Nobscot Complex, 5-8% Slopes	H (wind)	208
Miles-Nobscot Complex, 8-15% Slopes	H (wind/water)	692
Miles-Springer Complex, 3-5% Slopes	H (wind)	20
Zavala Fine Sandy Loam	H (wind)	129
Lincoln Soils	H (wind)	59
Sweetwater Soils	H (wind)	30
Water		30
TOTAL		**6714**

The geological stratification of the area consists of the Ogallala formation, the Cloud Chief formation, and the Rush Springs sandstone. The Ogallala formation consists of approximately 350 feet of fine to medium grained, quartzose, gray to light brown to white sands with some gravels, silts, clays, caliche, and mortar beds. The Cloud Chief formation, located just beneath the Ogallala formation, consists of 175-400 feet of red-brown to orange-brown shale with siltstone and sandstone in the middle, and much gypsum and some dolomite near the base. The Rush Springs sandstone formation, located just beneath the Cloud Chief formation, consists of 250-300 feet of fine-grained, orange-brown, cross-bedded sandstone (OWRB 1969).

I.3 Lakes Public Access

Lake Skipout is easily accessible from State Highway 47 and State Highway 30 via numerous paved county roads (Figure 1). A recreation area is located on the northeast side of the lake. Facilities available at the recreational area include 5 primitive campsites, restrooms, outdoor grills, picnic area, boat ramp, boat/fishing dock, and drinking water.

I.4 Lake User Population Impacted by Lake Degradation

Recreational users are affected by the degradation of Lake Skipout. Because there are few public recreational areas for fishing in this region, the lake is heavily utilized by the surrounding population. Lake Skipout is a popular recreational area for many people in western Oklahoma and the Texas panhandle. However, the lake is primarily used by the people residing in Cheyenne, Rankin, and Reydon, Oklahoma and the rural areas of Roger Mills County in close proximity to the lake. Cheyenne is the county seat of Roger Mills County. Undoubtedly, the public would benefit from the enhancement of Lake Skipout by improving its recreational potential.

I.5 Size and Economic Structure of Population Using Lake

The population of Cheyenne is 1,207, while the population of Reydon is 252. According to the 1990 census, the median age of Roger Mills County residents is 36.1 years and the total population is 4,147. Of this population, 95% is white, 4% is American Indian, and 1% is Hispanic. Table 2 summarizes the economic structure of the population of Roger Mills County (1990 Census).

Table 2. Economic structure of Roger Mills County.

Category	Roger Mills County
Total Persons	4,147
Total Families	1,197
Total Households	1,596
Per Capita Income	$9,886
Median Family Income	$22,798
Median Household Income	$20,106
Persons Below Poverty	722
% Persons Below Poverty	17.6%
Families Below Poverty	168
% Families Below Poverty	14.0%
Households Below Poverty	310
% Households Below Poverty	19.4%

I.6 Historical Lake Uses and Trends in Use

Lake Skipout serves as a flood control structure and recreational facility. Fishing, camping, boating, swimming, and picnicking are the major recreational activities at Lake Skipout.

Other recreational activities include nature study, hunting, hiking, horseback riding, and bicycling. According to the Oklahoma Water Quality Standards (OWQS), all lakes in the state are considered to have the beneficial uses of *warm water aquatic community*, *agriculture*, *industrial and municipal process and cooling water*, *primary body contact recreation*, and *aesthetics* (OWRB 1991).

As mentioned previously, Lake Skipout is located within the Black Kettle National Grasslands. According to U.S. Forest Service officials Lake Skipout seems to receive the most use of the lakes located within the Black Kettle National Grasslands. Based on fiscal year 1992 data, the Forest Service estimates that use of Lake Skipout was approximately 1,750 RVD (recreation visitor day). One RVD equals one person for 12 hours or 12 people for one hour, etcetera. Table 3 summarizes RVD estimates for recreational activities at Lake Skipout.

Table 3. Recreational use of Lake Skipout, FY 1992.

Recreation Activity	RVD	% of Total
Camping	450	25.7
Fishing	450	25.7
Boating & Other Watercraft	300	17.1
Picnicking	200	11.4
Nature Study	100	5.7
Swimming	50	2.9
Hunting (Waterfowl)	50	2.9
Hiking & Walking	50	2.9
Horseback Riding	50	2.9
Bicycling	50	2.9
TOTAL	1750	100.0

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

Seven lakes with known public access are located within an 80 km (50 mile) radius of Lake Skipout (Table 4). The lakes range in size from 38 acres at Spring Creek Lake to 8,800 acres at Foss Reservoir.

Table 4. Lakes with known public use within an 80 km radius of Lake Skipout.

Lake	County (State)	Owner	Location	Year Built	Surface Area (Ac)	Storage (Ac-ft)
Clinton	Washita (OK)	City of Clinton	Sec. 16-T11N-R19W	1931	335	3,980
Dead Indian	Roger Mills (OK)	USDA Forest Service	Sec. 26-T15N-R24W	1959	79	977
Elk City	Beckham (OK)	City of Elk City	Sec. 10-T10N-R21W	1970	240	2,583
Foss	Custer (OK)	Corps of Engineers	Sec. 2-T12N-R19W	1961	8,800	256,220
Marvin	Hemphill (TX)	USDA Forest Service	Latitude 35° 4' / Longitude 100° 50'	1938	65	390
Skipout	Roger Mills (OK)	USDA Forest Service	Sec. 5-T13N-R25W	1960	47	445
Spring Creek	Roger Mills (OK)	USDA Forest Service	Sec. 15-T15N-R25W	1961	38	337
Vincent	Ellis (OK)	State of Oklahoma	Sec. 7-T18N-R25W	1961	160	2,579

For comparative purposes, only the four lakes lying within the Black Kettle National Grasslands and owned by the USDA Forest Service (Marvin, Dead Indian, Spring Creek, and Skipout) will be examined in the following narrative. All four are open to the public year round. Lake Skipout is located 13 miles west Cheyenne on State Highway 47. Facilities at Lake Skipout include 5 primitive campsites, restrooms, outdoor grills, picnic areas, boat ramp, and dock. Dead Indian Lake is located 12 miles north of Cheyenne on U.S. Highway 283. Facilities at Dead Indian Lake include 6 primitive campsites, restrooms, outdoor grills, picnic areas, boat ramp, and dock. Spring Creek Lake can be reached by going 14 miles north of Cheyenne on U.S. Highway 283, then 8 miles west on State Highway 33. Facilities at Spring Creek Lake include 4 primitive campsites, restroom, outdoor grills, picnic areas, boat ramp, and dock. Lake Marvin is located approximately 123 miles east-northeast of Amarillo, Texas and 43 miles northwest of Cheyenne, Oklahoma. Facilities at Lake Marvin include primitive campsites, restrooms, picnic areas, boat ramp, 3 piers, and hiking trails (2.5 miles). Water sports on these lakes include fishing, motorized and non-motorized boating, and swimming.

I.8 Inventory of Point Source Pollutant Discharges

There are no permitted point source discharges in the Lake Skipout watershed; therefore, all pollutants are assumed to be attributed to nonpoint sources.

I.9 Watershed Landuse

The landuse was determined from a Geographical Information System (GIS) using GRASS (Geographic Resources Analysis Support System). Landuse data was obtained from 1985-89 using aerial photography interpretation and local knowledge of the area by the Soil Conservation Service (now the NRCS).

The landuse in Lake Skipout's watershed (Table 5) is primarily rangeland (51.2%) and pastureland (22.5%). Rangeland and pastureland are used primarily for cattle grazing. Another significant landuse is cropland (20.9%). Wheat and sorghum are the primary crops in the watershed. Much of the winter wheat is also used for winter grazing. Woodland, which comprised only 3.7% of the watershed area, was made up primarily of windbreaks. In addition, several gas wells are located in the watershed.

Table 5. Landuse in Lake Skipout watershed.

Landuse	**Acres**	**Percent**
Rangeland	3440	51.2
Pastureland	1513	22.5
Cropland	1404	20.9
Woodland	247	3.7
Oil or Gas Well Construction Site (~5 Ac.)	40	0.6
Farmsteads - (Greater than 5 Acres)	40	0.6
Water	30	0.5
TOTAL	**6714**	**100.0**

Approximately 13.4% (900 acres) of the watershed is enrolled in the Conservation Reserve Program (CRP). This program retired areas of highly erodible and highly eroding cropland on which permanent stands of grass and trees (windbreaks) were established.

Twelve homes are also located in the watershed. Based on the average household size in Roger Mills County, an estimated 31 people live in the watershed. Because the homes are located in a rural area, sewage is treated using septic systems, if at all. A restoration goal should be to ensure that properly working septic systems are in place at each household.

Although the lake is located on public land, most of the watershed is privately owned and in livestock or agricultural production. The USDA Forest Service owns and manages approximately 520 acres of the lake's watershed (Units 61 and 72) as part of the Black Kettle National Grasslands. Approximately 320 acres of this area (the western half of Section 5, Township 13N, Range 25W) are leased out for grazing annually primarily during the summer and early fall. From 1990-92 and in 1995, 58 head of cattle were allowed to graze. In 1993, only 28 head of cattle were allowed to graze. In 1994, the area was not grazed.

Approximately 200 head of cattle were observed during a windshield survey of the watershed on January 25, 1995. In general, 18-20 acres are needed per cow in this area. Of the 4,953 acres of pasture and range land in the watershed, 4,053 acres are available for grazing (900 acres are not available due to enrollment in CRP). Based on these data, the number of cattle in the watershed should be between 200-225. The number of cattle observed is within the carrying capacity calculated for the watershed. However, a significant portion of the cattle were observed at a dairy. Most cattle in the watershed have unrestricted access to the streams. This, in addition to localized overgrazing, may provide a substantial amount of nutrient and sediment loading to the lake. A restoration goal should be to restrict cattle access to streams and encourage proper grazing management.

I.10 Lake Limnology

A. Investigative Approach

Seasonal sampling by the Oklahoma Conservation Commission (OCC) from 1987 to 1992 indicated that Lake Skipout was hypereutrophic. Impairment of the recreational uses were recognized as potential results of the high trophic state. Algal blooms threaten body contact, aesthetics, and the fishery. 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 objectives of this study were to assess the lake water quality, physical conditions, and trophic state; and evaluate the watershed effects, such as sediment and nutrient loading, on the lake.

B. Experimental Procedures

1. Lake Location and Sampling Sites

Three lake sampling sites (near the dam and in the mid-point of each of the two arms) were established for assessment of the lake water quality. The major tributary to Lake Skipout (referred to as Skipout Creek henceforth) was also sampled. The stream site included a single stage sampler, and a staff and crest gauge for the purpose of determining lake hydrologic and nutrient budgets. A staff gauge was also located at the lake to monitor lake levels. Figure 1 identifies the lake location, watershed, and sampling sites.

2. Lake and Tributary Sampling

The lake (excluding the east arm) and its tributary were sampled at least monthly December 17, 1992 to November 23, 1993. From May through September, the lake and its tributary were sampled semimonthly. The east arm of Lake Skipout was only sampled quarterly. All water quality sampling was carried out according to Standard Operating Procedures on file at the OCC or as written in the project workplan. A brief summary of these follows.

Water temperature, dissolved oxygen, pH, and conductivity profiles were measured at each lake location by *in situ* measurements at 1-meter increments from the water surface to the lake bottom with the assistance of a Hydrolab Surveyor III - H_2O instrument. Water transparency was determined with a 20-cm Secchi disk. Water temperature, dissolved oxygen, pH, and conductivity was also determined *in situ* in the tributary.

A single grab sample of water was collected from 0.1 m below the surface at the tributary. At lake locations, water was collected at 0.1 m, mid-depth, and just above the bottom, and then composited into a single sample. In cases where thermal stratification had occurred, discrete samples were taken from 0.1 m and from just above the lake bottom. Routine water quality samples were analyzed for total Kjeldahl nitrogen (TKN), nitrate + nitrite (NO_2+NO_3), total nitrogen, ortho-phosphorous, total phosphorous, total alkalinity, dissolved calcium, dissolved magnesium, 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 pesticides and metals.

The normal flow of the tributary of Lake Skipout is generally less than 1 cfs indicating that a majority of the water enters the lake during high-flow events. Thus, a single stage sampler was located on the tributary. Composites of each runoff event were analyzed for the appropriate field parameters, nutrients, metals, and pesticides.

Sediment was collected from all lake sites using a ponar dredge and a standard limnological gravity corer, placed in a 16 oz. glass jars with Teflon lids, and stored on ice until delivered to the laboratory for analyses of nutrients, metals, and pesticides.

Fecal coliform and fecal streptococcus samples were collected monthly from May through September at all sites.

A 500 ml portion of the water composited at the dam was preserved for phytoplankton analysis on a quarterly basis. A single, bottom-to-surface vertical tow with a Wisconsin net was taken to collect zooplankton at the dam on a quarterly basis. These samples were sent immediately to the lab for taxonomic identification and community analysis.

Aquatic macrophytes were surveyed for their general taxonomic composition and distribution once during the study.

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 to determine the fish population structure. Fish were also collected once by OCC staff for fish flesh analysis of metals and pesticide residues. Collections were made with 100 m experimental gill nets of varying mesh size. Individuals were collected from all of the trophic levels.

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.

C. Morphological and Hydrological Characteristics of the Lake

1. Lake Morphology

A bathymetric survey of Lake Skipout was performed in 1996 (Figure 2). The morphological characteristics of Lake Skipout are listed in Table 6. Shallow lakes, such as Lake Skipout, are generally more susceptible to eutrophication. Shallow lakes have high depth-averaged light intensities to support photosynthesis and greater sediment/water contact, which can encourage nutrient recycling (EPA 1990).

Table 6. Morphological characteristics of Lake Skipout.

Parameter	Value
Surface Area	47 acres (19 hectares)
Storage Capacity	570 acre-feet (703,264 m^3)
Maximum Depth	25.6 feet (7.8 m)
Mean Depth	12.1 feet (3.7 m)

2. Lake Hydrology

Lake Skipout's main tributary, which forms the lake's west arm, is an un-named tributary (Skipout Creek) of Rush Creek. The lake's east arm is formed by a small un-named tributary to Skipout Creek. The lake's discharge feeds Rush Creek, a tributary of the Washita River. Discharge to and from the lake was measured by fixed staff and crest gages on Skipout Creek and below the dam, respectively. Lake levels were measured by a fixed staff gage. Staff gages were monitored daily by David Hillman and Nena Wells of the Upper Washita Conservation District. Flows on Skipout Creek were measured 6 times during the study. Based on this data, it was estimated that the total 1993 discharge to the lake was 204 acre-feet.

Figure 2. Bathymetric survey of Lake Skipout, 1996. Contours are in meters

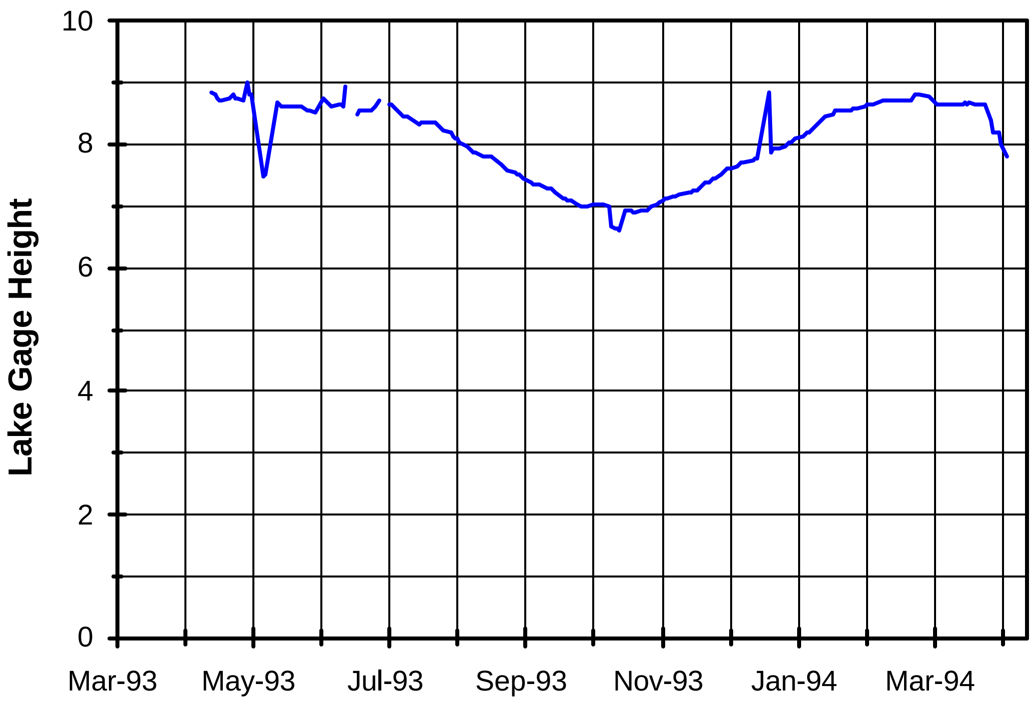
For comparative purposes, an alternative method of determining the discharge was used. Average annual runoff was determined from USGS data for nearby streams by dividing their total annual discharge by their watershed area. From this it was calculated that annual runoff averaged 0.37 inches in 1993. This compares closely with USGS estimations of annual runoff ranging from 0.2-0.5 inches for this area (Linsley et al. 1975). Using this method it was calculated that total annual discharge to Lake Skipout was 207 acre-feet in 1993. This also compares closely to the total annual discharge estimated using staff gage readings. Table 7 displays Lake Skipout's hydrologic budget.

Table 7. Hydrologic budget for Lake Skipout, 1993.

Input	**Volume**
Inflow	207 ac-ft
Rainfall	103 ac-ft
Output	
Lake Evaporation	251 ac-ft
Outflow	59 ac-ft

Rainfall input was determined by multiplying the 1993 precipitation of 26.3 inches or 0.668 meters by the lake surface area. Lake evaporation was determined by multiplying the average annual lake evaporation (1.6 m/yr) for Roger Mills County (Wells 1995) by the lake surface area. The outflow was calculated by subtracting lake evaporation from inputs. Mean hydraulic residence time (T), which was calculated by dividing the storage capacity by the total annual outflow (EPA 1990), was approximately 9.7 years. Lake levels (Figure 3) fluctuated very little during the study (2.4 ft).

Figure 3. Gage heights (feet) in Lake Skipout, 1993-94.



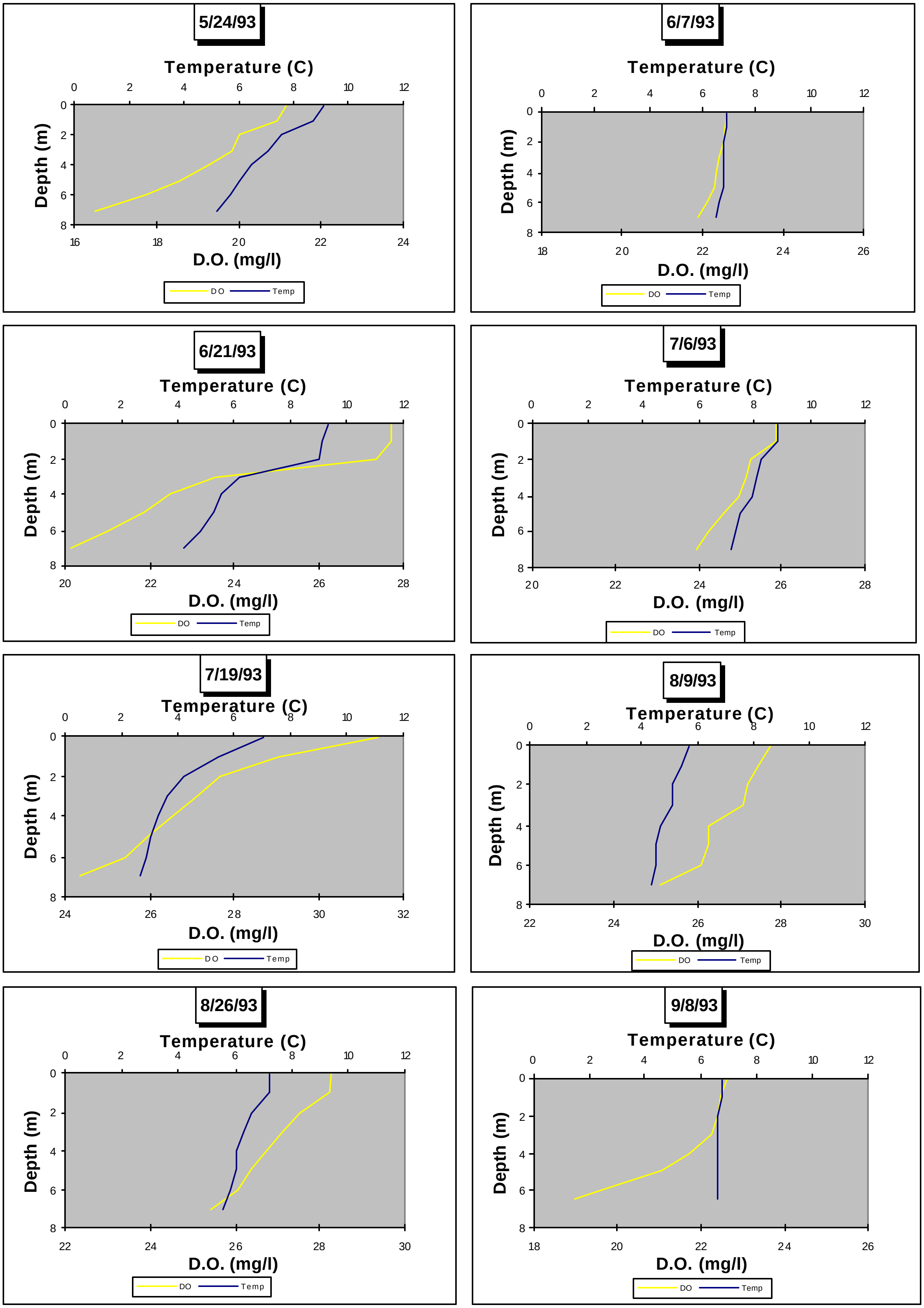
D. Water Quality of the Lake

Water quality in Lake Skipout and its tributary was monitored from December 17, 1992 to November 23, 1993. This involved semimonthly sampling from May 10 to September 20, 1993 and monthly sampling during the remaining seven months. The tributary was also sampled during 2 storm events. The results of the sampling program are discussed in the following sections. Routine water quality data collected from Lake Skipout can be found in Appendix A, while lake profile data can be found in Appendix B.

1. Thermal Structure of the Lake

Surface temperature ranged from 4°C in early March to 29°C in July. The lake remains well mixed throughout most of the year, experiencing short periods of weak thermal stratification only during relatively calm, hot periods. The greatest difference observed between top and bottom temperatures was 3.4°C on June 21, 1993. The temperature difference between the top and bottom temperatures rarely exceeded 2°C. Temperature profiles measured at the dam between May and September are displayed in Figure 4.

Figure 4. Temperature and D.O. profiles measured at the Lake Skipout dam, 1993.



2. Dissolved Oxygen

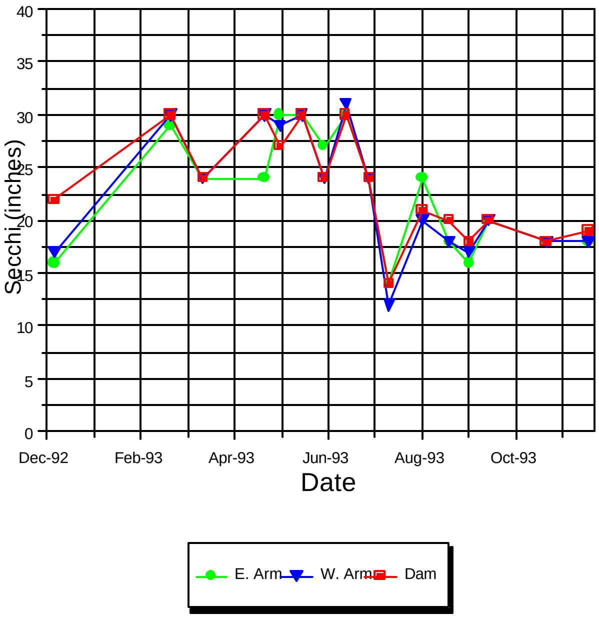
Dissolved oxygen was present at sufficient concentrations throughout the lake during most of the year. However, during the short periods of thermal stratification, dissolved oxygen concentrations in the hypolimnion were depleted (Figure 4). Generally, only the bottom 1-2 m of the water column contained dissolved oxygen concentrations of less than 2 mg/l. Bottom dissolved concentrations of less than 2 mg/l were observed on four occasions at the dam and one occasion in the west arm. The observed dissolved oxygen depletions severely impact the benthic macroinvertebrate community.

Supersaturation was also observed on numerous occassions. On June 21, July 19, August 26, and September 20, D.O. percent saturations of 143, 143, 117, and 127, respectively, were observed at the dam. On July 19 and September 20, D.O. percent saturations of 153 and 131, respectively, were observed in the West Arm. On June 21 and July 19, D.O. percent saturations of 134 and 140, respectively, were observed in the East Arm. Supersaturation provides a good indicator of algal blooms and probably night-time D.O. depletion.

3. Chlorophyll-a and Secchi Depth

Secchi depths at all three lake sites (Appendix C) were not significantly different (Figure 5). Average Secchi depth was 22.6 inches in the east arm and west arm, and 23.2 inches at the dam. In addition, Secchi depth varied little throughout the project. Secchi depth was also used as an indicator of lake trophic state (see Section I10.K).

Figure 5. Secchi depth (inches) in Lake Skipout, 1993.



Chlorophyll concentrations (Appendix D), which averaged 28.8 ug/l, did not vary significantly throughout the lake. During the study, chlorophyll concentrations averaged 28.5 ug/l (n=15, s=16.8) at the dam, 34.0 ug/l (n=4, s=16.9) in the east arm, and 27.7 ug/l (n=16, s=14.4) in the west arm. Chlorophyll concentrations expressed significant seasonality with highest concentrations occurring in the fall and lowest concentrations occurring in the spring.

Surface turbidity and Secchi ($r=-0.69$) were significantly correlated at the dam ($\alpha=0.05$) indicating that turbidity has a significant effect on water transparency at the dam. However, surface turbidity and surface chlorophyll ($r=0.18$), as well as surface chlorophyll and Secchi ($r=-0.39$) were not significantly correlated at the dam ($\alpha=0.05$) indicating that turbidity does not significantly affect chlorophyll (and vice versa) and chlorophyll does not significantly affect water transparency at the dam. In addition, surface turbidity and surface chlorophyll ($r=0.66$), surface chlorophyll and Secchi ($r=-0.42$), and surface turbidity and Secchi ($r=-0.53$) were not significantly correlated in the west arm ($\alpha=0.05$) indicating that turbidity does not significantly affect chlorophyll (and vice versa), chlorophyll alone does not significantly affect water transparency, and turbidity alone does not significantly affect water transparency. Not enough data was available for the east arm site to perform a correlation.

4. Nitrogen and Phosphorous

Mean concentrations of total Kjeldahl nitrogen (TKN), nitrite + nitrate (NO_2+NO_3), total nitrogen (TN), total phosphorous (TP), and orthophosphorous (PO_4) calculated from data (Appendix A) collected between December 17, 1992 and November 23, 1993 are listed in Table 8. Total nitrogen (TN) concentrations averaged 1.0 mg/l in Lake Skipout. Total nitrogen concentrations were controlled primarily by organic nitrogen concentrations.

Total phosphorous (TP) concentrations averaged 0.055 mg/l in Lake Skipout. Total phosphorous concentrations were also predominately controlled by organic phosphorous concentrations. Orthophosphorous, the biologically available form of phosphorous, was generally present at concentrations below detection. Phosphorous concentrations were present at levels known to cause hypereutrophication (EPA 1979). Total phosphorous concentrations were also used to determine lake trophic state (see Section I10.K). The TN:TP averaged 18:1 in Lake Skipout. Because phosphorous limitation is indicated by a TN:TP of 7:1 or greater (Wetzel 1983), Lake Skipout is considered phosphorous limited.

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

Mean concentrations of turbidity, alkalinity, total dissolved solids (TDS), total suspended solids (TSS), dissolved calcium (Ca), dissolved magnesium (Mg), chloride (Cl), sulfate (SO_4), fluoride (F), and total hardness calculated from data (Appendix A) collected between December 17, 1992 and November 23, 1993 are listed in Table 8.

Table 8. Mean concentrations of parameters measured in Lake Skipout, 1992-93.

Parameter	Dam	W. Arm	E. Arm
Turbidity (NTU)	19	19	18
Alkalinity (mg/l)	302	301	303
TDS (mg/l)	585	578	530
TSS (mg/l)	19	17	16
TKN (mg/l)	1	1	0.9
NO_2+NO_3 (mg N/l)	<0.05	<0.05	<0.05
TN (mg/l)	1	0.9	1
TP (mg/l)	0.06	0.05	0.05
PO_4 (P mg/l)	0.01	<0.01	<0.01
Diss. Ca (mg/l)	30	30	33
Diss. Mg (mg/l)	24	24	24
Cl (mg/l)	108	110	108
SO_4 (mg/l)	37	37	39
F (mg/l)	0.8	0.8	0.8
Total hardness (mg/l)	173	173	185

The pH varied little (CV < 5%) throughout the study. The pH averaged 8.56 in the lake and ranged from 8.13 to 9.10. The highest pH values likely occurred during times of algal blooms. The Oklahoma Water Quality Standards (OWQS) state “The pH values shall be between 6.5 and 9.0 in waters designated for fish and wildlife propagation; unless pH values outside that range are due to natural conditions” (OWRB 1991). This criteria was exceeded only once, on September 20, 1993 in the west arm.

Alkalinity varied little (CV < 10%) throughout the study. The alkalinity, which averaged 302 mg/l, was high giving the water a considerable pH buffering capacity. The water in Lake Skipout is classified as hard (hardness > 150 mg/l) (EPA 1986). Hard waters have a higher capacity to mitigate metal toxicity.

Total suspended solids (TSS) concentrations, which averaged 17.3 mg/l in the lake, were quite variable throughout the study (CV > 40%). The turbidity in Lake Skipout, which averaged 19 NTU, is comparable to other lakes in the region. However, the OWQS turbidity criteria to protect fish and wildlife propagation (25 NTU for lakes) was slightly exceeded in three hypolimnetic samples collected at the dam (July 19, August 26 & September 8) and in two hypolimnetic samples collected from the west arm (August 26 & September 20). In addition, two surface samples from the west arm (June 6 & September 8) slightly exceeded the OWQS turbidity criteria.

Conductivity and total dissolved solids (TDS) concentrations in Lake Skipout were comparable to those found in other lakes in the region. Conductivity, which averaged 1034 uS/cm, varied little (CV < 5%) throughout the study. Total dissolved solids concentrations, which averaged 564 mg/l, also varied little throughout the study. Coefficients of variation (CV) for TDS were 11% at the dam and west arm, and 24% in the east arm. High conductivities and TDS concentrations, such as those seen in Lake Skipout, are typical of central and western Oklahoma, as values tend to increase in a westerly trend. This is, in part, due to increasing salinity of the soils and high concentrations of divalent cations.

Sulfate, chloride, and fluoride concentrations in the lake, which varied little throughout the study, were not present in biologically significant quantities.

6. Metals

Metals were measured in Lake Skipout on July 6 and September 8, 1993 (Appendix E). Cadmium, lead, zinc, and selenium were not detected in lake water samples. Arsenic, chromium, copper, and nickel concentrations comply with the OWQS to protect fish and wildlife propagation. Mercury concentrations, which ranged from below detection to 0.6 ug/l, exceeded the chronic criteria (0.012 ug/l) to protect fish and wildlife propagation. Iron concentrations comply with the EPA Water Quality Criteria (EPA 1986) to protect freshwater aquatic life (1 mg/l). No biological criteria have been developed for barium or manganese.

E. Lake Sediment Quality

Sediment collected on September 8, 1993 was analyzed for nutrients, metals, and moisture content. As Table 9 indicates, sediment from the east arm is quite different from the sediment found at the dam and in the west arm. Sediment from the east arm consistently contained lower chemical concentrations than sediment collected from the dam or west arm.

Sediment Screening Values developed by EPA (1995) were used to assess the chemical concentrations found in Lake Skipout sediments. None of the chemical concentrations found in the Lake Skipout sediments exceeded the EPA Sediment Screening Values.

Table 9. Detected quantities of metals in Lake Skipout sediment (ug/g) as compared to EPA Screening Values (1995).

Metal	Dam	W. Arm	E. Arm	Screening Value
As	11	11	2	85
Ca	75,000	4,900	5,700	N/A
Cd	2	3	<1	9
Cr	20	20	4	145
Cu	18	20	2	390
Fe	17,000	16,000	2,400	N/A
Hg	0.01	0.03	<0.1	1.3
K	2,700	2,700	320	N/A
Mg	8,400	7,800	700	N/A
Mn	680	5,000	37	N/A
Na	910	840	140	N/A
Ni	30	30	<10	50
NH_3	320	54	2.8	N/A
NO_2/NO_3	97	63	21	N/A
Pb	30	30	<10	110
Se	<1	<1	<1	N/A
Zn	56	39	8	270
Moisture	76%	69%	21%	N/A

F. Lake Biological Resources

1. Algae

The algal community was sampled on March 22, July 6, and September 8, 1993. The algal community is presented in detail in Appendix F. Identification was carried out to genera. Species diversity was lowest on March 22. Lake Skipout was dominated by pollution tolerant algae. Twelve pollution tolerant algal genera were found in Lake Skipout. Blue-green algae composed 90.3% of the biovolume on March 22, 51.6% on July 6, and 26.8% on September 8 (Table 10). Euglenoid algae were dominant on September 8, composing 56.1% of the biovolume. Euglenoid algae are heterotrophic and generally develop seasonally or in areas with high NH_3 and/or dissolved organic matter (DOM). This may correspond to an algae or macrophyte die-off, or lake turnover in Lake Skipout.

Table 10. Relative percent biovolumes of algal divisions found in Lake Skipout, 1993.

Date	Cyano	Euglen	Chloro	Diatom	Dino	Chrypto
03/22/93	90.3	0.0	1.2	8.4	0.0	0.0
07/06/93	51.6	8.9	31.1	6.7	0.0	1.7
09/08/93	26.8	56.1	12.4	1.8	2.8	0.0

The blue-green algal genus _Anabaena_ dominated the March 22, 1993 sample. _Anabaena_ is a pollution tolerant algae and some species are capable of producing toxins. The blue-green algal genera _Oscillatoria_ dominated the July 6, 1993 sample. _Oscillatoria_ is also a pollution tolerant algae. The euglenoid algal genera _Phacus_ dominated the September 8, 1993 sample. _Phacus_ is also pollution tolerant.

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 blue-green algae or euglenoid algae if organically enriched or polluted (Wetzel 1983). Conditions in Lake Skipout are similar to this description indicating that it is nutrient enriched (eutrophic) and organically enriched or polluted.

2. Macrophytes

Cattails (Typha) encompass approximately three quarters of the lake's shoreline. The cattails provide good habitat for small forage fish and protect the shoreline from erosion. During senescence and after the death of macrophytes, a release of nutrients and dissolved organic matter occurs. This input of nutrients can have a marked influence on the phytoplankton community (Wetzel 1983).

3. Zooplankton

Zooplankton collections were made on March 22, July 6, and September 8, 1993 at the dam. Zooplankton abundance and length are listed in Appendix G. At least 8 zooplankton taxa were identified in the lake including rotifers, three copepods (Calanoids, Cyclopoids, and nauplius larvae), and four cladocerans (_Diaphanosoma_, _Ceriodaphnia_, _Bosmina_, and _Daphnia_).

The size of zooplankton is closely related to fish community structure (Mills and Schiavone 1982). Most zooplankton collected in Lake Skipout 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 planktivorous fish (gizzard shad) density.

Stocking and/or restrictive harvest of top predators (i.e. flathead catfish, largemouth bass, etc.) 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 increase exponentially with increasing body length (Wetzel 1983).

The planktonic insect *Chaoborus* (Order Diptera) was found in high numbers in the lacustrine and to some extent in the transition zone. *Chaoborus* (the phantom midge) larvae are 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. They were most abundant in the lacustrine zone. *Chaoborus* were found in 50% of the sediment samples and had an overall average density 7 organisms per square foot.

4. Benthic Macroinvertebrates

The benthic macroinvertebrate community was sampled on August 6, 1995. Thirty sediment samples were collected from Lake Skipout: ten from the riverine zone, ten from the transition zone, and ten from the lacustrine zone. A map showing the transects through each of the three zones may be found in Appendix H. The mean depth of the lacustrine zone was 4.7 meters with a mean bottom dissolved oxygen concentration of 3.0 mg/l. The mean depth of the transition zone was 1.6 meters with a mean bottom dissolved oxygen concentration of 6.4 mg/l. The mean depth of the riverine zone was 0.8 meters with a mean bottom dissolved oxygen concentration of 7.6 mg/l.

Benthic macroinvertebrates were not present at one sample site in the lacustrine zone (near the dam). The diversity of the benthic macroinvertebrate community consisted of 2 Phyla, 8 Families, and 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.

Chironomids & other dipterans

Chironomids of the subfamily Tanypodinae (Class Insecta, Order Diptera), which were found in 83% of the samples and had an overall average density of 33 organisms per square foot, were one of the most prevalent and abundant benthic macroinvertebrates. Their abundance was highest in the riverine zone and lowest in the lacustrine zone. They were least prevalent in the lacustrine zone.

The chironomids of the tribe Chironomini were also prevalent and abundant, being found in 77% of the samples and had an overall average density of 17 organisms per square foot. Their abundance was highest in the transition zone and lowest in the lacustrine zone. They were least prevalent in the lacustrine zone. The chironomids of the tribe Tanytarsini were found in four samples, two from the transition zone and two from 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 of the family Ceratopogonidae was also found. The ceratopogonids were found in all zones of the lake, but were least prevalent and abundant in the lacustrine zone. The ceratopogonids are considered tolerant according to Beck's Biotic Index and facultative by the Hilsenhoff FBI.

Oligochaetes

Oligochaetes were also very abundant and prevalent in Lake Skipout. Oligochaetes are classified as tolerant according to Beck's Biotic Index and Hilsenhoff's FBI, and are able to withstand very low dissolved oxygen levels. Tubificid oligochaetes were found in 83% of the samples. Three genera of tubificid worms (Class Oligochaeta, Family Tubificidae) were found in the lake: *Limnodrilus*, *Tubifex*, and *Aulodrilus* (*A. pigueti* and *A. limnobius*). *Limnodrilus* was the most abundant and prevalent genera, being found in 83% of the samples at an overall average density of 33 organisms per square foot. *Aulodrilus limnobius* was also prevalent and abundant, being present in 57% of the samples and having an overall average density of 20 organisms per square foot; however, they were not as prevalent as *Limnodrilus*. The oligochaete *Nais* (Family Naididae) was found in two samples in the riverine zone. Oligochaetes were least abundant and prevalent in the lacustrine zone. The only oligochaete found in the lacustrine zone was *Limnodrilus*.

Ephemeroptera (Mayflies)

The ephemeropteran *Hexagenia* was found in three samples (one sample from the transition zone and two samples from the riverine zone). The depths of the areas where ephemeropterans were found was less than 2 meters and bottom dissolved oxygen was greater than 6.0 mg/l. The ephemeropterans are intolerant of low dissolved oxygen, thus their absence from the profundal likely results from the stressful, anaerobic conditions found throughout much of the lake.

Trichoptera (Caddisflies)

The trichopteran *Oecetis* was found in one sample (in the riverine zone). The depth of the site was 0.8 meters and the dissolved oxygen concentration was 7.5 mg/l. The trichopterans are intolerant of low dissolved oxygen and pollution, thus explaining their absence from the profundal zone of the lake.

Coleoptera (Beetles)

The riffle beetle (Family Elmidae) *Dubiraphia* was found in one near-shore sample from the transition zone. The depth of the site was 0.8 meters and the bottom dissolved oxygen concentration was 7.0 mg/l. The riffle beetles are also intolerant of low dissolved oxygen concentrations and pollution, which explains their absence from the profundal zone of the lake.

Water Mites

A water mite (Acari) was found in one near-shore sample from the transition zone. The depth of the site was 1.7 meters, and the bottom dissolved oxygen concentration was 6.2 mg/l. They are generally considered pollution intolerant.

Reservoir Index of Biotic Integrity (RIBI) Metrics

Benthic macroinvertebrate metrics were used to assess the biotic integrity of Lake Skipout. The seven metrics used are discussed below. The metric *percent of samples with long lived taxa present* (0%) indicated that the lake bottom does not have sufficient dissolved oxygen to support benthic macroinvertebrates over a long period of time (>1 year). The average taxa richness (family level) per sample was low (2.4). Only thirteen percent of the samples contained sensitive taxa. Fifty percent of the samples contained only tubificids and/or chironomids indicating that 50% of the lake bottom will only support very tolerant organisms. Sixty-four percent of the total organisms were composed of tubificids and *Chironomini*. Only 2.3% of the total organisms were sensitive. Benthic macroinvertebrates were not present at one site indicating that approximately 3% of the lake bottom is not capable of supporting macroinvertebrates. According to the index, the benthic macroinvertebrate community is in poor health indicating that conditions at the sediment/water interface are also poor. In addition, the benthic community in the lacustrine zone is in very poor health. Only 3 percent of the total organisms (96 organisms) were collected from the lacustrine zone. Taxa richness (family level) per sample, which averaged 1.4, was also lower in the lacustrine zone. Only tubificids and chironomids were found in the lacustrine zone.

5. Fisheries

a. Past and Present Activities and Suitability of the Lake

The primary recreational use of Lake Skipout 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.

The fishery survey performed in 1976 found a lack of adult bass, which probably resulted from over harvest.

Fish surveys performed in 1986 by ODWC found that largemouth bass, white crappie, and channel catfish comprised most of the sport fishery at Lake Skipout, and bluegill made up most of the forage base. Quality and trophy-sized bass were abundant; however, bass were not evenly distributed among the size classes. White crappie and bluegills were abundant; however, individuals were small. This indicates overcrowding. In addition, channel catfish densities were low, even though they are stocked on a regular basis. Apparently, stocked channel catfish were over harvested and kept by fishermen before reaching quality size (Watkins 1986).

Lake Skipout has a history of fish kills. Gizzard shad are the most affected while some sunfish, white crappie, and channel catfish were also among the population killed. On July 26, 1989, Lake Skipout experienced a large gizzard shad die-off. It was estimated that approximately 100,000 shad died during a 3-day period. The recreation area was closed for 10 days in order to allow for clean-up of the lake and surrounding area, and provide for public health and safety. Two additional shad die-offs were observed throughout the fall and the spring of 1990. Each one of these incidents involved approximately 20,000 fish or less (Blackwell 1991).

In 1993, a total of 13 species were collected from Lake Skipout (Table 11), which compares favorably to other reservoirs in this area of similar size that were sampled using similar gear types and collection methods. Seven species collected are considered moderately tolerant and six are tolerant (Jester et al. 1992). Forty-six percent of the species collected were omnivores, thirty-one percent were invertivores/insectivores, and twenty-three percent were piscivores (Robinson and Buchanan 1992). A total of 4,959 individuals were collected.

Table 11. Tolerance of fish collected from Lake Skipout on September 29, 1993.

Fish Species	**Number**	**Tolerance**
Largemouth Bass	31	Moderate
Bluegill Sunfish	103	Moderate
Longear Sunfish	41	Moderate
Redear Sunfish	1	Moderate
Channel Catfish	67	Moderate
Gizzard Shad	4,383	Moderate
Saugeye	3	Moderate
White Crappie	244	Tolerant
Green Sunfish	50	Tolerant
Black Bullhead	3	Tolerant
Yellow Bullhead	13	Tolerant
Carp	13	Tolerant
Golden Shiner	7	Tolerant

Largemouth Bass (*Micropterus salmodies*)

Results of the 1993 survey are encouraging. The presence of several strong year classes indicate that both reproduction and recruitment are good. The population structure also appears to be sound. Results of the 1993 fall electrofishing survey yielded a Proportional Stock Density (PSD) of 84. Growth rates and conditions are also believed to be good, as this same survey yielded a mean Relative Weight (WR) of 102.

An introduction of the Florida strain was attempted in 1988 and again in 1992, with the addition of 2,400 and 900 fingerlings respectively. This project was discontinued after electrophoresis verified very little viability of Florida genetics. Under current regulations, there is a 12 inch length limit and the creel limit is 6. No regulation changes are anticipated in the near future (Cofer 1995).

Crappie (*Pomoxis annularis; P. nigromaculatus*)
The 1993 survey indicated that reproduction and recruitment are moderate at best, as several year classes were either missing or poorly represented. The 1993 fall electrofishing survey yielded a catch per unit effort (CPUE) of 15.8 which is up from 1990 when CPUE for the spring electrofishing survey was 1.4. The structure of the population appears to be poor based on 1993 fall gillnetting data, which yielded a PSD of 3.0 (N=217). Growth rates and condition also appear to be poor. Under current regulations there is no length limit and the creel limit is 37. No regulation changes are anticipated in the near future. This fishery is not heavily utilized; therefore, little management is needed (Cofer 1995).

Channel Catfish (*Ictaluras punctatus*)
Both reproduction and recruitment appear to be very poor. This is likely due to incompatible habitat requirements (Robinson and Buchanan 1992). However, the population structure appears to be very good. This is not surprising considering the influence of yearly stocking. Results of 1993 fall gillnetting yielded a PSD of 14. Growth rates and conditions appear to be good as results of this same survey yielded a WR of 90.

Grow-out size channel catfish were stocked annually at approximately 20/acre from 1978-86. Prior to 1978, channel catfish had not been stocked since 1966 (Watkins 1986). Recent stockings of grow-out size channel catfish include 1,140 in 1989 and 1,880 in 1991 and 1992. Currently there is no length limit and the creel is 6. No regulation changes are anticipated in the near future. This is Lake Skipout’s most heavily utilized fishery (Cofer 1995).

Saugeye (*Stizostideon canadense x S. vitreium*)
Saugeye were first introduced in 1990 (1,410 fingerlings) with hope that they would offer some means of control for the rapidly expanding gizzard shad population. Unfortunately, data from the 1993 survey suggested that saugeye growth rates and conditions were poor, and that their introduction had very little impact on the gizzard shad population. As a result, this project has been discontinued. The failure of the saugeye is believed to be due at least in part to their intolerance of the soft substrate and elevated turbidities of Lake Skipout (Cofer 1995).

Gizzard Shad (*Dorosoma cepedianum*)
Gizzard shad were inadvertently introduced during the late 1980's or early 1990's. Since that time they have replaced the bluegill sunfish as the primary forage fish. Given the small size and hypereutrophic status of this reservoir, coupled with the prolific nature of the gizzard shad, it was merely a matter of time before the population outgrew its environment.

The population flourished initially, but as of late, has experienced poor reproduction and recruitment. The bulk of the shad population is made up of large adults of deteriorating condition. These large adults (200-250 mm) are of sufficient quantity to keep the zooplankton community grazed to levels that are insufficient to control phytoplankton. This may explain the frequent algal blooms experienced lately.

Bluegill Sunfish (*Lepomis macrochirus*)

Bluegill sunfish were once the primary forage fish of this system, unfortunately they have been replaced in this role by the gizzard shad. Data from the 1993 survey suggests that their population structure is poor. Results of the 1993 fall electrofishing survey yielded a PSD of 0, with 72% of those collected being <4.75" in length (n=103). This could possibly be due to the dense stand of aquatic macrophytes (cattails) which encircle the reservoir. Macrophytes can achieve densities at which they act as a barriers, prohibiting utilization by large fish. However, insufficient utilization by largemouth bass might simply be a product of the extreme rate of availability of gizzard shad.

Overall, bluegill sunfish abundance was high with a CPUE of 60.59 reported for the 1993 fall electrofishing survey. However, reproduction and recruitment were moderate at best, as data suggest that several year classes are either missing or poorly represented. Growth rates and conditions are also poor. There is very little angler utilization of this fishery (Cofer 1995).

Longear Sunfish (*Lepomis megalotis*)

Longear sunfish make up a significant portion of the secondary forage base. Fall 1993 electro-fishing data suggest that longear sunfish abundance is high with a CPUE of 24.11. However, their population structure is poor with 100% of those collected being <4.75" in length. Reproduction and recruitment appear to be poor as several year classes were either missing or poorly represented. There is very little angler utilization of this fishery (Cofer 1995).

b. Wholesomeness of Fish Tissue

Zinc, copper, cadmium, chromium, lead, arsenic, selenium, and mercury were measured in carp, bullhead catfish, saugeye, and crappie (Appendix J). Only arsenic was not detected. Mercury concentrations were well below the OWQS alert and concern levels. No numeric criteria for other metals in fish flesh are listed in the OWQS or in the FDA Action Levels list.

Total PCBs and the following organochlorine pesticides were also measured in carp, bullhead catfish, and saugeye (Appendix J) from Lake Skipout:

a-BHC
B-BHC
d-BHC
g-BHC
p,p' DDE
p,p' DDT
p,p' DDD
Chlordane
Heptachlor
Dieldrin
Endrin
Aldrin
Endosulfan
Heptachlor Epoxide
Endrin Aldehyde
Endosulfan Sulfate

Only DDE and chlordane were detected. Chlordane did not exceed the OWQS Alert or Concern levels. DDE also did not exceed the legal limits for fish flesh (Nauen 1983).

G. Sanitary Quality of Lake and Tributaries

Table 12 presents bacteriological data for Lake Skipout during the summer of 1993. To protect the *primary body contact* use, the OWQS state that from May 1 to September 30, the monthly geometric mean of five fecal coliform 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 1991). 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 sample from Skipout Creek on July 7, 1993 was in violation of the water quality standards. However, because of the shallow nature of the stream, the probability of body contact with elevated levels of bacteria due to swimming or other recreational activities is essentially zero. However, because fecal coliform bacteria are often associated with BOD and nutrients and indicate their transport, the source of the bacteria should be identified and remediated. No lake sample violated the water quality criteria.

Table 12. Fecal coliform in Lake Skipout.

Date	Skipout Creek	Lake Dam	Lake W. Arm	Lake E. Arm
06/08/93	300	10	30	
06/22/93		30	60	
07/07/93	580	20	20	
07/19/93	<10	10	10	10
08/20/93	20	<10	<10	<10
09/21/93	60	<10	<10	<10

H. Characteristics of Skipout Creek

1. Basic Chemical Characteristics

Skipout Creek was sampled seventeen times between December 17, 1992 and April 11, 1994. Two of the samples (March 22, 1993 and April 11, 1994) represent runoff events. Stream data is included in Appendix K.

The stream water is hard and somewhat alkaline. The hardness in Skipout Creek is controlled by sodium, calcium, and magnesium, respectively. Average sulfate, chloride, fluoride, TSS, conductivity, and TDS concentrations are comparable to levels found in streams of this region. Excluding one sample date (May 10, 1993), dissolved oxygen was present at levels which were compliant with the OWQS criteria to protect fish and wildlife propagation. Temperature, turbidity, and pH in the stream were compliant with the OWQS criteria to protect fish and wildlife propagation throughout the study.

Nutrient concentrations in Skipout Creek were present at levels known to cause eutrophication in lakes. Total nitrogen concentrations, which averaged 2.1 mg/l, were primarily controlled by nitrate. This is important, because nitrate is a form of nitrogen readily useable by algae. Total phosphorous concentrations were high, averaging 0.22 mg/l. In addition, runoff TP concentrations were not significantly different from baseflow TP concentrations.

2. Pesticides and Metals

Pesticides were measured in Skipout Creek on June 30, 1993, March 9, 1994, and April 11, 1994 (Appendix L). Of the 41 pesticides and organics analyzed, only the herbicide 2,4-D was detected. It was detected on June 30, 1993 at a concentration of 0.66 ug/l. However, no water quality criteria to protect fish and wildlife propagation has been developed for 2,4-D.

Metals were measured in Skipout Creek on March 9 and April 11, 1994 (Appendix M). Cadmium, chromium, copper, lead, selenium, and mercury were not detected. Arsenic, barium, and nickel concentrations complied with the OWQS. However, zinc concentrations (340 & 960 ug/l) exceeded the OWQS acute and chronic criteria to protect fish and wildlife. In addition, iron concentrations in Skipout Creek (1.5 & 1.7 mg/l) exceeded the EPA chronic criteria (EPA 1986) to protect aquatic organisms (1.0 mg/l).

I. Nutrient Budget and Lake Response

The following nutrient budget (Table 13) was calculated using the inflows and outflows in Table 7, and the mean nutrient concentrations observed in Skipout Creek (for inflow) and at the Lake Skipout dam (for outflow). Ideally, direct measurement of outflow nutrient concentrations would be used. However, use of concentrations measured at the dam should provide a reasonable estimate of the outflowing nutrient loads, because lake discharge originates from the dam.

Table 13. Nutrient budget for Lake Skipout, 1993.

Inflow	**kg/yr**
P load	56
N load	536
Outflow	
P load	4
N load	73

As the nutrient budget indicates, the lake serves as a “sink” for nutrients.

Based on the mean total phosphorous concentration (P_1) observed in Skipout Creek (0.22 mg/l) and the mean hydraulic residence time (T) in Lake Skipout (9.7 years), the following model was used to predict the lake phosphorous (P) concentration (EPA 1990):

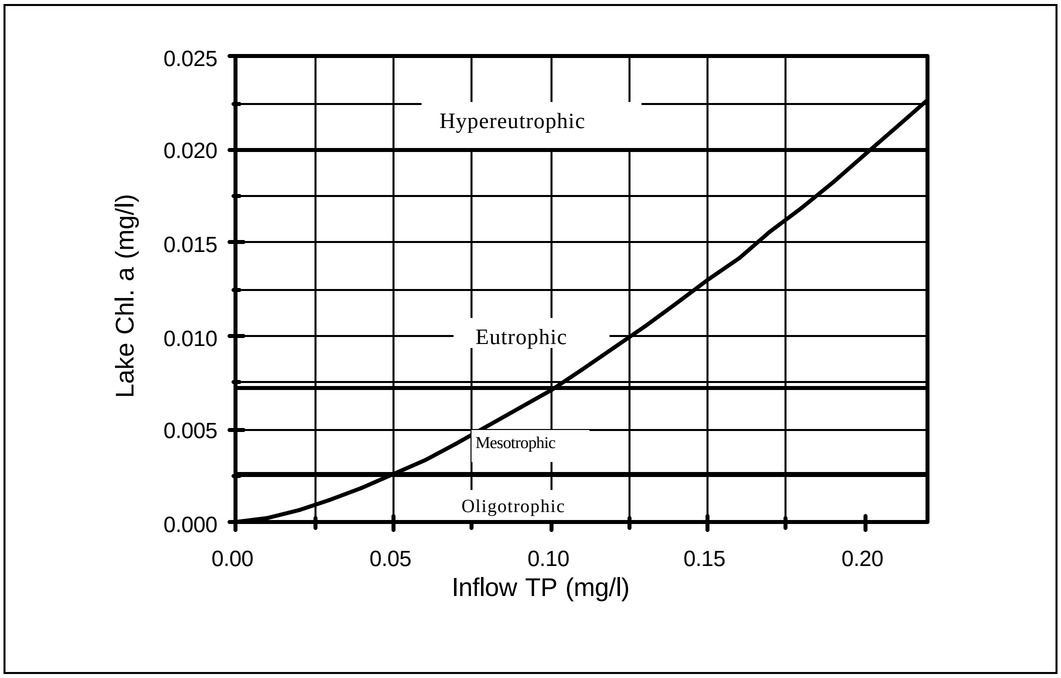
$$P\ (\text{ppb}) = P_1/(1+T^{0.5})$$

This model predicts that the lake phosphorous concentration (P) will be 0.053 mg/l. This estimate is not significantly different from the observed average lake phosphorous concentration of 0.055 mg/l. The following model was used to predict the chlorophyll *a* response to the predicted in lake phosphorous (P) concentration (EPA 1990):

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

The model predicts that the mean chlorophyll *a* concentration in the lake will be 0.022 mg/l. This estimate is not significantly different from the mean chlorophyll *a* concentration of 0.029 mg/l observed in the lake. However, the predicted chlorophyll concentration is slightly lower than the observed which may indicate that internal cycling of phosphorous has resulted in increased productivity in the lake. Regardless, both phosphorous and chlorophyll *a* concentrations indicate that the lake is currently hypereutrophic (see following section).

Figure 6. Predicted lake chlorophyll response for varying stream total phosphorous concentrations.



The lake response model predicts (Figure 6) that average stream TP concentrations would have to be reduced to 0.20 mg/l to achieve a trophic state of eutrophic (a 9% reduction), 0.10 mg/l to achieve a trophic state of mesotrophic (a 55% reduction), and 0.04 mg/l to achieve a trophic state of oligotrophic (an 82% reduction). However, the predicted responses may not be observed due to internal phosphorus cycling.

J. Assessment of Trophic State of Lake

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

Carlson Chlorophyll 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:

Parameter	TSI	Trophic State
obs. chlorophyll *a*	64	Hypereutrophic
est. chlorophyll *a*	61	Hypereutrophic
obs. Secchi	68	Hypereutrophic
obs. TP	62	Hypereutrophic
est. TP	61	Hypereutrophic

Obviously, Lake Skipout 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.

K. Discussion of Results

Lake Skipout is a heavily used recreational lake located in the Black Kettle National Grasslands of western Oklahoma. However, hypereutrophic conditions and fish kills prompted the initiation of this project.

Excessive nutrient loading from the watershed has resulted in high nutrient concentrations in the lake. This, along with nutrient recycling, has lead to eutrophication of the lake. Landuse in the watershed is made up of range, pasture, and cropland. In addition, 12 homes and a dairy are located in the watershed. Therefore, the primary sources of nutrients must be from cattle manure, fertilization, improperly treated sewage, and soil erosion. In addition, beavers inhabit portions of the stream and may be a minor source of nutrients.

Macrophytes encompass three quarters of the lake shoreline and pollution tolerant algae dominate the water column. Pollution tolerant blue-green algae dominate the lake in the spring and summer. Pollution tolerant euglenoids, which generally develop in areas with high ammonia or dissolved organic matter, dominate during the fall (macrophyte die-off).

The lake is relatively shallow and only stratifies during calm, hot periods. Although thermal stratification is generally weak and short lived, it has a considerable impact on the biotic integrity of the lake. During the short periods that the lake stratifies, the dissolved oxygen in the bottom 1-2 m of the water column was depleted to concentrations of less than 2 mg/l. This has severely impacted the benthic macroinvertebrate community.

Due to the high evaporation rate and low runoff rate in this region, the lake has a long retention time. This and the shallowness of the lake make it more susceptible to eutrophication. Due to the long retention time, the lake serves as a sink for nutrients. Because shallow lakes have greater sediment/water contact, nutrient recycling from the sediments occurs (EPA 1990).

Thus, reducing nutrient loading to the lake may not have a significant impact on its trophic state. Despite this, it is recommended that nutrient loading be reduced as much as possible. A lake response model used in the study predicted that the phosphorous loading would need to be reduced by 9% to achieve a eutrophic state, 55% to achieve a mesotrophic state, and 82% to achieve an oligotrophic state.

The introduction of gizzard shad has also impaired the quality of the lake. Analysis of the zooplankton community indicated an overabundance of these planktivorous fish. This has reduced the zooplankton’s ability to efficiently filter algae from the lake. The gizzard shad have also replaced the bluegill, longear sunfish, and crappie as the primary forage base in the lake. Analysis of the fish community indicated that the bluegill, longear sunfish, crappie, gizzard shad, and saugeye populations were in poor condition. However, the conditions of the largemouth bass and channel catfish populations are good.

II.1 Lake Restoration and Maintenance Goals

Based on the data presented and discussed in the previous report sections, there appear to be two major goals that should be addressed in order to best protect and maintain good water quality at Lake Skipout: 1) reduce algal productivity (trophic state) and 2) eradicate or actively manage the gizzard shad population. The following discussion describes various options for restoring the lake.

II.2 Lake Restoration and/or Pollution Control Alternatives

A. No Action

On a short term basis this alternative would be the least expensive The trophic state of Lake Skipout would remain hypereutrophic or advance even further over time as more nutrients enter the lake. Massive fish kills will continue to occur. Eventually, phytoplankton levels will severely compromise the aesthetic quality of the lake for fisherman and other recreational interests. This and poor fishing will result in the decreased use of the lake. 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, cost share funding may not be available and contractual costs would increase with inflation. In the long term, this could be the most expensive alternative.

B. Algal Control (Herbicides)

Algal control with copper sulfate is a common practice. However, copper sulfate 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 reservoirs. The disadvantages of copper sulfate use would not justify its use in Lake Skipout.

C. Algal 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 decreasing predation pressure on zooplankton by planktivorous fish (i.e. gizzard shad, blue-gill, shiners), 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 and possibly increase dissolved oxygen levels.

Since its inadvertent introduction, the gizzard shad has replaced the bluegill sunfish as the primary forage fish in this system and has created an imbalance in the fish community, as well as in the plankton community. This imbalance has perhaps led to the increased frequency of algal blooms experienced recently. Some of these blooms have created anoxic conditions, which have resulted in several fish kills. The obvious answer would be the eradication of the gizzard shad. However, their complete and exclusive eradication seems highly unlikely. There has been some precedent set by those who have used dilute concentrations of rotenone. However in most instances, periodic reapplication was necessary due to incomplete kills. A 5% survival rate would be more than enough to re-establish the population. A rotenone kill used in concert with stocking of flathead catfish and strict harvest regulations for largemouth bass may be a strategy that would limit the need for reapplication of rotenone.

Another possible solution to this problem might be the introduction of adult flathead catfish (*Pylodictus olivaris*). Once established, the adult flatheads might offer some means of control for the gizzard shad that are too large to be consumed by the large bass. However, the ODWC is concerned about controlling the flathead population, as current regulations prohibit the use of trotlines, limblines, and juglines which are the most effective means of harvest for this species. The ODWC is concerned that the flathead fishery would quickly show signs of underutilization and could potentially be harmful to the currently healthy bass population. The stocking of large voracious fish would not be expensive but would require some long term cooperation on the part of the ODWC. **This restoration alternative should be implemented.**

D. Draining and Dredging

Another consideration might be to completely drain the lake. Desirable fish could be captured and stocked in other reservoirs, or corralled and restocked in this reservoir upon completion of the project. Undesirable species should be removed from the lake basin prior to refilling, so as not to add to current nutrient problems.

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 Skipout, draining and dredging would facilitate the removal of accumulated nutrients and by-products of anaerobic decomposition, as well as eradicate the gizzard shad. In addition, selected sites could be deepened to enhance fish habitat.

This project should also include the dredging of the lake sediments and the grading of the banks to a 3:1 slope. This should offer some control for the extensive rooted macrophytes that encircle the lake. These aquatic macrophytes may be contributing to the current nutrient problem by cycling nutrients from the lake sediments to the water column (Wetzel 1983).

The cost of this alternative varies greatly depending on equipment used, the area involved, the depth of dredging, and the distance the sediment has to be hauled to be disposed of. If the sediment is used to build fishing berms in the lake, the cost of hauling the sediment would be eliminated. However, if the sediment is land applied, hauling fees could be considerable. A plan for the disposal of dredged material must be developed prior to initiation of the project. Improper disposal or storage can result in the discharge of nutrient rich runoff water to the lake or drainage which would result in algal blooms and in dissolved oxygen depletion of receiving waters. Because the lake will be drained, dozers, scrapers, and other heavy equipment can be used. Trackhoes and draglines should also be considered. Costs could range from $25,000 to $250,000 depending on the amount of sediment removed. The high costs may make this alternative not feasible. However, the amount of dredging can be tailored to the amount of money available.

In addition to the high costs, the long retention time (and thus filling time) may make this alternative not feasible. The retention time calculated during the study was 9.7 years. Therefore, draining and dredging may put the lake out of commission for over 10 years. However, if this alternative is chosen, it is imperative that improved land management practices be initiated prior to dredging.

E. Sediment Covering/Phosphorous Inactivation

If dredging is considered too expensive, phosphorous inactivation has been found to be an effective method in the reduction of algal and macrophytic 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 will result in the limitation of algal growth by sharply depleting this nutrient. This method is generally effective in reducing algal biomass in lakes which receive low external phosphorous loads and have high levels of internal phosphorous release from nutrient rich sediments. Because external phosphorous loading to Lake Skipout was significant, this method would likely be ineffective and would not provide a feasible alternative.

F. Implementation of best management practices (BMP)

The study and watershed survey revealed the following possible sources of NPS pollution: sediment cycling, overgrazing, streambank erosion, cattle in stream and riparian areas, dairy runoff, crop fertilizer, lack of residue on fields, and improperly working septic systems

An effort should be made to locate and reduce all significant nonpoint sources of nutrient loading that may exist within the basin. Land use in the Lake Skipout watershed is dominated by range (51%), pasture (23%), and cropland (21%). Best management practices (BMP) should be implemented throughout the watershed to reduce sediment and nutrient runoff from these land uses. In the following discussion, the BMP’s in *italics* are approved methods found in the Oklahoma Standards and Specifications Book (Specification number in parenthesis).

Proper Grazing Use (528), *Planned Grazing Systems* (556), or *Pasture and Hayland Management* (510) will prevent overstocking and overgrazing of both pasture and range, thus reducing both sediment and nutrient loading to streams.

Where the land along the tributaries is used as pasture the stream is often the sole source for livestock water. Unrestricted livestock access to the stream can be a significant nutrient source. Excessive livestock grazing can denude the stream banks causing severe stream bank erosion and sedimentation downstream. Moderate measures to reduce impact from livestock would include improved pasture management and controlled cattle rotation from pasture to stream side, effectively decreasing detrimental trampling of stream bottoms, banks, and riparian strips. This would also limit the exposure of grazing cattle to new woody growth in the riparian areas. Livestock exclusion from the streams may be considered, however, this may require purchase of easements and incentives for landowner cooperation. Streambank restoration can be achieved utilizing methods developed by Dave Rosgen. In addition, the BMPs *Streambank Protection* (580), *Livestock Exclusion* (472) from riparian areas and streams, *Fencing* (382) of riparian areas and streams, and *Deferred Grazing* (352) of riparian areas would effectively reduce streambank erosion and aid in stream channel stabilization by allowing the establishment of permanent vegetation. Fencing for riparian and stream protection would cost $0.56 per linear foot. This fencing would also serve, in part, as a facility for controlled cattle rotation, where applicable. The resulting revegetation of the riparian areas would also help trap soil bound nutrients and sediments, reducing the loading to Lake Skipout. 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.

Although cropland makes up only 1/5 of the watershed, it may be a significant source of the nutrient and sediment loading to the lake. Phosphorus loading from conventional till wheat was up to 10 times higher than that of native grass pasture. Improved tillage practices need to be encouraged in the watershed to reduce sediment and nutrient contributions to the lake. *Contour Farming* (330), *Conservation Tillage* (329), *Cover and Green Manure Crops* (340), *Crop Residue Use* (344), and *Field Windbreaks* (392) would significantly reduce wind and water erosion on cropland. *Nutrient Management* (680) through soil testing and proper fertilizer application rates will prevent runoff of excessive nutrients. In addition, *Filter Strips* (393) placed at the lower edges of fields and along streams would filter nutrients and sediment from runoff before it reaches the stream.

In order to reduce and treat runoff from animal holding areas (i.e. dairies, feedlots, etc.) *Terraces* (600) should be placed up gradient in order to divert water away from these holding areas. In addition, *Filter Strips* (393), *Waste Storage Ponds* (425), *Waste Treatment Lagoons* (359), or a combination of the three should be placed down gradient of the holding areas in order to treat and/or prevent runoff. This should effectively reduce nutrient and sediment loading to the stream.

In addition, *Critical Area Planting* (342) and *Dune Stabilization*, as well as *Livestock Exclusion* (472) from actively eroding areas should reduce sediment loading to the stream. Section 319 grants provide cost-share money for implementation of BMP's to control NPS pollution. All BMP selection and implementation should occur through the cooperation and coordination of the Upper Washita Conservation District, Natural Resource Conservation Service, and the Oklahoma Conservation Commission. Special effort will be needed to educate land owners on BMP implementation. Best management practices will be maintained by the landowners in cooperation with the Upper Washita Conservation District. **This is the most feasible restoration alternative.**

G. Inspect and Upgrade Sewage Treatment

If current septic systems aren't working, upgrading sewage treatment in the Lake Skipout watershed could substantially reduce nutrient loading. All septic systems in the watershed should be inspected to ensure that they are working properly. Those not working properly should be upgraded. Section 319 grants can provide cost-share money for installation of septic systems to rural residences on demonstration watersheds. **This restoration alternative is also highly recommended.**

H. Construct Fish Habitat

Like many reservoirs, Lake Skipout is experiencing a deterioration and loss of vital fish habitat. Fish flesh production cannot continue to be maintained at the current level if habitat quantity and quality are allowed to diminish. The ODWC has been responsible for constructing and maintaining fish attractors (brush piles) in the past. This effort should continue on a broader scale and might also include the construction of spawning areas. This might require involvement by other agencies and local volunteers.

II.3 Benefits versus Problems Associated With Each Alternative

A. No Action

Benefits	-Low to no cost of implementation.
Problems	-Eutrophication, siltation, and fish community imbalance remain unchecked -Eventual loss of recreational facility

B. Algal Control (Herbicides)

Benefits -Temporary elimination of algal blooms

Problems -Requires repeated treatment
-Treats only the symptoms of eutrophication
-Introduces potentially high concentrations of toxic metals
-High cost

C. Algal 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
-Benefits easily reversed

D. Draining and Dredging

Benefits -Decreased nutrient recycling due to removal of accumulated sediment and nutrients and increased depth
-Improvement of fish habitat and ultimately the fishery

Problems -Expensive
-Does not address nutrient inputs
-Temporary results unless linked to watershed measures
-Lake may not be useable for a long period of time due to draining, dredging and refilling (could be as long as 10 years based on retention time estimates)

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
-Could create adverse water quality conditions detrimental to fish
-Ineffective unless nutrient loading from watershed is limited

F. 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 -No guarantee of maintenance of the BMPs

G. Inspect and Upgrade Sewage Treatment

Benefits	-Proper treatment of sewage -Reduce nutrient loading -Reduce fecal coliform bacteria
Problems	-No guarantee of owner cooperation

H. Construct Fish Habitat

Benefits	-Improve fish community
Problems	-Cost

II.4 Description of Phase II Monitoring Program

The lake (at dam only) and creek should be monitored for one year after all implementation activities are completed. Post-implementation monitoring should include monthly sampling from September through April and semimonthly monitoring from May through August. Runoff sampling should also be performed at the creek site.

All samples should be analyzed for total phosphorous, phosphate, nitrite, nitrate, ammonia, total Kjeldahl nitrogen, alkalinity, hardness, turbidity, and total suspended solids. Dissolved oxygen, temperature, pH, and conductivity profiles should be measured in the lake. Dissolved oxygen, temperature, pH, and conductivity should be *in situ* in the stream.
In addition, surface chlorophyll concentrations and Secchi depth should be measured during each sampling event in the lake (at dam). The lake algae and zooplankton communities should be analyzed quarterly during the study. The fish, benthic macroinvertebrate, and macrophyte communities should be analyzed once during the post-implementation study.

II.5 Lake Restoration and Pollution Control Workplan

At this time, no Phase II workplan exists for a Lake Skipout restoration project. Before this can be developed, officials from the USDA Forest Service, Upper Washita Conservation District, Oklahoma Conservation Commission, Natural Resource Conservation Service, Oklahoma Department of Wildlife Conservation, and most importantly, the land owners from the watershed, will have to concur on a cooperative agreement which would include the commitment of funding for cost shared implementation. It would not be possible to draft any workplan without total commitment of resources from these parties.

II.6 Sources of Funds for Restoring the Lake

Funds for future restoration implementation practices could be derived from the USDA Forest Service, who manage and administer Lake Skipout; ODWC, who oversee fish and wildlife concerns; the Upper Washita Conservation District, who maintain the facility in an effort to enhance soil conservation in the watershed; the landowners; §319 grants through the Oklahoma Conservation Commission and EPA; and NRCS.

II.7 Relationship of Project to Other Pollution Control Programs and Watershed Maintenance Plan

Only conservation and education programs administered by the Upper Washita Conservation District, NRCS, and the Oklahoma Cooperative Extension Service are in progress at this time.

II.8 Summary of Public Participation Activities

To date, only the initial public meeting prior to the start of the Lake Skipout Clean Lakes Phase I study was held. This meeting summarized how these studies are performed and the goals of the study. Further meetings are anticipated to present the findings of this study and develop the restoration plan.

II.9 Necessary Permits

All necessary permits will be obtained prior to implementation of activities requiring them. If the dredging alternative is elected, U.S. Army Corps of Engineer 404 permits, as well as 401 certification from the Oklahoma Department of Environmental Quality will be obtained.

PROJECT ENVIRONMENTAL EVALUATION

III.1 Displacement of People

There will be no displacement of people as a result of this study.

III.2 Defacement of Residences and Residential Areas, Available and Applied Mitigative Actions

There will be no defacement of residences and residential areas as a result of any action(s) from this project.

III.3 Changes in Land Use Patterns

Implementation of best management practices will result in environmentally sound use of the land.

III.4 Impact on Prime Agricultural Land

Measures taken to reduce nutrient and sediment loading should result in beneficial impacts such as decreased top soil loss, increased fertility, and preservation of site productivity.

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

If the lake is drained and dredged, adjacent parkland would be effected for a short period of time until dredging activities are completed and the lake is refilled and stocked with fish. However, over the long haul, restoration should result in aesthetic improvements in Lake Skipout and consequently make the adjacent parkland more aesthetically pleasing. In addition, successful riparian revegetation should provide additional habitat for 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. Therefore, the quality of upland game hunting on adjacent parkland, as well as other parts of the watershed should increase over time.

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

Four sites of cultural value are located within the Lake Skipout watershed. Two sites are located in Section 5, T13N, R25W, and two sites are located in Section 18, T13N, R25W. However, none of the planned activities will impact these areas.

III.7 Long Term Energy Impacts

There are no long term energy impacts anticipated as a result of any implementation action.

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

If the lake is dredged, short term noise levels and possibly air quality in the immediate vicinity of the lake would be impacted. However, no long term ambient air quality and/or noise level impacts will result from restoration activities.

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

Chemical treatment, although mentioned in previous sections, is not highly recommended. The in-lake chemical treatments discussed in previous sections include the use of rotenone, copper sulfate, or alum. If properly used, rotenone would control the gizzard shad populations, while both copper sulfate or alum would reduce algae levels in Lake Skipout. However, if improperly applied, the biological community could be severally impacted. Therefore, if these alternatives are elected, appropriate precautions and the most conservative methodologies should be used to implement these restoration practices.

III.10 Flood Plain Impacts

Lake Skipout is a Flood Retarding Structure. Increased depth from dredging will increase the flood pool storage of the lake thus decreasing down stream flooding.

III.11 Impacts of Dredging Activities

If dredging is elected, it is recommended that the lake be drained and desirable fish be removed and restocked to other reservoirs. Dredged sediment could be used to construct fishing berms or land applied. If land applied, vegetation will be established on the dredged sediment as soon as possible after application.

In addition, filter strips down gradient of the land application will be used to filter runoff from areas where dredged sediment is applied. After berm construction is completed, vegetation and/or rip-rap may be used to stabilize them and prevent future shoreline erosion. These short term impacts will be adequately mitigated by long term benefits derived by the removal of nutrient rich sediment.

III.12 Wetland, Fish and Wildlife, Endangered Species Impacts

Fencing of riparian areas will provide protection to associated wetland areas. Eradication of the gizzard shad will return the proper balance of predators and prey to Lake Skipout enhancing the entire fish community in the long run. Re-establishment of riparian areas will also benefit native wildlife by providing habitat. No endangered species will be impacted by restoration activities.

III.13 Feasible Alternatives to Project

It was attempted to present all restoration alternatives, as well as their pros and cons, so that the deciding authorities can make well informed decisions as to what is finally implemented.

III.14 Other Measures and Impacts Not Previously Discussed

Although it was attempted to present all restoration alternatives, it is likely that some alternatives may have been overlooked. Those overlooked, as well as new technologies should be evaluated as they arise in the future.

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APPENDIX A

ROUTINE WATER QUALITY DATA

LAKE SKIPOUT

1992-93

Lake Skipout Dam

Date	Depth (ft)	Turb	Alk	TDS	TSS	TKN	NO2+NO3	TN	TP	Ortho P	Diss. Ca	Diss. Mg	Cl	SO4	F	Hard
12/17/92	**composite**			612	12	0.8		0.8	0.030		33	26	130	45	0.8	
03/01/93	**composite**	12	319	618	16	1.0	<0.05	1.0	0.050	0.030	37	24	120	43	0.7	190
03/22/93	**composite**	18	321	602	5	0.8	<0.05	0.8	0.040	<0.01	36	27	110	41	0.8	
04/30/93	0.5	13	303	557	5	0.9	<0.05	0.9	0.030	<0.01	35	25	110	38	0.7	
04/30/93	21	16	308	624	2	1.4	<0.05	1.4	0.090	<0.01	36	25	110	40	0.8	
05/10/93	**composite**	14	315	644	30	1.1	<0.05	1.1	0.070	<0.01	34	25	110	39	0.8	
05/24/93	0.5	15	292	587	5	1.2	<0.05	1.2	0.050	0.010	33	24	110	37	0.7	
05/24/93	21	19	317	296	10	1.3	0.051	1.4	0.110	0.070	34	25	110	33	0.8	
06/07/93	**composite**	24	310	602	19	1.1	<0.05	1.1	0.050	<0.01	32	22	110	36	0.8	
06/21/93	0.5	9	314	594	13	0.9	<0.05	0.9	0.070	<0.01	33	25	100	34	0.7	
06/21/93	21	11	307	583	10	1.1	<0.05	1.1	0.100	0.020	34	24	100	34	0.8	
07/06/93	0.5			608	35	0.7	<0.05	0.7	0.050	0.010	32	23	100	34	0.8	
07/06/93	21	20	293	608		0.7	<0.05	0.7	0.050	<0.01	31	23				
07/19/93	0.5	17	290	570	35	1.1	<0.05	1.1	0.070	<0.01	30	23	100	33	0.7	
07/19/93	21	27	310	601	31	1.2	<0.05	1.2	0.140	<0.01	27	23	100	33	0.7	
08/09/93	0.5			589	38	0.7	<0.05	0.7	0.010	<0.01	26	25	100	34	0.8	
08/09/93				673	30	0.9	<0.05	0.9	0.040	0.010	26	24	100	34	0.8	
08/26/93	0.5	22	289	577	11	0.8	<0.05	0.8	0.040	<0.01	23	24	110	34	0.8	
08/26/93	18	31	287	578	27	0.8	<0.05	0.8	0.040	<0.01	23	24	110	34	0.8	
09/08/93	0.5	22	275	574	8	0.8	<0.05	0.8	0.040	<0.01	23	24	110	37	0.8	
09/08/93	18	30	284	574	19	0.9	<0.05	0.9	0.050	<0.01	24	24	110	36	0.8	
09/20/93	0.5	17	302	584	23	1.1	<0.05	1.1	0.050	<0.01	23	22	110	39	0.9	
09/20/93	18			596	25	1.0	<0.05	1.0	0.050	<0.01	23	22	110	38	0.8	
10/27/93	**composite**	24	294	602	28	1.5	<0.05	1.5	0.110	<0.01			107	39		160
11/23/93	**composite**	14	305	582	23	1.3	<0.05	1.3	0.080	<0.01			114	50		168

Composite = sample composited from surface, mid-depth, and bottom samples

Lake Skipout West Arm

Date	Depth (ft)	Turb	Alk	TDS	TSS	TKN	NO2+NO3	TN	TP	Ortho P	Diss. Ca	Diss. Mg	Cl	SO4	F	Hard
12/17/92	**composite**			626	11	0.8		0.8	0.040		33	26	130	45	0.8	
03/01/93	**composite**	12		610	10	0.8	<0.05	0.8	0.050	0.030	37	24	120	43	0.7	190
03/22/93	**composite**	12	317	592	9	0.7	<0.05	0.7	0.040	<0.01	39	26	110	40	0.8	
04/30/93	**composite**	14	310	614	5	0.8	<0.05	0.8	0.050	<0.01	37	25	120	40	0.8	
05/10/93	**composite**	15	307	634	28	0.7	<0.05	0.7	0.040	<0.01	34	24	110	39	0.8	
05/24/93	0.5	16	310	590	3	1.3	<0.05	1.3	0.080	0.010	35	25	110	36	0.8	
05/24/93	15	18	309	598	6	0.7	<0.05	0.7	0.050	0.020	34	24	110	35	0.7	
06/07/93	**composite**	29	310	584	23	0.9	<0.05	0.9	0.050	<0.01	34	23	110	36	0.8	
06/21/93	0.5			591	10	0.6	<0.05	0.6	0.040	0.010	34	25	110	35	0.8	
06/21/93	15	11	311	590	9	0.8	<0.05	0.8	0.050	<0.01	34	25	100	35	0.8	
07/06/93	0.5	19	305	582	17								100	34	0.7	
07/06/93	15	24	303	289	31								100	34	0.7	
07/19/93	0.5	18	292	575	13	0.8	<0.05	0.8	0.060	0.020	26	23	100	33	0.7	
07/19/93	12			583	21	0.9		0.9	0.070		31	23	100	33	0.8	
08/09/93	0.5			585	10	1.3	<0.05	1.3	0.070	<0.01	24	20	98	34	0.8	
08/09/93				594	44	0.8	<0.05	0.8	0.030	<0.01	26	24	100	34	0.8	
08/26/93	0.5	21	284	574	10	1.0	<0.05	1.0	0.070	<0.01	24	23	120	34	0.8	
08/26/93	12	27	292	571	18	1.0	<0.05	1.0	0.070	<0.01	23	24	120	34	0.8	
09/08/93	**composite**	27	275	550	9	0.8	<0.05	0.8	0.040	<0.01	23	25	110	37	0.8	
09/20/93	0.5	18	291	592	18	1.6	<0.05	1.6	0.080	<0.01	22	22	110	40	0.9	
09/20/93	12	28	296	604	32	0.8	<0.05	0.8	0.030	<0.01	22	21	110	38	0.8	
10/27/93	**composite**	23	303	597	31	1.4	<0.05	1.4	0.050	<0.01			108	40		160
11/23/93	**composite**	15	300	566	26	1.4	<0.05	1.4	0.070	<0.01			113	50		168

Composite = sample composited from surface, mid-depth, and bottom samples

Lake Skipout East Arm

Date	Depth (ft)	Turb	Alk	TDS	TSS	TKN	NO2+NO3	TN	TP	Ortho P	Diss. Ca	Diss. Mg	Cl	SO4	F	Hard
03/01/93	**composite**	12	329	606	12	1.0	<0.05	1.0	0.06	0.01	37	24	120	42	0.7	190
07/06/93	0.5	19	298	574	14	0.7	<0.05	0.7	0.04	<0.01	31	24	100	34	0.8	
07/06/93	10.5	22	306	299	10	0.8	0.05	0.9	0.04	0.01	32	24	100	33	0.7	
09/08/93	**composite**	23	276	578	17	0.8	<0.05	0.8	0.04	<0.01			110	37	0.8	
11/23/93	**composite**	15	306	592	26	1.3	<0.05	1.3	0.07	<0.01			112	49		180

Composite = sample composited from surface, mid-depth, and bottom samples

APPENDIX B

LAKE PROFILE DATA

Lake Skipout Profiles

Site	Date	Depth	Temp	DO	Cond	pH
Dam	01-Mar-93	0.1	4.02	11.60	996	8.27
Dam	01-Mar-93	1.0	3.99	11.57	996	8.30
Dam	01-Mar-93	2.0	3.98	11.48	997	8.31
Dam	01-Mar-93	3.0	3.99	11.44	998	8.32
Dam	01-Mar-93	4.0	3.97	11.44	999	8.32
Dam	01-Mar-93	5.0	3.97	11.42	998	8.32
Dam	01-Mar-93	6.0	3.96	11.41	999	8.32
Dam	01-Mar-93	6.5	3.96	11.39	998	8.32
Dam	22-Mar-93	0.1	8.47	11.33	1003	8.40
Dam	22-Mar-93	1.0	8.35	11.22	1003	8.43
Dam	22-Mar-93	2.0	8.10	11.18	1003	8.45
Dam	22-Mar-93	3.0	8.07	11.08	1003	8.48
Dam	22-Mar-93	4.0	7.85	10.90	1005	8.50
Dam	22-Mar-93	5.0	7.82	10.70	1004	8.50
Dam	22-Mar-93	6.0	7.75	10.51	1005	8.50
Dam	22-Mar-93	7.0	7.72	10.38	1005	8.50
Dam	30-Apr-93	0.1	16.67	9.95	1102	8.62
Dam	30-Apr-93	1.0	16.62	9.89	1102	8.63
Dam	30-Apr-93	2.0	16.62	9.89	1102	8.63
Dam	30-Apr-93	3.0	16.59	9.81	1102	8.64
Dam	30-Apr-93	4.0	16.56	9.75	1102	8.64
Dam	30-Apr-93	5.0	16.32	8.90	1102	8.62
Dam	30-Apr-93	6.0	15.56	7.18	1102	8.56
Dam	30-Apr-93	7.0	15.46	6.25	1105	8.52
Dam	30-Apr-93	7.5	15.43	6.00	1102	8.49
Dam	10-May-93	0.1	17.77	8.45	1082	8.54
Dam	10-May-93	1.0	17.77	8.29	1085	8.54
Dam	10-May-93	2.0	17.73	8.15	1086	8.54
Dam	10-May-93	3.0	17.73	8.12	1085	8.54
Dam	10-May-93	4.0	17.67	7.98	1086	8.54
Dam	10-May-93	5.0	17.57	7.70	1085	8.53
Dam	10-May-93	6.0	17.47	7.57	1086	8.52
Dam	10-May-93	7.0	17.29	7.45	1085	8.52
Dam	10-May-93	7.5	17.27	7.53	1085	8.52

Site	Date	Depth	Temp	DO	Cond	pH
Dam	24-May-93	0.1	22.06	7.73	1073	8.49
Dam	24-May-93	1.0	21.81	7.41	1074	8.43
Dam	24-May-93	2.0	21.02	6.01	1070	8.42
Dam	24-May-93	3.0	20.72	5.74	1071	8.40
Dam	24-May-93	4.0	20.31	4.95	1072	8.37
Dam	24-May-93	5.0	20.00	3.81	1070	8.30
Dam	24-May-93	6.0	19.79	2.59	1074	8.25
Dam	24-May-93	7.0	19.44	0.76	1074	8.15
Dam	07-Jun-93	0.1	22.60	6.90	1050	8.42
Dam	07-Jun-93	1.0	22.60	6.84	1050	8.42
Dam	07-Jun-93	2.0	22.50	6.80	1050	8.44
Dam	07-Jun-93	3.0	22.50	6.60	1050	8.44
Dam	07-Jun-93	4.0	22.50	6.50	1050	8.44
Dam	07-Jun-93	5.0	22.50	6.40	1050	8.44
Dam	07-Jun-93	6.0	22.40	6.20	1050	8.43
Dam	07-Jun-95	7.0	22.30	5.80	1060	8.42
Dam	21-Jun-93	0.1	26.20	11.60	1035	8.70
Dam	21-Jun-93	1.0	26.10	11.60	1035	8.70
Dam	21-Jun-93	2.0	26.00	11.00	1035	8.70
Dam	21-Jun-95	3.0	24.10	5.30	1040	8.50
Dam	21-Jun-93	4.0	23.70	3.70	1040	8.50
Dam	21-Jun-93	5.0	23.50	2.80	1040	8.40
Dam	21-Jun-93	6.0	23.20	1.50	1025	8.40
Dam	21-Jun-93	7.0	22.80	0.20	1020	8.30
Dam	06-Jul-93	0.1	25.90	8.80	1008	8.60
Dam	06-Jul-93	1.0	25.90	8.80	1008	8.60
Dam	06-Jul-93	2.0	25.50	7.90	1008	8.60
Dam	06-Jul-93	3.0	25.40	7.70	1008	8.60
Dam	06-Jul-93	4.0	25.30	7.40	1008	8.58
Dam	06-Jul-93	5.0	25.00	6.90	1008	8.60
Dam	06-Jul-93	6.0	24.90	6.40	1008	8.50
Dam	06-Jul-93	7.0	24.80	5.90	1010	8.50

Lake Skipout Profiles

Dam	19-Jul-93	0.1	28.70	11.10	1000	
Dam	19-Jul-93	1.0	27.60	7.60	1000	
Dam	19-Jul-93	2.0	26.80	5.50	1010	
Dam	19-Jul-93	3.0	26.40	4.70	1010	
Dam	19-Jul-93	4.0	26.20	3.80	1010	
Dam	19-Jul-93	5.0	26.00	2.90	1010	
Dam	19-Jul-93	6.0	25.90	2.10	1010	
Dam	19-Jul-93	7.0	25.80	0.50	1010	
Dam	09-Aug-93	0.1	25.80	8.60	1000	8.60
Dam	09-Aug-93	1.0	25.60	8.20	1000	8.60
Dam	09-Aug-93	2.0	25.40	7.80	1000	8.60
Dam	09-Aug-93	3.0	25.40	7.60	1000	8.60
Dam	09-Aug-93	4.0	25.10	6.40	1000	8.50
Dam	09-Aug-93	5.0	25.00	6.40	1000	8.50
Dam	09-Aug-93	6.0	25.00	6.10	1000	8.50
Dam	09-Aug-93	7.0	24.90	4.70	1000	8.40
Dam	26-Aug-93	0.1	26.80	9.40	1013	8.80
Dam	26-Aug-93	1.0	26.80	9.30	1013	8.80
Dam	26-Aug-93	2.0	26.40	8.30	1013	8.70
Dam	26-Aug-93	3.0	26.20	7.70	1013	8.70
Dam	26-Aug-93	4.0	26.00	7.10	1013	8.70
Dam	26-Aug-93	5.0	26.00	6.60	1013	8.70
Dam	26-Aug-93	6.0	25.90	6.10	1013	8.70
Dam	26-Aug-93	7.0	25.70	5.20	1013	8.60
Dam	08-Sep-93	0.1	22.50	6.90	1020	8.70
Dam	08-Sep-93	1.0	22.50	6.70	1020	8.70
Dam	08-Sep-93	2.0	22.40	6.60	1020	8.70
Dam	08-Sep-93	3.0	22.40	6.40	1020	8.70
Dam	08-Sep-93	4.0	22.40	5.60	1020	8.60
Dam	08-Sep-93	5.0	22.40	4.60	1020	8.60
Dam	08-Sep-93	6.0	22.40	2.40	1026	8.40

Dam	20-Sep-93	0.1	20.90	11.40	1021	9.00
Dam	20-Sep-93	1.0	20.80	10.90	1021	9.00
Dam	20-Sep-93	2.0	19.90	7.60	1024	8.90
Dam	20-Sep-93	3.0	19.80	6.80	1028	8.80
Dam	20-Sep-93	4.0	19.80	6.30	1023	8.80
Dam	20-Sep-93	5.0	19.70	5.60	1023	8.80
Dam	20-Sep-93	6.0	19.70	4.60	1030	8.70
Dam	20-Sep-93	6.5	19.60	3.60	1030	8.70
Dam	27-Oct-93	0.1	13.20	9.00	1033	8.80
Dam	27-Oct-93	1.0	13.10	8.70	1033	8.80
Dam	27-Oct-93	2.0	13.00	8.50	1034	8.80
Dam	27-Oct-93	3.0	13.00	8.50	1035	8.80
Dam	27-Oct-93	4.0	13.00	8.50	1035	8.80
Dam	27-Oct-93	5.0	12.90	8.50	1035	8.50
Dam	27-Oct-93	6.0	12.80	8.40	1035	8.80
Dam	23-Nov-93	0.1	7.60	11.10	1035	8.50
Dam	23-Nov-93	1.0	7.50	11.10	1035	8.50
Dam	23-Nov-93	2.0	7.40	11.10	1035	8.50
Dam	23-Nov-93	3.0	7.30	11.00	1035	8.60
Dam	23-Nov-93	4.0	7.30	11.10	1040	8.60
Dam	23-Nov-93	5.0	7.20	11.10	1040	8.60
Dam	23-Nov-93	6.0	7.20	11.10	1040	8.60
Dam	23-Nov-93	6.5	7.20	11.10	1040	8.60

Lake Skipout Profiles

W. Arm	01-Mar-93	0.1	3.98	11.64	998	8.33
W. Arm	01-Mar-93	1.0	3.97	11.57	998	8.34
W. Arm	01-Mar-93	2.0	3.95	11.54	998	8.34
W. Arm	01-Mar-93	3.0	3.94	11.50	999	8.34
W. Arm	01-Mar-93	4.0	3.95	11.46	996	8.34
W. Arm	01-Mar-93	5.0	3.95	11.45	999	8.35
W. Arm	22-Mar-93	0.1	8.32	11.37	1005	8.40
W. Arm	22-Mar-93	1.0	8.27	11.28	1005	
W. Arm	22-Mar-93	2.0	8.20	11.26	1005	
W. Arm	22-Mar-93	3.0	8.20	11.26	1005	
W. Arm	22-Mar-93	4.0	8.09	11.16	1005	
W. Arm	22-Mar-93	5.0	8.05	11.12	1005	
W. Arm	30-Apr-93	0.1	16.57	9.35	1102	8.55
W. Arm	30-Apr-93	1.0	16.45	9.20	1102	8.55
W. Arm	30-Apr-93	2.0	16.37	8.90	1102	8.54
W. Arm	30-Apr-93	3.0	16.25	8.50	1102	8.54
W. Arm	30-Apr-93	4.0	16.15	8.22	1102	8.53
W. Arm	30-Apr-93	5.0	16.03	7.80	1102	8.51
W. Arm	10-May-93	0.1	17.67	8.33	1086	8.49
W. Arm	10-May-93	1.0	17.66	8.24	1085	8.49
W. Arm	10-May-93	2.0	17.66	8.48	1086	8.51
W. Arm	10-May-93	3.0	17.65	8.39	1085	8.51
W. Arm	10-May-93	4.0	17.65	8.39	1085	8.51
W. Arm	10-May-93	5.0	17.63	8.37	1086	8.51
W. Arm	10-May-93	5.5	17.64	8.31	1085	8.51
W. Arm	24-May-93	0.1	22.24	7.56	1069	8.49
W. Arm	24-May-93	1.0	21.97	7.40	1069	8.49
W. Arm	24-May-93	2.0	21.49	6.03	1066	8.46
W. Arm	24-May-93	3.0	20.65	5.61	1067	8.41
W. Arm	24-May-93	4.0	20.47	5.52	1067	8.41
W. Arm	24-May-93	5.0	20.26	4.70	1067	8.37

W. Arm	07-Jun-93	0.1	22.70	6.80	1050	8.40
W. Arm	07-Jun-93	1.0	22.60	6.70	1050	8.40
W. Arm	07-Jun-93	2.0	22.50	6.70	1050	8.40
W. Arm	07-Jun-93	3.0	22.50	6.60	1050	8.40
W. Arm	07-Jun-93	4.0	22.50	6.60	1050	8.40
W. Arm	07-Jun-93	5.0	22.40	6.40	1050	8.40
W. Arm	21-Jun-93	0.1	25.40	9.30	1035	8.60
W. Arm	21-Jun-93	1.0	25.30	9.20	1035	8.60
W. Arm	21-Jun-93	2.0	25.20	9.00	1035	8.60
W. Arm	21-Jun-93	3.0	24.10	5.40	1040	8.50
W. Arm	21-Jun-93	4.0	23.60	3.40	1040	8.50
W. Arm	21-Jun-93	5.0	23.30	1.70	1040	8.40
W. Arm	06-Jul-93	0.1	25.40	7.40	1010	8.50
W. Arm	06-Jul-93	1.0	25.40	7.40	1010	8.50
W. Arm	06-Jul-93	2.0	25.20	7.30	1010	8.60
W. Arm	06-Jul-93	3.0	25.20	7.20	1010	8.60
W. Arm	06-Jul-93	4.0	25.10	6.80	1010	8.50
W. Arm	06-Jul-93	5.0	25.00	6.60	1010	8.50
W. Arm	19-Jul-93	0.1	28.90	11.80	1000	
W. Arm	19-Jul-93	1.0	27.20	9.60	1010	
W. Arm	19-Jul-93	2.0	26.70	6.10	1010	
W. Arm	19-Jul-93	3.0	26.30	4.30	1010	
W. Arm	19-Jul-93	4.0	26.20	3.40	1010	
W. Arm	19-Jul-93	5.0	26.10	2.90	1014	
W. Arm	09-Aug-93	0.1	25.60	8.10	1000	8.60
W. Arm	09-Aug-93	1.0	25.40	7.90	1000	8.60
W. Arm	09-Aug-93	2.0	25.20	7.10	1000	8.50
W. Arm	09-Aug-93	3.0	25.10	6.40	1000	8.50
W. Arm	09-Aug-93	4.0	24.90	6.00	1000	8.50
W. Arm	09-Aug-93	5.0	24.90	5.60	1000	8.50

Lake Skipout Profiles

W. Arm	26-Aug-93	0.1	26.30	8.40	1013	8.80
W. Arm	26-Aug-93	1.0	26.30	8.30	1013	8.80
W. Arm	26-Aug-93	2.0	26.20	8.00	1014	8.80
W. Arm	26-Aug-93	3.0	26.00	7.80	1014	8.70
W. Arm	26-Aug-93	4.0	25.90	6.50	1015	8.70
W. Arm	26-Aug-93	5.0	25.80	5.70	1016	8.70

W. Arm	08-Sep-93	0.1	22.60	7.80	1020	8.70
W. Arm	08-Sep-93	1.0	22.60	7.60	1020	8.70
W. Arm	08-Sep-93	2.0	22.60	7.30	1020	8.70
W. Arm	08-Sep-93	3.0	22.50	7.20	1025	8.70
W. Arm	08-Sep-93	4.0	22.50	7.20	1025	8.70
W. Arm	08-Sep-93	4.5	22.50	7.10	1023	8.70

W. Arm	20-Sep-93	0.1	21.70	11.60	1023	9.10
W. Arm	20-Sep-93	1.0	21.60	12.20	1023	9.10
W. Arm	20-Sep-93	2.0	20.40	9.60	1022	9.00
W. Arm	20-Sep-93	3.0	19.90	7.60	1023	8.90
W. Arm	20-Sep-93	4.0	19.80	6.40	1026	8.80
W. Arm	20-Sep-93	5.0	19.80	6.80	1026	8.80

W. Arm	27-Oct-93	0.1	13.40	9.70	1036	8.80
W. Arm	27-Oct-93	1.0	13.20	9.20	1035	8.80
W. Arm	27-Oct-93	2.0	13.00	9.00	1035	8.80
W. Arm	27-Oct-93	3.0	13.00	8.90	1035	8.80
W. Arm	27-Oct-93	4.0	12.70	9.00	1035	8.80
W. Arm	27-Oct-93	4.5	12.40	9.00	1038	8.80

W. Arm	23-Nov-93	0.1	7.30	11.10	1055	8.50
W. Arm	23-Nov-93	1.0	7.20	11.10	1050	8.50
W. Arm	23-Nov-93	2.0	7.20	11.10	1050	8.50
W. Arm	23-Nov-93	3.0	7.20	11.00	1040	8.50
W. Arm	23-Nov-93	4.0	7.20	11.00	1040	8.50
W. Arm	23-Nov-93	5.0	7.10	10.90	1040	8.50

Lake Skipout Profiles

E. Arm	01-Mar-93	0.1	4.11	11.37	1005	8.13
E. Arm	01-Mar-93	1.0	4.11	11.32	1004	8.19
E. Arm	01-Mar-93	2.0	4.04	11.30	1004	8.21
E. Arm	01-Mar-93	3.0	4.02	11.30	997	8.22
E. Arm	01-Mar-93	3.5	4.02	11.26	997	8.23
E. Arm	22-Mar-93	0.1	8.37	11.19	1000	8.20
E. Arm	22-Mar-93	1.0	8.35	11.19	999	8.25
E. Arm	22-Mar-93	2.0	8.17	11.18	1000	8.41
E. Arm	22-Mar-93	3.0	8.11	11.13	1000	8.44
E. Arm	30-Apr-93	0.1	16.70	9.66	1101	8.57
E. Arm	30-Apr-93	1.0	16.44	9.36	1101	8.57
E. Arm	30-Apr-93	2.0	16.27	9.00	1101	8.57
E. Arm	30-Apr-93	3.0	16.08	8.70	1101	8.57
E. Arm	30-Apr-93	3.5	16.03	8.48	1101	8.56
E. Arm	10-May-93	0.1	17.81	9.00	1085	8.55
E. Arm	10-May-93	1.0	17.79	9.00	1086	8.55
E. Arm	10-May-93	2.0	17.79	8.95	1086	8.55
E. Arm	10-May-93	3.0	17.79	8.89	1086	8.56

E. Arm	24-May-93	0.1	22.10	7.72	1066	8.49
E. Arm	24-May-93	1.0	21.90	7.68	1066	8.49
E. Arm	24-May-93	2.0	21.58	6.95	1071	8.46
E. Arm	24-May-93	3.0	20.31	4.70	1069	8.37
E. Arm	07-Jun-93	0.1	23.00	7.10	1050	8.34
E. Arm	07-Jun-93	1.0	22.80	6.97	1050	8.36
E. Arm	07-Jun-93	2.0	22.50	6.20	1050	8.35
E. Arm	07-Jun-93	3.0	22.40	5.70	1050	8.33
E. Arm	21-Jun-93	0.1	26.20	10.90	1035	8.68
E. Arm	21-Jun-93	1.0	25.30	9.00	1035	8.68
E. Arm	21-Jun-93	2.0	24.80	8.00	1040	8.63
E. Arm	21-Jun-93	3.0	24.30	6.10	1040	8.60
E. Arm	06-Jul-93	0.1	26.10	8.40	1008	8.50
E. Arm	06-Jul-93	1.0	25.50	8.00	1008	8.60
E. Arm	06-Jul-93	2.0	25.20	6.80	1008	8.50
E. Arm	06-Jul-93	3.0	25.00	6.20	1008	8.50
E. Arm	06-Jul-93	3.5	25.00	6.20	1008	8.50

Lake Skipout Profiles

E. Arm	19-Jul-93	0.1	29.30	10.70	1000	
E. Arm	19-Jul-93	1.0	27.80	10.20	1000	
E. Arm	19-Jul-93	2.0	26.80	6.10	1000	
E. Arm	19-Jul-93	3.0	26.30	3.80	1014	

E. Arm	09-Aug-93	0.1	26.00	9.30	998	8.60
E. Arm	09-Aug-93	1.0	25.30	7.90	1000	8.60
E. Arm	09-Aug-93	2.0	25.20	7.20	1000	8.60
E. Arm	09-Aug-93	3.0	25.10	6.80	1000	8.50
E. Arm	09-Aug-93	3.5	25.00	6.60	1000	8.50

E. Arm	26-Aug-93	0.1	26.80	9.20	1010	8.75
E. Arm	26-Aug-93	1.0	26.50	8.30	1010	8.73
E. Arm	26-Aug-93	2.0	26.20	7.30	1010	8.70
E. Arm	26-Aug-93	3.0	26.20	7.30	1010	8.70

E. Arm	08-Sep-95	0.1	22.40	7.20	1021	8.70
E. Arm	08-Sep-93	1.0	22.40	7.30	1020	8.70
E. Arm	08-Sep-93	2.0	22.40	7.50	1020	8.70
E. Arm	08-Sep-93	2.5	22.30	7.70	1020	8.70

E. Arm	20-Sep-93	0.1	21.00	10.20	1023	9.00
E. Arm	20-Sep-93	1.0	20.10	9.50	1023	8.90
E. Arm	20-Sep-93	2.0	19.90	8.80	1023	8.90
E. Arm	20-Sep-93	3.0	19.90	7.50	1023	8.80

E. Arm	27-Oct-93	0.1	13.20	9.00	1039	8.80
E. Arm	27-Oct-93	1.0	13.20	9.00	1039	8.80
E. Arm	27-Oct-93	2.0	13.10	9.00	1039	8.80
E. Arm	27-Oct-93	2.4	13.00	9.00	1039	8.80

E. Arm	23-Nov-93	0.1	7.70	11.10	1035	8.60
E. Arm	23-Nov-93	1.0	7.50	11.10	1035	8.60
E. Arm	23-Nov-93	2.0	7.30	10.80	1035	8.60
E. Arm	23-Nov-93	2.5	7.30	10.70	1035	8.60

APPENDIX C

SECCHI DEPTH DATA

Lake Skipout Secchi Depth (in.)

Date	E. Arm	W. Arm	Dam
12/17/92	16	17	22
03/01/93	29	30	30
03/22/93	24	24	24
04/30/93	24	30	30
05/10/93	30	29	27
05/24/93	30	30	30
06/07/93	27	24	24
06/21/93	30	31	30
07/06/93	24	24	24
07/19/93	14	12	14
08/09/93	24	20	21
08/26/93	18	18	20
09/08/93	16	17	18
09/20/93	20	20	20
10/27/93	18	18	18
11/23/93	18	18	19
Average	22.6	22.6	23.2
s	5.6	6.0	5.1
CV	24.6%	26.4%	21.8%

APPENDIX D

LAKE CHLOROPHYLL DATA

Lake Skipout Chlorophyll - Dam

Date	Top	Bottom	Mean/Comp.
7/1/89	33.00		
10/1/89	12.80		
1/1/90	19.80		
4/1/90	23.60		
7/1/90	14.80		
10/1/90	22.60		
2/1/91	24.00		
5/1/91	9.30		
9/3/91	30.70		
11/25/91	15.10		
2/26/92	14.60		
5/31/92	23.30		
8/17/92	45.80		
12/3/92	26.10		
3/1/93			20.87
3/22/93			22.64
4/30/93	23.10	20.19	21.65
5/10/93			29.74
5/24/93	6.06	4.27	5.17
6/7/93			8.92
6/21/93	28.01	9.69	18.85
7/7/93	17.44	22.43	19.94
7/20/93	17.84	17.36	17.60
8/9/93	28.84	18.27	23.56
8/26/93	63.89	75.69	69.79
9/8/93	36.49	37.38	36.94
9/20/93	52.63	45.84	49.24
10/27/93			44.46
11/23/93			38.06
Mean	25.64	27.90	28.49
s	13.76	22.02	16.76
CV	54%	79%	59%
n	23	9	15

Lake Skipout Chlorophyll - W. Arm

Date	Top	Bottom	Mean/Comp.
12/17/92			24.20
3/1/93			21.38
3/22/93			23.58
4/30/93			18.79
5/10/93			29.60
5/24/93	7.78	3.83	5.81
6/7/93			11.76
6/21/93	19.44	9.69	14.57
7/7/93	23.71	23.38	23.55
7/20/93	19.63	18.92	19.28
8/9/93	25.63	16.38	21.00
8/26/93	54.98	42.48	48.73
9/8/93			49.09
9/20/93	59.63	52.87	56.25
10/27/93			38.05
11/23/93			37.97
Mean	30.11	23.94	27.72
s	19.47	17.66	14.42
CV	65%	74%	52%
n	7	7	16

Lake Skipout Chlorophyll - E. Arm

Date	Top	Bottom	Mean/Comp.
3/1/93			20.09
7/7/93	19.33	18.35	18.84
9/8/93			50.49
11/23/93			46.67
Mean	19.33	18.35	34.02
s	N/A	N/A	16.89
CV	N/A	N/A	50%
n	1	1	4

APPENDIX E

LAKE METALS DATA

LAKE SKIPOUT - METALS

Site	Date	Depth	Ca	Mg	Na	K	As	Ba	Cd	Cr	Cu	Fe	Pb	Mn	Ni	Zn	Se	Hg
Units		ft	mg/l	mg/l	mg/l	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
W. Arm	09/08/93	**composite**	22	25	160	3.7	9	100	<1	<1	1	470	<1	30	1	<10	<1	0.2
Dam	07/06/93	**composite**	30	23	130	3.7	8	100	<1	<1	<1	300	<1	50	2	<10	<1	<0.1
Dam	09/08/93	0.5	22	23	160	3.7	9	100	<1	1	2	360	<1	30	1	<10	<1	<0.1
Dam	09/08/93	18	21	23	160	3.8	8	100	<1	1	1	460	<1	40	1	<10	<1	0.6
E. Arm	07/06/93	0.5	31	24	140	3.1	8	200	<1	<1	<1	340	<1	50	2	<10	<1	
E. Arm	07/06/93	10.5	32	23	130	3.7	8	200	<1	<1	<1	330	<1	40	2	<10	<1	0.4
E. Arm	09/08/93	**composite**	21	24		3.7	9	100	<1	<1	1	340	<1	30	2	<10	<1	0.2

Composite = sample composited from surface, mid-depth, and bottom samples

APPENDIX F

LAKE ALGAL DATA

ALGAL SAMPLE ANALYSIS
Lake Skipout
Date: 03/22/93

Taxa	Division	GALD (µm)	Conc. Unit/ml	Rel% Conc.	Biov. ($\mu M^3/U$)	Rel% Biov.
Cyclotella sp.	Diatom	5.0	3906.5	43.8	33.3	3.6
Synedra sp.	Diatom	110.0	243.1	2.7	724.1	4.8
Ankistrodesmus sp.	Chloro	52.8	347.2	3.9	52.5	0.5
Dictyosphaerium sp.	Chloro	27.5	34.7	0.4	375.9	0.4
Elakatothrix sp.	Chloro	66.0	17.4	0.2	89.2	TR
Selenastrum sp. (?)	Chloro	6.6	451.4	5.1	18.8	0.2
Colonial chlorophyta - type	Chloro	44.0	17.4	0.2	133.7	0.1
Anabaena sp.[1,2]	Cyano	231.9	1336.9	15.0	2361.2	86.4
Merismopedia sp.	Cyano	8.8	17.4	0.2	44.6	TR
Oscillatoria sp.[1]	Cyano	141.5	156.3	1.8	909.5	3.9
Misc. blue-greens	Cyano	1.1	1562.6	17.5	0.7	TR
Misc. micros, 1 flagellum	Misc.	2.2	69.4	0.8	5.6	TR
Misc. micros, 2 flagella	Misc.	2.2	763.9	8.6	5.6	0.1

[1] Pollution tolerant algae
[2] Some species produce toxins

ALGAL SAMPLE ANALYSIS
Lake Skipout
Date: 07/06/93

Taxa	Division	GALD (µm)	Conc. Unit/ml	Rel% Conc.	Biov. (μM^3/U)	Rel% Biov.
Cyclotella sp.	Diatom	6.6	382.0	0.2	79.0	1.6
Stephanodiscus sp.	Diatom	27.5	17.4	TR	5550.7	5.1
Ankistrodesmus sp.	Chloro	23.8	208.3	0.1	21.5	0.2
Coelastrum sp.	Chloro	11.0	34.7	TR	44.6	0.1
Cosmarium sp.	Chloro	12.7	104.2	0.1	406.8	2.2
Crucigenia sp.	Chloro	13.0	86.8	TR	255.6	1.2
Dictyosphaerium sp.	Chloro	38.5	34.7	TR	534.6	1.0
Gonium sp.	Chloro	22.0	17.4	TR	178.2	0.2
Oocystis sp.	Chloro	11.0	625.0	0.3	31.8	1.0
Scenedesmus sp.[1]	Chloro	9.7	347.2	0.2	64.8	1.2
Selenastrum sp. (?)	Chloro	6.6	243.1	0.1	18.8	0.2
Stigeoclonium sp.[1]	Chloro	11.0	17.4	TR	33.4	TR
Arthrodesmus sp.	Chloro	33.0	17.4	TR	1524.0	1.4
Colonial chlorophyta - type	Chloro	16.5	34.7	TR	150.4	0.3
Non-motile chlorococcales	Chloro	5.5	156.3	0.1	87.0	0.7
Phacotus sp.	Chloro	11.0	1163.3	0.6	209.1	12.8
Sphaerellopsis sp.	Chloro	11.4	225.7	0.1	724.0	8.6
Cryptomonas sp.	Crypto	27.5	17.4	TR	1760.3	1.6
Rhodomonas sp.	Crypto	8.8	34.7	TR	29.8	0.1
Anabaena sp.[1,2]	Cyano	264.0	17.4	TR	6014.4	5.5
Aphanocapsa sp.	Cyano	33.0	364.6	0.2	94.0	1.8
Chroococcus sp.	Cyano	27.5	34.7	TR	153.1	0.3
Lyngbya sp.[1,2]	Cyano	77.0	17.4	TR	32.9	TR
Merismopedia sp.	Cyano	11.0	34.7	TR	66.8	0.1
Oscillatoria sp.[1]	Cyano	275.0	382.0	0.2	1850.1	37.1
Gomphosphaeria sp.[2]	Cyano	14.7	52.1	TR	159.6	0.4
Misc. blue-greens	Cyano	1.1	170,000.0	96.9	0.7	6.3
Misc. blue-greens, type	Cyano	2.2	243.1	0.1	5.6	0.1
Euglena sp.[1]	Euglen	38.5	34.7	TR	2962.1	5.4
Trachelomonas sp.	Euglen	15.1	69.4	TR	957.2	3.5
Misc. micros, 1 flagellum	Misc.	2.2	69.4	TR	5.6	TR
Misc. micros, 2 flagella	Misc.	2.2	555.6	0.3	5.6	0.2

[1] Pollution tolerant algae
[2] Some species produce toxins

ALGAL SAMPLE ANALYSIS
Lake Skipout
Date: 09/08/93

Taxa	Division	GALD (µm)	Conc. Unit/ml	Rel% Conc.	Biov. (µM^3/U)	Rel% Biov.
Cyclotella sp.	Diatom	8.4	1458.4	3.9	164.8	1.0
Navicula sp.[1]	Diatom	22.0	104.2	0.3	882.7	0.4
Nitzschia sp.[1]	Diatom	30.3	520.9	1.4	118.5	0.2
Denticula sp.	Diatom	22.0	104.2	0.3	441.3	0.2
Ankistrodesmus sp.	Chloro	22.0	104.2	0.3	11.2	TR
Chlamydomonas sp.[1]	Chloro	11.0	208.3	0.6	445.5	0.4
Coelastrum sp.	Chloro	11.0	208.3	0.6	44.6	TR
Crucigenia sp.	Chloro	15.4	104.2	0.3	300.7	0.1
Dictyosphaerium sp.	Chloro	22.0	937.6	2.5	326.8	1.2
Oocystis sp.	Chloro	16.1	1250.1	3.3	272.8	1.4
Pediastrum sp.	Chloro	44.0	104.2	0.3	1463.6	0.6
Scenedesmus sp.[1]	Chloro	24.2	312.5	0.8	998.3	1.2
Staurastrum sp.	Chloro	22.0	104.2	0.3	376.0	0.2
Tetraedron sp.[1]	Chloro	22.0	104.2	0.3	2789.8	1.2
Arthrodesmus sp.	Chloro	22.0	104.2	0.3	1524.0	0.6
Non-motile chlorococcales	Chloro	6.6	1145.9	3.1	150.4	0.7
Phacotus sp.	Chloro	13.2	312.5	0.8	361.3	0.5
Sphaerellopsis sp.	Chloro	11.7	1458.4	3.9	742.5	4.3
Anabaena sp.[1,2]	Cyano	74.8	1562.6	4.2	757.4	4.7
Anabaenopsis sp.	Cyano	38.7	2083.5	5.6	831.6	6.9
Lyngbya sp.[1,2]	Cyano	44.9	1458.4	3.9	50.5	0.3
Merismopedia sp.	Cyano	11.0	208.3	0.6	100.2	0.1
Oscillatoria sp.[1]	Cyano	163.5	3333.6	8.9	472.9	6.3
Gomphosphaeria sp.[2]	Cyano	19.3	9688.2	25.9	219.0	8.5
Misc. blue-greens	Cyano	1.1	5729.6	15.3	0.7	TR
Misc. blue-greens, type	Cyano	2.2	2187.6	5.8	5.6	TR
Phacus sp.[1]	Euglen	28.6	1562.6	4.2	7981.6	49.9
Trachelomonas sp.	Euglen	18.4	729.2	1.9	2125.0	6.2
Peridinium sp.	Dinofl	20.9	208.3	0.6	3385.4	2.8

[1] Pollution tolerant algae

[2] Some species produce toxins

APPENDIX G

LAKE ZOOPLANKTON DATA

Zooplankton Abundance (organisms/liter) in Lake Skipout

Zooplankton	03/22/93	07/06/93	09/08/93
Copepoda			
Calanoids	10	22	30
Cyclopoids	2.5	16	29
nauplius larvae	69	104	116
Cladocera			
Daphnia	0.4	23	2.6
Ceriodaphnia		43	25
Bosmina	4.5	7.3	32
Diaphanosoma		2.7	8.2
Rotifers	abundant	not common	N/A

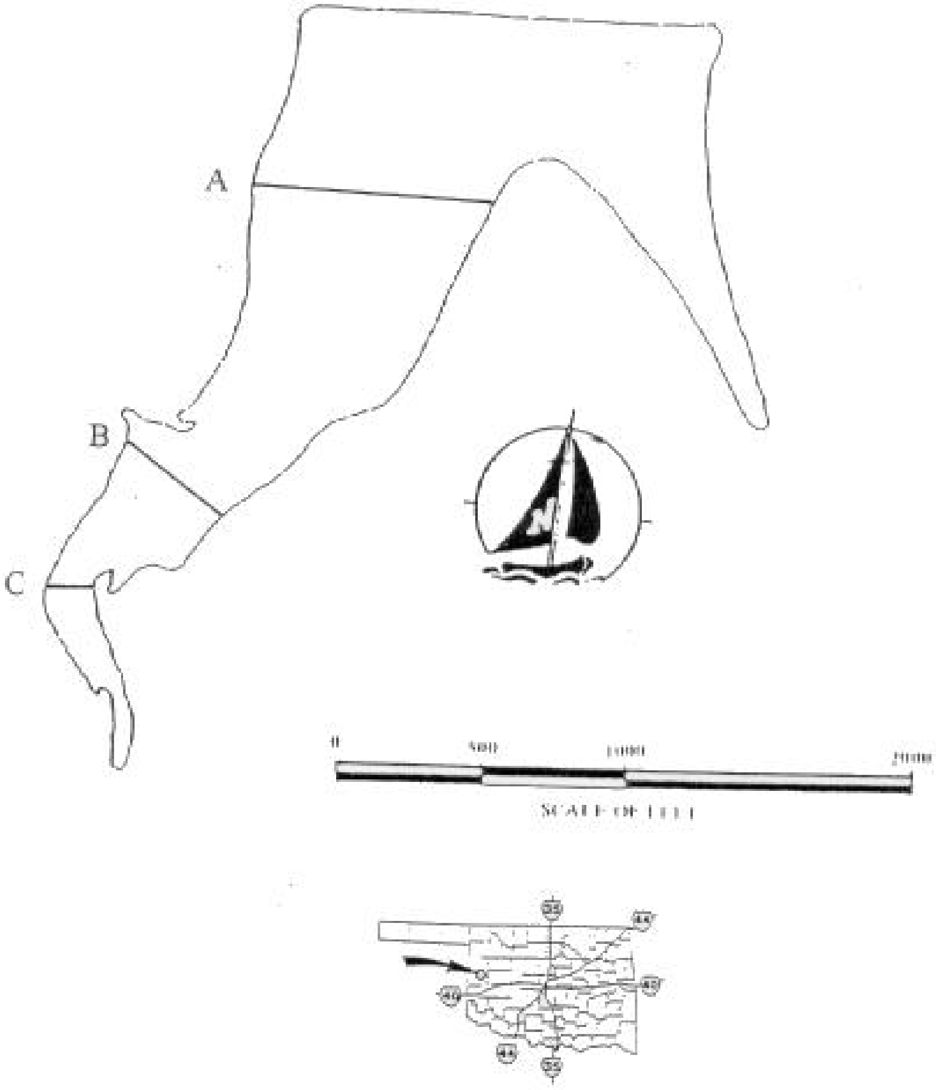
Zooplankton length (mm) in Lake Skipout

Zooplankton	07/06/93 Mean	07/06/93 Std. Dev.	09/08/93 Mean	09/08/93 Std. Dev.
Copepoda				
Calanoids	0.83	0.25	0.75	0.33
Cyclopoids	0.57	0.22	0.71	0.19
Cladocera				
Daphnia	0.72	0.16	0.79	0.11
Ceriodaphnia	0.47	0.14	0.51	0.08
Bosmina	0.31	0.06	0.32	0.06
Diaphanosoma	0.67	0.1	0.66	0.18

APPENDIX H

MAP SHOWING LOCATIONS OF BENTHIC MACROINVERTEBRATE COLLECTIONS

SKIPOUT LAKE



APPENDIX I

BENTHIC MACROINVERTEBRATE DATA

Benthic Macroinvertebrates in Lake Skipout

Phylum	Class	Order	Family	Subfam/Trib/Genus
Annelida	Oligachaeta		Tubificidae	*Limnodrilus*
				Tubifex
				Aulodrilus pigueti
				Aulodrilus limnobius
				Nais
Arthropoda	Ascari	N/A	N/A	N/A
	Insecta	Ephemeroptera	Ephemeridae	*Hexagenia*
		Trichoptera	Leptoceridae	*Oecetis*
		Coleoptera	Elmidae	*Diburaphia*
		Diptera	Ceratopogonidae	N/A
			Chironomidae	*Tanypodinae*
				Chironomini
				Tanytarsini

Benthic Macroinvertebrate Densities in Lake Skipout

Organism	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Limnodrilus	5					1	1		24	2	20	20	1	28	52	16	40	44	4	125	12	200	45	32	40	29	24	68	17	143
Tubifex																												4		
Aulodrilus pigueti																8	8													14
Aulodrilus limnobius												12		4	16	16	8	28	4	83	16	100	27		20	43	8	44	56	114
Nais																								4	8					
Acari												4																		
Hexagenia												4												4					22	
Oecetis																								4						
Diburaphia																				42										
Ceratopogonidae									1			8		4	4		12	4	4		4			8				8	6	29
Tanypodinae		1			1	2		1	1		13	156	6	12	20	36	24	56	4	111	16	175	109	24	12	36	8	28	11	129
Chironomini	14		1							40	14	36	6	44	12	8	24	28	12	56	16	50	9	12	20	7	16	24	6	43
Tanytarsini																			4	14					4			4		

APPENDIX J

FISH FLESH ANALYSIS DATA

Lake Skipout Fish Flesh Analysis

Parameter	Units	Carp	Bullhead	Saugeye	Crappie
Tot. PCB's	ug/kg	<30	<30	<30	
a-BHC	ug/kg	<20	<20	<20	
B-BHC	ug/kg	<20	<20	<20	
d-BHC	ug/kg	<20	<20	<20	
g-BHC	ug/kg	<20	<20	<20	
Heptachlor	ug/kg	<20	<20	<20	
Heptachlor Epox.	ug/kg	<20	<20	<20	
Aldrin	ug/kg	<20	<20	<20	
DDE	ug/kg	**34.3**	<20	**37.8**	
DDT	ug/kg	<20	<20	<20	
DDD	ug/kg	<20	<20	<20	
Dieldrin	ug/kg	<20	<20	<20	
Chlordane	ug/kg	**37.4**	**23.3**	<20	
Endosulfan I	ug/kg	<20	<20	<20	
Endrin	ug/kg	<20	<20	<20	
Endosulfan II	ug/kg	<20	<20	<20	
Endrin Ald.	ug/kg	<20	<20	<20	
Endosulfan Sul.	ug/kg	<20	<20	<20	
Zinc	mg/kg	25.00	6.90	6.90	12.00
Copper	mg/kg	1.00	0.63	0.89	0.46
Cadmium	mg/kg	0.32	0.40	0.30	0.56
Chromium	mg/kg	0.24	<0.10	0.13	<0.10
Lead	mg/kg	0.15	<0.10	0.19	<0.10
Arsenic	mg/kg	<0.10	<0.10	<0.10	<0.10
Selenium	mg/kg	1.60	<0.10	1.30	1.30
Mercury	mg/kg	<0.01	<0.01	<0.01	0.01

APPENDIX K

STREAM DATA

Skipout Creek Data

Date	Temp	DO	Cond.	pH	Turb	Alk	Hard	TDS	TSS	TKN	NO2+NO3	TN	TP	Ortho P	Diss. Ca	Diss. Mg	Cl	SO4	F
12/17/92								674	5	0.60			0.17		66	24	120	37	0.6
03/01/93							260	646	28	1.00	0.84	1.84	0.20	0.23	66	22	96	34	0.6
03/22/93	**9.9**	**9.5**	**1063**	**8.2**	**36**	**395**		**682**	**38**	**0.70**	**0.30**	**1.00**	**0.20**	**0.14**	**57**	**25**	**100**	**29**	**0.6**
04/30/93	18.2	10.7	1100	8.1	12	366		648	1	0.70	1.10	1.80	0.21	0.16	70	24	87	28	0.7
05/10/93	16.3	4.0	1048	7.9				646	17	0.90	1.00	1.90	0.33	0.26	61	23	78	25	0.7
05/24/93	20.7	6.1	962	7.8	21	324		575	25	0.80	1.50	2.30	0.32	0.26	63	20	64	26	0.6
06/07/93	22.0	7.1	1050	7.8	11	310		622	6	0.70	0.79	1.49	0.26	0.21	73	24	70	23	0.7
06/21/93	22.2	5.9	911	7.9	15	306		560	21	0.70	1.50	2.20	0.29	0.22	60	19	70	31	0.6
07/06/93	23.5	5.7	813	7.5	27	347		574	75	1.10	1.70	2.80	0.39	0.22	62	17	58	28	0.6
07/19/93	24.1	7.4	892	7.8	10	320		581	15	0.80	1.70	2.50	0.24	0.18	69	20	78	33	0.6
08/09/93								617	5	0.70	1.40	2.10	0.16	0.12	69	22	83	39	0.7
08/26/93	24.4	8.4	953	7.7	6	296		564	1	0.50	2.20	2.70	0.15	0.12	74	20	67	43	0.7
09/08/93	18.2	5.9	920	7.4	6	282		546	1	0.40	2.30	2.70	0.14	0.09	72	21	69	43	0.7
09/20/93	19.0	5.8	934	7.6	13	305		556	26	0.50	2.30	2.80	0.10	0.08	71	19	66	45	0.7
10/27/93	11.1	8.5	1155	7.6	6	382	290	676	11	0.58	1.71	2.29	0.14	0.09			92	58	
11/23/93	9.7	10.2	1333	7.8	4	417	324	646	10	0.58	1.11	1.71	0.11	0.08			129	53	
04/11/94							**248**	**687**	**86**	**1.44**	**<0.5**	**1.44**	**0.29**	**0.13**			**91**	**<5**	
Average	18.4	7.3	1010	7.8	14	338	287	618	22	0.75	1.36	2.10	0.22	0.16	67	21	83	34	0.7
s	5.3	2.0	136	0.2	10	43	38	49	25	0.25	0.64	0.54	0.08	0.06	5	2	20	13	0.1
CV	29%	27%	13%	3%	69%	13%	13%	8%	113%	34%	47%	26%	39%	40%	8%	11%	24%	37%	8%

Runoff samples are in bold

APPENDIX L

STREAM PESTICIDE DATA

Pesticides in Skipout Creek

Date	a_BHC ug/l	b_BHC ug/l	d_BHC ug/l	g_BHC ug/l	Simazine ug/l	Prometryn ug/l	Prometon ug/l	Deisoprop Atrazine ug/l	Deethyl Atrazine ug/l	Cyanazine ug/l	Ametryn ug/l	Propazine ug/l
06/30/93					<0.05	<0.05	<0.05	<0.05	<0.05	<0.2	<0.05	<0.05
03/09/94	<1	<1	<1	<1								
04/11/94	<1	<1	<1	<1								

Date	Perthane ug/l	PCN ug/l	Aldrin ug/l	Lindane ug/l	Chlordane ug/l	DDD ug/l	DDE ug/l	DDT ug/l	Dieldrin ug/l	Endosulfan I ug/l	Endosulfan II ug/l	Endosulfan Su ug/l
06/30/93	<0.1	<0.1	<0.01	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01		
03/09/94			<1		<1	<1	<1	<1	<1	<1	<1	<1
04/11/94			<1		<1	<1	<1	<1	<1	<1	<1	<1

Date	Endrin ug/l	Endrin Unf ug/l	Endrin Aldehyde ug/l	Toxaphene ug/l	Heptachlor ug/l	Metolachlor ug/l	Heptachlor Epoxide ug/l	Methoxychlor ug/l	PCB ug/l	Atrizine ug/l	2,4-D ug/l	2,4,5-T ug/l
06/30/93		<0.01		<1	<0.01	<0.05	<0.01	<0.01	<0.1	<0.05	0.66	<0.01
03/09/94	<1		<1		<1		<1		<1			
04/11/94	<1		<1		<1		<1		<1			

Date	Mirex ug/l	Silvex ug/l	Alachlor ug/l	2, 4-DP ug/l	Metribuzin ug/l
06/30/93	<0.01	<0.01	<0.05	<0.01	<0.05
03/09/94					
04/11/94					

APPENDIX M

STREAM METAL DATA

SKIPOUT CREEK- METALS

Site	Date	Ca	Mg	Na	K	As	Ba	Cd	Cr	Cu	Fe	Pb	Mn	Ni	Zn	Se	Hg
Units		mg/l	mg/l	mg/l	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
Skipout Cr	03/09/94	59	24	74	3.4	<10	170	<10	<5	<40	1520	<100	290	<100	340	<10	<1
Skipout Cr	04/11/94	60	25	131	4.8	16	150	<10	<5	<40	1690	<100	350	180	960	<10	<1