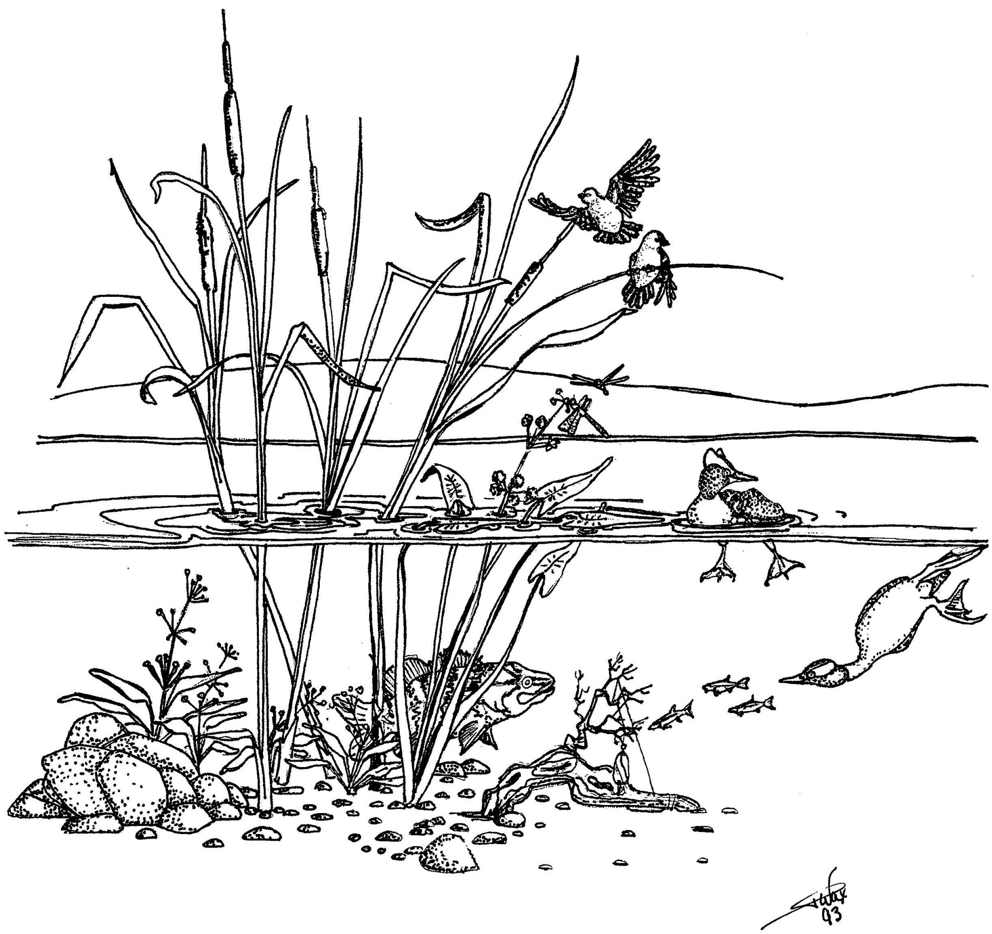
NORTH DAKOTA
LAKE ASSESSMENT ATLAS



North Dakota State Department of Health
and Consolidated Laboratories
1993

NORTH DAKOTA
LAKE ASSESSMENT ATLAS

A Final report submitted to the
United States Environmental Protection Agency
Clean Lakes Program

North Dakota State Department of Health
and Consolidated Laboratories

Division of Water Quality

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INTRODUCTION

This Lake Water Quality Assessment (LWQA) Atlas contains data collected from 66 North Dakota lakes and reservoirs. Collection and analysis of water quality data was preformed by the North Dakota State Department of Health and Consolidated Laboratories (NDSDHCL) with financial and technical assistance from the North Dakota Game and Fish Department (NDG&F). Funding for the project was acquired through a grant from the EPA Clean Lakes Program.

The assessments were conducted over a two-year period. Thirty lakes and reservoirs were assessed in 1991-1992 and 36 in 1992-1993. The objective of the assessment project was to define the general physical and chemical condition of the state's lakes and reservoirs. The reports are written to be useful for lake managers and the general public.

The lakes and reservoirs targeted for assessment were chosen in conjunction with the NDG&F. Criteria used during the selection process was geographic distribution, local and regional significance, fishing and recreational potential, and relative trophic condition. Lakes without much historical monitoring information were given the highest priority. Lakes chosen for the 1991-1992 and 1992-1993 assessments are listed in Tables 1 and 2 respectively. Figure 1 shows the distribution of the lakes in North Dakota.

Table 1. Lakes and reservoirs assessed in 1991-1992.

Armourdale Dam	Harvey Dam	North Golden Lake
Bisbee-Big Coulee Dam	Indian Creek Dam	Northgate Dam
Blacktail Dam	Kulm-Edgeley Dam	Pheasant Lake
Brewer Lake	Lake Hoskins	Rice Lake
Brush Lake	Lake LaMoure	Short Creek Dam
Cedar Lake	Long Lake	South Golden Lake
Clausen Springs Dam	Matejcek Dam	Strawberry Lake
Crooked Lake	McGregor Dam	Velva Sportsman's Dam
Epping-Springbrook Dam	Nieuwsma Dam	Welk Dam
Green Lake	North Carlson Lake	Whitman Dam

Table 2. Lakes and reservoirs assessed in 1992-1993.

Alkali Lake	Heinrich Martin Dam	Odland Dam
Arnegard Dam	Hiddenwood Lake	Patterson Lake
Balta Dam	Kota-Ray Dam	Red Willow Lake
Baukol Noonan Dam	Lake Elsie	Riverdale Spillway Pond
Beaver Lake	Lake Isabel	Sheep Creek Dam
Braddock Dam	Lake Metigoshe	Silver Lake
Carbury Dam	Lake Tschida	Skjermo Lake
Clearwater Lake	Lake Williams	Smishek Lake
Crown Butte Dam	Larimoure Dam	Sweet Briar Dam
Dead Colt Creek Dam	McVille Dam	Tolna Dam
Fordville Dam	Mirror Lake	Warsing Dam
Froelich Dam	North Lemmon Lake	White Earth Dam

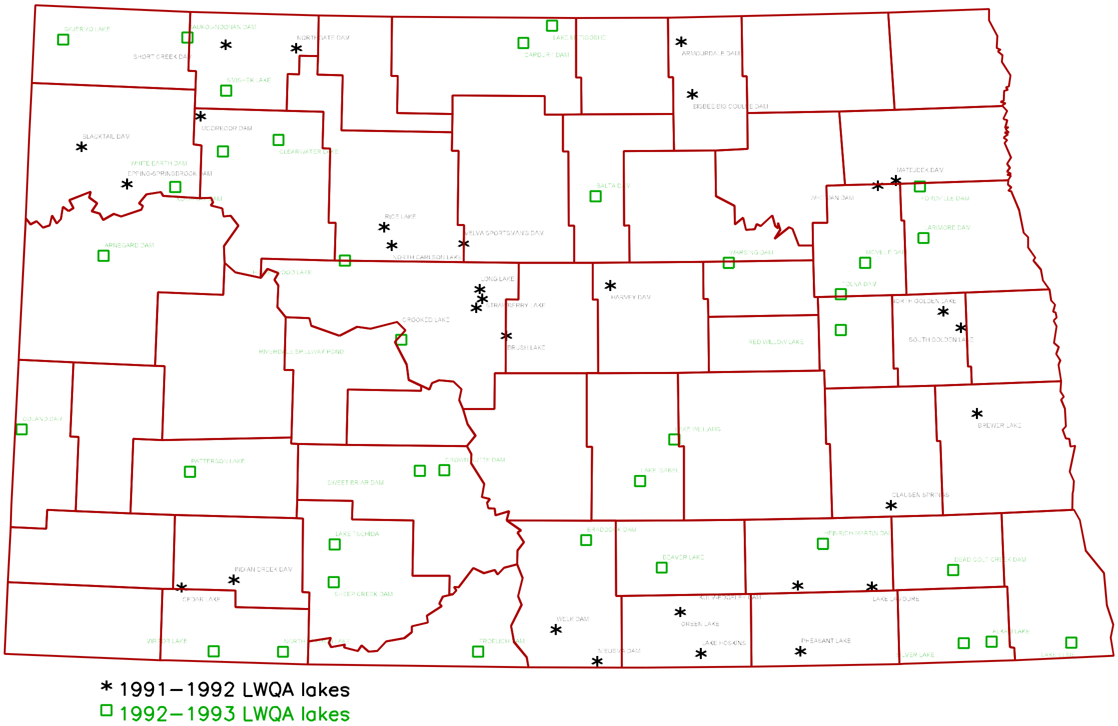

Figure 1. Distribution of LWQA project lakes and reservoirs.

The basic criteria used in selecting lakes and reservoirs for the LWQA project was their distribution throughout the state. This process placed the 66 lakes and reservoirs into several different ecological and physiological regions. These regions vary significantly in geologic formation, annual precipitation, soil type and land use. A good general description of the major physiographic regions in North Dakota is contained in "The Face of North Dakota" (Bluemle, 1991). Bluemle divides North Dakota into regions based on geological formation and physiographic characteristic (Figure 2). Since geologic formation and current physical conditions dictate many of the physical characteristics of an individual lake's watershed, Bluemle's physiographic delineations were used in combination with precipitation, land use and general soil types to describe the dominant characteristic for each region.

In general, North Dakota is composed of two major regions, the Central Lowlands and the Great Plains. The present land forms of the central lowlands were formed through glacial action, and for our purposes, divided into five subdivisions; the Red River Valley, Prairie Coteau, Glaciated Plains, Turtle Mountains and the Missouri Coteau (Figure 2). The Great Plains were also impacted by glacial advances. Land forms have since been significantly altered by wind and water erosion to the degree that in some instances no glacial evidence is present. For the purposes of the LWQA Project, this region is divided into three subdivisions; the Coteau Slope, Missouri Slope Upland and the Little Missouri Badlands (Figure 2).

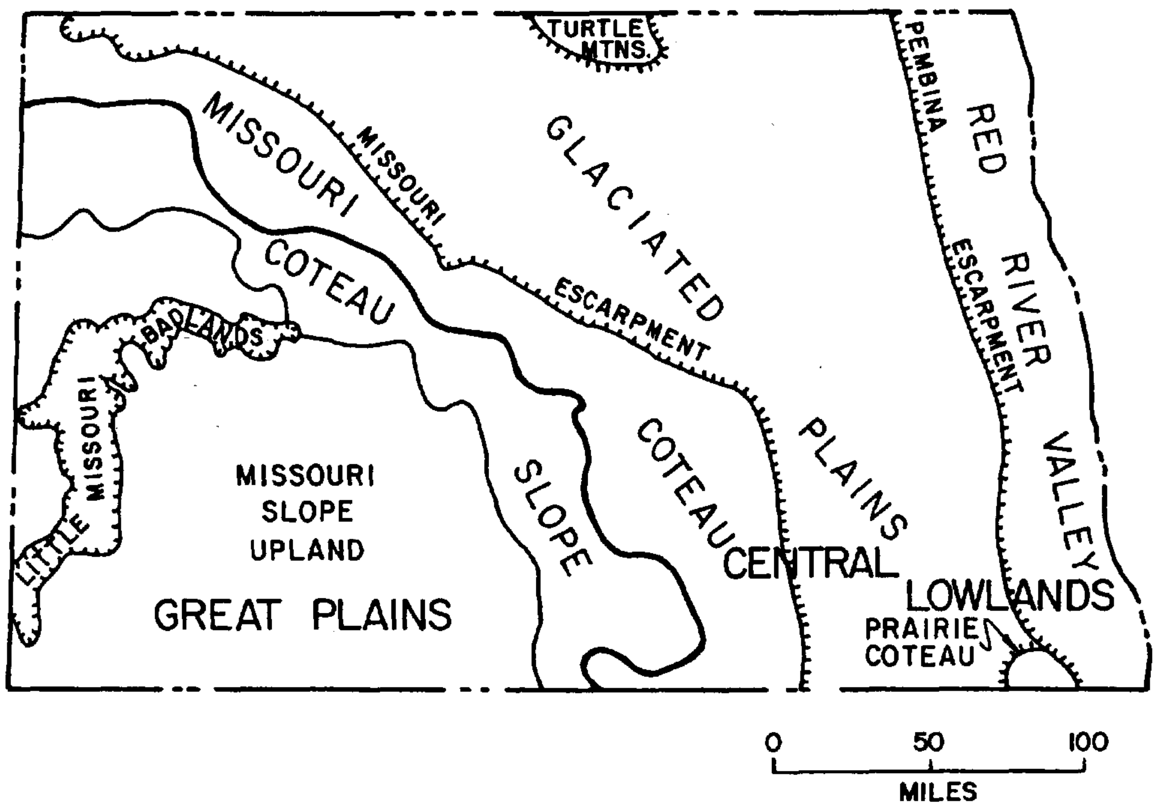

Figure 2. Major regions of North Dakota from "The Face of North Dakota" (Bluemle, 1991).

The Red River Valley

The Red River Valley subregion was formed through sedimentation of glacial Lake Agassiz. It is extremely level with very gradual changes in topography. Soils of this region are primarily deep highly fertile with slope rarely exceeding two percent. In general, soils are moderately erodible with a good moisture retention. Annual rain fall in the Red River Valley is between 19 and 21 inches.

Land use is primarily agricultural with areas approaching 99 percent in small grain and row crop production. The Red River Valley is the most heavily agriculturally impacted region in North Dakota. A small percentage of the original wetlands or prairies remain. The Red River Valley is home to the first and third largest municipalities in North Dakota and contains a number of industries and small rural communities.

Prairie Coteau

The Prairie Coteau region is a plateau of glacial moraine near the south-eastern corner of North Dakota. The formation was formed by collapsed glacial sediments. Soils of the region are in a complex pattern ranging from fairly well drained to well drain. Soils in this region are sometimes sandy and in other areas clayey. The majority of slopes range between six and nine percent and are moderately erodible. Annual rainfall in the Prairie Coteau region is between 15 and 20 inches. Land use is predominantly agricultural, with pastures and cultivated fields integrated within watersheds. Due to formation events many of the waterbodies in this region are connected to surficial aquifers.

Glaciated Plains

The Glaciated Plains region of North Dakota extends through the center of North Dakota and occupies nearly two-thirds of the northern half of the state. This region is characterized by rolling to hilly glaciated plains with many small potholes and integrated drainages. The irregular pattern of hills and valleys caused by glacial thrusting and sedimentation overlie a relatively deep deposit of glacial till. Within this region are three main river drainages and one large lake basin. The river drainages are the James, Sheyenne and Souris Rivers. The major lake basin belongs to Devils Lake, a closed basin lake near the town of Devils Lake.

Soils in this region vary significantly but generally are formed from medium to course textured sandy or clayey loamy glacial till. Soils are predominately moderately erodible and moderately to well drained. Annual precipitation is between 15 and 20 inches with considerable variation between years.

Topography is rolling to hilly with a maximum shift in elevation of approximately 300 feet, however few shifts exceed 100 feet. Water quality in the lakes and reservoirs in this region vary significantly with high concentrations of total dissolved solids and total alkalinity in closed basin lakes and relatively low concentrations in lakes with outlets or connections to surficial aquifers.

Principle land use in the glaciated plains is agriculture. The percentages of cropped to livestock production varies significantly from minor watershed to watershed.

Turtle Mountains

The Turtle Mountain region is significantly different in appearance than most of the North Dakota landscape. The relief of the Turtle Mountains varies between 300 and 500 feet. The topography of the region is hilly with many intricate drainages and small closed basins. The landscape is covered with brush and hardwoods. The Turtle Mountains were most likely formed by sedimentation of collapsed superglaciers.

Soils in the Turtle Mountain region are relatively shallow, moderately fertile and well drained. The majority of slopes range between six and nine percent. Annual rainfall in the Turtle Mountain region is between 15 and 18 inches. Land use is primarily agricultural with an even mixture of pasture to cropped lands. The Turtle Mountains are an area of significant recreational value to the state of North Dakota.

Missouri Coteau

The Missouri Coteau region marks a glacial terminal advance. The region is characterized by an irregular pattern of hills and shallow depressions. Topography is rolling with shifts in relief ranging to 300 feet but primarily range from 50 to 80 feet. Soils in this region are generally formed from rocky, gravelly or sandy glacial till and are moderately to well drained. Slopes range from nearly level to steep, with the average slopes between 2 and 9 percent. The area is highly erodible when poor land management is employed on the sandier soils and steeper slopes. Normal annual precipitation ranges from 15 to 18 inches with large variations common between years.

Land use is predominantly agricultural with a relatively even mixture of range and cropland. Major resource activities in this region include industry, strip mining operations and oil exploration.

Coteau Slope

The Coteau Slope is characterized by partially glaciated terrain separating the glaciated areas of North Dakota from the southwestern quarter of the state. Glacial deposits in the region are thin and discontinuous with remnants of unglaciated topography present. Soils in this region, other than river bottom soils, which can be clayey, are predominantly silty or loamy and moderately to well drained. Generally, soils in this region are moderately fertile to fertile, easily worked and highly susceptible to both wind and water erosion. Annual precipitation ranges between 14 and 17 inches.

Land use in the Coteau Slope is primarily agricultural. Resource industries also include strip mining and oil exploration. Agricultural land use is primarily small grain and livestock production.

Missouri Slope Upland

The Missouri Slope Upland is composed primarily of rolling to hilly uplands except in badlands areas and near prominent buttes. Slopes generally are gentle with relief ranging from 300 to 500 feet. Some areas have either never been glaciated or were glaciated so long ago as to have no glacial evidence remaining. This region unlike the Glaciated Plains and the Missouri Coteau has well defined drainages in the form of intermittent and perennial streams. Few surficial aquifers exist in this area other then along stream drainages.

Soils in the Missouri Coteau Slope Upland are moderately deep to shallow formed from weathered loamy glacial till or soft bedrock. Generally, soils are moderately fertile to fertile, well drained and susceptible to wind and water erosion. Average precipitation ranges from 14 to 16 inches with between 80 and 90 percent of the annual precipitation occurring between April and September. Principal land use is small grain and livestock production. Other industries include oil and coal production.

Approximately 20 percent of this region is composed of badlands. The badlands are an eroded formation composed of buttes and steeply eroded drainages. Soils are generally thin, formed from sandy and clayey material. Badland areas are not well protected by vegetative cover and are highly susceptible to wind and water erosion.

Little Missouri Badlands

The Little Missouri Badlands are one of the most scenic and fragile environments in North Dakota. They are a mosaic of multicolored formations exposed through rapid erosion. The rapid erosion is a result of the Little Missouri River being diverted by a glacier approximately 600,000 years ago. Presently the badlands are still being eroded at a vigorous pace through slope and gully washing, slumping and wind erosion. The Little Missouri River channel depth increases between 0.5 inches and 1.0 inch per decade.

Soils in the Little Missouri Badlands are predominantly shallow and excessively drained. Soils are highly susceptible to both wind and water erosion. Average annual precipitation ranges from 14 to 16 inches. Rainfall in this area can be swift and severe with 20 percent of the annual precipitation arriving in less than 48 hours. Land use is predominantly livestock production with areas of intensive oil and mineral exploration.

METHODOLOGY

The assessment atlas includes 66 lakes and reservoirs throughout North Dakota. The lakes are listed in alphabetical order and by year assessed. Each lake assessment is divided into a general description of the waterbody, general water quality characteristics, plant and phytoplankton diversity, trophic status estimate and watershed condition. The following is a brief description of the sections found in each lake assessment, the techniques used in sample collection and data interpretation.

Water Chemistry

General water quality samples were collected in the deepest area of the lake three times during the LWQA Project. Twice during the summer and once during the ice covered period. A complete list of water quality parameters analyzed for are provided in Table 3.

Samples were collected at three discrete depths if the lake was thermally stratified and at two depths if no thermal stratification was occurring or the lake was 3 meters deep or less. The three samples collected during thermal stratification and in the deeper waterbodies were collected at one meter depth to represent the epilimnion, just below the thermocline to represent the transitional zone and just off the bottom of the lake or reservoir representing the hypolimnion.

A volume-weighted mean was calculated using this stratified sampling technique to describe the general chemical characteristics of the lake or reservoir. The volume-weighted mean was calculated by weighting the parameter analyzed by the percentage of water volume represented at each depth interval.

Table 3. Water quality parameters analyzed during the LWQA.

Total Alkalinity ($CaCO_3$)	Sodium Absorption Ratio
Ammonia (N)	Conductivity
Carbonate (CO_3)	Total Kjeldahl Nitrogen
Chloride (Cl)	Nitrate + Nitrite as N
Total Hardness as Calcium (as $CaCO_3$)	Calcium (Ca)
pH	Iron (Fe)
Percent Sodium	Magnesium (Mg)
Sulfate (SO_4)	Manganese (Mn)
Total Dissolved Solids	Potassium (K)
Total Phosphate as P	Sodium (Na)
Cation Sum	Anion Sum

For example, if the epilimnion represented 60 percent of the total water volume, the transition zone 10 percent and the hypolimnion 30 percent, the concentrations of the corresponding parameters would be multiplied by 0.6, 0.1 and 0.3 respectively. The resulting concentrations would then be summed to equal the weighted-volume mean.

For comparison purposes a North Dakota long-term average was calculated. The long-term average was calculated as a arithmetic mean from a STORET retrieval of all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991. STORET is the EPA storage and retrieval database for all water quality data collected by the NDSDHCL.

Aquatic Vegetation

A qualitative survey of the macrophyte community was preformed on each lake or reservoir. The surveys were conducted in either July or August to coincide with the period of maximum plant growth. The survey was performed by sampling transects bisecting the entire width of the waterbody. At one meter intervals the macrophyte specie(s) present were identified and relative density determined.

Phytoplankton & Chlorophyll-a

Phytoplankton and chlorophyll-a samples are two of the most important biological parameters measured during the LWQA. Chlorophyll-a is important because of its close relationship to phytoplankton biomass and as a key indicator of trophic status. Phytoplankton community assemblages can be excellent indicators of water quality and limiting nutrients.

Phytoplankton and chlorophyll-a samples were collected twice each summer at approximately one month intervals during July and August. A six-foot deep integrated sample was collected over the deepest area of the lake. A measured amount of sample was filtered for chlorophyll-a analysis while an aliquot of the sample was preserved for phytoplankton identification and enumeration.

Trophic Status

The trophic condition or status was assessed for each of the 66 lakes and reservoirs included in the LWQA. Trophic status refers to the present condition, or measure of eutrophication (i.e., the aging process by which a lake becomes more fertile).

Accurate trophic status assessments for the lakes and reservoirs in the LWQA project are essential as management tools for making sound preservation or improvement recommendations. In order to minimize errors in classification a multiple indicator approach was initiated.

Since trophic status indices specific to North Dakota waters have not been developed, Carlson's Trophic Status Index (TSI) (Carlson, 1977) was chosen as the initial step in delineating a LWQA project lake or reservoir's trophic status. Carlson's TSI was selected because it is commonly used among limnologists and because it was developed for Minnesota Lakes, a region close to North Dakota geographically.

Carlson's TSI uses a mathematical relationship based on three indicators, secchi disk transparency in meters, surface total phosphorus in $\mu g\ L^{-1}$ and chlorophyll-a in $\mu g\ L^{-1}$ to create a numerical TSI value. This numerical value then corresponds to a trophic condition ranging from 0 to 100 with increasing values indicating a more eutrophic condition. Carlson's TSI estimates are calculated using the following equations:

Trophic status based on secchi disk (TSIS):
$TSIS = 60 - 14.41 \ln (SD)$
Where SD = Secchi disk transparency in meters.

Trophic status based on total phosphorus (TSIP):
$TSIP = 14.20 \ln (TP) + 4.15$
Where TP = Total phosphorus concentration in $\mu g\ L^{-1}$.

Trophic status based on chlorophyll-a (TSIC):
$TSIC = 9.81 \ln (TC) + 30.60$
Where TC = Chlorophyll-a concentrations in $\mu g\ L^{-1}$.

Trophic Status using Carlson's trophic status index is depicted graphically in Figure 3.

A major drawback to using Carlson's TSI is that it was developed for lakes that are primarily phosphorus limited. Because most North Dakota lakes and reservoirs have an abundance of phosphorus, ancillary information, such as dissolved oxygen concentrations, frequency of nuisance algal blooms, phytoplankton community structure and macrophyte biomass, was combined with Carlson's numerical TSI to prevent misclassification. Since interpretation of ancillary information can be subjective, as large a database as available, incorporating both historical and LWQA data, was used to promote consistency between assessing scientists.

Due to variations in geological and ecological regions in the state and lake type (manmade, natural), a numerical trophic status assessment was not assigned to individual waterbodies during the LWQA project. Instead, the general trophic condition of the waterbody (e.g., mesotrophic, eutrophic, hypereutrophic) was identified.

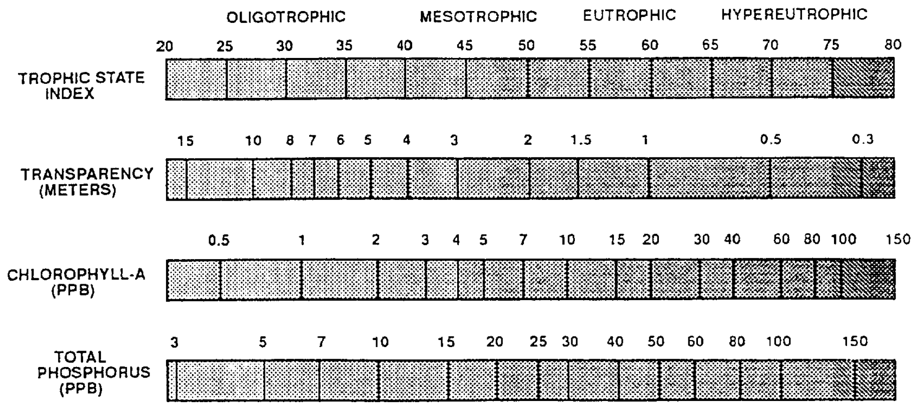

Figure 3. A graphic representation of Carlson's Trophic Status Index.

Lake Bottom Sediment Sampling & Contaminants Analyzed

Bottom sediments were collected from the inlet(s), littoral and deepest areas of each lake or reservoir assessed. One sediment sample was collected at each location using a standard two-inch core sampler. Each sample was analyzed individually for selected trace elements, PCBs, and organic compounds. A complete list of contaminants tested for in the sediment samples is contained in Table 4.

In order to evaluate the results of the sediment contaminant analysis from each lake, the results from each lake were compared to the results for all lakes combined for each location (i.e., deepest, littoral, inlet). To facilitate these comparisons the 25 percentile, 50 percentile (median) and 75 percentile concentration for all the lakes combined were used. The data were entered into a computer database. Percentile concentrations were determined by site location and for all sites combined using the Statistical Analysis System (SAS) software. Sediment contaminant data collected during the 1991-1992 LWQA project were only compared to data collected for lakes sampled during that time period while sediment contaminant data collected during the 1992-1993 LWQA project were compared to all lake data collected during 1991-1992 and 1992-1993.

For purposes of this study, the littoral area was defined as the shallow water area where submergent vegetation was present. An effort was made to collect littoral samples in typical areas of each individual lake. The deepest area of the lake was defined using lake maps and a depth finder. Samples collected from the deepest area were at the same location as that for the water quality samples. Inlet area samples were collected as far into the center of the inlet as possible, generally stopping when the boat could not proceed under it's own power.

Fish Sampling & Contaminants Analyzed

Fish sampled for contaminant analysis were collected in conjunction with the NDG&F, Fisheries Division. An effort was made to collect two types of fish from each lake or reservoir. A bottom feeder (e.g., white sucker, carp, bullhead) a piscivore (e.g., northern pike, walleye, bass) and/or an insectivore (e.g., crappie, bluegill). However, on some lakes and reservoirs only one group could be captured.

An attempt was made to collect a sample which consisted of a composite of 3 to 5 of the largest fish present of a single species. Fish samples were ground whole and thoroughly mixed before analysis. Each composite sample consisted of fish with an individual weight within a range of $\pm$25 percent of the mean weight of the entire composite group. Deviations from this procedure occurred periodically on some lakes and reservoirs due to poor populations or absence of particular fish types. A complete list of contaminants tested for in whole fish samples is contained in Table 4.

To evaluate the whole fish contaminant data, each fish sample was grouped by type (e.g., piscivore, bottom feeder, insectivore) and compared to the 25 percentile, median and 75 percentile concentrations within the corresponding group for all lakes sampled. The data were entered into a computer database and the percentile concentrations were generated using SAS software. The whole fish contaminant data collected during the 1991-1992 LWQA project were compared to data collected during that time period while whole fish contaminant data collected during the 1992-1993 LWQA project were compared to all fish data collected during 1991-1992 and 1992-1993.

Watershed Assessment

The watersheds for each lake and reservoir were assessed to identify major nonpoint and point pollution sources. The nonpoint source assessment included inventorying the land use and land use practices by interviewing the local Soil Conservation District office and the state Soil Conservation Service office personnel. This inventory was ground truthed for accuracy in the late fall. An aerial watershed survey was also preformed on approximately half of all lakes assessed.

Nonpoint source pollution from the surrounding watershed accounts for nearly all of the nutrient loadings and pollution discharges to the lakes assessed during the 1991-1992 and 1992-1993 assessment years. The EPA defines nonpoint source pollution as: "Pollution caused by diffused sources that are not regulated as point sources and is normally associated with agricultural, silvicultural and urban runoff, runoff from construction activities, etc. Such pollution results in the human-made or human-induced alteration of the chemical, physical, biological and radiological integrity of the water. In practical terms, nonpoint source pollution does not result from a discharge at a specific, single location (such as a single pipe) but generally results from land runoff, precipitation, atmospheric deposition, or percolation. Pollution from nonpoint sources occurs when the rate at which pollutant materials entering waterbodies or groundwater exceeds natural levels."

Table 4. List of contaminants analyzed and their detection limits in sediment and whole fish samples collected during the 1991-1992 and 1992-1993 LWQA.

Parameter	Detection Limit($\mu g\ g^{-1}$)	Parameter	Detection Limit($\mu g\ g^{-1}$)
Copper	1.400	Endosulfan I	0.002
Zinc	0.900	Endosulfan II	0.002
Barium	0.900	Endosulfan Sulfate	0.002
Mercury	0.010	Endrin	0.002
Chromium	0.020	Heptachlor	0.001
Arsenic	0.020	Methoxychlor	0.004
Selenium	0.100	Hoelon	0.010
Cadmium	0.020	PCB (Total)	0.010
Lead	0.020	Nonachlor	0.010
Aldrin	0.001	Alachlor	0.001
BHC-Alpha	0.001	Parathion Ethyl	0.003
BHC-Beta	0.001	Parathion Methyl	0.002
Lindane	0.001	Fenvalerate	0.020
Chlordane	0.002	Triallate	0.002
DDD	0.001	Trifluralin	0.001
DDE	0.001	Pendimethalin	0.002
DDT	0.001	Metolachlor	0.001
Dieldrin	0.001		

[1]Detection limit values are based on a one gram sample.

In the watershed section of each lake assessment the term "adequately treated" is defined as the amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated the average "T" value in North Dakota is 3 to 5 tons per acre.

Point source assessments for each watershed was accomplished with the assistance of the NDSDHCL permit program using information from the North Dakota Pollutant Discharge Elimination System. All contributing point sources were identified and an estimate made of the probable nutrient and organic loading to each lake or reservoir and its impact. Point sources are those pollution sources that are permitted and regulated as a point source discharges.

1991-1992 LAKES & RESERVOIRS

LIST OF 1991-1992 ASSESSED LAKES

LIST OF APPENDIXES

ARMOURDALE DAM

TOWNER COUNTY

Peter N. Wax

Armourdale Dam is a small reservoir on Armourdale Coulee. It is located approximately 10 miles east and 2 miles west of Rolla, North Dakota. The reservoir was built through the combined efforts of the NDG&F, the State Water Commission (SWC) and Towner County. Completed in 1961, Armourdale Dam filled the following spring. At full pool the reservoir has a maximum depth of 36 feet and a surface area covering 85.5 acres (Figure 1). Armourdale Dam was built for water based recreation and presently also serves as a waterfowl rest area.

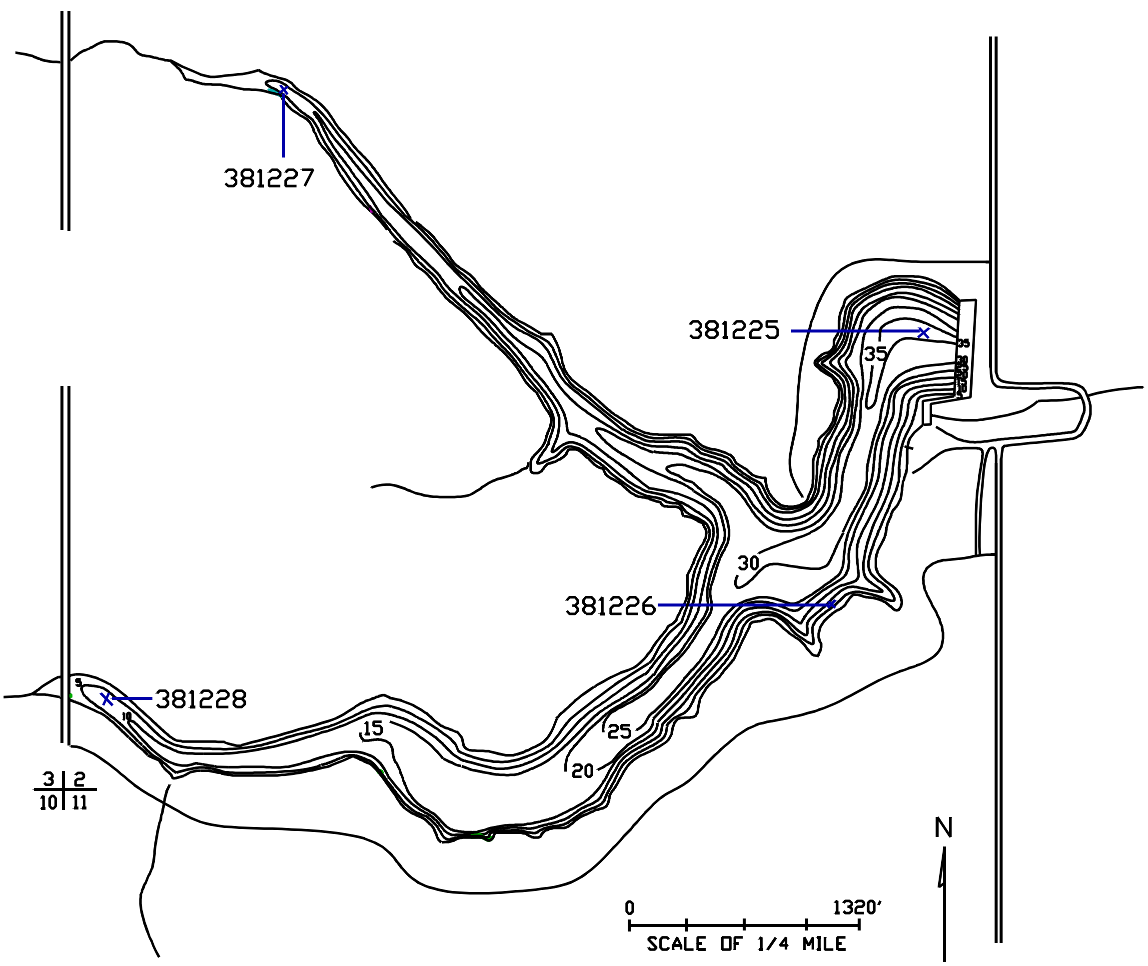

Figure 1. Morphometric map of Armourdale Dam.

Armourdale Dam's 7,770 acre watershed is a mixture of flats, rises and depressions located on the Glaciated Plains physiographic region. Slopes are short and irregular ranging from 0 to 3 percent. The level to nearly level areas within the watershed have soils that are highly calcarious and poorly to moderately drained. Ridges and knolls are moderately to well drained and depressions are poorly drained. Primary land use in the Armourdale Dam watershed is small grain production. Primary management concerns of these cultivated lands is controlling wind and water erosion.

Armourdale Dam is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The fishery on Armourdale Dam is managed by the NDG&F. Management includes a yearly assessment of the fish community through test netting, fish stockings to maintain populations, dissolved oxygen monitoring and an assortment of habitat and biomanipulations.

In recent years stockings have been limited to walleye. Bluegill and other species in Armourdale Dam have maintained their populations through natural reproduction. Test netting operations conducted in 1991 captured fathead minnows, bluegills, northern pike and walleye. Of note are the bluegill captured which averaged nearly 1.25 pounds. Northern pike were introduced to Armourdale Dam through unauthorized stockings by the public. Though not captured in 1991 test netting operations, a single stocking of largemouth bass was performed by the NDG&F in the spring of 1986.

Armourdale Dam was initially stocked with rainbow trout in the spring of 1962. Introduction of northern pike was believed to have occurred in 1963. The northern pike substantially impacted the trout fishery and in 1965 the lake was eradicated. In the spring of 1968 the lake was opened again and excellent sport and trout fishing was reported. The trout fishery was eventually phased out being replaced by a bluegill and walleye fishery with the first stockings occurring during the fall of 1977.

Public facilities on Armourdale Dam include a boat ramp, picnic area and toilets. The excellent facilities are maintained by the Towner County Park Board. Public access is good from both the south and north side of the dam. Public use on Armourdale Dam is heavy seasonally, with limited availability to the public in the fall due to its status as a waterfowl rest area.

Water Quality

Armourdale Dam is a well-buffered lake. The volume-weighted mean total alkalinity as ($CaCO_3$) concentration is 262 mg L^{-1}. The dominant anions were sulfate and bicarbonate. Sulfate concentrations ranged from 113 to 157 mg L^{-1} while bicarbonate concentrations ranged from 226 to 424 mg L^{-1} with volume-weighted mean concentrations of 133 and 288 mg L^{-1} respectively. The water column also contained relatively high concentrations of total phosphate as P, total kjeldahl nitrogen and ammonia with volume-weighted means of 0.676, 2.93 and 0.789 mg L^{-1} respectively. Volume-weighted mean concentrations for Armourdale Dam and North Dakota long-term arithmetic mean concentrations are depicted in Table 1.

At the time Armourdale Dam was sampled, both during summer and iced cover, thermal stratification was observed. During the July and August sample collection thermal stratification occurred at a depth between 5 and 7 meters below the surface. Oxygen concentrations during this period were between 7 and 11 mg L^{-1} above the thermocline declining to below 2 mg L^{-1} near the bottom. During the ice cover period in February thermal stratification occurred at a depth between 1 and 3 meters below the surface. Dissolved oxygen concentrations were between 1 and 3 mg L^{-1} above the thermocline and near 1 mg L^{-1} below the thermocline. (Figure 2, Figure 3).

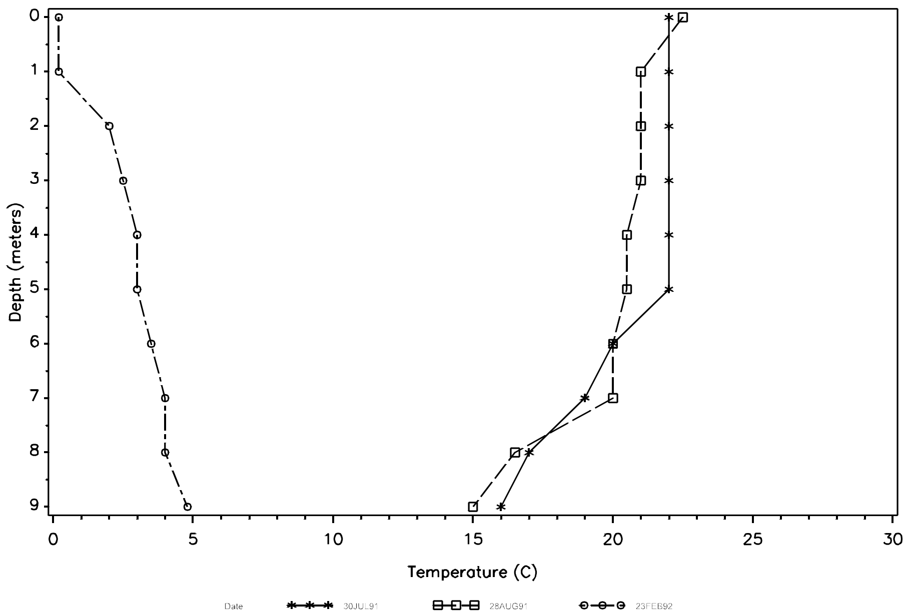

Figure 2. Temperature profiles for Armourdale Dam.

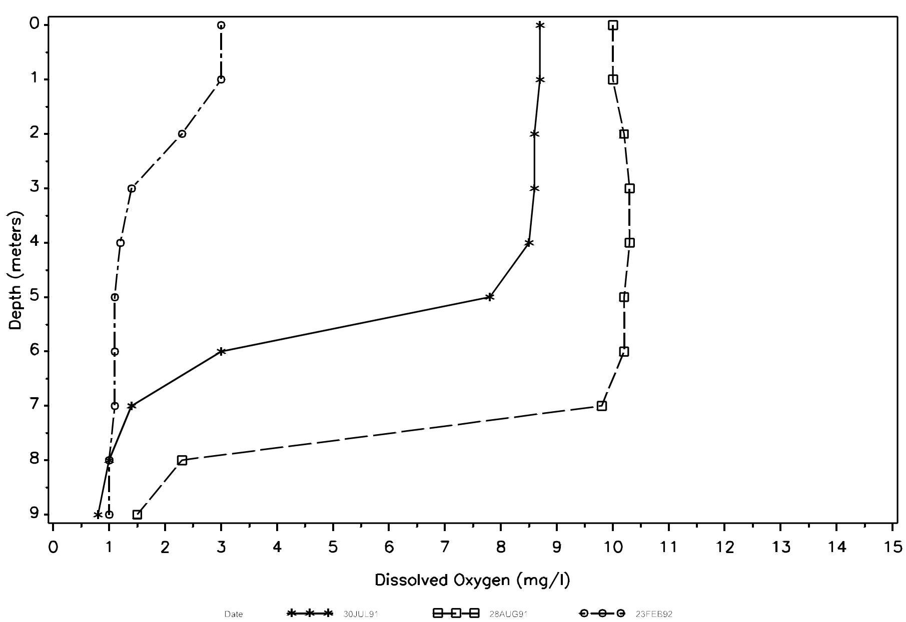

Figure 3. Oxygen profiles for Armourdale Dam.

Oxygen depletion is rapid below the hypolimnion and under ice cover conditions. This situation is probably a result of a highly fertile watershed generating nutrients to the reservoir and the internal cycling of nutrients. The abundance of nutrients causes the growth of aquatic plants and algae that when they die in the fall and winter create a significant oxygen demand. Other contributing factors are the morphometric configuration of the reservoir which encourages stratification and possibly the nutrient and organic load delivered from large concentrations of resting waterfowl just prior to ice over.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 30, 1991 and February 28, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Armourdale Dam		1982-1991	
Total Dissolved Solids	441	mg L^{-1}	1209	mg L^{-1}
Conductivity	716	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	339	mg L^{-1}	488	mg L^{-1}
Sulfates	133	mg L^{-1}	592	mg L^{-1}
Chloride	5.9	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.676	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.028	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	262	mg L^{-1}	296	mg L^{-1}
Ammonia	0.785	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.93	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	288	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

During the summer of 1991 approximately 10 percent of Armourdale Dam's surface area had submergent and emergent aquatic vegetation. The macrophyte community identified on Armourdale Dam was composed of water milfoil (Myriophyllum spp.), sago pondweed (Potamogeton pectinatus), curly leaf pondweed (Potamogeton crispus) and cattails (Typha spp.). The dominant species was water milfoil representing approximately 60 percent of the macrophyte community. While nearly 100 percent of Armourdale Dam's surface area to a depth of 9 feet had aquatic vegetation no attached vegetation was observed below a depth of 10 feet. A map depicting macrophyte coverage on Armourdale Dam is contained in Appendix B.

Phytoplankton

Armourdale Dam's phytoplankton community during the summer of 1991 was represented by five divisions and 36 genera. Blue-green algae, Cyanophyta, were the dominant division by density during both the July and August samplings. The dominance by blue-green algae was substantial as the mean cell density of the 2 samples collected was 170,300 cells mL^{-1}, threefold greater than the next most abundant division, the green algae, Chlorophyta. The phytoplankton community on Armourdale Dam by volume was more evenly distributed than by density with the blue-green algae still dominant by a small margin. A summary of the phytoplankton data is contained in Appendix C.

Trophic Status

Armourdale Dam is a hypereutrophic reservoir. During both summer sample collection times surface total phosphorus exceeded 520 $\mu g\ L^{-1}$, chlorophyll-a concentrations ranged between 23 and 43 $\mu g\ L^{-1}$ and secchi disk transparency was less than 1 meter. Ancillary evidence including a macrophyte community occupying nearly 100 percent of the surface area to a depth of 3 meters, a phytoplankton population dominated by blue-green algae species and low dissolved oxygen concentrations during ice cover and below the hypolimnion during the ice free periods of the year support Armourdale Dam's trophic status classification as hypereutrophic.

Sediments

Sediment samples collected from the deepest area off Armourdale Dam displayed detectable concentrations of all trace elements tested for except mercury. Reported trace metal concentrations were generally above the median concentration yet below the 75th percentile concentration for all lake sediment samples collected from the deepest areas in 1991. The exception was the selenium concentration of 1.07 $\mu g\ g^{-1}$ which is threefold the median and above the 75th percentile for all lakes sampled.

Concentrations of all trace elements tested for including mercury, were above analytical detection limits in the sediments collected from the littoral area of Armourdale Dam. Most of the reported concentrations were near or slightly above the median for all lakes assessed in 1991, with the exceptions of selenium and mercury which were at or above the 75th percentile for all lakes assessed.

Sediment samples were collected from both major inlet areas to Armourdale Dam. Reported trace elements concentrations in these areas were above the median concentration for all lakes assessed in 1991 with most at or above the 75th percentile for all lakes assessed in 1991. The only exception was the reported arsenic concentration which was slightly below the median.

PCB concentrations and concentrations of selected organic compounds were below the detectible limits for all sediment samples collected from Armourdale Dam with the exception of triallate. Triallate, commonly known as Far-Go, is a selective pre-emergent herbicide. Triallate was detected in sediment samples collected from Armourdale Dam's southern most inlet in concentrations of 0.003 $\mu g\ g^{-1}$. A complete listing of all sediment contaminant data is contained in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Armourdale Dam on June 4, 1991. Three walleye were collected, representing the piscivore group and five bluegill representing the insectivore group. The walleye had a mean weight of 433 grams and a mean length of 28.6

centimeters. The bluegills had a mean weight of 568 grams and a mean length of 23.0 centimeters.

Trace element concentrations of the walleye sample collected from Armourdale Dam were generally near or slightly below the median concentration for all fish collected, with the exception of selenium and cadmium, which were fivefold the median concentrations for all piscivore samples collected from LWQA Project lakes in 1991 (Table 2). Trace element concentrations for copper, zinc, barium, mercury and lead in the bluegill sample collected from Armourdale Dam were near the median concentrations reported for all insectivore samples collected during the 1991 LWQA project. Chromium, selenium and cadmium were above the 75 percentile with reported concentrations of 0.176, 0.601 and 0.030 $\mu g\ g^{-1}$ respectively. Of note, are the selenium concentrations which were the highest reported for any insectivore sample collected in 1991.

Detectable pesticide residues in the composite whole fish samples collected from Armourdale Dam include DDE, nonachlor, triallate and trifluralin. DDE is a degenerate by product of the insecticide DDT and exhibits similar characteristics to the parent compound in the ecosystem. Nonachlor can be a by product of the pesticide chlordane or a insecticide used in treating harvested grains. Triallate is a pre-emergent selective herbicide used with small grains, peas and lentils. Trifluralin, commonly known as treflan, is also a pre-emergent herbicide.

The walleye sample collected from Armourdale Dam showed detectable concentrations of DDE, nonachlor, triallate and trifluralin of 0.018, 0.005, 0.019 and 0.011 $\mu g\ g^{-1}$ respectively. Reported concentrations for pesticide residues exceeded the 75th percentile for all predators analyzed during the 1991-1992 LWQA. The trifluralin concentration of 0.011 $\mu g\ g^{-1}$ in the walleye sample was the highest concentration reported for any piscivore sample collected during the 1991 LWQA Project.

The bluegill sample showed detectable concentrations of DDD and trifluralin. The reported concentration for DDE of 0.004 $\mu g\ g^{-1}$ is the same as the median for all insectivores while the reported concentration of trifluralin at 0.004 $\mu g\ g^{-1}$ is equal to the reported 75 percentile for all insectivores analyzed. A complete listing of the fish contaminant results is provided in Appendix E.

Watershed

Armourdale Dam and its contributing watershed have a combined surface area of approximately 7,770 acres in northern Towner County, North Dakota. Principal land use is small grain production occupying nearly 5,440 acres. The checker board appearance of fallow and active fields is broken only by the occasional farm, coulee or prairie pothole. Nonpoint source pollution from the surrounding watershed accounts for nearly all of the nutrient loadings and pollution discharges to Armourdale Dam.

Land use within the Armourdale Dam watershed is 96 percent agricultural, with 70 percent actively cultivated. The remaining 30 percent is in low density urban development haylands, pasture, and conservation reserve program (CRP) areas. There is one concentrated livestock feeding areas within the contributing drainage and five farmsteads. According to the information provided by the Towner County Soil Conservation District, 30 percent of the cultivated lands and between 0 and 60 percent of the remaining lands within the watershed are "adequately treated" against soil loss.

Armourdale Dam's contributing watershed has a calculated soil loss rate of 6 to 7 tons per acre, which takes into account all land uses within the watershed. It is estimated that approximately 47,768 tons of soil are lost annually in the watershed. Assuming a conservative delivery rate to the reservoir of 10 to 15 percent, between 4,777 tons to 7,165 tons of soil reaches Armourdale Dam annually.

Table 2. Land use in the Armourdale Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	70	30
Pasture land	0	0
Hayland	25	60
CRP	1	100
Wet/Wild[1]	2	N/A
Other	2	N/A
Farmsteads	1[3]	N/A
Feedlots[2]	5[3]	80

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

BISBEE-BIG COULEE DAM

TOWNER COUNTY

Peter N. Wax

Bisbee-Big Coulee Dam (Bisbee Dam) is a reservoir, located in Towner County, approximately 1 mile northeast of Bisbee, North Dakota. The dam is multipurpose, serving as the municipal water supply for the city of Bisbee, a recreational fishery for the surrounding area, and a waterfowl rest area.

Bisbee Dam was filled in 1969 and experienced problems within the first few years with the emergency spillway and dam face. These problems, combined with poor drinking water quality for the city of Bisbee led to the dam being raised an additional 4 feet in 1986. The raising of the dam 4 feet, redesigning the outlet and emergency spillway cured the problems originally experienced and increased the surface area of the reservoir from 194 acres to 226 acres (Figure 1).

Topography of the Bisbee Dam watershed and surrounding area is characterized by level to rolling hills with slopes ranging from 0 to 20 percent. Soils are moderately well drained to well drained, formed from glacial till. The watershed is a heterogenous mixture of integrated drainages and small basins typical of the Northern Glaciated Plains physiographic region. A small portion of the watershed extends into the Turtle Mountains, a region with many small hills, valleys and marshes.

The NDG&F manages the fishery on Bisbee Dam by evaluating the fish community through regular test netting operations and stocking accordingly. In recent years stockings have included northern pike and walleye.

Test netting conducted by the NDG&F in 1991 showed populations of northern pike, walleye, bluegill, yellow perch, and fathead minnows. Other fish and aquatic biota captured between the years of 1987 and 1991 were crayfish, walleye and one largemouth bass. Bisbee Dam does not have a regular history of fish kills, however, a partial kill occurred during the winter of 1990-1991. To prevent fish kills and improve water quality, Bisbee Dam is aerated and equipped with a low level draw down.

Public facilities on Bisbee Dam include a poured concrete boat ramp, toilets, parking lot and picnic grounds. Recreational use by fisherman on Bisbee Dam is limited to winter, spring and summer due to its status as a waterfowl rest area.

Water Quality

Bisbee Dam is a well-buffered reservoir, with volume-weighted mean total alkalinity as $CaCO_3$ concentration of 262 mg L^{-1}. The dominant anions in the water column were sulfates and bicarbonates. Bicarbonate concentrations ranged from 297 to 454 mg L^{-1} and sulfates ranged from 94 to 141 mg L^{-1}. The volume-weighted mean concentration for total phosphorus, total kjeldahl nitrogen, and ammonia concentrations were higher in Bisbee Dam than the arithmetic mean reported for all North Dakota lakes sampled between 1982 and 1991 (Table 1).

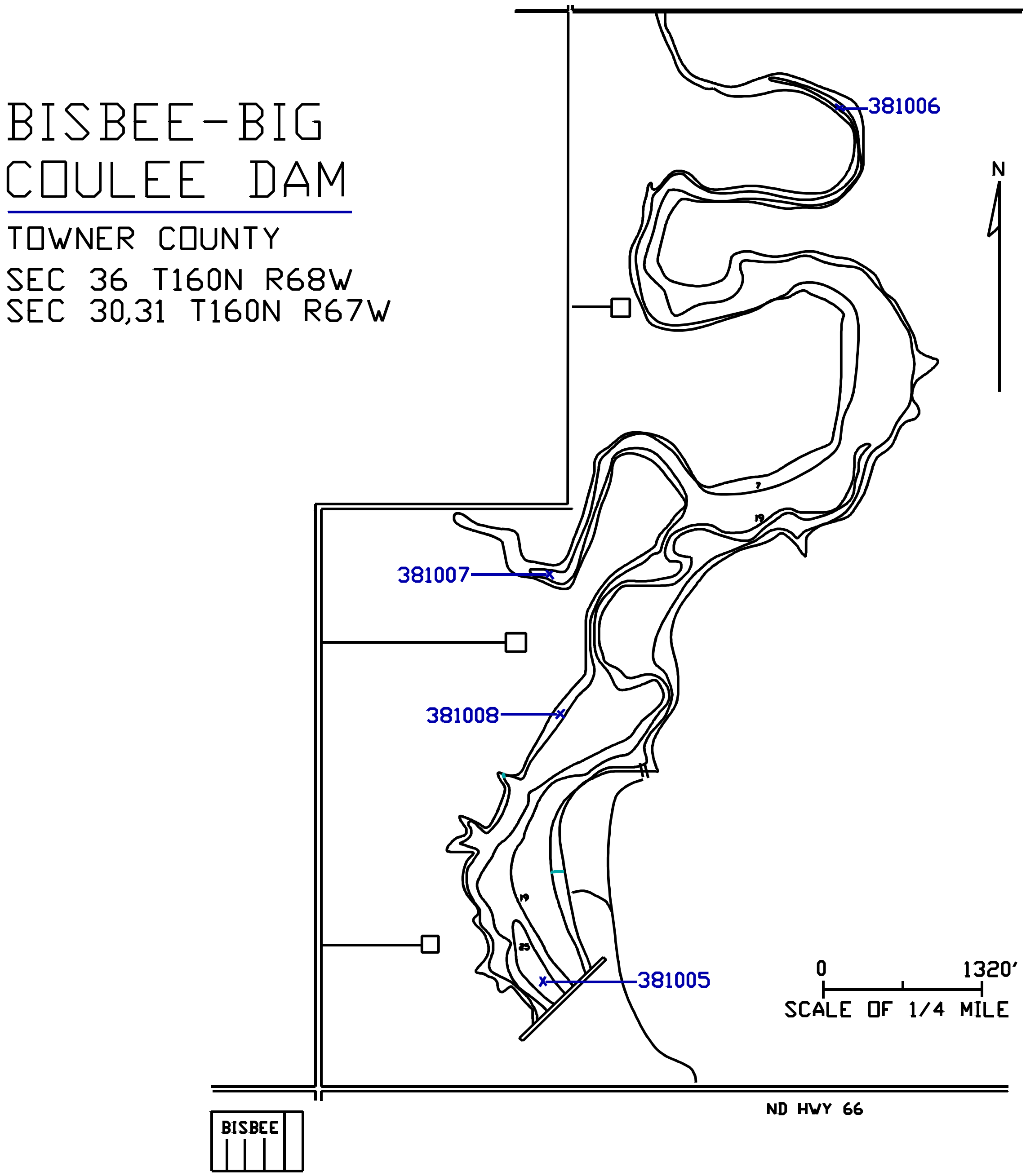

Figure 1. Morphometric map of Bisbee Dam.

The volume-weighted mean concentrations for total phosphorus as P was 0.84 mg L^{-1}, exceeding the state's target concentration of 0.02 mg L^{-1} on all occasions sampled during 1991 and 1992. The volume-weighted mean nitrate + nitrite as N concentration was 0.01 mg L^{-1}, which was below the long-term arithmetic mean, as well as the state's target concentration of 0.25 mg L^{-1}. A comparison of nitrate + nitrite as N to total phosphorus in Bisbee Dam shows a surplus of phosphorus and a nitrogen deficit. This situation reflects an aquatic plant community dependent on the available supply of nitrogen. This situation is often referred to as a nitrogen-limited lake or reservoir. However, in Bisbee Dam there is generally never a real short supply of nitrogen, but, actually an overabundance of phosphorus. Under these conditions, nitrogen fixing species such as certain blue-green algae are favored.

During the summer of 1991 Bisbee Dam was not thermally stratified during the three sample periods (Figure 2). During these time periods dissolved oxygen concentrations were at or near saturation to a depth of 4 meters and were adequate to maintain all manner of aquatic life (Figure 3). Samples collected during January 1992 showed dissolved oxygen concentrations at or below 2.0 mg L^{-1} at all depths (Figure 3). Along with low dissolved oxygen during ice cover, ammonia concentrations increased over 13 fold from a summer average of 0.115 mg L^{-1} to a winter average of 1.556 mg L^{-1}.

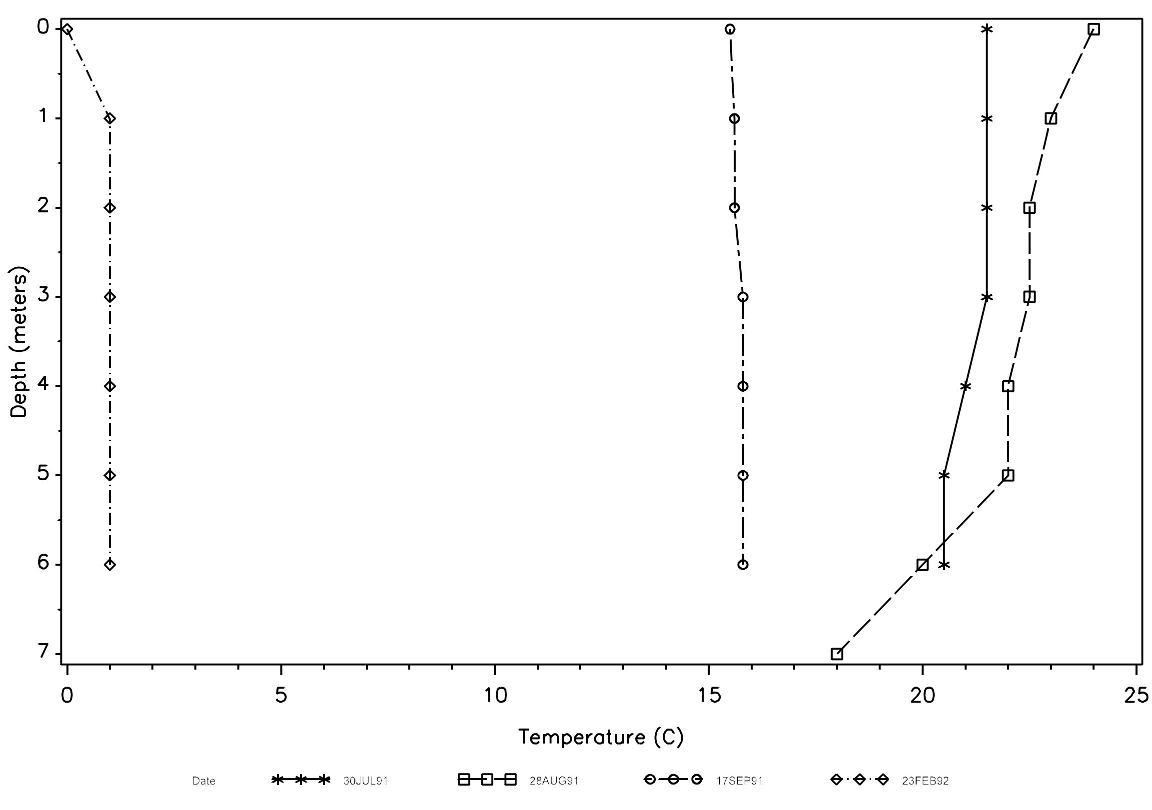

Figure 2. Temperature profile for Bisbee Dam.

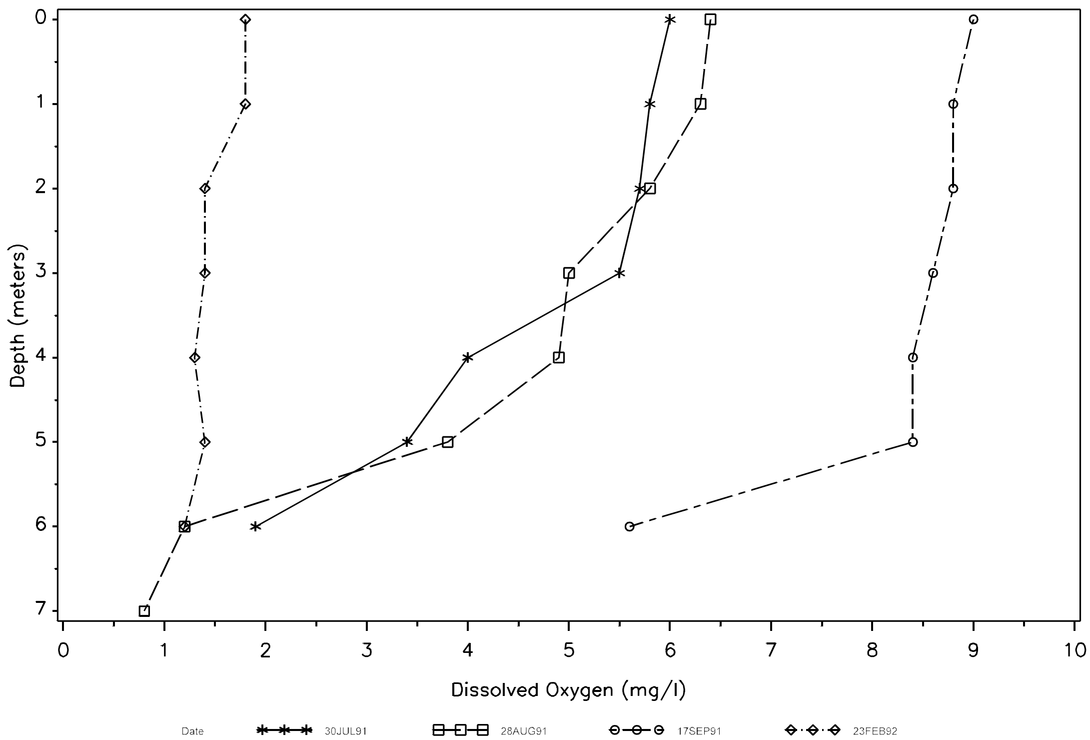

Figure 3. Oxygen profile for Bisbee Dam.

A complete compilation of all water quality data collected during 1991 and 1992 is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 26, 1991 and February 27, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Bisbee Dam		1982-1991	
Total dissolved solids	479	mg L^{-1}	1209	mg L^{-1}
Conductivity	793	mg L^{-1}	1604	mg L^{-1}
Hardness as calcium	379	mg L^{-1}	488	mg L^{-1}
Sulfates	112	mg L^{-1}	592	mg L^{-1}
Chlorides	20.7	mg L^{-1}	81	mg L^{-1}
Total phosphate as P	0.804	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.011	mg L^{-1}	0.069	mg L^{-1}
Total Kjeldahl Nitrogen	2.95	mg L^{-1}	2.34	mg L^{-1}
Ammonia	0.445	mg L^{-1}	0.347	mg L^{-1}
Bicarbonate	352	mg L^{-1}	326	mg L^{-1}
Total Alkalinity	300	mg L^{-1}	296	mg L^{-1}

Aquatic Vegetation

During the summer of 1991, approximately 20 percent of Bisbee Dam's surface area was covered by aquatic vegetation. Nearly 90 percent of the lake's surface area to a depth of approximately four feet had either sago pondweed

(Potamogenton pectinatus), cattails, (Typha spp.), curly leaf pondweed (Potamogenton crispus) or a combination of all three. Also a small population of arrowhead (Sagittarian con-neata) was identified on the southeastern shore near the boat ramp (Appendix B).

Phytoplankton

During the two summer sampling periods, the phytoplankton community was represented by four divisions and 49 genera. The largest contributors by density were blue-green algae, Cyanophyta. The mean density of blue-green algae during the summer of 1991 was 2,193,892 cells mL^{-1}, representing a population five times greater by density than the three other divisions combined. The other three divisions represented were Chlorophyta, Cryptophyta and Bacillariophyta.

During the same period, the phytoplankton community expressed as density by volume was dominated by the division Bacillariophyta. The diatom Stepharodiscus rotula is very large and accounts for the variation in community structure from density to volume. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Bisbee Dam is a hypereutrophic reservoir based on the three primary indicators, secchi disk transparency, total phosphate as P, and chlorophyll-a concentrations. Supporting ancillary information which suggests that Bisbee Dam is hypereutrophic includes dissolved oxygen deficiencies throughout the water column during the ice cover conditions, a phytoplankton community dominated by blue-green algae, large macrophyte population utilizing nearly 100 percent of the water column to a depth of four feet, and a history of a fish kill.

Sediment Analysis

Sediments collected from Bisbee Dam contained detectable levels of all trace elements analyzed. Concentrations of the trace elements copper, zinc, mercury, and barium were above the median for all lakes sampled in 1991 while chromium, arsenic, selenium, cadmium, and lead were near or below the median for all lakes sampled. PCB concentrations and concentrations of selected organic compounds were below detectable limits for all samples collected from Bisbee Dam. A complete listing of the sediment results is provided in Appendix D.

Fish Flesh Analysis

Fish were collected for contaminant analysis from Bisbee Dam on June 6, 1991. Northern pike were collected for contaminant analysis representing the piscivore group. The northern pike composite group was composed of five fish with a mean weight of 1256 grams and a mean length of 55.3 centimeters.

Trace element concentrations in the whole fish composite sample collected from Bisbee Dam were below the median concentration for all lakes assessed in 1991-1992 with the exceptions of zinc and mercury. Zinc was four times the median concentration at 80.4 $\mu g\ g^{-1}$ and mercury was slightly above the median concentration at 0.28 $\mu g\ g^{-1}$.

Detectable pesticide residues in the composite whole fish sample collected from Bisbee Dam was limited to DDE. DDE is a breakdown derivative of DDT that behaves similarly to the parent compound when present in the environment. The reported concentration of DDE in the northern pike sample collected from Bisbee Dam was below the 25 percentile for all piscivore samples collected during the 1991 LWQA. A complete listing of the fish tissue results is contained in Appendix E.

Watershed

Bisbee Dam, and its contributing watershed, has a combined surface area of 73,580 acres extending in a northwesterly/southeasterly direction. Approximately 90 percent of the watershed lies in the Northern Glaciated Plains physiographic region. The remaining 10 percent extends into the southeast corner of the Turtle Mountains, an area comprised of forested hills, valleys and marshes. The portion that lies in the Northern Glaciated Plains is characterized by level to rolling hills with slopes ranging from 0 to 20 percent. Soils are moderately well drained to well drained, formed from glacial till.

Nonpoint source pollution from the surrounding watershed accounts for nearly 100 percent of the nutrient load and pollution discharge to Bisbee Dam.

Land use within the Bisbee Dam watershed is 95 percent agricultural with 70 percent actively cultivated. The remaining 30 percent is in low density urban development, haylands, pasture and conservation reserve program (CRP) acres. There are 14 concentrated livestock areas within the watershed (Table 2).

The city of Rolla's wastewater stabilization pond system is the only point source discharge within the Bisbee Dam watershed. The city's treated wastewater discharges are monitored by the state and must meet standards for biological oxygen demands (BOD) and total suspended solids (TSS). Due to these regulations and distance the discharge has to travel (approximately 26 miles) before reaching Bisbee Dam, it is believed that it poses little threat to the water quality of Bisbee Dam.

According to the information provided by the Towner County Soil Conservation District, 30 percent of the cultivated lands and 60 percent of the remaining lands within the Bisbee Dam watershed are "adequately treated" against soil loss. Based on an average soil loss of 2 to 3 tons per acre, approximately 43,850 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate to the reservoir of 10 to 15 percent, between 4,385 tons to 6,578 tons of soil reaches Bisbee Dam annually.

Table 2. Land use in the Bisbee-Big Coulee Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	70	30
Hayland	25	60
CRP	1	100
Wet/Wild[1]	2	N/A
Other	2	N/A
Farmsteads	5[3]	N/A
Feedlots[2]	14[3]	N/A

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number within watershed.

BLACKTAIL DAM

WILLIAMS COUNTY

Peter N. Wax

Blacktail Dam is located in west central Williams County. It was constructed in 1959 by the Williams County Park Board (WCPB), State Water Commission and the NDG&F. In 1967 the spillway and glory hole structure were rebuilt, raising the reservoir 4 feet. The reservoir now covers 160 acres with an average depth of 17.3 feet and maximum depth of 40 feet (Figure 1).

Blacktail Dam is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F currently stock northern pike, walleye, bluegill and largemouth bass.

Test netting in 1991 conducted by the NDG&F captured walleye, northern pike, bluegill, white sucker, and stunted yellow perch. Largemouth bass were not collected during test netting, however this could be due to gear method as bass are considerably net shy. Historically Blacktail Dam has been a source of adult perch for other lakes around the state. Large numbers of perch have been netted and transported to other lakes in the spring during the perch spawn.

The shoreline surrounding Blacktail Dam is mostly under public ownership, the majority being owned by the WCPB. When the lake was sampled on July 16, 1991, 147 cabins were counted surrounding Blacktail Dam. Virtually all cabin sites are leased from the WCPB except for a small block on the northeast corner of the reservoir. Angler use is moderate to high with good access through a fairly large recreation area. Facilities at the public access include a boat ramp, toilets and picnic areas.

Water Quality

Water quality samples were collected from Blacktail Dam twice during the summer of 1991 and once during the winter of 1919-1992. Samples were collected at one sample site located in the deepest area of the lake (Site 380540, Figure 1). Water column samples were collected for analysis at three separate depths, surface, middle and bottom.

Stratification of Blacktail Dam was observed during both sampling periods in the summer of 1991. On the July 16 sample date the thermocline occurred at approximately six meters below the lake surface. On August 6, 1991 the thermocline was observed at nine meters (Figure 2). Oxygen levels below the thermocline declined to less than 2 mg L^{-1} during both summer sampling periods (Figure 3).

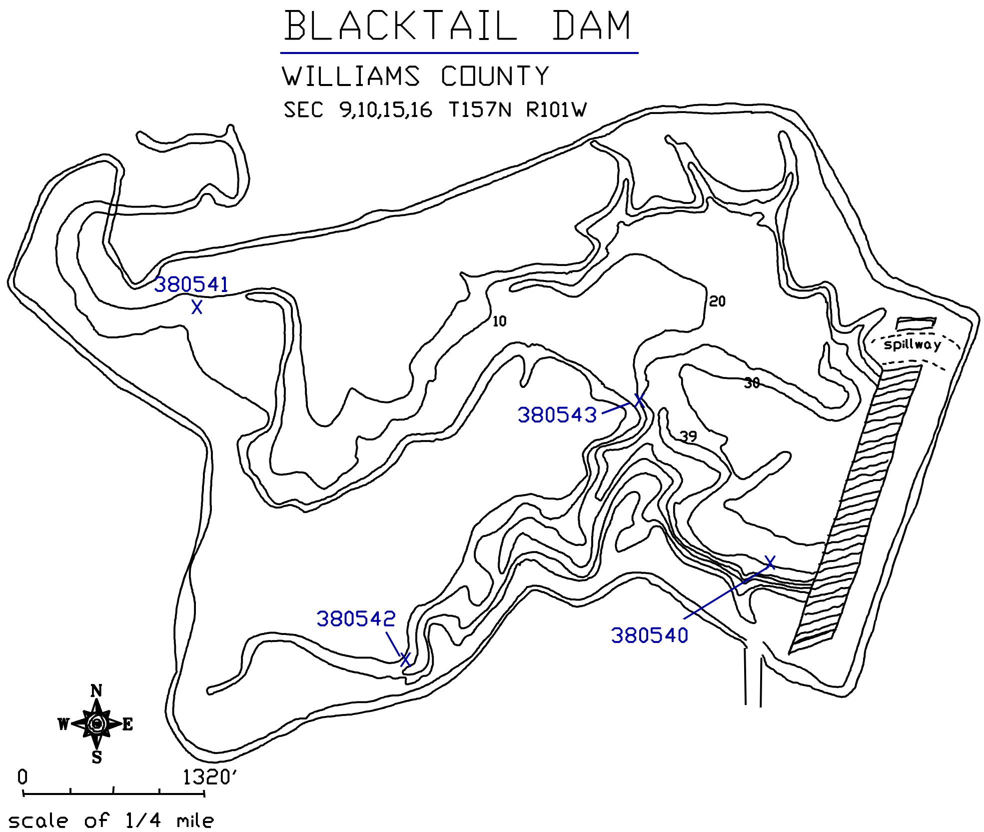

Figure 1. Morphometric map of Blacktail Dam.

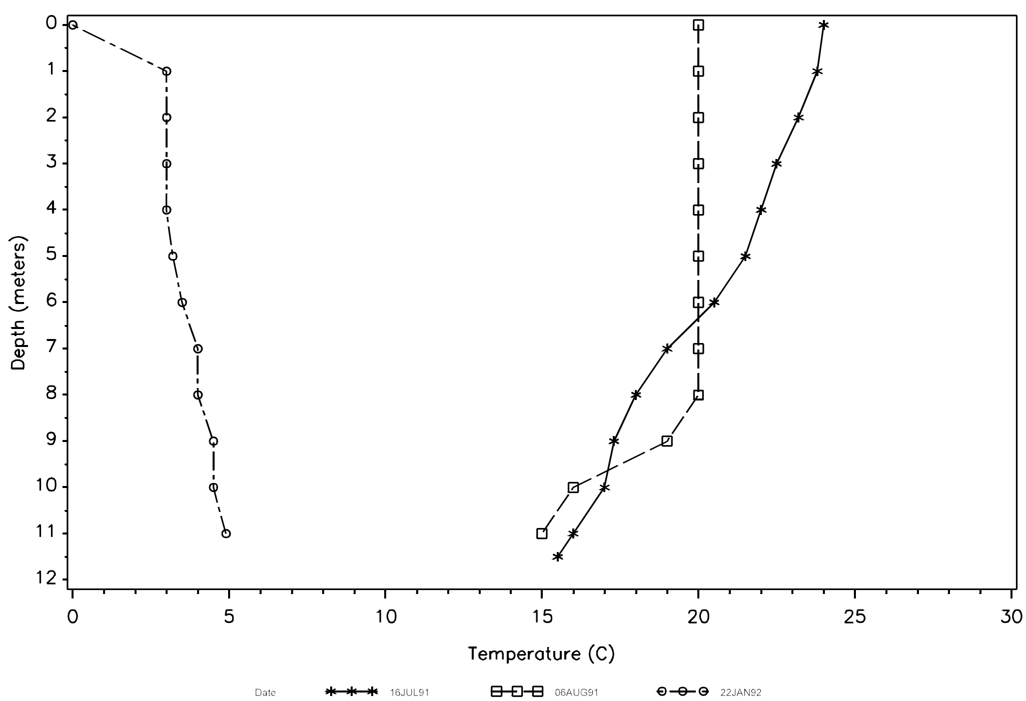

Figure 2. Temperature profile for Blacktail Dam.

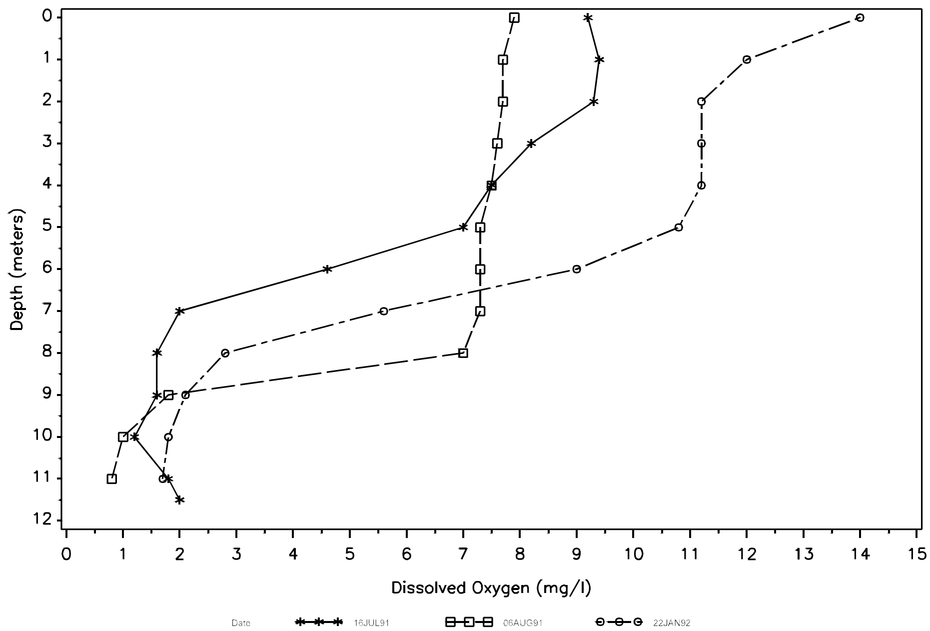

Figure 3. Oxygen profile for Blacktail Dam.

Water quality analyses performed on Blacktail Dam during the 1991 LWQA project show a well-buffered water-body with total alkalinity as $CaCO_3$ concentrations ranging between 241 and 400 mg L^{-1}. Major anions in the water column were bicarbonate and sulfates. Bicarbonate concentrations ranged between 270 and 311 mg L^{-1}. Sulfate concentrations ranged between 377 and 396 mg L^{-1}.

Concentrations of the main nutrients total phosphate as P and nitrate + nitrite as N suggest nitrogen as the limiting nutrient. True nitrogen limitation is not present on Blacktail Dam, however, there is an overabundance of phosphorus. Under these conditions, nitrogen fixing organisms, such as, some blue-green algal species are favored (Table 1).

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 16, 1991 and January 22, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 to December 31, 1991.

Parameter	Blacktail Dam		1982-1991	
Total Dissolved Solids	835	mg L^{-1}	1209	mg L^{-1}
Conductivity	1251	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	348	mg L^{-1}	488	mg L^{-1}
Sulfates	405	mg L^{-1}	592	mg L^{-1}
Chloride	6.7	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.113	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.065	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	276	mg L^{-1}	296	mg L^{-1}
Ammonia	0.230	mg L^{-1}	0.347	mg L^{-1}
TKN	1.70	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	319	mg L^{-1}	326	mg L^{-1}

Total phosphate as P concentrations in Bisbee Dam during 1991-1992 ranged between 0.058 and 0.563 mg L^{-1} with a weighted-volume mean for the three sample dates of 0.113 mg L^{-1}. These concentrations are well above the state's target concentration of 0.025 although below the long-term mean concentration for the state of North Dakota of 0.248 mg L^{-1}. A compilation of all 1991-1992 LWQA Project data is contained in Appendix A.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on August 6, 1991. At the time of the macrophyte survey, approximately 40 percent of Blacktail Dam's surface area had aquatic vegetation. Nearly 100 percent of the lakes surface area to a depth of five feet had a combination of sago pondweed (Potamogeton pectinatus), water milfoil (Myriophyllum spp.) and curly leaf pondweed (Potamogeton crispus). Cattails (Typha spp.) were found at various locations around the shoreline. A map depicting location and areal coverage of macrophytes on Blacktail Dam is contained in Appendix B.

Phytoplankton

The Blacktail Dam phytoplankton community was sampled twice during the summer of 1991. Blacktail Dam's phytoplankton community was represented by 5 divi-sions and 16 genera. The largest contributors to the community by density are the blue-green algae, Cyanophyta, with a mean density of 88,470 cells mL^{-1}. This is almost 19 times greater than the mean density of all other algae species combined. Mean blue-green algae concentrations expressed as volume also showed a dominance. While densities for the divisions Bacillariophyta and Pyrrophyta are low, their volume is large. This is due to the large size of the organisms when compared to the size of the green algae (Chlorophyta)and blue-green algae species present. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Blacktail Dam is considered a highly eutrophic to hypereutrophic reservoir. This assessment is defined using data collected during the 1991-1992 LWQA project and reviewing historical data. Primary indicators of a hypereutrophic condition are summer surface concentrations of total phosphate as P concen-trations which ranged between 067 and 118 µg L^{-1}, secchi disk transparency of 1.6 meters and chlorophyll-a concentrations between 13 and 33 µg L^{-1}.

Supporting ancillary information included a large macrophyte biomass, low dissolved oxygen below the hypolimnion and during ice cover, and a phytoplankton population dominated by blue-green algae species.

Sediment Analysis

Sediment samples collected from the deepest, littoral, and inlet areas on Blacktail Dam showed detectable levels of all trace elements analyzed except mercury. Mercury concentrations in the littoral and inlet areas were below the detection limit of 0.01 µg g^{-1}.

When compared to the median concentrations for all lakes assessed in 1991-1992, littoral zone trace metal concentrations for Blacktail Dam are at or below the 25th percentile for all lakes. The deepest area trace element concentrations were at or above the 75th percentile for all lakes except selenium which was slightly above the median. The inlet areas varied between each site sampled. Inlet #1 (Blacktail Creek) showed concentrations very near or below the median while inlet #2 (south tributary) displayed concentrations at or above the 75th percentile for all lakes. It is doubtful that soils differ by this much in the watershed, but differences in farming practices could contribute to the increased levels of trace elements found in the southern inlet to Blacktail Dam. A small local "landfill" is also located in this area and may be another source of the elevated trace metal levels. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for analysis from Blacktail Dam on June 27, 1991. Two species of fish were collected for contaminant analysis, northern pike represented the piscivore group and white sucker represented the bottom feeder group. The piscivore group was split into two samples because of the size difference among fish collected.

Trace element concentrations were similar to the median concentrations for all fish collected in 1991 sample except for mercury in the large piscivore sample. Mercury in the large piscivore sample was 0.42 $\mu g\ g^{-1}$, approximately two times the median concentration for all piscivores samples. Since this is a whole fish and mercury tends to accumulate in the flesh or meat of fish, investigation is warranted to further study fish in Blacktail Dam to see if larger fish have levels of mercury which would suggest the need for a consumption advisory. A complete list of the fish tissue results is available in Appendix E.

Detectable contaminant residues in the fish collected from Blacktail Dam included DDT, DDD, DDE, PCBs, nonachlor and trifluralin. DDT (dichloro diphenyl trichloroethane) was an agricultural insecticide that was discontinued in 1973 due to environmental risks. DDE and DDD are primary and secondary metabolites of DDT and produces biological effects similar to the parent compound.

PCBs are generally considered industrial wastes commonly used in plasticizers and dielectric fluids. Nonachlor is a principle ingredient in technical chlordane. Chlordane is an agricultural insecticide discontinued at about the same time as DDT, trifluralin commonly known as treflan, is a selected agricultural preemergent herbicide.

The piscivore sample composed of larger fish (piscivore #1) contained residues of DDT, DDD, DDE, PCBs, nonachlor and trifluralin. The concentrations reported for DDT, PCBs and nonachlor were near the median concentration of all piscivores sampled in 1991, with DDT and PCB concentrations exceeding the 75th percentile. In the smaller piscivore sample (piscivore #2), detectible residues of DDT, PCBs, nonachlor and trifluralin were present. DDT and PCBs concentrations in the piscivore #2 sample were above the 75th percentile for all piscivores sampled in 1991. All other organic residues were below analytical detection limits. The bottom feeder sample had reported residues of DDE and trifluralin. The trifluralin concentration reported was above the 75th percentile for all bottom feeders analyzed in 1991 while the DDE concentration was below the 25th percentile. A summary of the 1991-1992 whole fish results is contained in Appendix E.

Watershed

The Blacktail Dam watershed lies on the Missouri Slope Upland physiographic region and encompasses 18,035 acres in west central Williams County. Nonpoint source pollution accounts for all the nutrient loading and pollution discharges to Blacktail Dam. Land use within the Blacktail Dam watershed is 98 percent agricultural with 74 percent in active crop production. The remaining two percent is in other land uses including farms, roads, etc. (Table 2). There are three concentrated livestock feeding areas in the Blacktail Dam watershed. These areas are located fairly close to the reservoir and may be a significant source of nutrients. Another source of potential nutrients is the estimated 147 cabins surrounding Blacktail Dam. Most of the septic systems are located in close proximity to the high water mark and pose a potential threat to water quality.

According to information provided by the Williams County Soil Conservation District 50 percent of the cultivated lands and 70 percent of the range lands are in the Blacktail Dam watershed are "adequately treated" against soil loss. It should noted that "adequately treated" still allows soil erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that the average "T" value should be below 5 tons per acre per year. The estimated soil loss in the assessed area of the Blacktail Dam watershed is 85,583 tons of soil loss annually. This is approximately 4.7 tons per acre soil loss per year. Assuming a conservative delivery rate of 10 to 15 percent, between 8500 and 13,000 tons of soil reaches Blacktail Dam annually.

Table 2. Land use in the Blacktail Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	74	50
Rangeland	22	70
Hayland	2	100
CRP	0	0
Wet/Wild[1]	0	0
Other	2	0
Farmsteads	85[3]	0
Feedlots[2]	3[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

BREWER LAKE

CASS COUNTY

Peter N. Wax

Brewer Lake is a recreational impoundment located on a tributary to the Rush River in north central Cass County, North Dakota. Brewer Lake was built in 1970 through the cooperative efforts of the State Water Commission (SWC), the NDG&F, the Bureau of Outdoor Recreation, and the Rush River Water Resource District. It is a relatively small yet deep reservoir with a surface area of 128.8 acres and a maximum depth of 31 feet (Figure 1).

The contributing watershed for Brewer Lake's is composed of some of the most fertile lands in the Red River Valley. Nearly 90 percent of the 7,360 acre watershed is in agricultural production, with 81 percent actively cultivated. This intensely cultivated landscape contributes to the declining trend in water quality and the cycle of nutrient enrichment, algal blooms and summer kills, which periodically occurs on Brewer Lake. The most recent fish kill occurred in 1986, affecting predominantly the rainbow trout fishery.

Concern over degrading water quality and repeated fish kills occurring in Brewer Lake prompted a five-year study performed by Dr. Gabriel Comita of North Dakota State University. The study monitored the nutrient availability within Brewer Lake and gross productivity in relation to rainfall over a five-year period starting in 1974 and ending in 1979.

After five years of studying Brewer Lake, Dr. Comita concluded that Brewer Lake experiences fish kill due to a cycle of precipitation runoff, nutrient enrichment and uplift and subsequent algal bloom. The heavy blooms eventually decay, producing ammonia rich waters concentrated below the hypolimniom during calm, hot weather. This zone is eventually mixed by wind and wave action, releasing the concentrated dose of unionized ammonia to the entire water column (Comita 1985).

A hypolimnic drawdown was installed in 1975 to allow release of this nutrient rich water and to help prevent future fish kills. When operated properly, it has had limited effects in preventing fish kills.

Brewer Lake is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated biota" (NDSDHCL, 1991). The NDG&F manage the fishery by assessing the fish community annually through test netting operations and stocking accordingly. In recent years, the stocking regiment has included rainbow trout, walleye, and largemouth bass. Test netting operations performed in 1991 captured bluegills, smallmouth bass, and walleye.
The initial fishery on Brewer Lake was rainbow trout, with plans to develop a second story of walleye. The trout fishery, due to poor water quality, fish kills and possibly inferior stock, was of poor quality, while the walleye fishery improved each year.

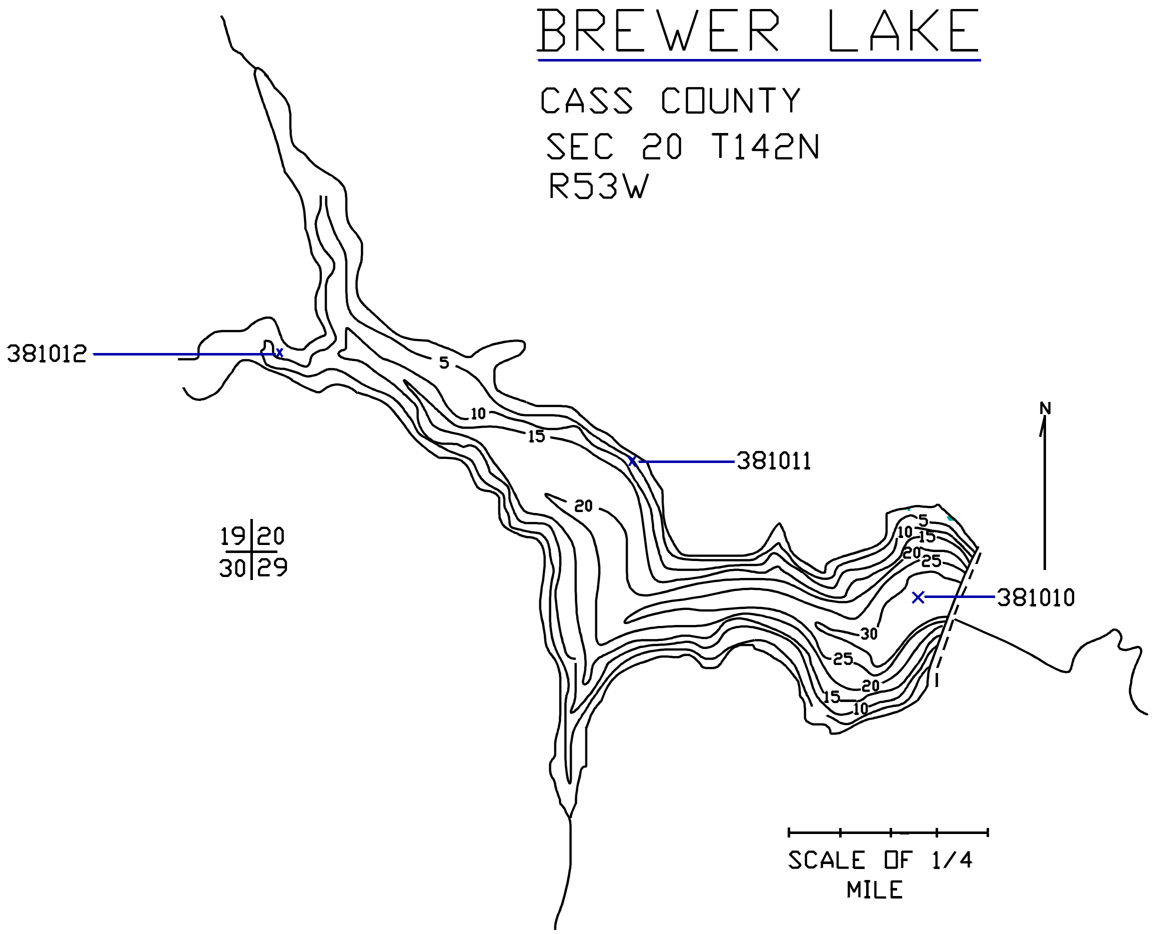

Figure 1. Morphometric map of Brewer Lake.

In the spring of 1979, high water in the Rush River damaged Brewer Lake's emergency spillway. Bullheads were captured in test nets set the following year. In 1982 the lake was eradicated and restocked the following year with rainbow trout. The rainbow trout stocked in 1983 were a transitional fishery to overlap the development of a largemouth bass, smallmouth bass, and bluegill fishery.

Brewer Lake is 100 percent publicly owned, with approximately one percent of the shoreline area developed. Facilities on Brewer Lake include a campground, picnic area, boat launch, and swim beach. The lake is equipped with a hypolimnic drawdown installed in 1975. The public facilities are managed by the Cass County Park Board. Public use and concern for Brewer Lake is high, as evident by the amount of work and local support that has gone into previous studies and developments.

Water Quality

Water quality samples were collected from Brewer Lake two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381010, Figure 1). Water column samples were collected for analysis at three discrete depths, 1 meter, 5 meters, and 9 meters in the summer of 1991 and 1 meter, 4 meters, and 8 meters in February of 1992.

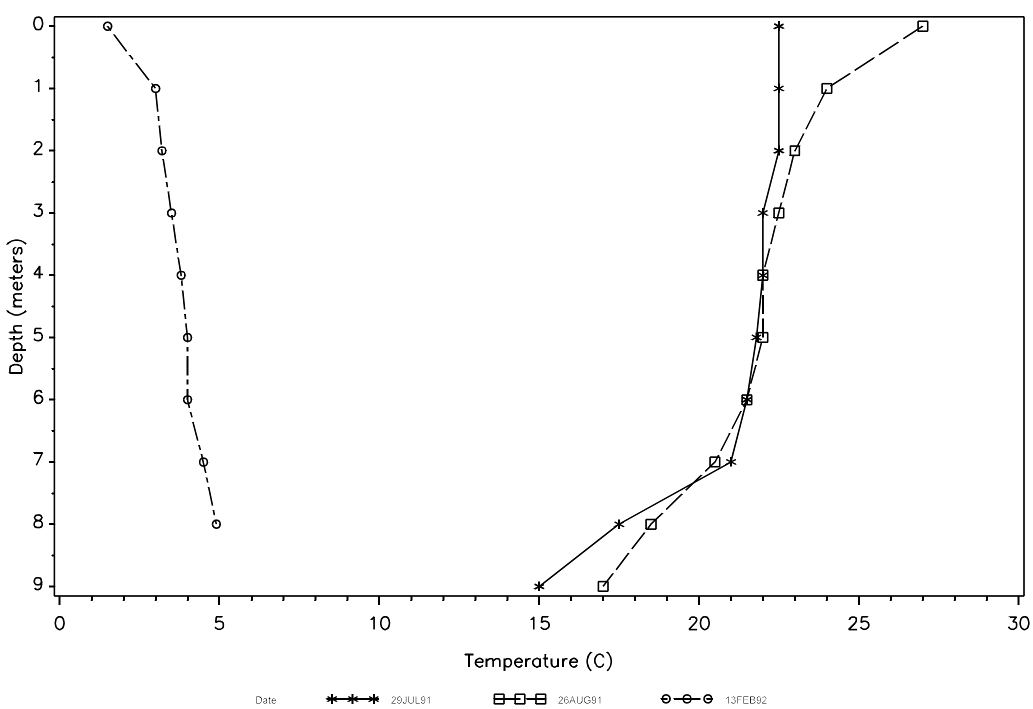

Figure 16. Temperature profiles for Brewer Lake.

During the LWQA Project Brewer Lake was thermally stratified at approximately 7 meters below the lake surface in July and 1 meter below in August (Figure 2). During these time periods, dissolved oxygen concentrations were at or near saturation to the depth of 1 meter falling off rapidly to 1.0 mg L^{-1} or less near the bottom of the lake (Figure 3). Samples collected during February 1992 showed Brewer Lake not to be thermally stratified with dissolved oxygen concentrations ranging from 9.2 mg L^{-1} near the surface to approximately 1 mg L^{-1} near the bottom (Figure 3).

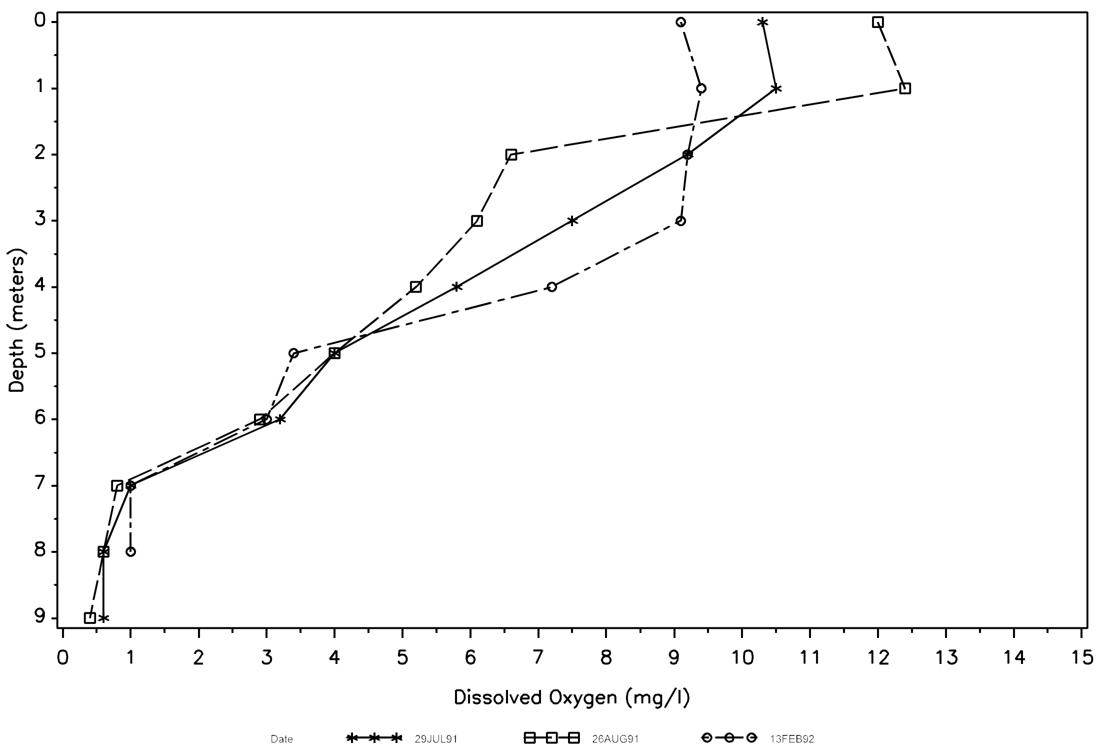

Figure 17. Oxygen profiles for Brewer Lake.

Sulfate and bicarbonates were the dominant anions in the Brewer Lake water column. Sulfate concentrations ranged from 46 to 106 mg L^{-1} while bicarbonate concentrations were between 180 and 394 mg L^{-1}. The average volume-weighted mean concentration for total phosphate as P was 0.188 mg L^{-1} exceeding the State's target concentration of 0.02 mg L^{-1} on all occasions sampled during the 1991-1992 LWQA project. The concentrations of nitrate + nitrite as N were below the state's target concentration of 0.25 mg L^{-1} in all but one sample collected in February of 1992, and had a average volume-weighed concentration of 0.100 (Table 1). A complete list of water quality sample data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 10, 1991 and February 13, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Brewer Lake	1982-1991
Dissolved solids	296 mg L^{-1}	1209 mg 1^{-1}
Conductivity	507 umhos cm^{-1}	1604 umhos cm^{-1}
Hardness as calcium	245 mg L^{-1}	488 mg L^{-1}
Sulfates	59 mg L^{-1}	592 mg L^{-1}
Chlorides	3.2 mg L^{-1}	81 mg L^{-1}
Total phosphate as P	0.188 mg L^{-1}	0.248 mg L^{-1}
Nitrate + Nitrite as N	0.100 mg L^{-1}	0.069 mg L^{-1}
Total kjeldahl nitrogen	2.33 mg L^{-1}	2.34 mg L^{-1}
Ammonia	0.493 mg L^{-1}	0.326 mg L^{-1}
Bicarbonate	222 mg L^{-1}	326 mg L^{-1}
Total Alkalinity	215 mg L^{-1}	296 mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Brewer Lake on August 26, 1991. At the time of the macrophyte survey approximately 10 percent of Brewer Lake's surface area had aquatic vegetation. Nearly 100 percent of the lakes surface area to a depth of five feet had sago pondweed (Potamogeton pectinatus) with intermittent stands of cattails (Typha spp.) or a combination of both. A map depicting the macrophyte population and areal extend in contained in Appendix B.

Phytoplankton

The Brewer Lake phytoplankton community was sampled two times during the summer of 1991. The Brewer Lake phytoplankton community, when sampled in July and August, 1991, was represented by 4 divisions and 10 genera. The greatest contributors by density were the blue-green algae, Cyanophyta, with 5 genera present. Mean density of blue-green algae for the two samples collected during the summer of 1991 was 257,739 cells mL^{-1}, which was 265 times greater than the other three divisions combined.

At the time of the LWQA samples were collected, mean phytoplankton concentrations by volume were also dominated by blue-green algae, Cyanophyta. The blue-green algae occupied over 98 percent of the population by volume. The division, Cryptophyta followed representing less than 2 percent of the community by volume. The remainder was made up of Chlorophyta and Bacillariophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the summer of 1991 on Brewer Lake described a hypereutrophic waterbody. Primary indicators are total phosphate as P concentrations that averaged 199 µg L^{-1}, concentrations of chlorophyll-a that averaged 70 µg L^{-1} and secchi disk readings that averaged 1.0 meters. Ancillary data supportive of a hypereutrophic condition are dissolved oxygen deficiencies throughout the water column during ice cover and below the hypolimnion in the summer, large macrophyte biomass, frequent nuisance algal blooms, a phytoplankton community dominated by blue-green Cyanophyta and frequent fish kills.

Sediment Analysis

Sediments were collected from Brewer Lake and analyzed for trace elements, PCBs and selected pesticides. Sediment samples were collected at three sites, the deepest area of the lake (Site 381010, Figure 1), the littoral zone (Site 381011, Figure 1), and the inlet (Site 3801012, Figure 1).

Sediment samples collected from Brewer Lake had detectable levels of all trace elements tested for except mercury. Reported concentrations of trace elements in the sediments collected at each location in Brewer Lake were compared to the median concentration reported for all lakes assessed in the 1991 LWQA project. In general reported trace element concentrations were near the median concentration for all lakes sampled. The exceptions were the reported arsenic concentrations in the deepest area of the lake and the reported selenium and lead concentrations in the inlet area. These concentrations ranged from 4 to 10-fold the median concentration for each parameter. Concentrations of selected organic compounds were below detectible limits for all samples collected from Brewer Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Whole fish samples were collected for contaminant analysis from Brewer Lake on June 25, 1991. Two age classes of largemouth bass and one age class of smallmouth bass were collected, representing three separate piscivore samples. The samples are labeled, piscivore 1, for the largest largemouth bass; piscivore 2, for the smaller largemouth bass; and piscivore 3, for the smallmouth bass.

In order to evaluate the fish tissue data for Brewer Lake, the results for each fish group was compared to that group for all lakes assessed in 1991-1992. Reported trace element concentrations in the fish samples collected from Brewer Lake were generally near the median concentrations for all fish collected during the 1991 LWQA project. The exceptions were the reported mercury concentrations of 0.61 and 0.25 µg g^{-1} in the larger and smaller groups of largemouth bass respectively.

Detectable residues of organic compounds in the bass sampled from Brewer Lake included, DDD, DDE, dieldrin, PCBs, nonachlor, trifluralin, and heptachlor. DDD and DDE are degenerate by-products of DDT and behave similarly to the parent compound when available in the environment. Dieldrin is an insecticide that is toxic to certain aquatic biota. In toxicity testing, it was shown to prevent daphnia from completing metamorphosis to adulthood in concentrations as low as 5.6 µg L^{-1} and was lethal to 50 percent of largemouth bass and walleye after 96 hours of exposure (96-hour LC50) at average concentrations of 1.5 and 2.9 μg L^{-1}, respectively. Dieldrin has been discontinued since the early 1970's.

Nonachlor is a agricultural pesticide and a major constituent of technical chlordane and heptachlor. Heptachlor is an insecticide commonly used for termite control and is toxic to certain aquatic biota. The 96-hour LC50 rates for heptachlor on bluegill and rainbow trout is 0.19 and 0.15 μg L^{-1}, respectively. Trifluralin, commonly known as treflan, is a selective preemergent herbicide, with a 96-hour LC50 for bluegills of 58.0 μg L^{-1}.

Polychlorinated biphenyls and terphenyls, commonly called aroclor or PCB, are generally considered industrial wastes, commonly used for plasticizers and dielectric fluids. PCBs are present in a multiple of different forms or isotopes. The 96-hour LC50 ranges considerably from each form. An example would be aroclor 1016, which has a 96-hour LC50 rating for bluegills of 460 μg L^{-1}, while aroclor 1248 has a 96-hour LC50 of 2740 μg L^{-1} (Johnson and Finely 1980).

The larger class of largemouth bass had reported concentrations of DDD, DDE, dieldrin, PCBs, nonachlor, and trifluralin, which were equal to or exceeded the 75th percentile for all piscivores sampled during the 1991 LWQA project. The smaller class of largemouth bass contained reported residues of DDD, DDE, dieldrin, PCBs, and trifluralin. Concentrations were near the median, with exceptions for PCBs and trifluralin, which were equal to or above the 75th percentile. The smallmouth bass sample contained reported concentrations of dieldrin, nonachlor, trifluralin, and heptachlor, at concentrations near or above the 75th percentile for all lakes sampled in the 1991 LWQA project. Reported concentrations of DDD and DDE in the smallmouth sample were at or below the median. A complete listing of contaminant results is contained in Appendix E.

Watershed

Brewer Lake and its contributing watershed have a combined surface area of 7,360 acres. It is located in the Red River Valley in Cass County, North Dakota. The Red River Valley is one of the most fertile valleys in the United States. The surrounding landscape is characteristically level taking on a checkerboard areal appearance broken only by the occasional stream or farmstead. Nonpoint source pollution from the surrounding watershed accounts for nearly all of the nutrient loading and pollution discharges to Brewer Lake.

Land use within the Brewer Lake watershed is 86 percent agricultural with 81 percent actively cultivated. The remaining 19 percent is in low density urban development, haylands, pasture, and conservation reserve program (Table 2). According to the information provided by the Cass County Soil Conservation District in 1991, 65 percent of the cultivated lands and between 0 and 85 percent of the remaining lands within the Brewer Lake watershed are "adequately treated" against soil loss.

It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Brewer Lake watershed the average "T" value is

3 to 5 tons per acre. Based on an average soil loss of 5 to 6 tons per acre, which takes into account the untreated portions of the watershed, approximately 42,855 tons of soil are lost annually from within that watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 4,286 to 6,428 tons of soil reaches Brewer Lake annually.

Table 2. Land use in the Brewer Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	81	65
Pasture land	2	85
Hayland	0	0
CRP	3	100
Wet/Wild[1]	12	100
Other	2	N/A
Farmsteads	39[3]	N/A
Feedlots[2]	0[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number present in watershed.

BRUSH LAKE

MCLEAN COUNTY

Peter N. Wax

Brush Lake is located on the edge of the Missouri Coteau physiographic region in eastern McLean County, North Dakota. Brush Lake is a classic coteau lake in that it is small, shallow and was formed from glacial melting and outwashing (Figure 1).

The topography of the watershed is rolling to hilly with many integrated drainages, typifying the northern prairie pothole region. Soils are predominantly well to excessively well drained built from sandy, rocky glacial material.

Brush Lake is connected to the Lake Netti Aquifer. The Lake Netti Aquifer is a buried bedrock valley created by glacial activities. The aquifer flows from east to west with a average elevation near Bush Lake of 1,823 feet above mean sea level. Brush Lake is nearly 20 feet deep with a surface elevation of 1,810 feet above mean sea level. Brush Lake receives groundwater inflows from the east and discharges to the aquifer from the northwest. Even though Brush Lake is a closed basin, in this way it is able to disgorge its excess water without flooding.

Brush Lake receives a portion of its hydrologic budget during normal and high precipitation periods through surface water runoff. The majority of runoff enters from the southeast after passing through a series of marshes and small lakes. These areas act as natural filters and sediment traps relieving the runoff of portions of its nutrient and sediment load.

Brush Lake is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage the fishery on Brush Lake. Management activities include annual fish community assessments, fish stockings, assisting in the operation of aeration system and biological manipulations.

In recent years stockings by the NDG&F have included northern pike, walleye, bluegill, smallmouth bass and fathead minnows. Test netting operations conducted in 1991 by the NDG&F captured walleye, yellow perch, bluegill, white suckers, sticklebacks and a single largemouth bass.

The initial fishery was created on Brush Lake in 1941 with the stockings of a variety of species. Cooperative analytical and physical management was not initiated until 1951. During the following ten years, rough fish (i.e., bullhead, white sucker) were stocked, as well as game and pan fish. Brush Lake's fishery historically is intermittent with partial and complete winter kills occurring every 5 to 10 years. Severe winter kills occurred in the winters of 1950-1951, 1968-1969 and 1978-1979. The NDG&F in an attempt to control the booming rough fish population eradicated Brush Lake following the winterkills of 1959 and again in 1979. In 1980 an aeration system was added to Brush Lake. The aeration system has been effective in preventing fish kills since its installation.

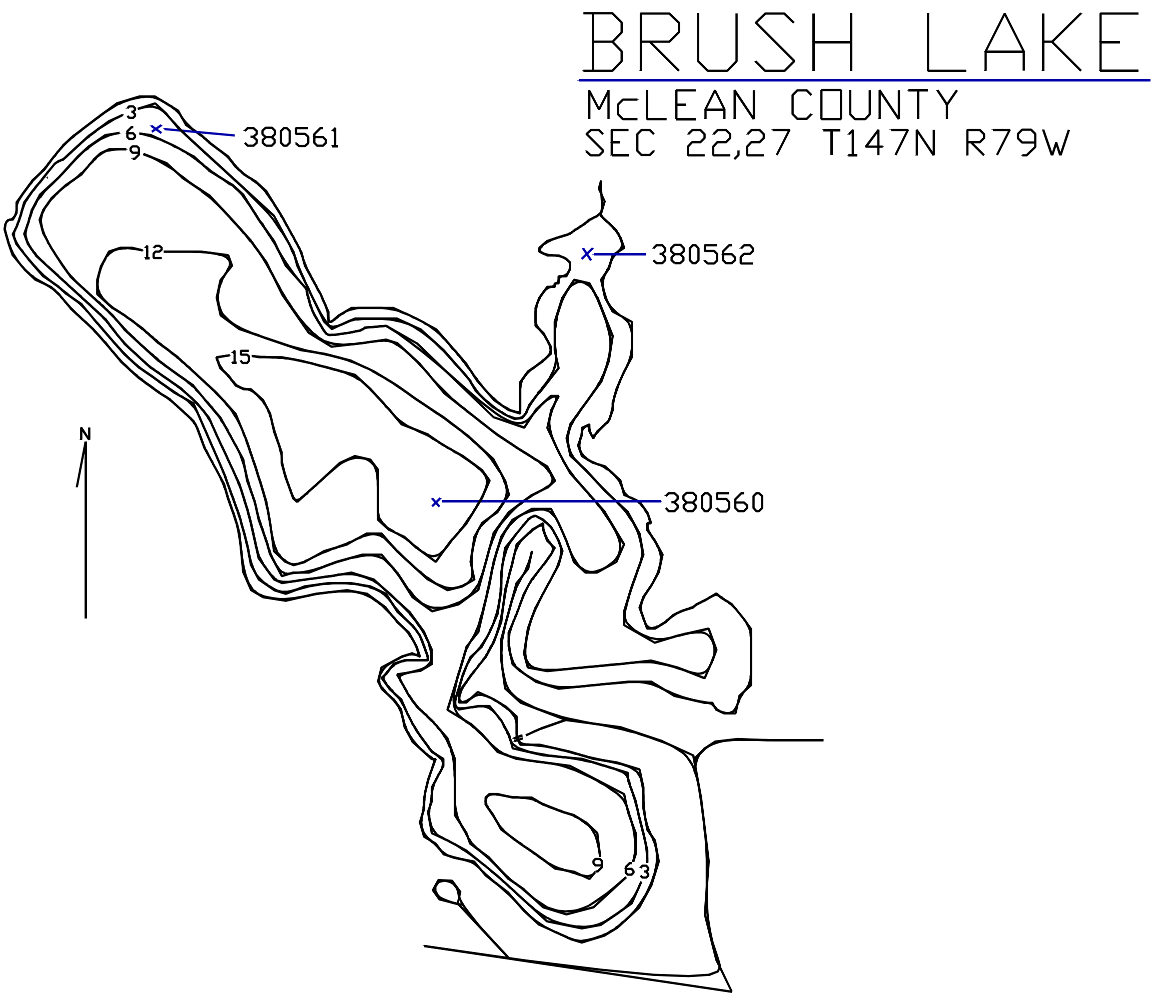

Figure 1. Morphometric map of Brush Lake.

Brush Lake's shoreline is 100 percent privately owned with one public access. Public facilities include a boat ramp, picnic area, parking lot and toilets. The shoreline is nearly 100 percent developed with approximately 190 lake cabins and a seasonal general store. Sanitary facilities for the permanent and summer homes vary from septic systems, holding tanks and pit toilets.

Water Quality

Water quality data collected between July 1991 and January 1992 showed Brush Lake as extremely well-buffered. The volume-weighted mean total concentrations of total alkalinity as $CaCO_3$ at 838 mg L^{-1}. The dominant anions in the water column were bicarbonates and sulfates. Bicarbonate concentrations ranged from 442 to 622 mg L^{-1} and sulfate concentrations ranged from 212 to 296 mg L^{-1}. Total hardness as calcium concentrations averaged 416 mg L^{-1} and total dissolved solid concentration of 866 mg L^{-1} describe a lake with relatively hard water.

The average volume-weighted mean total phosphorus as P concentration was 0.076 mg L^{-1}, exceeding the state's target concentration of 0.02 mg L^{-1} in all occasions sampled. The volume-weighted mean nitrate + nitrite as N concentrations was 0.006 mg L^{-1}, which is below the state's target goal of 0.25 mg L^{-1}. The ratio between total phosphorus as P and nitrate + nitrite as N concentrations would suggest that Brush Lake is nitrogen limited, however the total phosphorus as P remains considerably less than most lakes in North Dakota. This is of note, as it indicates primary production could possibly be reduced by controlling the total phosphorus loadings to Brush Lake (Table 1).

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 9, 1991 and January 31, 1992 and long-term averages from all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1992.

Parameter	Brush Lake		1982-1991	
Total Dissolved Solids	866	mg L^{-1}	1209	mg L^{-1}
Conductivity	1399	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	416	mg L^{-1}	488	mg L^{-1}
Sulfates	244	mg L^{-1}	592	mg L^{-1}
Chloride	15.1	mg L^{-1}	81	mg L^{-1}
Total phosphate as P	0.076	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.006	mg L^{-1}	0.069	mg L^{-1}
Total kjeldahl nitrogen	2.57	mg L^{-1}	2.34	mg L^{-1}
Ammonia	0.070	mg L^{-1}	0.326	mg L^{-1}
Bicarbonate	505	mg L^{-1}	326	mg L^{-1}
Total Alkalinity	838	mg l^{-1}	296	mg l^{-1}

Data collected during the summer of 1991, showed Brush Lake as not thermally stratified (Figure 2). Dissolved oxygen concentrations during both sample periods were near saturation to a depth January 1992 again of three meters and were adequate to maintain aquatic life (Figure 3).

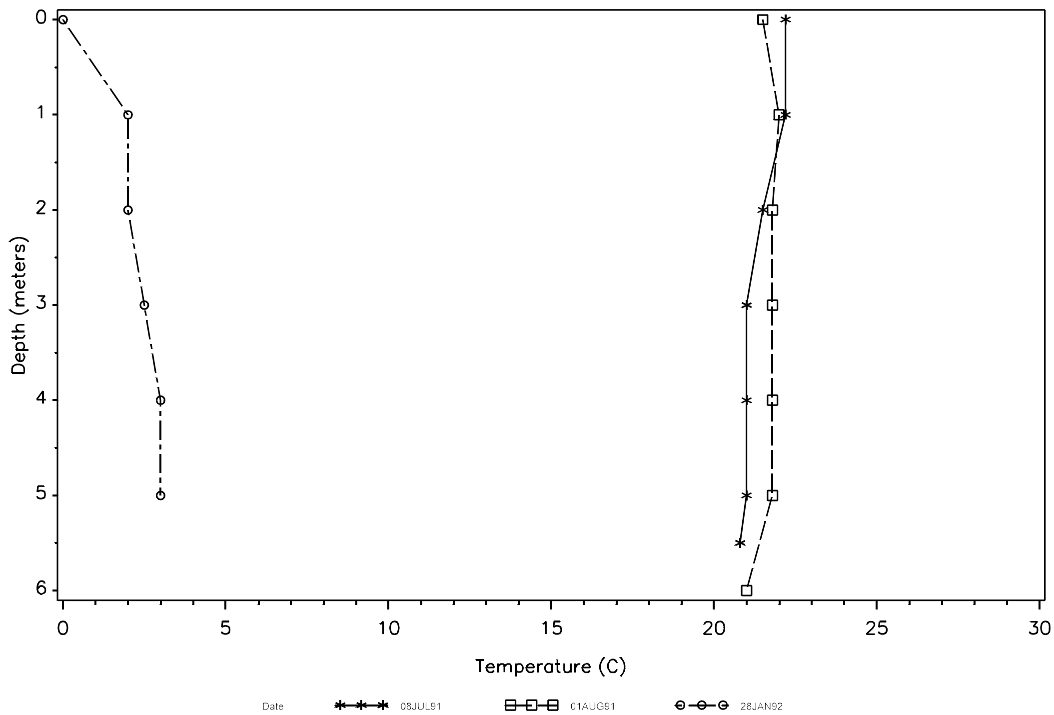

Figure 2. Temperature profiles for Brush lake.

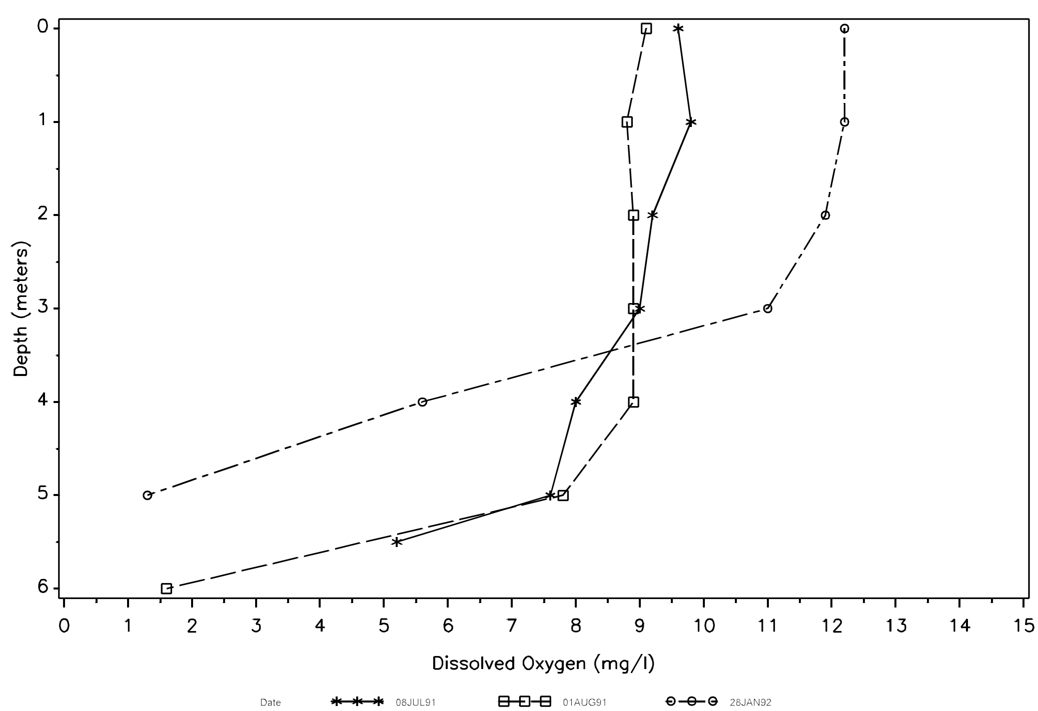

Figure 3. Oxygen profiles for Brush Lake.

Samples collected during showed a water column which was not thermally stratified (Figure 2). Dissolved oxygen concentrations ranged from 12.2 mg L^{-1} and 11.0 mg L^{-1} above three meters of depth to 5.6 mg L^{-1} to 1.3 mg L^{-1} below three meters of depth (Figures 2 and 3).

Aquatic Vegetation

A qualitative survey of the macrophyte (vascular aquatic plant) community was conducted on Brush Lake on August 1, 1991. At the time of the macrophyte survey approximately 30 percent of Brush Lake's surface area had aquatic vegetation. Nearly 90 percent of Brush Lake's surface area to a depth of six feet had mixed stands of sago pondweed (Potamogeton pectinatus) and water milfoil (Myriophyllum spp.). In the northwestern region and on the shallow island there were almost pure stands of sago pondweed (Potamogeton Pectinatus). The edges of the lake also had intermittent stands of bulrush (Scirpus spp.). A map depicting the areal coverage of macrophytes on Brush Lake can be found in Appendix B.

Phytoplankton

Brush Lake's phytoplankton community is relatively diverse, with representation from 6 divisions and 46 genera. The largest contributors by density were the blue-green algae, Cyanophyta with 16 genera present. Mean densities of blue-green algae during the summer of 1991 were 1,419,135 cells mL^{-1}, and 100 times greater than all other divisons combined.

During the summer of 1991, the phytoplankton community by volume was much more evenly distributed with blue-green algae still dominating. The shift in community structure from extremely uneven by density to one more evenly distributed by volume is due to the variation in size of individual organisms. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Based on water quality data collected and the ancillary information examined during 1991 and 1992, Brush Lake is a hypereutrophic lake. Surface total phosphorus as P concentrations exceeded 75 $\mu g\ L^{-1}$, chlorophyll-a concentrations ranged from 19 to 34 $\mu g\ L^{-1}$ and secchi disk transparencies were near 1 meter depth at all sample times during the summer of the 1991. Supporting ancillary information suggesting a hypereutrophic lake are a macrophyte population which inhabits nearly 100 percent of the surface area within the photic zone. A phytoplankton community severely dominated by blue-green algae and the necessity to aerate Brush Lake to prevent low dissolved oxygen conditions and fish kills.

Sediment Analysis

Sediments collected from Brush Lake showed detectable levels of all trace elements tested for except mercury in the deepest and littoral areas. Reported trace element concentrations were near or below the median concentrations for all lakes sampled, with the exception of selenium in the deepest sediments and selenium, lead and arsenic in the inlet area sediments, which were above the reported median. Concentrations of selected organic compounds were below the detectable limits for samples collected from Brush Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Brush Lake on May 21, 1991. Walleye and white suckers were collected for analysis. The walleye were used to represent the piscivore group and white suckers the bottom feeder group.

Reported trace element concentrations in fish samples collected from Brush Lake were generally near or slightly below the median concentrations for all fish collected. The exceptions were the reported selenium and mercury concentrations which were slightly above the median concentrations for all fish collected in 1991 and 1992.

Detectable contaminant residues in the white sucker and walleye samples collected from Brush Lake included DDD, DDE, nonachlor and PCBs. DDD and DDE are degenerate by-products of DDT and behave similarly to the parent compound when available in the environment. Nonachlor is an ingredient in technical grade chlordane, which can be stable in the environment. Polychlorinated biphenyls and terphenyls, commonly known as aroclors or PCBs, are generally considered industrial wastes. PCBs are commonly used as plasticizers and dielectric fluids. PCBs are present in a multitude of different forms or isotopes, each having variable effects in the environment. An example would be aroclor 1016, which has a 96-hour LC50 for bluegills of 460 $\mu g\ L^{-1}$, while aroclor 1248 has a 96-hour LC50 of 2740 $\mu g\ L^{-1}$ (Johnson and Finley 1980). The 96-hour LC50 refers to the concentration necessary to cause mortality to half the study specimens over a 96-hour exposure.

Reported concentrations of the contaminants DDD and DDE in the walleye samples were above the 75th percentile for all predator samples collected during the 1991-1992 LWQA project. The reported concentrations of nonachlor and PCBs were the highest concentrations reported in any lake assessed during the 1991-1992 LWQA project at 0.006 and 0.06 $mg\ g^{-1}$, respectively. The reported concentrations of DDD and nonachlor in the white suckers collected were also above the median and 75th percentile, however, the reported concentrations of DDE was below the median. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Brush Lake's contributing watershed is comprised of 26,700 acres located in the Missouri River Basin. Topography of the watershed is gently rolling to hilly. Soils are mostly excessively to well drained formed from sandy, rocky glacial material. The watershed is predominately integrated drainages typifying characteristics of the northern prairie pothole region.

Nonpoint source pollution from agricultural fields and low density urban development accounts for nearly 100 percent of nutrient and sediment loadings to Brush Lake.

Land use within the Brush Lake watershed is 89 percent agricultural, with 28 percent actively cultivated. The remaining 72 percent is in low density urban development, haylands, pasture, conservation reserve program (CRP) areas and wildlife management areas (Table 2). According to information provided by the McLean County Soil Conservation District, 50 percent of the cultivated lands and between 85 and 100 percent of all the remaining lands within the Brush Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance of (T). It is estimated that within the Brush Lake watershed, the average T value is 3 to 5 tons per acre.

Based on an average soil loss of 3 to 4 tons per acre, which takes into account all land uses, approximately 92,435 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent between 9,244 and 13,865 tons of soil reaches Brush Lake annually. Other sources of nonpoint source pollution discharges to Brush Lake include concentrated livestock feeding areas and watering in the immediate upstream drainage, irrigation and low density urban runoff from construction sites and lawns. Another potentially significant source of nutrients of Brush Lake is the estimated 190 cabins surrounding Brush Lake. Most of the septic systems are located in close proximity to the high water mark and pose a potential threat to water quality.

Table 2. Land use in the Brush Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	28	50
Pasture land	33	85
Hayland	5	85
CRP	23	100
Wet/Wild[1]	6	100
Other	5	N/A
Farmsteads	25[3]	N/A
Feedlots[2]	20[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number present in watershed.

CEDAR LAKE

SLOPE COUNTY

Peter N. Wax

Cedar Lake lies in the Missouri Slope Upland physiographic region at the confluence of Cedar and North Cedar Creeks in southeastern Slope County, North Dakota. The dam was built in 1935 by the Civilian Conservation Corp for recreation. When originally constructed, the reservoir had a surface area of 198.5 acres and a maximum depth of 18 feet (Figure 1).

The topography of the contributing watershed varies from nearly level to undulating on the uplands to very steep and complex near drainages and valleys. Soils are predominantly shallow, moderately fertile, coarse textured, and erodible. Agriculture is the principal land use, with 58 percent of the surface area actively cultivated, 28 percent in livestock production, and the remainder in Conservation Reserve Program (CRP) acreage and low density urban development.

Cedar Lake is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manages the fishery by annually assessing the fish community through test netting operations and stocking accordingly.

In recent years, stockings have included northern pike, yellow perch, bluegill, and black crappie. Cedar Lake is impacted from high nutrient and sediment loads which create a hypereutrophic lake condition resulting in frequent fish kills. Test netting operations conducted by the NDG&F in 1991 captured, in order of most abundant, black bullheads, yellow perch, carp, and black crappie. Some nice bluegill and northern pike were also captured.

Access to Cedar Lake is good. Public facilities include a boat ramp, toilets, and picnic area. Fishing pressure on Cedar Lake is variable from light to moderate, depending on water levels and availability of fish.

Cedar Lake is high in total dissolved solids, sulfates, and the nutrients, total phosphorus as P and nitrate + nitrite as N. The high concentrations of total dissolved solid are possibly due to the soils in the area. Local soils are fine and may remain suspended in the water column for extended periods of time.

Water Quality

Sulfates was the dominant anion in the water column with an average volume-weighted mean concentration of 1091 mg L^{-1}. Average volume-weighted mean bicarbonate and chloride concentrations were 377 and 16.7 mg L^{-1}, respectively. Total hardness as calcium concentrations was 557 mg L^{-1}, total alka-linity as $CaCO_3$ concentration was 187 mg L^{-1}, describing a lake with high ion and mineral concentrations when compared with most lakes statewide (Table 1).

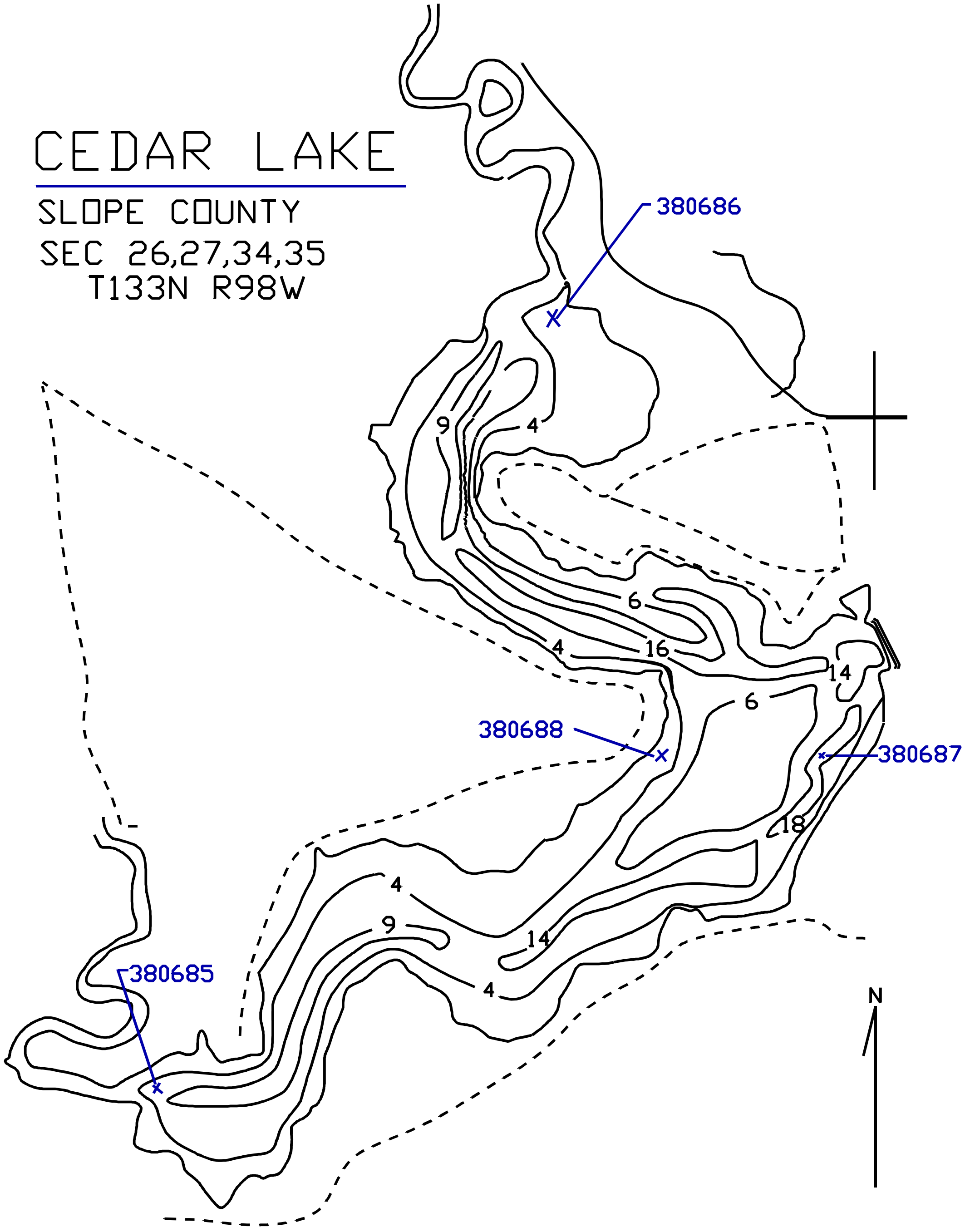

Figure 1. Morphometric map of Cedar Lake.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled on July 25 and August 14, 1991 and February 11, 1992 and long-term averages from all

North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Cedar Creek		1982-1991	
Total Dissolved solids	1920	mg L^{-1}	1209	mg L^{-1}
Conductivity	2737	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	551	mg L^{-1}	488	mg L^{-1}
Sulfates	1091	mg L^{-1}	592	mg L^{-1}
Chlorides	16.7	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.354	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.023	mg L^{-1}	0.069	mg L^{-1}
Total Kjeldahl Nitrogen	3.70	mg L^{-1}	2.34	mg L^{-1}
Ammonia	0.075	mg L^{-1}	0.326	mg L^{-1}
Bicarbonate	377	mg L^{-1}	326	mg L^{-1}
Total Alkalinity	362	mg L^{-1}	296	mg L^{-1}

The volume-weighted mean concentration of total phosphorus as P was 0.354 mg L^{-1} exceeding the state's target concentrations of 0.02 mg L^{-1} on all occasions sampled. The volume-weighted mean nitrate + nitrite as N concentration was 0.023 mg L^{-1}, below the state's target concentration of 0.25 mg L^{-1} on all occasions sampled. A complete list of water quality sample data is contained in Appendix A.

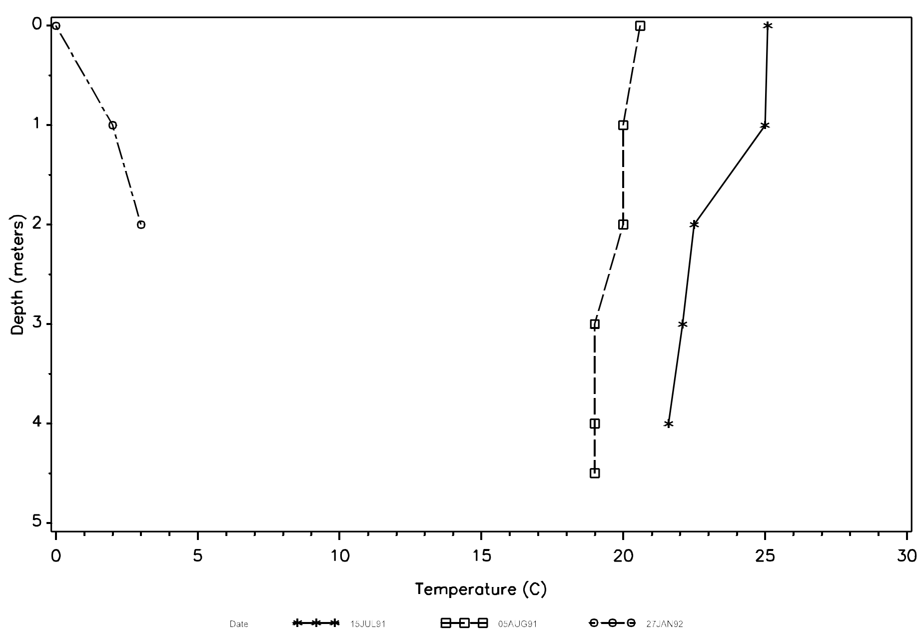

Figure 2. Temperature profiles for Cedar Lake.

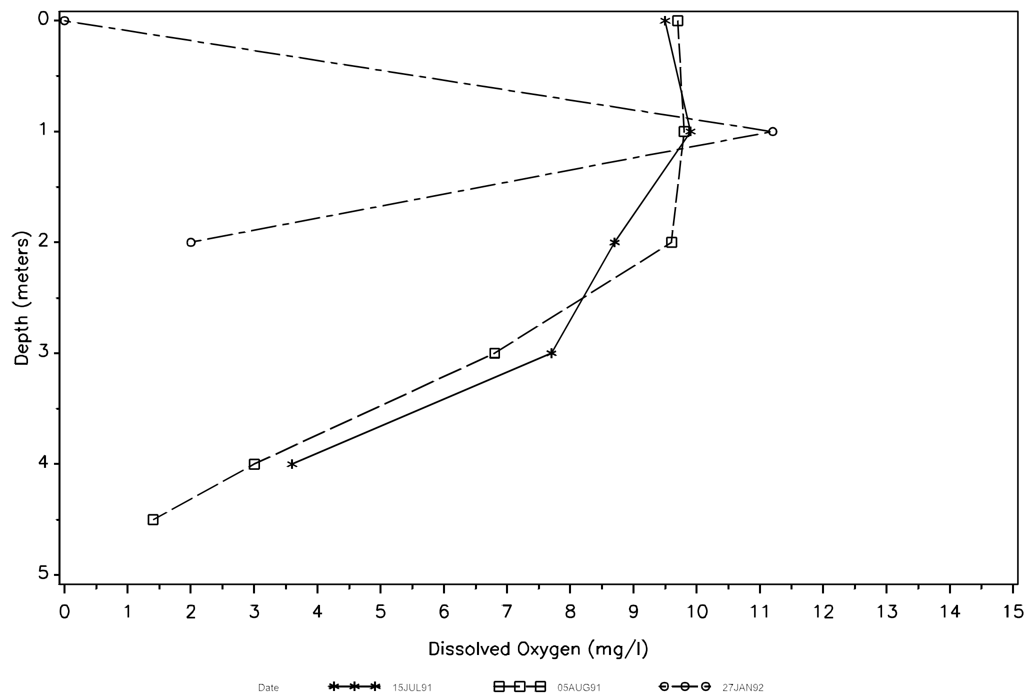

Figure 3. Oxygen profiles for Cedar Lake.

During July of 1991, Cedar Lake thermally stratified between 1 and 2 meters below the lake's surface. In August, thermostratification was not apparent (Figure 2). Dissolved oxygen concentrations at both the sample times were at or near saturation to a depth of 2 to 3 meters and were adequate to maintain aquatic life (Figure 3). Samples collected during January 1992 were inadequate to show if the lake again stratified, as the deepest area was not located. Oxygen concentrations were between 11.2 mg L^{-1} at the surface and 2.0 mg L^{-1} near the bottom (Figure 3).

Aquatic Vegetation

A qualitative survey of the macrophyte (vascular aquatic plant) community was conducted on Cedar Lake as part of the 1991 LWQA project. At the time of the macrophyte survey nearly 60 percent of Cedar Lake's surface area had aquatic vegetation. Macrophyte species identified were sago pondweed (Potamogeton pectinatus), coontail (Ceratophyllum demersum), cattails (Typha spp.), and bulrush (Scirpus spp.). A map depicting the areal coverage of macrophytes on Cedar lake is contained in Appendix B.

Phytoplankton

During the summer of 1991, Cedar Lake's phytoplankton community was sampled two times. Cedar Lake's phytoplankton community at these two times was relatively diverse, with representation from 6 divisions and 36 genera. The largest contributors by density were the blue-green algae, Cyanophyta, with five genera represented. Mean densities of blue-green algae during the summer of 1991 were 174,938 cells mL^{-1}, which is over three times greater than all other divisions combined.

During the summer of 1991, the phytoplankton community by volume changed between sample periods. The order (Cryptophyta) dominated on July 15, 1991, while the order (Bacillariophyta) was dominant on August 8, 1991. The shift in community structure was quite dramatic. The order (Bacillariophyta) represented nearly 50 percent of the total community by volume on August 8, 1991, while on July 15, 1991, none were identified. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Trophic status estimates for Cedar Lake based on secchi disk transparency, surface total phosphorus as P concentrations, and a single chlorophyll-a concentration suggests Cedar Lake is highly eutrophic to hypereutrophic. Summer surface total phosphorate as P concentrations were high ranging between 192 and 318 $\mu g\ L^{-1}$, a single chlorophyll-a concentration and was greater than 23 $\mu g\ L^{-1}$, and secchi disk transparency was between 0.6 and 2.2 meters. Supporting ancillary information of a hypereutrophic to a highly eutrophic condition is a phytoplankton community dominated by blue-green algae species, low dissolved oxygen conditions during ice cover and in the hypolimnion during the summer, historical fish kills, and a large macrophyte biomass.

Sediment Analysis

Sediment samples collected from Cedar Lake show detectable levels of all trace elements tested, except for mercury in sediments collected from the deepest area of the lake. Reported concentrations in the sediments at each sample location within Cedar Lake were compared to the concentrations reported for all lakes sampled in the 1991-1992 LWQA project. In general, reported trace element concentrations from the sediments collected from Cedar Creek were near or above the reported 75th percentile concentrations for all lakes sampled with the exception of copper, zinc, barium and mercury concentrations in the sample collected from the deepest area of the lake and arsenic concentrations in samples collected from the two inlet areas. Copper, zinc, barium and mercury concentrations in the deepest area sampled were at or below the median concentrations for all lakes and the arsenic concentrations for the two inlets samples were less than the 25th percnetile concentration for all inlet area samples collected. Concentrations of selected organic compounds were below detectible limits for all samples collected from Cedar Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Cedar Lake on August 14, 1991. A composite of two northern pike made up the piscivore sample and a composite of five white suckers were used to make the bottom feeder sample.

Trace element concentrations in fish samples collected from Cedar Lake were generally near or slightly below the median concentrations for all fish collected during the 1991 LWQA. The exception was the reported selenium concentration in the northern pike sample, the lead and mercury concentrations in the white sucker sample and the zinc concentrations in both the northern pike and white sucker samples. These parameters were at or greater than the 75th percentiles for all fish sampled in each group.

Detectable pesticide residues found in the composite fish samples collected from Cedar Lake included trifluralin in the white sucker sample and DDE in both the northern pike and white sucker samples. Trifluralin, commonly known as treflan, is a selective, pre-emergent herbicide. Trifluralin has a 96-hour LC50 rating for bluegill of 58 $\mu g\ g^{-1}$ (Johnson & Finley 1980). The 96-hour LC50 refers to the concentration required to kill 50 percent of the study specimens during a 96-hour exposure. DDE is a degenerate by-product of DDT and behaves similarly to the parent compound when available to the environment.

The reported concentration for trifluralin of 0.005 $\mu g\ g^{-1}$ in the white sucker sample collected from Cedar Lake is above the median concentration for all bottom feeders sampled in the 1991 LWQA, but below the 75th percentile. The reported concentration of DDE was 0.004 $mg\ L^{-1}$ was below the 25th percentile for both the white sucker and piscivore samples. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Cedar Lake and its contributing watershed have a combined surface area of 133,000 acres. The dam is located at the confluence of the North Cedar and Cedar Creeks in southeastern Slope County, North Dakota. Slope County is located in the Missouri Slope Upland physiographic region.

Nonpoint source pollution accounts for 100 percent of the nutrient and sediment load to Cedar Lake. Land use within the Cedar Lake watershed is 94 percent agricultural, with 58 percent actively cultivated. The remaining 42 percent is in low density urban development, haylands, pasture and CRP (Table 2).

Table 2. Land use in the Cedar Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	58	20
Pasture land	22	40
Hayland	6	25
CRP	8	100
Wet/Wild[1]	1	100
Other	5	N/A
Farmsteads	105[3]	N/A
Feedlots[2]	39[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number present in watershed.

According to the information provided by the Slope County Soil Conservation District, 20 percent of the cultivated lands and between 25 and 50 percent of all the remaining lands within the Cedar Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Cedar Lake watershed, the average T value is 3 to 5 tons per acre. Based on an average soil loss of 4 to 5 tons per acre, which takes into account the land that is not adequately treated, an estimated 640,136 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent between 64,014 and 96,020 tons of soil reaches Cedar Lake annually. Other sources of nonpoint source pollution discharges to Cedar Lake include concentrated cattle feeding and watering in the immediate upstream drainage and oil exploration.

CLAUSEN SPRINGS

BARNES COUNTY

Peter N. Wax

Clausen Springs is located in the Glaciated Plains in south central Barnes County. Clausen Springs was created in 1967 by damming Spring Creek. This small impoundment of 46.8 acres has a maximum depth of 33 feet and an average depth of 13.4 feet (Figure 1). The immediate area surrounding the reservoir is managed by the county and NDG&F as a campground and game management area, respectively.

Topography of the area is predominantly nearly level to rolling hills with slopes ranging from 0 to 15 percent. A limited amount of the watershed contains hills with valley slopes of up to 35 percent. Soils are well to moderately drained, of medium texture and made up of glacial till. Water and wind erosion is a problem within the cultivated areas of the watershed (Soil survey of Barnes County, North Dakota 1990).

Clausen Springs is classified as a cold water fishery "Waters capable of supporting growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). A fishery was established in Clausen Springs when it was stocked with rainbow trout by the NDG&F in 1968. Subsequent stockings included coho salmon, brown trout and brook trout. These trout stocking were minimally successful. In 1976 Clausen Springs was chemically eradicated to remove undesirable species. Since that time rainbow trout, largemouth bass, walleye and bluegill have been stocked and since 1988 walleye, largemouth bass and channel catfish have been stocked into Clausen Springs. Fish population test netting results for Clausen Springs in 1991 showed a population dominated by small bluegill, black bullhead and white sucker.

Lands surrounding Clausen Springs are owned by the NDG&F. Maintenance of the public facilities is partially provided by the Barnes County Park Board. Public facilities include a boat ramp, campground and swim beach. Currently Clausen Springs is limited to electric motors only and has a slot limit restriction on largemouth bass between the sizes of 8 to 12 inches. Clausen Springs receives heavy use during the spring and moderate use during the winter.

Water Quality

Water quality samples were collected from Clausen Springs twice during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 380691, Figure 1). Water column samples were collected for analysis at three separate depths, surface, middle and bottom.

Thermal stratification of Clausen Springs was observed during both sampling periods in the summer of 1991. On the July 23, 1991, sample date the thermocline occurred at four meters below the lake surface (Figure 2). On August 21, 1991, the thermocline was observed at six meters (Figure 2). Oxygen levels below the thermocline, declined to less than 2 mg L^{-1} during both summer sampling periods (Figure 3).

Thermal stratification was not observed during the winter sampling period on February 12, 1993, however, a significant oxygen reduction occurred between 4 and 5 meters of depth (Figure 2, Figure 3).

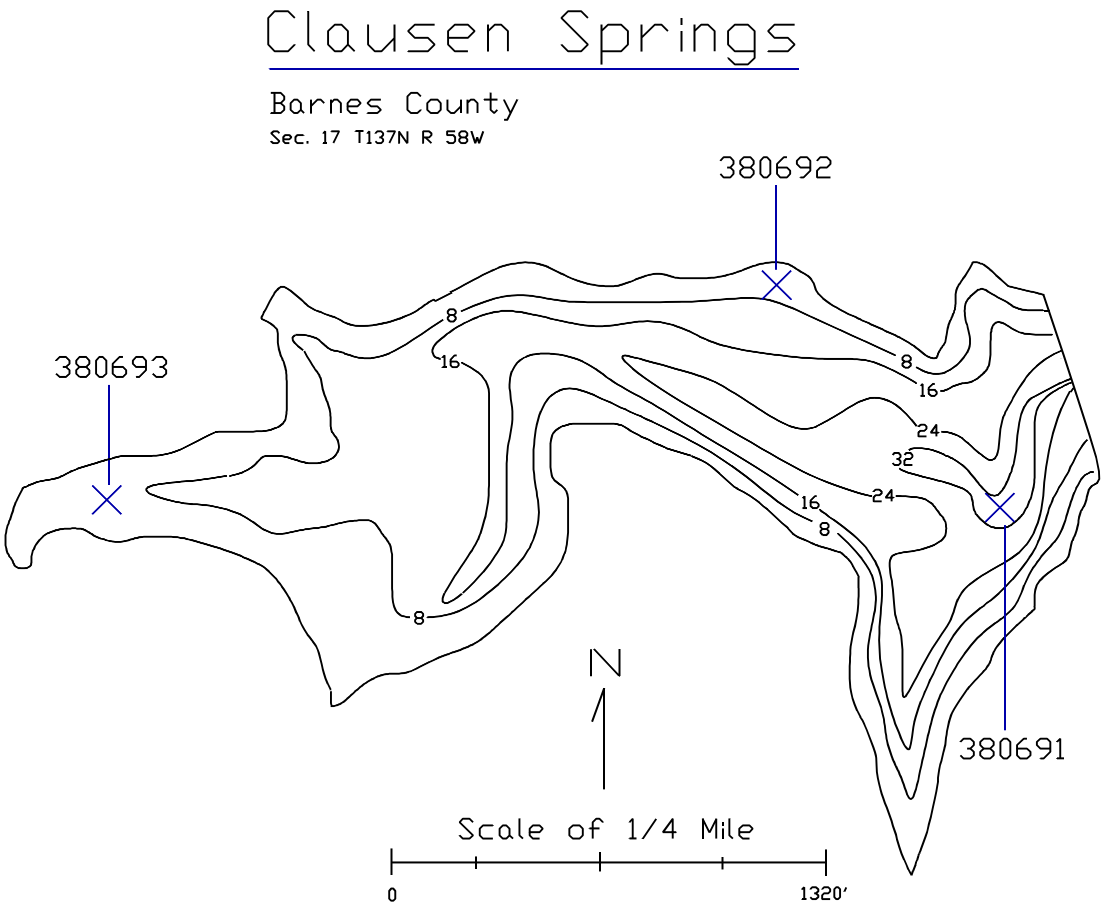

Figure 1. Morphometric map of Clausen Springs.

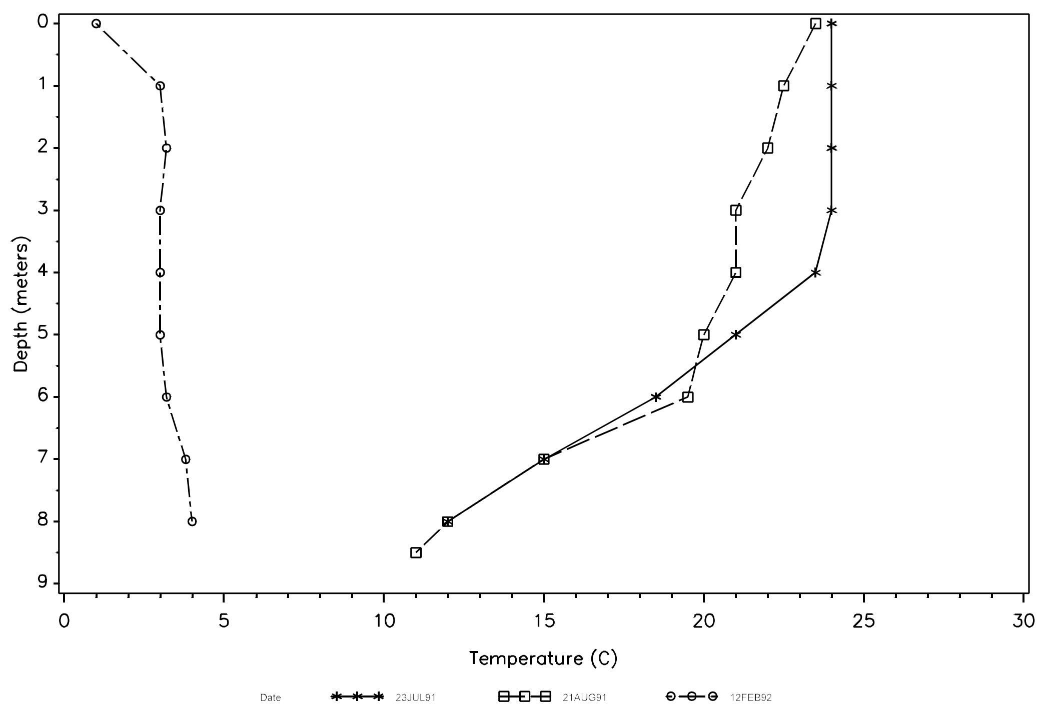

Figure 2. Temperature profile for Clausen Springs.

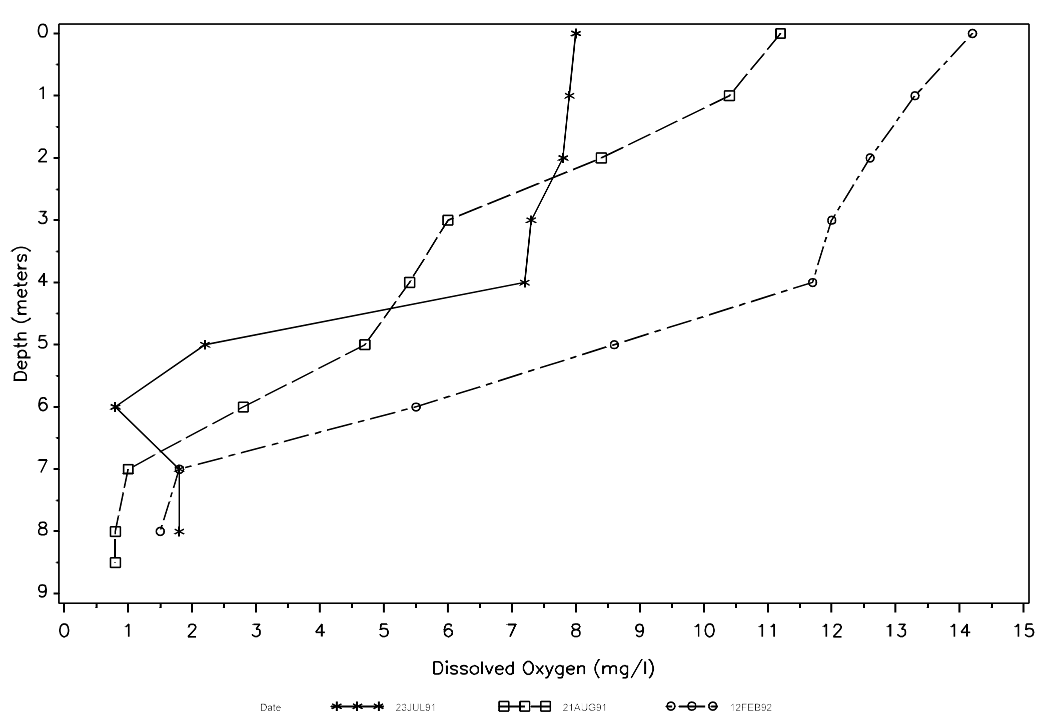

Figure 3. Oxygen profile for Clausen Springs.

Water quality samples collected from Clausen Springs in the summer of 1991 and winter of 1992 as part of the LWQA project describe a well-buffered lake with high concentrations of total dissolved solids and nutrients. The volume-weighted mean concentration of total alkalinity as $CaCO_3$ was 289 mg L^{-1}, total dissolved solids was 566 mg L^{-1}, and total phosphate as P was 0.184 mg L^{-1} (Table 1, Appendix A).

Dissolved oxygen concentrations experienced a rapid decline below the hypolimnion. This along with significant increases in ammonia and total kjeldahl nitrogen indicate internal cycling and an excessive supply of nutrient availability.

Bicarbonate and sulfates were the dominant anions in the water column. The volume-weighted mean bicarbonate concentration was 333 mg L^{-1}, while the sulfates concentration was 149 mg L^{-1} (Table 1, Appendix A). The ratios between total phosphate as P and nitrate + nitrite as N of 2.3:1 suggests Clausen Springs is nitrogen limited. However, under these conditions, primary producers such as some blue-green algae species, which fix free nitrogen are favored. A complete compilation of all LWQA project data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 23, 1991 and February 12, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 to December 31, 1991.

Parameter	Clausen Springs		1982-1991	
Total Dissolved Solids	566	mg L^{-1}	1209	mg L^{-1}
Conductivity	960	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	291	mg L^{-1}	488	mg L^{-1}
Sulfates	149	mg L^{-1}	592	mg L^{-1}
Chloride	52	mg L^{-1}	81.29	mg L^{-1}
Total Phosphate as P	0.184	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.081	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	289	mg L^{-1}	296	mg L^{-1}
Ammonia	0.118	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.23	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	333	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Clausen Springs on August 12, 1991. At the time of the macrophyte survey, nearly 100 percent of the lakes surface area to a depth of 6 feet was covered by aquatic vegetation. Cattails (typha spp.), surrounded most of the shoreline with water milfoil (Myriophyllum spp.), sago pondweed (Potamogeton pectinatus) and coontail (Ceratophyllum demersum) being the dominant submergent macrophytes. American pondweed (Potamogeton americanus) and duckweed (Lemna minor) were present as well. A map depicting the areal extent of the macrophyte community of Clausen Springs is contained in Appendix B.

Phytoplankton

The Clausen Springs phytoplankton community was sampled twice during the summer of 1991. During the two sample periods, Clausen Springs' phytoplankton community was represented by 5 divisions and 20 genera. The largest contributors to the community by density were the green algae, Chlorophyta and the blue-green algae, Cyanophyta. The relatively high density of blue-greens in the lake is indicative of a eutrophic lake condition. While the density of the divisions Bacillariophyta, Cryptophyta, and Pyrrophyta is small in rela-tion to the Chlorophyta, their volume is large. This is due to differences in the size of the algal species among the orders. A complete listing of phytoplankton data is listed in Appendix C.

Trophic Status

Clausen Springs presently is eutrophic. Primary indicators of this condition are the concentrations of total phosphate as P and secchi disk transparencies. Total phosphate as P concentrations during the summer at the lakes surface were 157 and 172 $\mu g\, L^{-1}$ indicating a hypereutrophic lake and secchi disk transparencies of 2.0 and 2.3 meters indicating a eutrophic lake. Other collaborating ancillary information used in the trophic status assessment were low dissolved oxygen conditions below the hypolimnion, yet sufficient oxygen above, no history of fish kills, and a algal community dominated by species other than blue-greens.

Sediment Analysis

Sediment samples were collected from Clausen Springs in the deepest area of the lake (Site 380691) the littoral zone (Site 380692) and the inlet (Site 380693 Figure 1). Sediment samples collected from Clausen Springs showed detectible levels of all trace elements analyzed. When compared to the data for all lakes assessed in the 1991 LWQA project concentrations for Clausen Springs were generally near the median. The exceptions were barium and chromium which were slightly less than the median at all sites and mercury which was slightly greater than the median in the littoral area sample. PCB's and selected pesticides were below detectable limits for all sediment samples collected from Clausen Springs. A complete listing of sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Clausen Springs on June 25, 1991. Two species of fish were collected for contaminant analysis, white sucker represented the bottom feeder group and bluegill represented the insectivores. No predators were collected during the 1991 LWQA project.

In order to evaluate the fish tissue data for Clausen Springs the results for each fish group are compared to that group for all lakes assessed in 1991-1992. Reported trace element concentrations in the fish samples collected from Clausen Springs were near the median concentrations for all trace elements tested. The exceptions were arsenic, selenium and cadmium which were less than the detection limits.

Organic chemical residues detected in the fish samples collected from Clausen Springs included DDD, DDE, BHC, dieldrin, nonachlor, trifluralin, and PCBs. DDD and DDE are degenerate by-products of the insecticide DDT and behave similarly to the parent compound when present in the environment. BHC, commonly known as benzene hexachloride, dieldrin, and nonachlor, an ingredient in technical grade chlordane, are all insecticides which like DDT have been discontinued due to there potential environmental risks. Trifluralin is a pre-emergent herbicide commonly known as treflan. PCBs are generally considered industrial waste. PCBs are commonly used as plasticizers and as dielectric fluids.

The bluegill sample from Clausen Springs was composed of four fish with a mean length of 21.9 centimeters and weight of 241 grams. These fish contain DDE, dieldrin, and trifluralin in reported concentrations of 0.004, 0.002, and 0.003 ug g^{-1}, respectively. In comparison to all other insectivores sampled during the 1991-1992 LWQA project, these concentrations are below the median except for the dieldrin concentration of 0.002 ug g^{-1} which was the highest concentration reported during the 1991-1992 LWQA project.

The composite white sucker sample contained detectable levels of DDD, DDE, BHC, heptachlor, PCBs, nonachlor, and trifluralin. In general, the reported concentrations were above the 75th percentile concentrations reported for all bottom feeders analyzed during the 1991-1992 LWQA project. The exceptions were BHC, which were just slightly above the median and DDD and DDE which were below the reported median concentrations for all bottom feeders. A complete listing of the whole fish analysis data is contained in Appendix E.

Watershed

The Clausen Springs watershed encompasses just over 55,000 acres in the Sheyenne River basin located in the southwest corner of Barnes County, North Dakota. The topography of the land is level to rolling hills with moderately well drained soils made up of glacial till. Nonpoint source pollution accounts for all the nutrient loading and pollution discharges to the lake.
Land use within the Clausen Springs watershed is 80 percent agricultural with 71 percent in crop production. The remaining 20 percent is in Conservation Reserve Program acreage, wildlife, wetland and wooded acres (Table 2). According to the information provided by the Barnes County Soil Conservation District 70 percent of the cropland is "adequately treated" against soil loss. It should be noted that "adequately treated" still allows soil erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

The estimated soil loss value for the Clausen Spring watershed is 3.9 tons per acre. This estimate results in just under 214,000 tons of soil lost per year. Assuming a conservative delivery rate to Clausen Springs of 10 to 15 percent, approximately 21,000 to 32,000 tons of soil reaches Clausen Springs annually. Also present in the watershed are 10 concentrated livestock areas which are only 50 percent adequately treated. Many of these areas are located close to the waterbody and pose an increased potential for additions of nutrient and pollution loading.

Table 2. Land use in the Clausen Springs Watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	71	70
Rangeland	3	100
Hayland	6	100
CRP	14	100
Wet/Wild[1]	4	100
Woodland	1	100
Other	1	N/A
Farmsteads	32	N/A
Feedlots[2]	10	50

[1] Wet/Wild are wildlife management areas, wetlands and lakes.
[2] Feedlots are areas where livestock are concentrated to be fed.

CROOKED LAKE

MCLEAN COUNTY

Peter N. Wax

Crooked Lake is a natural glacial lake located in northeastern McLean County, North Dakota on the Missouri Coteau physiographic region. It is the last lake in a chain of four lakes (Figure 1). Crooked lake is a relatively shallow lake, with a maximum depth of 15 feet and an average depth of just over nine feet (Figure 2).

Crooked Lake's watershed is composed of many small hills, valleys and potholes. Soils are mostly well drained to well drained, formed from sandy, rocky glacial material. The watershed is predominantly integrated drainages typifying the characteristics of the northern prairie pothole region.

Crooked Lake is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). Crooked Lake is managed by the NDG&F through annual assessments of the fish community with test netting, fish stockings and habitat manipulations.

In recent years stockings have included northern pike, walleye, bluegill, smallmouth bass and fathead minnows. Test netting operations conducted in 1991 showed good populations of walleye, yellow perch and northern pike. Other fish species captured included white suckers, brook sticklebacks and channel catfish.

Crooked Lake's fishery periodically experiences winterkills caused by fluctuating water levels and fish migrations into Long Lake. Gabbian barriers have been constructed at the inlet to Crooked to prevent fish migration, however little can be done to prevent the fluctuations in water level. At the time of the 1991-1992 assessment, Crooked Lake was between 4 and 5 feet below full pool.

The local community takes an active interest in Crooked Lake as evident by the gabbian barriers, fish screens and snow removal attempts made in the past. Recreational use on Crooked Lake is moderate to heavy. Public access is good. Public facilities include three boat ramps, associated parking and vault toilets at the north end of the lake.

Water Quality

Water quality samples were collected from Crooked Lake two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381030, Figure 2). Water column samples were collected for analysis at three separate depths, 1 meter, 1.5 meters and three meters, in July and August, 1991 and at 0.5 meters, 1 meter, 3 meters in January 1992.

During 1991 and 1992, Crooked Lake did not thermally stratify (Figure 3). Dissolved oxygen concentrations at both these sampling periods were at or near saturation to a depth of 2 meters and were adequate to maintain most aquatic life (Figure 4).

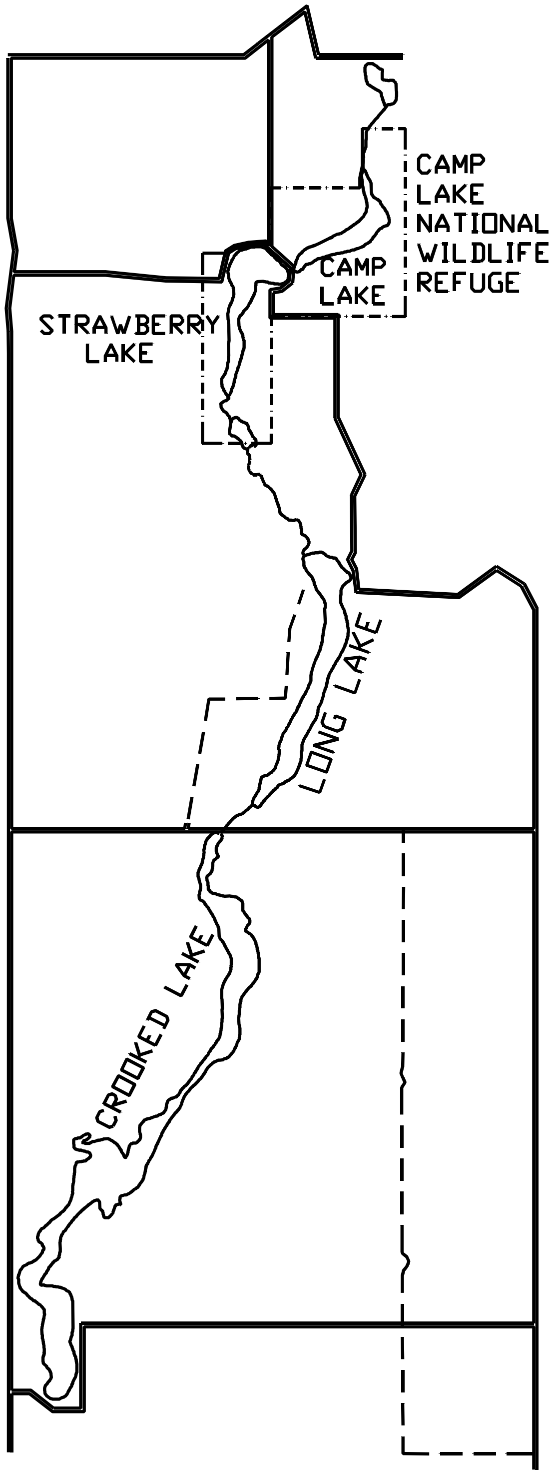

Figure 1. Map depicting the location of Crooked lake in relation to the ent
chain.

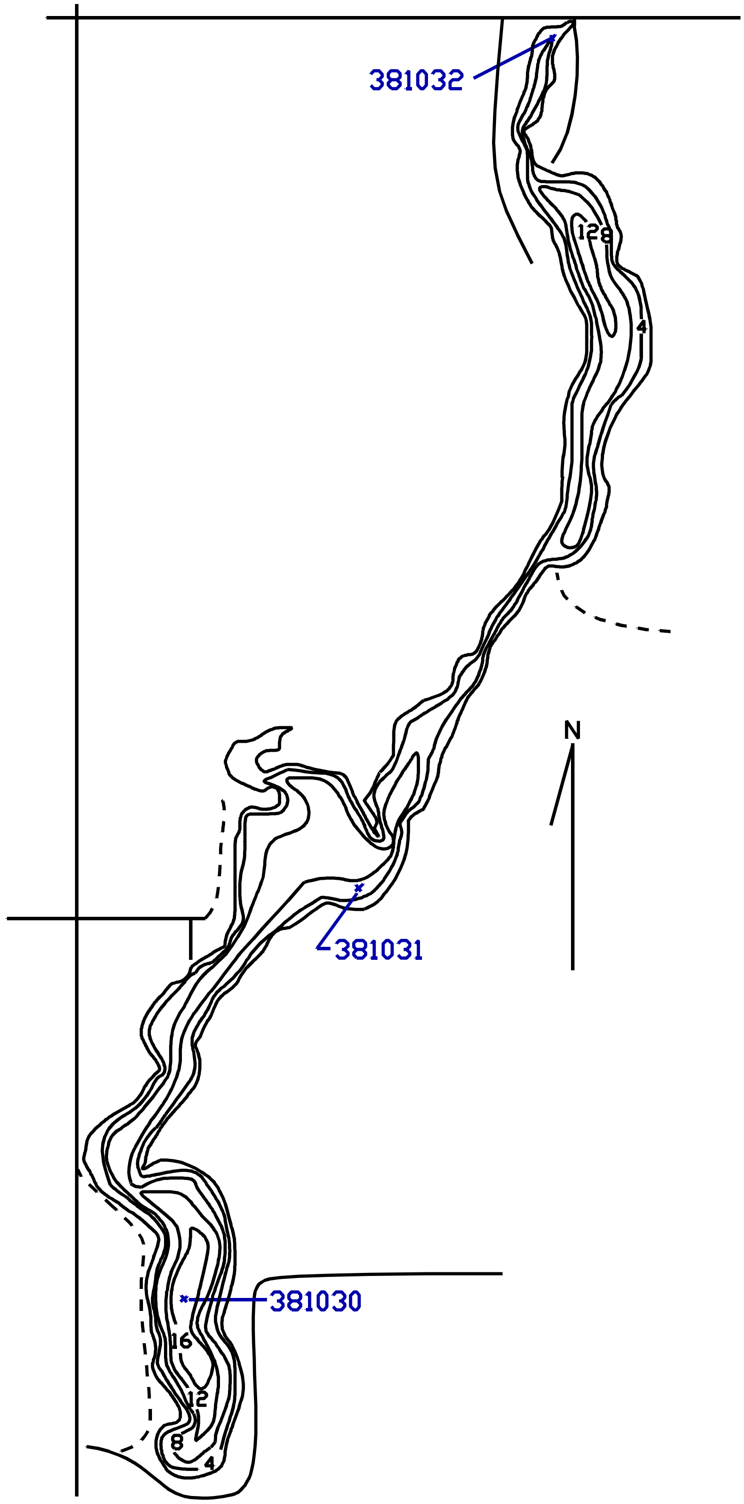

Figure 2. Morphometric map of Crooked Lake, McLean County.

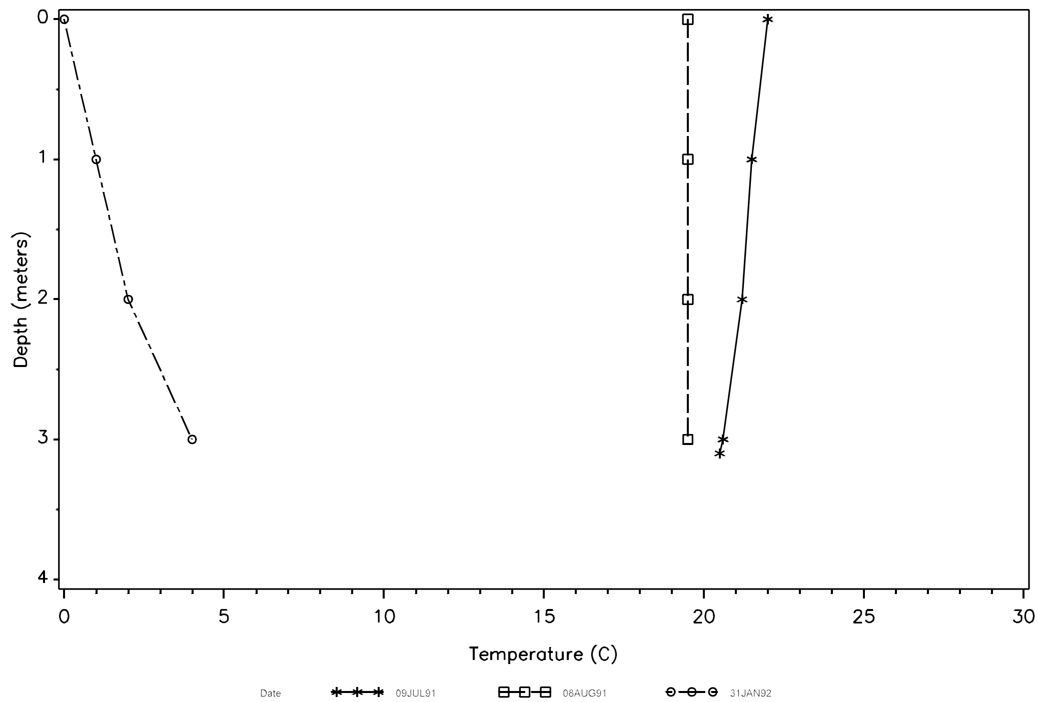

Figure 3. Crooked Lake temperature profiles for July and August, 1991 and January, 1992.

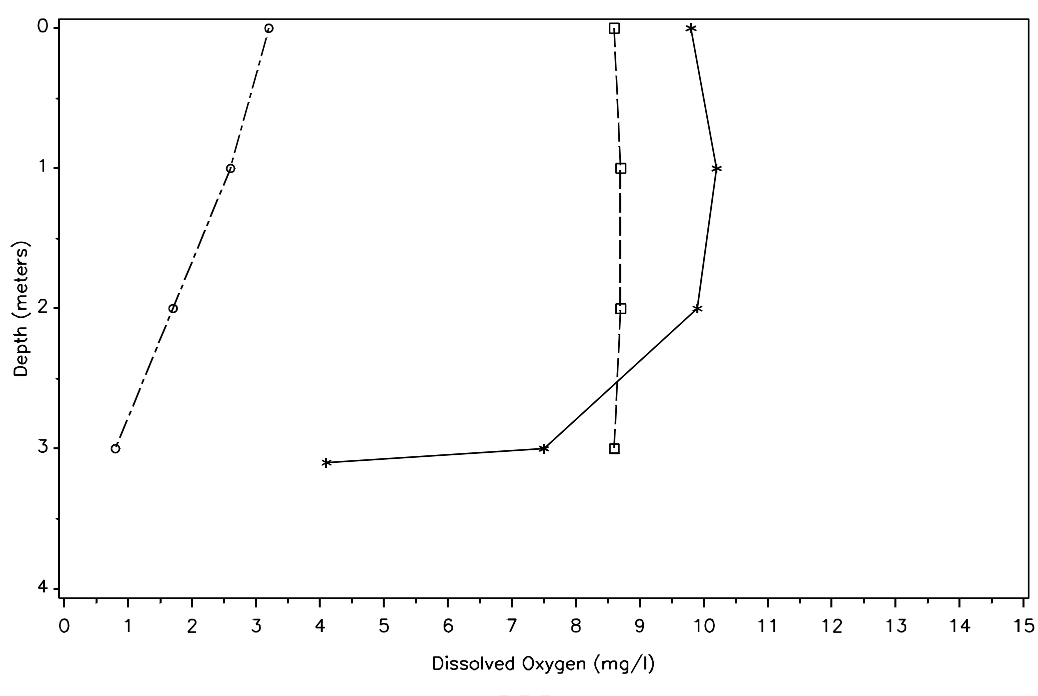

Figure 4. Crooked Lake dissolved oxygen profiles for July and August, 1991 and January, 1992.

Samples collected during January 1992 again showed no thermal stratification. Dissolved oxygen concentrations ranged from 3.2 mg L^{-1} at the surface to 0.8 mg L^{-1} near the bottom. Crooked Lake is a extremely well-buffered waterbody with a volume-weighted mean total alkalinity as $CaCO_3$ concentration of 858 mg L^{-1}. Bicarbonates and sulfates were the dominant anions, with volume-weighted concentrations of 542 mg L^{-1} and 385 mg L^{-1}, respectively, followed by chlorides at 28.1 mg L^{-1}. The volume-weighted mean total hardness as calcium concentration was 790 mg L^{-1}, total alkalinity was 858 mg L^{-1}, and total dissolved solids 1,321 mg L^{-1}, describing a lake with relatively hard water when compared with most lakes statewide (Table 1). The average volume-weighted mean total phosphorus as P concentration of 0.100 mg L^{-1} and exceeded the state's target concentrations of 0.02 mg L^{-1} on all occasions sampled. A complete list of water quality sample data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled on July 9 and August 8, 1991 and January 31, 1992 and long-term averages from all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Crooked Lake		1982-1991	
Total Dissolved Solids	1321	mg L^{-1}	1209	mg L^{-1}
Conductivity	1921	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	790	mg L^{-1}	488	mg L^{-1}
Sulfate	385	mg L^{-1}	592	mg L^{-1}
Chloride	28.1	mg L^{-1}	81	mg L^{-1}
Total phosphate as P	0.100	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.008	mg L^{-1}	0.069	mg L^{-1}
Total Kjeldahl Nitrogen	4.18	mg L^{-1}	2.34	mg L^{-1}
Ammonia	0.37	mg L^{-1}	0.326	mg L^{-1}
Bicarbonate	542	mg L^{-1}	326	mg L^{-1}
Total Alkalinity	858	mg L^{-1}	296	mg L^{-1}

Phytoplankton

Crooked Lake's phytoplankton community was sampled concurrently with the water quality samples on July 9 and August 8, 1991.

As reflected by these two samples, Crooked Lake's phytoplankton community had representation from 5 divisions and 52 genera. The largest contributors by density were the blue-green algae Cyanophyta with 20 genera represented. Blue-green algae mean densities during the summer of 1991 were 426,995 cells mL^{-1}, which is greater than 8 times all other divisions combined.

During the summer of 1991, the phytoplankton community by volume fluctuated with the division Bacillariophyta being dominant on July 9, 1991, being replaced by the division Cyanophyta on August 8, 1991. The shift in community structure was quite dramatic, as the division Bacillariophyta on July 9, 1991, represented nearly 75 percent of the total phytoplankton community by volume, while on August 8, 1991 it represented less then 8 percent. A complete listing of phytoplankton data is contained in Appendix C.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Crooked Lake on August 8, 1991. At the time of the macrophyte survey nearly 100 percent of Crooked Lake's surface area had aquatic vegetation. The main portion of the lake had solid stands of sago pondweed (Potamogeton pectinatus). In the northern region of the lake there was a mixture of sago pondweed (Potamogeton pectinatus) and water milfoil (Myriophyllum spp.). The edges of the lake had intermittent stands of cattails (Typha spp.) and bulrush (Scirpus spp.). A map depicting the macrophyte community and areal coverage is contained in Appendix B.

Trophic Status

Trophic status assessment data collected during the summer of 1991 suggest that Crooked Lake is hypereutrophic. This assessment is primarily based on high concentrations of total phosphate as P, Chlorophyll-a, and low secchi disk trans-parency readings. Total phosphate as P concentrations ranged from 93 to 105 $\mu g\ L^{-1}$, Chlorophyll-a ranged from 14 to 71 $\mu g\ L^{-1}$ and secchi disk transparency depth was constant at 0.8 meters. Supporting ancillary information was a large macrophyte biomass, frequent algal blooms, dissolved oxygen deficiencies under ice cover conditions, and a history of fish kills.

Sediment Analysis

Sediments were collected from Crooked Lake and analyzed for trace elements, PCBs, and selected pesticides. Sediments were collected from the deepest area of the lake (Site 381030), the littoral zone (Site 381031), and the inlet (Site 381032)(Figure 1).

Sediment samples collected from Crooked Lake showed detectable levels of all trace elements tested for except mercury. Trace element concentrations in the sediments at each sample location within Crooked Lake were also compared to the data for all lakes assessed in the 1991 LWQA project. Reported trace element concentrations were generally below the median concentrations for all lakes sampled. The exceptions were the reported arsenic and chromium concentrations in the sediments collected from the deepest area of the lake which were near or above the 75th percentile of all sediment samples collected from the areas of lakes in 1991-1992. Concentrations of selected organic compounds were below detectible limits for all samples collected from Crooked Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Crooked Lake on May 21, 1991. Walleye and white suckers were collected for analysis. The walleye sample representing the piscivore group, was composed of five fish with a mean weight of 1302 grams and a mean length of 53 centimeters. The white sucker sample, representing the bottom feeder group, was composed of five fish with a mean weight of 1580 grams and a mean length of 50.5 centimeters.

In order to evaluate the fish tissue data for Crooked Lake, the results of each group was compared to data for that group of fish for all lakes assessed in the 1991 LWQA project.

Results for the piscivore showed reported trace element concentrations of copper, zinc, arsenic cadmium and lead were all near or below the reported median for all piscivores sampled during the 1991 LWQA project. The reported concentrations of chromium, selenium and mercury were all above reported median concentrations while the reported concentration of barium exceeded the reported 75th percentile by two-fold.

Reported concentrations of trace elements in the white sucker sample collected from Crooked Lake were generally below the reported median concentration for all bottom feeders collected during the 1991 LWQA project. The exceptions were zinc and chromium concentrations which were at or above the 75th percentile for all fish samples collected.

Detectable pesticide residues in the white sucker and walleye samples col-lected from Crooked Lake were limited to DDE. DDE is a degenerate by-product of DDT. DDE behave similarly to the parent compound in the environment. The reported DDE concentrations of 0.006 μg^{-1} for the white sucker sample and 0.007 $\mu g\ g^{-1}$ for the walleye sample are below the median concentration for all lakes sampled in the 1991 LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Crooked Lake's contributing watershed covers a surface area of 7960 acres. It is located at the bottom of a series of four lakes in the Missouri River basin. Topography of the watershed is gently rolling to hilly. Soils are mostly well to excessively well drained, formed from sandy, rocky glacial material. The watershed is predominately integrated drainages typifying the characteristics of the northern prairie pothole region. Nonpoint source pollution from agricultural fields and low density development accounts for nearly 100 percent of the nutrient and sediment loadings to Crooked Lake.

Land use within the Crooked Lake watershed is 45 percent cropland. The remaining 55 percent is in low density urban development, haylands, pasture, and conservation reserve (CRP) acreage (Table 2). According to the information provided by the McLean County Soil Conservation District, 60 percent of the cultivated lands and between 85 and 100 percent of all the remaining lands within the Crooked Lake watershed are "adequately treated" against soil loss.

It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve soil loss tolerant (T). It is estimated that within the Crooked Lake watershed the average "T" value is 3 to 5 tons per acre.

Based on an average soil loss of 2 to 3 tons per acre, approximately 30,420 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent between 3,042 and 4,563 tons of soil reaches Crooked Lake annually. Other sources of nonpoint source pollution discharges to Crooked Lake include concentrated cattle feeding and watering in the immediate upstream drainage, irrigation and cabin development.

Table 2. Land use in the Crooked Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	45	60
Rangeland	31	85
Hayland	0	N/A
CRP	15	100
Wet/Wild[1]	8	100
Other	1	N/A
Farmsteads	5[3]	N/A
Feedlots[2]	2[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number present in watershed.

EPPING-SPRINGBROOK DAM

WILLIAMS COUNTY

Peter N. Wax

Epping-Springbrook Dam is located in the Missouri Coteau physiographic region in south central Williams County. According to State Water Commission files, original construction was completed in 1936 by the Works Progress Administration. Several major and minor repairs occurred in the following years to the spillway and chute structures. In 1976 the spillway was in immediate need of repair or replacement. Three alternatives were drafted to remedy the situation, but due to insufficient funds to secure lands surrounding the reservoir for public use no work was performed.

On June 14, 1978, representatives from the Corps of Engineers and State Water Commission conducted inspections of the Dam and further recommended the emergency spillway be replaced, embankment height raised and to periodically inspect and monitor seepage areas. In late April of the following year, high runoff volumes nearly washed out and completely undermined the spillway structure. As a result, the Corps of Engineers and State Water Commission informed the Williams County Water Management Board that immediate action had to be taken to lower the reservoir level. By mid-May two pumps were used to lower the level of the reservoir in hopes this action would exceed inflow. Pumping continued for two weeks, but lowering the reservoir to a safe level was unsuccessful. On May 29, 1979 breaching operations began on the site. By June 1, the reservoir had been lowered to a level which no longer posed a threat to life and property downstream.

In October 1979, the State Water Commission informed the Williams County Water Management Board that acquisition of approximately 180 acres was needed for project development and dam rebuilding. Costs of the project were estimated at $510,000. Shortly thereafter the decision was made to build a chute-bridge combination which included a low level drain replacing the damaged spillway and constructing a new bridge which met 1980 highway standards. Construction started on June 16, 1980 and was completed and by October 21, 1980.

The reservoir now covers approximately 150 acres with an average depth of 14.5 feet and maximum depth of 34 feet (Figure 1). Epping-Springbrook Dam is classified as a cool water fishery "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The ability of the lake to support a fishery is affected by annual variations in climate or other natural occurrences which alter the lake's characteristics (e.g., depth, volume). The NDG&F currently stock northern pike, walleye, bluegill and largemouth bass.

Test netting conducted by the NDG&F in 1991 showed low numbers of walleye, northern pike and black bullhead . Bluegill, white sucker and small yellow perch were the dominant species. Historical reports indicate Epping-Springbrook Dam was eradicated in 1964 to reduce large carp, bullhead and white sucker populations. Trout were then stocked the following spring but winter-kills were reported the following 3 years. In 1969 eight to ten inch rainbows were reportedly taken frequently.

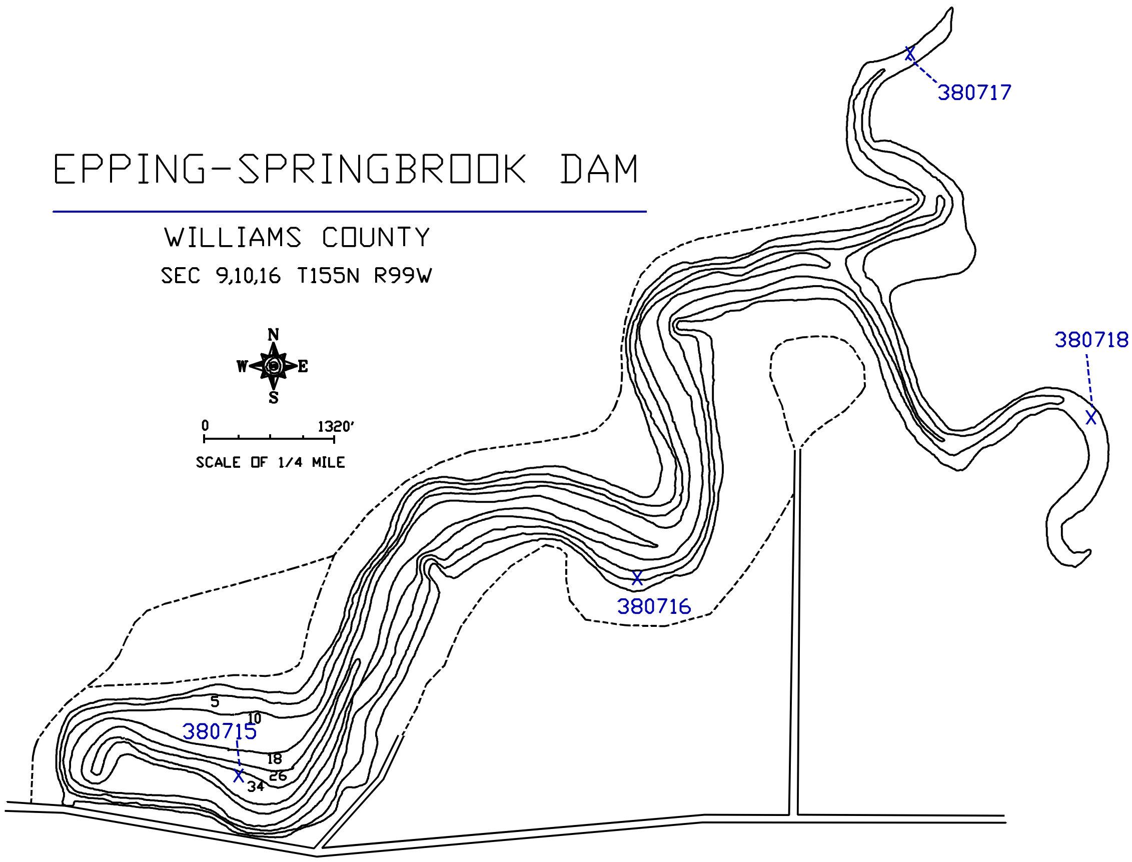

Figure 1. Morphometric map of Epping-Springbrook Dam.

The shoreline surrounding Epping-Springbrook Dam is approximately 80 to 90 percent in public use area. The remaining lands belong to a church camp and to private landowners located near the northern end of the reservoir. Angler use is moderate with good access through an established recreation area including a boat ramp, picnic areas, swim beach, toilets and fishing piers.

Water Quality

Water quality samples were collected from Epping-Springbrook Dam twice during the summer of 1991 and once during the winter of 1992. Samples were collected from one sample site located in the deepest area of the lake (Site 380715, Figure 1). Water column samples were collected for analysis at three separate depths, surface, middle and bottom.

Thermal stratification was not observed in Epping Spring-brook Dam at any time during the summer or winter sample periods (Figure 2). The gradual decline in temperature during the summer or increase in the winter does not indicate thermocline. Dissolved oxygen levels are adequate in Epping-Springbrook Dam to support fish or any other aquatic biota except at the lower depths during the summer months where levels approached 1 mg L^{-1} (Figure 3).

Epping-Springbrook Dam is a well-buffered waterbody. The average volume-weighted total alkalinity as $CaCO_3$ concentration of 346 mg L^{-1} (Table 1, Appendix A). Total phosphate as P concentrations are also high as compared to other North Dakota lakes (Table 1). Samples collected during 1991-1992 showed concentrations between 0.558 to 0.884 mg L^{-1}.

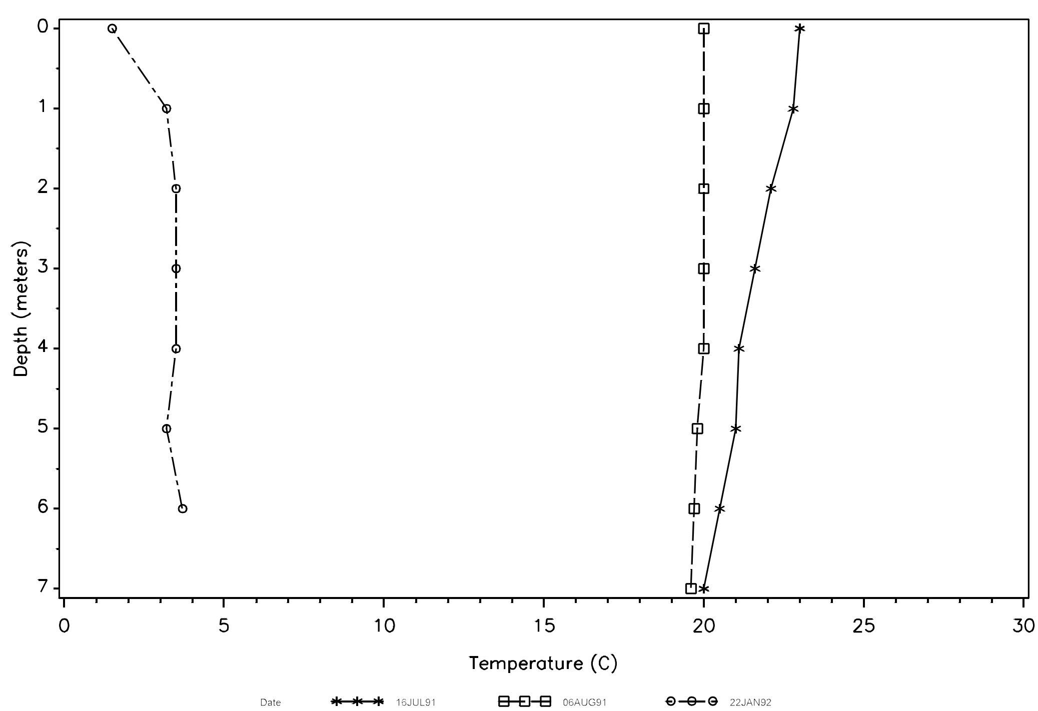

Figure 2. Temperature profile for Epping-Springbrook dam.

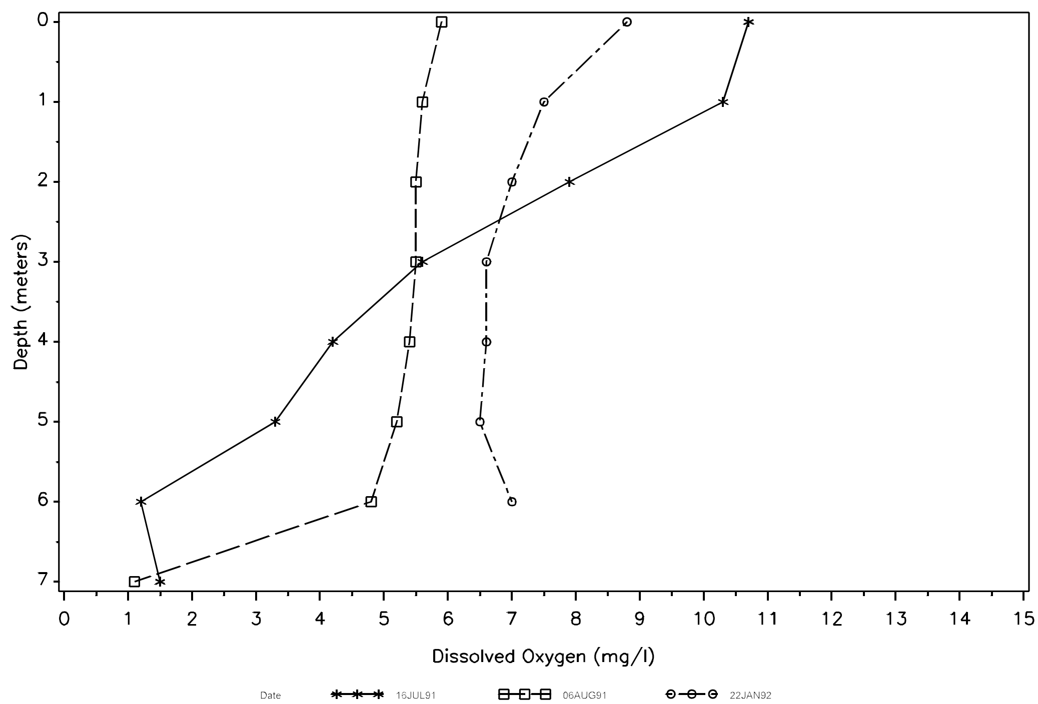

Figure 3. Oxygen profile for Epping-Springbrook Dam.

Bicarbonate and sulfates were the dominant anions in the water column with average volume-weighted mean concentrations of 315 and 323 mg L^{-1}, respectively (Table 1). The total phosphate as P and nitrate + nitrite as N ratio of 27.2:1 suggest Epping-Springbrook Dam is nitrogen limited. However, as in most North Dakota waters, Epping-Springbrook Dam can be best described as having an overabundance of phosphorus. A compilation of all LWQA project data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 16, 1991 and January 22, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 to December 31, 1991.

Parameter	Epping-Spring Brook Dam		1982-1991	
Total Dissolved Solids	797	mg L^{-1}	1209	mg L^{-1}
Conductivity	1179	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	410	mg L^{-1}	488	mg L^{-1}
Sulfates	323	mg L^{-1}	592	mg L^{-1}
Chloride	11.0	mg L^{-1}	81	mg L^{-1}
Total phosphate as P	0.681	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.025	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	346	mg L^{-1}	296	mg L^{-1}
Ammonia	0.361	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.73	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	315	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Epping-Springbrook Dam on August 6, 1991. At the time of the macrophyte survey, approximately 40 percent of the surface area was covered with aquatic vegetation. Sago pondweed (Potamogeton pectinatus) and Curly leaf pondweed (Potamogeton crispus) were the dominant macrophyte species present in the lower two-thirds of the reservoir (Appendix B) and were present to a depth of five feet. Elodea (Elodea canadensis) and water milfoil (Myriophyllum spp.) were the dominant macrophyte in the upper one-third of the reservoir. A map showing the areal extent of the macrophyte community is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled twice during the summer of 1991. During these sample periods, Epping-Springbrook Dam's phytoplankton community was represented by 4 divisions and 11 genera. The largest contributors to the community by density were the blue-green algae, Cyanophyta, with a mean density of 81,376 cells mL^{-1}, this density is 60 times greater than all other algal species combined.

The phytoplankton community as expressed by volume also showed a dominance by the blue-green algae. The density of blue-green algae by volume was more than 3.5 times greater than all other species combined. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Lake water quality assessment data collected during the summer of 1991 combined with present and historic ancillary data indicate Epping-Springbrook Dam is hypereutrophic. While chlorophyll-a concentrations and secchi disk transparency measurements suggest Epping-Springbrook Dam is eutrophic, total phosphorous concentrations suggest it is hypereutrophic. When these assessments are combined with ancillary information such as a phytoplankton community dominated by blue-green algae, anoxic conditions present in the water column, a large macrophytes biomass, and a history of fish kills, overwhelmingly support a hypereutrophic trophic status assessment for the reservoir.

Sediment Analysis

Sediments were collected from Epping-Springbrook Dam and analyzed for trace elements, PCB's and selected pesticides. Sediment samples were collected in the deepest area of the lake (Site 380715, Figure 1) the littoral zone (Site 380716, Figure 1) and at the two inlets (Site 380717, 380718, Figure 1).

Sediment samples collected from Epping-Springbrook Dam showed detectable levels of all trace elements with the exception of mercury in the littoral and inlet area sediments. PCB's and pesticides were not detected in any of the sediment samples collected from Epping-Springbrook Dam. Mercury was present in detectable concentrations in the sample collected from the deepest areas of the lake.

When sediment sample results for Epping-Springbrook Dam were compared to the results for all lakes assessed in 1991-1992 each area displays variable trends. In general the reported trace element concentrations in the littoral and inlet area samples were equal to or above the 75th percentile, while only chromium and arsenic were near the 75th percentile in the deepest area sample. Both inlets were very similar in trace element concentrations although inlet no. 2 (Stoney Creek) displayed slightly greater concentrations as compared to inlet no. 1. A compilation of all sediment data is contained in Appendix D.

Whole Fish Analysis

Fish were collected from Epping-Springbrook Dam for contaminant analysis on June 25, 1991. Three samples composed of two fish species were collected for contaminant analysis. The walleye samples represented the piscivore group and white sucker represented the bottom feeder group. The piscivore group was split into two different samples because of the size difference among fish collected. In order to evaluate the fish tissue data for Epping-Springbrook Dam the results for each fish group were compared to that group for all lakes assessed in 1991.

Trace element concentrations were below the median concentrations reported for all groups except mercury in the piscivore group. The mercury concentration in the piscivore sample containing the larger fish was greater than the fish consumption advisory level for the state. The other piscivore sample was also very near this level. Further investigation and testing of fish tissues is needed from Epping-Springbrook Dam to determine the levels of mercury in the fillets of fish and to determine whether or not these fish should be added to the fish consumption advisory for the state. A compilation of the whole fish analysis data for Epping-Springbrook Dam is contained in Appendix E.

Watershed

The Epping-Springbrook Dam watershed encompasses approximately 45,000 acres in south central Williams County. Nonpoint source pollution accounts for all the nutrient loading and pollution discharges to the reservoir.

Land use within the watershed is 99 percent agricultural with 92 percent actively cropped. The remaining one percent not used for agricultural includes areas used for farms and roads (Table 2). There are approximately eight concentrated livestock feeding areas in the watershed. These areas though small in comparison to the total watershed are possible the largest local source of nutrients.

According to information provided by the Williams County Soil Conservation District, 50 percent of the cultivated lands and 70 percent of the range lands are "adequately treated" against soil loss. It should noted that "adequately treated" still allows soil erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that the average "T" value in the watershed is less than 5 tons per acre per year. Soil loss in the watershed is estimated to be 242,622 tons of soil annually. This is approximately 5.7 tons per acre soil loss per year. Assuming a conservative delivery rate of 10 to 15 percent, it is estimated that between 24,000 and 36,000 tons of soil reaches Epping-Springbrook Dam annually.

The main tributary to Epping Springbrook Dam, Stoney Creek, enters the reservoir from the east. Approximately three miles upstream a small irrigation impoundment is located on the creek. This reservoir is beneficial to Epping-Springbrook Dam by providing a sediment trap for a portion of the watershed. Another tributary entering Stoney Creek below the irrigation impoundment drains a majority of the watershed. This tributary is a significant source of sediments and nutrients to Epping-Springbrook Dam undermining the benefits the small dam provides.

Table 2. Land use in the Epping-Springbrook Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	92	50
Rangeland	6	70
Hayland	1	100
CRP	0	100
Wet/Wild[1]	0	100
Other	1	NA
Farmsteads	23[3]	NA
Feedlots[2]	8[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

GREEN LAKE

MCINTOSH COUNTY

Peter N. Wax

Green Lake is located in the Missouri Coteau in central McIntosh County. Green Lake is a natural lake enhanced with a small rolled earthen dam with a steel sheet pile weir outlet control structure. Overflows eroded the dam during the wet years of 1965 and 1966, at which time culverts were installed. These culverts produced maintenance problems and in 1973 a weir was placed on the outlet.

Green Lake is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota", (NDSDHCL, 1991). The capability of the lake to support a fishery is affected by annual climatic variations or other natural occurrences which may alter the lake characteristics (e.g., depths, volume).

The first introduction of walleye to Green Lake occurred in 1982. Recently the NDG&F have stocked walleye, northern pike, and yellow perch. Past lake reports indicate a marginal fishery due to fish kills and overabundant populations of black bullheads, white suckers and yellow perch. In 1977-1978 a major winterkill occurred reducing the nongame fish population signifi-cantly. The following years, recruitment of walleye and northern pike was very successful. NDG&F catch records for 1991 indicate good numbers of walleye and northern pike and angler success has been reported as moderate to excellent. Access to Green Lake is good through Doyle Memorial Park. Facilities include a boat ramp, picnic area, toilets and a fishing pier.

Water Quality

Water quality samples were collected from Green Lake twice during the summer of 1991 and once during the winter of 1991-1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381045, Figure 1). Green Lake is a very well-buffered lake with a average volume-weighted mean total alkalinity as $CaCO_3$ concentration of 443 mg L^{-1} (Table 1). The dominant anions were bicarbonates and sulfates. Bicarbonate concentrations in the water ranged from 184 to 1020 mg L^{-1} and sulfates ranged from 315 to 733 mg L^{-1}.

Nutrient concentrations in Green Lake are high. Average volume-weighted mean total phosphate as P and total kjeldahl nitrogen concentrations were 0.707 and 5.06 mg L^{-1}, respectively. The ratio between total phosphate as P and nitrate + nitrite as N concentrations of 13:1 suggests Green Lake is nitrogen limited. As in most North Dakota waterbodies, true nitrogen limitation is not present on Green Lake, rather it can more accurately be described as having an overabundance of phosphorus. A complete list of all LWQA project water quality data is contained in Appendix A.

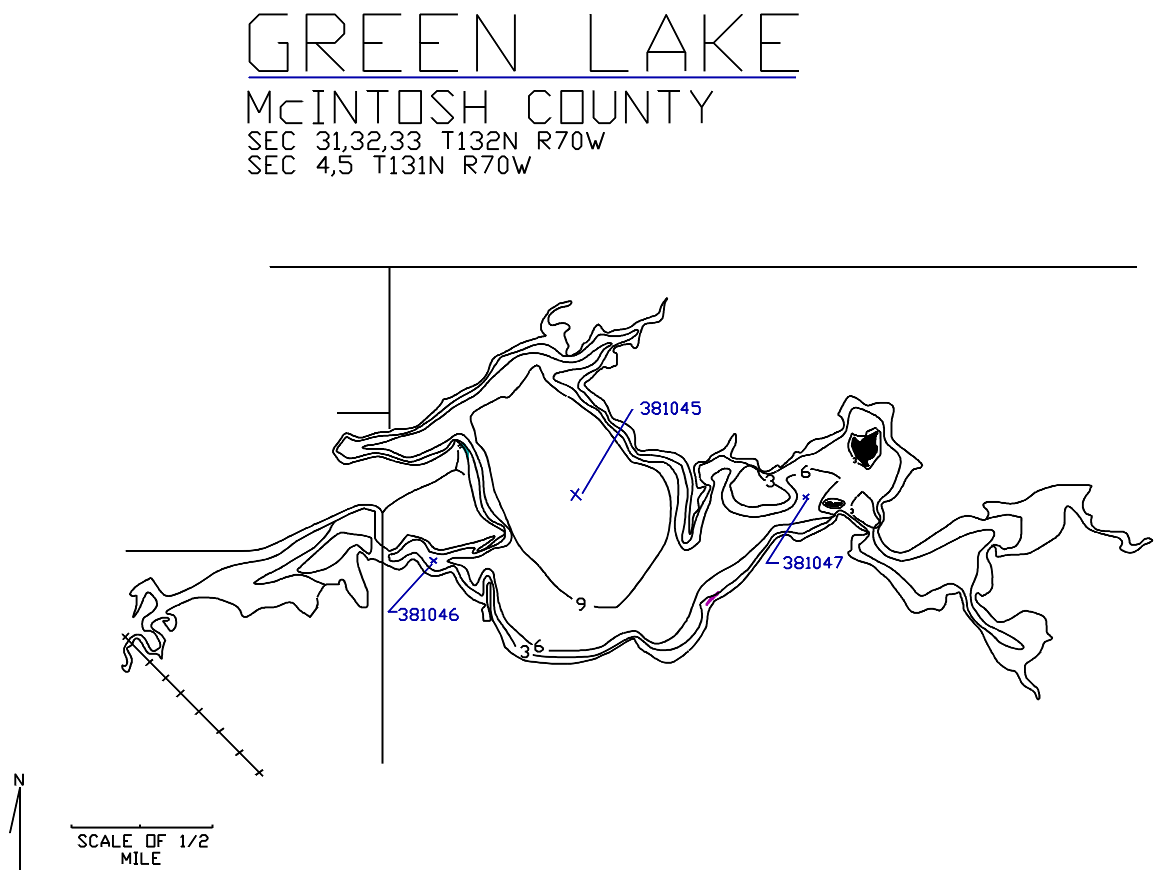

Figure 34. Morphometric map of Green Lake.

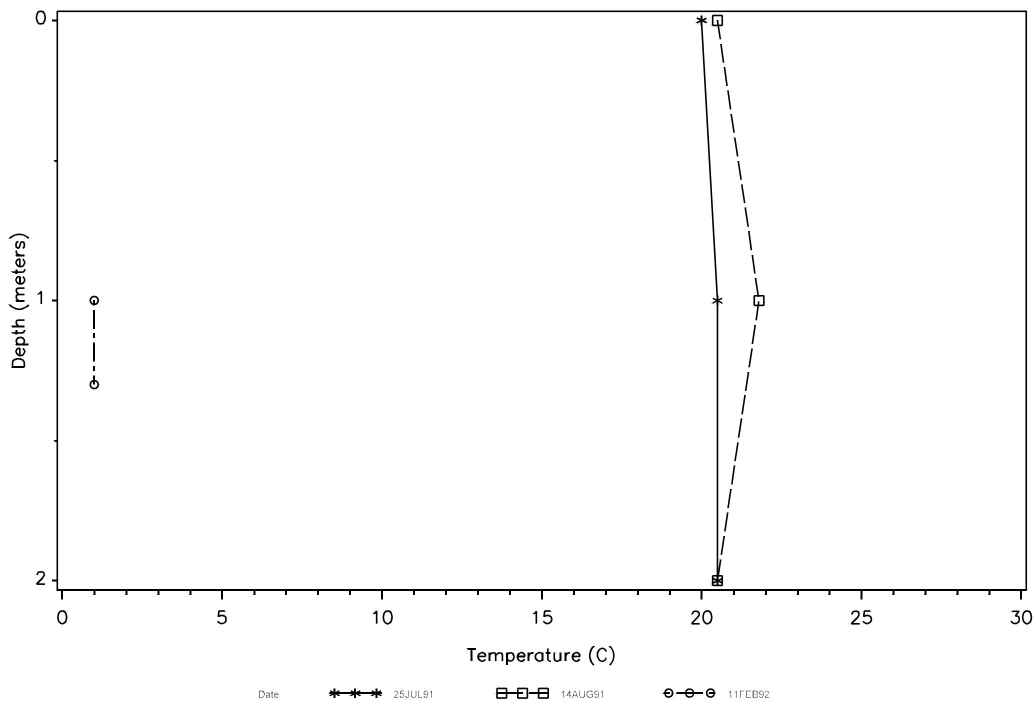

Figure 2. Temperature profile for Green Lake.

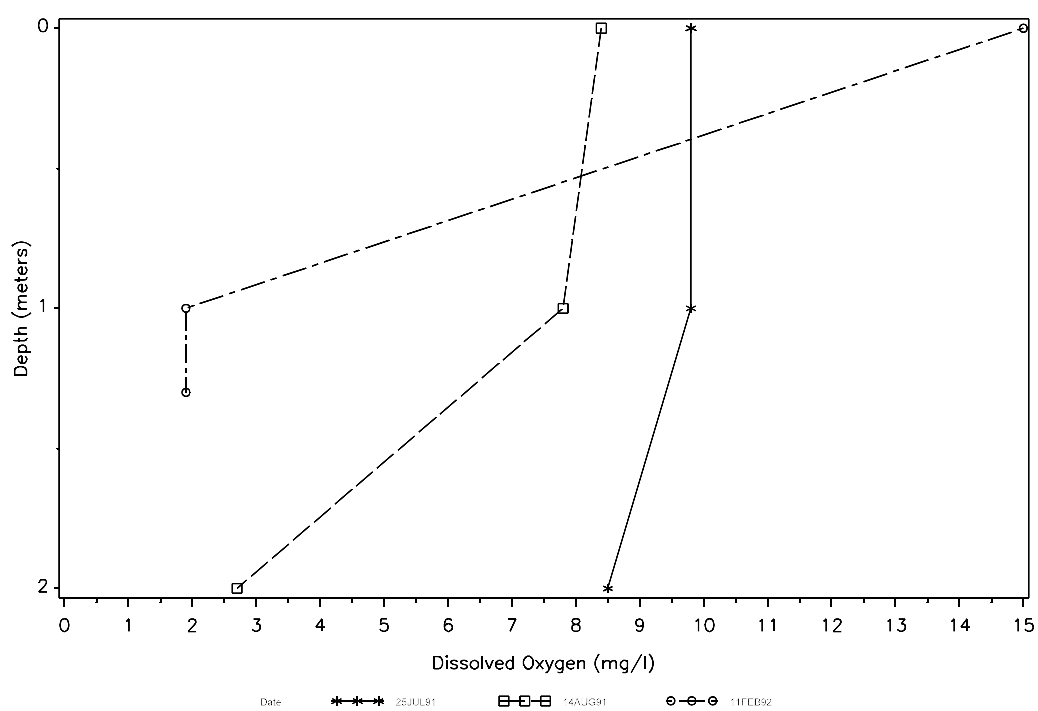

Figure 3. Oxygen profile for Green Lake.

Due to the shallow nature of Green Lake during the project period thermal stratification was not observed (Figure 2). Oxygen levels were fairly uniform throughout the water column with the exception of the bottom measurement taken in August and the surface measurement taken in February. The high dissolved oxygen concentration at the surface in February may be due in part to the ice auger aerating the water (Figure 3).

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 25, 1991 and February 11, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 to December 31, 1991.

Parameter	Green Lake		1982-1991	
Total Dissolved Solids	1104	mg L^{-1}	1209	mg L^{-1}
Conductivity	1648	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	317	mg L^{-1}	488	mg L^{-1}
Sulfates	419	mg L^{-1}	592	mg L^{-1}
Chloride	30.1	mg L^{-1}	81	mg L^{-1}
Total phosphate as P	0.707	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.054	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	443	mg L^{-1}	296	mg L^{-1}
Ammonia	0.394	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	5.06	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	357	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Green Lake on August 14, 1991. At the time of the macrophyte survey nearly 100 percent of Green Lake's surface area had aquatic vegetation. A nearly 100 percent monoculture of sago pondweed (Potamogeton pectinatis) was found at all locations on Green Lake. Intermittent stands of bulrush (Scirpus spp.) and cattails (Typha spp.) were found along the shoreline as well. A map depicting the areal extent of the macrophyte community is contained in Appendix B.

Phytoplankton

The Green Lake phytoplankton community was sampled twice during the summer of 1991. During the two sample periods the phytoplankton community was represented by 5 divisions and 44 genera. Mean density by number of blue-green algae during the summer of 1991 was 14,091,438 cells mL^{-1} which is greater than 17 times the density for all other algae species combined.

Mean density by volume was also dominated by the division Bacillariophyta. Although the Bacillariophyta showed a mean density greater than the blue-green algae it was only due to one species, Surirella ovalis, which is a very large organism. The size of this species accounts for the difference in phytoplankton density by volume as compared to by number. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Green Lake is a hypereutrophic waterbody which exhibits classic symptoms of its conditions. Total phosphate as P concentrations at the surface ranged from 489 to 603 $\mu g\ L^{-1}$, chlorophyll-a ranged from 151 to 292 $\mu g\ L^{-1}$ and secchi disk transparency was 0.2 meters during both summer sample periods. Collaborating ancillary evidence is a history of frequent algal blooms and phytoplankton community dominated by blue-green algal species, 100 percent macrophyte coverage, a shallow lake, low dissolved oxygen under ice cover conditions and frequent fish kills.

Sediment Results

Sediments were collected from Green Lake and were analyzed for trace elements, PCBs and selected pesticides. Sediment samples were collected in the deepest area of the lake (Site 381045, Figure 1), the littoral zone (Site 381047, Figure 1), and the inlet (Site 381048, Figure 1).

Sediment samples collected from Green Lake showed detectable levels of all trace elements tested for except mercury. When compared to the sediment sample results for all lakes assessed in 1991-1992, trace element concentrations were at or below the median concentrations reported except for arsenic in the deepest and inlet areas which were slightly greater than the median concentrations for all lakes sampled. PCBs and pesticides were not detected in any of the sediment samples collected from Green Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Green Lake on June 11, 1991. Two species of fish were collected for analysis, a composite northern pike sampled represented the piscivore group and a composite black bullhead sample represented the bottom feeder group. In order to evaluate the fish tissue data for Green Lake the results for each fish group were compared to that group for all lakes assessed in 1991-1992. Trace element concentrations in northern pike samples collected from Green Lake were similar to median concentrations for all piscivores sampled in 1991-1992. Trace element concentrations in the bottom feeder group for Green Lake were slightly less than the median concentration for all bottom feeders sampled.

Detectable pesticide residues in fish samples collected from Green Lake were limited to DDE in the northern pike sample and, DDE and trifluralin in the black bullhead sample. DDE is a breakdown derivative of DDT and trifluralin is a selective preemergent herbicide commonly known as Treflan. Reported concentrations of DDE in both the northern pike and black bullhead samples were 0.004 $\mu g\ g^{-1}$ and 0.007 $\mu g\ g^{-1}$, respectively. These concentrations were less than the reported median concentration for each group for all fish samples collected. Reported concentration of trifluralin in the bottom feeder was 0.006 ug g^{-1} which is greater than the reported 75th percentile for all bottom feeders sampled in 1991. A complete listing of the whole fish analysis for 1991-1992 lakes is contained in Appendix E.

Watershed

The Green Lake watershed encompasses over 45,000 acres in the Prairie Coteau physiographic region in north central McIntosh County. Nonpoint source pollution accounts for all the nutrient loading and pollution discharges to Green Lake.

Land use within the Green Lake watershed is 95 percent agricultural with 58 percent in cropland production. The remaining five percent is in the Conservation Reserve Program (CRP) and wildlife/wetland areas (Table 2). In the assessed watershed there are 20 farmsteads and 16 concentrated livestock feeding areas. These livestock areas are located throughout the watershed and are not in close proximity to Green Lake.

According to the information provided by the McIntosh County Soil Conservation District, 58 percent of the cultivated lands and between 0 and 29 percent of other agricultural lands within the Green Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion and soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). In North Dakota the estimated (T) value is 3 to 5 tons per acre per year. The estimated soil loss in the Green Lake watershed is estimated at 547,617 tons annually, this is just over 12 tons per acre per year. Assuming a conservative delivery rate of 10 to 15 percent, it is estimated that between 54,000 and 82,000 tons of soil reaches Green Lake annually.

Table 2. Land use in the Green Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	58	58
Range	29	29
Hayland/Pasture	8	9
CRP	4	100
Wet/Wild[1]	0	N/A
Other	1	N/A
Farmsteads	20[3]	N/A
Feedlots[2]	16[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

HARVEY DAM

WELLS COUNTY

Peter N. Wax

Harvey Dam is located near the headwaters of the Sheyenne River in northwest Wells County. The dam was originally completed in the 1920. The Works Progress Administration (WPA) rebuilt the dam in 1936. In 1967 the dam was reconstructed again raising it four feet and creating the existing 282 acre reservoir. It has a maximum depth of 22 feet and average depth of 7 feet (Figure 1).

Topography of the area is characterized by level to undulating hills with slopes averaging 0 to 6 percent. The area along the river channel is characterized by rolling hills with slopes from 12 to 30 percent. All soils are well to moderately well drained and composed of glacial till and glacial fluvial materials.

Harvey Dam is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). Currently the NDG&F stock walleye, northern pike and largemouth bass into the reservoir.

Test netting conducted by the NDG&F in 1991 showed limited numbers of walleye, northern pike, black crappie and yellow perch with an overabundance of small black bullheads. Analysis of the trap net results showed 99 percent of the species composition by number and by weight was small black bullheads. NDG&F reports indicate a history of fish kill for the reservoir due to low oxygen conditions. An aeration system was installed in the mid 70's, however it could not provide the oxygen needed for fish survival in the winter. In 1978 the lake again experienced a 100 percent winterkill. Use of the aeration system was discontinued due to the high cost and ineffectiveness.

A low level drawn down was installed in 1980. In addition, several upstream artisan wells were opened creating continuous flow to the reservoir. This practice was soon stopped due to impacts to local groundwater drying up surrounding wells. It was noted that no fish kills were observed during this time of operation. The shoreline along Harvey Dam is approximately 90 percent in private ownership. Public use facilities include a boat ramp, swim beach, picnic area and toilets.

Water Quality

Water quality samples were collected from Harvey Dam twice during the summer of 1991 and once during the winter of 1991-1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381050, Figure 1). Thermal stratification was not observed on Harvey Dam during the sample periods, July 9, 1991 and August 8, 1991 (Figure 2), however, a rapid decrease in dissolved oxygen concentrations were observed below 4 meters on both sample occasions in the summer and was less than 2 mg L^{-1} at all depths in the winter (Figure 3).

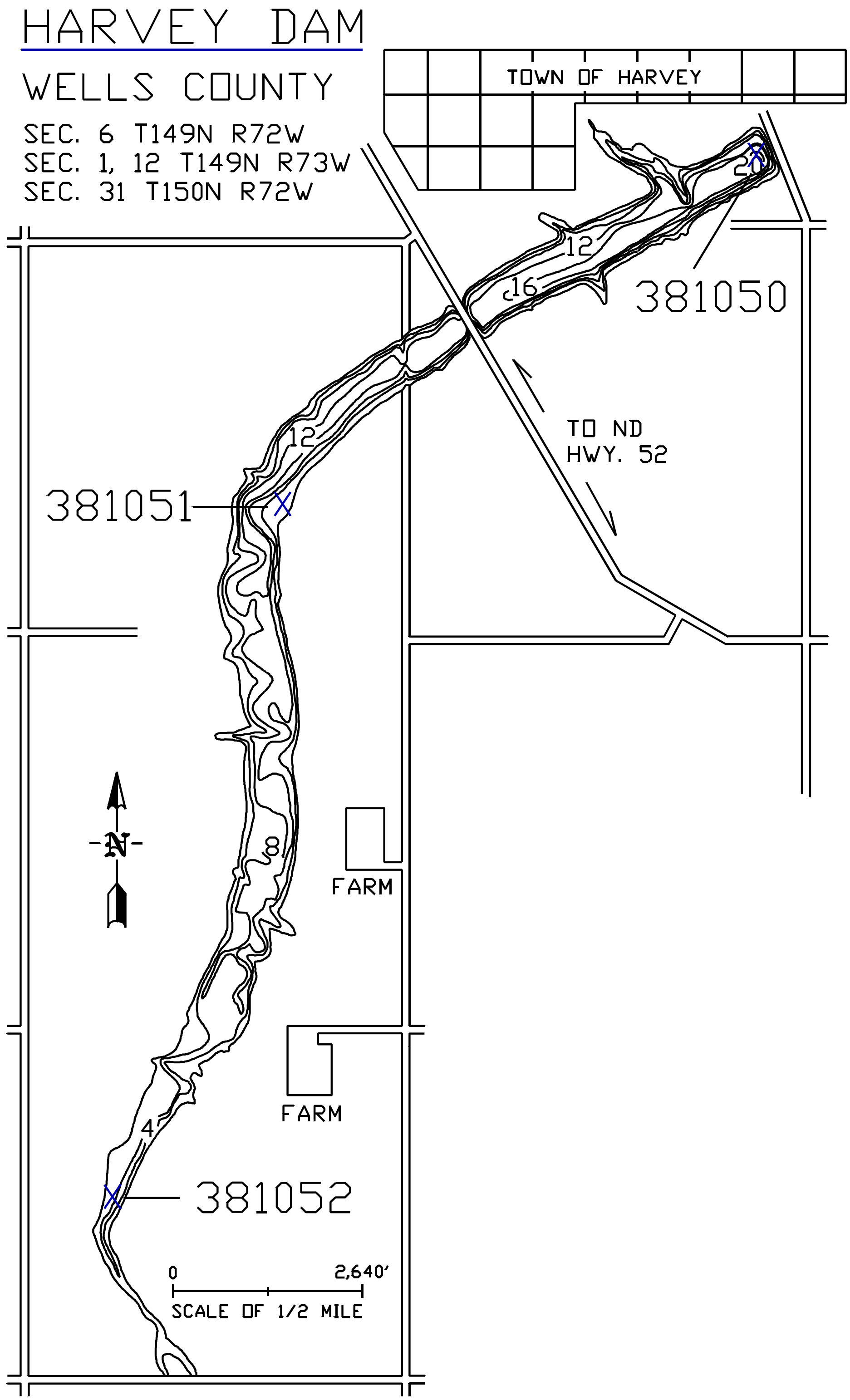

Figure 1. Morphometric map of Harvey Dam.

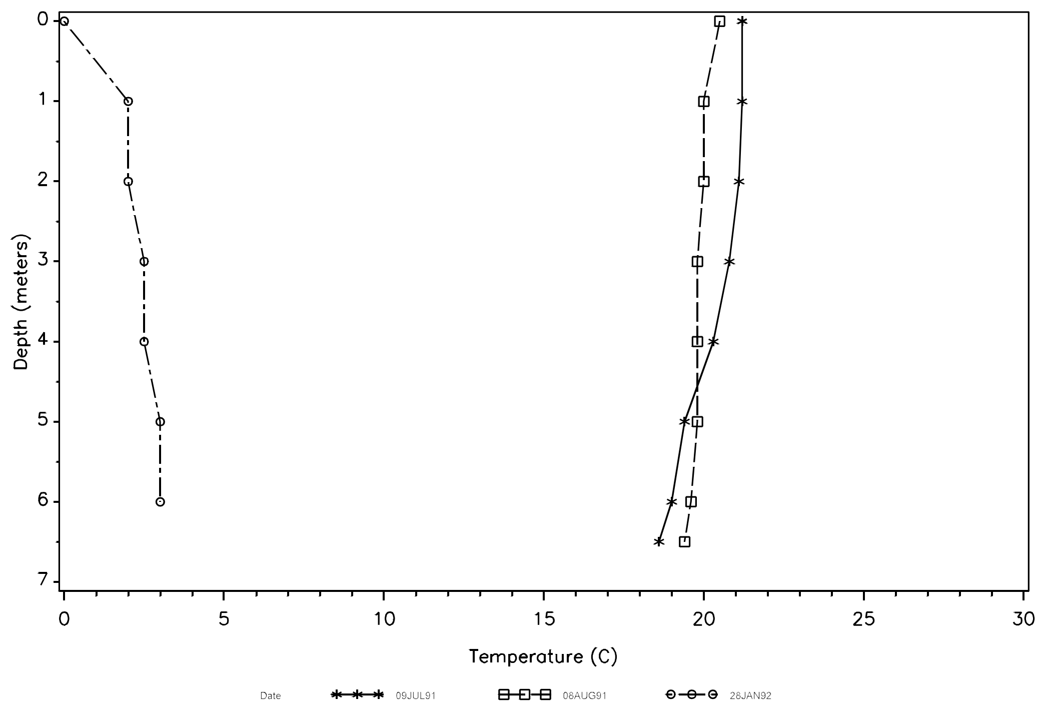

Figure 2. Temperature profile for Harvey Dam.

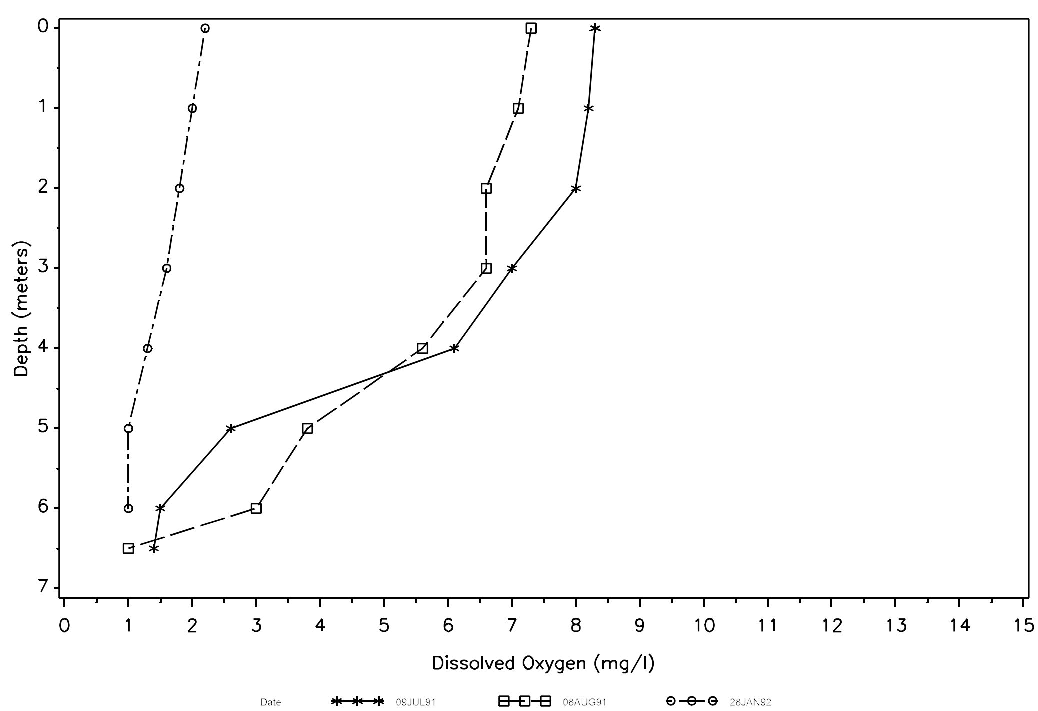

Figure 3. Oxygen profile for Harvey Dam.

Lake water quality assessment data collected in 1991-1992 showed Harvey Dam was extremely well-buffered with total alkalinity as $CaCO_3$ concentrations between 734 and 896 mg L^{-1}. High concentrations of total dissolved solids and the nutrients, total phosphate as P and nitrate + nitrite as N, were also observed in samples collected for Harvey Dam. Total dissolved solids concentrations ranged from 1160 to 1460 mg L^{-1}, while total phosphate as P concentrations were between 0.813 to 1.070 mg L^{-1}. Average volume-weighted mean concentrations were 1277, 0.905 and 0.087 mg L^{-1}, respectively for total dissolved solids, total phosphorous and nitrate + nitrite (Table 1 and Appendix A).

Bicarbonates and sulfates were the dominant anions in the water column. Bicarbonate concentrations ranged from 718 to 978 mg L^{-1} and sulfates concentrations were between 259 and 366 mg L^{-1}. Average volume-weighted mean bicarbonate and sulfate concentrations were 806 and 296 mg L^{-1}, respectively (Table 1 and Appendix A).

The ratio between total phosphate as P and nitrate + nitrite as N was over 10:1. This ratio suggests Harvey Dam is nitrogen limited. This condition usually implies primary production is limited by the available supply of nitrogen. However, in the case of Harvey Dam the condition represents an over abundance of phosphorus and encourages nitrogen fixing organisms such as some species of blue-green algae.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 10, 1991 and January 30, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 to December 31, 1991.

Parameter	Harvey Dam		1982-1991	
Total Dissolved Solids	1277	mg L^{-1}	1209	mg L^{-1}
Conductivity	1977	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	193	mg L^{-1}	488	mg L^{-1}
Sulfates	296	mg L^{-1}	592	mg L^{-1}
Chloride	30.7	mg L^{-1}	81.29	mg L^{-1}
Total phosphate as P	0.905	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.087	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	790	mg L^{-1}	296	mg L^{-1}
Ammonia	0.214	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.9	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	806	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

While a formal macrophyte survey was not conducted on Harvey Dam, field notes taken during the summer showed the presence of sago pondweed (Potamogeton pectinatis) to a depth of 5 to 6 feet. In addition cattails (Typha spp.) were present along the shoreline.

Phytoplankton

The Harvey Dam phytoplankton community was sampled twice during the summer of 1991. The Harvey Dam phytoplankton community during the two sample periods was represented by 4 divisions and 15 genera. These numbers normally indicate a diverse population but are very misleading. Blue-green algae, Cyanophyta, dominated the phytoplankton community with a mean density of 55,737 cells mL^{-1}. This is 5 times greater than all other algal species combined. Mean density by volume for blue-greens was two times greater than the volume of all other algae species combined. A complete listing of phytoplankton data is contained in Appendix B.

Trophic Status

Harvey Dam is assessed as a hypereutrophic reservoir. This assessment is based primarily on secchi disk transparency, summer surface total phosphates as P concentrations and chlorophyll-a concentrations, and ancillary information.

The secchi disk transparency and chlorophyll-a concentrations correspond well, indicating Harvey Dam is eutrophic based on Carlson's TSI. However, summer surface total phosphorous as P indicate a hypereutrophic waterbody. A hypereutrophic assessemnt based on total phosphate as P is supported by such ancillary information as a phytoplankton community dominated by blue-green algae. Also, low dissolved oxygen conditions observed in the hypolimnion during the summer and throughout the water column during the winter and a history of fish kills.

Sediment Analysis

Sediments were collected from Harvey Dam and were analyzed for trace elements, PCBs, and selected pesticides. Sediment samples collected from Harvey Dam showed detectable levels of all trace elements tested for except mercury. Sediment samples were collected in the deepest area of the lake (Site 381050) the littoral zone (Site 381051) and the inlet (Site 381052) (Figure 1).

When compared to sediment sample results for all sites assessed in 1991-1992, trace metal concentrations were at or below the median concentrations reported for all lakes. PCBs and pesticides were less than detection limits at all sites sampled in Harvey Dam. A complete listing of the sediment results is provided in Appendix C.

Whole Fish Analysis

Fish were collected for contaminant analysis from Harvey Dam on June 9, 1991. Two species of fish were collected for contaminant analysis, black crappie representing the insectivore group and black bullhead representing the bottom feeder group. In order to evaluate the fish tissue data for Harvey Dam the results for each fish group was compared to that group for all lakes assessed in 1991-1992. Trace metals concentrations were very similar to median concentrations reported for both categories. Reported mercury concentrations were not high enough to warrant a need for consumption advisory.

Detectable pesticide residues in each composite fish sample collected from Harvey Dam was limited to DDD and DDE while trifluralin was present in the bottom feeder sample only. DDD and DDE are breakdown derivatives of DDT while trifluralin is a selective preemergent herbicide, commonly known as treflan. A complete listing of the fish tissue results is provided in Appendix D.

Watershed

Harvey Dam's watershed encompasses over 300 square miles, of which, about 200 square miles is contributing. Of the 200 contributing square miles, approximately 60 square miles is above the Sheyenne Lake Refuge and Coal Mine Lake. These two waterbodies are believed to act as sedimentation basins and should remove a significant portion of the sediment and nutrient load which would otherwise would reach Harvey Dam unchecked. The head waters of the Sheyenne River is the beginning of the watershed. A total of 138 square miles or 88,000 acres was included in the land use assessment for Harvey Dam. This area has the most impact upon the reservoir. The watershed is located mainly in west central Wells and east central Sheridan counties. The assessed watershed is generally level to undulating hills along a well defined river channel characterized by rolling hills. The soils are predominately well drained made up of glacial till and glacial fluvial material. Nonpoint source pollution from the surrounding watershed accounts for all the nutrient loading and pollution discharges to Harvey Dam.

Land use within the Harvey Dam watershed is 84 percent agricultural with 67 percent croplands. The remaining 16 percent is in the Conservation Reserve Program (CRP), wildlife/wetland areas and other land uses, including roads, farmsteads, etc. (Table 2). In the assessed areas below Sheyenne Lake there are 119 farmsteads and 21 concentrated livestock feeding areas. Many of these livestock feeding areas are located in close proximity to the reservoir and are probably adding a major source of nutrients. Twenty-five other concentrated livestock areas are located outside the assessed watershed area, but would still be considered in the watershed.

Table 2. Land use in the Harvey Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	67	50
Pasture Land	16	100
Hayland	1	100
CRP	4	100
Wet/Wild[1]	7	100
Other	5	N/A
Farmsteads	119	N/A
Feedlots[2]	46	10

[1] Wet/Wild are wildlife management areas, wetlands and lakes.
[2] Feedlots are areas where livestock are concentrated to be fed.

According to information provided by the Wells and Sheridan County Soil Conservation Districts, 50 percent of the cultivated lands and nearly all the remaining lands within the Harvey Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated for the Harvey Dam watershed the average "T" value is between 3 and 5 tons per acre per year. The estimated soil loss in the assessed area of the Harvey Dam watershed is 542,770 tons of soil loss each year. This is just over 6 tons of soil per acre, per year. Assuming a conservative delivery rate of 10 to 15 percent, between 54,000 and 82,000 tons of soil reaches Harvey Dam annually.

INDIAN CREEK DAM

HETTINGER COUNTY

Peter N. Wax

Indian Creek Dam was constructed in 1978 and first filled in the spring of 1979. The dam is located on Indian Creek, a tributary to the Cannonball River in south central Hettinger County, North Dakota. It is a relatively small impoundment encompassing 216 acres with a maximum depth of 26 feet (Figure 1).

The dam was constructed in anticipation of high nutrient and sediment runoff from the contributing watershed. To help alleviate the negative water quality impacts, an automatic hypolimnion drawdown was installed and repairs made to two small dams on the southwest and western drainages to act as sediment retention ponds. The dam on the west side was so successful that until recently it had been managed as a put and take trout fishery. The NDG&F own the dam, and the immediate area surrounding Indian Creek Dam, including the two sediment ponds located on the major tributaries (Figure 2). The northern half of the lake is leased from the NDG&F by the Hettinger County Water Board which manages the area for public use. Developments include a swimming beach, boat ramp, and park facilities.

Indian Creek Dam is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manages the fishery through annual population surveys conducted by test netting. Fish stocking is based on these surveys.

The initial fishery, established in 1979 consisted of rainbow trout, followed by stockings of smallmouth bass, walleye, bluegill and northern pike. A regiment of maintenance stockings of walleye and trout have been employed, however the NDG&F have relied primarily on natural reproduction to sustain the bluegill, northern pike and smallmouth bass populations. Test netting results from Indian Creek Dam conducted in 1991 showed a fish community dominated by small bluegill, however a good number of walleye were also captured.

Indian Creek summer killed in 1981 and 1983. The summer kills were likely due to the morphometric characteristics of the lake, which are favorable to cause thermal stratification and subsequent anoxic conditions below the hypolimnion. This condition in the hypolimnion produces high concentrations of unionized ammonia, which is highly toxic to fish. When mixed throughout the water column by wind and wave action, it can cause a summer kill.

Public facilities at Indian Creek Dam include a swim beach, boat ramp, and picnic area with shelters. These facilities are maintained by the Hettinger County Water Board and are easily accessible from good gravel roads. Public use on Indian Creek Dam is moderate to heavy, depending on the fishing. It is a popular lake with young families due to the abundant panfish population.

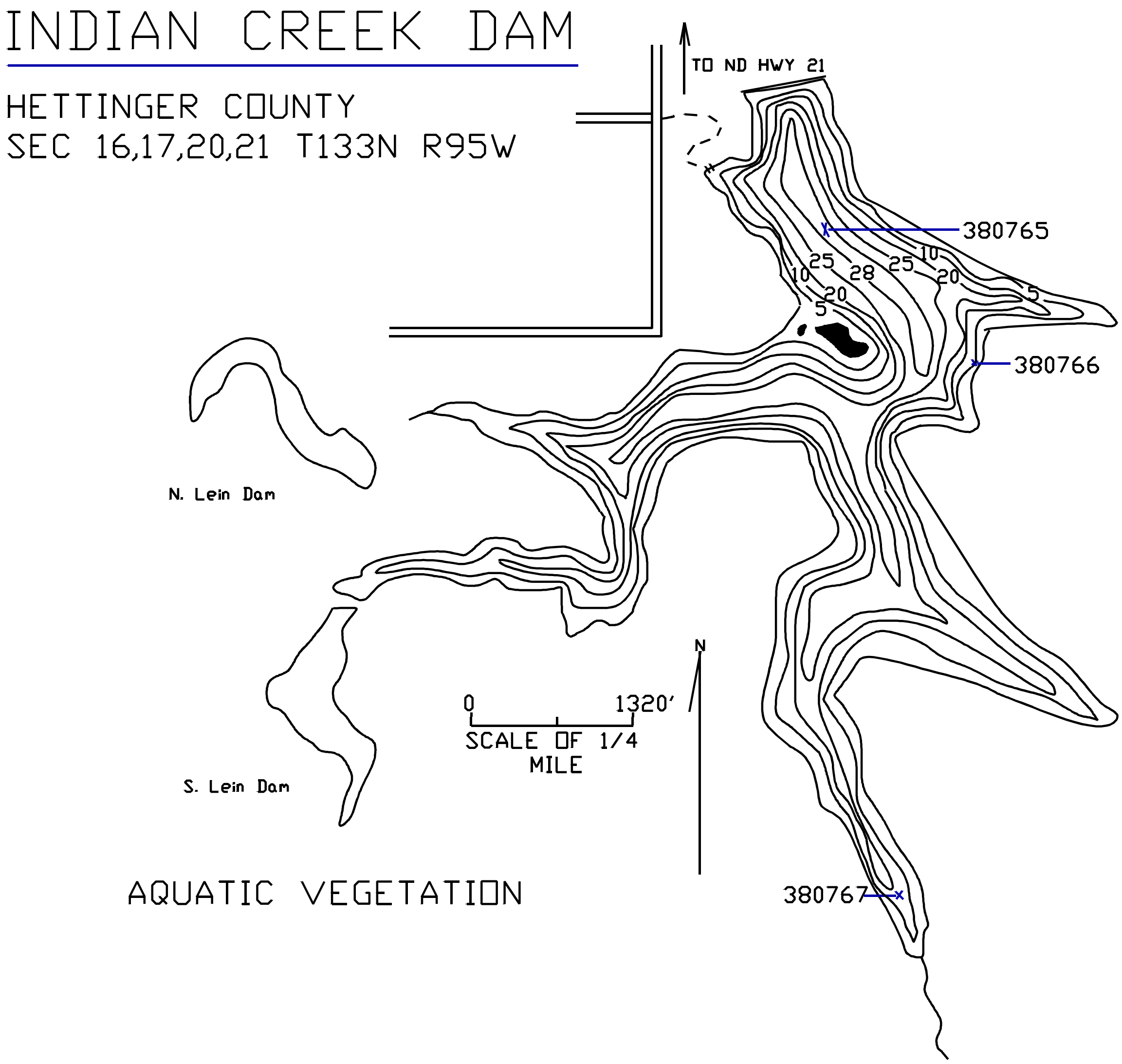

Figure 1. Morphometric map of Indian Creek Dam.

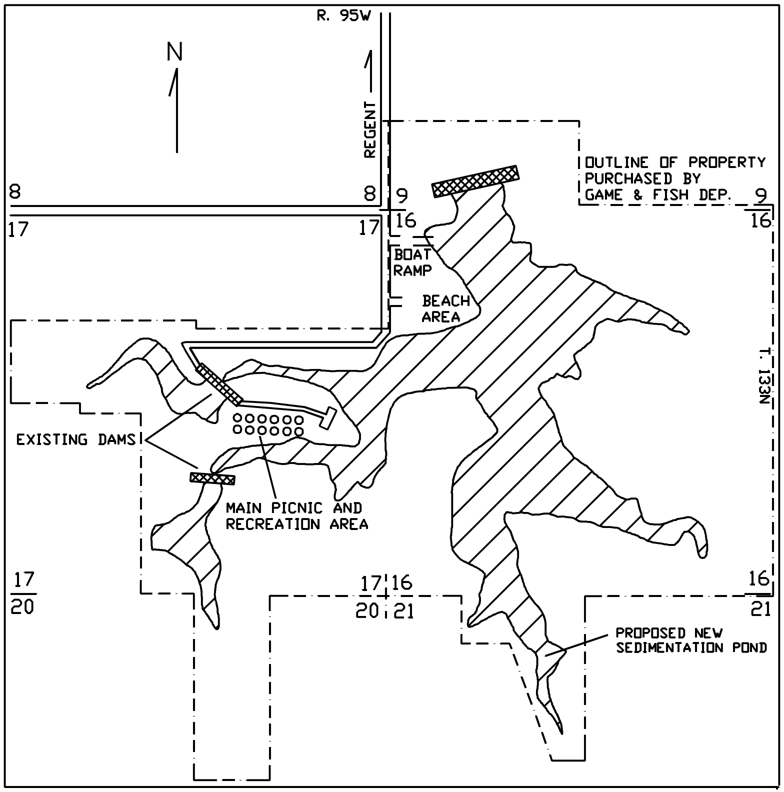

Figure 2. Location of facilities and water quality structures on Indian Creek Dam.

Water Quality

Water quality samples were collected from Indian Creek Dam two times during the summer of 1991 and once during the winter of 1991-1992. Samples were collected at one sample site located in the deepest area of the lake (Site 380765, Figure 1). Water column samples were collected for analysis at three separate depths during the summer and winter. Summer samples were collected at 1, 3 and 6 meters; winter samples were collected at 1, 3, and 5 meters.

During the summer water quality sampling periods, Indian Creek Dam was not thermally stratified (Figure 3). At these time periods, dissolved oxygen concentrations were near saturation to a depth of 3 to 5 meters and
were adequate to maintain aquatic life (Figure 4). During the January 1992 sample period the lake again was also not thermally stratified. Dissolved oxygen concentrations in January were approximately 3 mg L^{-1} or less throughout most of the water column (Figures 3 and 4).

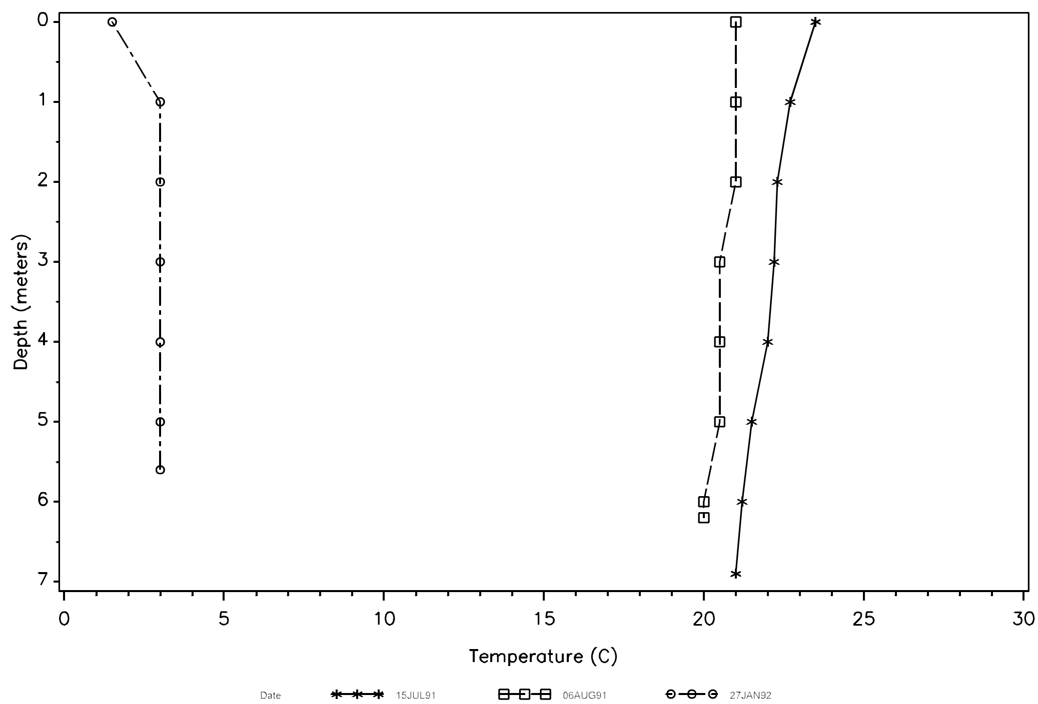

Figure 3. Temperature profile for Indian Creek Dam.

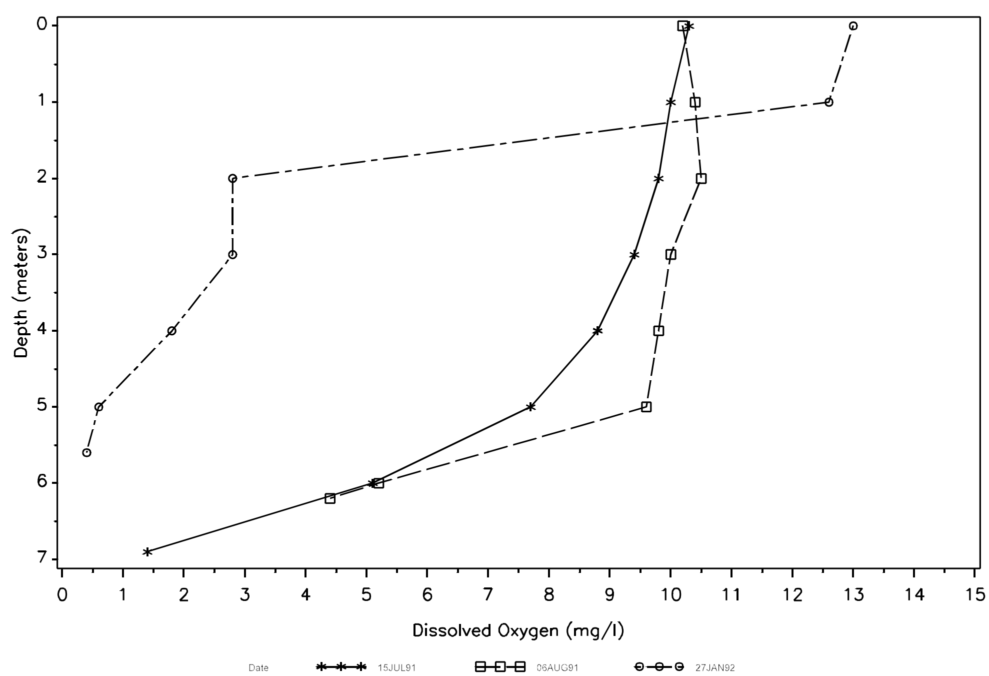

Figure 4. Oxygen profile of Indian Creek Dam.

In general, the water quality data for Indian Creek Dam describes a lake with extremely hard water, rich in both minerals and nutrients. Bicarbonate and sulfates were the dominant anions in the water column, with average volume-weighted mean concentrations of 400 mg L^{-1} and 1192 mg L^{-1}, respectively. The average volume-weighted mean total hardness as calcium concentrations was 495 mg L^{-1}, and total alkalinity was 427 mg L^{-1}. The only parameters which did not exceed the North Dakota long-term average were the nutrients, total phosphorus as P, nitrate + nitrite as N, and ammonia. The volume-weighted mean for total phosphate was 0.195 mg L^{-1}. While relatively low in comparison to many North Dakota lakes it still exceeded the states target concentration of 0.02 mg L^{-1} by nearly 10 fold. A completed list of the LWQA project water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 15, 1991, August 6, and January 11, 1992 and long-term averages from all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Indian Creek Dam	1982-1991
Dissolved solids	2163 mg L^{-1}	1209 mg L^{-1}
Conductivity	3085 umhos cm^{-1}	1604 umhos cm^{-1}
Hardness as calcium	495 mg L^{-1}	488 mg L^{-1}
Sulfates	1192 mg L^{-1}	592 mg L^{-1}
Chlorides	25.8 mg L^{-1}	81 mg L^{-1}
Total phosphate as P	0.195 mg L^{-1}	0.248 mg L^{-1}
Nitrate + Nitrite as N	0.035 mg L^{-1}	0.069 mg L^{-1}
Total Kjeldahl nitrogen	2.82 mg L^{-1}	2.34 mg L^{-1}
Ammonia	0.044 mg L^{-1}	0.326 mg L^{-1}
Bicarbonate	400 mg L^{-1}	326 mg L^{-1}
Total Alkalinity	421 mg L^{-1}	296 mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted for Indian Creek Dam on August 6, 1991. At the time of the macrophyte survey approximately 25 percent of Indian Creek Dam's surface area had aquatic vegetation. The macrophyte species identified were sago pondweed (Potamogeton pectinatus), and water milfoil (Myriophyllum spp.). A map depicting location and areal extent of macrophytes in Indian Creek Dam can be found in Appendix B.

Phytoplankton

The phytoplankton community was sampled two times during the summer of 1991. Samples collected during 1991, indicate Indian Creek Dam's phytoplankton community is relatively diverse. The phytoplankton community was represented by 5 divisions and 28 genera. The largest contributors by density were blue-green algae, Cyanophyta, with 15 genera present. Mean density of blue-green algae during the summer of 1991 were 211,695 cells mL^{-1}, which is nearly 11 times greater than all the other groups combined.

During the July and August 1991 sample periods, phytoplankton densities by volume varied significantly from density express by number. By volume the dominant phytoplankton were the Pyrrophyta followed by the Cyanophyta and then the Bacillariophyta. The difference in phytoplankton density by volume and by number is a result of the variation in size between individual species. The species Ceratiom hirondinella and Glenodinium gymnodinium in the division, Pyrrophyta, are very large organisms as compared to the other species present including the Cyanophyta. A compilation of the 1991-1992 LWQA project phytoplankton data is contained in Appendix C.

Trophic Status

Lake water quality assessment data collected during the summer of 1991 indicated Indian Creek Dam is presently hypereutrophic. Principal indicators are secchi disk transparency readings of 1 meter or less throughout the summer, surface total phosphate as P concentrations between 170 and 274 $\mu g\ L^{-1}$ and chlorophyll-a concentrations between 19 and 39 $\mu g\ L^{-1}$.

An examination of the ancillary information for Indian Creek Dam also supports this trophic status assessment. Evidence supporting this condition includes a large macrophyte biomass covering approximately 20-25 percent of the lake with surface area, a phytoplankton community dominated by one or two species of blue-green algae, frequent nuisance algal blooms, low dissolved oxygen concentrations below the hypolimnion and throughout the majority of the water column under ice covered conditions and a history of fish kills.

Sediment Analysis

Sediments were collected from Indian Creek Dam and analyzed for trace elements PCBs, and selected pesticides. Sediments were collected from the deepest area of the lake (Site 380765), the littoral zone (Site 380766) and the inlet (Site 380767) (Figure 1).

Sediment samples collected from Indian Creek Dam showed detectable levels of all trace elements tested for, except mercury in sediment samples collected from the deepest area of the reservoir. Sediment sample concentrations at each sample location within Indian Creek Dam were also compared to the results for all lakes assessed in 1991-1992. Trace element concentrations from samples collected from Indian Creek Dam were above the 75th percentile concentration for all lakes sampled for each location. The reported barium concentration reported from all areas and the cadmium concentration at the inlet showed the greatest concentrations for all the lakes assessed in 1991-1992. Concentrations of selected organic compounds were below detectible limits for all samples collected from Indian Creek Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Indian Creek Dam on August 6, 1991. Walleyes were the only fish used in the contaminant analysis and represented the piscivore group. No bottom feeders were captured during 1991 netting operations.

In an effort to evaluate fish tissue data for Indian Creek Dam, the results of each fish group were compared to the results for that group for all lakes assessed in the 1991-1992 LWQA project. Trace element concentrations in the walleye sample collected from Indian Creek Dam were generally near the median concentrations for all fish collected during the 1991 LWQA project. The exception was the reported mercury concentrations of 0.66 $\mu g\ g^{-1}$, which was above the reported 75th percentile concentrations for all piscivores and the second highest concentration reported for all piscivore samples collected in the LWQA project.

Detectable pesticide residues in the walleye sample collected from Indian Creek Dam were DDE, DDD, and nonachlor. DDE and DDD are degradation products of the insecticide DDT and produce biological effects similar to the parent compound when available to the environment. Nonachlor is a principle ingredient in technical chlordane, an insecticide no longer in use. Very little data is available for nonachlor, but, chlordane is highly toxic to aquatic fish with a 96-hour LC50 for rainbow trout and bluegill of between 9.3-13.1 and 40-81 $\mu g\ g^{-1}$, respectively (Finley and Johnson 80). Ninety-six hour LC50 refers to the concentration needed for a given compound to cause death to 50 percent of the study specimens over a 96-hour exposure.

Reported concentrations of pesticide residues in the walleye flesh were 0.004 $\mu g\ g^{-1}$ for DDD, 0.013 $\mu g\ g^{-1}$ for DDE, and 0.003 $\mu g\ g^{-1}$ for nonachlor. Of note is the DDE concentration of 0.013 $\mu g\ g^{-1}$, which was the highest concentration reported in the 1991 LWQA. A complete listing of fish tissue results is provided in Appendix E.

Watershed

Indian Creek Dam and its contributing watershed has a combined surface area of 9,068 acres. Located in the Cannonball Drainage, in south central Hettinger, County, North Dakota. The region is characterized by level to rolling topography, interspersed with out croppings of sandstone, clay and lignite. The majority of soils are well drained, moderately permeable with slopes ranging from 3 to 6 percent. Nonpoint source pollution accounts for 100 percent of nutrient and sediment loadings to Indian Creek Dam.

Land use within the Indian Creek Dam watershed is 87 percent agricultural, with 77 percent actively cultivated. The remaining 23 percent is in low density urban development, haylands, pasture, conservation reserve (CRP), and wildlife habitat (Table 2). According to the information provided by the Hettinger County Soil Conservation District, 75 percent of the cultivated lands and between 80 and 100 percent of all the remaining lands within the Indian Creek watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve soil loss tolerant (T). It is estimated that within the Indian Creek Dam watershed, the average "T" value is 3 to 5 tons per acre.

Based on an average soil loss of 5 to 6 tons per acre, which takes into account the land that is not adequately treated, 50,734 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 5,073 and 7,610 tons of soil reaches Indian Creek Dam annually.

Table 2. Land use in the Indian Creek Dam watershed.

Land use	Percent of total Watershed acreage	Percent Adequately treated
Cropland	77	75
Pasture land	7	80
Hayland	1	80
CRP	2	100
Wet/Wild[1]	12	100
Other	1	N/A
Farmsteads	5[3]	N/A
Feedlots[2]	2[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number present in watershed.

KULM EDGELEY DAM

LAMOURE COUNTY

Peter N. Wax

Kulm Edgeley Dam is located in the Glaciated Plains physiographic region in southwestern Lamoure County, North Dakota on the eastern edge of the James River drainage. Kulm Edgeley Dam is a manmade lake, created when a tributary to the Maple River was dammed in 1968. It is a relatively deep lake with a maximum depth of 29 feet and an average depth of 11.4 feet (Figure 1).

The topography of the area is nearly level to undulating with most slopes ranging from 3 to 6 percent. Soils are moderately well drained, formed from glacial till. The watershed is predominately integrated drainages typifying the characteristics of the northern prairie pothole region.

Kulm Edgeley Dam is classified as a cool water fishery "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Kulm Edgeley Dam by annually assessing the fish community by test netting and stocking accordingly. In recent years, the stocking regimen has included catfish, largemouth bass and walleye. After the reservoir filled in 1968, the NDG&F initially stocked exclusively rainbow trout. Bluegill, largemouth bass and walleye were stocked after the dam had been repaired and a hypolimnitic drain added in 1977. Other fish species present include yellow perch and northern pike. These fish species are believed to be present as a result of unauthorized stockings by the public.

Approximately 40 percent of the shoreline is publicly owned. Facilities include a boat ramp, associated parking, and toilets. Even though heavy growths of aquatic vegetation make shore fishing difficult, Kulm Edgeley Dam still remains popular with children due to the abundant pan fish population.

Water Quality

Water quality samples were collected from Kulm Edgeley Dam two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 380790, Figure 1). Water column samples were collected for analysis at three separate depths, 1, 4, and 7 meters.

During the summer sampling period, Kulm Edgeley Dam was thermally stratified between 3 and 4 meters below the lake surface (Figure 2). During this time period dissolved oxygen concentrations were at or near saturation to a depth of 3 meters and were adequate to maintain aquatic life (Figure 3). Samples collected during January 1992 showed dissolved oxygen concentrations at or below 2.0 mg L^{-1} at all depths (Figure 3).

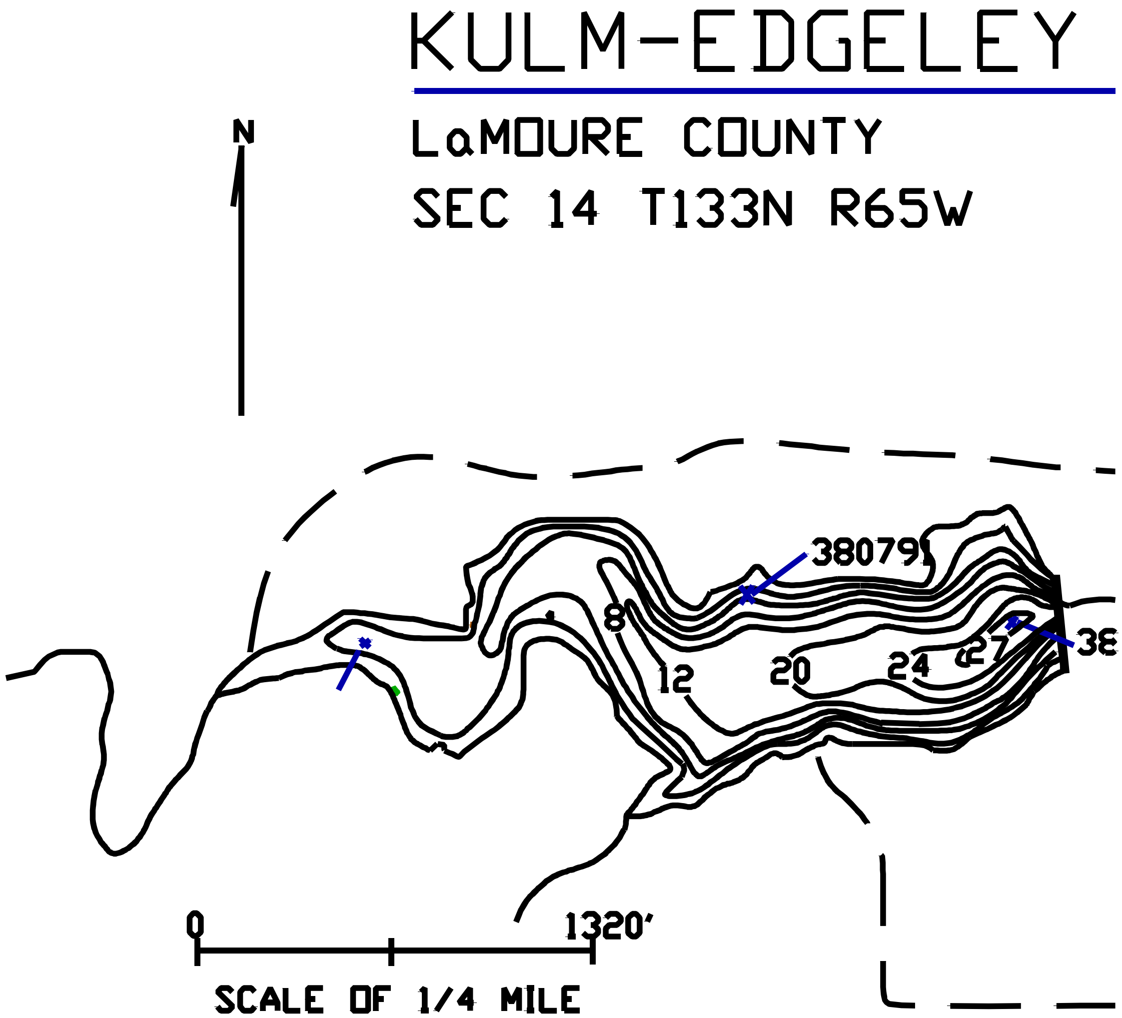

Figure 1. Morphometric map of Kulm-Edgeley Dam.

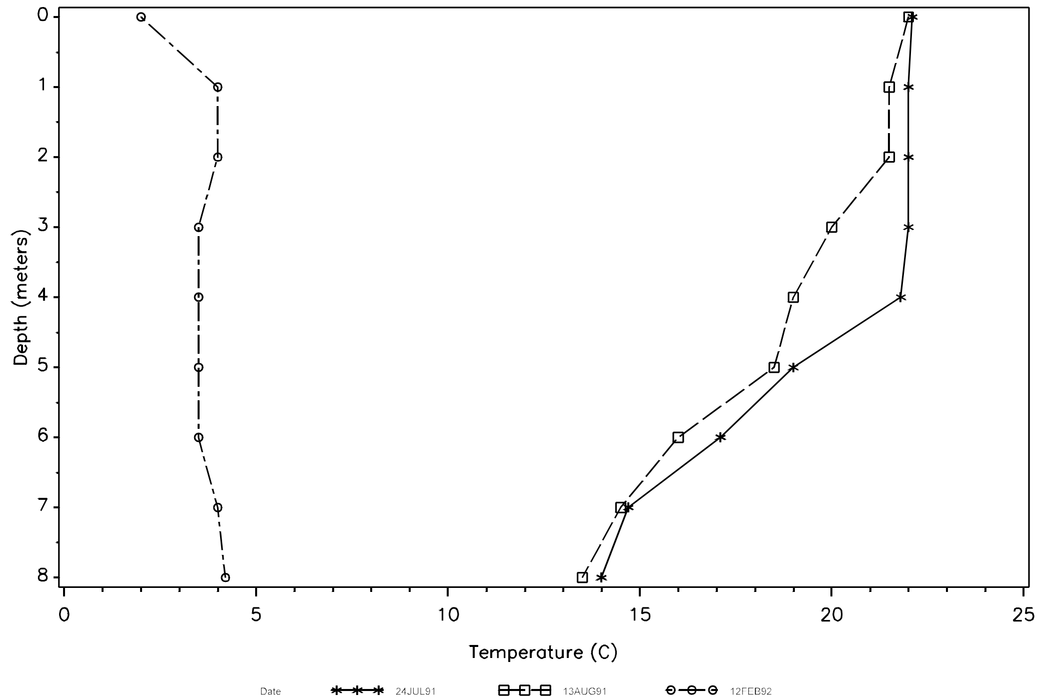

Figure 2. Temperature profile for Kulm-Edgeley Dam.

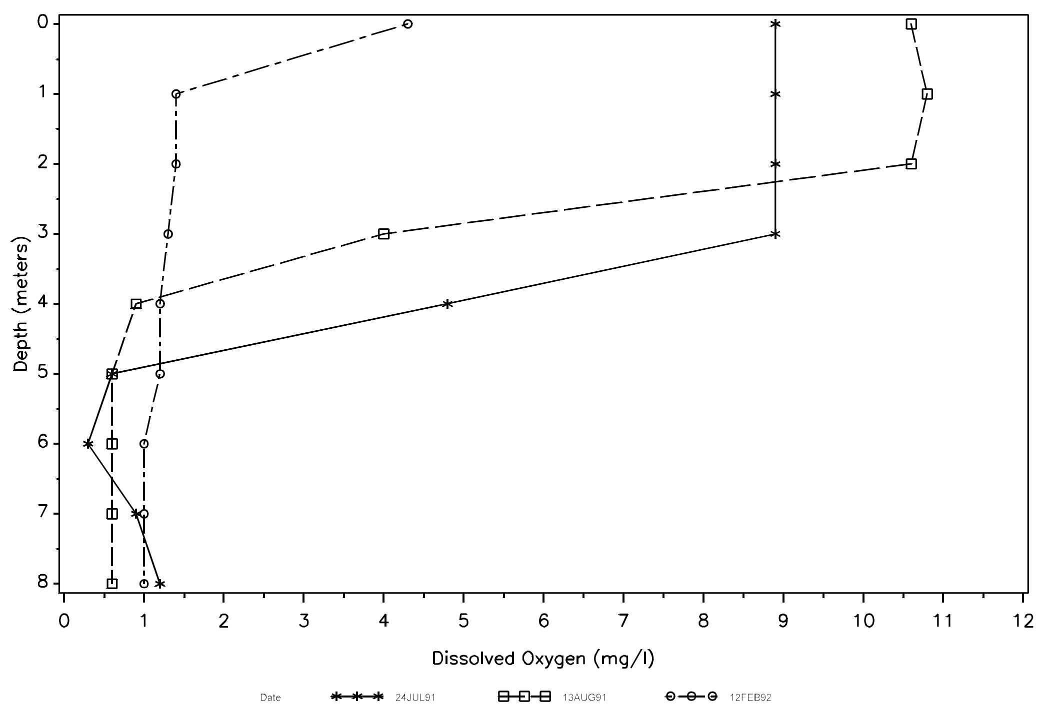

Figure 3. Oxygen profile for Kulm-Edgeley Dam.

Concentrations of total dissolved solids, hardness as calcium and conductivity were significantly lower than the long-term average and less than concentrations reported for most other lakes sampled during the 1991-1992 LWQA. Sulfate and bicarbonates were the dominant anions in the water column. Sulfate concentrations ranged from 31 to 93 mg L^{-1} while bicarbonate concentrations were between 157 and 378 mg L^{-1}.

Total phosphorous as P concentrations within Kulm Edgeley were greater than the long-term average for North Dakota lakes while below average for nitrite + nitrate as N. The average volume-weighted mean concentrations for total phosphate as P was 0.979 mg L^{-1} exceeding the state's target concentration of 0.02 mg L^{-1} on all occasions sampled during the 1991-1992 LWQA project. The nitrate + nitrite as N concentration was considerably below the target concentration of 0.25 mg L^{-1} with an average volume mean weighted concentration of 0.02 mg L^{-1}. A complete list of water quality sample data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 10, 1991 and January 30, 1992 and long-term averages from all North Dakota lakes sampled by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Kulm Edgeley		1982-1991	
Total Dissolved Solids	333	mg L^{-1}	1209	mg L^{-1}
Conductivity	572	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	225	mg L^{-1}	488	mg L^{-1}
Sulfate	66	mg L^{-1}	592	mg L^{-1}
Chloride	7.1	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.692	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.020	mg L^{-1}	0.069	mg L^{-1}
Total Kjeldahl Nitrogen	2.67	mg L^{-1}	296	mg L^{-1}
Ammonia	0.99	mg L^{-1}	0.347	mg L^{-1}
Bicarbonate	304	mg L^{-1}	2.34	mg L^{-1}
Total Alkalinity	227	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Kulm Edgeley Dam as part of the 1991-1992 LWQA project. The survey was conducted on August 13, 1991. At the time of the macrophyte survey approximately 20 percent of Kulm Edgeley Dam's surface area had aquatic vegetation. Nearly 100 percent of the lakes surface area to a depth of seven feet had either sago pondweed (Potamogeton pectinatus), water milfoil (Myriophyllum spp.), cattails (Typha spp.) or a combination of all three. A map depicting the areal extent macrophyte community of macrophyte coverage on Nieuwsma Dam is contain in Appendix B.

Phytoplankton

The phytoplankton community was sampled two times during the summer of 1991. Kulm Edgeley Dam had one of the least diverse phytoplankton communities of all the lakes sampled in 1991-1992. The phytoplankton community was represented by only 3 divisions and 9 genera.

The largest contributors in terms of density were blue-green algae, Cyanophyta, with 5 genera present. Mean blue-green algae density of the two samples collected during the summer of 1991 was 278,575.5 cells mL^{-1}. Density of blue-green algae were 139 times greater than the other two groups combined.

At the time of the assessment mean phytoplankton concentrations by volume were also dominated by blue-green algae. Blue-green algae represented over 91 percent of the community by volume. The division Cryptophyta represented a little over 8 percent of the phytoplankton community and the remainder was made up of Chlorophyta. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during 1991 describe Kulm-Edgeley Dam as hypereutrophic. Primary indicators are high concentrations of surface total phosphate as P and chlorophyll-a, and shallow secchi disk transparencies. Total phosphate as P concentrations averaged 549 $\mu g\ L^{-1}$, whole average chlorophyll-a concentrations were 0.034 $mg\ L^{-1}$ and average secchi disk transparency depth were 1.15 meters.

Ancillary information also suggests a hypereutrophic lake condition. Collaborating information included a large macrophyte biomass, frequent algal bloom, a phytoplankton community dominated by blue-green algae and a history of fish kills.

Sediment Analysis

Sediments were collected from Kulm Edgeley Dam and analyzed for trace elements, PCBs, and selected pesticides. Sediments were collected at the deepest area of the lake (Site 380790), the littoral zone (Site 380791), and the inlet (Site 380792) (Figure 1).

Sediment samples collected from Kulm Edgeley Dam showed detectable levels of all trace elements tested for except, mercury in the littoral zone. Sediment sample results from each sample location within Kulm Edgeley Dam were compared to the results reported for all lakes assessed in the 1991-1992 LWQA project. In general, trace element concentrations were near or above the median concentrations for all lakes sampled while below the 75th percentile. The only exceptions were the reported barium concentrations in the deepest and inlet area sediment samples which exceeded the 75th percentile concentration for all lakes. Concentrations of selected organic compounds were below detection limits for all samples collected from Kulm Edgeley Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Kulm Edgeley Dam on August 13, 1991. Walleyes were the only species collected, representing the piscivore group.

In order to evaluate the fish tissue data for Kulm Edgeley Dam, the results were compared to the piscivore group for all lakes assessed in 1991-1992. Trace element concentrations in fish samples collected from Kulm Edgeley Dam were generally near or slightly greater than the median concentrations for all fish collected during the 1991-1992 LWQA project. The exception was the reported mercury concentrations of 0.67 $\mu g\ g^{-1}$ which is above the 75th percentile. This was the second highest concentration reported for samples collected during the 1991-1992 LWQA project.

Detectable pesticide residues in the walleye sample collected from Kulm Edgeley Dam included DDE, dieldrin, nonachlor and trifluralin. DDE is a degradation product of the insecticide DDT and produces biological effects similar to the parent compound. Dieldrin is a agricultural insecticide that in toxicity testing has been shown to prevent daphnia from completing metamorphosis to adults at concentrations as low as 5.6 $\mu g\ L^{-1}$ and was lethal to 50 percent of largemouth bass and walleye during a 96 hour exposure at average concentration of 1.5 and 2.9 $\mu g\ L^{-1}$, respectively. The chemical nonachlor is also a agricultural insecticide. Trifluralin, commonly known as treflan, is a selective, preemergent herbicide. The DDE concentration of 0.006 $\mu g\ g^{-1}$ for the Kulm Edgeley Dam walleye sample was below the median concentration for all fish sampled in 1991-1992. While nonachlor was slightly above the median concentration at 0.002 $\mu g\ g^{-1}$. The reported concentration of 0.003 $\mu g\ g^{-1}$ for dieldrin was the maximum reported for 1991-1992 lakes and the reported concentration of 0.006 $\mu g\ g^{-1}$ for trifluralin was above the 75th percentile concentration. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Kulm Edgeley Dam with its contributing watershed has a combined surface area of 3540 acres. It is located on the Missouri Coteau physiographic region in LaMoure County. The Missouri Coteau is a glacial erosion remnant of the Wisconsin age. The surrounding landscape is characterized by rolling hills and valleys. Soils are predominately excessively drained, built from gravely, sandy glacial materials. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to Kulm Edgeley Dam.

Land use within the Kulm Edgeley Dam watershed is 97 percent agricultural with 57 percent actively cultivated. The remaining 43 percent is in low density urban development, haylands, pasture, and Conservation Reserve Program (CRP) acreage (Table 2). According to the information provided by the LaMoure County Soil Conservation District, 75 percent of the cultivated lands and nearly all the remaining lands within the Kulm Edgeley watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Kulm Edgeley Dam watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of 2 to 3 tons per acre approximately 9,549 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 955 tons to 1432 tons of soil reaches Kulm Edgeley Dam annually.

Another source of nonpoint source pollution discharges to Kulm Edgeley Dam are from the cattle feeding and watering in it and the 10 percent of the shoreline which is developed. These sources have the capability to contribute nutrients to the lake and may be the most significant source due to this proximity to the waters edge.

Table 2. Land use in the Kulm Edgeley Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	57	75
Pasture Land	25	80
Hayland	10	80
CRP	5	100
Wet/Wild[1]	1	100
Other	2	N/A
Farmsteads	2[3]	N/A
Feedlots[2]	1[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number present in watershed.

LAKE HOSKINS

MCINTOSH COUNTY

Peter N. Wax

Lake Hoskins resides in the Missouri Coteau physiographic region in south central McIntosh County three miles west of Ashley, North Dakota. Lake Hoskins is a natural lake with a small rolled earthen dam to help enhance and control lake levels. Lake Hoskins covers a total of 554 acres with a maximum depth of 10 feet and average depth of 8 feet (Figure 1). Current drought conditions have affected the reservoir with water level fluctuations from four to six feet.

Lake Hoskins is classified as a cool water fishery "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). However, the capability of the lake to support a fishery may be affected by climatic variations or other natural occurrences which may alter the lake characteristics.

Stocking records from the NDG&F show regular stockings of northern pike to help maintain a fishery. Historic NDG&F lake reports also indicate that adult yellow perch have been stocked when available.

Test netting conducted by the NDG&F in 1991 shows the presence of northern pike, yellow perch and black bullhead. The latter seem to be the dominate fish species in the lake. Lake Hoskins has a history of winterkill which makes management of the fishery difficult. During the winter of 1985-1986 a complete winterkill of all fish except black bullhead occurred.

The shore and land surrounding Lake Hoskins is 95 percent privately owned with the remaining 5 percent in public ownership. The public lands are maintained by the city of Ashley. Facilities include a boat ramp, park, picnic areas, toilets, telephone and waste dump. Lake Hoskins receives moderate use mostly by local residents.

Water Quality

Water quality samples were collected from Lake Hoskins twice during the summer of 1991 and once during the winter of 1991-1992. Samples were collected at one sample site located in the deepest area of the lake (Site 380760, Figure 1). Thermal stratification was not apparent on Lake Hoskins when the lake was sampled in July 24, 1991 and August 13, 1991 (Figure 2). Dissolved oxygen levels were fairly constant in the lake on all sample dates (Figure 3). At current water levels Lake Hoskins is shallow enough to allow frequent mixing of the water column due to wind and wave action.

Lake Hoskins is a well-buffered lake with a average volume-weighted mean total alkalinity as $CaCo_3$ concentration of 443 mg L^{-1}. The dominant anions were bicarbonates and sulfates. Bicarbonates ranged from 402 to 710 mg L^{-1}, while sulfates were between 256 to 486 mg L^{-1} with average volume-weighted mean concentrations of 488 and 310 mg L^{-1}, respectively (Table 1, Appendix A).

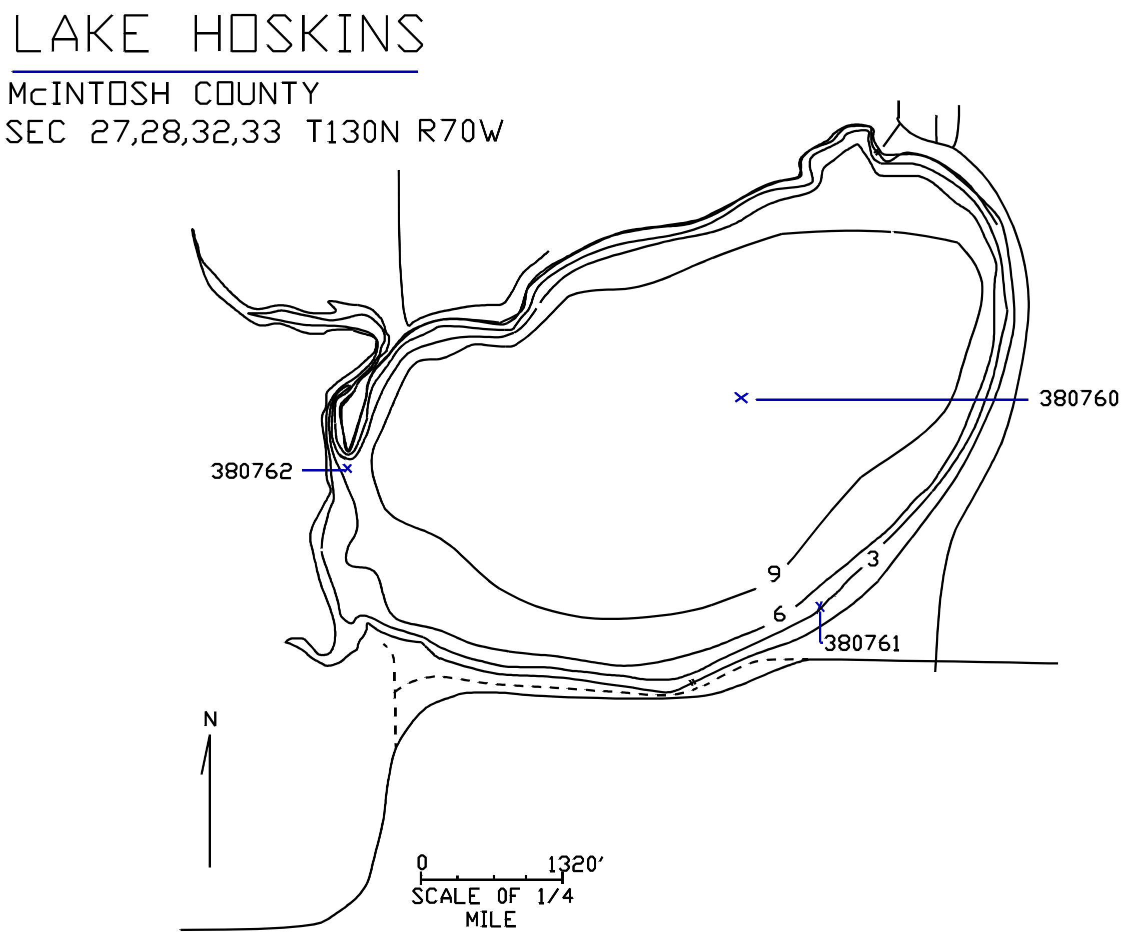

Figure 1. Morphometric map of Lake Hoskins.

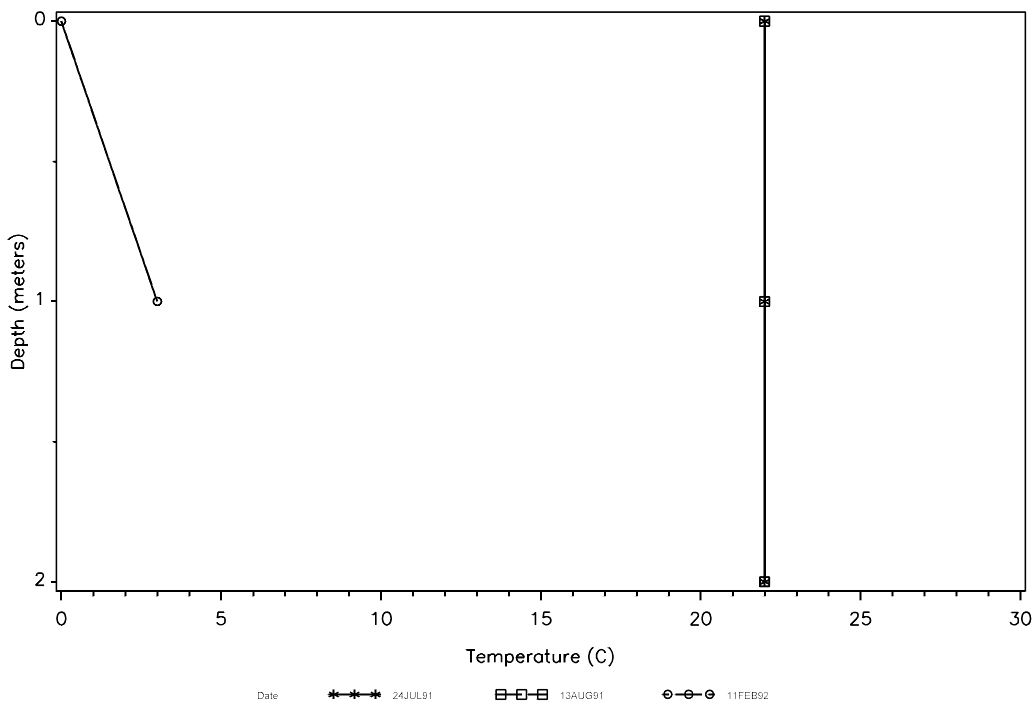

Figure 2. Temperature profile for Lake Hoskins.

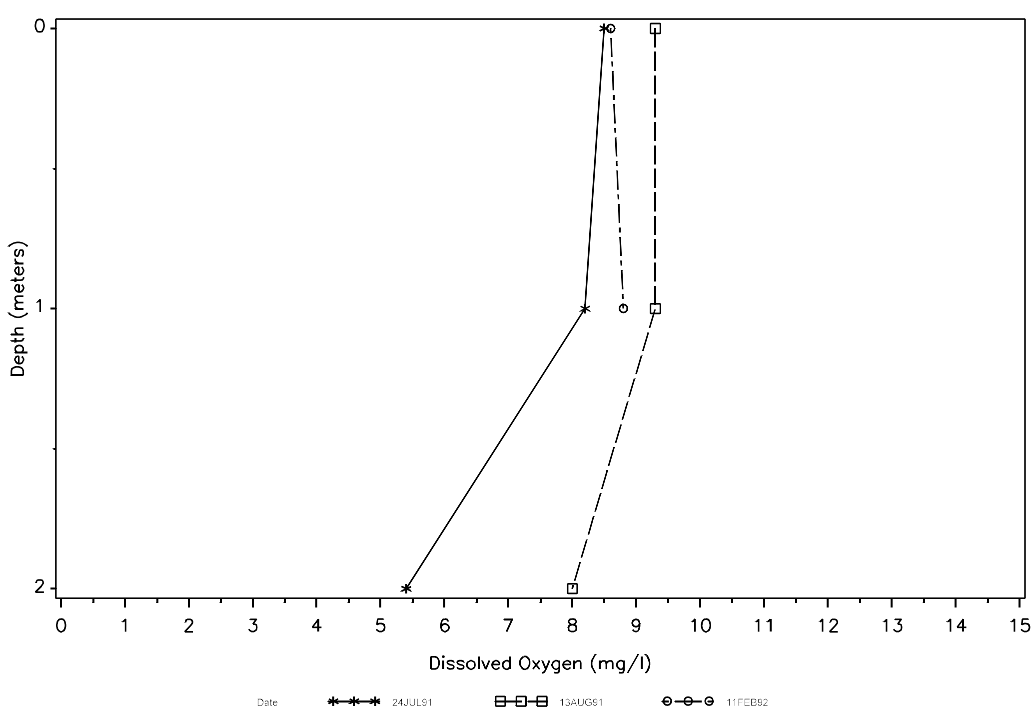

Figure 3. Oxygen profile for Lake Hoskins.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 24, 1991 and February 11, 1992, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 to December 31, 1991.

Parameter	Lake Hoskins		1982-1991	
Total Dissolved Solids	961	mg L^{-1}	1209	mg L^{-1}
Conductivity	1438	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	416	mg L^{-1}	488	mg L^{-1}
Sulfates	310	mg L^{-1}	592	mg L^{-1}
Chloride	42.08	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	1.66	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.008	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	443	mg L^{-1}	296	mg L^{-1}
Ammonia	0.041	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.26	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	448	mg L^{-1}	326	mg L^{-1}

Water quality samples indicate Lake Hoskins has high concentrations of total phosphate as P, total kjeldahl nitrogen and total dissolved solids. The ratios of total phosphate as P to nitrate + nitrite as N concentrations was 107.5:1. This ratio would normally suggest an extremely nitrogen-limited condition in the lake. However, the actual condition is caused by an overabundance of phosphorus.

Due to the large amount of phosphorus available in the water column, the lake is extremely productive. In highly productive lakes there is a large organic load from senescent phytoplankton and macrophyte which quickly depletes the water column of dissolved oxygen under ice condition and when the lake stratifies. At present, Lake Hoskins does not stratify due to wind and wave action during summer and is aerated during ice cover. A complete compilation of all 1991-1992 LWQA data is contained in Appendix A.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Lake Hoskins on August 13, 1991. At the time of the macrophyte survey, nearly 100 percent of Lake Hoskins surface area had aquatic vegetation. Sago pondweed (Potamogeton pectinatus) was found at all locations and was the dominant macrophyte present. Intermittent stands of bulrush (Scirpus spp.) and cattails (Typha spp.) were found along the shoreline as well. A map showing the areal extent of the macrophyte population on Lake Hoskins is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled twice during the summer of 1991. The largest contributors to the phytoplankton community by number were the blue-green algae, Cyanophyta, with a mean density of 2,378,125 cells mL^{-1} and the green algae, Chlorophyta, with a density of 1,238,407 cells mL^{-1}. Density expressed as volume showed a reverse in dominance with green algae at 7,386,738 μm^3 mL^{-1} and blue-greens only 4,487,057 μm^3 mL^{-1}. This difference in density by volume is due to the size differences of individual species green algae as compared to the blue-green algae. A complete list of phytoplankton data is contained in Appendix C.

Trophic Status

LWQA data collected in 1919-1992 indicates that presently Lake Hoskins is hypereutrophic. Principal indicators of a hypereutrophic lake condition are the high summer surface total phosphate as P and chlorophyll-a concentrations and low secchi disk transparency readings. Average summer surface total phosphate as P concentrations were 1.595 mg L^{-1}, chlorophyll-a was 0.029 mg L^{-1} and secchi disk transparency was 0.25 meters. Collaborating ancillary information included a phytoplankton community dominated by blue-green algae, a large macrophyte biomass, history of dissolved oxygen deficiencies necessitating the need for an aeration system in the winter, and fish kills.

Sediment Analysis

Sediments were collected from Lake Hoskins and were analyzed for trace elements, PCB's and selected pesticides. Sediment samples were collected in the deepest area of the lake, Site 380760, the littoral zone, Site 387761, and the inlet, Site 380762 (Figure 1).

Sediment samples collected from Lake Hoskins showed detectable levels of all trace elements tested for except mercury. When the results for Lake Hoskins are compared to the data all lakes assessed in 1991-1992 trace elements concentrations were similar to the median concentrations for all lakes. PCBs and pesticides were less than detection limits at all sites sampled in Lake Hoskins. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Lake Hoskins on June 11, 1991. Two species of fish were collected for contaminant analysis, northern pike represented the piscivore group, while black bullhead represented the bottom feeder group.

In order to evaluate the fish tissue data for Lake Hoskins the results for each fish group was compared to that group for all lakes assessed in 1991-1992. Trace elements concentrations for the piscivore group from Lake Hoskins were at or below the median concentrations for all piscivores sampled in 1991-1992 except for zinc, chromium and selenium which were about the 75th percentile. Trace element concentrations in the bottom feeder group from Lake Hoskins were slightly lower than the median for all bottom feeders tested in 1991-1992 except for barium and selenium which were near the 75th percentile. Mercury concentrations were not high enough to suggest the need for a consumption advisory.

Detectable pesticide residues in each composite fish sample collected from Lake Hoskins were limited to DDD, DDE and trifluralin for the piscivore sample, and DDE and trifluralin for the bottom feeder sample. DDD and DDE are breakdown derivatives of DDT while trifluralin is a selective preemergent herbicide known as Treflan. A complete listing of the fish tissue results is provided in appendix E.

Watershed

The Lake Hoskins watershed encompasses over 25,000 acres in the Missouri Coteau physiographic region in south central McIntosh County. Nonpoint source pollution accounts for all the nutrient loading and pollution discharges to Lake Hoskins.

Land use within the Lake Hoskins watershed is 89 percent agricultural with 46 percent in active crop production. The remaining 11 percent is in the Conservation Reserve Program (CRP), wildlife/wetland areas and other lands including roads and farmsteads (Table 2). In the assessed watershed area there are 22 farmsteads and 10 concentrated livestock feeding areas. These livestock areas are located throughout the watershed with a few located very near the lake. These may be contributing substantially to the lake through runoff and should be evaluated in greater detail. Other concentrated feeding areas may also be contributing but have less of an impact since runoff can be absorbed and nutrients taken up in the vegetation before it reaches the lake.

According to the information provided by the McIntosh County Soil Conservation District, 56 percent of the cultivated lands and even less of the other agricultural lands within the Lake Hoskins watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion and soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). For the state of North Dakota this estimated "T" value should be less than 5 tons per acre per year. The estimated soil loss in the Lake Hoskins watershed is 288,000 tons of soil loss annually, this is just over 11 tons per acre soil loss per year. Assuming a conservative delivery rate at 10 to 15 percent, between 28,000 and 43,000 tons of soil reaches Lake Hoskins annually.

Table 2. Land use in the Lake Hoskins watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	46	51
Range	33	29
Hayland/Pasture	16	22
CRP	3	100
Wet/Wild[1]	5	N/A
Other	2	N/A
Farmsteads	22[3]	N/A
Feedlots[2]	10[3]	0

[1] Wet/Wild are wildlife management areas, wetlands and lakes.
[2] Feedlots are areas where livestock are concentrated to be fed.
[3] Number of farms and feedlots.

LAKE LAMOURE

LAMOURE COUNTY

Peter N. Wax

Lake LaMoure is a manmade reservoir, located on Cottonwood Creek just south of the city of LaMoure in LaMoure County, North Dakota. It is an earthen dam with a concrete outlet and emergency spillway equipped with a hypolimnetic drawdown. The reservoir was created in 1973. It has a surface area of 495 acres, a maximum depth of 36.5 feet, and a volume of 7,755 acre feet at full pool (Figure 1). Lake LaMoure was created primarily for water based recreation in an area of the state with few natural lakes.

The landscape surrounding Lake LaMoure is characterized by level to nearly level topography with well defined drainages. Nearly 100 percent of the watershed is in agricultural production. Soils are fertile, moderately permeable and moderately well drained.

Lake LaMoure is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manages the fishery through annual evaluations of the fish community through test netting operations and stocking accordingly. In recent years, the stocking regimen has included walleye, muskie, northern pike and largemouth bass.

The NDG&F began managing the fishery in 1974 by introducing rainbow trout followed by walleye, tiger muskie, pure muskie, brown trout, largemouth bass, bluegill, crappie, and smallmouth bass. Possible incomplete eradication before dam closure combined with unauthorized stockings by the public have contributed bullheads, yellow perch, rock bass, catfish, suckers and carp. In all, the fish community is composed of eight fish species managed by the NDG&F and seven introduced by the public or naturally occurring.

The rainbow trout fishery was initially successful but declined as the walleye and other piscivore populations matured. Test netting operations performed in the spring of 1991 show a fish community dominated by crappie. Other species captured were black bullheads, white suckers, carp and muskie.

Developments to Lake LaMoure have included the installation of a concrete boat ramp, creation of a city park, which has a swimming beach, playground, camp sites and picnic area. Access to the lake is good from county and state roads.

Water Quality

Water quality samples were collected from Lake LaMoure two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 380795, Figure 1). Water column samples were collected for analysis at three depths, 1 meter, 5 meters, and 10 meters. During the summer of 1991, samples collected on Lake LaMoure showed no distinct thermal stratification (Figure 2). At the time samples were collected dissolved

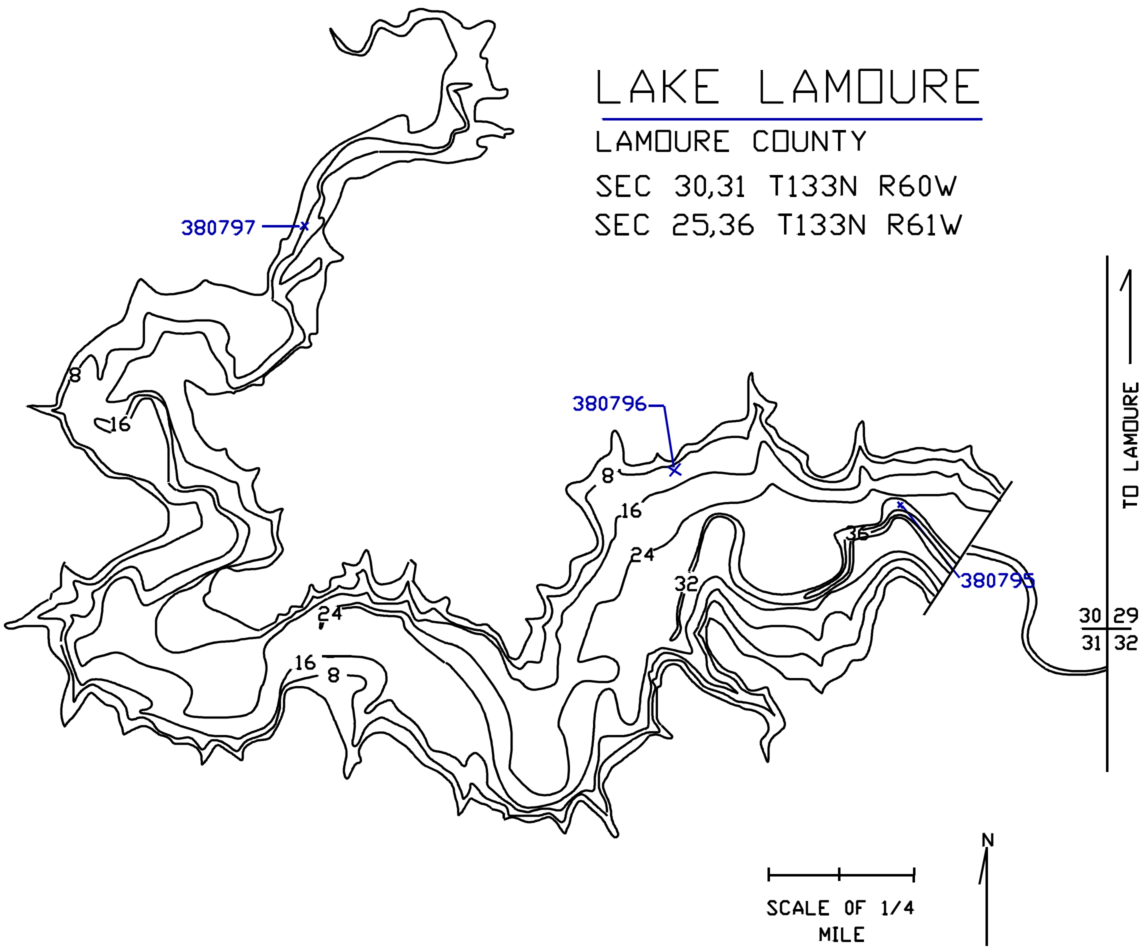

Figure 1. Morphometric map of Lake LaMoure.

oxygen concentrations were adequate to maintain aquatic life ranging from above 10 mg L^{-1} at the surface to between 0.5 and 3.4 mg L^{-1} near the bottom (Figure 3). Samples collected during the winter of 1992 showed dissolved oxygen concentrations ranging from 7.6 mg L^{-1} at the surface to 3.4 mg L^{-1} at the bottom (Figure 2 and 3).

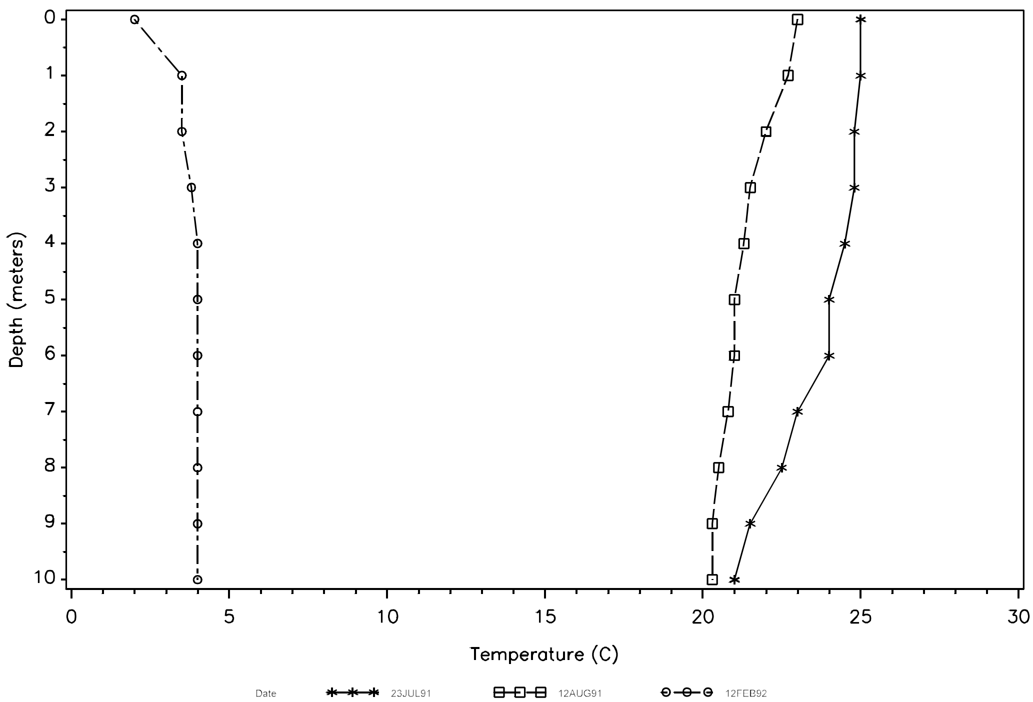

Figure 2. Temperature profile for Lake LaMoure.

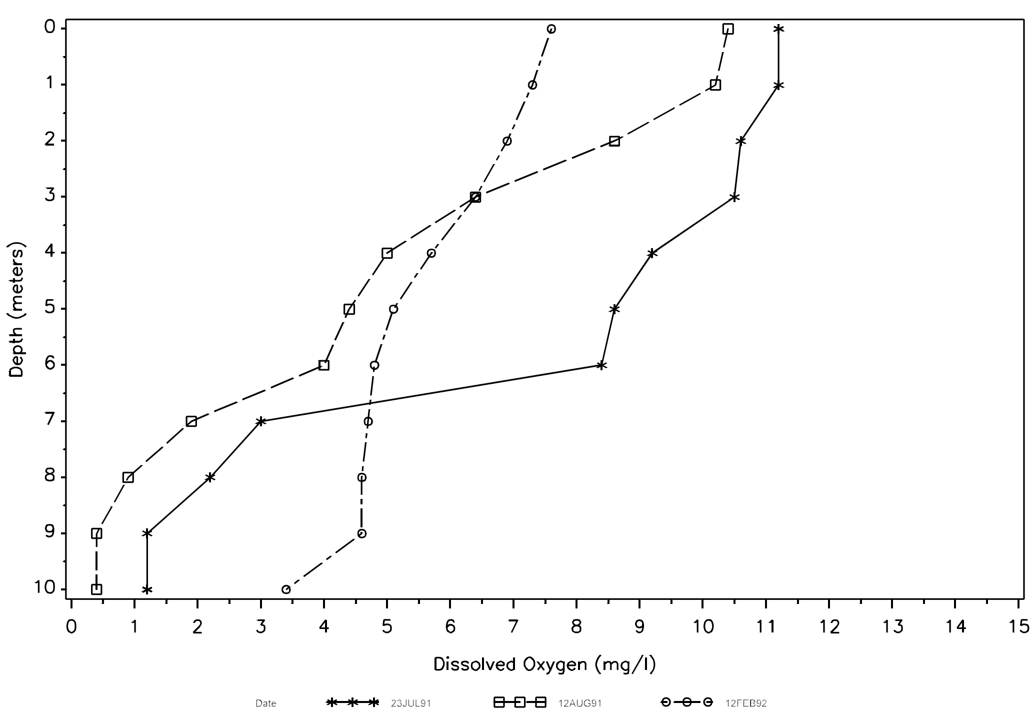

Figure 3. Dissolved oxygen profile for Lake LaMoure.

Sulfate and bicarbonates were the dominant anions in the water column. Sulfate concentrations ranged from 53 to 76 mg L^{-1} while bicarbonate concentrations were between 178 and 258 mg L^{-1}.

The average volume-weighted mean total phosphate as P concentration was 0.137 mg L^{-1} and exceeded the state's target concentration of 0.02 mg L^{-1} on all occasions sampled during 1991 and 1992. The nitrate + nitrite as N concentrations were below the target concentration of 0.25 mg L^{-1} on all occasions sampled with an average volume-weighted mean concentration of 0.140 mg L^{-1}. A complete list of water quality sample data is provided in Appendix A (Table 1).

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July and August, 1991 and January 1992, and long-term averages from all North Dakota data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	LaMoure Lake		1982-1991	
Total Dissolved Solids	305	mg L^{-1}	1209	mg L^{-1}
Conductivity	536	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	215	mg L^{-1}	488	mg L^{-1}
Sulfate	63	mg L^{-1}	592	mg L^{-1}
Chloride	19.6	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.137	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.140	mg L^{-1}	0.069	mg L^{-1}
Total Kjeldahl Nitrogen	1.65	mg L^{-1}	2.34	mg L^{-1}
Ammonia	0.261	mg L^{-1}	0.347	mg L^{-1}
Bicarbonate	216	mg L^{-1}	326	mg L^{-1}
Total Alkalinity	191	mg L^{-1}	296	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Lake LaMoure on August 12, 1991. The survey was preformed by sampling at one meter depth intervals along transects bisecting the entire width of the lake. At the time of the survey, no submerged macrophyte vegetation was observed on Lake LaMoure. Along the southern shore and inlet areas, intermittent cattails (Typha spp.) were identified. A macrophyte map is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled two times during the summer of 1991. Lake LaMoure's phytoplankton community during the summer of 1991 was represented by 3 divisions and 22 genera. The largest contributors in terms of density were the blue-green algae, Cyanophyta, with 10 genera present. The second most common division by density were the green algae, Chlorophyta with 9 genera represented. The mean density of the blue-green algae for the two sample periods was 194,414 cell mL^{-1}, representing a population two times greater than the mean for all other divisions combined. The dominant species of blue-green was Aphanizomenom flos aquae.

During the July sampling period mean phytoplankton concentrations by volume were dominated by the blue-green algae. The concentrations of blue-green algae was 12,039,016 $\mu m^3 L^{-1}$ and represented a dominance ratio of 8 to 1 when compared to all other divisions combined. In August a much smaller and more diversified community as represented by volume was identified, with concentrations of Chlorophyta, Cyptophyta, and Cyanophyta having a 1:2:3 ratio, respectively. A complete list of the phytoplankton data is contained in Appendix C.

Trophic Status

Trophic status estimates for Lake LaMoure based on total phosphorous, chlorophyll-a concentrations and secchi disk transparency agreed quite well and suggest Lake LaMoure is in an advanced stage of eutrophication, bordering on hypereutrophication.

An examination of the ancillary information for Lake LaMoure, also suggests it is eutrophic. This evaluation is due in large part to the significant nuisance algae blooms experienced in the summer months and an phytoplankton community dominated by blue-greens. Also, before the carp population became abundant, local reports suggests there was a heavy macrophyte density throughout the littoral zone and inlet areas of the lake.

Sediment Analysis

Sediments were collected from Lake LaMoure and analyzed for trace elements, PCBs, and selected pesticides. Sediments samples were collected from the deepest area of the lake (Site 380795), the littoral zone (Site 380796), and the inlet (Site 380797) (Figure 1).

Sediment samples collected from Lake LaMoure showed detectable levels of all trace elements tested for except mercury. Sediment concentrations at each sample location within Lake LaMoure were also compared to the concentrations reported for all lakes assessed as part of the 1991-1992 LWQA project. Trace element concentrations were generally near the median concentrations for all lakes sampled during the 1991-1992 LWQA project with the exception of barium in the deepest area which was near the 75th percentile. Concentrations of selected organic compounds were below detectible limits for all samples collected from Lake LaMoure. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Walleye, crappie and carp were collected for contaminant analysis from Lake LaMoure in 1991. The walleye collected represent the piscivore group, the carp collected represented the bottom feeder group and crappie the insectivore group.

In order to evaluate the fish tissue data for Lake LaMoure, the results for each fish group were compared to that group for all lakes assessed during the 1991-1992 LWQA project. Trace element concentrations in fish samples collected from Lake LaMoure varied among species in comparison to the median concentrations for all fish collected during the 1991-1992 LWQA project.

The insectivore sample collected from Lake LaMoure displayed trace element concentrations that were generally near or slightly above the median concentration for all lakes sampled. Trace element concentrations reported in the bottom feeder sample were near or slightly above the median concentrations for all lakes sampled with the exception of zinc, which was four and a half times the reported median. The piscivore sample showed trace element concentrations that were generally near or above the reported median. The exception was mercury which was approximately three times the median with a concentration of 0.67 $\mu g\ L^{-1}$ and 0.03 $\mu g\ L^{-1}$.

Detectable pesticide residues in the whole fish samples collected from Lake LaMoure included DDD, DDE, dieldrin, nonachlor and trifluralin. DDD and DDE are degenerate products of DDT and exhibit similar properties of the parent compound. Dieldrin is a insecticide that was primarily used for grasshopper control and is presently no longer in use. Dieldrin rapidly accumulates in invertebrates from a few hundred to several thousand times the exposure level in concentrations as low as 50 $\mu g\ L^{-1}$. Nonachlor is a stable degenerate by-product of chlordane an insecticide that is highly toxic to aquatic biota. Chlordane also is no longer in use. Trifluralin commonly known as Treflan, is a selective pre-emergent herbicide still in use.

The walleye sample collected from Lake LaMoure displayed detectable concen-trations of DDE, dieldrin, nonachlor and trifluralin. The concentrations of nonachlor, trifluralin and dieldrin were above the reported median concen-trations for the piscivore group, while DDE was below. The crappie collected from Lake LaMoure had showed detectable concentrations of trifluralin and DDE. The reported trifluralin concentration in the crappie sample collected was the same as the median concentration for all insectivores, while DDE was below. Reported concentrations of pesticide residues in the bottom feeder group were below the median concentration for all bottom feeder samples collected as part of the 1991-1992 LWQA project.

Watershed

Lake LaMoure's watershed is characterized by highly fertile uplands, primarily in row crop and small grain production, and well defined drainages used in livestock production. According to the LaMoure County Soil Survey, the predominant soils in the watershed are Barnes-Svea loam. These soils are formed on slopes of 3 to 6 percent and are deep, medium textured, well drained to moderately well drained soils on undulating uplands. These soils are very fertile with high moisture-holding capabilities. Most of these soils in the watershed are cultivated. These soils are resistant to wind erosion but moderately susceptible to water erosion. Watershed covers approximately 107,000 acres and contributes nearly 100 percent of the pollution loadings to Lake LaMoure.

Land use within the Lake LaMoure watershed is 94 percent agricultural with 66 percent actively cultivated. The remaining 34 percent is in low density urban development, haylands, pasture, Conservation Reserve Program (CRP) (Table 2). According to information provided by the

LaMoure County Soil Conservation District, 75 percent of the cultivated lands and 80 percent of the remaining lands within the Lake LaMoure watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Lake LaMoure watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of 3 tons per acre, which takes into account the untreated portions of the watershed approximately 316,820 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 31,682 and 47,523 tons of soil reaches Lake LaMoure annually.

Other sources of nonpoint source pollution to Lake LaMoure include the 50 trailers adjacent to the lake with their attached septic and from the 70 concentrated livestock feeding areas in the watershed. These sources are contributing nutrients to the lake and due to their close proximity to the lake and its tributaries may be imparting the most significant impact. Fertilizer runoff from lawns and new construction activities are other possible sources of nonpoint source pollution to Lake LaMoure.

Table 2. Land Use in the Lake LaMoure watershed

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	66	75
Rangeland	5	80
Hayland	20	80
CRP	3	100
Wet/Wild[1]	3	100
Other	3	N/A
Farmsteads	14[3]	N/A
Feedlots[2]	70[3]	10

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number present in watershed.

Though no official point source pollution discharges are documented in the Lake LaMoure watershed, both the town of Judd and the Fairview Settlement have discharge permits. The Fairview Settlement experienced an accidental bypass between lagoon cell 1 and 2 causing a sewage spill to Cottonwood Creek in the fall of 1991.

LONG LAKE

MCLEAN COUNTY

Peter N. Wax

Long Lake is a natural lake created by glacial action during the late Wisconsin Age. It is the third lake in a chain of four lakes located in the Missouri Coteau. Long Lake is north of the town of Turtle Lake in northeastern McLean County, North Dakota (Figure 1). As its name implies, it is long and narrow, with a mean depth of 5.1 feet, a maximum depth of 8 feet. It has a surface area of 206 acres (Figure 2).

Long Lake and its contributing watershed have a combined surface area of 2,625 acres. Discharges from Strawberry Lake in the spring of the year are the primary source of surface water recharge for Long Lake. Watershed land use is over 91 percent agricultural, with approximately 10 percent actively cultivated.

Topography of the surrounding watershed is characterized by many integrated drainages, hills and valleys and is typical of the northern prairie pothole region. Soils are predominantly well to excessively well drained, formed from sandy, rocky, glacial material.

Long Lake is classified as a marginal fishery "Waters capable of supporting a fishery on a seasonal basis" (NDSDHCL 1991). The NDG&F manages Long Lake as a marginal fishery through annual fish community assessments and occasional stockings of fish species tolerant to low dissolved oxygen conditions. The initial fishery was established on Long Lake between 1932 and 1951 through natural migrations from Strawberry.

The NDG&F first stocked Long Lake in 1984 with northern pike. Fish have been stocked almost yearly since that time. Fish species stocked include walleye, northern pike, yellow perch and bluegill. Test netting operations conducted in the spring of 1991 captured yellow perch, northern pike and bluegill.

A gabbian barrier was constructed at the outlet of Long Lake in the summer of 1984. This structure was designed to prevent movement of spawning fish from traveling upstream into Long Lake from Crooked Lake. Previous to the construction of the barrier, fish would become trapped in Long Lake and parish due to oxygen depletion the following winter.

Public use of Long Lake is light to moderate during all seasons of the year. A single public access is located on Long Lake. Public facilities include a boat ramp and associated parking.

Water Quality

Water quality samples were collected from Long Lake two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381335, Figure 2). Water column samples were collected for analysis at three separate depths in the summer of 1991 and two during the winter of 1992. July and August samples were collected at the surface, 1 and 2 meter depths. January samples were collected at 1 and 2 meter depths.

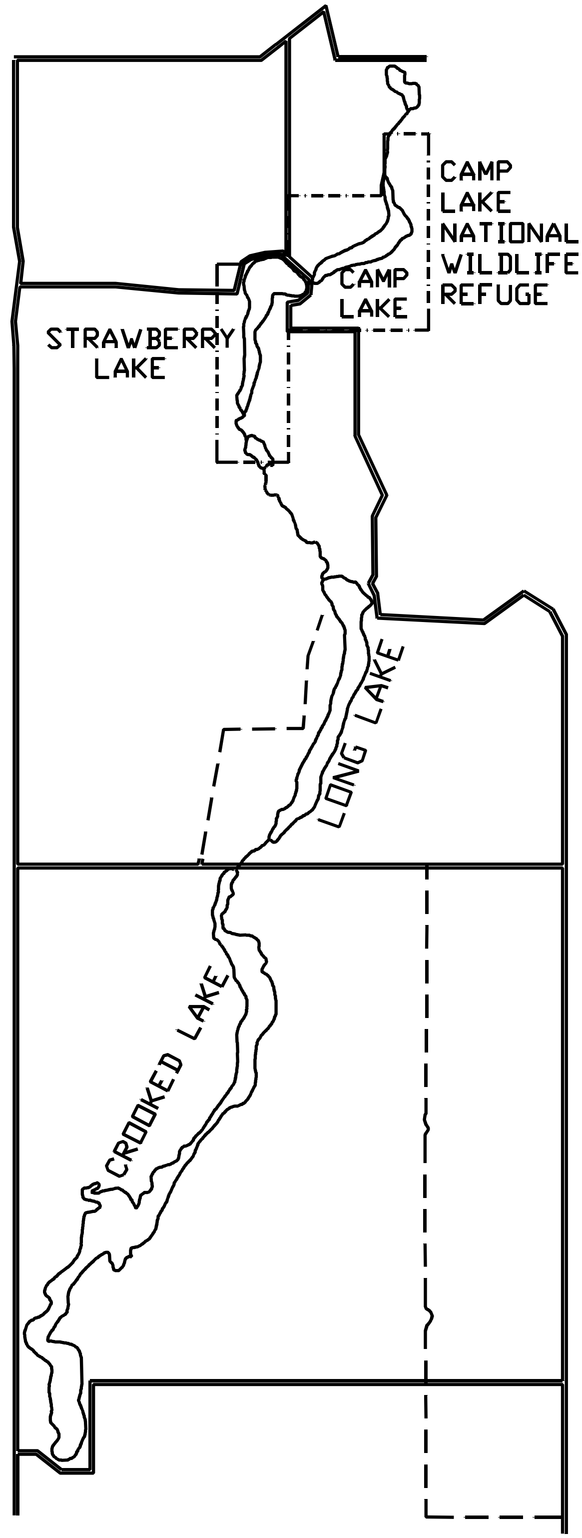

Figure 1. Map showing Long Lake in relation to string of four lakes.

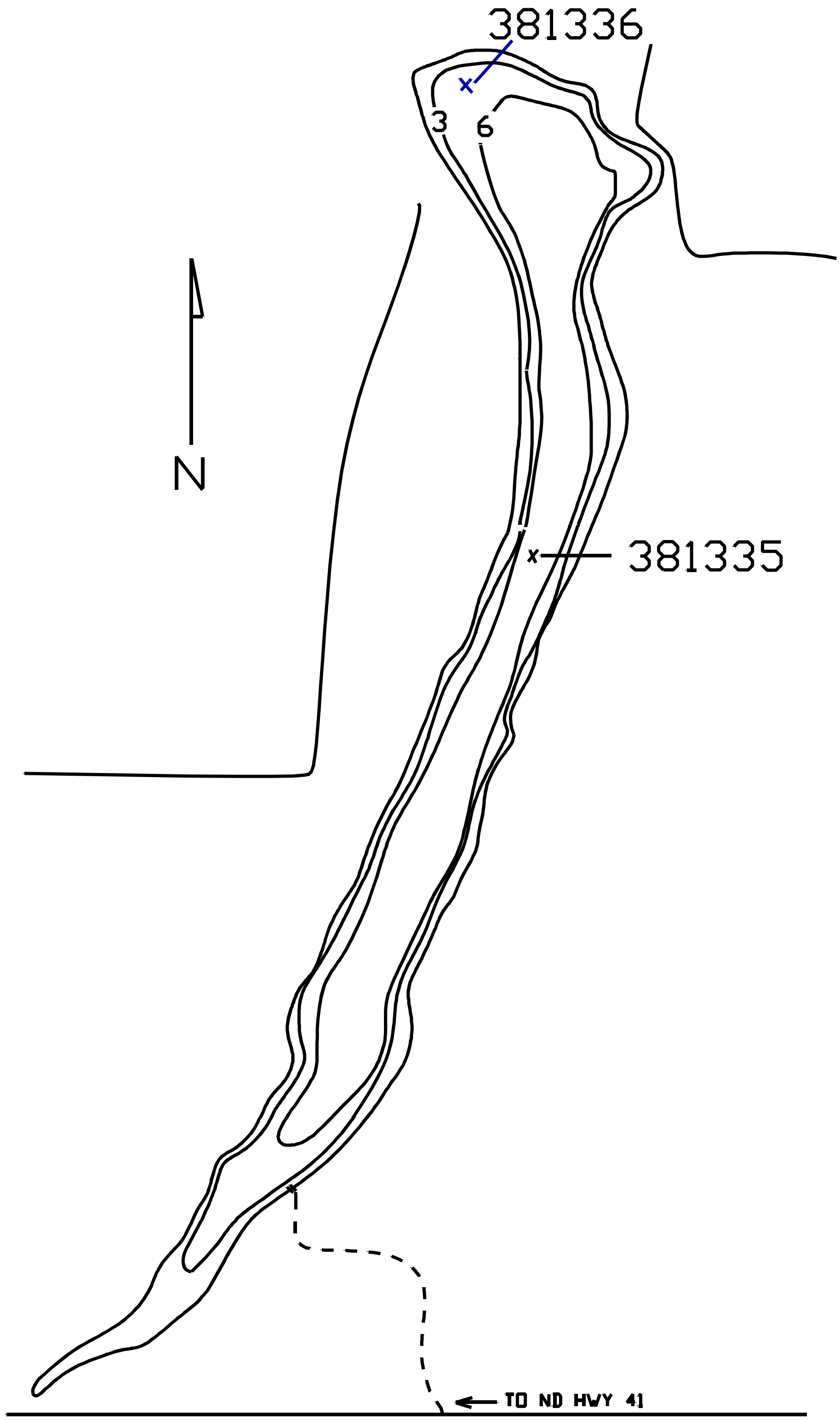

Figure 54. Morphometric map of Long Lake.

During the summer of 1991, Long Lake was not thermally stratified during either of the two sampling times (Figure 3). At these sample times, dissolved oxygen concentrations were between 8.5 and 3.5 mg L^{-1} and were adequate to maintain aquatic life (Figure 4).

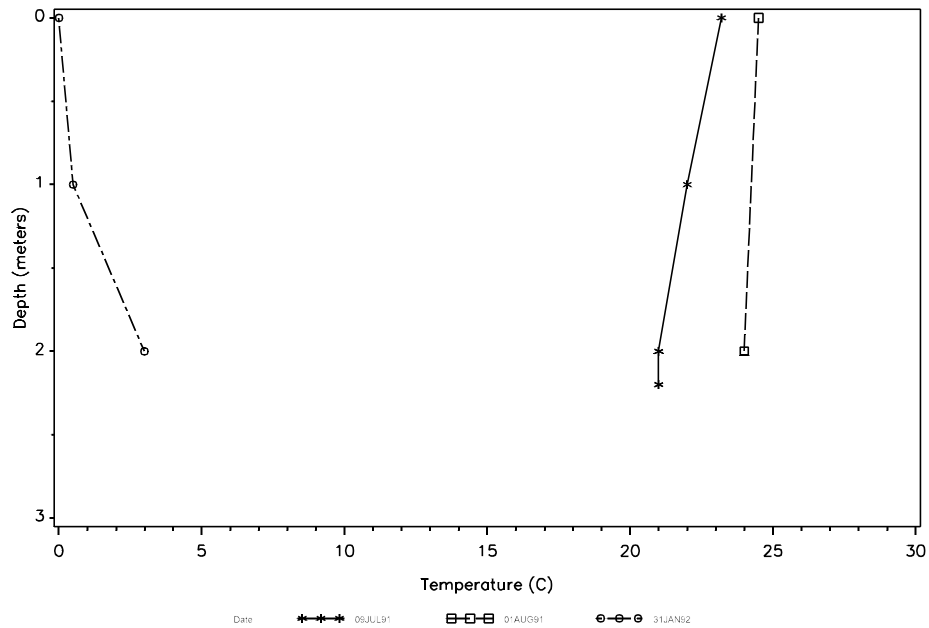

Figure 55. Long Lake oxygen profiles for July and August, 1991, and January, 1992.

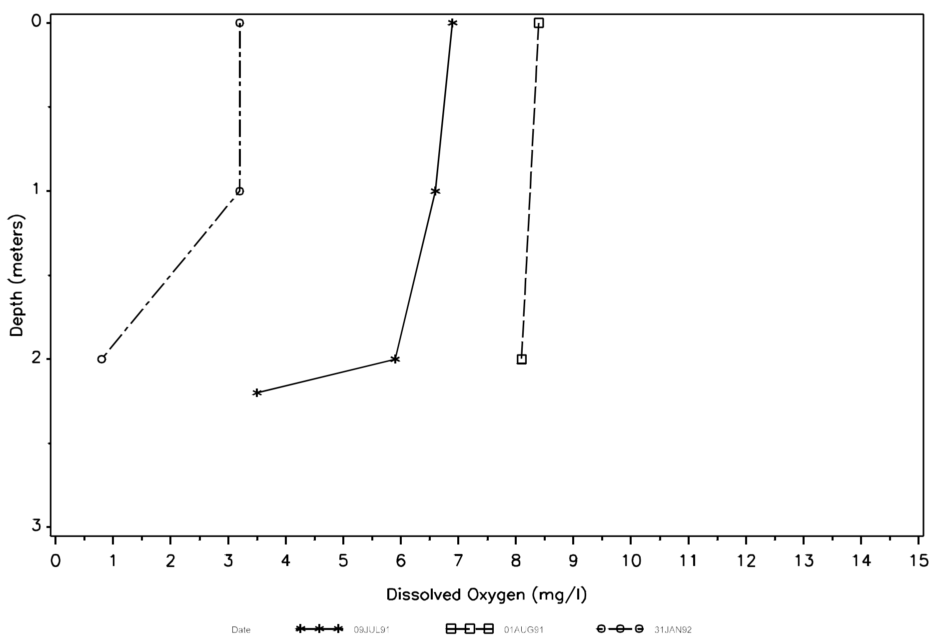

Figure 56. Long Lake dissolved oxygen profiles for July and August, 1991 and January, 1992.

Samples collected during January 1991 suggest Long Lake was thermally stratified at approximately 1 meter below the lakes surface. Thermal stratification is difficult to determine, since the lake was only 2 meters deep at this time. Oxygen concentrations were near 3 mg L^{-1} above the 1 meter depth interval and between 3.0 mg L^{-1} and 0.6 mg L^{-1} below (Figures 3 and 4).

Sulfate and bicarbonates were the dominant anions in the water column. Sulfate concentrations ranged from 87 to 130 mg L^{-1} while bicarbonate concentrations were between 259 and 348 mg L^{-1}. Total dissolved solids and hardness concentrations and conductivity were considerably less than the long-term average for lakes in North Dakota sampled between January 1, 1982, and December 31, 1991 (Table 1).

The average volume-weighted mean total phosphorus as P concentration was 0.047 mg L^{-1} exceeding the State's target concentration of 0.02 mg L^{-1} on all occasions sampled during 1991 and 1992. The volume-weighted mean nitrate + nitrite as N concentration was below the state's target concentration of 0.25 mg L^{-1}, at 0.16 mg L^{-1}. A complete list of the water quality data for Long Lake is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 1991 and January 1992, and long-term averages for all North Dakota lake data collected by the NDSDHCL between
January 1, 1982, and December 31, 1991.

Parameter	Long Lake	1982-1991
Dissolved solids	473 mg L^{-1}	1209 mg L^{-1}
Conductivity	801 umhos cm^{-1}	1604 umhos cm^{-1}
Hardness as calcium	341 mg L^{-1}	488 mg L^{-1}
Sulfates	101 mg L^{-1}	592 mg L^{-1}
Chlorides	9.37 mg L^{-1}	81 mg L^{-1}
Total phosphate as P	0.047 mg L^{-1}	0.248 mg L^{-1}
Nitrate + Nitrite as N	0.016 mg L^{-1}	0.069 mg L^{-1}
Total Alkalinity	321 mg L^{-1}	296 mg L^{-1}
Ammonia	0.191 mg L^{-1}	0.347 mg L^{-1}
Total kjeldahl nitrogen	2.00 mg L^{-1}	2.34 mg L^{-1}
Bicarbonate	344 mg L^{-1}	326 mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Long Lake on August 1, 1991. At the time of the macrophyte survey, nearly 100 percent of Long Lake's surface area had submergent and emergent macrophyte vegetation. The macrophyte community was composed of water milfoil (Myriophyllum spp.), sago pondweed (Potamogeton pectinatus), curly leaf pondweed (Potamogeton crispus), and bulrush (Scirpus spp.). The dominant species was water milfoil occupying nearly 90 percent of the entire surface area. A map depicting the areal extent of the macrophyte community is contained in Appendix B.

Phytoplankton

Long Lake's phytoplankton community during the summer of 1991 was relatively diverse with representation from 6 divisions and 39 genera. Blue-green algae, Cyanophyta, were the dominant division by number both sample times in the summer of 1991. The dominance by blue-green algae was substantial, with a mean density of 271,789 cells mL^{-1}. The blue-green algae were 35 times greater than all the other groups combined.

At the time of the LWQA, mean phytoplankton concentrations by volume were relatively more evenly distributed among four of the six divisions; Bacillariophyta, Chlorophyta, Cyanophyta, and Cryptophyta. The division Pyrrophyta experienced a large advantage by volume in August. This substantial increase in volume over the other species present is due to the large size of the species Ceratium hirundinella and Glenodinium gymnodinium. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

LWQA data collected on Long Lake during the summer of 1991 described a hypereutrophic lake condition. This hypereutrophic assessment was based on the primary indicator, surface total phosphate as P, chlorophyll-a and secchi disk depth transparency. Surface total phosphate as P concentrations averaged 90 $\mu g\ L^{-1}$, while chlorophyll-a concentrations averaged 10 $\mu g\ L^{-1}$ and secchi disk transparency depth averaged 1.0 meters. Other ancillary information used in describing Long Lake's trophic status was a large macrophyte biomass, an abundant phytoplankton community dominated by Cyanophyta, frequent algal blooms, low dissolved oxygen conditions and history of fish kills.

Sediment Analysis

Sediments were collected from Long Lake and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381335) and the littoral zone (Site 381336, Figure 1). No inlet sample was collected from Long Lake.

Sediment samples collected from Long Lake showed detectable levels of all trace elements tested for, except mercury at both locations and selenium in the littoral area. Trace element concentrations in the sediments from both sample locations were also compared to the concentrations reported for all lakes assessed in 1991-1992. Reported trace element concentrations were below the median concentrations for all lakes sampled. PCB concentrations and concentrations of selected organic compounds were below detectible limits for all samples collected from Long Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Long Lake on June 19, 1991. A composite sample consisting of five northern pike, represented the piscivore group. This had a mean weight of 1086 grams and a mean length of 550 centimeters.

In order to evaluate the fish tissue data for Long Lake, the results were compared to the data collected for the piscivore group for all lakes assessed in 1991-1992. Trace element concentrations in the fish samples collected from Long Lake were generally near or slightly below the median concentration for all fish collected during 1991-1992 assessment, with the exception of zinc, which was two fold the median.

Detectable pesticide residues in the composite whole fish sample collected from Long Lake were DDD and DDE. Both DDD and DDE are breakdown derivatives of DDT and exhibit similar characteristics to the parent compound in the ecosystem. Reported concentrations of DDD and DDE in the northern pike collected from Long Lake was 0.005 and 0.019 $\mu g\ g^{-1}$, respectively. The reported concentration of DDD is near the median concentration for all piscivores sampled, while the reported concentration for DDE is two fold the median concentration and above the 75th percentile. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Long Lake and its contributing watershed cover a surface area of 2,625 acres. In addition to the 2,625-acre watershed, Long Lake receives much of its yearly surface water budget from Strawberry Lake (Figure 1). Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loadings and pollution discharges to Long Lake.

Land use within the Long Lake watershed is 91 percent agricultural, with only 10 percent actively cultivated. The remaining 90 percent is in haylands, pasture, Conservation Reserve Program (CRP) and wildlife management areas (Table 2). There are two concentrated livestock feeding areas within the contributing drainage and two farmsteads. According to the information provided by the McLean County Soil Conservation District, 75 percent of the cultivated lands and between 90 and 95 percent of the remaining lands within the Long Lake watershed are "adequately treated" against soil loss.

It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Long Lake watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of 2 to 3 tons per acre, which takes into account all land uses within the watershed, approximately 5,810 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 554 tons to 831 tons of soil potentially reaches Long Lake annually.

Other nonpoint source pollution impacts to Long Lake include the cabins and developments on Strawberry Lake, livestock feeding and watering in the immediate drainage and construction activities. It is likely that the 130 summer and permanent homes on Strawberry Lake only impact Long Lake's water quality only during high flows and then only minimally as Strawberry Lake acts as a trap, assimilating a significant portion of the nonpoint pollutants discharged from these sources. Concentrated livestock feeding areas have a greater potential for negatively impact Long Lake due to their close proximity to the lake. This is especially true of the concentration livestock feeding area located on the northwest bank of Long Lake.

Table 2. Land use in the Long Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	10	75
Pasture land	69	95
Hayland	2	90
CRP	10	100
Wet/Wild[1]	9	N/A
Other	0	N/A
Farmsteads	2[3]	N/A
Feedlots[2]	2[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

MATEJCEK DAM

WALSH COUNTY

Peter N. Wax

Matejcek Dam is located on the Middle Branch of the Forest River in southeastern Walsh County, North Dakota. It was constructed for the dual-purpose of flood control and recreation by the Soil Conservation Service (SCS) under the Watershed Protection Plan. Additional support and funds for the construction of Matejcek Dam were secured through the NDG&F and Walsh County. The Dam was completed in August, 1966 and filled in the spring of 1967. The lake has a surface area of 130.4 acres and a maximum depth of 40 feet (Figure 1). The impoundment dam also serves as a farm to market road.

Matejcek Dam is classified as a cold water fishery, "Waters capable of supporting growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991) and assigned the beneficial uses of recreation, agriculture, aquatic life and municipal water supply. The fishery is managed by the NDG&F. Management includes annual fish community assessments through test netting, fish stockings, and biological and habitat manipulations.

The fishery was established on Matejcek Dam in 1967 following a complete chemical eradication of the watershed. The fishery was first established by stocking rainbow trout and walleye. This initially fishery slowly declined due to an over abundance of white suckers which necessitated a second chemical eradication in 1978. In 1979 walleye and rainbow trout were stocked again. Eventually the rainbow trout fishery was phased out as stockings of crappie and bluegill were initiated in 1982 and 1983. Recent stockings have included northern pike, walleye, smallmouth bass and muskie. Test netting operations conducted in the spring of 1991 captured, in order of most abundant, black crappie, white suckers, walleye, northern pike and yellow perch.

Matejcek Dam's shoreline is approximately 98 percent privately owned with two public access points. Public facilities include a boat ramp, parking, picnic area, beach area and toilets. Public facilities are maintained by the Walsh County Park Board and the NDG&F. Public use is heavy to moderate depending on the season and the status of the fishery.

Water Quality

Water quality samples were collected from Matejcek Dam two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381270, Figure 1). Water column samples were collected for analysis at three separate depths, 1, 6, and 12 meters in July and August, 1991 and at 1, 6, and 11 meters in February 1992.

During the summer of 1991 sample periods Matejcek Dam was thermally stratified at approximately 5 meters of depth below the lake surface in July and August, 1991 (Figure 2). Matejcek Dam experiences rapid oxygen depletion below the hypolimnion and under ice cover conditions (Figure 3). During these time periods, dissolved oxygen concentrations were near saturation to the depth of stratification and were adequate to maintain aquatic life (Figure 3). Samples

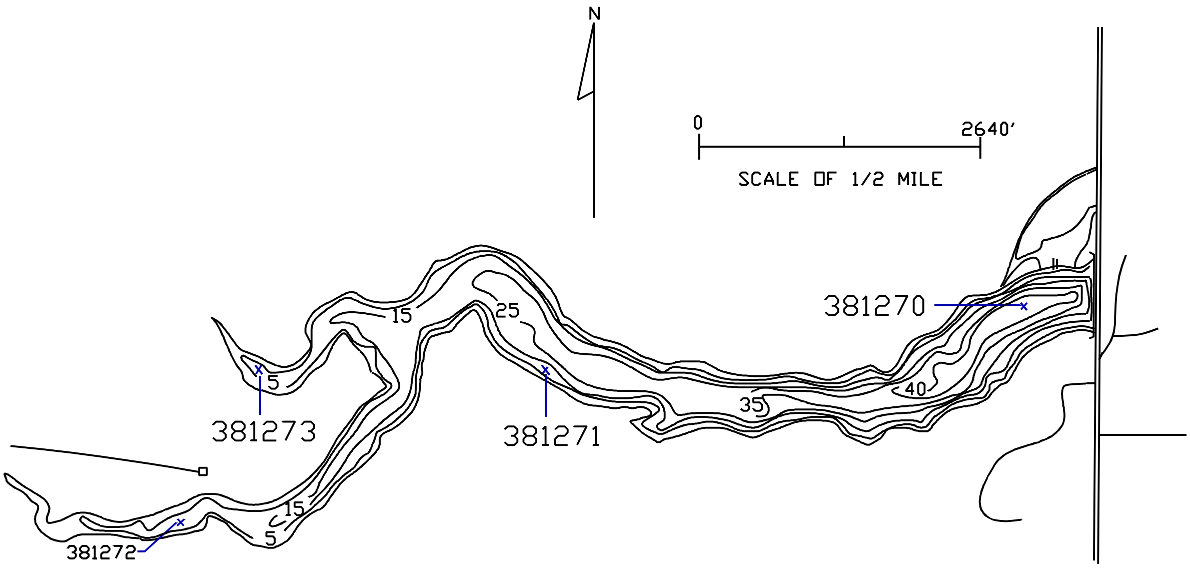

Figure 1. Morphometric map of Matejcek Dam.

collected during February of 1992 showed thermal stratification occurring on Matejcek Dam between 1 and 3 meters of depth below the lakes surface (Figure 2). Dissolved oxygen concentrations were adequate above thermocline with concentrations between 7.8 mg L^{-1} and 6.4 mg L^{-1}. Dissolved oxygen concentrations ranged between 0.7 mg L^{-1} to 1.0 mg L^{-1} below the thermocline during both the two summer sampling periods and during the winter (Figure 3).

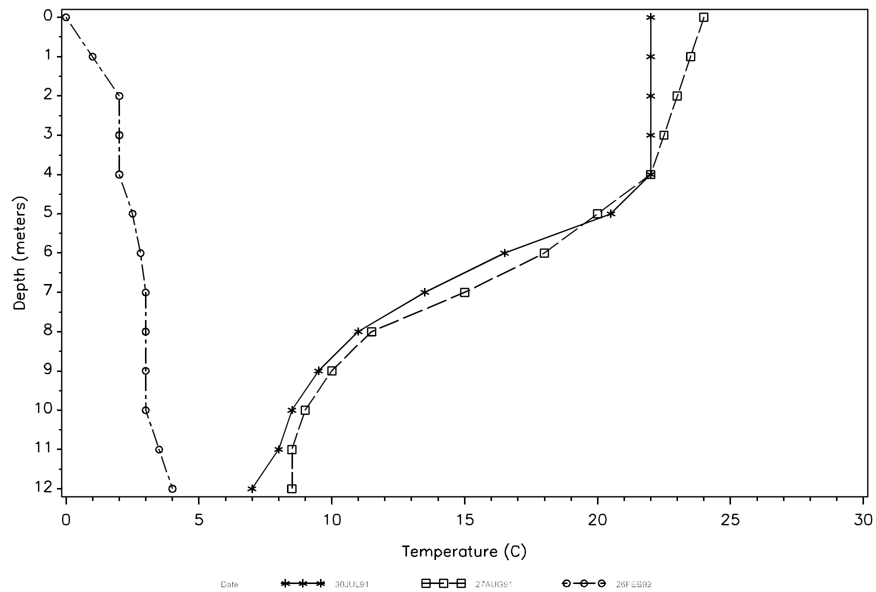

Figure 2. Temperature profiles for Matejcek Dam.

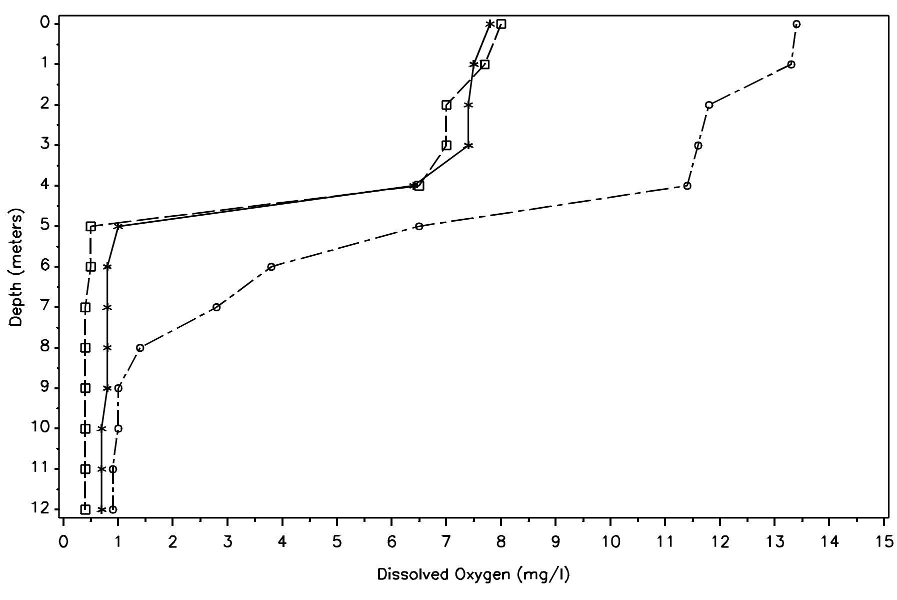

Figure 3. Oxygen profiles for Matejcek Dam.

Matejcek Dam is a well-buffered reservoir with a average volume-weighted mean total alkalinity as $CaCO_3$ concentration of 272 mg L^{-1}. Sulfate and bicarbonates were the dominant anions in the water column. Sulfate concentrations ranged from 174 to 257 mg L^{-1} while bicarbonate concentrations were between 238 and 338 mg L^{-1}. Levels of total dissolved solids, hardness and conductivity were considerably less than the long-term average for lakes in North Dakota.

The average volume-weighted mean total phosphorus as P concentration was 0.428 mg L^{-1} exceeding the State's target concentration of 0.02 mg L^{-1} on all occasions sampled during 1991 and 1992. The nitrate + nitrite as N concentration was below the target concentration of 0.25 mg L^{-1}, with an average volume-weighted mean concentration of 0.025 mg L^{-1}. A complete list of water quality data for Matejcek Dam is contained in Appendix A.

The total phosphate as P and nitrate + nitrate as N ratios of 17:1 suggests Matejcek Dam is nitrogen limited. However, the high total phosphorus as P concentrations indicate Matejcek Dam has an over abundance of phosphorus. Under these conditions nitrogen fixing algae such as some types of blue-green algae are favored.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 1991 and February 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Matejcek Dam		1982-1991	
Total Dissolved Solids	551	mg L^{-1}	1209	mg L^{-1}
Conductivity	867	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	325	mg L^{-1}	488	mg L^{-1}
Sulfates	202	mg L^{-1}	592	mg L^{-1}
Chloride	19.8	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.428	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.025	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	231	mg L^{-1}	296	mg L^{-1}
Ammonia	0.170	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.49	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	272	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Matejcek Dam. At the time of the macrophyte survey, no macrophytes were observed on major portions of Matejcek Dam. Low density populations of macrophytes were observed at the two inlet areas in the very western end of the dam. These areas had intermittent populations of cattails (Typha spp.), and mixed stands of sago pondweed (Potamogeton pectinatis), water milfoil (Myriophyllum spp.) and common duckweed (Lemna minor). A map of the macrophyte community depicting its areal extent and coverage is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled two times during the summer of 1991. During the summer of 1991 the phytoplankton community was represented by 5 divisions and 39 genera. The dominant group by number were green algae, Chlorophyta, with 21 genera present followed by the blue-green algae, Cyanophyta, with 8 genera present.

Green algae dominated the algal community during both sampling periods. The mean green algae density collected during the summer of 1991 was 70,941 cells mL^{-1}, over 3 times greater than the next most abundant group, the blue-green algae.

At the time of the assessment mean phytoplankton concentrations by volume were more evenly distributed among four of the five divisions; Chlorophyta, Cyanophyta, Bacillariophyta and Cryptophyta. The species of Cyanophyta, Bacillariophyta and Cryptophyta presented are large organisms in comparison to the species of (Chlorophyta), accounting for the difference in community structure when a comparison is made between density expressed as number versus volume. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

The trophic status for Matejcek Dam was assessed to be highly eutrophic to hypereutrophic. Principle indicators used to make this estimate were an average summer total phosphate as P concentration of 0.280 and an average secchi disk transparency of 1.3 meters. Due to difficulties encountered collecting chlorophyll-a samples from Matejcek Dam this information is not available.

Ancillary data supporting a highly eutrophic to hypereutrophic lake condition include frequent nuisance algal blooms and rapid loss of dissolved oxygen below the hypolimnion. Indicators of a less eutrophic condition are a small macrophyte biomass, no history of fish kills and relatively good water clarity.

Sediment Analysis

Sediments and whole fish were collected from Matejcek Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected from the deepest area of the lake (Site 381270), the littoral zone (Site 381271), the south inlet (381272) and the north inlet (Site 381273) (Figure 1).

Sediment samples collected from Matejcek Dam showed detectable levels of all trace elements analyzed. Reported trace elements concentrations varied from each area of the lake including the two inlets. In the sample collected from the deepest area of the lake the reported lead concentration of 33.8 $\mu g\ g^{-1}$ is above the 75th percentile for all lakes assessed. This was also the greatest lead concentration reported during the 1991-1992 LWQA project. The reported mercury concentration of 0.020 was also above the 75th percentile for all lakes sampled. All other trace element concentrations reported were near or slightly below the median concentration for all lakes sampled during the 1991-1992 LWQA project. Reported trace element concentrations from samples collected from the littoral zone of Matejcek Dam exceeded the 75th percentile for all littoral sediment samples analyzed during the 1991-1992 LWQA project. These were lead, zinc, copper, mercury and barium with reported concentrations of 22.1, 63.0 7.05, 0.022 and 95.7 μg g^{-1}, respectively. The lead and zinc concentrations represent the highest reported concentrations for any of the littoral area sediments samples analyzed during the 1991-1992 LWQA project. All other trace metals were either below or near the median concentrations reported during the 1991-1992 LWQA project.

Two inlet area sediment samples were collected from Matejcek Dam, one from the southern inlet and one from the northern inlet (Figure 1). Reported concentrations of zinc, mercury, selenium and lead in the sample collected from the southern inlet exceeded the 75th percentile for all inlet samples collected during the 1991-1992 LWQA project. The mercury concentration of 0.026 μg g^{-1} represents the greater concentration reported for inlet samples collected during the project. All other trace elements concentrations in the southern inlet were near or below the median concentrations for all lakes assessed during 1991-1992. The reported concentrations of zinc, mercury and selenium in the sediments collected from the northern inlet were at or above the 75th percentile for all inlet area samples collected during the 1991-1992 LWQA project. All other trace element concentrations were near or below the median concentration reported for all lakes. PCB concentrations and concentrations of selected organic compounds were below detectable limits for all samples collected from Matejcek Dam. A complete listing of sediment results is provided in Appendix D.

Whole Fish Analysis

Whole fish were collected for contaminant analysis from Matejcek Dam on June 5, 1991. White suckers, representing the bottom feeder group, were the only species of fish collected for contaminant analysis. The white suckers composite sample collected had a mean weight of 1080 grams and mean length of 452 centimeters.

In order to evaluate the fish tissue data for Matejcek Dam, the results for Matejcek Dam were compared to the results for bottom feeders for all lakes assessed during the 1991 LWQA project. In general, trace element concen-trations in the sample collected from Matejcek Dam were near or slightly below the median concentrations for all fish collected. The exceptions were the reported selenium and cadmium concentrations of 0.667 and 0.010 μg g^{-1}, respectively. These concentrations were above the reported 75th percentile for all bottom feeders with the selenium concentrations exceeding all other concentrations reported during the 1991-1992 LWQA project. The mercury concentration in the white sucker sample collected was below detectable limit. Detectable pesticide residues in the composite whole fish sample collected from Matejcek Dam included DDD, DDE and trifluralin. DDD and DDE are breakdown derivatives of DDT and behave similar to the parent compound in the ecosystem. Trifluralin, commonly known as treflan is a selective preemergent herbicide which can be very toxic to aquatic vertebrates like rainbow trout.

DDD and DDE white sucker samples collected from Matejcek Dam were 0.003 $\mu g\ g^{-1}$ and 0.011 $\mu g\ g^{-1}$, respectively. These concentrations are only slightly above the median concentrations for all bottom feeders collected. The reported concentration of 0.009 $\mu g\ g^{-1}$ for trifluralin in the white sucker sample collected from Matejcek Dam is the same as the 75th percentile for all bottom feeders analyzed during the 1991-1992 LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Matejcek Dam and its contributing watershed have a surface area of 30,720 acres. It is located west of the Red River Valley on the glaciated plains in Walsh County, North Dakota. The surrounding landscape is characterized by nearly level to rolling topography with well-defined drainages. Soils are deep, moderately well drained, and fertile. The soils are built from fine to medium textured glacial till. Nonpoint source pollution from the surrounding watershed accounts for nearly 100 percent of the nutrient loadings and pollution discharges to Matejcek Dam.

Land use within the Matejcek Dam watershed is 87 percent agricultural with 60 percent actively cultivated. The remaining 40 percent is in low density urban development, haylands, pasture, Conservation Reserve Program (CRP) and woodlands. There are 19 concentrated livestock feeding areas in the watershed (Table 2). According to the information provided by the Walsh County Soil Conservation District, 60 percent of the cultivated lands and between 60 and 100 percent of the remaining lands within the Matejcek Dam watershed are "adequately treated" against soil loss.

Table 2. Land use in the Matejcek Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	60	60
Range	2	75
Hayland/Pasture	2	90
CRP	23	100
Wet/Wild[1]	8	100
Other	4	100
Farmsteads	16[3]	N/A
Feedlots[2]	6[3]	60

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Matejcek Dam watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of between 3 and 4 tons per acre, which takes into account the treated and untreated lands in the watershed, approximately 103,895 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 10,389 tons to 15,584 tons of soil potentially reaches Matejcek Dam annually. Other major sources of nonpoint source pollution contributing to Matejcek Dam are the concentrated livestock feeding areas, construction activities, and bank erosion. These sources due their proximity to the lake and major tributaries can have a significant impact on the water quality of Matejcek Dam.

MCGREGOR DAM

WILLIAMS COUNTY

Peter N. Wax

McGregor Dam is located in the northeast corner of Williams County, one mile south of McGregor, North Dakota. Completed in 1969 the reservoir covers 54.3 acres with an maximum depth of 37 feet and average depth of 13.7 feet (Figure 1). During the 1991-1992 LWQA project, lake levels were down approximately 10 feet below full pool.

Topography of the area is characterized by rolling hills and valleys with slopes averaging between 3 percent to 25 percent. The McGregor Dam watershed is made up of deep well drained with moderately to slowly permeable soils formed from glacial till.

McGregor Dam is classified as a cold water fishery "Waters capable of supporting growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The capability of the lake to support a fishery may be affected by seasonal climate variations and other natural occurrences which may alter the lake's water quality characteristics.

The NDG&F stock McGregor Dam with rainbow trout, brown trout and occasionally walleye. Test netting operations conducted by the NDG&F in 1991 captured walleye, rainbow trout, brown trout, and fathead minnows. Survival of the fishery is precarious due to low dissolved oxygen conditions observed during the 1992 winter sampling. Historic winter data for the years 1985 and 1988 also showed fluctuations of dissolved oxygen in the water column. McGregor Dam appears to have a potential for winter kill due to low oxygen levels. The shoreline of McGregor Dam is publicly owned, surrounded by a wildlife management area. McGregor Dam is a popular recreational area and receives heavy use from the surrounding communities.

Water Quality

Water quality samples were collected from McGregor Dam twice during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 380820, Figure 1). Water column samples were collected for analysis at three separate depths, surface, middle and bottom.

During the July 16, 1991 sample period thermal stratification was observed approximately 3 meters below the lake surface (Figure 2). Twenty-one days later on August 6, the thermocline layer was at 8 meters (Figure 2). Temperature/dissolved oxygen profile data collected on January 19, 1992, showed McGregor Dam thermally stratified at approximately 5 meters (Figure 2). During these periods, dissolved oxygen concentrations were adequate above the thermocline with rapid depletion of dissolved oxygen below (Figure 3).
Oxygen depletion in the hypolimnion and under ice-covered conditions is probably the result of nutrient loading from a highly fertile watershed and

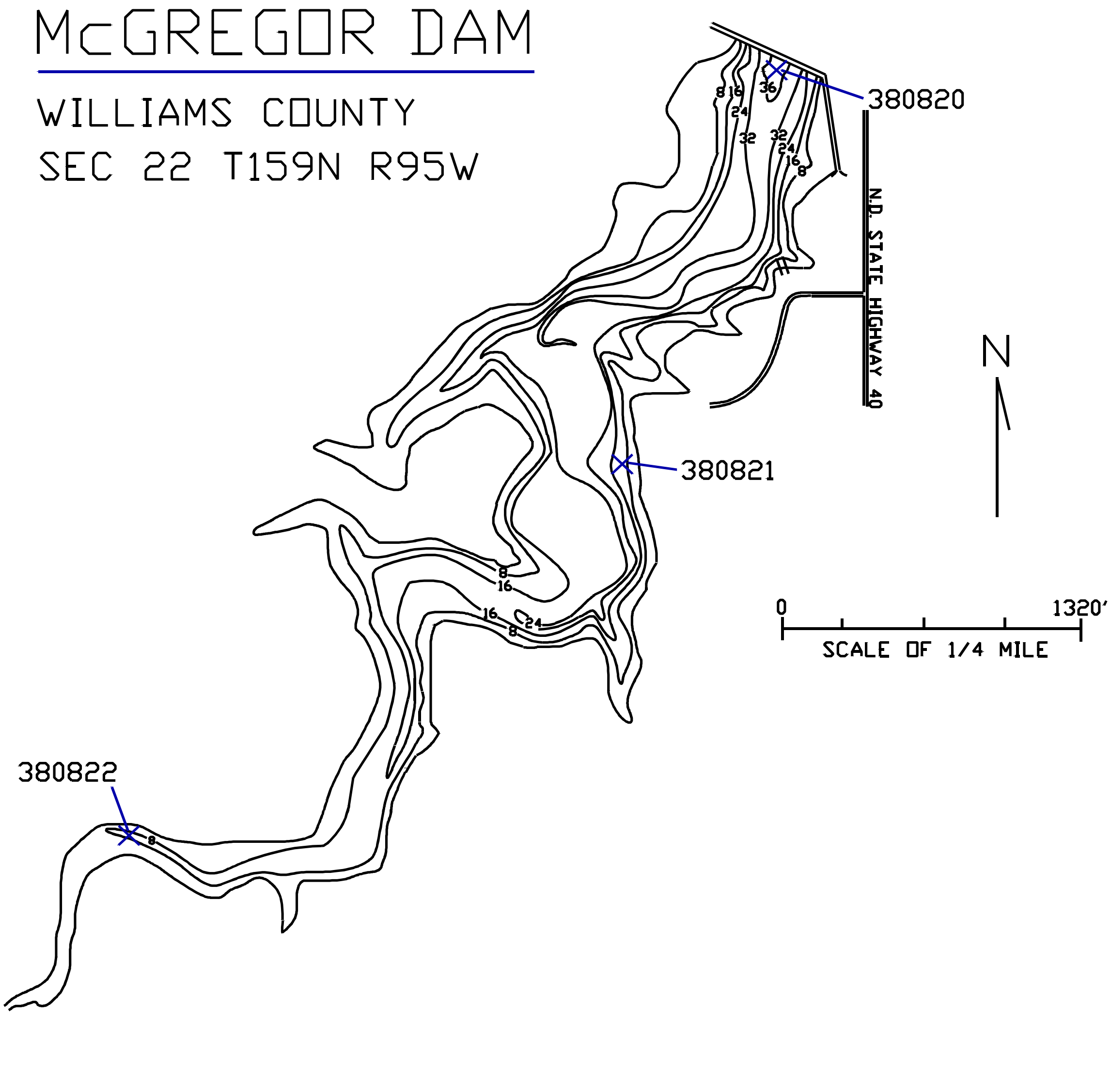

Figure 1. Morphometric map of McGregor Dam.

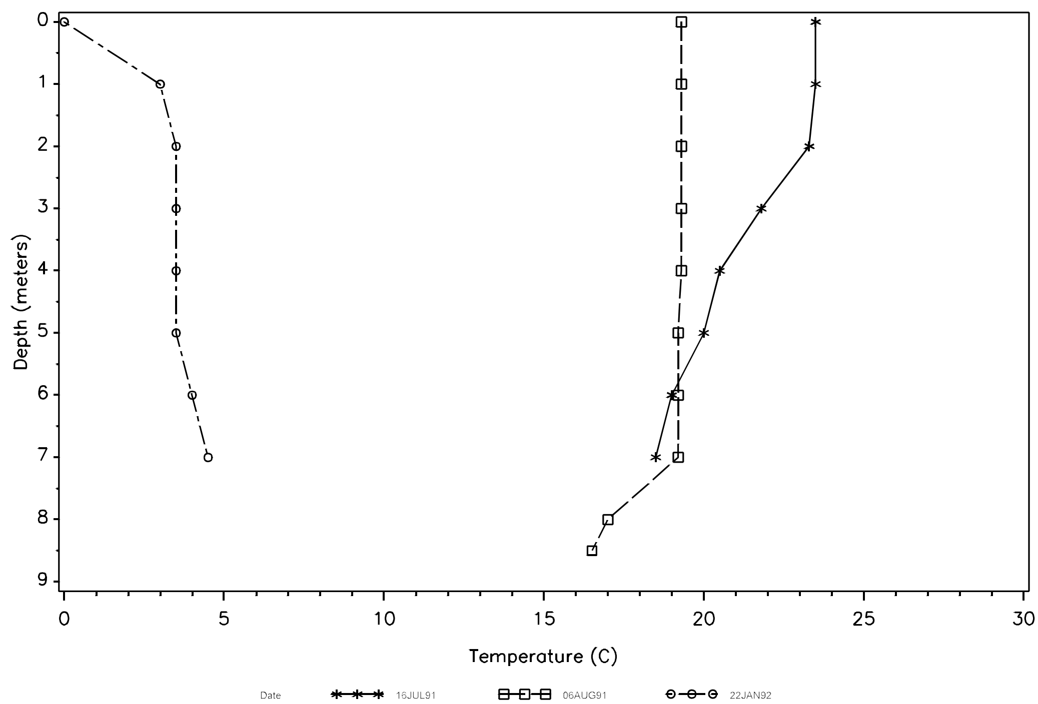

Figure 2. Temperature profile for McGregor Dam.

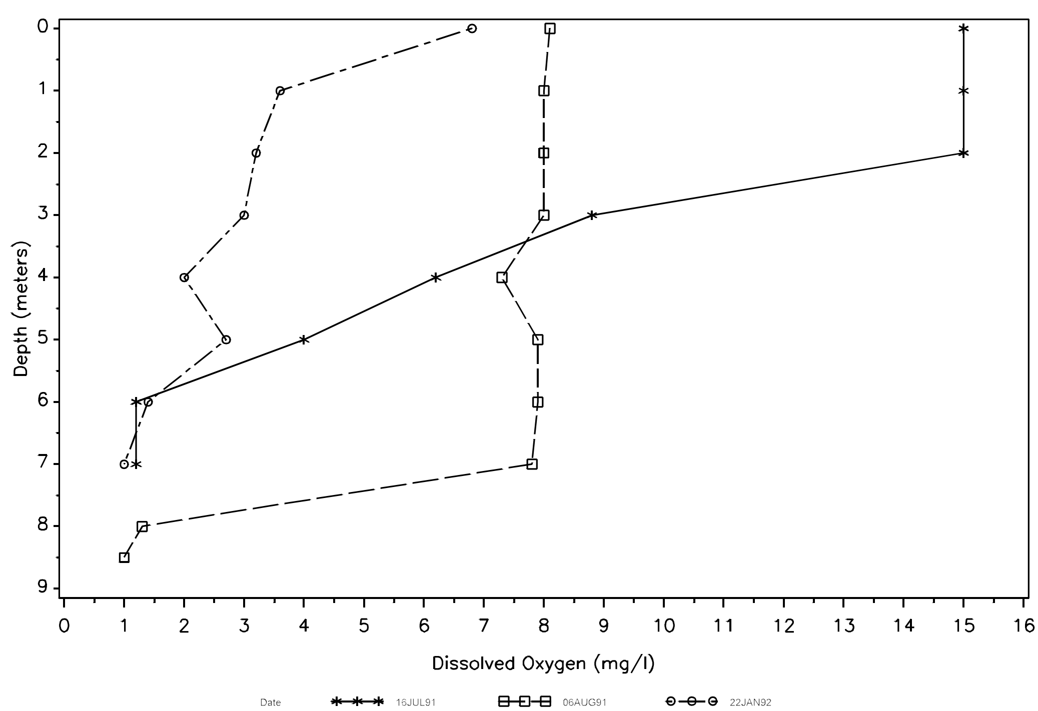

Figure 3. Oxygen profile for McGregor Dam.

from nutrient internal cycling creating a highly productive lake. Other contributing factors were the calm, hot weather experienced in the early part of the summer causing stratification just after the annual spring load of nutrients.

General water quality analysis performed on McGregor Dam during the summer of 1991 and winter of 1992 showed a relatively well-buffered waterbody. The dominant anions were bicarbonate and sulfate. The average volume-weighted mean concentrations of total alkalinity as $CaCO_3$, bicarbonates and sulfates were 174, 193, and 131 mg L^{-1}, respectively (Table 1, Appendix A).

The average volume-weighted total phosphorus as P concentrations was similar to the long-term average for all North Dakota lakes at 0.245 mg L^{-1}. The ratio between the primary nutrients total phosphate as P and nitrate + nitrite as N is 35:1, indicating a nitrogen limited lake condition. A nitrogen limited lake generally implies that its primary production is limited by the available supply of nitrogen. However, in the case of McGregor Dam, true nitrogen limitation does not exist, but rather it contains a surplus of phosphorus. A complete list of 1991-1992 LWQA project data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 10, 1991 and January 30, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 to December 31, 1991.

Parameter	McGregor Dam		1982-1991	
Total Dissolved Solids	365	mg L^{-1}	1209	mg L^{-1}
Conductivity	610	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	276	mg L^{-1}	488	mg L^{-1}
Sulfates	131	mg L^{-1}	592	mg L^{-1}
Chloride	11.67	mg L^{-1}	81.29	mg L^{-1}
Total phosphate as P	0.245	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.007	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	174	mg L^{-1}	296	mg L^{-1}
Ammonia	0.307	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	3.31	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	193	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on McGregor Dam on August 6, 1991. At the time of the macrophyte survey approximately 40 percent of McGregor Dam's surface area had aquatic vegetation. The shallow southern one-third of McGregor Dam to a depth of eight feet contained a mixture of water milfoil (Myriophyllum spp.) and elodea (Elodea canadensis). The area surrounding the deeper two-thirds of the dam between the depths of 2 to 5 feet contained a combination of sago pondweed (Potamogeton pectinatus) and curly leaf pond weed (Potamogeton crispus). A map depicting the areal extent and species of macrophytes on McGregor Dam is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled twice during the summer of 1991. During the summer of 1991, Mcgregor Dam's phytoplankton community was represented by 4 divisions and 7 genera. The largest contributors to the community in terms of both number and volume were the blue-green algae, Cyanophyta, occupying over 99 percent of the community. The mean blue-green algae density of 943,688 cells mL^{-1} was approximately 3,260 times greater than all other algae species combined. Mean blue-green algae density by volume was 53,656,604 µm mL^{-1} which is approximately 681 times greater than the density of all other algae combined.

A complete listing of phytoplankton data is contained in Appendix D. The large n
umber of algae present in McGregor Dam could account for the high TKN concentrations and for the supersaturation of dissolved oxygen in samples collected above the hypolimnion in the summer of 1991. Phytoplankton populations this dense have a cyclic affect on oxygen concentrations.

Trophic Status

Presently, McGregor Dam is considered a hypereutrophic waterbody. Collaborating evidence includes high surface total phosphate as P and chlorophyll-a concentration and shallow secchi disk transparency. Total phosphate as P concentrations were 203 and 261 µg L^{-1}, while chlorophyll-a concentrations were 218 and 112 µg L^{-1} and secchi disk transparency was 0.5 and 0.7 meters. Supporting ancillary data, which suggests a hypereutrophic assessment includes a phytoplankton community dominated completely by blue-green algae, low dissolved oxygen concentrations in the hypolimnion and under ice cover conditions and a large macrophyte biomass.

At the time samples were collected, McGregor Dam was 10 feet below normal pool evaluation. This condition has possibly concentrated nutrients and minerals within the water column promoting increased nutrient cycling, algal growth, and poor clarity. Even if this assessment is only temporary, it is an indication of the future condition of McGregor Dam if current nutrient load continued.

Sediment Analysis

Sediment samples were collected from McGregor Dam in the deepest area of the lake (Site 380820), the littoral zone (Site 380821), and the inlet (Site 380822) (Figure 1). Sediment samples collected from McGregor Dam showed detectible levels of all trace elements tested for except mercury in the littoral area and the inlet. Mercury was only detected in the deepest area of the lake. Concentrations from each area were at or greater than the median concentration for all lakes sampled except for selenium and mercury which were slightly lower at the inlet site. No detectable concentrations of PCB's or selected pesticides were found in the sediments at any site. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

There was no fish collected and analyzed for contaminants.

Watershed

McGregor Dam and its contributing watershed has a combined surface area of 5,492 acres. It is located on the northeast corner of Williams County, North Dakota in the Glaciated Plains physiographic region. Soils in the watershed are highly erodible due to water and wind. One hundred percent of the pollution loading to McGregor Dam are from nonpoint source pollution.

Land use within the McGregor Dam watershed is 97 percent agricultural with 82 percent actively cultivated. The remaining three percent is in other areas such as farmsteads, hayland and pasture (Table 2). In the assessed area their is one concentrated livestock area. The livestock are located some distance from the reservoir. Due to its location and distance from McGregor Dam, it appears to pose a low risk to the reservoir.

According to the information provided by the Williams County Soil Conservation District 50 percent of the cultivated lands and 75 percent of the range lands in the McGregor Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

The estimated "T" value for the McGregor Dam watershed is 3 to 5 tons per acre. Based on an average soil loss in the watershed of just over 5 tons per acre, which accounts for all land uses and treatments, approximately 28,500 tons of soil are lost from the watershed annually. Assuming a conservative delivery rate of 10 to 15 percent, approximately 2,850 tons to 4,250 tons of soil potentially reaches McGregor Dam annually.

Table 2. Land Use in the McGregor Dam Watershed

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	82	50
Rangeland	15	75
Hayland	2	100
CRP	0	100
Wet/Wild[1]	0	100
Other	1	N/A
Farmsteads	32	N/A
Feedlots[2]	1	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.

NIEUWSMA DAM

EMMONS COUNTY

Peter N. Wax

Nieuwsma Dam was built in 1936 under the Work Projects Administration (WPA). When originally constructed, Nieuwsma Dam was designed to have a maximum depth of 24 feet at full pool. Presently, the dam has a maximum depth of 22 feet at full pool and a surface area of 53 acres (Figure 1).

The topography of the 10,000-acre watershed is nearly level on the uplands to rolling and hilly on the side slopes and drainages. The majority of soils are deep, well drained, and moderately permeable. The majority of slopes in the watershed vary from three to nine percent.

Nieuwsma Dam is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991).

The NDG&F manages Nieuwsma Dam by regularly assessing the fish community through test nettings and stocking accordingly. In recent years, the stocking regiment has included northern pike and walleye. Initially, Nieuwsma Dam was an excellent rainbow and brown trout fishery until the winter of 1968-69, when a severe fish kill occurred. It was restocked with trout the following year, which were eventually phased out with species more tolerant to low dissolved oxygen conditions.

Test netting operations conducted in 1991 showed populations of walleye, northern pike, bluegill, and bullheads with walleye the dominant species. Though not captured in 1991 test nettings, Nieuwsma Dam also has a good largemouth bass population.

Access to Nieuwsma Dam is good. Public facilities include a boat ramp, toilets and a fishing pier built in 1987. Due to low water caused by the drought, the fishing pier was unusable at the time of the assessment. Public use on Nieuwsma Dam is sporadic and use is primarily from the local community. Fishing can be difficult beginning in mid to late summer due to heavy macrophyte infestations.

Nieuwsma Dam was built to provide flood protection, stock watering and recreation. It is at least partially supporting all of these uses, however, the recreation benefits are threatened due to sedimentation and accelerated eutrophication from nonpoint source pollution.

Water Quality

Water quality samples were collected from Nieuwsma Dam two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381330, Figure 1).

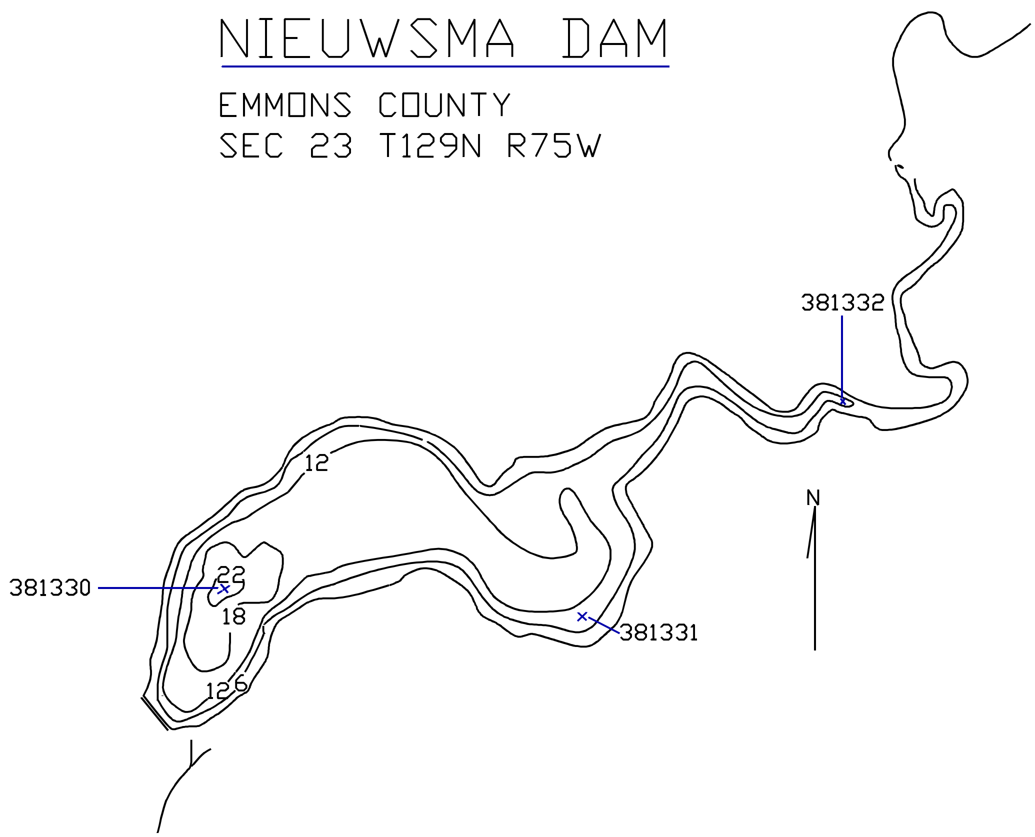

Figure 1. Morphometric map of Nieuwsma Dam.

Water column samples were collected for analysis at three separate depths during the summer and two separate depths during the winter. Summer samples were collected at 1 meter, 2 meters, and 4 meters, winter samples were collected at 1 meter and 3 meters.

During the summer of 1991 Nieuwsma Dam was not thermally stratified (Figure 2). During this time period, dissolved oxygen concentrations were at or near saturation to a depth of 3 meters in July (Figure 3). This depth was reduced to 2 meters when sampled again in August (Figure 3). Samples collected during January 1992 showed thermal stratification between 2 and 3 meters below the lake's surface (Figure 2). Oxygen concentrations at this time were greater than 9 mg L^{-1} above the thermocline and 2 mg L^{-1} or less below the thermocline (Figure 3).

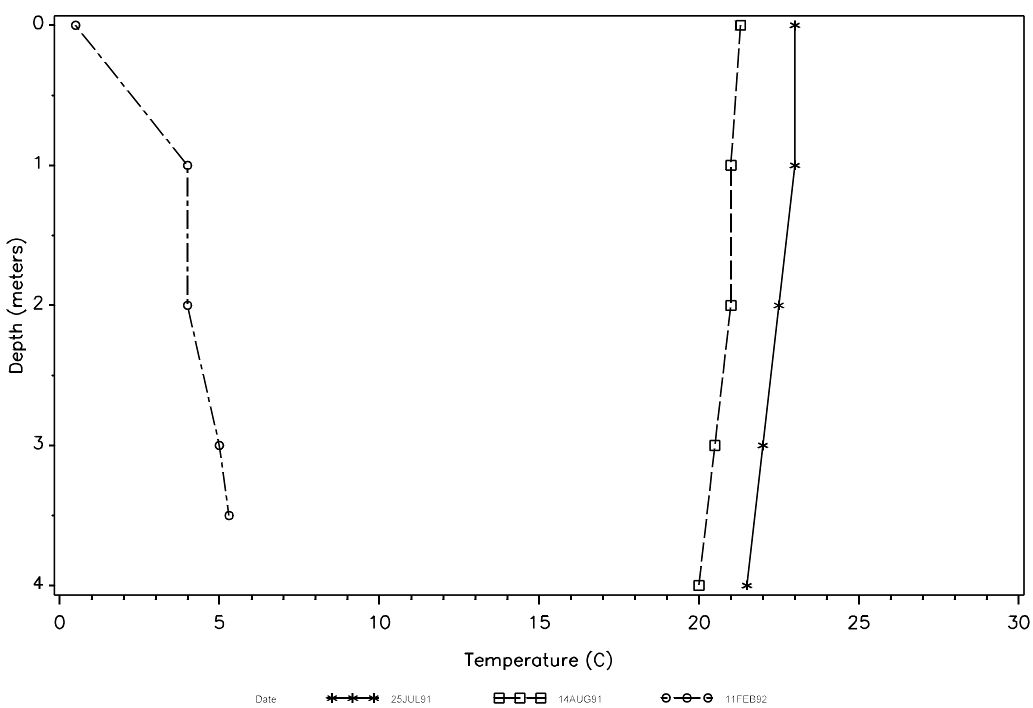

Figure 2. Temperature profile for Nieuwsma Dam, summer 1991 and winter 1991-1992.

Bicarbonate was the dominant anion in the water column. The volume-weighted mean concentration for bicarbonates was 104 mg L^{-1}, followed by chlorides at 9.7 mg L^{-1} and sulfates at 5.3 mg L^{-1}. The volume-weighted mean concentrations for hardness as Calcium and total dissolved solids was 143 and 222 mg L^{-1}, respectively, describing a lake with relatively fresh water when compared to most lakes statewide. The volume-weighted mean concentration of total phosphorus as P at 0.637 mg L^{-1} exceeded the state's target concentration of 0.02 mg L^{-1}. A completed list of LWQA water quality data is contained in Appendix B (Table 1).

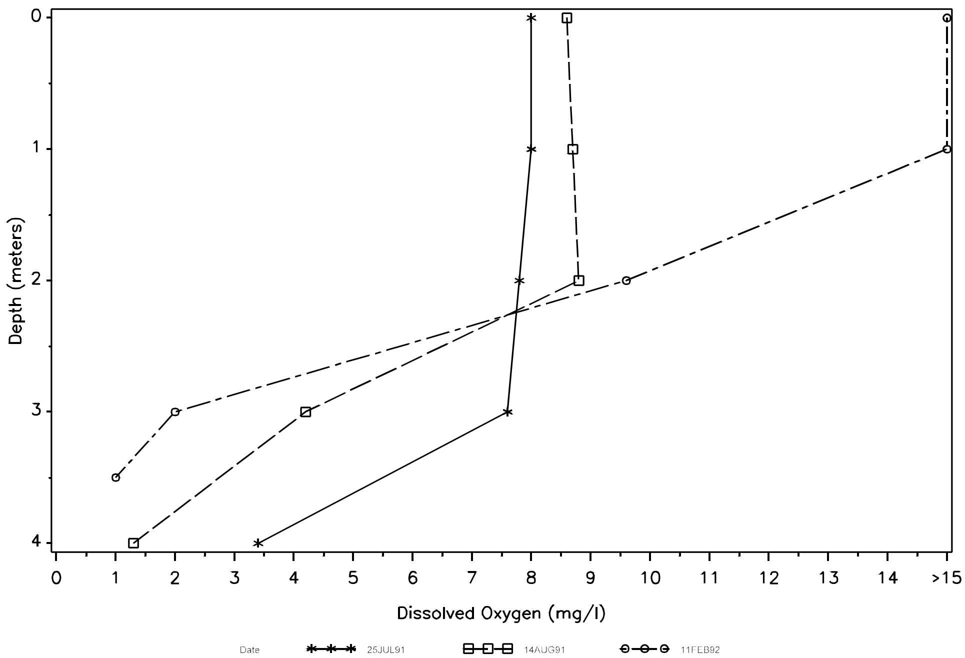

Figure 3. Oxygen profile for Nieuwsma Dam, summer 1991 winter 1991-1992.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July and August, 1991 and February, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Nieuwsma Dam	1982 - 1991
Total Dissolved solids	222 mg L^{-1}	1209 mg L^{-1}
Conductivity	381 umhos cm^{-1}	1604 umhos cm^{-1}
Hardness as calcium	143 mg L^{-1}	488 mg L^{-1}
Sulfates	5.3 mg L^{-1}	592 mg L^{-1}
Chlorides	9.7 mg L^{-1}	81 mg L^{-1}
Total phosphate as P	0.637 mg L^{-1}	0.248 mg L^{-1}
Nitrate + Nitrite as N	0.009 mg L^{-1}	0.069 mg L^{-1}
Total kjeldahl nitrogen	1.84 mg L^{-1}	2.34 mg L^{-1}
Ammonia	0.084 mg L^{-1}	0.326 mg L^{-1}
Bicarbonate	104 mg L^{-1}	326 mg L^{-1}
Alkalinity	227 mg L^{-1}	296 mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Nieuwsma Dam as part of the 1991-1992 LWQA project. The survey was conducted on August 14, 1991. At the time of the macrophyte survey nearly 100 percent of Nieuwsma Dam's surface area had aquatic vegetation. American Elodea (Elodea canadensis) comprised approximately 85 percent of the population. Other species present were curly leaf pondweed (Potamogeton crispus), sago pondweed (Potamogeton Pectinatus), and water milfoil (Myriophyllum spp.). The southern shore of the lake was lined with cattails (Typha Spp.). A map depicting the area of the macrophyte community is contained in Appendix B.

Phytoplankton

Nieuwsma Dam's phytoplankton community was represented by 4 divisions and 16 genera. The largest group of algae by number were the green algae, Chlorophyta, and were represented by 4 genera. Mean green algae densities during the summer of 1991 were 374,756 cells mL^{-1}, 19 times greater than all the other groups combined.

During the summer of 1991, the phytoplankton community by volume fluctuated between the two sampling periods in July and August. On July 25, 1991 the division Cryptophyta dominated the phytoplankton community, being replaced by the division Chlorophyta on August 14, 1991. The shift in community structure was quite dramatic, as the Chlorophyta represented over 50 percent of the total community by volume on August 14, 1991. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Nieuwsma Dam is presently eutrophic. This assessment is based primarily on large summer, surface, total phosphate as P concentrations and low secchi disk transparency's. Total phosphate as P concentrations average 494 $\mu g\ L^{-1}$, while average secchi disk transparency was 1.55 meters. Other supporting evidence of a highly eutrophic lake condition include large macrophyte biomass, frequent nuisance algae blooms, rapid depletion of dissolved oxygen in the hypolimnion and under ice cover and a history of periodic fish kills.

Sediment Analysis

Sediments were collected from Nieuwsma Dam and analyzed for trace elements, PCBs, and selected pesticides. Sediments samples were collected from the deepest area of the lake (Site 381330), the littoral zone (Site 381331), and the inlet (Site 381332) (Figure 1).

Sediment samples collected from Nieuwsma Dam showed detectable levels of all trace elements tested for, except mercury. Trace element concentrations within the sediments collected from Nieuwsma Dam were compared to the sediment results for all lakes assessed in the 1991-1992 LWQA project. In general reported concentrations of trace elements in sediments collected from

Nieuwsma Dam were near or at the median concentrations for all lakes sampled, with the exception of barium in the inlet area sediments and chromium in all three areas sampled. These elements had reported concentrations that were at or above the 75th percentile for all lakes sampled during in the 1991-1992 LWQA project. Concentrations of PCBs and selected organic compounds were below detection limits for all samples collected from Nieuwsma Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Nieuwsma Dam on August 14, 1991. Walleyes were collected representing the piscivore group and bullheads were collected representing the bottom feeder group.

In order to evaluate the fish tissue data for Nieuwsma Dam, the results of each fish group were compared to that group for all lakes assessed in the 1991 LWQA project. Trace element concentrations in samples from both the piscivore and the bottom feeder groups collected from Nieuwsma Dam were generally slightly below the median concentrations reported for all the piscivore and bottom feeder samples analyzed during the 1991 LWQA project. The exceptions were reported concentrations of barium, chromium, and selenium from both the piscivore and bottom feeder samples collected. These results were greater than the respective median concentrations for all lakes. The mercury concentration of 0.64 $\mu g\ g^{-1}$ in the walleye sample was above the 75th percentile concentration for all lakes sampled.

Detectable pesticide residues in the walleye sample collected from Nieuwsma Dam contained DDE. DDE is a degradation product of the insecticide DDT and produces biological effects similar to the parent compound. Detectable pesticide residues in the bullhead sample collected from Nieuwsma Dam included trifluralin. Trifluralin, also known as treflan, is a selective preemergent herbicide. The DDE and trifluralin concentrations reported were below the median concentration for all fish samples collected during the 1991 LWQA at 0.004 and 0.003 $\mu g\ g^{-1}$, respectively. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Nieuwsma Dam with its contributing watershed has a combined surface area of approximately 10,000 acres. It is located on the eastern bank of the Missouri Coteau physiographic region in southern Emmons County, North Dakota. The region is characterized by nearly level to rolling topography. The majority of soils are deep, well drained, moderately permeable, with slopes ranging from 3 to 9 percent. Nonpoint source pollution accounts for 100 percent of the external nutrient and sediment load to Nieuwsma Dam.

Land use within the Nieuwsma Dam watershed is 91 percent agricultural, with 42 percent of the watershed actively cultivated. The remaining 48 percent is in low density urban development, haylands, pasture, or Conservation Reserve Program (CRP) (Table 2). According to the information provided by the Emmons County Soil Conservation District, 40 percent of the cultivated lands and 40 to 60 percent of the remaining lands (i.e., pasture, hayland) within the Nieuwsma watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve soil loss tolerant (T). It is estimated that within the Nieuwsma Dam watershed, the average "T" value is 3 to 5 tons per acre.

Based on an average soil loss of 6 to 7 tons per acre, which also takes into account the land not adequately treated, 62,063 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 6,206 and 9,309 tons of soil potentially reaches Nieuwsma Dam annually. Other sources of nonpoint source pollution discharges to Nieuwsma Dam include concentrated cattle feeding and watering areas in the immediate upstream drainage.

Table 2. Land use in the Nieuwsma Dam watershed.

Land use	Percent of total Watershed acreage	Percent Adequately treated
Cropland	42	40
Pasture land	45	50
Hayland	4	65
CRP	0	0
Wet/Wild[1]	0	0
Other	9	N/A
Farmsteads	7[3]	N/A
Feedlots[2]	4[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number present in watershed.

NORTH CARLSON LAKE

WARD COUNTY

Peter N. Wax

North Carlson Lake is located in the Missouri Coteau physiographic region in south central Ward County; four miles north and two miles east of Douglas, North Dakota. This natural lake covers 79.5 acres with a mean depth of 8.9 feet and a maximum depth of 23 feet (Figure 1). Topography of the area is characterized by rolling hills and valleys with slopes ranging from 1 percent to 20 percent. Soils are excessively drained, formed from sandy, rocky glacial material.

North Carlson Lake is classified as a cool water fishery "Waters capable of supporting growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F currently stock northern pike, walleye, and perch. Past stockings have also included bluegill and fathead minnows. Test nettings conducted by the NDG&F in 1991 showed the presence of bluegill, perch, and white sucker. The low numbers of fish and lack of predators is not surprising. Historically, North Carlson Lake experiences partially winter kills approximately one out of three to five years.

The small watershed in general is maintained quite well. The major land uses in the watershed include Conservation Reserve Program (CRP), wildlife and wetland areas.

North Carlson Lake is a popular recreational area and receives very high use throughout the summer from residents of Minot and surrounding communities. Public facilities consist of a swim beach, boat ramp and toilets.

Water Quality

Water quality samples were collected from North Carlson Lake three times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381345, Figure 1). Water column samples were collected for analysis at three separate depths, surface, middle, and bottom.

North Carlson Lake was weakly thermally stratified during the July 10 and August 21, 1991 sample periods. Thermal stratification occurred at approximately 4 to 5 meters below the surface on July 10, 1991 and was observed again near the surface on August 21, 1991 (Figure 2). Of note is that on July 31, 1991 no thermal stratification occurred. The winter sample collected on January 30, 1992, again showed no apparent thermal stratifi-cation, however, oxygen profiles suggest weak stratification occurred between 3 and 5 meters below the surface (Figure 2, Figure 3). Oxygen concentrations measured in conjunction with the temperature profiles showed dissolved oxygen concentrations above 6.0 mg L^{-1} throughout much of the water column on July 31, 1991 and on January 30, 1992. During the two periods of weak thermal stratification, dissolved oxygen concentration declined to less than 2 mg L^{-1} in the hypolimnion.

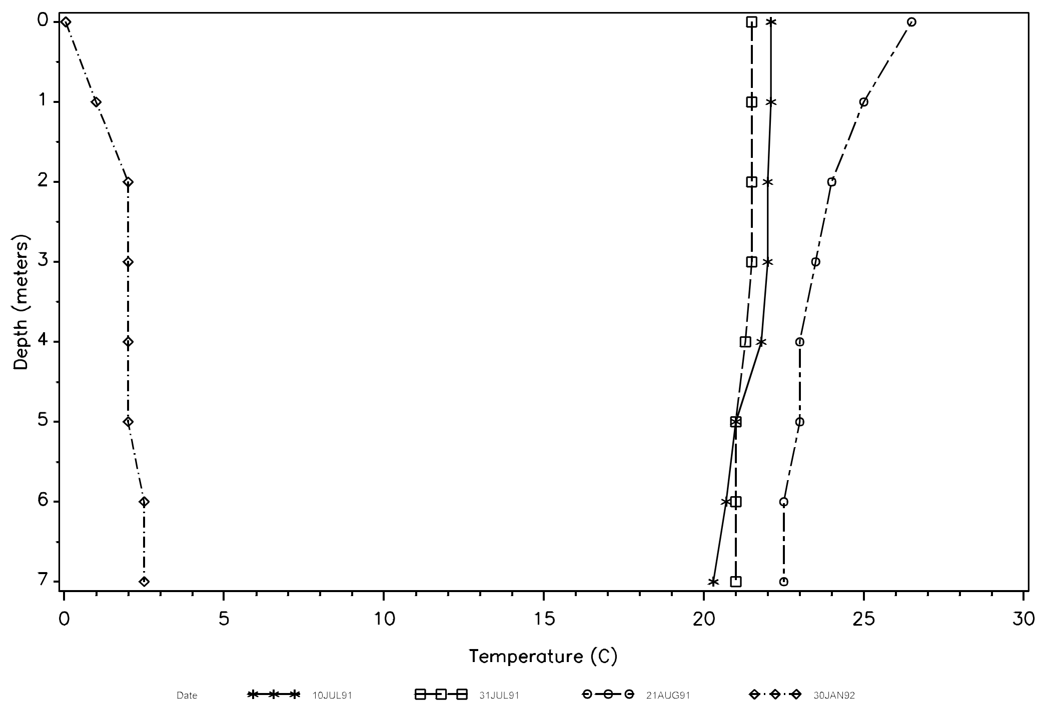

Figure 2. Temperature profile for North Carlson Lake.

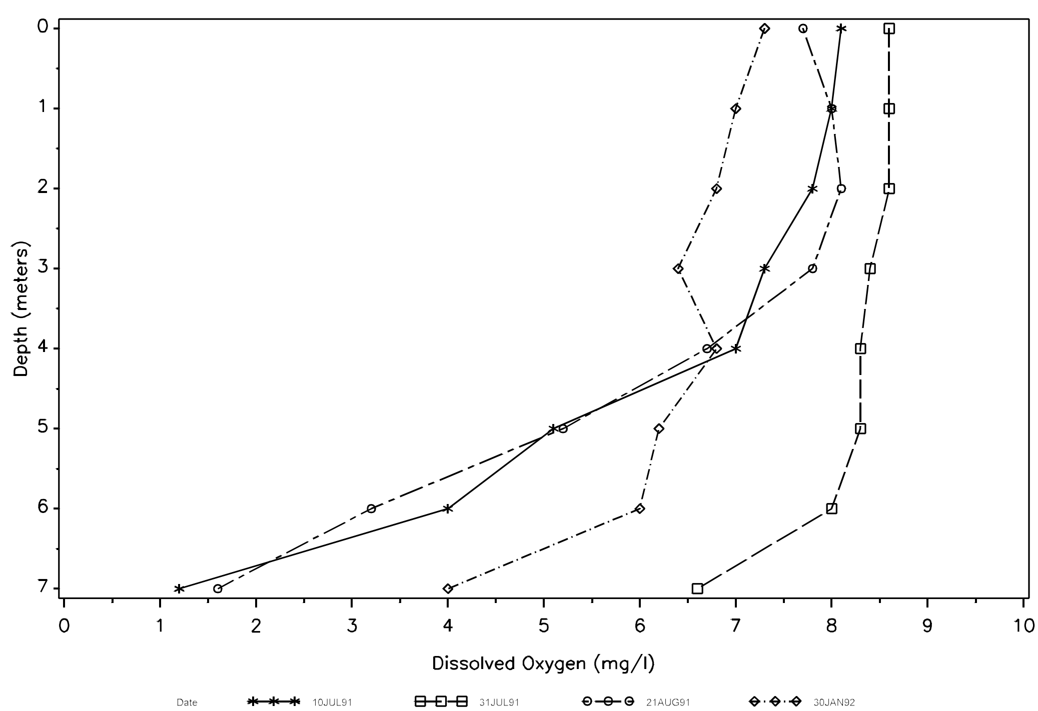

Figure 3. Oxygen profile for North Carlson Lake.

Water quality data collected from North Carlson Lake during the summer of 1991 and winter of 1992 showed an extremely well-buffered waterbody with concentra-tions of total dissolved solids, bicarbonates and sulfates typical for lakes in North Dakota (Table 1). Of note was the relatively low concentrations of total phosphate as P. The ratio of total phosphate as P concentrations to nitrate + nitrite as N was 1:2, indicating North Carlson Lake is nitrogen limited (Table 1).

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 10, 1991 and January 30, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 to December 31, 1991.

Parameter	North Carlson		1982-1991	
Total Dissolved Solids	1347	mg L^{-1}	1209	mg L^{-1}
Conductivity	2005	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	555	mg L^{-1}	488	mg L^{-1}
Sulfates	535	mg L^{-1}	592	mg L^{-1}
Chloride	12.4	mg L^{-1}	81.29	mg L^{-1}
Total Phosphate as P	0.049	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.079	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	629	mg L^{-1}	296	mg L^{-1}
Ammonia	0.226	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.34	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	624	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A macrophyte survey was conducted on North Carlson Lake on August 21, 1991. At the time of macrophyte survey, submergent aquatic vegetation was virtually nonexistent. Historical records also describe a macrophyte community limited to sparse submergents with intermittent stands of bulrush (Scirpus spp.) and cattails (Typha spp.) surrounding the lake. The lack of submergent aquatic vegetation might be attributed to fluctuating lake levels throughout the lake's history and/ or lack of availability nutrients. A map depicting the macrophyte community and its areal coverage is depicted in Appendix B.

Phytoplankton

The phytoplankton community was sampled three times during the summer of 1991 on July 1, July 31 and August 21, 1991. During the three sampling periods the phytoplankton community was represented by six divisions and 27 genera. The community by numerical density shows blue-green algae, Cyanophyta, occuppying 98.9 percent of the community. Blue-greens are 91 times greater by density than all other phytoplankton species combined. Mean density as represented by volume showed that the diatoms, Bacillariophyta, green algae, Chlorophyta, and blue-green algae, Cyanophyta, were all fairly equally distributed. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

The primary trophic status indicators of total phosphate as P and chlorophyll-a concentrations and secchi disk transparency indicate North Carlson Lake is eutrophic. Total phosphate as P concentrations at the surface averaged 0.049 mg L^{-1}, chlorophyll-a concentrations averaged 0.011 mg L^{-1} and secchi disk depth averaged 1.9 meters. Other supporting evidence includes a history of fish kills, a phytoplankton community dominated by blue-green algae and rapid dissolved oxygen depletion below the hypolimnion.

Nonsupporting ancillary information for a eutrophic lake status is the absence of a large macrophyte biomass. This is especially puzzling, as no herbaceous fish are present in North Carlson Lake. A possible explanation is frequent lake level fluctuations preventing permanent establishment of macrophytes. It is possible that if macrophytes were present they may utilize enough nutrients to improve water quality conditions on North Carlson Lake.

Sediment Analysis

Sediments were collected at the deepest area of the lake (Site 381345) and the littoral zone (Site 381346, Figure 1). Since North Carlson Lake does not have a well-defined tributary no inlet sediment sample was collected.

Sediment samples collected from North Carlson Lake showed detectible levels of all trace elements tested for except selenium and mercury. Sediment concentrations at each sample location within North Carlson Lake were also compared to concentrations reported for all lakes assessed in 1991. Trace element concentrations were below the median concentrations for all lakes sampled during the 1991 LWQA project. Concentrations of PCB's and selected organic compounds were below detectable limits for all samples collected from North Carlson Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Two species of fish were collected from North Carlson Lake for contaminant analysis. Fish samples were collected on May 30, 1991. White sucker were collected to represent the bottom feeder group and northern pike were collected representing the piscivore group. Only one individual northern pike was collected and analyzed. While the data for the northern pike sample are reported, it should be kept in mind that this is not a composite sample and therefore does not meet the workplan and quality assurance guidelines of this project.

In order to evaluate fish tissue data for North Carlson Lake, the results for each fish group were compared to that group for all lakes assessed in 1991-1992. Trace element concentrations in fish samples collected from North Carlson Lake were generally near or slightly below the median concentrations for all fish collected during 1991. The exception was the reported concentration of zinc in the piscivore sample, which was three times that of the median for all piscivores sampled in 1991. Mercury was present at low concentrations in the piscivore sample only.

Detectable pesticide residues in both fish samples collected from North Carlson Lake was limited to DDD and DDE. These two compounds are both breakdown derivatives of DDT. The white sucker sample collected from North Carlson Lake contained 0.015 and 0.025 $\mu g\ g^{-1}$ of DDD and DDE, respectively. The concentrations for both of these were above the 75th percentile for all bottom feeders sampled in 1991.

The whole fish sample of northern pike contained 0.084 $\mu g\ g^{-1}$ of DDD and 0.130 $\mu g\ g^{-1}$ of DDE. These levels were considerably greater than the 75th percentile for all piscivores collected in 1991. A complete listing of the fish tissue results for all lakes sampled in 1991 is provided in Appendix E.

Watershed

North Carlson Lake has a watershed of approximately 1300 acres. Its landscape is characterized by rolling hills and valleys made from soils which are predominantly excessively drained, built from gravelly, sandy glacial materials. The small watershed is the only contributor of sediments and nutrients to the lake (i.e., nonpoint source loading).

Land use within the North Carlson Lake watershed is only 24 percent agricultural, 74 percent is in CRP and wildlife/wetland areas (Table 2). The watershed is very well protected, with the exception of a small portion of rangeland surrounding the lake. Excessive grazing can remove the buffering potential shoreline vegetation provides. Since 97 percent of the watershed is uncultivated, soil loss is very low. Estimated soil loss is only 225 tons per year. Average soil loss per acre is under 0.2 tons, which is well below the acceptable soil loss tolerance value. These statistics were provided by the Ward County Soil Conservation District.

Table 2. Land Use in the North Carlson Lake Watershed

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	3	50
Rangeland	18	80
Hayland	3	80
CRP	39	100
Wet/Wild[1]	35	100
Other	2	N/A
Farmsteads	0	N/A
Feedlots[2]	0	N/A

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.

NORTH GOLDEN LAKE

STEELE COUNTY

Peter N. Wax

North Golden Lake lies on the western edge of the Red River Valley in Steele County, North Dakota. It is part of a three wetland system which includes Golden-Rush Lake, South Golden Lake, and North Golden Lake (Figure 1). North Golden Lake was just a marsh until 1956, when the NDG&F and the North Dakota State Water Commission (SWC) cooperated in developing a system which diverted stream flows from Beaver Creek to Golden Rush Lake through South Golden Lake, creating a fishery in South Golden Lake. As an added bonus during high water periods the natural outlet of South Golden Lake flows into North Golden Lake creating a 180 acre lake with a maximum depth of 12 feet (Figure 2). North Golden Lake has a control structure at its outlet. The outlet flows back to Beaver Creek.

Topography of North Golden Lake's watershed is level to gently sloping with well defined drainages, interspersed with many small glacial basins. Soils in the region are primarily deep, nearly level to gently sloping on the till plains, and well drained on the side slopes and knolls. Soils in the valley and low lying plains are well drained to moderately well drained, alkaline and in some areas stony. These soils are ideal for growing wheat and sunflowers with 7 to 8 inches of black loam on the surface and 9 to 10 inches of dark brown clay loam as subsoil. Permeability is moderately slow with a high capacity to hold water. Land use is nearly 100 percent agricultural.

North Golden Lake is classified as a warm water fishery "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated biota" (NDSDHCL, 1991). Little data is available on the development of the fishery, though it is generally assumed the original stockings were a result of natural migrations from South Golden Lake to North Golden Lake during high water periods. The NDG&F initiated limited stocking beginning in the 1980's. Due to the shallowness of North Golden Lake and its tendency for dissolved oxygen deficiencies during the winter, stockings have been limited to species tolerant of these conditions such as northern pike. Test netting results conducted by the NDG&F in 1991 show a fish community dominated by black bullheads. North Golden Lake's fishery potential is limited to the number of years it can survive without a partial or complete winter kill.

North Golden Lake was 100 percent privately own until 1970 when the NDG&F purchased a small portion of lake front on the eastern shore. At present the only facilities are a boat ramp, boat dock, and outdoor toilets. There are plans to eventually improve the outlet structure to increase the lake depth to 18 feet. At present there is a small earthen structure which aids in maintaining present lake levels. Public use on North Golden Lake was limited until 1970 due to poor access. Since that time, the primary users have been fishermen.

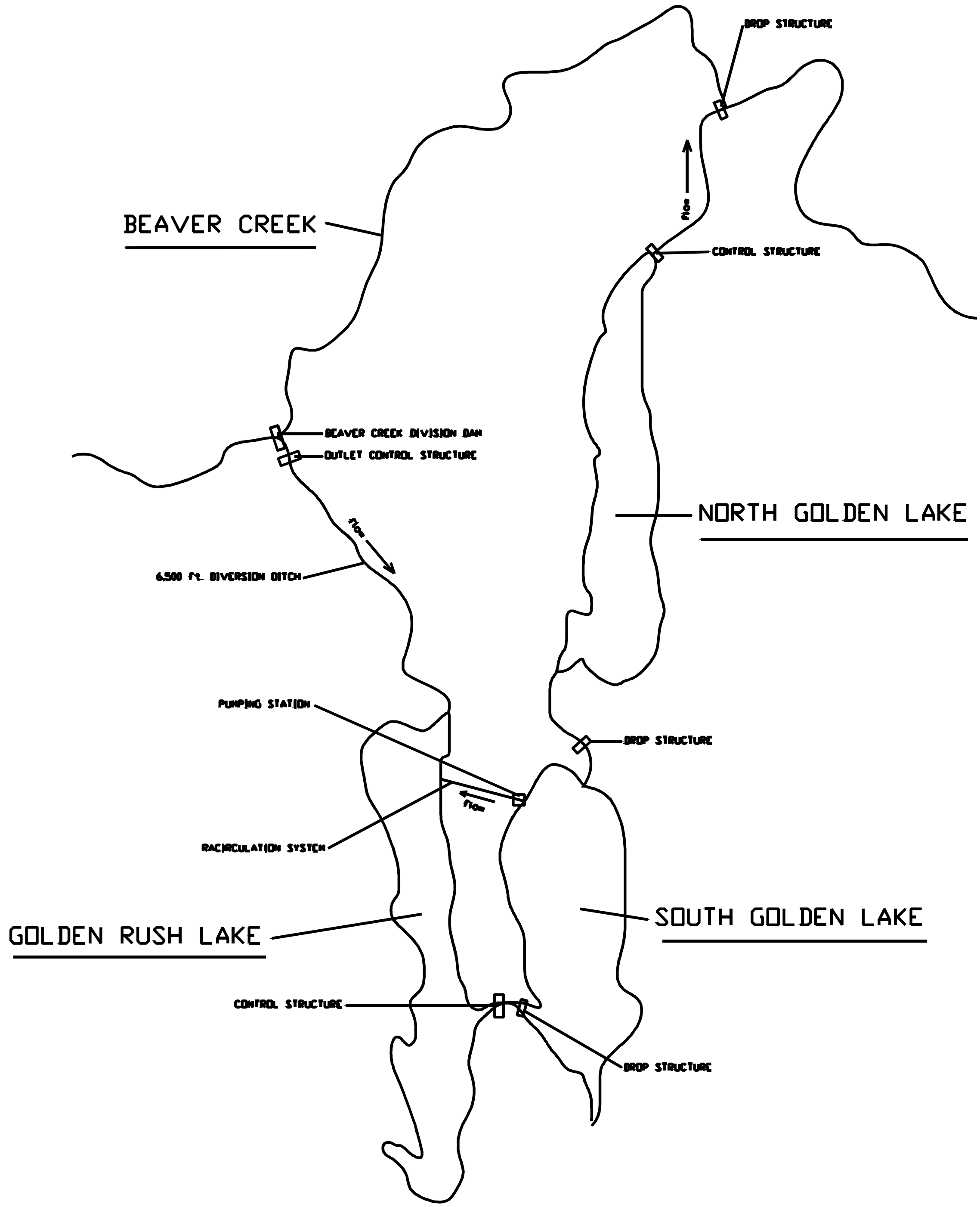

Figure 1. Map of North Golden Lake, South Golden Lake, Golden Rush Lake and location of water control structures.

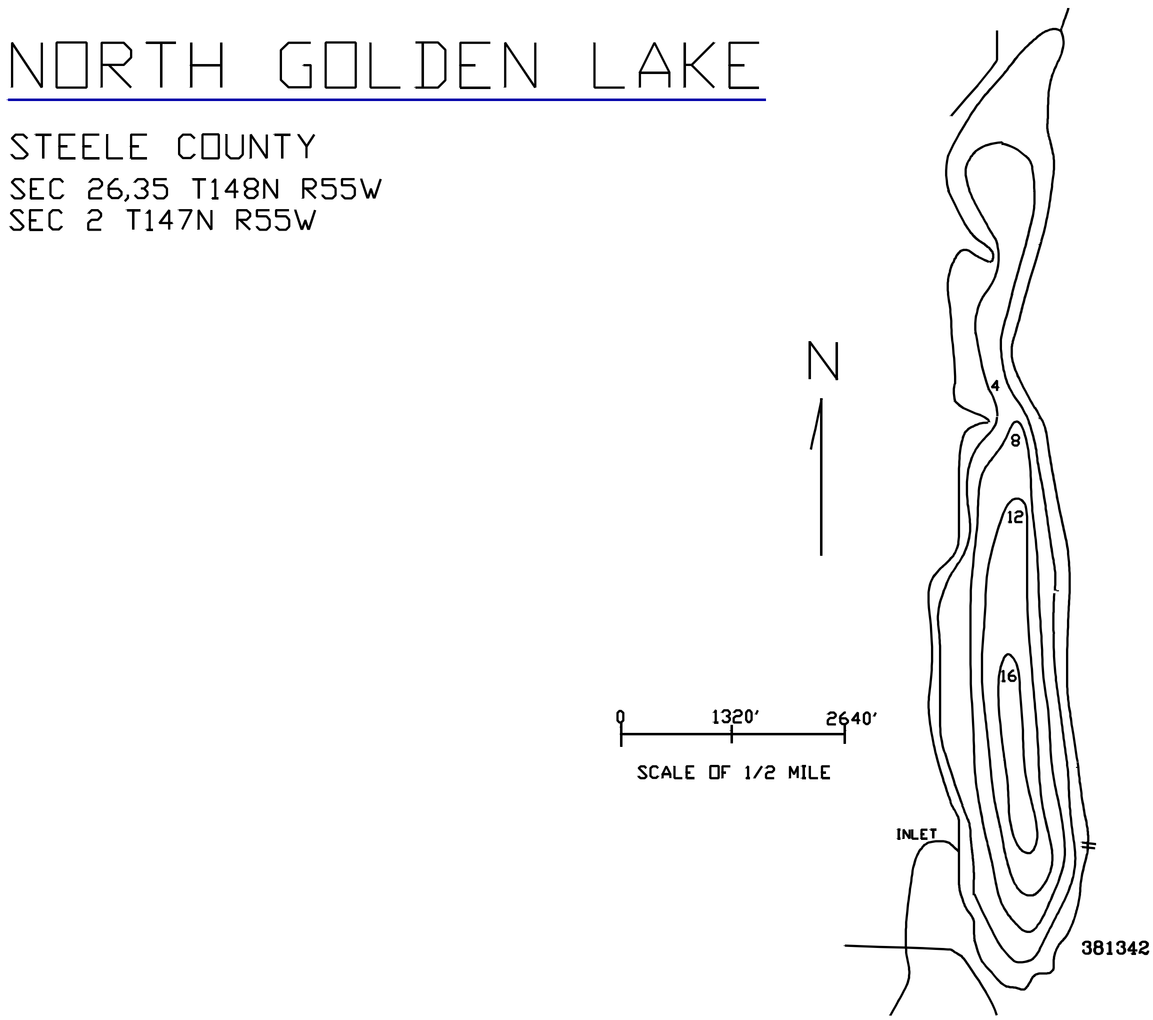

Figure 2. Morphometric map of North Golden Lake.

Water Quality

North Golden Lake was sampled two times during the summer of 1991 and once during the winter of 1992. Water quality samples were collected at one location, in the deepest area of the lake (Figure 2). In general, water quality in North Golden Lake is high in total dissolved solids and well-buffered. Average volume-weighted mean total dissolved solids, hardness as calcium, and total alkalinity as $CaCO_3$ concentrations during 1991 were 1,142, 578, 304 mg L^{-1}, respectively (Table 1). Sulfate and bicarbonates were the dominant anions in the water column. Sulfate concentrations ranged from 448 to 751 mg L^{-1} while bicarbonate concentrations ranged from 262 to 445 mg L^{-1}.

The average volume-weighted mean total phosphate as P concentration was 0.084 mg L^{-1} exceeding the State's target concentration of 0.02 mg L^{-1} on all occasions sampled during the 1991-1992 LWQA project. Nitrate + nitrite as N concentrations were below 0.004 mg L^{-1} (Table 1).

North Golden Lake is benefiting from the lake improvement project that was initiated to improve water quality in South Golden Lake. This system which involves using Golden Rush Lake as a filtration and nutrient assimilation pool is intended to improve the water quality in South Golden Lake. Since a substantial portion of North Golden Lake's water budget is a result of water it receives from South Golden Lake, it too receives a benefit from this project.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 10, 1991 and February 27, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and January 1, 1991.

Parameter	North Golden Lake		1982-1991	
Total Dissolved Solids	1142	mg L^{-1}	209	mg L^{-1}
Conductivity	1699	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	578	mg L^{-1}	488	mg L^{-1}
Sulfates	561	mg L^{-1}	592	mg L^{-1}
Chloride	49	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.084	mg L^{-1}	0.248	mg L^{-1}
Nitrate & Nitrite	0.003	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	284	mg L^{-1}	296	mg L^{-1}
Ammonia	0.276	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.97	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	304	mg L^{-1}	326	mg L^{-1}

During the summer of 1991, North Golden was thermally stratified at approximately 2 meters below the lake surface (Figure 3). During this time period dissolved oxygen concentrations were near or at saturation to a depth of 2 meters and were adequate to maintain aquatic life (Figure 4). Samples collected during January 1992 showed an nonstratified water column with dissolved oxygen concentrations at or below 2.0 mg L^{-1} at all depths sampled (Figure 3 and Figure 4). A complete listing of all LWQA water quality data is contained in Appendix A.

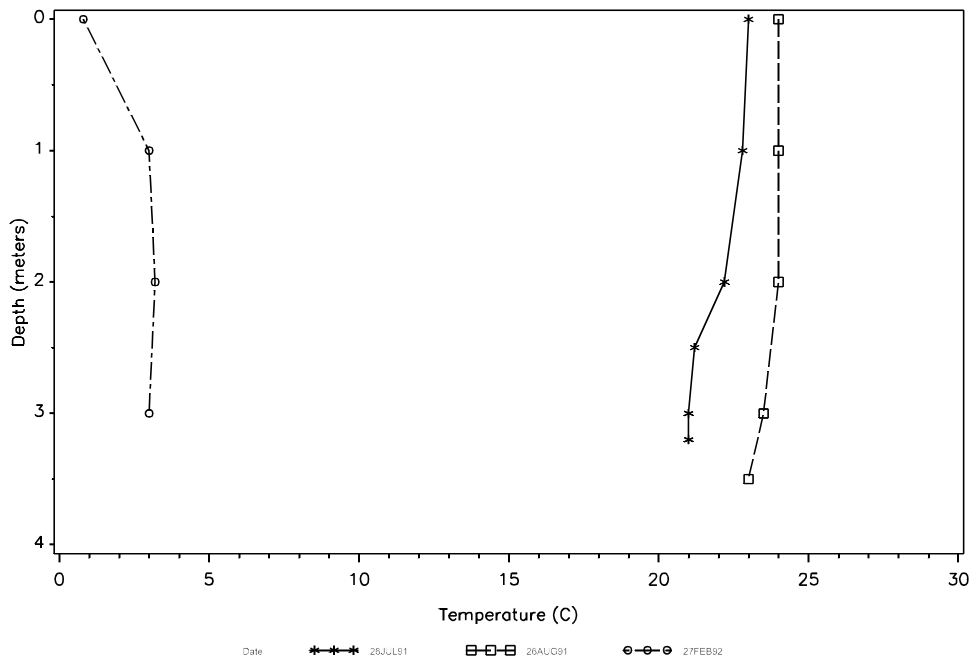

Figure 3. Temperature profile for North Golden Lake.

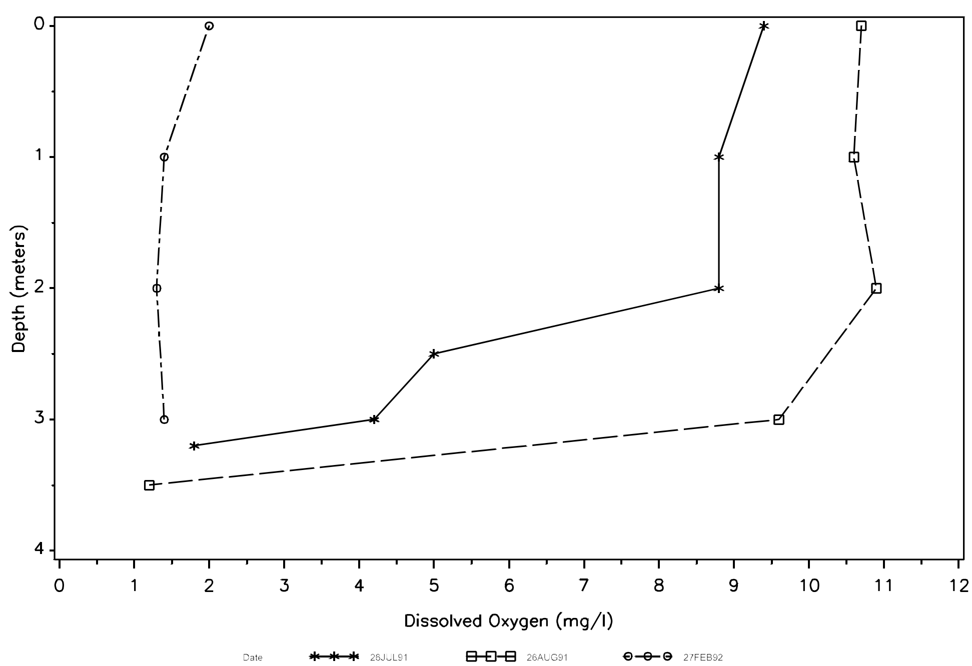

Figure 4. Oxygen profile for North Golden lake.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on North Golden Lake on August 26, 1991. At the time of the macrophyte survey approximately 20 percent of the North Golden Lake surface area had aquatic vegetation. The entire shoreline had a intermittent ring of bulrush (Scirpus spp.) and cattails (Typha spp.) to a depth of 3 to 4 feet. Other macrophytes present included sago pondweed (Potamogeton pectinatus), and curly leaf pondweed (Potamogeton crispus). A macrophyte map for North Golden Lake can be found in Appendix B.

Phytoplankton

The phytoplankton community was sampled two times during the summer of 1991. During these sample times, the phytoplankton community was represented by 5 divisions and 25 genera. The blue-green algae, Cyanophyta, were the largest contributors in terms of density by number. Mean density of the two samples collected during the summer of 1991 was 183,383 cells mL^{-1}, which was approximately 36.5 times greater than all other phytoplankton species combined.

At the time of the assessment, mean phytoplankton concentrations by volume were slightly more evenly distributed than by number, but were still dominated by the blue-greens. The diatoms, Bacillariophyta occupied approximately 27 percent of the community by volume, while the blue-greens occupied 62 percent. The remaining 11 percent was composed of Chlorophyta, Cryptophyta and Pyrrophyta. A compilation of all phytoplankton data is contained in Appendix C.

Trophic Status

A trophic status estimate based on total phosphorus concentrations, secchi disk transparency, and chlorophyll-a concentrations suggests it is hypereutrophic. Surface total phosphorus concentrations ranged between 81 and 88 $\mu g\ L^{-1}$. Chlorophyll-a concentrations ranged from 20 to 44 $\mu g\ L^{-1}$, and secchi disk transparency measurements were near 1 meter. Supporting ancillary information of a hypereutrophic trophic status lake assessment are low dissolved oxygen conditions throughout the water column in the winter, a phytoplankton population dominated by blue-greens, nuisance algae blooms and periodic fish kills.

Sediment Results

Sediment samples collected from North Golden Lake showed detectable levels of all trace elements tested for except mercury. Sediment concentrations at each sample location within North Golden Lake were also compared to sediment data collected from all the lakes sampled in 1991. Trace element concentrations were generally near or below the median concentrations for all lakes sampled. PCB concentrations and concentrations of selected organic compounds were below detectible limits for all samples collected from North Golden Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from North Golden Lake on June 6, 1991. Two species of fish were collected for contaminant analysis, white sucker represented the bottom feeder group, while northern pike represented the piscivore group.

In order to evaluate the fish tissue data for North Golden Lake, the results for each fish group was compared to that group for all lakes assessed during the 1991 LWQA project. Trace element concentrations in the northern pike sample from North Golden Lake were generally near or slightly greater than the median concentration for all piscivores sampled during 1991. The exceptions were the selenium and cadmium concentrations of 0.336 and 0.040 $\mu g\ g^{-1}$, respectively, which were above the 75th percentile reported for all piscivores. Reported mercury concentration was below the median for all piscivore samples collected in the 1991 LWQA project at 0.210 $\mu g\ g^{-1}$.

Trace element concentrations in the bottom feeder group collected from North Golden Lake were similar to the piscivore sample results in that selenium was two times greater than the median concentration for all bottom feeders collected at 0.370 $\mu g\ g^{-1}$, while cadmium was five times greater than the median with a concentration of 0.01 $\mu g\ g^{-1}$. Both concentrations represented the maximum reported for bottom feeders collected during the 1991 LWQA project.

Detectable pesticides residues in the two composite fish samples collected from North Golden Lake included DDD, DDE, triallate and trifluralin. DDD and DDE are primary metabolites of DDT and produce biological effects similar to those of DDT. Triallate also known as Far-go herbicide is a preemergent selective herbicide used with small grains, peas and lentils. Trifluralin, commonly known as treflan, is also a preemergent herbicide.

Tissue samples of the white sucker sample collected from North Golden Lake contained 0.053 $\mu g\ g^{-1}$ of DDD, 0.063 $\mu g\ g^{-1}$ of DDE, 0.005 $\mu g\ g^{-1}$ of triallate and 0.007 $\mu g\ g^{-1}$ of trifluralin. The concentrations of DDD and DDE and trifluralin represented the highest concentrations of these parameters reported during the 1991 LWQA project. The northern pike sample collected contained concentrations of 0.009 $\mu g\ g^{-1}$ of DDD, 0.083 $\mu g\ g^{-1}$ DDE and 0.003 $\mu g\ g^{-1}$ of trifluralin. The DDD and DDE concentrations reported were also the highest concentrations reported for the piscivore group. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

North Golden Lake with its contributing and partially contributing watershed has a combined surface area of 10,940 acres. It is located on the eastern edge of the Red River Valley in Steele County, North Dakota. The surrounding landscape is level to gently sloping with well defined drainages. Soils are predominately excessively well drained on the crest of hills and low knolls to moderately well drained in the valleys.

Nonpoint source pollution from the surrounding watershed including South Golden Lake accounts for all of the nutrient loadings and pollution discharges to North Golden Lake. Land use within the North Golden Lake watershed is 90 percent agricultural. Sixty-nine percent of the watershed is actively cultivated. The remaining 31 percent is in low density urban development, haylands, pasture, conservation reserve program (CRP), and one concentrated livestock feeding area (Table 2).

According to the information provided by the Steele County Soil Conservation District, 50 percent of the cultivated lands and nearly all the remaining lands within the North Golden Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the North Golden Lake watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of 2 to 3 tons per acre approximately 60,579 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 6,058 tons to 9,087 tons of soil potentially reaches the waters within the watershed annually. Only a fraction of this actually reaches North Golden Lake however, since the majority of the sediment is filtered through Golden Rush Lake and South Golden Lake before reaching North Golden Lake.

Another source of nonpoint source pollution discharges to North Golden Lake are from the numerous summer and permanent homes surrounding South Golden Lake. Approximately 50 percent of the area immediately adjacent to the South Golden Lake is developed with septic systems, holding tanks and/or pit toilets. Each of these could be contributing nutrients to the lake and may be the most significant source of nutrients to South Golden, eventually reaching North Golden lake. Fertilizer runoff from lawns and the construction of new homes are other possible sources of nonpoint source pollution to South Golden Lake which could directly affect the water quality of North Golden lake.

Table 2. Land use in the North Golden Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	69	35
Hayland	10	100
CRP	11	100
Wet/Wild[1]	6	100
Other	4	N/A
Farmsteads	2[3]	N/A
Feedlots[2]	1[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represents the number present within the watershed.

NORTHGATE DAM

BURKE COUNTY

Peter N. Wax

Northgate Dam is located on Stoney Run Creek in northern Burke County, North Dakota. It has an earthen dam with a concrete spillway. The Dam was created for recreation in 1968 by the NDG&F. Northgate Dam presently has a surface area of 150.8 acres, an average depth of 8.8 feet and a maximum depth of 25 feet (Figure 1).

Northgate Dam's contributing watershed spans approximately 28,160 acres of nearly 100 percent agricultural lands. The city of Flaxton's wastewater lagoons are the only point source discharge in the watershed. Flaxton is a community of approximately 180 people. Topography in the watershed is nearly level, except for the extreme southern portion which lies on the Missouri Coteau.

Northgate Dam is classified as a cool water fishery "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage the fishery by annual assessments of the fish community through spring test netting operations, fish stocking and biological manipulations. In recent years stockings have included largemouth bass, bluegill and walleye. Test netting operations conducted in the spring of 1991 showed good populations of both walleye and bluegill.

Northgate Dam experienced a complete fish kill in the summer of 1972, a partial winterkill in 1980-1981 and a partial summer kill in 1983. The 1972 fish kill was investigated by the U.S. Environmental Protection Agency (EPA). The investigation indicated the kill was caused by chemical pollutants. The die-off in the winter of 1980-81 was most likely caused by low water levels created when the dam was lowered in the summer of 1978-1979 for repairs and failed to fill after stocking. The summer kill of 1983 was probably a result of a combination of heat stress and the cyclic bloom and die-off of algae.

The lake was drained in 1978-1979 to repair the spillway. An automatic hypolimnetic drain was installed at this time. Public facilities and access to Northgate Dam are excellent, including a swimming beach, boat ramp, picnic tables, available drinking water, and a camping area.

Water Quality

Water quality samples were collected from Northgate Dam two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 380845, Figure 1). Water column samples were collected for analysis at three separate depths, 1 meter, 2 meters and 6 meters.

On July 17, 1991, Northgate Dam was thermally stratified at approximately 4 meters below the surface (Figure 2). On August 7, 1991, Northgate Dam was not thermally stratified (Figure 2). At these times, dissolved oxygen concentrations were at or near saturation to a depth of 3 to 4 meters and were adequate to maintain aquatic life (Figure 3). Northgate Dam did not appear to be thermally stratified when it was sampled on January 7, 1992. During this time period dissolved oxygen concentrations were between 12.4 mg L^{-1} near the surface gradually declining to 3.2 mg L^{-1} near the bottom (Figure 2, Figure 3).

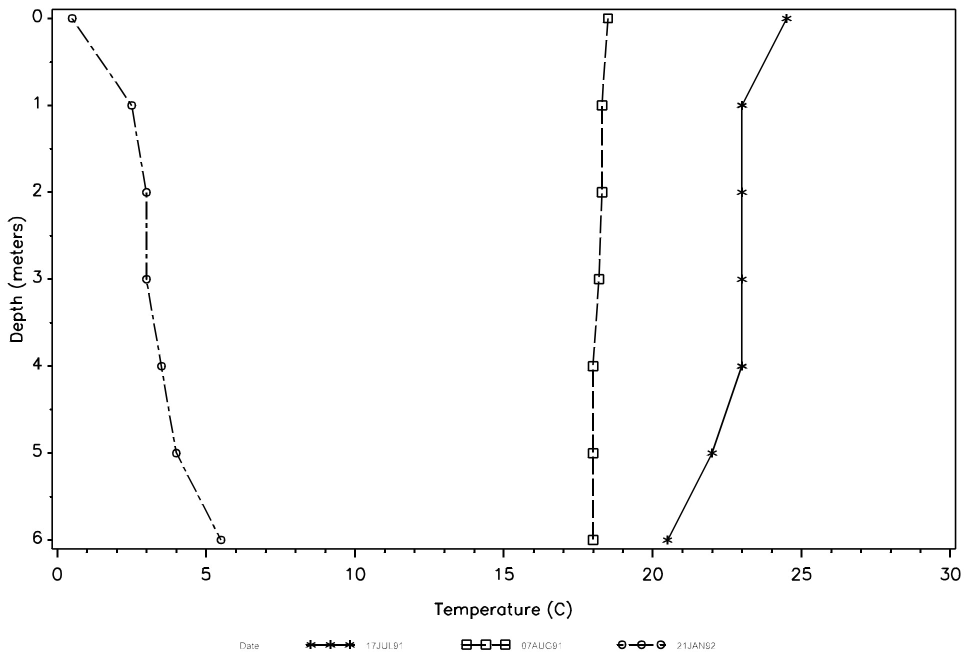

Figure 72. Temperature profile for Northgate Dam.

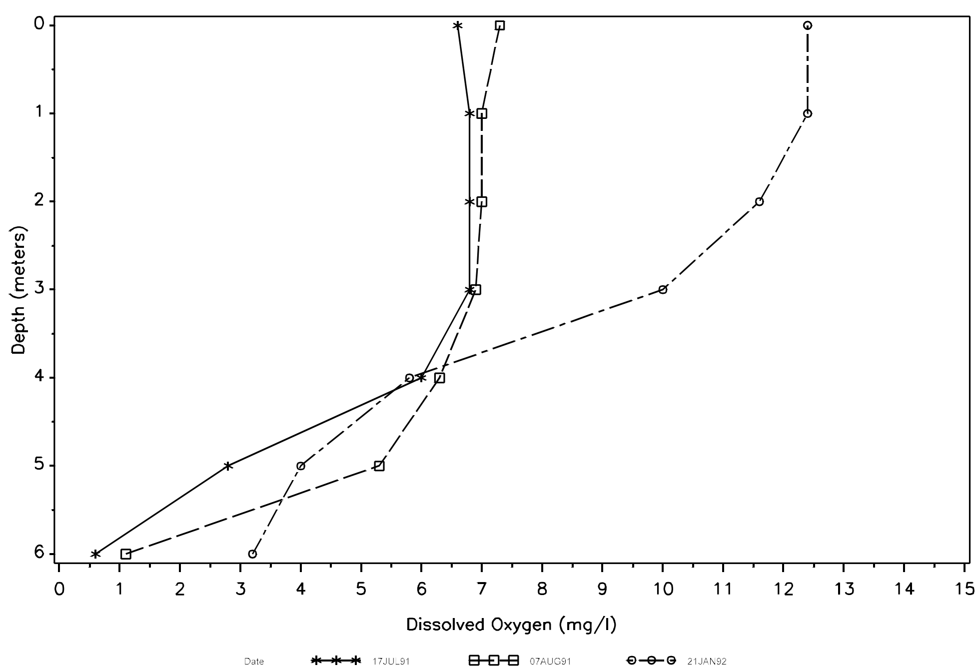

Figure 73. Oxygen profile for Northgate Dam.

Northgate Dam is well-buffered with a average volume-weighted mean total alkalinity as $CaCo_3$ concentration of 243 mg L^{-1}. Sulfate and bicarbonate were the dominant anions in the water column. Sulfate concentrations ranged from 3.0 to 58 mg L^{-1} while bicarbonate concentrations were between 225 and 317 mg L^{-1}. Levels of total dissolved solids, hardness, and conductivity were less than the long-term average for lakes sampled by the NDSDHCL in North Dakota from 1982 to 1991 (Table 1).

The average volume-weighted mean total phosphorus as P concentration was 0.287 mg L^{-1} exceeding the State's target concentration of 0.02 mg L^{-1} on all occasions sampled during 1991 and 1992. Nitrate + nitrite as N concentrations were below the state's target concentration of 0.25 mg L^{-1} on all occasions sampled. The average volume-weighted mean nitrate + nitrite as N concentration was 0.03 mg L^{-1}. A complete list of water quality sample data is contained in Appendix B.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 17, 1991 and January 2, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Northgate Dam		1982-1991	
Dissolved solids	283	mg L^{-1}	1209	mg L^{-1}
pH	8.2	SU	8.36	SU
Conductivity	509	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	180	mg L^{-1}	488	mg L^{-1}
Sulfates	31	mg L^{-1}	592	mg L^{-1}
Chlorides	11.9	mg L^{-1}	81	mg L^{-1}
Total phosphate as P	0.287	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.030	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	218	mg L^{-1}	296	mg L^{-1}
Ammonia	0.175	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.57	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	243	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Northgate Dam as part of the 1991-1992 LWQA project. The survey was performed on August 8, 1991. At the time of the macrophyte survey, approximately 50 percent of the Northgate Dam's surface area had submergent and emergent macrophyte vegetation. The macrophyte species identified on Northgate Dam were flat stem pondweed (Potamogeton pusillus), water milfoil (Myriophyllum spp.), sago pondweed (Potamogeton pectinatus), coontail (Ceratophyllum demersum), curly leaf pondweed (Potamogeton crispus) and cattails (Typha spp.). A map depicting the areal extent of the macrophyte community is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled two times during the summer of 1991. Phytoplankton or algae can be used as indicators of nutrient availability and as an additional indication of the trophic condition of a water body.

During the summer of 1991 the phytoplankton community was represented by 5 divisions and 21 genera. Green algae, Chlorophyta, were the dominant algae by number during July, while blue-green, Cyanophyta, were dominant in August. The domination of the algal community by blue-green algae in August was substantial as the mean density, 9,662 cells mL^{-1} represented nearly an 11-fold increase as compared to July. The blue-green algae concentration in August was also four times the density of all algae combined.

At the time of the assessment mean phytoplankton concentrations by volume were more evenly distributed among four of the divisions, Pyrrophyta, Chlorophyta, Cyanophyta, and Cryptophyta. The density by volume of Bacillariophyta which was not found in the July sample was significant in August. This substantial increase in volume over the other species present is due to the large size of the species Stephanodiscus rotulas, a large organism. The large size of this species of algae accounts for the difference between density by number and volume. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Northgate Dam, during the LWQA project, was highly eutrophic. This assessment was based on three primary water quality indicators; summer surface total phosphate as P concentrations, chlorophyll-a concentrations, and secchi disk transparency measurements. Due to difficulties encountered during sample collection only one chlorophyll-a sample was available for the assessment. The surface total phosphate as P concentration averaged 0.227 mg L^{-1}, the single chlorophyll-a concentration was 0.019 mg L^{-1} and secchi disk transparency averaged 2.8 meters.

Supporting ancillary information included a rapid decline in dissolved oxygen within the hypolimnion, a large macrophyte biomass, frequent algae blooms and a single fish kill related to nutrient cycling. The fish kill is significant in that it indicates an increasing eutrophic condition and possibly a preview of a further declining lake.

Sediment Analysis

Sediments were collected from Northgate Dam during the spring of 1991 and analyzed for trace elements, PCBs and selected organic compounds (pesticides). Sediments were collected from the deepest area of the lake (Site 380845), the littoral zone (Site 380846), and the inlet (Site 380847) (Figure 1).

Sediment samples collected from Northgate Dam showed detectable levels of all trace elements tested for except mercury. Sediment concentrations at each sample location within Northgate Dam were also compared to sediment data reported for all lakes assessed in 1991 as part of LWQA project. In general, trace element concentrations were near or below the median concentrations for all lakes sampled during 1991. The exceptions were barium, arsenic, and chromium, which were slightly above the reported median.

PCB concentrations and concentrations of selected organic compounds were below detectible limits for all samples collected from Northgate Dam. A complete listing of the sediment data is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Northgate Dam on June 6, 1991. Walleye were collected and represented the piscivore group, and bluegills were collected representing the insectivore group. The walleye sample was a composite of five fish having a mean weight of 300 grams and a mean length of 330 cm, the bluegill sample was a composite of five. Mean weight and mean length were not recorded.

In order to evaluate the fish tissue data for Northgate Dam, the results were compared to the corresponding group for all lakes assessed as part of the 1991 LWQA. Trace element concentrations in the fish samples collected from Northgate Dam in general were near or slightly below the median concentration for all fish collected during the 1991 LWQA project.

Detectable pesticide residues in the composite whole fish samples collected from Northgate Dam includes DDD, DDE, and trifluralin. Both DDD and DDE are breakdown derivatives of DDT and exhibit similar characteristics to the parent compound in the ecosystem. Trifluralin, commonly known as treflan, is selective preemergent herbicide.

Analysis of the walleye collected from Northgate Dam showed the concentrations of DDE was 0.004 $\mu g\ g^{-1}$, DDD was 0.007 $\mu g\ g^{-1}$ and trifluralin was 0.007 $\mu g\ g^{-1}$. The concentrations of DDD and DDE are near the median concentrations for all lakes sampled, while the trifluralin concentration was above the 75th percentile for all piscivores sampled in 1991 as part of the LWQA project. The bluegills collected contained reported concentrations of DDD and DDE that were equal to the reported 75th percentile for all insectivores sampled, while the trifluralin concentration of 0.006 $\mu g\ g^{-1}$ was greater than the 75th percentile. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Northgate Dam and it's contributing watershed has a combined surface area of 28,160 acres. It is located in northern Burke County, North Dakota. The discharge from Northgate Dam travels down Stoney Run Creek into Saskatchewan, Canada where it confluences with the Souris River. Topography is nearly level, broken only by agricultural fields and small creeks. Nonpoint source pollution from the surrounding watershed accounts for nearly all of the nutrient loadings and pollution discharges to Northgate Dam.

Land use within the Northgate Dam watershed is 97 percent agricultural, with 89 percent actively cultivated. Eight percent of the remaining lands are in haylands, pasture, and Conservation Reserve Program (CRP) and three percent in low density urban development (Table 2). There are six concentrated livestock feeding areas within the contributing drainage and one small municipality. According to the information provided by the Burke County Soil Conservation District, 30 percent of the cultivated lands and between 30 and 40 percent of the remaining lands within the Northgate Dam watershed are "adequately treated" against soil loss.

It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Northgate Dam watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of nearly 11 tons per acre, which accounts for the untreated portion of the watershed, approximately 307,734 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 30,773 tons to 46,160 tons of soil potentially reaches Northgate Dam annually.

Flaxton, a community of approximately 180, is the only municipality in the Northgate Dam watershed. The city of Flaxton's wastewater lagoons are the only point source discharge in the watershed. The most recent discharge occurred in 1985. The discharge location is into an unnamed slough approximately five miles west of Northgate Dam.

Table 2. Land use in the Northgate Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	89	30
Pasture land	5	30
Hayland	2	40
CRP	1	100
Wet/Wild[1]	1	100
Other	2	N/A
Farmsteads	25[3]	N/A
Feedlots[2]	6[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding.

PHEASANT LAKE

DICKEY COUNTY

Peter N. Wax

Pheasant Lake is a small reservoir located on the Elm River in central Dickey County, North Dakota. The reservoir was constructed through the involvement of North Dakota State Water Commission, NDG&F, and the Dickey County Water Management Board. Construction was completed and the dam closed in 1963. Physically, Pheasant Lake is narrow and long with one small arm near the dam. The average depth is less than eight feet and the maximum depth at full pool is approximately 18 feet. (Figure 1).

The topography of Pheasant Lake's watershed varies considerably from east to west. The eastern quarter lies in the Missouri Coteau physiographic region, an erosion remnant of the late Wisconsin Age. The Missouri Coteau extends in a north-south direction and is characterized by rolling hills and valleys with slopes ranging from 3 to 20 percent. Soils in this region are deep and well drained form from medium-textured to moderately fine glacial till. The remaining three quarters of the watershed lies in the Glaciated Plains physiographic region. A region that is less hilly and more fertile with slopes ranging from 0 to 6 percent.

Pheasant Lake is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated biota" (NDSDHCL, 1991). It is managed by the NDG&F through annual fish community assessments through test netting and fish stockings. In recent years the stocking regiment has included largemouth bass, northern pike, channel catfish, and walleye. In 1991, test netting results showed the fish community dominated by black bullheads. Other fish species captured were black crappie, bluegill, yellow perch, walleye and northern pike.

Prior to stocking the reservoir, the entire watershed was eradicated in the fall of 1962. High water breached the dam in the spring of 1963, necessitating additional eradication. However, the second eradication only treated the area behind the dam, allowing the reservoir to contain a population of bullheads before the initial trout stockings.

The initial fishery was established by stocking rainbow trout in 1964, followed by stocks of northern pike, walleye, yellow perch, crappie, bluegill, largemouth bass and smallmouth bass. Since the first test nettings conducted in 1969, black bullhead have been the dominant species. The abundant black bullhead in combination with periodic winterkills have prevented Pheasant Lake from developing into a good sport fishery. The NDG&F and the Dickey County Wildlife Club joined forces to improve Pheasant Lake, following a severe fish kill during the winter of 1977-1978.

The improvement goals for Pheasant Lake were threefold; (1) to increase stockings of adult panfish and fingerling game fish, (2) to enhance water quality and (3) to implement a fish biomass removal program. The first of these goals was accomplished by building of a rearing pond on the shores of Pheasant Lake with money raised from the Dickey County Wildlife Club. The second of these goals was partially accomplished through the addition of a hypolimnetic drawdown and aeration system and the third goal is being accomplished by spring netting and removal of black bullheads.

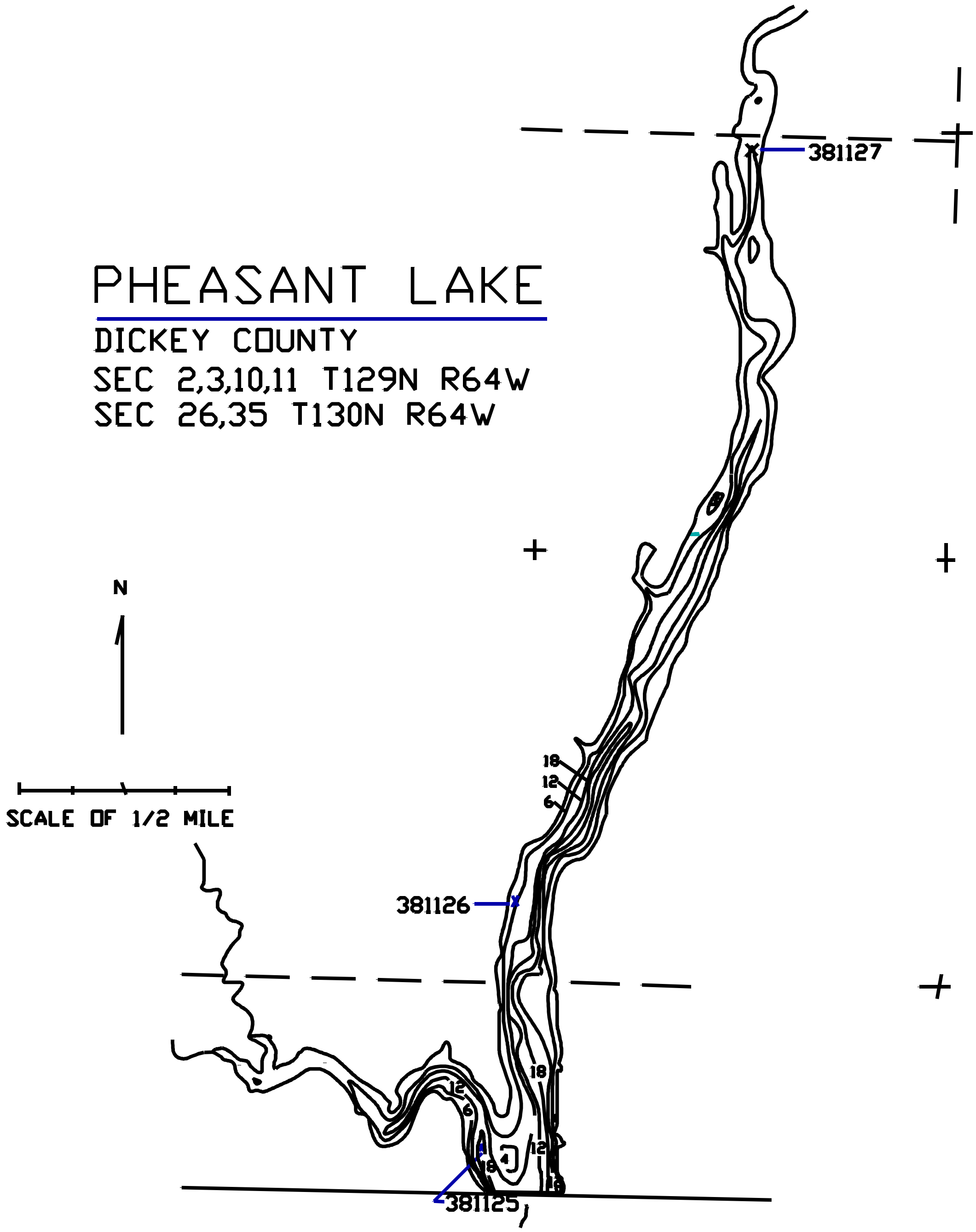

Figure 1. Morphometric map of Pheasant lake.

Public access to Pheasant Lake is good. Public facilities include a boat ramp, parking lot, toilet, swimming beach and picnic area. Pheasant Lake is a very popular lake with the local community as evident by their involvement in many projects to improve the lake.

Water Quality

Water quality samples were collected from Pheasant Lake two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381125, Figure 1). Water column samples were collected for analysis at three separate depths, 1 meter, 3 meters, and 5 meters.

During the summer of 1991 Pheasant Lake was not thermally stratified at the time of sampling (Figure 2). During these time periods dissolved oxygen concentra-tions were adequate to maintain aquatic life except near the bottom where concentrations were less than 5 mg L^{-1} (Figure 3). Samples collected during the winter of 1992 showed dissolved oxygen concentrations near saturation at all depths (Figure 3).

Pheasant Lake is well-buffered with an average volume-weighted mean total alkalinity as $CaCO_3$ concentration of 171 mg L^{-1}. Sulfate and bicarbonates were the dominant anions in the water column. Sulfate concentrations ranged from 57 to 90 mg L^{-1} while bicarbonate concentrations were between 169 and 268 mg L^{-1}.

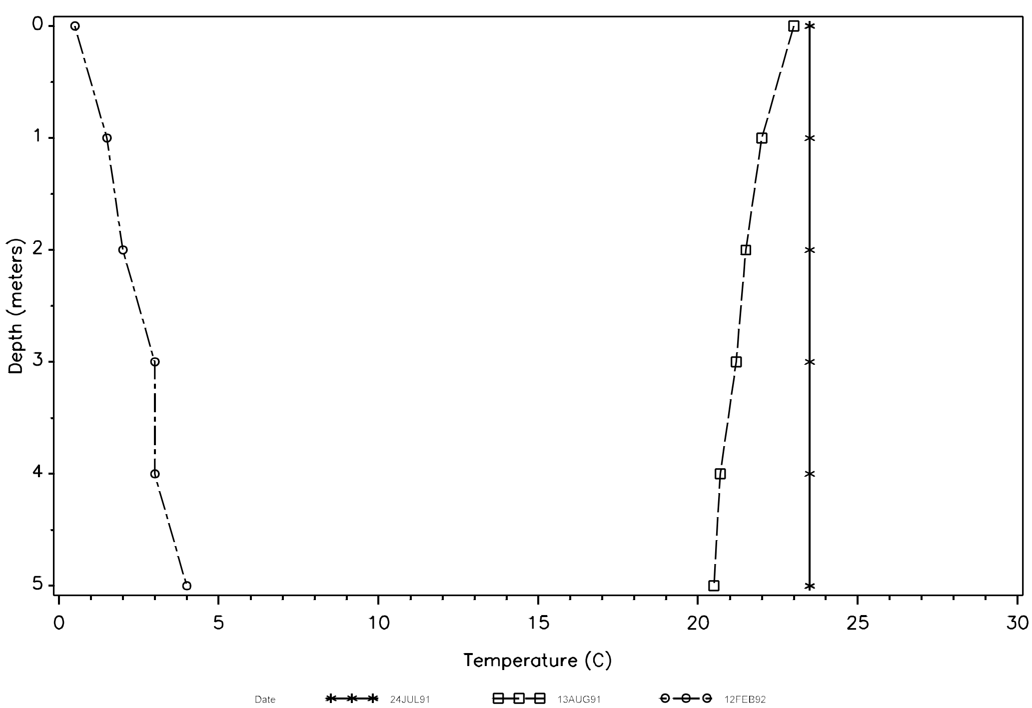

Figure 2. Temperature profile for Pheasant Lake.

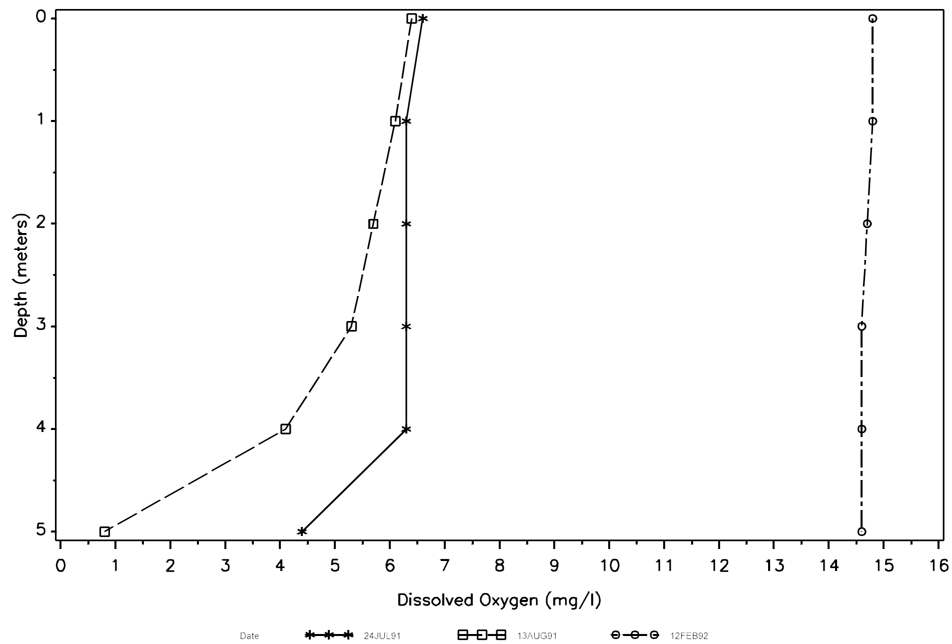

Figure 3. Oxygen profile for Pheasant Lake.

The average volume-weighted mean concentrations for total phosphate as P was 0.667 mg L^{-1} exceeding the State's target concentration of 0.02 mg L^{-1} on all occasions sampled during 1991 and 1992. The nitrate + nitrite as N concentration was below the target concentration of 0.25 mg L^{-1} with an average volume-weighted mean concentration of 0.205 mg L^{-1}. A complete list of water quality sample data is contained in Appendix A.

The ratio of total phosphate as P to nitrate + nitrite as N of 3:1 suggests Pheasant Lake is phosphorus limited. However, true nitrogen limitation does not exist on Pheasant Lake but rather is an over abundance of phosphorus. Under these conditions nitrogen fixing algae like some blue-green algae species are favored (Table 1).

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July and August, 1991 and January 1992, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Pheasant Lake		1982-1991	
Total Dissolved Solids	302	mg L^{-1}	1209	mg L^{-1}
Conductivity	524	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness of Calcium	157	mg L^{-1}	488	mg L^{-1}
Sulfates	69	mg L^{-1}	592	mg L^{-1}
Chlorides	20.5	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.667	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.205	mg L^{-1}	0.069	mg L^{-1}
Total Kjeldahl Nitrogen	1.52	mg L^{-1}	2.34	mg L^{-1}
Ammonia	0.172	mg L^{-1}	0.347	mg L^{-1}
Bicarbonate	205.42	mg L^{-1}	326	mg L^{-1}
Total Alkalinity	171.23	mg L^{-1}	296	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on August 13, 1991. At the time of the macrophyte survey Pheasant Lake had a diverse and abundant macrophyte population with nearly 50 percent of the surface area containing aquatic vegetation. Nearly 100 percent of the lakes surface area to a depth of four feet had one or a combination of sago pondweed (Potamogenton pectinatus), water milfoil (Myriophyllum spp.), cattails (Typha spp.), duckweed (Lemna spp.), bulrush (Scripus spp.), coontail (Ceratophyllus demersom), and sedge grass (Carex spp.). A map depicting the macrophyte community and it's areal extent is depicted in Appendix B.

Phytoplankton

The phytoplankton community was sampled two times during the summer of 1991. The phytoplankton community is comparatively diverse with representation from 6 divisions and 29 genera. The largest contributors by density depicted by number were the green algae, Chlorophyta, with 6 genera present. The mean density of green algae for the two samples collected during the summer of 1991 was 36,025 cells mL^{-1} which is 6 times greater then the next most abundant group, the blue-green algal, Cyanophyta.

At the time of the assessment mean phytoplankton concentrations by volume fluctuated substantially between the July and August sample dates. In July, the diatoms, Bacillariophyta dominated the algal community by 2.5-fold over all other groups combined. In August, the blue-green algae, Cyanophyta, had taken over in dominance in almost equal proportions. Complete phytoplankton data is contained in Appendix C.

Trophic Status

The trophic status of Pheasant Lake is estimated to be hypereutrophic. This estimate is based on summer total phosphate as P concentrations, secchi disk transparency and ancillary information. Surface total phosphate concentrations average 0.766 mg L^{-1} while secchi disk transparency was 0.6 meters. Supporting ancillary information includes a large macrophyte biomass, frequent algal blooms and a history of fish kills.

Sediment Analysis

Sediments were collected from Pheasant Lake and analyzed for trace elements, PCBs, and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381125), the littoral zone (Site 381126), and the inlet (Site 381127) (Figure 1).

Sediment samples collected from Pheasant Lake showed detectable levels of all trace elements tested for, except mercury at the inlet and littoral zones. Sediment concentrations at each sample location within Pheasant Lake were also compared to the sediment data for all lakes assessed during 1991. Trace element concentrations were near or below the median concentrations for all lakes sampled except for barium and selenium in the littoral area and selenium in the deepest location.

Concentrations of selected organic compounds were below detectible limits for all samples collected from Pheasant Lake except DDE. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Bluegill and bullheads were collected for contaminant analysis from Pheasant Lake in 1991. The bluegill represented the insectivore group and bullheads the bottom feeder group.

In order to evaluate the fish tissue data for Pheasant Lake, the results for each fish group was compared to that group for all lakes assessed during the 1991 LWQA project. Trace element concentrations in the fish samples collected from Pheasant Lake were generally near or slightly below the median concentra-tions for all fish analyzed during the LWQA. The exceptions were the reported mercury concentration of 0.15 $\mu g\ g^{-1}$ for the insectivore group and reported mercury and selenium concentrations of 0.13 and 0.414 $\mu g\ g^{-1}$, respectively, for the bottom feeder group.

Detectable pesticide residues in the fish samples collected from Pheasant Lake included DDE and trifluralin. DDE is a degradation product of the insecticide DDT and produces biological effects similar to the parent compound. Trifluralin, commonly known as Treflan, is a selective pre-emergent herbicide. The DDE concentration reported was below the median concentration for all fish samples collected in 1991 at 0.004 $\mu g\ g^{-1}$ for the insectivore group and 0.003 $\mu g\ g^{-1}$ for the bottom feeder group. Trifluralin was found only in the bottom feeder group and was above the median concentration at 0.005 $\mu g\ g^{-1}$. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Pheasant Lake's watershed varies substantially from east to west. In the west the topography is composed of rolling hills and intricate drainages, characteristic of the Missouri Coteau physiographic region, a glacial remnant of the late Wisconsin Age. Land use is a mixture of pastures on the steeper slopes and valleys with cultivated lands predominating on the uplands. Throughout the remainder of the watershed topography is much more level and intensely cropped. Soils are mostly deep and well drained formed from medium-textured to moderately-fine glacial till. The watershed covers approximately 59,520 acres and contributes nearly 100 percent of the pollution loadings to Pheasant Lake.

Land use within the Pheasant Lake watershed is 95 percent agricultural with 60 percent in croplands. The remaining 40 percent is in low density urban development, haylands, pasture, conservation reserve program (CRP) (Table 2). According to the information provided by the Dickey County Soil Conservation District, 60 percent of the cultivated lands and 40-80 percent of the remaining lands within the Pheasant Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Pheasant Lake watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of 11 to 13 tons per acre, which takes into account the untreated portions of the watershed approximately 791,456 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 79,156 tons to 108,718 tons of soil reaches Pheasant Lake annually.

Other sources of nonpoint source pollution affecting Pheasant Lake are from the 25 or more cabins and associated waste treatment systems and from concentrated livestock in the watershed. These sources contribute nutrients to the lake and may be imparting the most significant impact due to their close proximity to the lake water. Fertilizer runoff from lawns and the construction of new homes are other possible sources of nonpoint source pollution.

Table 2. Land Use in the Pheasant Lake watershed

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	60	60
Pasture Land	10	50
Hayland	5	80
CRP	20	100
Wet/Wild[1]	3	100
Other	2	N/A
Farmsteads	2[3]	N/A
Feedlots[2]	15[3]	40

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number present in watershed.

RICE LAKE

WARD COUNTY

Peter N. Wax

Rice Lake is located in southern Ward County, North Dakota on the eastern edge of the Missouri Coteau physiographic region. Rice Lake is a natural lake formed by glacial outwashing during the late Wisconsin Age. It is a relatively deep lake with a maximum depth of 30 feet and an average depth of almost 8 feet (Figure 1).

Topography of the area is characterized by rolling hills and valleys with slopes ranging from 1 to 20 percent. Soils are excessively drained, formed from sandy, rocky glacial material. The watershed is predominately integrated drainages typifying characteristics of the northern prairie pothole region.

Rice Lake is classified as a cool water fishery "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). Rice Lake is managed through annual fish community assessments and fish stocking by the NDG&F. The NDG&F regularly stock fingerling northern pike with supplemental stockings of adult yellow perch. Walleye and bluegill were introduced in the early 1980's, and occasional stockings have occurred since that time. Subsequent test netting showed poor survival rates. Fish population sampling conducted in 1991 show the population dominated by stunted yellow perch, black bullheads and white suckers.

The potential for Rice Lake to become a stable fishery is hampered by partial winter kills which occur approximately one out of four years. This dictates fisheries management to fishes tolerant to low dissolved oxygen conditions.

The shore and land surrounding Rice Lake is 100 percent privately owned with over 50 percent developed into lots occupied by seasonal and permanent homes. Access is limited to one boat ramp and parking lot provided by the NDG&F. Rice Lake is a popular recreational area and receives heavy use throughout the summer months from residents of Minot and the Minot Air Force Base.

Water Quality

Water quality samples were collected from Rice Lake three times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381090, Figure 1). Water column samples were collected for analysis at three separate depths, surface, middle and bottom.

During the summer of 1991 Rice Lake stratified at approximately 6 meters below the lake surface or 3 meters off the bottom (Figure 2). During this time period dissolved oxygen concentrations were at or near saturation to a depth of 7 meters and were adequate to maintain all manner of aquatic life (Figure 3). Samples collected during January 1992 showed dissolved oxygen concentrations at or below 3.5 mg L^{-1} at all depths (Figure 3).

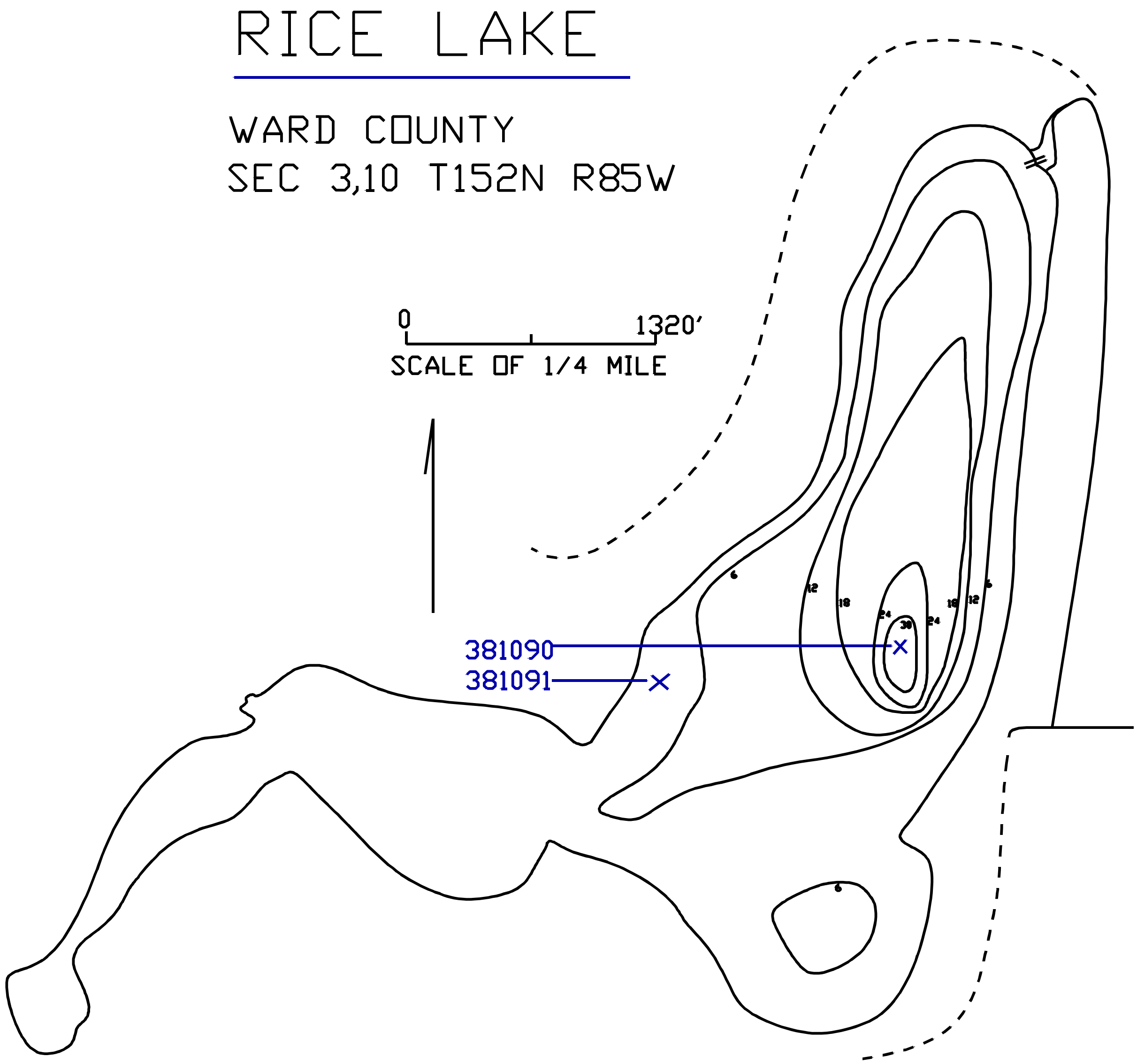

Figure 1. Morphometric map of Rice Lake.

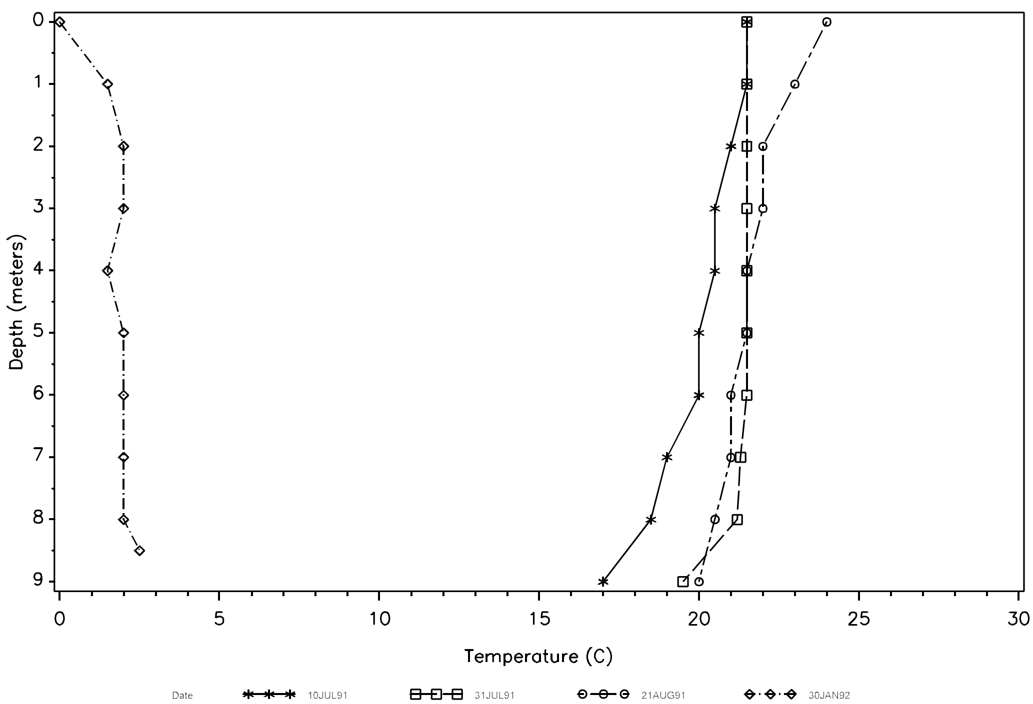

Figure 2. Temperature profile for Rice Lake.

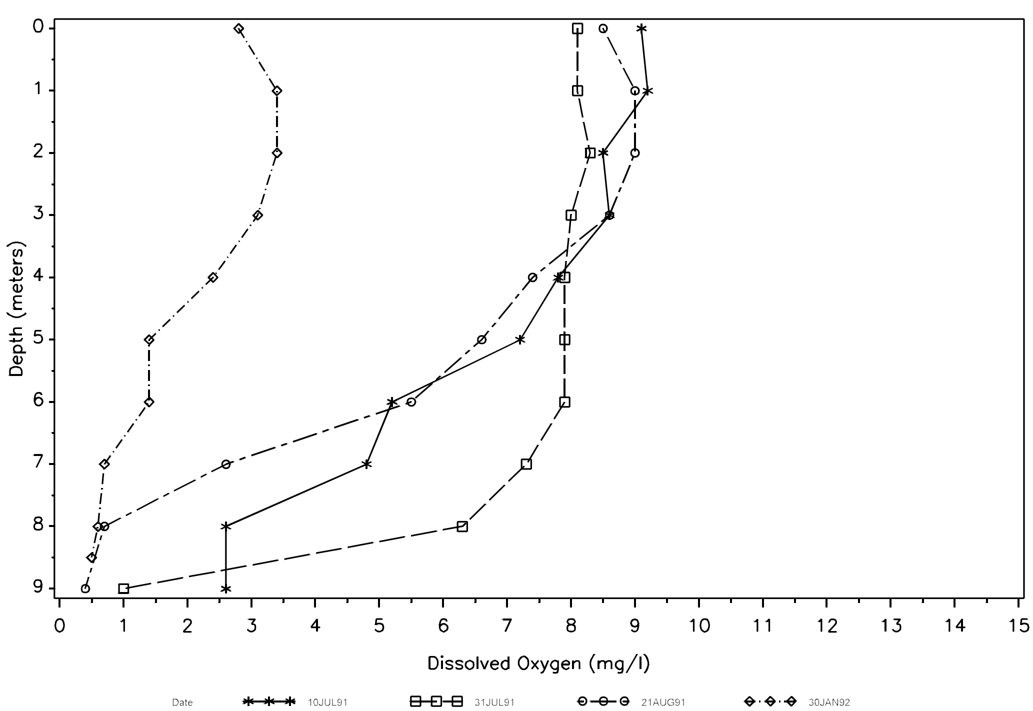

Figure 3. Oxygen profile for Rice Lake.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 10, 1991 and January 30, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Rice Lake		1982-1991	
Total Dissolved Solids	1570	mg L^{-1}	1209	mg L^{-1}
Conductivity	1995	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	1042	mg L^{-1}	488	mg L^{-1}
Sulfate	644	mg L^{-1}	592	mg L^{-1}
Chloride	35	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.037	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.012	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	719	mg L^{-1}	296	mg L^{-1}
Ammonia	2.09	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	0.059	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	569	mg L^{-1}	326	mg L^{-1}

Concentrations of total dissolved solids, hardness and conductivity were elevated generally greater than other lakes sampled between 1982-1991. The relatively high concentrations of these parameters could be due in part to the drought, resulting in lowered water levels.

Sulfate and bicarbonates were the dominant anions in the water column. Sulfate concentrations ranged from 551 to 606 mg L^{-1}, while bicarbonate concentrations were between 512 and 846 mg L^{-1}. The average volume-weighted mean concentrations for total phosphate as P was 0.036 mg L^{-1} and exceeded the state's target concentration of 0.02 mg L^{-1} on all occasions sampled during 1991 and 1992. The nitrate + nitrite as N concentration was considerably below the target concentration of 0.25 mg L^{-1}. A complete list of the LWQA project data for Rice Lake is contained in Appendix A.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on August 21, 1991. At the time of the macrophyte survey approximately 50 percent of the Rice Lake surface area had aquatic vegetation. Nearly 100 percent of the lakes surface area to a depth of seven feet had either sago pondweed Potamogeton pectinatus, water milfoil Myriophyllum spp., bulrush, Scirpus spp. or a combination of all three. A map depicting the macrophyte community and areal extent is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled three times during the summer of 1991. Rice Lake's phytoplankton community was relatively diverse with representation from 5 divisions and 44 genera. The largest contributors by density were the green algae, Chlorophyta, and the blue-green algae, Cyanophyta with 22 and 16 genera, respectively.

Blue-green algae dominated the algal community during all three sample times. Mean density of the three samples collected during the summer of 1991 was 146,126 cells mL^{-1}, and was approximately 10 times greater than the next abundant group, the green algae.

At the time of the assessment mean phytoplankton concentrations by volume were fairly well distributed among three divisions; Chlorophyta, Cyanophyta, and Pyrrophyta. Two species of Pyrrophyta, Ceratium hirundinella and Glenodinium gymnoginium are large organisms and accounted for the large volume displaced as compared to their low density by number. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

In general, the trophic status estimates based on secchi disk transparency and total phosphate as P concentration agree quite well and suggest Rice Lake is mesotrophic to eutrophic. An examination of the ancillary information for Rice Lake however, suggests it is eutrophic bordering on hypereutrophic. This decline in trophic status is due in large part to oxygen deficiencies throughout the water column in the winter and in the hypolimnion in the summer, a significant portion of the lake surface area covered by macrophytes, and a phytoplankton community dominated by blue-greens.

Sediment Analysis

Sediment samples collected from Rice Lake showed detectable levels of all trace elements tested for except selenium and mercury. Reported trace element concentrations at each sample location within Rice Lake were also compared to trace element concentrations reported for all the LWQA project lakes assessed in 1991. Trace element concentrations were near or below the median concen-trations reported for all lakes sampled, while PCB concentrations and the concentrations of selected organic compounds were below detectible limits for all samples collected from Rice Lake. A complete listing of the sediment results for all lakes sampled in 1991 including Rice Lake is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Rice Lake on May 30, 1991. Two species of fish were collected for contaminant analysis, white sucker represented the bottom feeder group and northern pike represented the piscivore group. The northern pike collected were divided into two age classes. Group number one had a mean weight of 1406 grams and a mean length of 58.3 centimeters, group number two had a mean weight of 1985 grams and a mean length of 69.5 centimeters.

In order to evaluate the fish tissue data for Rice Lake the results for each fish group were compared to that group for all lakes assessed in 1991. Trace element concentrations in fish samples collected from Rice Lake were generally near or slightly greater than the median concentrations for all fish collected during 1991. The exception was the zinc concentration reported for the two piscivore samples collected from Rice Lake. The reported concentrations of

35.9 and 46.2 $\mu g\ g^{-1}$ was two fold greater than the median concentration for all piscivores combined. Reported mercury concentrations were below the detection limits for the bottom feeder sample collected, but were 0.16 and 0.03 $\mu g\ g^{-1}$ in piscivore samples #1 and #2, respectively.

Detectable pesticide residues in the three composite fish samples collected from Rice Lake were limited to DDD and DDE. Both of these compounds are breakdown derivatives of DDT. Tissue samples of the white suckers collected from Rice Lake contained 0.006 $\mu g\ g^{-1}$ of DDD and 0.022 $\mu g\ g^{-1}$ of DDE.

The two northern pike samples collected contained concentrations of DDD of 0.003 $\mu g\ g^{-1}$ for group number one and less than detectable for group number 2. DDE concentrations were 0.015 $\mu g\ g^{-1}$ for group number one and 0.011 $\mu g\ g^{-1}$ for group number two. The median DDE and DDD concentrations for bottom feeder in all lakes sampled in 1991 were 0.009 and 0.004 $\mu g\ g^{-1}$, respectively. The median concentrations of DDD and DDE in flesh of all predator fish collected in 1991 were 0.003 and 0.008 $\mu g\ g^{-1}$, respectively. A complete listing of the fish tissue results for all lakes sampled in 1991 is provided in Appendix E.

Watershed

Rice Lake with its contributing watershed has a combined surface area of 4620 acres. It is located on the eastern edge of the Missouri Coteau physiographic region in Ward County, North Dakota. The watershed is located on a glacial erosion remnant of the Wisconsin Age. The surrounding landscape is characterized by rolling hills and valleys. Soils are predominately excessively well drained, built from gravelly, sandy glacial materials. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loadings and pollution discharges to Rice Lake.

Land use within the Rice Lake watershed is 82 percent agricultural with 46 percent actively cultivated. The remaining 18 percent is in low density urban development, haylands, pasture, Conservation Reserve Program (CRP), and one concentrated livestock feeding area (Table 2). According to the information provided by the Ward County Soil Conservation District, 50 percent of the cultivated lands and nearly all the remaining lands within the Rice Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Rice Lake watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of 2 to 3 tons per acre approximately 10,610 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 1061 to 1592 tons of soil potentially reaches Rice Lake annually.

Another source of nonpoint source pollution discharges to Rice Lake are from the numerous summer and permanent homes surrounding the lake. Approximately 50 percent of the area immediately adjacent to the lake is developed with septic systems, holding tanks and/or pit toilets.

Each of these could be contributing nutrients to the lake and may be the most significant source of nutrients to the lake. Fertilizer runoff from lawns and construction of new homes are other possible sources of nonpoint source pollution to Rice Lake.

Table 2. Land use in the Rice Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	46	50
Pasture Land	23	80
Hayland	8	80
CRP	5	100
Wet/Wild[1]	14	100
Other	4	N/A
Farmsteads	2	N/A
Feedlots[2]	1	0

[1] Wet/Wild are wildlife management areas, wetlands and lakes.
[2] Feedlots are areas where livestock are concentrated to be fed.

SHORT CREEK DAM

BURKE COUNTY

Peter N. Wax

Short Creek Dam is located on the East Branch Short Creek, approximately 6 miles north of Columbus, North Dakota and a quarter mile south of Saskatchewan, Canada in Burke County. Short Creek Dam has a surface area of 96 acres and a maximum depth of 26 feet (Figure 1). Built for recreation, Short Creek Dam was funded and designed by the NDG&F, the State Water Commission and the Burke County Water Management District. Construction of Short Creek Dam was completed in 1962 and the reservoir filled the following spring. Short Creek Dam and nearly 100 percent of the immediate shoreline is owned and managed by the NDG&F.

Short Creek Dam has an international watershed encompassing 102,400 acres. Approximately 2,500 acres extend into Saskatchewan, Canada. Topography of the watershed varies from hilly and rolling in the southern portions to nearly level throughout the central and northern regions. Outlet discharges from Short Creek Dam travel in a northerly direction into Canada and the Souris River Basin.

Land use within the Short Creek Dam's watershed is nearly an even mixture of pastures and cultivated fields. The pasture land predominates in the southern section of the watershed with land use in the northern portions being nearly 70 percent cultivated. The city of Lignite, a community of approximately 300, and 75 farmsteads are the only developments within the watershed.

Short Creek Dam is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The fishery is managed by the NDG&F. Management has included annual fish community assessments, fish stockings, winter oxygen monitoring and an assortment of biological and habitat manipulations.

The fishery was first established on Short Creek Dam in 1963. The initial fishery consisted of rainbow trout, walleye and fathead minnows. Short Creek Dam opened to fishing in 1965, with good success reported for approximately 10 years. To create a more diverse fishery the NDG&F introduced largemouth bass in 1975. The bass initially had excellent reproduction and growth rates until 1979-1980. After 1980 the largemouth bass fishery started to decline. Possibly due to predation by large walleye, climatic conditions during spawning and competition from white suckers. Recent fish stockings have included walleye, bluegill and largemouth bass. Test netting operations conducted in the spring of 1991 captured in order of most abundant, white suckers, bluegill, walleye and yellow perch.

Short Creek Dam has received heavy to moderate fishing pressure depending on the season and productivity of the fishery. During the 1970's Short Creek Dam's bass fishery drew international attention, with people traveling from Canada to fish for largemouth bass. Access to Short Creek Dam is good. An excellent public use area is maintained on the southwest end of the lake and includes picnic shelters, toilets, boat ramp, and swim beach.

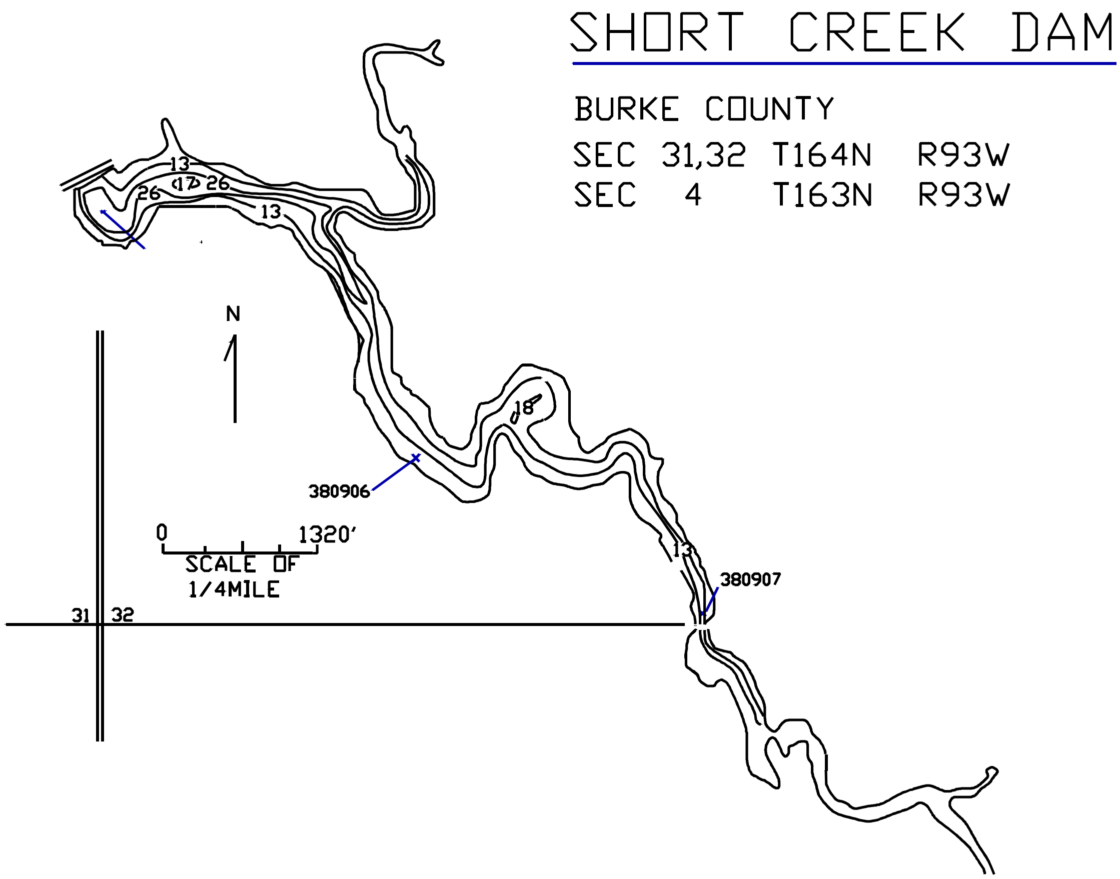

Figure 1. Morphometric map of Short Creek Dam.

Water Quality

Water quality samples were collected from Short Creek Dam two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 380905, Figure 1). Water column samples were collected for analysis at three discrete depths, 1 meter, 3.5 meters, and 7 meters in the July and August, 1991 and at 1 meter, 3 meters, and 5 meters in January, 1992.

On July 17, 1991, at the time of sampling Short Creek Dam was thermally stratified at approximately 2 meters below the surface, or 4 meters from the bottom. On August 7, 1991, Short Creek Dam was not thermally stratified (Figure 2). At the time of sample collection in July and August, dissolved oxygen concentrations were adequate to maintain aquatic life (Figure 3). Samples collected on January, 22, 1991 showed that Short Creek Dam was thermally stratified at approximately 1 meter below the surface with dissolved oxygen concentrations ranging from 3.9 mg L^{-1} at the surface to 1.5 mg L^{-1} near the bottom (Figure 3).

Short Creek Dam is a well-buffered waterbody with an average volume-weighted mean total alkalinity as $CaCO_3$ concentration of 277 mg L^{-1}. Sulfate and bicarbonates were the dominant anions in the water column. Sulfate concentrations ranged from 122 to 158 mg L^{-1} while bicarbonate concentrations were between 251 and 405 mg L^{-1}. Levels of total dissolved solids, hardness, and conductivity were less than the long-term average for all North Dakota lakes sampled between 1982-1991 (Table 1).

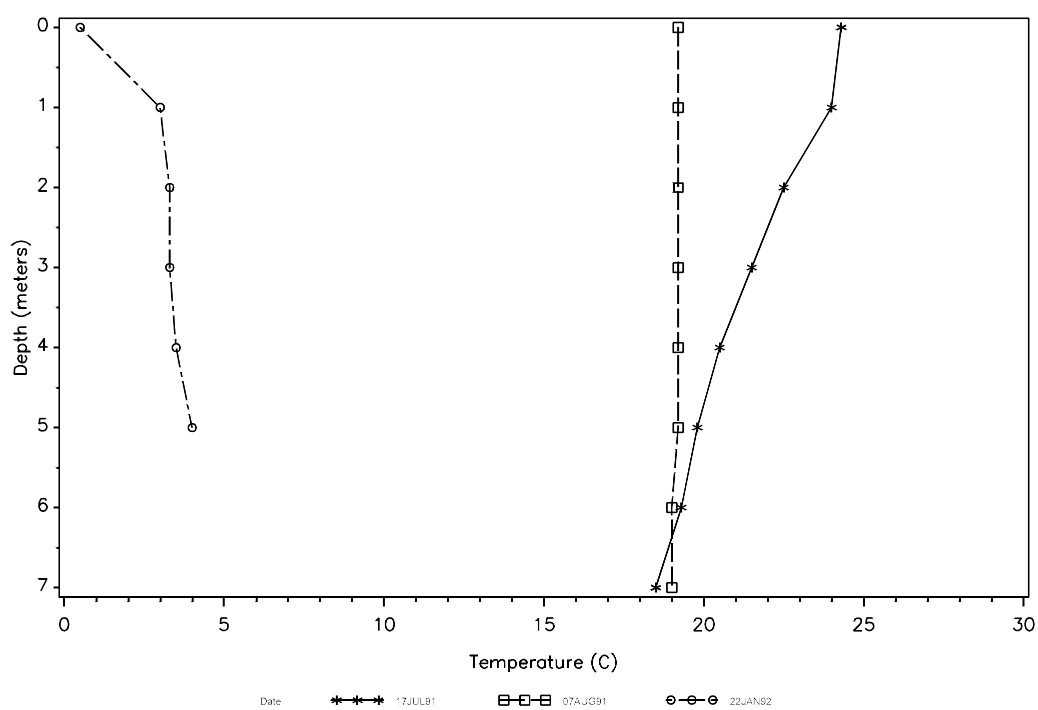

Figure 2. Temperature profiles for Short Creek Dam.

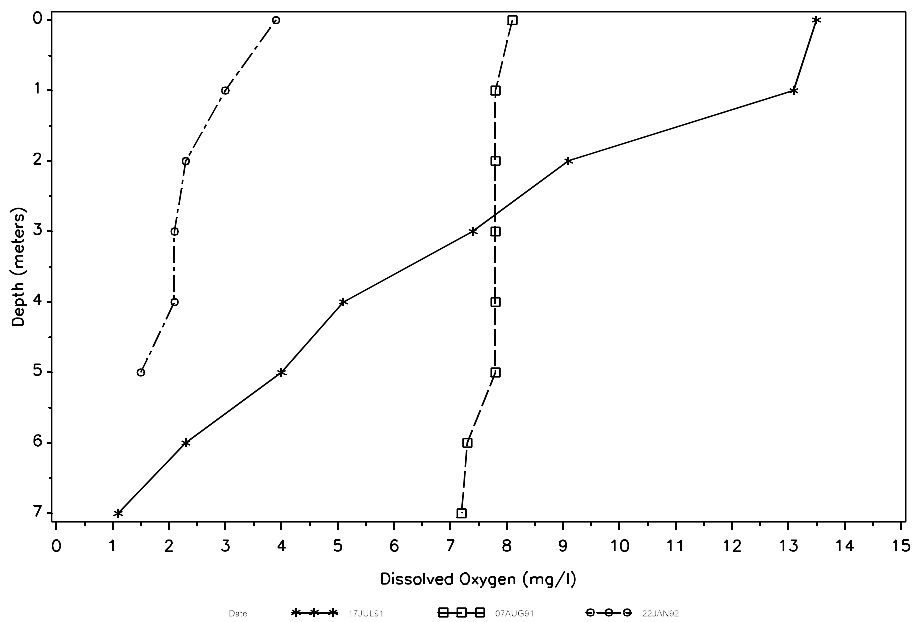

Figure 3. Oxygen profiles for Short Creek Dam.

The average volume-weighted mean concentration for total phosphate as P was 0.205 mg L^{-1} and exceeded the state's target concentration of 0.02 mg L^{-1} on all occasions sampled during 1991 and 1992. The nitrate + nitrite as N concentration was below the state's target concentration of 0.25 mg L^{-1}, with an average volume-weighted mean concentration of 0.027 mg L^{-1}. A complete list of water quality sample data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 1991 and February 1992, and long-term average for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Short Creek Dam		1982-1991	
Total Dissolved Solids	507	mg L^{-1}	1209	mg L^{-1}
Conductivity	825	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	180	mg L^{-1}	488	mg L^{-1}
Sulfates	135	mg L^{-1}	592	mg L^{-1}
Chloride	18.2	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.205	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.027	mg L^{-1}	0.069	mg L^{-1}
Alkalinity	277	mg L^{-1}	296	mg L^{-1}
Ammonia	0.320	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.25	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	313	mg L^{-1}	326	mg L^{-1}

The historical water quality data available for Short Creek Dam suggest its water quality is stable and has possibly improved over the last 6 years. This is notable, since the majority of the lakes assessed in the 1991 LWQA project showed water quality declines. Short Creek Dam has probably benefited from the drought through less runoff thereby reducing external nutrient loads, resulting in the utilization of internal nutrients. This suggests that Short Creek Dam would significantly benefit from reductions in external loadings.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Short Creek Dam as part of the 1991 lake assessment. The survey was preformed on August 7, 1991. At the time of the macrophyte survey, approximately 15 percent of the Short Creek Dam's surface area had submergent and emergent macrophyte vegetation. The macrophyte community identified on Short Creek Dam was composed of sago pondweed, Potamogeton pectinatus, and cattails, Typha spp..

The cattails inhabited a narrow strip around nearly 100 percent of the shoreline. A second inner ring of vegetation composed of sago pondweed extended approximately 5 feet out from the cattails and was found on approximately 80 percent of the shoreline. The rest of the lake is nearly devoid of macrophyte vegetation. A map depicting the macrophyte community and its areal extent is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled two times during the summer of 1991. The phytoplankton community on Short Creek Dam was represented by 5 divisions and 11 genera. The community was lacking in diversity with blue-green algae, Cyanophyta, dominating over 90 percent of the community by number and volume. A complete listing summary of the phytoplankton data is contained in Appendix C.

Trophic Status

Short Creek is estimated to be a hypereutrophic waterbody. This estimate was based on surface total phosphate as P concentrations of 0.170 and 0.169 mg L^{-1}, chlorophyll-a concentrations of 0.078 and 0.024 mg L^{-1} and secchi disk transparency depths of 0.8 and 0.9 meters. Supporting ancillary information includes a macrophyte community occupying nearly 100 percent of the photic zone, a phytoplankton community dominated by the blue-greens, frequent nuisance algal blooms and rapid oxygen depletion in the hypolimnion and under ice cover conditions.

Sediment Analysis

Sediments were collected from Short Creek Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected from the deepest area of the lake (Site 380905), the littoral zone (Site 380906), and the inlet (Site 380907) (Figure 1).

Sediment samples collected from Short Creek Dam showed detectable levels of all trace elements analyzed. Reported concentrations of trace elements in sediments collected from Short Creek Dam were also compared to the concentrations reported for all lakes assessed in the 1991 LWQA project. The reported trace element concentrations of copper, zinc, barium, mercury, chromium, arsenic, cadmium and lead in the sediments collected from the deepest area of Short Creek Dam exceeded the median concentrations reported for all lake sediment samples collected during the 1991 LWQA project. Of these, all but lead exceeded the 75th percentile.

The trace element concentrations in the littoral area of Short Creek Dam also had a significant portion of the trace elements analyzed which exceeded the reported median concentrations. Only copper, arsenic and chromium exceeded the 75th percentile for all littoral sediments collected during the 1991 LWQA project. Reported selenium, cadmium and mercury concentrations were either at or below the median concentrations for this group.

Trace element concentrations for the inlet area sediment sample were generally below the reported median concentrations for all inlet area samples collected during the 1991 LWQA project. The only exception was the arsenic concentration of 2.84 $\mu g\ g^{-1}$ which exceeded the reported 75th percentile of 2.07 $\mu g\ g^{-1}$ for all inlet area sediment samples collected.

Concentrations of PCB's and pesticides were below detectible limits for all sediment samples collected from Short Creek Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

One whole fish sample was collected for contaminant analysis from Short Creek Dam on June 6, 1991. The white sucker sample, representing the bottom feeder group was a composite of 5 fish with a mean weight of 490 grams and a mean length of 1720 centimeters.

In order to evaluate the fish tissue data for Short Creek Dam, the results were compared to the corresponding group for all lakes assessed during the 1991 LWQA project. Trace element concentrations in fish samples collected from Short Creek Dam were generally near or slightly below the median concentration for all bottom feeders collected during the LWQA. The exception was mercury, with a reported concentration of 0.14 $\mu g\ g^{-1}$ which exceeded the reported 75th percentile concentration for all bottom feeders.

Detectable pesticide residues in the composite whole fish sample collected from Short Creek Dam included DDE and trifluralin. DDE is a breakdown derivative of DDT and exhibits similar characteristics to the parent compound in the ecosystem. Trifluralin, commonly known as treflan, is a selective pre-emergent herbicide. The white sucker sample collected from Short Creek Dam showed 0.079 $\mu g\ g^{-1}$ of DDE, 0.004 $\mu g\ g^{-1}$ of trifluralin. The reported concentration of DDE was below the 25th percentile of 0.008 $\mu g\ g^{-1}$ for all bottom feeders reported during the 1991 LWQA project. The trifluralin concentration of 0.004 was the source as the reported median concentration for all bottom feeders sampled during the 1991 LWQA. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Short Creek Dam has an international watershed encompassing 102,400 acres with approximately 2,500 acres extending into Canada. Topography of the watershed varies significantly from rolling in the southern portions to nearly level throughout the central and northern regions. Outlet discharges from Short Creek Dam travels in a northerly direction into Saskatchewan Canada and the Souris River basin.

The city of Lignite, a community with a population of less than 300, lies within Short Creek Dam's watershed. Two point source discharges are registered with the NDSDHCL in this community. One for the city's wastewater lagoons and one is for the Lignite Oil Company.

According to the NDSDHCL's records, Lignite's lagoon is discharged nearly every year. The discharge enters an unnamed tributary to the East Branch Short Creek and travels approximately 16 miles before reaching Short Creek Dam. The Lignite Oil Company discharges into a gravel pit. Due to the distance of travel and the relatively small size of community it is unlikely the city's lagoon discharges pose a significant environmental risk to Short Creek Dam in terms of nutrient loading.

Land use within the watershed is 97 percent agricultural, with 45 percent actively cultivated and 52 percent in haylands, pasture, and the Conservation Reserve Program (CRP). Three percent is in low density urban development and wildlife management areas (Table 2). There are 22 concentrated livestock feeding areas within the contributing drainage.

According to information provided by the Burke County Soil Conservation District, 30 percent of the cultivated lands and between 30 and 40 percent of the remaining lands within the Short Creek Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated"

Table 2. Land use in the Short Creek Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	45	30
Pasture Land	39	30
Hayland	6	40
CRP	7	100
Wet/Wild[1]	1	100
Other	2	N/A
Farmsteads	75[3]	N/A
Feedlots[2]	22[3]	10

[1] Wet/Wild are wildlife management areas, wetlands and lakes.
[2] Feedlots are areas where livestock are concentrated to be fed.
[3] Represents the number present in watershed.

still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Short Creek Dam watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of nearly 7 tons per acre, which takes into account the untreated percentages of the watershed, approximately 716,800 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 71,680 tons to 107,520 tons of soil potentially reaches Short Creek Dam annually.

SOUTH GOLDEN LAKE

STEELE COUNTY

Peter N. Wax

South Golden Lake is a natural wetland located on the western edge of the Red River Valley physiographic region. It was too shallow to support a fishery when in 1956 a diversion dam and canal system was constructed on Beaver Creek to divert flows to South Golden Lake. The restoration project involved three wetlands, Golden Rush Lake, South Golden Lake, and North Golden Lake (Figure 1).

South Golden Lake was enhanced by this project and has a surface area of 323.5 acres and a maximum depth of 18 feet (Figure 2). A second restoration project was initiated in the 1980's involving the use of Golden Rush Lake as a filtration system. This project is twofold. The first phase is to hold Beaver Creek diversion water in Golden Rush Lake until late May, allowing nutrients to be assimilated by wetland vegetation and sediments to be deposited into marsh. The second phase recycles water from South Golden Lake into Golden Rush Lake assimilating nutrients and settling out suspended solids, improving the general water quality of the return flows to South Golden Lake.

The South Golden Lake watershed lies in the Glaciated Plains Region, just west of the Red River Valley. The dividing line is a subdued southern and western extension of the Lake Agassiz beach line. Elevations of this region range from approximately 1500 feet above sea level along the western margin of the watershed to 1100 feet above sea level along the Lake Agassiz beach line.

Physical characteristics of the watershed are level to sloping with well defined drainages. Soils are deep and well drained on the side slopes and crests of rolling knolls. Low lying slopes are composed of moderately well drained, alkaline soils that are in some instances rocky.

South Golden Lake is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F in recent years have managed the fishery by stocking northern pike, walleye and crappie. Past stockings have also included bluegills. Test nettings performed by the NDG&F in 1991 showed the fish community dominated by black bullheads and white suckers. Other fish species present in South Golden Lake are fathead minnows, yellow perch and stickleback.

Of the 3.5 miles of shoreline surrounding South Golden Lake approximately 90 percent is privately owned and contains 150 cabins, a grocery store and a restaurant. The remaining shoreland is public with one access point. Public facilities at this point include a park, boat ramp, swimming beach, changes houses, and picnic shelters. South Golden Lake contributes substantially to the local community with large numbers of users from Grand Forks and the Grand Forks Air Force Base.

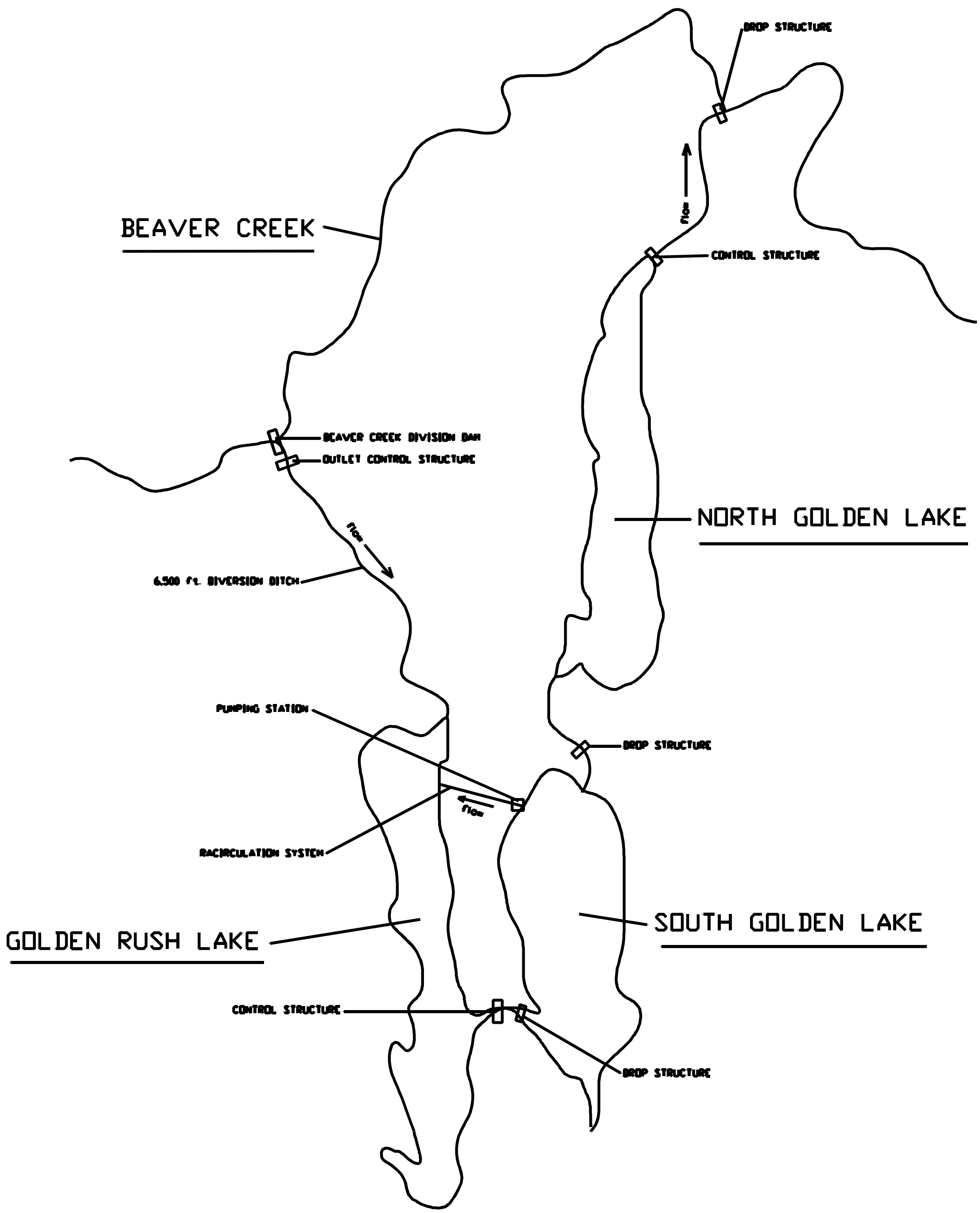

Figure 1. Map of South Golden Lake, Golden Rush Lake, North Golden Lake and location of water control structures.

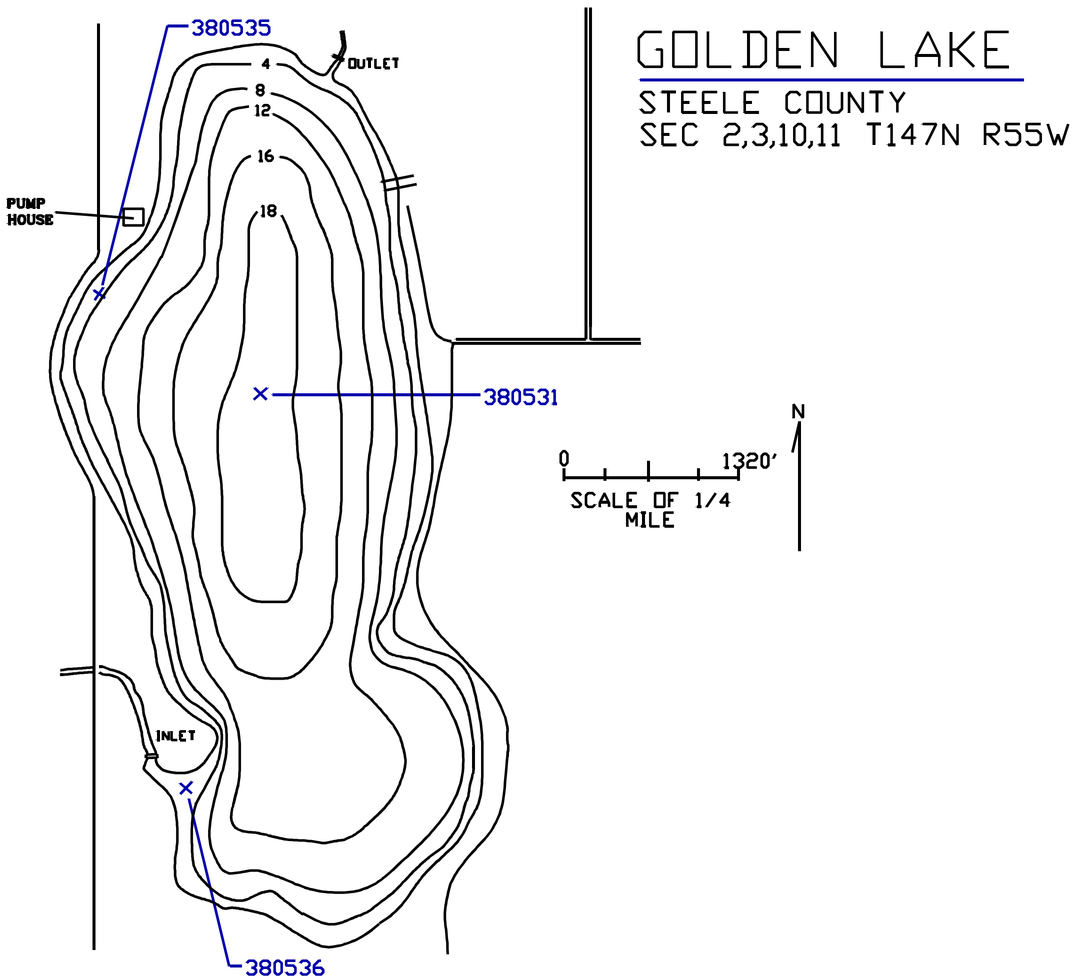

Figure 2. Morphometric map of South Golden Lake.

Water Quality

Water quality of South Golden Lake can be described as relatively hard water and well-buffered. The average volume-weighted mean total alkalinity concentration was 228 mg L^{-1}, while the total dissolved solids concentration was 944 mg L^{-1} and total hardness as calcium was 508 mg L^{-1}. Sulfates and carbonates were the dominant anions in the water column. Sulfate concentrations ranged from 425 to 584 mg L^{-1} while bicarbonate concentrations were between 210 and 319 mg L^{-1}.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 26, 1991 and February 27, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	South Golden Lake		1982-1991	
Total Dissolved Solids	944	mg L^{-1}	1209	mg L^{-1}
Conductivity	1386	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	508	mg L^{-1}	488	mg L^{-1}
Sulfate	482	mg L^{-1}	592	mg L^{-1}
Chloride	32	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.155	mg L^{-1}	0.248	mg L^{-1}
Ammonia	0.374	mg L^{-1}	0.347	mg L^{-1}
Nitrate + Nitrite as N	0.024	mg L^{-1}	0.069	mg L^{-1}
Total Kjeldahl Nitrogen	2.65	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	248	mg L^{-1}	326	mg L^{-1}
Total Alkalinity	228	mg L^{-1}	296	mg L^{-1}

During the two summer sampling periods in 1991, South Golden Lake did not exhibit thermal stratification (Figure 3). During these times, dissolved oxygen concentrations were at or near saturation to a depth of 4 meters and were adequate to maintain aquatic life (Figure 4). During February 1992, the water column was thermally stratified between 1 and 2 meters below the lakes surface. Dissolved oxygen concentrations range from 4.0 mg L^{-1} at the surface to 1.0 mg L^{-1} at the bottom (Figure 4). The average volume-weighted mean concentration for total phosphorus as P was 0.155 mg L^{-1} exceeding the state's target concentration of 0.02 mg L^{-1} on all occasions sampled during the 1991 LWQA. The nitrate + nitrite as N concentration was considerably below the state's target concentration of 0.25 mg L^{-1} as 0.025 mg L^{-1} (Table 1). A comparison of South Golden Lake's nitrate + nitrite as N and total phosphorus as P concentrations suggest a lake nutrient condition that is nitrogen limited. It should be noted that true nitrogen limited is probably not present in South Golden Lake, but instead it has an overabundance of phosphorus. Under these conditions, nitrogen fixing primary producers, such as some species of blue-green algae, will be favored.

Oxygen depletion under ice cover conditions and below the hypolimnion is quite rapid. This situation is more than likely the result of a highly fertile watershed and internal cycling. This is evident in the winter samples as ammonia concentrations increase and the oxygen concentrations decrease with lake depth (Appendix A). A complete compilation of all 1991-1992 LWQA data is contained in Appendix A.

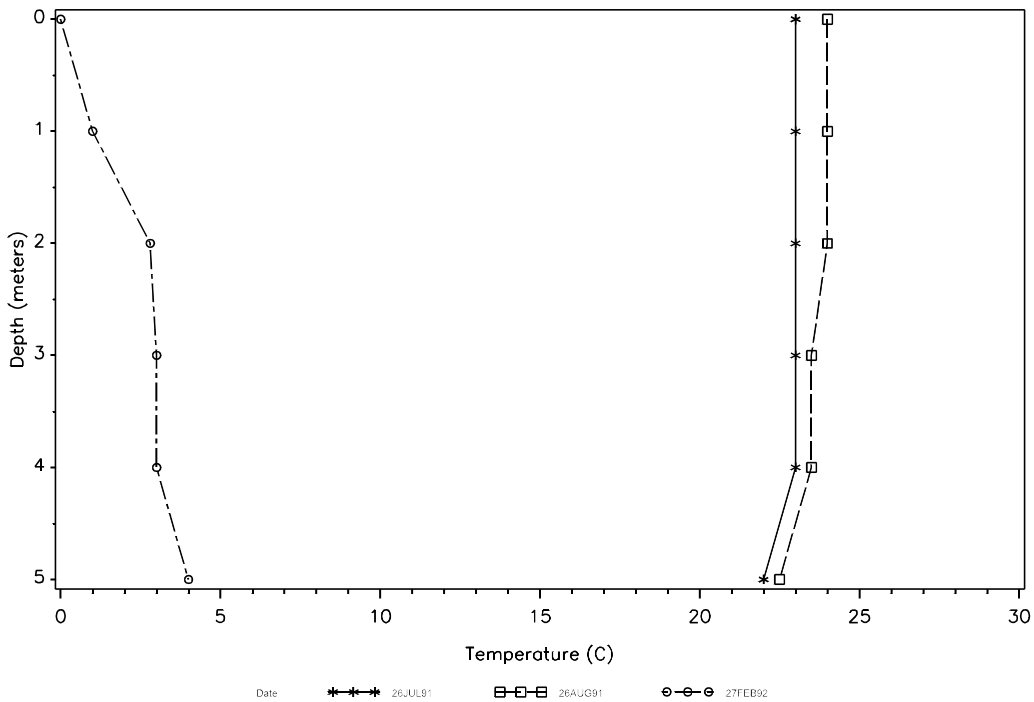

Figure 3. Temperature profile for South Golden Lake.

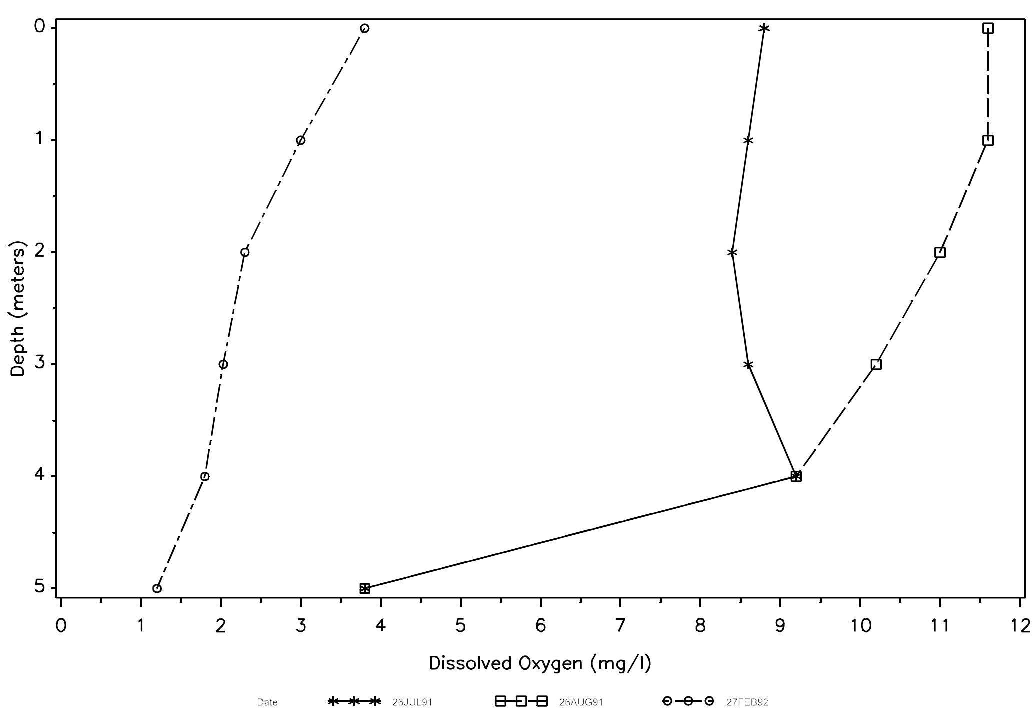

Figure 4. Oxygen profile for South Golden Lake.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on South Golden Lake on August 26, 1991. At the time of the macrophyte survey, approximately 10 percent of the surface area had aquatic vegetation. Nearly 90 percent of the lake surface area to a depth of approximately 4 feet had either sago pondweed, Potamogeton pectinatus, water milfoil, Myriophyllum spp., cattails, Typha spp., curly leaf pondweed, Potamogeton cruspus or a combination of all four.

Over the last several years the South Golden Lake Improvement Association has operated a mechanical weed harvester. Results of the effectiveness of harvesting is inconclusive, however a species shift to low profile macrophyte species (i.e., Myriophyllum spp. and Ceratophyllus demersum) could occur with long-term macrophyte harvesting. These species would be selected since they are susceptible to the action of the harvester. Macrophyte species such as Myriophyllum spp. which can vegetatively reproduce would also be encouraged since the activity of the harvester causes plant fragments to be dispersed throughout the entire water column. A color map of the areal extent of the macrophyte community is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled twice during the summer of 1991. South Golden Lake's phytoplankton community was represented by 5 divisions and 14 genera. The largest contributors by density and volume were the blue-green algae, Cyanophyta. Blue-green algae dominated the algal community at both sample times. Mean blue-green algae density during the summer of 1991 was 397,111.5 cells mL^{-1} which was approximately 575 times greater than the next abundant division, the Bacillariophyta. Phytoplankton concentrations by volume reflected this dominance as well. A complete listing of the phytoplankton data can be found in Appendix C.

Trophic Status

In general, trophic status estimates based on the three indicators, secchi disk transparency, surface total phosphorus and chlorophyll-a concentrations, agreed quite well and suggests South Golden Lake is hypereutrophic. An examination of the ancillary information for South Golden Lake confirms this assessment. Substantiating ancillary information for a hypereutrophic assessment are low dissolved oxygen throughout the water column in the winter, a phytoplankton community dominated by blue-greens, nuisance algal blooms and periodic fish kills.

Sediment Analysis

Sediment samples collected from South Golden Lake showed detectable levels of all trace elements tested for except mercury. Trace element concentrations from sediment samples collected at each location in South Golden Lake were also compared to the sediment data reported for all lakes assessed in the 1991 LWQA. In general, trace element concentrations were near or below the median concentrations for all lakes sampled. The only exception was the cadmium concentration in the inlet area sediment sample which was greater than the median concentration for all inlet samples collected. PCB concentrations and the concentrations of selected pesticides were below detectible limits for all samples collected from South Golden Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Whole fish tissue samples were collected for contaminant analysis from South Golden Lake on August 26, 1991. White suckers were collected for contaminant analysis representing the bottom feeder group. No piscivores were captured during 1991. The composite sample of white suckers had a mean weight of 1183 grams and a mean length of 46 centimeters.

In order to evaluate the fish tissue data for South Golden Lake, the results were compared to the bottom feeder group for all lakes assessed in 1991. In general, trace element concentrations from fish samples collected from South Golden Lake were slightly below the median concentrations for all bottom feeders collected during the 1991 LWQA project. The exceptions were the report of concentrations of chromium and cadmium which were greater than the respective median concentrations for all bottom feeders collected during the 1991 LWQA project. The reported mercury concentration was below detectable limits for the white sucker sample collected from South Golden Lake.

Detectable pesticide residues in the composite whole fish sample collected from South Golden Lake included DDD, DDE, nonachlor, and trifluralin. DDD and DDE are breakdown derivatives of DDT and behave similarly to the parent compound when present in the environment. Nonachlor is a stable ingredient in the insecticide chlordane and is also an insecticide. Nonachlor can cause acute toxicity for aquatic invertebrates. Trifluralin, commonly known as treflan, is a pre-emergent herbicide. The composite white sucker sample collected from South Golden Lake contained 0.006 $\mu g\ g^{-1}$ of DDD, 0.018 $\mu g\ g^{-1}$ of DDE, 0.002 $\mu g\ g^{1}$ of nonachlor, and 0.033 $\mu g\ g^{1}$ of trifluralin. These concentrations are greater than the median concentrations for all bottom feeders sampled during the 1991 LWQA project. The median concentrations of DDD, DDE, nonachlor and trifluralin for bottom feeders in lakes sampled in the 1991 LWQA project were 0.003, 0.008, 0.001 and 0.004 $\mu g\ g^{-1}$, respectively. A complete listing of the fish tissue results are contained in Appendix E.

Watershed

South Golden Lake with its contributing watershed has a combined surface area of 10,940 acres and is located just west of the Red River Valley in Steele County, North Dakota. The surrounding landscape is nearly level to sloping with well defined drainages. Soils are predominately well drained, deep and fertile with a high capacity to hold water.

Nonpoint source pollution from the surrounding watershed accounts for most of the nutrient loadings and pollution discharges to South Golden Lake. Land use within the South Golden Lake watershed is 90 percent agricultural with 69 percent actively cultivated. The remaining 31 percent is in low density urban development, haylands, pasture and the Conservation Reserve Program (Table 2). There is one concentrated livestock feeding area within the immediate watershed and four immediately upstream of the Beaver Creek diversion dam.

According to information provided by the Steele County Soil Conservation District, 50 percent of the cultivated lands and nearly all the remaining lands within the South Golden Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the South Golden Lake watershed the average "T" value is 3 to 5 tons per acre.

Table 2. Land use in the South Golden Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	69	35
Hayland	10	100
CRP	11	100
Wet/Wild[1]	6	N/A
Other	4	N/A
Farmsteads	16[3]	N/A
Feedlots[2]	1[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number within watershed.

Based on a conservative average soil loss of 2 to 3 tons per acre, approximately 60,576 tons of soil is lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 6058 tons to 9087 tons of soil reaches the waters within the South Golden Lake watershed annually. Only a fraction of this amount reaches the South Golden Lake due to the ability of Golden Rush Lake to trap sediments.

Another potential source of nonpoint source pollution discharges to South Golden Lake is from the numerous summer and permanent homes surrounding the lake. Approximately 80 percent of the area immediately adjacent to the lake is developed with septic systems, holding tanks or pit toilets. Inadequateseptic systems, failing drain fields and leaky holding tanks may contribute a significant percentage of the annual nutrient budget to South Golden Lake.

STRAWBERRY LAKE

MCLEAN COUNTY

Peter N. Wax

Strawberry Lake is the second lake in a chain of four lakes. It is located in northeastern McLean County, North Dakota (Figure 1). It was enhanced in 1932 by the construction of a dam and spillway at its outlet. The dam was built under the Works Protect Administration (WPA). In 1954 it was repaired and raised an additional two feet.

The dam built on the outlet to Strawberry Lake also raised and stabilized water levels in Camp Lake. Camp Lake was a deep natural slough separated from Strawberry Lake by a county road (Figure 1). Originally culverts connected the two water bodies. In 1981 gabbian barriers were installed in the culverts to prevent spawning fish from entering Camp Lake. Strawberry Lake and Camp Lake are interconnected for they share groundwater, surface water and aquatic biota.

Strawberry Lake has a surface area of 140 acres and a maximum depth of 21 feet (Figure 2). Camp Lake is actually little more than a deep slough with a surface area of 82 acres and a maximum depth of 12 feet (Figure 3).

Strawberry Lake has a relatively small watershed with an areal extent of 2680 acres. Camp Lake's watershed is partially owned and managed by the U.S. Fish and Wildlife Service as a migratory waterfowl refuge. It has a large watershed covering 17,700 surface acres or 27.66 square miles and is the principal source of surface water for Strawberry Lake. Both Strawberry Lake and Camp Lakes watersheds are within the Missouri Coteau physiographic region.
Topography of the area is characterized by rolling hills and valleys, with slopes ranging from 1 to 20 percent. Soils are primarily excessively well drained, formed from sandy, rocky glacial material. Both watersheds are predominantly integrated drainages typifying characteristics of the northern prairie pothole region.

Strawberry Lake is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated biota" (NDSDHCL, 1991). Camp Lake, while not classified by the NDSDHCL (1991) fits the definition of a marginal fishery, "Waters capable of supporting a fishery on a seasonal basis." The NDG&F manages both Strawberry Lake and Camp lake. Management includes annual assessments of the fish community through test netting and fish stocking. The NDG&F have also kept extended records of winter dissolved oxygen concentrations, snow cover, and the macrophyte community. Camp Lake at present is not actively managed by the NDG&F, however fish stockings have been performed over the years.

The fisheries in both Strawberry Lake and Camp Lake were established in 1932 with the completion of the WPA dam on Strawberry Lake's outlet. Original stockings made to Strawberry Lake included northern pike, black bass, bluegills, yellow perch, walleye and crappie. Other species present are shiners, fathead minnows, sticklebacks and bullheads. Camp Lake was stocked through natural migrations from Strawberry Lake.

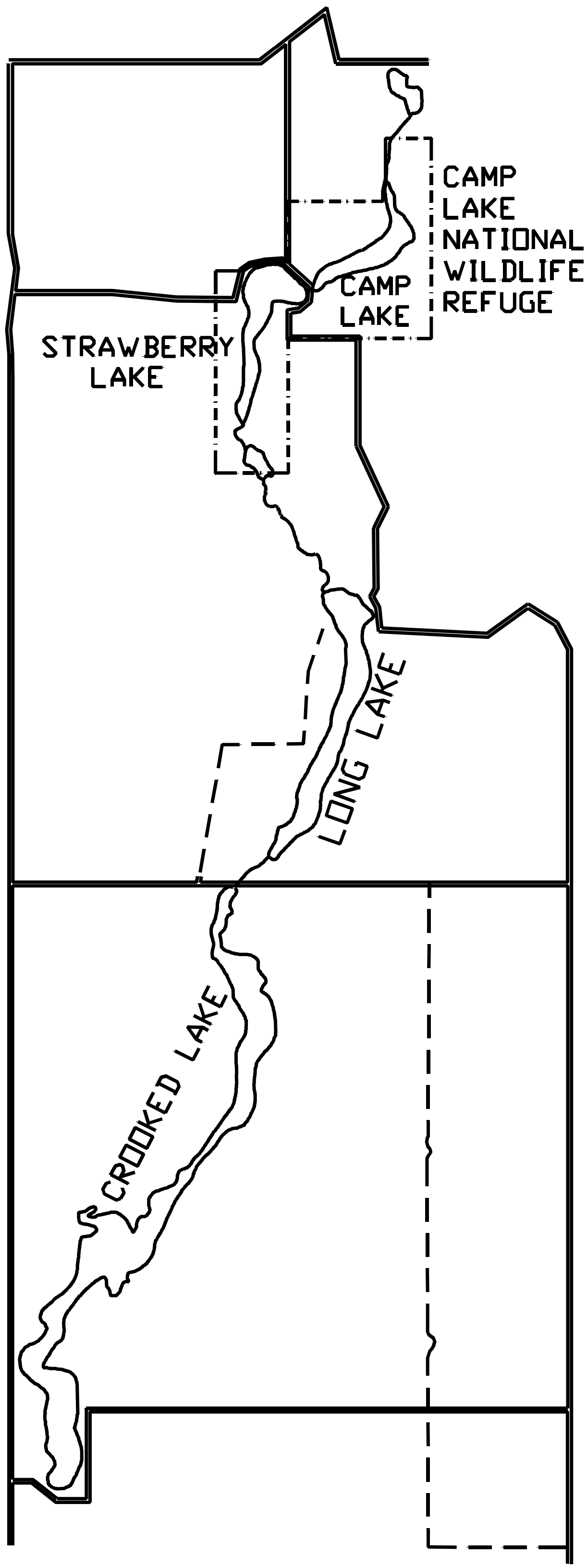

Figure 1. Map of Camp Lake, Strawberry Lake, Long Lake and Crooked Lake northeastern McLean County, North Dakota.

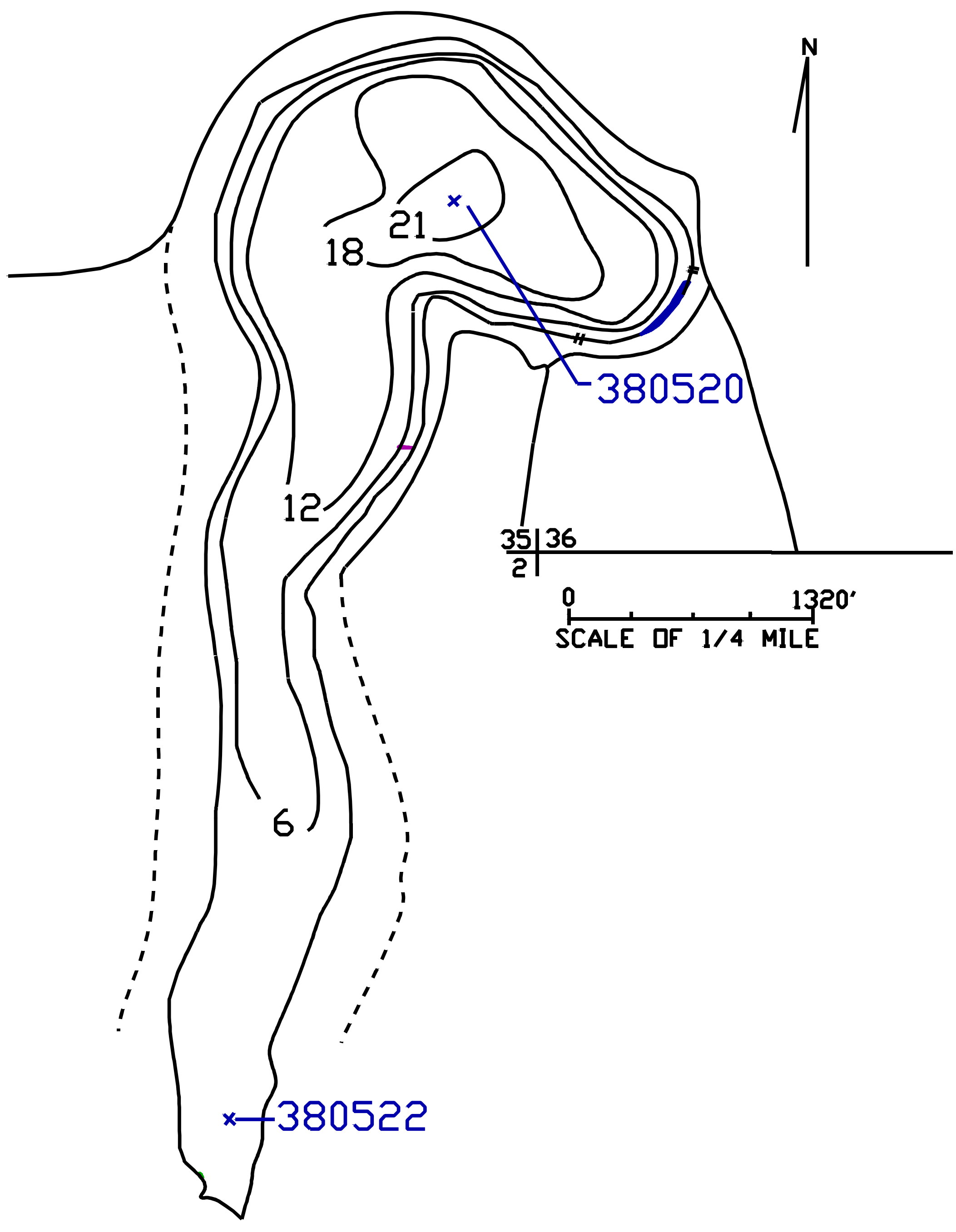

Figure 2. Morphometric map of Strawberry Lake.

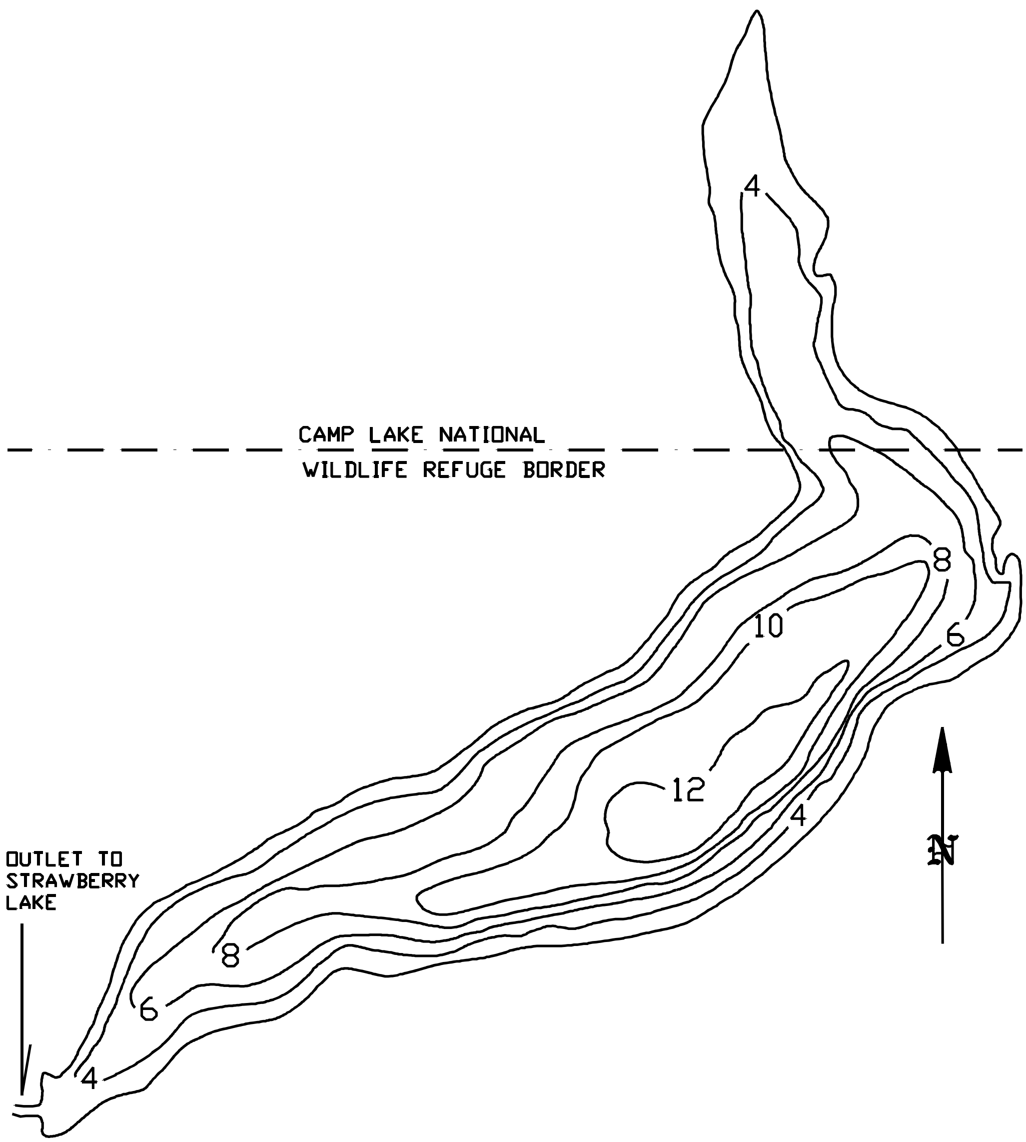

Figure 3. Morphometric map of Camp Lake.

In recent years fish stockings have been limited to Strawberry Lake and have included northern pike, walleye and largemouth bass. Test netting operations conducted in 1991 also captured bluegill and yellow perch.

Both Strawberry Lake and Camp Lake have experienced substantial difficulties in maintaining stable fisheries, primarily due to fluctuating water levels and detrimental introduction of undesirable fish species. Many adult breeding fish are also lost each year due to upstream migration into Camp Lake and the marshes to the north. These fish usually did not survive the following winter.

Strawberry Lake has been chemically eradicated twice. Both followed partial winter kills, once in 1954 and again in 1981. The water levels which historically had been a problem have remained stable since the filling of Lake Audubon in 1975. Upstream movement of adult breeding fish has been prevented by the addition of gabbian barriers at the culverts which join Strawberry Lake and Camp Lake.

Nearly 100 percent of Strawberry Lake's shoreline is developed with between 130 to 150 summer and permanent homes, two convenience stores and two picnic areas. Camp Lake has very little development on it with only one access owned by the NDG&F. Fishing pressure can be high at certain times of the year on both lakes.

Strawberry Lake's property owners have formed a lake improvement association. The association, known as the Strawberry Lake Improvement Association (SLIA), has purchased a macrophyte harvester to remove submerged vegetation near cabin lot frontages. Goals of the SLIA are to improve water quality by promoting controlled development on Camp and Strawberry Lakes, cleaning private sewer systems and promoting limited livestock use on Strawberry and Camp Lake.

Water Quality

Water quality samples were collected from Strawberry Lake two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 380520, Figure 2). Water column samples were collected for analysis at three separate depths, one meter, three meters and six meters. A complete list of all LWQA data is contained in Appendix A.

On July 9, 1991, Strawberry Lake was thermally stratified at approximately 4 meters below the lakes surface (Figure 4). During this time period dissolved oxygen concentrations were at or near saturation to a depth of 2 meters and were adequate to maintain aquatic life (Figure 5). Samples collected on August 1, 1991, and January 31, 1992, showed that Strawberry Lake's water column was not thermally stratified. Dissolved oxygen concentrations were between 9.6 mg L^{-1} and 1.4 mg L^{-1} in August and between 9.3 mg L^{-1} and 1.6 mg L^{-1} in January (Figure 4, Figure 5).

Strawberry Lake is a well-buffered waterbody with an average volume-weighted mean total alkalinity concentration of 197 mg L^{-1}. Sulfate and bicarbonates were the dominant anions in the water column. Sulfate concentrations ranged from 0.0 to 69 mg L^{-1} while bicarbonate concentrations were between 175 and 279 mg L^{-1}.

The average volume-weighted mean concentration for total phosphate as P was 0.056 mg L^{-1} exceeding the State's target concentration of 0.02 mg L^{-1} on all occasions sampled during 1991 and 1992. Nitrate + nitrite as N concentrations were below the state's target concentration of 0.25 mg L^{-1} with an average volume-weighted mean concentration of 0.081 mg L^{-1} (Table 1).

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 26, 1991 and February 27, 1992 and long-term averages for all North Dakota lakes collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Strawberry Lake		1982-1991	
Total Dissolved solids	2.54	mg L^{-1}	1209	mg L^{-1}
Conductivity	464	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	209	mg L^{-1}	488	mg L^{-1}
Sulfates	49	mg L^{-1}	592	mg L^{-1}
Chlorides	5.4	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.056	mg L^{-1}	0.248	mg L^{-1}
Ammonia	0.172	mg L^{-1}	0.347	mg L^{-1}
Nitrate + Nitrite as N	0.081	mg L^{-1}	0.069	mg L^{-1}
Total Kjeldahl Nitrogen	1.41	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	222	mg L^{-1}	326	mg L^{-1}
Total Alkalinity	197	mg L^{-1}	296	mg L^{-1}

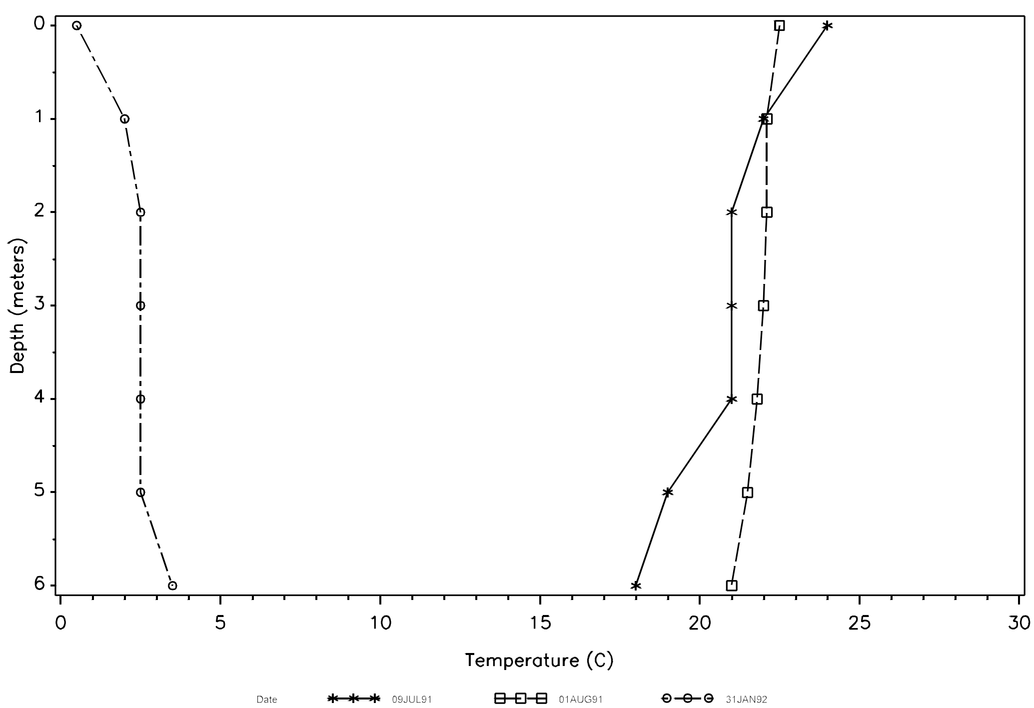

Figure 4. Temperature profiles for Strawberry Lake.

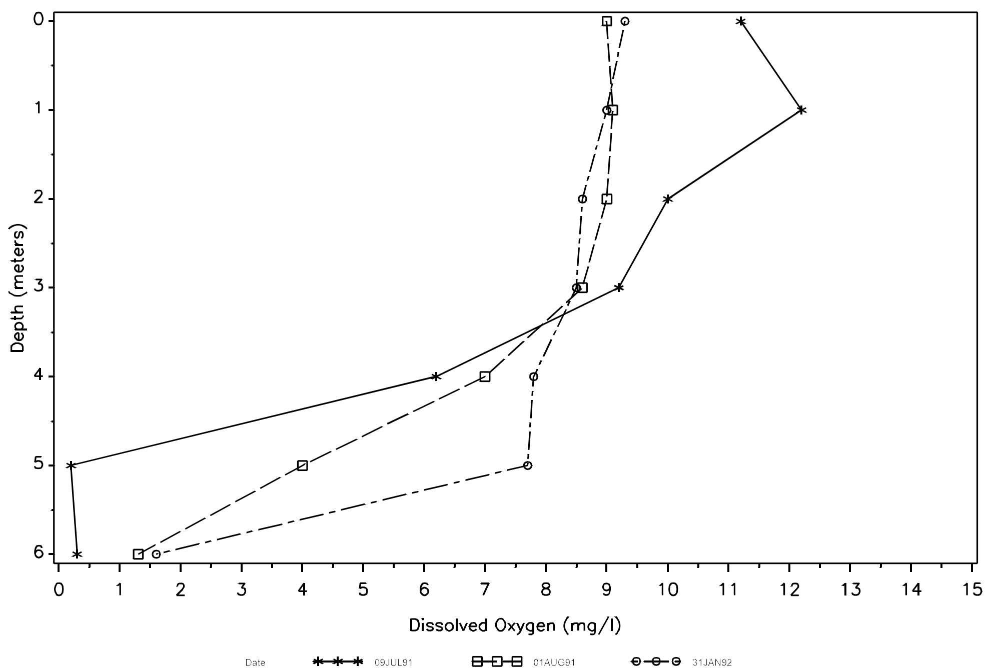

Figure 5. Oxygen profiles for Strawberry Lake.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on August 1, 1991. At the time of the macrophyte survey approximately 60 percent of Strawberry Lake's surface area had aquatic vegetation. Nearly 90 percent of the lakes surface area to a depth of approximately nine feet had mixed stands of sago pondweed (Potamogenton pectinatus), water milfoil (Myriophyllum spp.), and coontail (Ceratophyllum demersum). The northeast bay of Strawberry Lake also contained a small population of curly-leaf pondweed (Potamogenton crispus). A map depicting the areal extent of Strawberry Lake's macrophyte community is contained in Appendix B.

Since 1981 the SLIA has operated a mechanical weed harvester. Results of the effectiveness of harvesting is inconclusive, however a species shift to low profile macrophyte species (i.e., Myriophyllum spp. and Ceratophyllum demersum) could be occurring with long term macrophyte harvesting.   These species would be selected since they are less susceptible to the action of the harvester. Macrophyte species such as Myriophyllum spp. which can vegetatively reproduce would also be encouraged since the activity of the harvester causes plant fragments to be dispersed throughout the entire water column.

Phytoplankton

The phytoplankton community was sampled twice during the summer of 1991. During these times Strawberry Lake's phytoplankton community was represented by 6 divisions and 29 genera. The largest contributors to the community by number and volume were the blue-green algae, Cyanophyta. Mean blue-green algae density by number for the two samples collected during the summer of 1991 was 105,804 cells mL^{-1}, which is approximately 18 times greater than the next abundant group, the green algae, Chlorophyta. Phytoplankton concentrations by volume reflected this dominance as well, though not as dramatically. A complete list of the phytoplankton data can be found in Appendix C.

Trophic Status

Lake water quality assessment data collected during the summer of 1991 indicate Strawberry Lake is highly eutrophic to hypereutrophic. This assess-ment is based primarily on the three indicators; secchi disk transparency and total phosphate as P and chlorophyll-a concentrations.

Secchi disk transparency remained constant between the two summer sampling periods at 0.8 meters, chlorophyll-a concentration ranged from 420 to 55 $\mu g\ L^{-1}$ and total phosphate as P concentrations were between 73 to 91 $\mu g\ L^{-1}$. Ancillary information which supports a highly eutrophic to hypereutrophic assessment was a large macrophyte biomass, frequent nuisance algal blooms, history of fish kills and low dissolved oxygen concentrations.

Sediment and Whole Fish Analysis

Sediments were collected from Strawberry Lake and analyzed for trace elements, PCBs, and selected pesticides. Sediments were collected from the deepest area of the lake (Site 380520) and the littoral zone (Site 380522) (Figure 2). Attempts to collect whole fish from Strawberry Lake for similar analysis were unsuccessful.

Sediments collected from Strawberry Lake showed detectable levels of all trace elements tested for, except mercury. Sediment concentrations in samples collected from Strawberry Lake were also compared to sediment results reported for all lakes sampled during the 1991 LWQA project. In general, trace element concentrations were near or below the median concentrations for all lakes sampled during the LWQA, except for selenium from the sample collected from the deepest area which was two-fold the median concentration. Reported PCB concentrations and concentrations of selected organic compounds were below detection limits for all sediment samples collected from Strawberry Lake. A complete listing of the sediment results is provided in Appendix D.

Watershed

Strawberry Lake's contributing watershed has a surface area of 2,688 acres. A majority of Strawberry Lake's annual hydrologic budget is from Camp Lake. Camp Lake has a contributing watershed of 17,700 acres. Both watersheds are located in the Missouri Coteau physiographic region in northeastern McLean County, North Dakota.

Topography of the region is characterized by rolling hills and valleys with slopes ranging from 1 to 20 percent. Soils are primarily well, to excessively well drained, formed from sandy, rocky glacial material. Both watersheds are predominantly composed of integrated drainages typifying characteristics of the northern prairie pothole region. Nonpoint source pollution from the surrounding watershed accounts for a large portion of the nutrient loading and pollution discharges to Strawberry Lake.

Land use within the Strawberry Lake watershed is 92 percent agricultural with 8 percent actively cultivated. The remaining 84 percent is in low density urban development, haylands, pasture and the Conservation Reserve Program (CRP). There are two concentrated livestock feeding areas within the actual watershed and six more immediately upstream in the Camp Lake watershed (Tables 2 and 3).

According to information provided by the McLean County Soil Conservation District 90 percent of the cultivated lands and nearly all of the remaining lands within the Strawberry Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Strawberry Lake watershed the average "T" value is 3 to 5 tons per acre.

Based on a conservative estimated soil loss of just over 2 tons per acre, which takes into account the percentage of the watershed not cultivated, approximately 5,540 tons of soil are lost annually from within Strawberry Lake's watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 554 tons and 831 tons of soil potentially reaches Strawberry Lake annually.

Using similar logic for Camp Lake's watershed between 6,622 and 9,991 tons of soil is potentially delivered to Camp Lake annually. Camp Lakes acts as a sediment and nutrient trap removing a substantial portion of this load before it can enter Strawberry Lake.

Other nonagricultural sources of nonpoint source pollution discharges to Strawberry Lake are from the numerous summer and permanent homes surrounding the lake. The close proximity to the Lake provides a unchecked conduit for nutrients, organic compounds and sediments to reach Strawberry Lake from inadequate septic systems, failing drain fields, leaking holding tanks, leaching from pit toilets and fertilizer, pesticide, and sediment runoff from lawns and construction sites. These pollutants can combine to be a significant percentage of Strawberry Lake's annual nutrient, sediment and contaminant budget.

Table 2. Land use in the Strawberry Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	8	90
Hayland	38	90
CRP	48	90
Wet/Wild[1]	8	N/A
Other	0	N/A
Farmsteads	1[3]	N/A
Feedlots[2]	2[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number within watershed.

Table 3. Land use in the Camp Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	30	60
Hayland/Pasture	60	90
CRP	6	100
Wet/Wild[1]	1	100
Other	5	N/A
Farmsteads	10[3]	N/A
Feed Lots[2]	6[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number within watershed.

VELVA SPORTSMAN DAM

WARD COUNTY

Peter N. Wax

Velva Sportsman Dam was constructed through the cooperative efforts of the North Dakota Game and Fish Department and the local community in order establish a trout fishery in an area of the state that did not have one. Construction was initiated and completed in 1967. The dam consisted of a rolled earthen structure with a glory hole type outlet. When first constructed the reservoir had a surface area of 6.5 acres and a maximum depth of 26 feet (Figure 1).

Velva Sportsman Dam's watershed covers 281 acres, consisting of cropland, pastures and abandoned coal mine spoils. Attempts at reclamation within the coal mine area of the watershed include plantings of hardy deciduous trees and native grasses. However, due to the severe gradient of the spoil banks and poor soil only partial ground cover has been achieved. The watershed, especially the abandoned coal mine area, causes substantial siltation impacts to Velva Sportsman Dam, primarily at the inlet area. The nutrient load associated with the sediments also negatively impact the reservoir, providing the necessary ingredients for nuisance algal blooms and large mats of aquatic vegetation.

Velva Sportsman Dam is classified as a cold water fishery, "Waters capable of supporting growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The fishery and reservoir are managed by the NDG&F. Management has included annual fish community assessments through test netting, fish stocking, and biological and habitat manipulations.

A rainbow trout fishery was first established on Velva Sportsman Dam in 1969 through stocking by the NDG&F. By the fall of 1969 the fishery was nearly fished out necessitating opening and closing the fishery on alternate years. The regiment was quite successful, providing an excellent fishery supported by regular stockings. In 1982 fresh water scuds (Gammarus) were also introduced to increase forage diversity. In recent years through improved hatchery technology and management the NDG&F has been able to sustain a trout fishery on Velva Sportsman Dam that is open annually.

Stockings in recent years have been exclusively rainbow trout. Fish community assessments conducted in the spring of 1991 showed good populations of rainbow trout and forage species such as fathead minnows and sticklebacks. Also captured were six yellow perch, a species not managed in Velva Sportsman Dam by the NDG&F.

Public facilities on Velva Sportsman Dam are limited to parking and toilets. Access is good during the summer, and poor during the winter. Public use is heavy during the spring and early summer but tapers off during mid to late summer as submerged vegetation makes fishing difficult.

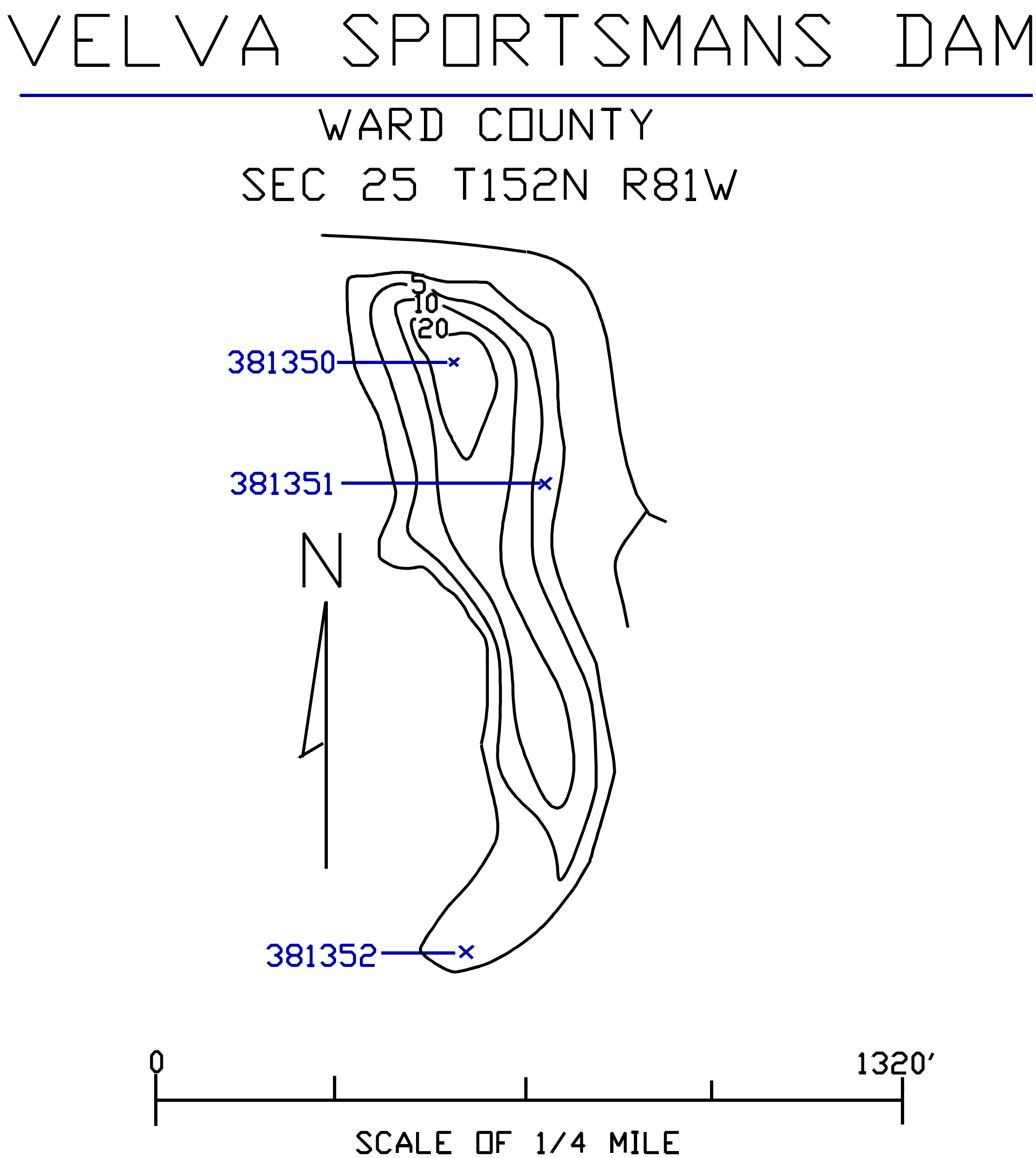

Figure 1. Morphometric map of Velva Sportsman Dam.

Water Quality

Water quality samples were collected from Velva Sportsman Dam three times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381350, Figure 1). Water column samples were collected for analysis at three discrete depths, 1 meter, 4 meters, and between 7 and 7.5 meters.

During the summer of 1991 Velva Sportsman Dam was thermally stratified between 2 and 4 meters below the lake's surface (Figure 2). During this time period dissolved oxygen concentrations were near saturation to a depth of 2 to 5 meters (Figure 3). Temperature and dissolved oxygen samples collected during January, 1992 showed that Velva Sportsman Dam was thermally stratified between 1 and 2 meters below the lake's surface with dissolved oxygen concentrations declining to 0.6 mg L^{-1} near the bottom (Figure 3).

The reservoir does experience rapid oxygen loss in the hypolimnion and under ice-cover conditions (Figure 1, Figure 2). The rapid decline in dissolved oxygen concentrations is most likely the result of internal cycling of nutrients stored in the lake sediments. The most obvious nutrient discharges to Velva Sportsman Dam are a result of the erosion occurring in the abandoned coal mine spoils.

Sulfate and bicarbonates were the dominant anions in the water column. Sulfate concentrations ranged from 312 to 446 mg L^{-1}, while bicarbonate concentrations were between 333 and 561 mg L^{-1}.

Velva Sportsman Dam is a well-buffered waterbody with an average volume-weighted mean total alkalinity as $CaCO_3$ concentration of 340 mg L^{-1}. The
average volume-weighted mean total phosphate as P concentration was 0.075
mg L^{-1}, exceeding the state's target concentration of 0.02 mg L^{-1} on all occasions sampled during the LWQA project. The average volume-weighted mean nitrate + nitrite as N concentration was below the states target concentration of 0.25 mg L^{-1} at 0.0253 mg L^{-1} (Table 1).

While Velva Sportsman Dam is not phosphorus limited as indicated by the total phosphorous to nitrogen ratio and domination by blue-green algae, the ratios do indicate that the presence of blue-green algae and macrophytes could be reduced in Velva Sportsman Dam through control measures directed at limiting total phosphorous. A complete list of water quality data collected in 1991 and 1992 is contained in Appendix A.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Velva Sportsman Dam on August 22, 1991. At the time of the macrophyte survey approximately 20 percent of the surface area had aquatic vegetation.

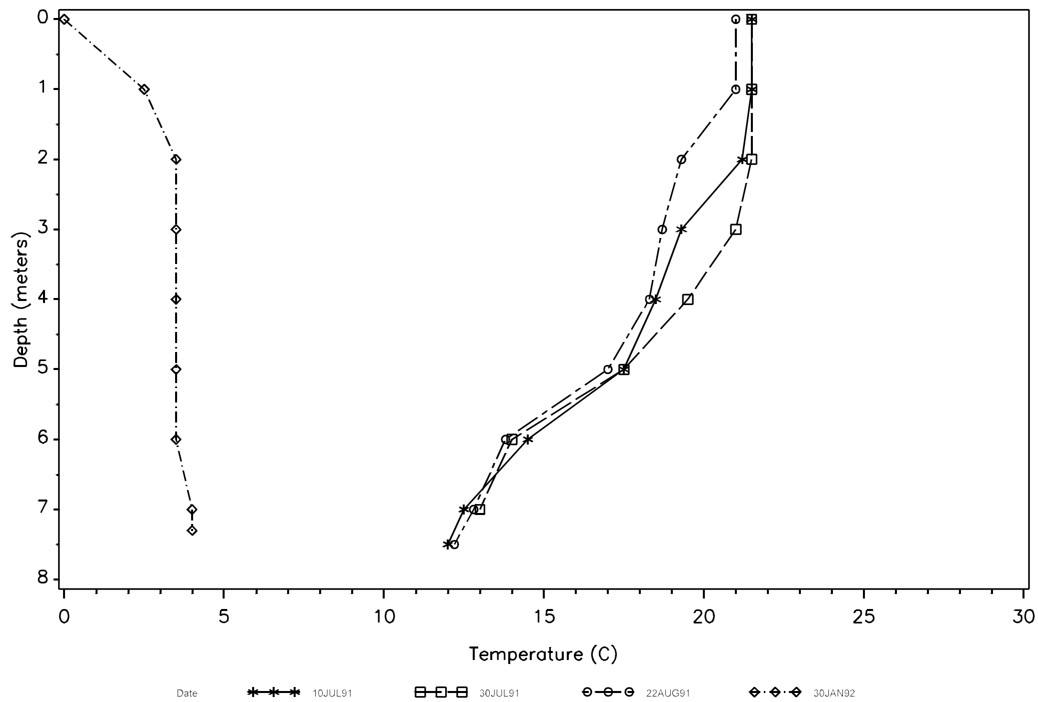

Figure 2. Temperature profiles for Velva Sportsman Dam.

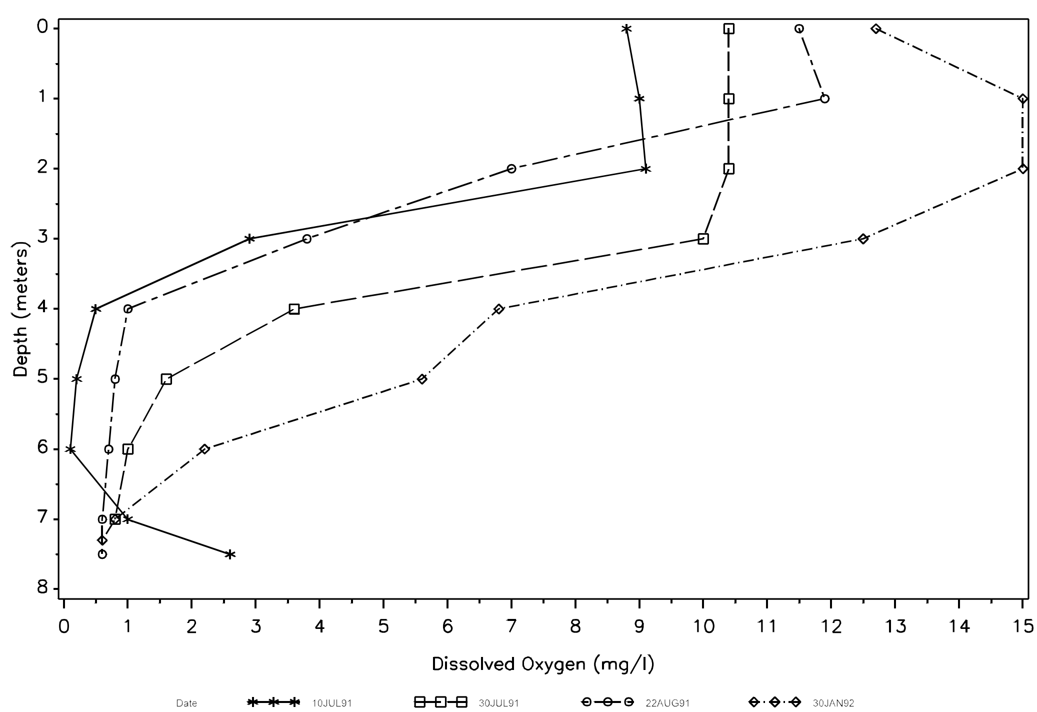

Figure 3. Oxygen profiles for Velva Sportsman Dam.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 10, 1991 and January 30, 1992 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Velva Sportsman Dam		1982-1991	
Total Dissolved Solids	869	mg L^{-1}	1209	mg L^{-1}
Conductivity	1335	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	528	mg L^{-1}	488	mg L^{-1}
Sulfates	393	mg L^{-1}	592	mg L^{-1}
Chloride	3.03	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.075	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.253	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	340	mg L^{-1}	296	mg L^{-1}
Ammonia	0.212	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.15	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	406	mg L^{-1}	326	mg L^{-1}

Nearly 100 percent of the lake's surface area to a depth of five feet had sago pondweed (Potamogenton pectinatus) including a small amount of coontail (Cerataphyllum demersum). The shoreline also had a narrow ring of cattails (Typha spp.) Mixed in with the sago pondweed and coontail were dense mats of (Chara spp.). A map depicting the location and areal extend of the macrophyte community is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled three times during the summer of 1991. The phytoplankton community at the time of sampling was relatively diverse with representation from 7 divisions and 37 genera. The largest contributors to phytoplankton density as represented by number were the blue-green algae, Cyanophyta, with 7 genera present. Mean density of the blue-green algae for the three samples collected during the summer of 1991 was 959,031 cells mL^{-1}. This group represented a 66 fold dominance over the next abundant division, the green algae, Chlorophyta.

During the 1991 LWQA mean phytoplankton concentrations by volume were dominated by the division, Pyrrophyta, occupying over 72 percent of the community by volume. The order Pyrrophyta is composed of large organisms, accounting for the difference between community structure by volume and density. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

In general, the trophic status estimates based on the three indicators secchi disk transparency, chlorophyll-a and total phosphorous concentrations agreed quite well and suggest Velva Sportsman Dam is between mesotrophic and eutrophic. An examination of the ancillary information for Velva Sportsman Dam, support this assessment. This evaluation is due in large part to a significantly diverse phytoplankton community, macrophyte biomass representing less than 20 percent of the available surface area and no history of fish kills.

Sediment Analysis

Sediments were collected from Velva Sportsman Dam and analyzed for selected trace elements, PCBs and pesticides. Sediments were collected from the deepest area of the lake (Site 381350), the littoral zone (Site 381351), and the inlet (Site 381352) (Figure 1).

Sediment samples collected from Velva Sportsman Dam showed detectable levels of all trace elements tested for, except mercury and selenium. Sediment concentrations at each sample location within Velva Sportsman Dam were also compared to the sediment results reported for all lakes assessed during the 1991 LWQA. Trace element concentrations were generally near or slightly below the median concentrations for all lakes sampled with no analyte matching or exceeding the 75th percentile. Concentrations of PCBs and selected organic compounds were below detectible limits for all sediment samples collected from Velva Sportsman Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Velva Sportsman Dam on June 20, 1991. Rainbow trout were the species collected, representing the piscivore group.

In order to evaluate the fish tissue data for Velva Sportsman Dam, the results for each fish group were compared to that group for all lakes assessed during the 1991 LWQA. Trace element concentrations in whole fish samples collected from Velva Sportsman Dam were generally below the median concentrations for all piscivores collected. The exception was the reported barium concentra-tions of 28.3 $\mu g\ g^{-1}$ which is above the median concentration yet below the 75th percentile.

Detectable pesticide residues in the rainbow trout sample collected from Velva Sportsman Dam included DDE and trifluralin. DDE is a degenerate by product of the insecticide DDT and produces biological effects similar to the parent compound. Trifluralin, commonly known as Treflan, is a selective preemergent herbicide. The DDE concentration reported was below the median concentration for all fish samples collected in the 1991 LWQA at 0.005 $\mu g\ g^{-1}$. The trifluralin concentrations of 0.005 $\mu g\ g^{-1}$ was the same as the 75th percentile but below the maximum reported concentration of 0.011 $\mu g\ g^{-1}$. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Velva Sportsman Dam and its contributing watershed has a combined surface area of 2081 acres. It is located on the edge of an abandon coal mine in eastern Ward County, North Dakota. The surrounding landscape outside of the coal mine is characterized by rolling hills and valleys. Soils are predominately excessively drained, built from gravely, sandy glacial materials. The landscape within the coal mine area is a mixture of spoils and trenches, sparsely covered with deciduous trees and native grasses. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient load and pollution discharges to Velva Sportsman Dam.

Land use within the Velva Sportsman Dam watershed is 98 percent agricultural with 32 percent actively cultivated. The remaining 66 percent is in pasture (Table 2). According to information provided by the Ward County Soil Conservation District, 80 percent of the cultivated lands and none of the remaining lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Velva Sportsman Dam watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of less then a ton per acre which takes into account the pasture land, approximately 262 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 26 and 39 tons of soil reaches Velva Sportsman Dam annually.

Table 2. Land use in the Velva Sportsman Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	32	80
Rangeland	66	0
Hayland	0	0
CRP	0	0
Wet/Wild[1]	0	0
Other	2	N/A
Farmsteads	0[3]	N/A
Feedlots[2]	0[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number present in watershed.

WELK DAM
EMMONS COUNTY
Peter N. Wax

Welk Dam is a small reservoir located on Little Beaver Creek in Emmons County, North Dakota. It was constructed in 1930 under the Works Project Administration (WPA). The original outlet structure and concrete spillway have since been repaired creating an impoundment covering 28 acres with a maximum depth of approximately 18 feet (Figure 1).

The surrounding 11,000 acre watershed lies in the Missouri Coteau physio-graphic region, an area characterized by short, irregular slopes, built from glacial deposits. There are areas of bedrock out croppings and areas where glacial deposits are thin within the watershed. Also in many locations severe geologic erosion has resulted in prominent buttes and badlands. Soils are composed primarily of loess, a wind deposited sediment that is commonly unstratified and unconsolidated, primarily made up of silt-sized particles.

Welk Dam is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). Welk Dam's fishery is managed by the NDG&F. Management includes annual fish community assessments, fish stockings, and habitat and biological manipulations. The most recent stocking occurred in 1989 with a single plant of 2,800 fingerling northern pike. Initially, Welk Dam was a perch, crappie, northern pike fishery that suffered from an overabundance of white suckers, perch and bullheads. Between 1956 and 1960 Welk Dam was eradicated and a good trout fishery maintained until 1966. Unauthorized stockings of yellow perch and bullhead first noted in 1964 caused rapid deterioration of the trout fishery. In 1967 the lake was again chemically eradicated and restocked with trout. Following a severe fish kill in the winter of 1969-1970, the stocking regiment was modified to include northern pike, crappie and bluegill. In all, Welk Dam's fishery has been unstable due to natural and chemical die offs and the unauthorized introduction of undesirable species by the public.

Test netting operations conducted in the spring of 1991 captured no rough fish. The most frequently captured sport fish was bluegill followed by northern pike and crappie. Fathead minnows and a single Iowa Darter were also captured.

Water Quality

Water quality samples were collected from Welk Dam two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381325, Figure 1).

Water column samples were collected for analysis at three separate depths during the summer and two separate depths during the winter. Summer samples were collected at 1 meter, 2 meters, and 5 meters. Winter samples were collected at 1 meter and 4 meters.

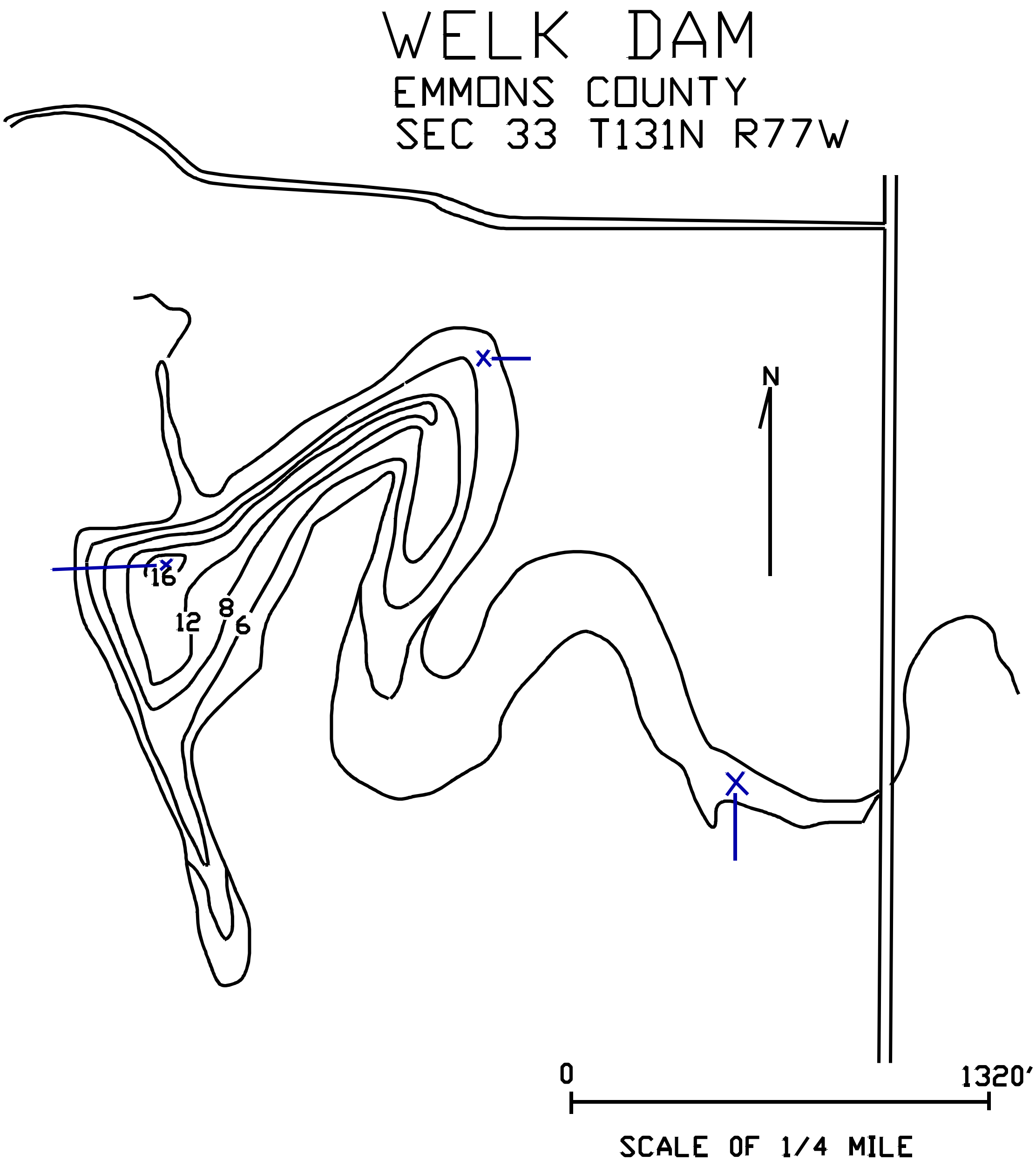

Figure 1. Morphometric map of Welk Dam.

During the summer of 1991, Welk Dam was not or was only weakly thermally stratified between 1 and 2 meters below the lake surface (Figure 2). During this time period, dissolved oxygen concentrations were above 8 mg L^{-1} and was adequate to maintain aquatic life (Figure 3). Samples collected during January 1992 showed that the lake was thermally stratified between 3 and 4 meters. Dissolved oxygen concentrations at this time ranged from 16.8 mg L^{-1} near the surface to 0.5 mg L^{-1} near the bottom of the reservoir (Figure 3).

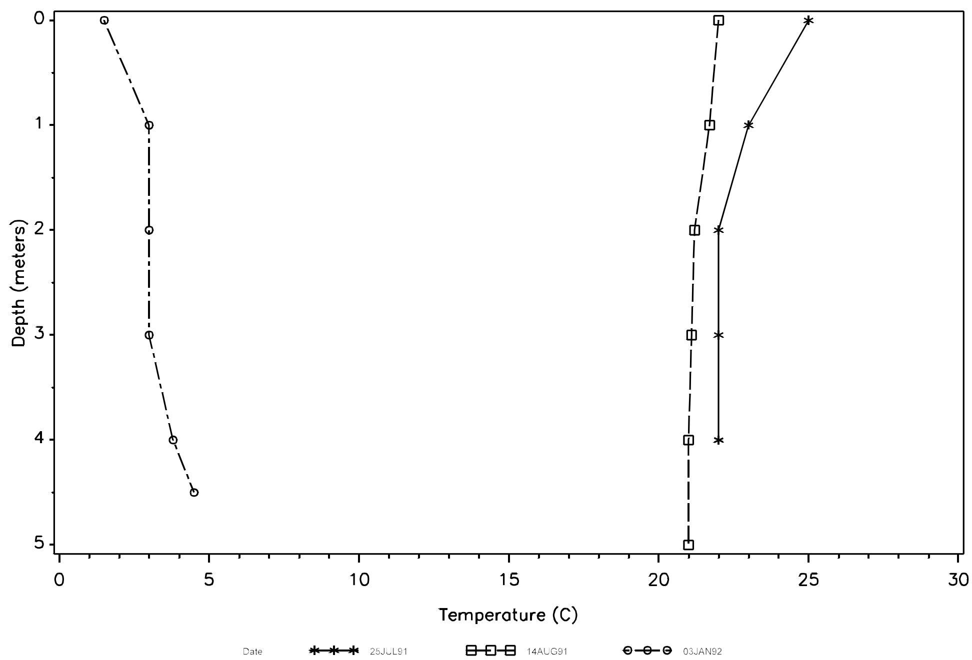

Figure 2. Temperature profiles for Welk Dam.

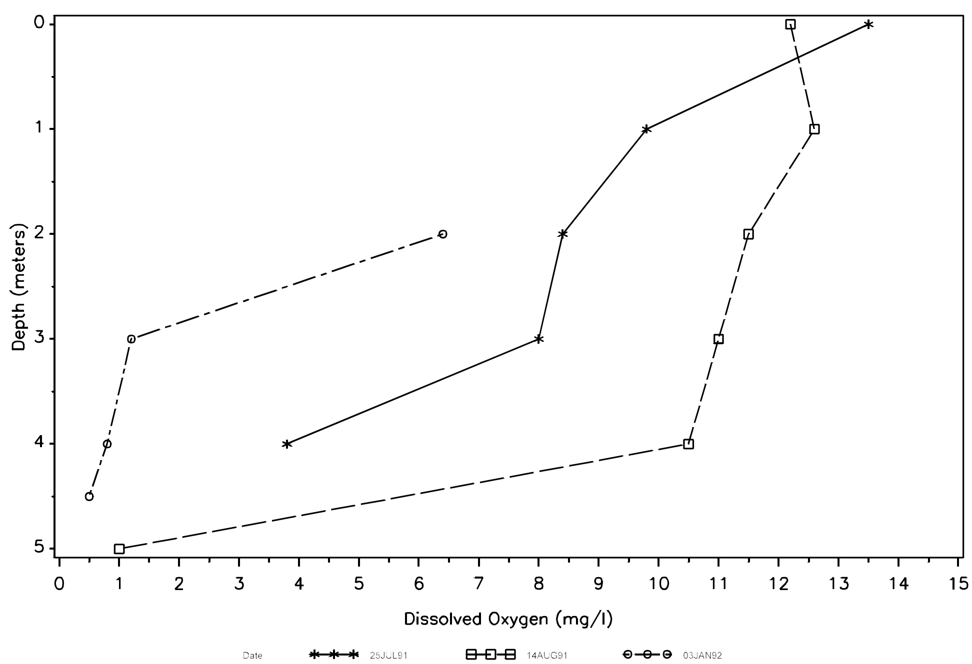

Figure 97. Oxygen profiles for Welk Dam.

Welk Dam is a well-buffered waterbody with an average volume-weighted mean total alkalinity as $CaCO_3$ of 550 mg L^{-1}. Bicarbonates and sulfates were the dominant anions in the water column, with an average volume-weighted mean con-centrations of 390 mg L^{-1} and 541 mg L^{-1}, respectively. Total phosphorous as P was above the long-term average for all North Dakota lakes at 0.906 mg L^{-1}, exceeding the state's target concentration of 0.02 mg L^{-1} at all times sampled. In general, average volume-weighted mean concentrations for all general water quality parameters sampled in Welk Dam were near or above the long-term average for all North Dakota lakes. A completed list of the LWQA project water quality data is contained in Appendix A.

The ratio of total phosphate as P to nitrate + nitrite as N of 76:1 suggest Welk Dam is severely nitrogen limited. A more accurate description would be it has an over abundance of phosphorus. Under these conditions, blue-green algae species which are able to fix free nitrogen are favored (Table 1).

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 25, August 14, 1992 and January 3, 1992 and long-term averages from all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Welk Dam		1982-1991	
Total Dissolved Solids	1380	mg L^{-1}	1209	mg L^{-1}
Conductivity	2018	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	259	mg L^{-1}	488	mg L^{-1}
Sulfate	541	mg L^{-1}	592	mg L^{-1}
Chloride	15.3	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.906	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.012	mg L^{-1}	0.069	mg L^{-1}
Total Kjeldahl Nitrogen	3.53	mg L^{-1}	2.34	mg L^{-1}
Ammonia	0.028	mg L^{-1}	0.326	mg L^{-1}
Bicarbonate	390	mg L^{-1}	326	mg L^{-1}
Total Alkalinity	550	mg L^{-1}	296	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Welk Dam as part of the 1991 lake assessment. The survey was conducted on August 14, 1991.

At the time of the macrophyte survey nearly 25 percent of Welk Dam's surface area had aquatic vegetation. A mixed stand of sago pondweed (Potamogeton pectinatus), water milfoil (Myriophyllum Spp.) and coon tail (Ceratophyllum demerson) occupied nearly 100 percent of the surface area to a depth of six feet. An outer ring of bulrush (Scirpus Spp.) lined nearly 80 percent of the shoreline. A map depicting the macrophyte community including its areal extent is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled two times during the summer of 1991. At this time the phytoplankton community had representation from 5 divisions and 37 genera. The largest contributors to the phytoplankton community density by number were the blue-green algae, Cyanophyta, with 20 genera present. Mean blue-green algae densities during the summer of 1991 were 620,000 cells mL^{-1}, 17 times greater than the next abundant division the green algae, Chlorophyta.

During the summer of 1991, phytoplankton community density by volume was also dominated by the blue-green algae. Community domination was quite dramatic as blue-greens represented over 75 percent of the total community by volume on both sample dates. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

During the summer of 1991 Welk Dam exhibited classic symptoms of a hyper-eutrophic lake. Primary indicators were surface total phosphate as P concen-trations of 1.080 and 0.887 mg L^{-1}, chlorophyll-a concentrations of 0.102 and 0.105 mg L^{-1} and secchi disk transparency depths of 0.5 and 0.6 meters. Supporting ancillary data include frequent algal blooms, a phytoplankton community dominated by blue-green algae, low dissolved oxygen condition within the hypolimnion and during ice cover, history of fish kills and a large macrophyte biomass with the photic zone.

Sediment Analysis

Sediments were collected from Welk Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381325), the littoral zone (Site 381326), and the inlet (Site 381327) (Figure 1).

Sediment samples collected from Welk Dam showed detectable levels of all trace elements tested for, except mercury. Sediment concentrations at each sample location within Welk Dam were compared to sediment sample results reported for all lakes sampled during the 1991 LWQA project. Trace element concentrations reported for the inlet sample collected from Welk Dam were near or below the median concentrations for all lakes sampled with the exception of barium and chromium which exceeded the 75th percentile for all inlet samples collected. Reported trace element concentrations in the littoral and deepest sediment samples were near or above the median concentration for all lake samples collected from these areas in the 1991 LWQA with the exceptions of copper, zinc, barium and chromium concentrations from the deepest area which exceeded the 75th percentile and zinc, barium, chromium and lead concentrations from the littoral area which exceeded the 75th percentile. Concentrations of selected organic compounds were below detectible limits for all samples collected from Welk Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Welk Dam on June 11, 1991. Northern pike were collected, representing the piscivore group. In order to evaluate the fish tissue data for Welk Dam, the results were compared to the corresponding group for all lakes assessed during the 1991 LWQA project. Reported trace element concentrations in the fish sample collected from Welk Dam were generally near the median concentrations for all piscivores analyzed during the 1991 LWQA. The exceptions were the reported chromium and zinc concentrations which were above the 75th percentile for all piscivores.

Pesticide analysis of the northern pike sample collected from Welk Dam showed detectable levels of DDD, DDE and trifluralin. DDE and DDD are a degradation product of the insecticide DDT and produces biological effects similar to the parent compound. Trifluralin, commonly known as Treflan, is a selective, pre-emergent herbicide. The DDE and trifluralin concentrations reported were slightly above the median concentration for all piscivore samples analyzed during the 1991 LWQA project at 0.004 $\mu g\ g^{-1}$ each. The reported DDE concentration was slightly below the median concentration at 0.008 $\mu g\ g^{-1}$. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Welk Dam's contributing watershed has a surface area of approximately 11,000 acres. It is located on the eastern edge of the Missouri Coteau physiographic region, in central Emmons County, North Dakota. The region is characterized by short, irregular slopes built from glacial deposits. The majority of soils are composed of loess, a wind deposited sediment that is commonly unstratified, unconsolidated and made up of silt-size particles. Nonpoint source pollution accounts for 100 percent of nutrient and sediment loadings to Welk Dam.

Land use within the Welk Dam watershed is 93 percent agricultural, with 73 percent actively cultivated. The remaining 27 percent is in low density urban development (e.g., farmsteads), haylands, pasture, and the Conservation Reserve Program (CRP) (Table 2). According to the information provided by the Emmons County Soil Conservation District, 45 percent of the cultivated lands and between 60 and 70 percent of all the remaining lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve soil loss tolerant (T). It is estimated that within the Welk Dam watershed, the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of 7 to 8 tons per acre, which takes into account the land that is not adequately treated, 87,032 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent between 8,703 and 13,055 tons of soil potentially reaches Welk Dam annually. Other sources of nonpoint source pollution discharges to Welk Dam include concentrated cattle feeding and watering areas in the immediate upstream drainage.

Table 2. Land use in the Welk Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	73	45
Pasture Land	13	60
Hayland	2	70
CRP	5	100
Other	7	N/A
Farmsteads	16[2]	N/A
Feedlots[1]	6[2]	0

[1]Feedlots are areas where livestock are concentrated to be fed.
[2]Number within watershed.

WHITMAN DAM

NELSON COUNTY

Peter N. Wax

Whitman Dam is a Soil Conservation Service (SCS) multipurpose dam, constructed for flood control and recreation in 1964. The dam is located on the Middle Branch Forest River in Nelson County, North Dakota. Originally constructed with an elevation of 1517.1 feet, the dam was raised by the SCS to 1518.8 feet to accommodate additional drainage in the watershed. At present, the dam has a surface area of 142 acres and a maximum depth of 14.1 feet (Figure 1).

Whitman Dam is classified as a cold water fishery, "Waters capable of supporting growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The fishery was first established on Whitman Dam in 1964 with the introduction of rainbow trout. Since that time, fisheries management has incorporated warm and cool water species (e.g., northern pike, bluegill). The NDG&F manages Whitman Dam by evaluating the fish community through annual test netting operations and stocking accordingly. In recent years, species stocked have included walleye, northern pike, smallmouth bass, bluegill, crappie, and rainbow trout. The 1991 test netting conducted by the NDG&F showed a fish community dominated by white suckers. Other species captured include walleye, crappie and smallmouth bass.

Access to Whitman Dam is good. Facilities are maintained by the Whitman Wildlife Club and the Nelson County Water Management Board. Facilities at Whitman Dam include sheltered picnic areas, a swimming beach, boat launch, drinking water, and toilets.

Water Quality

Water quality samples were collected from Whitman Dam two times during the summer of 1991 and once during the winter of 1992. Samples were collected at one sample site located in the deepest area of the lake (Site 381255, Figure 1). Water column samples were collected for analysis at three discrete depths, 1 meter, 2 meters, and 6 meters.

During the summer of 1991, at the time of the collection, Whitman Dam was thermally stratified at approximately 2 meters below the lake surface in July and 4 meters in August (Figure 2). During these time periods, dissolved oxygen concentrations were at or near saturation in the epilimnion and were adequate to maintain aquatic life (Figure 3). Samples collected during February 1991 showed that Whitman Dam was thermally stratified between 1 and 2 meters below the lake's surface. At this time, dissolved oxygen concentrations were above 5.0 mg L^{-1} to a depth of 3 meters declining to less than 1 mg L^{-1} at the lake's bottom (Figure 3).

Sulfate and bicarbonate were the dominant anions in the water column, with volume-weighted means ranging from 198 to 245 mg L^{-1}, and 287 to 372 mg L^{-1}, respectively. Average volume-weighted mean concentrations for total dissolved solids, hardness and conductivity were considerably less than the long-term average for lakes sampled in North Dakota between 1982-1991 (Table 1).

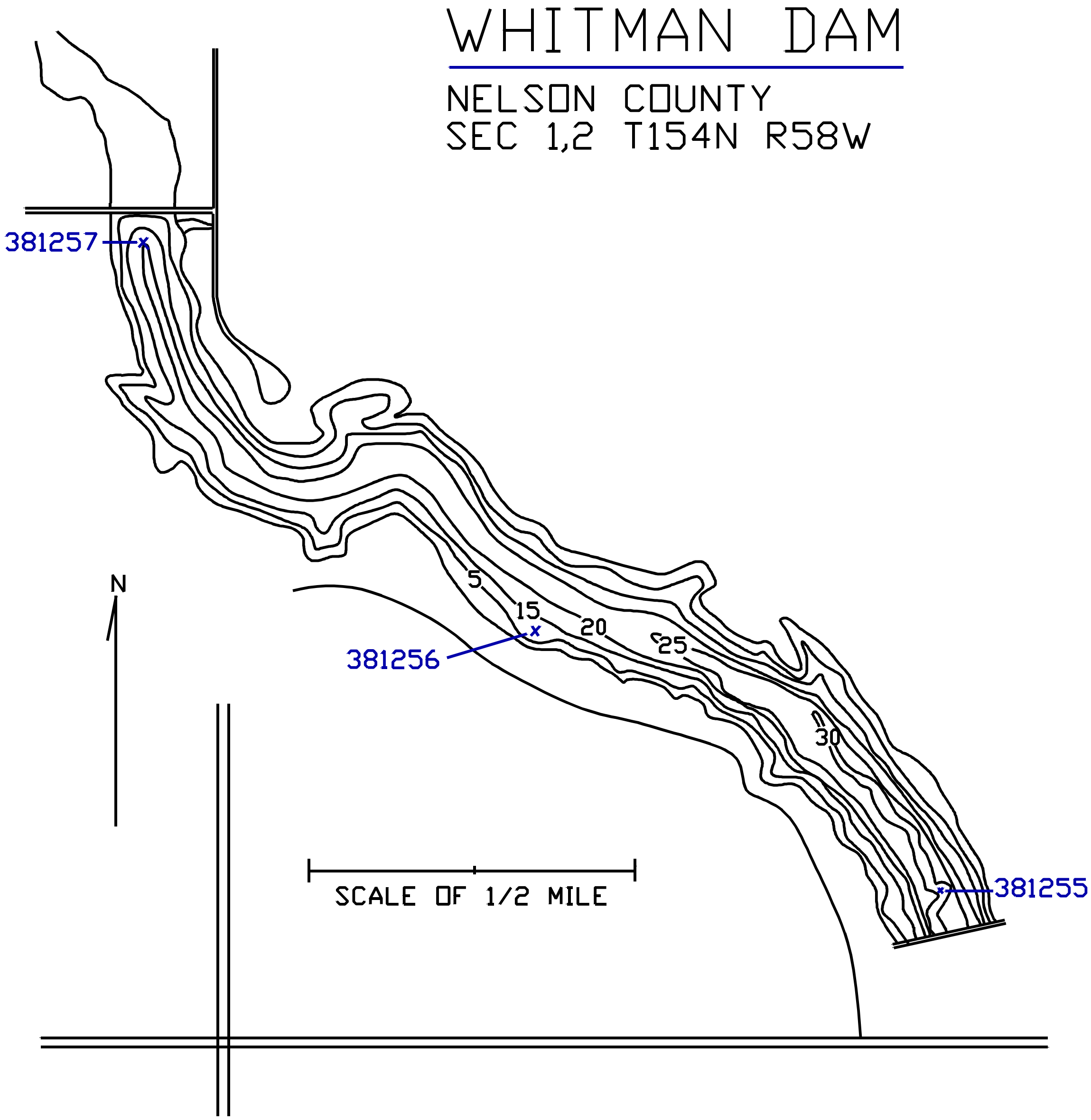

Figure 1. Morphometric map of Whitman Dam.

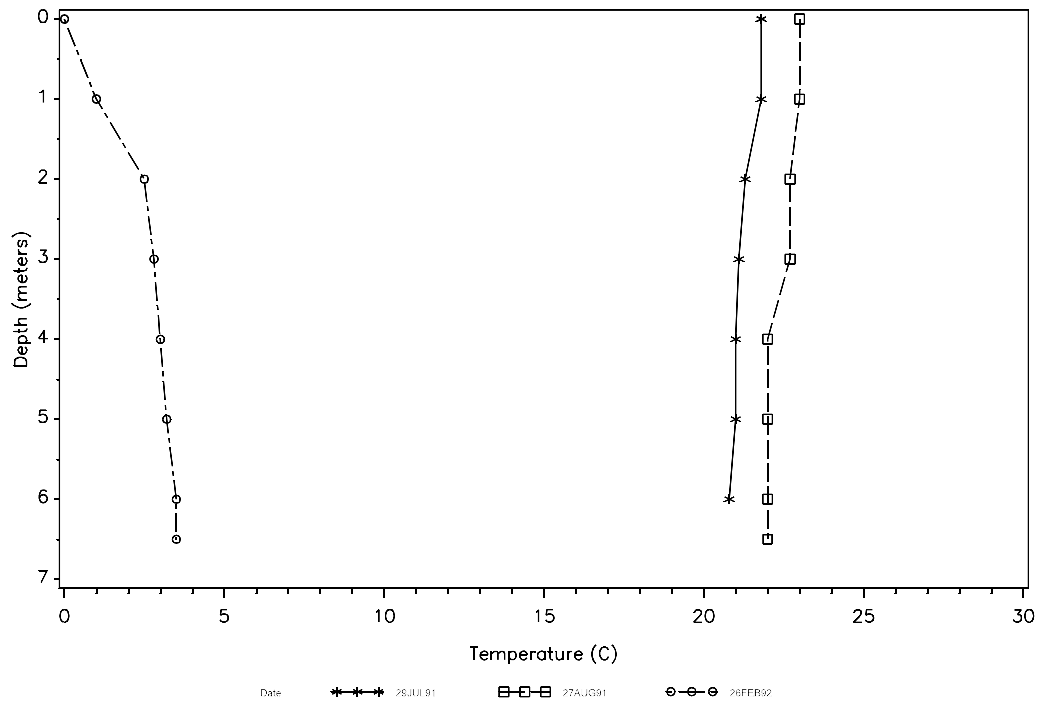

Figure 2. Temperature profile for Whitman Dam.

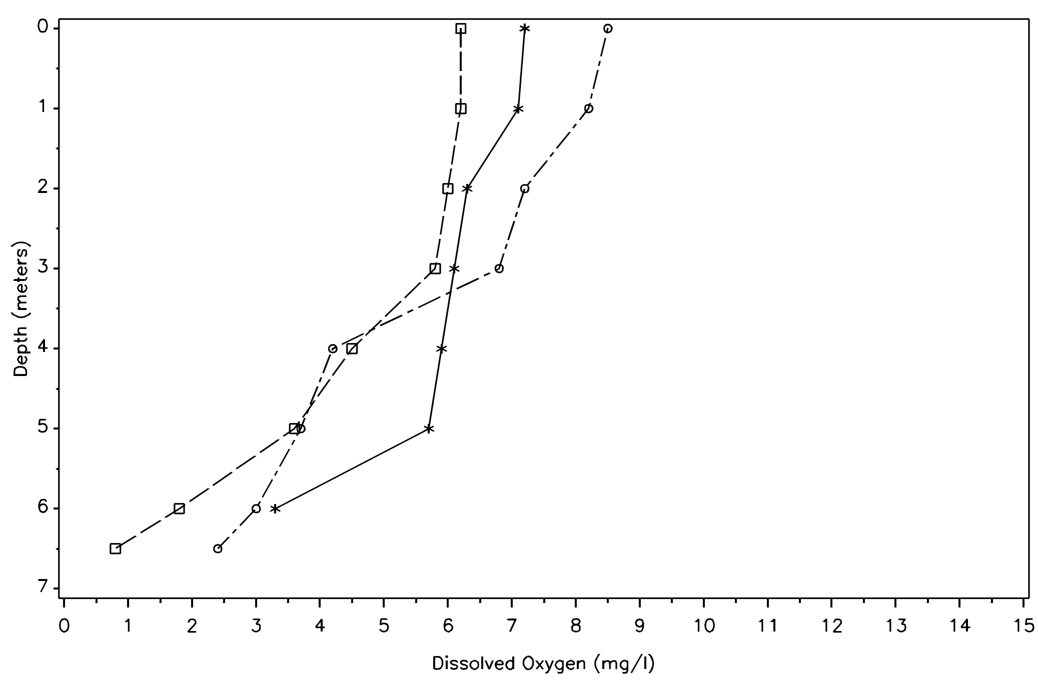

Figure 3. Oxygen profile for Whitman Dam.

The average volume-weighted mean concentration for total phosphorus as P was 0.459 mg L^{-1}, exceeding the State's target concentration of 0.02 mg L^{-1} on all occasions sampled during 1991 and 1992. The average volume-weighted mean nitrate + nitrite as N concentration was below the State's target concentration of 0.25 mg L^{-1} at 0.193 mg L^{-1}. However, the nitrate + nitrite as N concentrations for Whitman Dam is three times the long-term average concentration for all North Dakota lakes. A complete list of water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 1991 and February 1992, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Whitman Dam	1982-1991
Total Dissolved Solids	612 mg L^{-1}	1209 mg L^{-1}
Conductivity	966 umhos cm^{-1}	1604 umhos cm^{-1}
Hardness as Calcium	332 mg L^{-1}	488 mg L^{-1}
Sulfates	218 mg L^{-1}	592 mg L^{-1}
Chlorides	28.6 mg L^{-1}	81 mg L^{-1}
Total Phosphate as P	0.459 mg L^{-1}	0.248 mg L^{-1}
Nitrate + Nitrite as N	0.193 mg L^{-1}	0.069 mg L^{-1}
Total Alkalinity	268 mg L^{-1}	296 mg L^{-1}
Ammonia	0.220 mg L^{-1}	0.347 mg L^{-1}
Total Kjeldahl Nitrogen	1.92 mg L^{-1}	2.34 mg L^{-1}
Bicarbonate	321 mg L^{-1}	326 mg L^{-1}

Aquatic Vegetation

A survey of the macrophyte community was conducted on Whitman Dam as part of the 1991 LWQA project. The survey was conducted on August 21, 1991. At the time of the macrophyte survey, no submergent macrophytes were observed on Whitman Dam. Nearly 100 percent of the lake's shore had emergent macrophytes. The emergent macrophytes found were bulrush (Scirpus spp.) and cattails (Typha spp.) A map depicting the macrophyte community is contained in Appendix B.

Phytoplankton

The phytoplankton community was sampled two times during the summer of 1991. During these two sample periods the phytoplankton community was represented by 3 divisions and 14 genera. The largest contributors to the phytoplankton density as represented by number were the green algae, Chlorophyta, with 5 species present, followed by the blue-greens, Cyanophyta, with 6 species present. The only other divisions present during the two sampling times were the Cryptophyta.

At the time of the assessment mean phytoplankton concentrations by volume were more evenly distributed among three divisions. The blue-green and species represented are large organisms when compared to the green algae species present. This accounts for the difference between density and volume. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Whitman was assessed as a eutrophic lake. This trophic status assessment is based primarily on surface total phosphorus concentrations which ranged between 0.46 and 0.53 mg L^{-1} and secchi disk transparency measurements which range between 1.8 and 1.9 meters. Collaborating evidence which supports a eutrophic lake assessment is low dissolved concentrations throughout the water column in the winter and in the hypolimnion in the summer, frequent nuisance algal blooms and reoccurring fish kills. Supporting evidence of a better trophic status assessment include a phytoplankton community dominated by green algae and a low macrophyte biomass.

Sediment Analysis

Sediment samples collected from Whitman Dam at all three sites, the inlet, the littoral and the deepest areas, showed detectable levels of all trace elements tested for except mercury in the deepest and littoral areas. Trace element concentrations at each sample location within Whitman Dam were compared to all sediment samples assessed during the 1991 LWQA project. Trace element concentrations were near or below the median concentrations for all lakes sampled except lead in the deepest area, which was greater than the 75th percentile value reported for all LWQA lakes. PCB concentrations and the concentrations of selected pesticides in sediment samples were below detectible limits for all samples collected from Whitman Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Whitman Dam on July 16, 1991. Only one composite white sucker sample was collected for contaminant analysis. This sample represents the bottom feeder group. The composite white sucker sample was a composite of five fish with a mean weight of 1474 grams and a mean length of 51.6 centimeters.

In order to evaluate the fish tissue data for Whitman Dam, the results for Whitman Dam were compared to the bottom feeder group for all lakes assessed in 1991. Trace element concentrations in fish samples collected from Whitman Dam were generally near or slightly below the median concentration for all fish collected during the 1991 LWQA project. The reported selenium and lead concentrations, 0.397 and 0.105 $\mu g\ g^{-1}$, respectively, were the only exceptions. These concentrations were greater than the 75th percentile for all bottom feeder samples collected in 1991. The reported mercury concentration in the white sucker sample was below the detectable limit.

Detectable pesticide residues in the composite whole fish sample collected from Whitman Dam were limited to DDD and DDE, both breakdown derivatives of DDT. The white suckers sample collected from Whitman Dam contained 0.003 $\mu g\ g^{-1}$ of DDD and 0.06 $\mu g\ g^{-1}$ of DDE. These concentrations are the same as the median concentration for all bottom feeders collected during the 1991-1992 assessment. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Whitman Dam with its contributing watershed has a surface area of 11,000 acres. It is located in the Glaciated Plains physiographic region near the western edge of the Red River Valley in Nelson County, North Dakota. The surrounding landscape is characterized by nearly level to rolling topography. Soils are deep, moderately well drained, and fertile. The soils are built from fine to medium textured glacial till. Nonpoint source pollution from the surrounding watershed accounts for all of the external sediment and nutrient loadings and pollution discharges to Whitman Dam.

Land use within the Whitman Dam watershed is 93 percent agricultural with 73 percent actively cultivated. The remaining 27 percent is in low density developments (e.g., farmsteads), haylands, pasture, Conservation Reserve Program (CRP), and six concentrated livestock feeding areas (Table 2).

According to the information provided by the Nelson County Soil Conservation District, 45 percent of the cultivated lands and between 60 and 100 percent of the remaining lands within the Whitman Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. Based on an average soil loss of nearly 8 tons per acre, which takes into account the untreated percentages of the watershed, approximately 837,032 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 8,703 and 13,055 tons of soil potentially reaches the waters within Whitman Dam's watershed annually.

Other sources of nonpoint source pollution contributing to Whitman Dam are from the concentrated livestock feeding areas and lakeshore developments. Approximately 5 percent of the land adjacent to the lake is developed. These sources due their proximity to the lake may have a significant impact on the lake's nutrient budget through fertilizer runoff, construction of new homes, and septic systems in the immediate drainage.

Table 2. Land use in the Whitman Dam watershed.

Land use	Percent of total Watershed acreage	Percent Adequately treated
Cropland	73	45
Pasture land	13	60
Hayland	2	70
CRP	5	100
Wet/Wild[1]	0	100
Other	7	N/A
Farmsteads	16[3]	N/A
Feedlots[2]	6[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Number of farms and concentrated livestock feeding areas.

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Appendix A

1991-1992 LWQA Water Quality Data

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381225	30JUL91	0	22.0	8.7	692	239	239	26	0.017	2.48
2	381225	30JUL91	1	22.0	8.7	.	.	.	.	.	.
3	381225	30JUL91	2	22.0	8.6	.	.	.	.	.	.
4	381225	30JUL91	3	22.0	8.6	.	.	.	.	.	.
5	381225	30JUL91	4	22.0	8.5	684	237	241	24	0.054	2.44
6	381225	30JUL91	5	22.0	7.8	.	.	.	.	.	.
7	381225	30JUL91	6	20.0	3.0	.	.	.	.	.	.
8	381225	30JUL91	7	19.0	1.4	.	.	.	.	.	.
9	381225	30JUL91	8	17.0	1.0	.	.	.	.	.	.
10	381225	30JUL91	9	16.0	0.8	760	288	352	0	4.790	4.82
11	381225	28AUG91	0	22.5	10.0	647	238	229	30	0.055	2.50
12	381225	28AUG91	1	21.0	10.0	.	.	.	.	.	.
13	381225	28AUG91	2	21.0	10.2	.	.	.	.	.	.
14	381225	28AUG91	3	21.0	10.3	.	.	.	.	.	.
15	381225	28AUG91	4	20.5	10.3	.	.	.	.	.	.
16	381225	28AUG91	5	20.5	10.2	662	237	226	31	0.019	2.26
17	381225	28AUG91	6	20.0	10.2	.	.	.	.	.	.
18	381225	28AUG91	7	20.0	9.8	.	.	.	.	.	.
19	381225	28AUG91	8	16.5	2.3	.	.	.	.	.	.
20	381225	28AUG91	9	15.0	1.5	774	322	393	0	5.820	8.00
21	381225	17SEP91	1	.	.	659	243	297	0	0.396	1.56

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.009	0.521	0.460	292	54.4	37.9	23.1	8.1	0.000	0.238	5.7	113	386
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.155	0.506	0.459	303	56.5	39.2	24.3	8.4	0.000	0.243	5.3	142	418
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.011	1.820	1.820	337	66.6	41.4	25.2	11.9	0.133	2.960	6.1	120	445
11	0.000	0.549	0.456	338	64.4	43.1	26.5	10.0	0.034	0.173	4.8	123	415
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.000	0.561	0.439	335	64.0	42.6	27.0	9.6	0.032	0.182	5.0	123	414
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.025	1.690	1.580	350	68.9	43.2	26.6	11.0	0.099	6.910	5.4	122	471
21	0.033	0.596	.	344	66.1	43.5	25.6	9.8	0.055	0.369	4.9	112	408

DISSOLVED LAB TOTAL BICARBONATE CARBONATE TOTAL TOTAL KJELDAHL

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	OXYGEN (mg/L)	CONDUCTIVITY (umhos/cm)	ALKALINITY (mg/L)	ALKALINITY (mg/L)	ALKALINITY (mg/L)	AMMONIA AS N (mg/L)	NITROGEN AS N (mg/L)
22	381225	17SEP91	4	.	.	657	243	297	0	0.417	1.58
23	381225	17SEP91	8	.	.	658	243	297	0	0.440	1.50
24	381225	23FEB92	0	0.2	3.0	.	.	.	.	.	.
25	381225	23FEB92	1	0.2	3.0	790	289	353	0	0.530	2.42
26	381225	23FEB92	2	2.0	2.3	.	.	.	.	.	.
27	381225	23FEB92	3	2.5	1.4	.	.	.	.	.	.
28	381225	23FEB92	4	3.0	1.2	.	.	.	.	.	.
29	381225	23FEB92	5	3.0	1.1	775	290	354	0	0.647	2.45
30	381225	23FEB92	6	3.5	1.1	.	.	.	.	.	.
31	381225	23FEB92	7	4.0	1.1	.	.	.	.	.	.
32	381225	23FEB92	8	4.0	1.0	.	.	.	.	.	.
33	381225	23FEB92	9	4.8	1.0	873	347	424	0	4.370	6.74

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.029	0.583	.	330	63.0	41.9	24.8	9.2	0.047	0.355	4.8	111	401
23	0.032	0.583	.	338	64.9	42.8	25.7	9.2	0.039	0.360	4.7	110	404
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.033	0.486	0.430	375	72.1	47.4	29.5	10.3	0.057	1.020	6.8	156	496
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	0.007	0.532	0.469	377	71.8	48.1	29.7	10.3	0.138	1.440	6.7	149	490
30	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.
33	0.003	1.940	1.800	408	79.2	51.0	30.8	11.1	0.366	2.400	7.2	157	545

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381225	30JUL91	0	22.0	8.7	692	239	239	26	0.017	2.48
2	381225	30JUL91	1	22.0	8.7	.	.	.	.	.	.
3	381225	30JUL91	2	22.0	8.6	.	.	.	.	.	.
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5	381225	30JUL91	4	22.0	8.5	684	237	241	24	0.054	2.44
6	381225	30JUL91	5	22.0	7.8	.	.	.	.	.	.
7	381225	30JUL91	6	20.0	3.0	.	.	.	.	.	.
8	381225	30JUL91	7	19.0	1.4	.	.	.	.	.	.
9	381225	30JUL91	8	17.0	1.0	.	.	.	.	.	.
10	381225	30JUL91	9	16.0	0.8	760	288	352	0	4.790	4.82
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13	381225	28AUG91	2	21.0	10.2	.	.	.	.	.	.
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OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.009	0.521	0.460	292	54.4	37.9	23.1	8.1	0.000	0.238	5.7	113	386
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.155	0.506	0.459	303	56.5	39.2	24.3	8.4	0.000	0.243	5.3	142	418
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.011	1.820	1.820	337	66.6	41.4	25.2	11.9	0.133	2.960	6.1	120	445
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12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.000	0.561	0.439	335	64.0	42.6	27.0	9.6	0.032	0.182	5.0	123	414
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.025	1.690	1.580	350	68.9	43.2	26.6	11.0	0.099	6.910	5.4	122	471
21	0.033	0.596	.	344	66.1	43.5	25.6	9.8	0.055	0.369	4.9	112	408

DISSOLVED LAB TOTAL BICARBONATE CARBONATE TOTAL TOTAL KJELDAHL

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22	381225	17SEP91	4	.	.	657	243	297	0	0.417	1.58
23	381225	17SEP91	8	.	.	658	243	297	0	0.440	1.50
24	381225	23FEB92	0	0.2	3.0	.	.	.	.	.	.
25	381225	23FEB92	1	0.2	3.0	790	289	353	0	0.530	2.42
26	381225	23FEB92	2	2.0	2.3	.	.	.	.	.	.
27	381225	23FEB92	3	2.5	1.4	.	.	.	.	.	.
28	381225	23FEB92	4	3.0	1.2	.	.	.	.	.	.
29	381225	23FEB92	5	3.0	1.1	775	290	354	0	0.647	2.45
30	381225	23FEB92	6	3.5	1.1	.	.	.	.	.	.
31	381225	23FEB92	7	4.0	1.1	.	.	.	.	.	.
32	381225	23FEB92	8	4.0	1.0	.	.	.	.	.	.
33	381225	23FEB92	9	4.8	1.0	873	347	424	0	4.370	6.74

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.029	0.583	.	330	63.0	41.9	24.8	9.2	0.047	0.355	4.8	111	401
23	0.032	0.583	.	338	64.9	42.8	25.7	9.2	0.039	0.360	4.7	110	404
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.033	0.486	0.430	375	72.1	47.4	29.5	10.3	0.057	1.020	6.8	156	496
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	0.007	0.532	0.469	377	71.8	48.1	29.7	10.3	0.138	1.440	6.7	149	490
30	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.
33	0.003	1.940	1.800	408	79.2	51.0	30.8	11.1	0.366	2.400	7.2	157	545

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380540	16JUL91	0.0	24.0	9.2	1199	243	272	12	0.010	1.33
2	380540	16JUL91	1.0	23.8	9.4	.	.	.	.	.	.
3	380540	16JUL91	2.0	23.2	9.3	.	.	.	.	.	.
4	380540	16JUL91	3.0	22.5	8.2	.	.	.	.	.	.
5	380540	16JUL91	4.0	22.0	7.5	.	.	.	.	.	.
6	380540	16JUL91	5.0	21.5	7.0	1195	241	276	9	0.007	1.33
7	380540	16JUL91	6.0	20.5	4.6	.	.	.	.	.	.
8	380540	16JUL91	7.0	19.0	2.0	.	.	.	.	.	.
9	380540	16JUL91	8.0	18.0	1.6	.	.	.	.	.	.
10	380540	16JUL91	9.0	17.3	1.6	.	.	.	.	.	.
11	380540	16JUL91	10.0	17.0	1.2	.	.	.	.	.	.
12	380540	16JUL91	11.0	16.0	1.8	1207	255	311	0	0.566	2.26
13	380540	16JUL91	11.5	15.5	2.0	.	.	.	.	.	.
14	380540	06AUG91	0.0	20.0	7.9	1155	253	270	19	0.160	2.19
15	380540	06AUG91	1.0	20.0	7.7	.	.	.	.	.	.
16	380540	06AUG91	2.0	20.0	7.7	.	.	.	.	.	.
17	380540	06AUG91	3.0	20.0	7.6	.	.	.	.	.	.
18	380540	06AUG91	4.0	20.0	7.5	.	.	.	.	.	.
19	380540	06AUG91	5.0	20.0	7.3	1160	253	274	17	0.162	1.65
20	380540	06AUG91	6.0	20.0	7.3	.	.	.	.	.	.
21	380540	06AUG91	7.0	20.0	7.3	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.004	0.067	0.036	273	36.6	44.2	120	8.8	0.060	0.022	6.1	385	747
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.004	0.077	0.052	310	40.7	50.5	140	10.9	0.084	0.037	5.9	378	771
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.004	0.224	0.156	314	41.4	51.2	141	10.6	0.511	0.982	6.0	386	789
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.032	0.118	0.074	330	46.9	51.7	137	10.8	0.243	0.143	7.3	396	802
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	0.014	0.101	0.076	324	43.2	52.6	139	10.4	0.110	0.151	7.0	377	781
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.

DISSOLVED LAB TOTAL BICARBONATE CARBONATE TOTAL TOTAL KJELDAHL

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	OXYGEN (mg/L)	CONDUCTIVITY (umhos/cm)	ALKALINITY (mg/L)	ALKALINITY (mg/L)	ALKALINITY (mg/L)	AMMONIA AS N (mg/L)	NITROGEN AS N (mg/L)
22	380540	06AUG91	8.0	20.0	7.0	.	.	.	.	.	.
23	380540	06AUG91	9.0	19.0	1.8	.	.	.	.	.	.
24	380540	06AUG91	10.0	16.0	1.0	.	.	.	.	.	.
25	380540	06AUG91	11.0	15.0	0.8	1156	284	347	0	1.810	4.35
26	380540	22JAN92	0.0	0.0	14.0	.	.	.	.	.	.
27	380540	22JAN92	1.0	3.0	12.0	1350	311	374	3	0.132	1.15
28	380540	22JAN92	2.0	3.0	11.2	.	.	.	.	.	.
29	380540	22JAN92	3.0	3.0	11.2	.	.	.	.	.	.
30	380540	22JAN92	4.0	3.0	11.2	.	.	.	.	.	.
31	380540	22JAN92	5.0	3.2	10.8	.	.	.	.	.	.
32	380540	22JAN92	6.0	3.5	9.0	1360	314	383	0	0.096	1.49
33	380540	22JAN92	7.0	4.0	5.6	.	.	.	.	.	.
34	380540	22JAN92	8.0	4.0	2.8	.	.	.	.	.	.
35	380540	22JAN92	9.0	4.5	2.1	.	.	.	.	.	.
36	380540	22JAN92	10.0	4.5	1.8	.	.	.	.	.	.
37	380540	22JAN92	11.0	4.9	1.7	1630	400	488	0	0.604	1.32

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.005	0.563	0.506	305	41.3	49.0	129	9.0	0.565	1.600	7.3	350	757
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	0.208	0.057	0.040	409	58.6	63.9	163	11.9	0.042	0.045	6.6	426	917
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.
32	0.172	0.058	0.049	408	58.8	63.4	159	12.0	0.050	0.104	7.0	438	927
33	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.
37	0.059	0.103	0.049	534	82.9	79.5	179	11.4	0.691	0.845	8.3	550	1150

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381010	29JUL91	0	22.5	10.3	450	194	211	13	0.011	3.17
2	381010	29JUL91	1	22.5	10.5	.	.	.	.	.	.
3	381010	29JUL91	2	22.5	9.2	.	.	.	.	.	.
4	381010	29JUL91	3	22.0	7.5	.	.	.	.	.	.
5	381010	29JUL91	4	22.0	5.8	456	194	217	10	0.132	2.19
6	381010	29JUL91	5	21.8	4.0	.	.	.	.	.	.
7	381010	29JUL91	6	21.5	3.2	.	.	.	.	.	.
8	381010	29JUL91	7	21.0	1.0	.	.	.	.	.	.
9	381010	29JUL91	8	17.5	0.6	.	.	.	.	.	.
10	381010	29JUL91	9	15.0	0.6	494	219	268	0	1.750	3.95
11	381010	26AUG91	0	27.0	12.0	457	191	180	26	0.012	2.63
12	381010	26AUG91	1	24.0	12.4	.	.	.	.	.	.
13	381010	26AUG91	2	23.0	6.6	.	.	.	.	.	.
14	381010	26AUG91	3	22.5	6.1	.	.	.	.	.	.
15	381010	26AUG91	4	22.0	5.2	468	191	197	18	0.069	1.78
16	381010	26AUG91	5	22.0	4.0	.	.	.	.	.	.
17	381010	26AUG91	6	21.5	2.9	.	.	.	.	.	.
18	381010	26AUG91	7	20.5	0.8	.	.	.	.	.	.
19	381010	26AUG91	8	18.5	0.6	.	.	.	.	.	.
20	381010	26AUG91	9	17.0	0.4	557	242	295	0	4.890	5.94
21	381010	13FEB92	0	1.5	9.1	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.007	0.212	0.120	219	41.3	28.1	16.5	8.5	0.082	0.290	3.1	51	265
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.018	0.163	0.158	.	.	.	.	.	.	.	2.8	56	283
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.011	0.631	0.613	240	46.8	29.9	17.0	9.0	0.099	1.490	3.1	49	287
11	0.000	0.185	0.127	220	39.3	29.6	17.0	8.0	0.073	0.138	2.8	50	261
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.004	0.149	0.115	216	38.5	29.2	17.1	8.0	0.095	0.202	2.7	46	257
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.003	1.230	1.230	253	50.2	30.9	17.7	8.9	0.196	4.090	3.0	50	306
21	.	.	.	.	.	.	.	.	.	.	.	.	.

DISSOLVED LAB TOTAL BICARBONATE CARBONATE TOTAL TOTAL KJELDAHL

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	OXYGEN (mg/L)	CONDUCTIVITY (umhos/cm)	ALKALINITY (mg/L)	ALKALINITY (mg/L)	ALKALINITY (mg/L)	AMMONIA AS N (mg/L)	NITROGEN AS N (mg/L)
22	381010	13FEB92	1	3.0	9.4	594	253	309	0	0.220	1.47
23	381010	13FEB92	2	3.2	9.2	.	.	.	.	.	.
24	381010	13FEB92	3	3.5	9.1	.	.	.	.	.	.
25	381010	13FEB92	4	3.8	7.2	597	248	303	0	0.192	1.41
26	381010	13FEB92	5	4.0	3.4	.	.	.	.	.	.
27	381010	13FEB92	6	4.0	3.0	.	.	.	.	.	.
28	381010	13FEB92	7	4.5	1.0	.	.	.	.	.	.
29	381010	13FEB92	8	4.9	1.0	761	323	394	0	1.300	2.24

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.272	0.106	0.102	277	53.0	35.1	21.5	8.3	0.036	0.280	3.8	75	349
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.377	0.107	0.093	287	54.4	36.7	22.0	8.6	0.074	0.410	3.8	71	346
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	0.046	0.277	0.248	369	84.6	38.2	24.5	8.5	0.173	2.360	4.2	106	460

BRUSH LAKE

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380560	08JUL91	0.0	22.2	9.6	1295	495	462	70	0.037	2.03
2	380560	08JUL91	1.0	22.2	9.8	.	.	.	.	.	.
3	380560	08JUL91	2.0	21.5	9.2	.	.	.	.	.	.
4	380560	08JUL91	3.0	21.0	9.0	1304	493	457	71	0.015	1.86
5	380560	08JUL91	4.0	21.0	8.0	.	.	.	.	.	.
6	380560	08JUL91	5.0	21.0	7.6	.	.	.	.	.	.
7	380560	08JUL91	5.5	20.8	5.2	.	.	.	.	.	.
8	380560	08JUL91	6.0	.	.	1325	495	468	67	0.026	1.78
9	380560	01AUG91	0.0	21.5	9.1	1342	499	443	82	0.031	3.08
10	380560	01AUG91	1.0	22.0	8.8	.	.	.	.	.	.
11	380560	01AUG91	2.0	21.8	8.9	.	.	.	.	.	.
12	380560	01AUG91	3.0	21.8	8.9	1322	499	442	82	0.026	2.89
13	380560	01AUG91	4.0	21.8	8.9	.	.	.	.	.	.
14	380560	01AUG91	5.0	21.8	7.8	.	.	.	.	.	.
15	380560	01AUG91	6.0	21.0	1.6	1323	498	447	79	0.023	2.77
16	380560	28JAN92	0.0	0.0	12.2	.	.	.	.	.	.
17	380560	28JAN92	1.0	2.0	12.2	1540	624	593	83	0.076	3.11
18	380560	28JAN92	2.0	2.0	11.9	.	.	.	.	.	.
19	380560	28JAN92	3.0	2.5	11.0	1548	613	584	81	0.109	1.97
20	380560	28JAN92	4.0	3.0	5.6	.	.	.	.	.	.
21	380560	28JAN92	5.0	3.0	1.3	1567	628	622	71	0.210	3.61

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.051	0.070	0.068	353	13.8	77.4	124	23.7	0.028	0.024	13.7	217	767
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.006	0.086	0.056	351	13.8	76.9	119	23.4	0.036	0.027	13.6	212	755
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.003	0.076	0.031	361	14.7	78.8	124	24.3	0.116	0.026	13.7	214	767
9	0.005	0.098	0.028	392	14.4	86.4	139	26.3	0.042	0.038	14.6	222	803
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.006	0.094	0.030	393	14.4	86.8	139	26.0	0.054	0.040	14.1	228	808
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.003	0.087	0.016	401	14.6	88.5	142	26.5	0.040	0.040	14.1	224	809
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	0.000	0.058	0.025	488	17.3	108.0	172	30.9	0.021	0.016	17.7	284	1010
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	0.000	0.054	0.026	485	17.7	107.0	176	31.0	0.020	0.017	17.4	295	1010
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	0.064	0.063	0.022	505	19.1	111.0	184	31.8	0.027	0.041	17.4	296	1040

CEDAR LAKE

DISSOLVED LAB TOTAL BICARBONATE CARBONATE TOTAL TOTAL KJELDAHL

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	OXYGEN (mg/L)	CONDUCTIVITY (umhos/cm)	ALKALINITY (mg/L)	ALKALINITY (mg/L)	ALKALINITY (mg/L)	AMMONIA AS N (mg/L)	NITROGEN AS N (mg/L)
1	380687	15JUL91	0.0	25.1	9.5	2220	280	301	20	0.070	1.91
2	380687	15JUL91	1.0	25.0	9.9	.	.	.	.	.	.
3	380687	15JUL91	2.0	22.5	8.7	2240	280	301	20	0.076	2.18
4	380687	15JUL91	3.0	22.1	7.7	.	.	.	.	.	.
5	380687	15JUL91	4.0	21.6	3.6	2260	284	312	17	0.104	2.20
6	380687	05AUG91	0.0	20.6	9.7	.	.	.	.	.	.
7	380687	05AUG91	1.0	20.0	9.8	2400	304	279	45	0.024	2.36
8	380687	05AUG91	2.0	20.0	9.6	.	.	.	.	.	.
9	380687	05AUG91	3.0	19.0	6.8	.	.	.	.	.	.
10	380687	05AUG91	4.0	19.0	3.0	.	.	.	.	.	.
11	380687	05AUG91	4.5	19.0	1.4	2410	304	280	45	0.043	2.76
12	380687	27JAN92	0.0	0.0	0.0	.	.	.	.	.	.
13	380687	27JAN92	1.0	2.0	11.2	3560	492	503	48	0.093	7.72
14	380687	27JAN92	2.0	3.0	2.0	3560	497	607	0	0.149	3.51

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.035	0.318	0.303	453	60.9	73.1	332	14.2	0.146	0.077	12.6	883	1540
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	0.031	0.330	0.310	455	61.7	73.2	335	13.5	0.263	0.86	12.1	867	1530
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.030	0.366	0.349	450	60.6	72.6	327	14.0	0.336	0.126	12.2	900	1560
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.003	0.194	0.099	457	62.3	73.2	344	15.2	0.318	0.079	14.8	942	1630
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.004	0.200	0.091	495	68.9	78.5	347	16.1	0.890	0.085	15.5	925	1630
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.020	0.586	0.135	741	92.1	124	579	21.4	0.184	0.216	23.1	1430	2570
14	0.045	0.365	0.201	702	86.4	118	539	19.8	0.206	0.322	22.7	1470	2550

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380691	23JUL91	0.0	24.0	8.0	957	278	309	15	0.038	1.57
2	380691	23JUL91	1.0	24.0	7.9	.	.	.	.	.	.
3	380691	23JUL91	2.0	24.0	7.8	.	.	.	.	.	.
4	380691	23JUL91	3.0	24.0	7.3	.	.	.	.	.	.
5	380691	23JUL91	4.0	23.5	7.2	957	280	315	13	0.048	0.98
6	380691	23JUL91	5.0	21.0	2.2	.	.	.	.	.	.
7	380691	23JUL91	6.0	18.5	0.8	.	.	.	.	.	.
8	380691	23JUL91	7.0	15.0	1.8	.	.	.	.	.	.
9	380691	23JUL91	8.0	12.0	1.8	940	307	375	0	1.110	2.23
10	380691	12AUG91	0.0	.	.	950	279	300	20	0.006	1.12
11	380691	12AUG91	4.0	.	.	957	277	326	6	0.050	1.12
12	380691	12AUG91	8.0	.	.	963	307	375	0	1.390	3.23
13	380691	21AUG91	0.0	23.5	11.2	.	.	.	.	.	.
14	380691	21AUG91	1.0	22.5	10.4	.	.	.	.	.	.
15	380691	21AUG91	2.0	22.0	8.4	.	.	.	.	.	.
16	380691	21AUG91	3.0	21.0	6.0	.	.	.	.	.	.
17	380691	21AUG91	4.0	21.0	5.4	.	.	.	.	.	.
18	380691	21AUG91	5.0	20.0	4.7	.	.	.	.	.	.
19	380691	21AUG91	6.0	19.5	2.8	.	.	.	.	.	.
20	380691	21AUG91	7.0	15.0	1.0	.	.	.	.	.	.
21	380691	21AUG91	8.0	12.0	0.8	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.013	0.172	0.157	250	54.1	27.8	84.1	8.3	0.024	0.197	55.4	136	533
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.013	0.151	0.152	229	50.1	25.2	76.8	8.0	0.034	0.199	55.8	120	504
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.005	0.773	0.779	259	59.5	26.7	74.1	8.6	0.161	5.270	51.3	116	521
10	0.004	0.173	0.172	303	66.0	33.5	96.6	8.1	0.127	0.131	57.6	156	586
11	0.014	0.190	0.189	295	64.8	32.2	95.6	8.0	0.040	0.182	56.9	155	579
12	0.020	0.991	0.916	287	66.0	29.6	78.2	7.8	0.116	9.330	54.9	136	557
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.

DISSOLVED LAB TOTAL BICARBONATE CARBONATE TOTAL TOTAL KJELDAHL

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	OXYGEN (mg/L)	CONDUCTIVITY (umhos/cm)	ALKALINITY (mg/L)	ALKALINITY (mg/L)	ALKALINITY (mg/L)	AMMONIA AS N (mg/L)	NITROGEN AS N (mg/L)
22	380691	21AUG91	8.5	11.0	0.8	.	.	.	.	.	.
23	380691	12FEB92	0.0	1.0	14.2	.	.	.	.	.	.
24	380691	12FEB92	1.0	3.0	13.3	917	292	357	0	0.080	1.01
25	380691	12FEB92	2.0	3.2	12.6	.	.	.	.	.	.
26	380691	12FEB92	3.0	3.0	12.0	.	.	.	.	.	.
27	380691	12FEB92	4.0	3.0	11.7	1050	320	389	1	0.051	0.90
28	380691	12FEB92	5.0	3.0	8.6	.	.	.	.	.	.
29	380691	12FEB92	6.0	3.2	5.5	.	.	.	.	.	.
30	380691	12FEB92	7.0	3.8	1.8	.	.	.	.	.	.
31	380691	12FEB92	8.0	4.0	1.5	1100	338	413	0	0.398	1.04

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	0.281	0.074	0.071	317	73.3	32.5	78.5	7.5	0.053	0.323	38.2	151	557
25	.	.	.	.	.	.	.	.	.	.	.	.	.
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	0.107	0.065	0.066	344	76.8	36.9	102.0	9.2	0.027	0.347	52.7	179	649
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.
31	0.225	0.356	0.342	377	86.1	39.4	98.9	8.0	0.105	3.980	49.5	182	667

CROOKED LAKE

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381030	09JUL91	0.00000	22.0	9.8	1881	827	566	218	0.005	3.39
2	381030	09JUL91	1.00000	21.5	10.2	1865	825	570	215	0.026	3.72
3	381030	09JUL91	2.00000	21.2	9.9	.	.	.	.	.	.
4	381030	09JUL91	3.00000	20.6	7.5	1877	825	570	215	0.018	3.78
5	381030	09JUL91	3.10000	20.5	4.1	.	.	.	.	.	.
6	381030	08AUG91	0.00000	19.5	8.6	1819	850	480	274	0.001	4.12
7	381030	08AUG91	1.00000	19.5	8.7	1802	848	470	278	0.000	4.26
8	381030	08AUG91	2.00000	19.5	8.7	.	.	.	.	.	.
9	381030	08AUG91	3.00000	19.5	8.6	1801	847	467	279	0.042	4.39
10	381030	31JAN92	0.00000	0.0	3.2	.	.	.	.	.	.
11	381030	31JAN92	1.00000	1.0	2.6	2410	1190	661	388	0.178	6.14
12	381030	31JAN92	2.00000	2.0	1.7	.	.	.	.	.	.
13	381030	31JAN92	3.00000	4.0	0.8	2440	1210	724	369	0.452	5.94

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.004	0.105	0.038	699	8.0	165	157	35.5	0.035	0.006	25.1	336	1220
2	0.006	0.107	0.052	732	8.2	173	162	36.4	0.042	0.009	24.8	330	1230
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.004	0.108	0.046	703	7.9	166	156	35.2	0.026	0.007	24.6	330	1220
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.003	0.093	0.035	782	6.5	186	181	40.3	0.027	0.006	28.5	375	1330
7	0.005	0.093	0.041	763	7.4	181	174	38.1	0.062	0.008	28.3	364	1300
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.003	0.104	0.029	748	6.1	178	170	37.0	0.017	0.006	28.4	359	1290
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.030	0.082	0.042	1050	8.4	249	261	51.8	0.056	0.009	37.1	597	1920
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.000	0.098	0.049	1150	8.2	274	257	50.8	0.043	0.011	37.6	630	1980

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380715	16JUL91	0	23.0	10.7	1113	329	274	63	0.005	2.51
2	380715	16JUL91	1	22.8	10.3	.	.	.	.	.	.
3	380715	16JUL91	2	22.1	7.9	.	.	.	.	.	.
4	380715	16JUL91	3	21.6	5.6	1132	331	290	56	0.175	1.95
5	380715	16JUL91	4	21.1	4.2	.	.	.	.	.	.
6	380715	16JUL91	5	21.0	3.3	.	.	.	.	.	.
7	380715	16JUL91	6	20.5	1.2	.	.	.	.	.	.
8	380715	16JUL91	7	20.0	1.5	1150	339	328	42	0.569	2.95
9	380715	06AUG91	0	20.0	5.9	1090	333	288	58	0.662	3.52
10	380715	06AUG91	1	20.0	5.6	.	.	.	.	.	.
11	380715	06AUG91	2	20.0	5.5	.	.	.	.	.	.
12	380715	06AUG91	3	20.0	5.5	1080	333	289	58	0.711	3.32
13	380715	06AUG91	4	20.0	5.4	.	.	.	.	.	.
14	380715	06AUG91	5	19.8	5.2	.	.	.	.	.	.
15	380715	06AUG91	6	19.7	4.8	.	.	.	.	.	.
16	380715	06AUG91	7	19.6	1.1	1081	333	282	61	0.689	3.31
17	380715	22JAN92	0	1.5	8.8	.	.	.	.	.	.
18	380715	22JAN92	1	3.2	7.5	1340	374	383	36	0.329	2.59
19	380715	22JAN92	2	3.5	7.0	.	.	.	.	.	.
20	380715	22JAN92	3	3.5	6.6	1310	375	358	49	0.311	2.11
21	380715	22JAN92	4	3.5	6.6	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.003	0.615	0.570	354	54.7	52.8	100.0	13.1	0.054	0.064	10.0	316	745
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.007	0.633	0.630	349	53.9	52.1	98.9	12.6	0.105	0.101	9.8	309	735
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.004	0.884	0.816	335	51.7	50.0	93.7	12.4	0.067	0.293	9.4	299	720
9	0.009	0.805	0.728	405	65.4	58.6	106.0	15.2	0.206	0.222	11.7	288	745
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.063	0.774	0.732	426	70.2	60.8	114.0	16.1	0.469	0.240	11.9	286	759
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.009	0.770	0.721	433	69.3	63.2	118.0	16.5	0.249	0.252	12.0	291	770
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.026	0.679	0.649	463	66.7	72.1	138.0	15.4	0.066	0.230	11.2	368	896
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.081	0.647	0.620	470	68.1	72.9	138.0	15.3	0.071	0.228	11.7	372	903
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380715	22JAN92	5	3.2	6.5	.	.	.	.	.	.
23	380715	22JAN92	6	3.7	7.0	1330	377	383	38	0.210	1.86

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.028	0.558	0.506	463	66.5	72.2	139.0	15.8	0.209	0.157	11.7	379	911

1991-1992 Water Quality Data
GREEN LAKE

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381045	31JAN91	1.00000	.	.	3130	835	1020	0	0.029	5.02
2	381045	25JUL91	0.00000	20.0	9.8	1380	400	257	114	0.016	4.58
3	381045	25JUL91	1.00000	20.5	9.8	1370	398	254	114	0.021	4.20
4	381045	25JUL91	2.00000	20.5	8.5	1380	400	256	114	0.039	4.60
5	381045	14AUG91	0.00000	20.5	8.4	1314	346	184	117	0.033	3.86
6	381045	14AUG91	1.00000	21.8	7.8	1308	346	188	115	0.025	4.38
7	381045	14AUG91	2.00000	20.5	2.7	1309	344	186	115	0.018	4.12
8	381045	11FEB92	0.00000	-0.5	15.0	2490	654	734	32	1.490	8.50
9	381045	11FEB92	1.00000	1.0	1.9	2630	658	803	0	1.510	6.20
10	381045	11FEB92	1.30000	1.0	1.9	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.014	0.787	.	697	68.1	128.0	460	81.9	0.335	0.346	49.6	733	2020
2	0.006	0.603	0.261	251	22.8	47.1	169	33.2	0.204	0.159	23.5	315	851
3	0.003	0.618	0.250	330	30.7	61.5	220	45.1	0.238	0.214	23.2	318	938
4	0.005	0.610	0.207	287	27.9	52.7	199	40.3	0.201	0.205	23.4	310	893
5	0.013	0.489	0.075	272	23.2	52.0	237	44.1	0.283	0.133	24.6	340	929
6	0.008	0.485	0.065	247	21.2	47.2	212	39.0	0.198	0.124	24.4	332	883
7	0.012	0.524	0.071	248	21.1	47.4	215	40.2	0.167	0.120	24.4	334	889
8	0.048	1.130	0.617	435	45.1	78.4	385	55.4	0.416	0.131	49.3	695	1700
9	0.338	1.200	0.562	467	47.4	84.6	408	59.3	0.463	0.233	48.0	707	1750
10	.	.	.	.	.	.	.	.	.	.	.	.	.

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OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381050	09JUL91	0.0	21.2	8.3	.	.	.	.	.	.
2	381050	09JUL91	1.0	21.2	8.2	1878	734	733	80	0.005	1.38
3	381050	09JUL91	2.0	21.1	8.0	.	.	.	.	.	.
4	381050	09JUL91	3.0	20.8	7.0	1901	734	729	82	0.020	1.45
5	381050	09JUL91	4.0	20.3	6.1	.	.	.	.	.	.
6	381050	09JUL91	5.0	19.4	2.6	.	.	.	.	.	.
7	381050	09JUL91	6.0	19.0	1.5	1909	735	765	65	0.499	2.01
8	381050	09JUL91	6.5	18.6	1.4	.	.	.	.	.	.
9	381050	08AUG91	0.0	20.5	7.3	1829	742	717	93	0.086	1.59
10	381050	08AUG91	1.0	20.0	7.1	.	.	.	.	.	.
11	381050	08AUG91	2.0	20.0	6.6	.	.	.	.	.	.
12	381050	08AUG91	3.0	19.8	6.6	1807	743	718	93	0.102	2.28
13	381050	08AUG91	4.0	19.8	5.6	.	.	.	.	.	.
14	381050	08AUG91	5.0	19.8	3.8	.	.	.	.	.	.
15	381050	08AUG91	6.0	19.6	3.0	1802	744	727	89	0.210	2.41
16	381050	08AUG91	6.5	19.4	1.0	.	.	.	.	.	.
17	381050	28JAN92	0.0	0.0	2.2	.	.	.	.	.	.
18	381050	28JAN92	1.0	2.0	2.0	2220	891	951	67	0.439	2.18
19	381050	28JAN92	2.0	2.0	1.8	.	.	.	.	.	.
20	381050	28JAN92	3.0	2.5	1.6	2220	889	978	53	0.426	2.11
21	381050	28JAN92	4.0	2.5	1.3	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.012	0.831	0.750	197	30.5	29.3	384	10.6	0.261	0.032	27.0	259	1180
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.014	0.858	0.745	188	29.6	27.6	365	10.0	0.263	0.034	26.9	261	1160
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.013	1.070	0.952	190	30.3	27.8	375	10.5	0.359	0.144	26.9	264	1180
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.024	0.839	0.760	189	29.7	28.0	404	10.8	0.306	0.030	29.9	270	1220
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.023	0.813	0.760	181	29.2	26.2	359	10.2	0.175	0.026	29.9	264	1170
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.023	0.836	0.822	196	30.9	28.9	396	10.9	0.271	0.056	29.9	261	1200
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.229	1.000	0.969	203	30.8	30.6	460	11.5	0.314	0.046	35.0	356	1460
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.235	0.992	0.972	197	30.0	29.7	449	11.2	0.452	0.047	35.7	366	1460
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381050	28JAN92	5.0	3.0	1.0	.	.	.	.	.	.
23	381050	28JAN92	6.0	3.0	1.0	2250	896	964	64	0.518	2.62

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.189	1.070	0.999	200	30.7	30.0	450	10.9	0.335	0.085	34.8	353	1450

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380765	15JUL91	0.00000	23.5	10.3	2280	399	335	75	0.044	2.74
2	380765	15JUL91	1.00000	22.7	10.0	.	.	.	.	.	.
3	380765	15JUL91	2.00000	22.3	9.8	.	.	.	.	.	.
4	380765	15JUL91	3.00000	22.2	9.4	2830	398	338	73	0.029	3.16
5	380765	15JUL91	4.00000	22.0	8.8	.	.	.	.	.	.
6	380765	15JUL91	5.00000	21.5	7.7	.	.	.	.	.	.
7	380765	15JUL91	6.00000	21.2	5.1	2820	400	376	55	0.078	2.33
8	380765	15JUL91	6.90000	21.0	1.4	.	.	.	.	.	.
9	380765	06AUG91	0.00000	21.0	10.2	.	.	.	.	.	.
10	380765	06AUG91	1.00000	21.0	10.4	3070	396	309	86	0.020	2.80
11	380765	06AUG91	2.00000	21.0	10.5	.	.	.	.	.	.
12	380765	06AUG91	3.00000	20.5	10.0	3070	395	314	83	0.014	2.59
13	380765	06AUG91	4.00000	20.5	9.8	.	.	.	.	.	.
14	380765	06AUG91	5.00000	20.5	9.6	.	.	.	.	.	.
15	380765	06AUG91	6.00000	20.0	5.2	3060	396	319	81	0.048	2.57
16	380765	06AUG91	6.20000	20.0	4.4	.	.	.	.	.	.
17	380765	27JAN92	0.00000	1.5	13.0	.	.	.	.	.	.
18	380765	27JAN92	1.00000	3.0	12.6	3620	466	520	24	0.067	3.24
19	380765	27JAN92	2.00000	3.0	2.8	.	.	.	.	.	.
20	380765	27JAN92	3.00000	3.0	2.8	3710	470	574	0	0.064	2.68
21	380765	27JAN92	4.00000	3.0	1.8	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.001	0.170	0.119	485	44.8	90.6	517	20.2	0.195	0.064	22.3	1050	1980
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.002	0.172	0.118	372	35.2	68.9	406	15.2	0.110	0.068	21.6	1000	1790
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.004	0.228	0.147	420	40.3	77.7	446	17.6	0.371	0.256	21.5	1000	1840
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.004	0.274	0.171	491	42.8	93.4	523	20.5	0.314	0.098	25.4	1050	1990
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.004	0.267	0.162	483	41.8	91.9	517	20.2	0.236	0.091	25.6	1080	2010
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.011	0.259	0.162	478	41.6	90.9	534	20.6	0.213	0.105	25.6	1030	1980
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.145	0.129	0.041	560	52.9	104.0	608	20.8	0.102	0.202	29.4	1500	2600
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.042	0.131	0.058	558	53.6	103.0	607	20.5	0.171	0.301	30.3	1480	2580
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380765	27JAN92	5.00000	3.0	0.6	3690	477	582	0	0.090	2.47
23	380765	27JAN92	5.60000	3.0	0.4	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.033	0.167	0.163	552	53.0	102.0	603	20.4	0.036	0.011	30.3	1490	2590
23	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380790	24JUL91	0	22.1	8.9	527	212	175	41	0.040	2.68
2	380790	24JUL91	1	22.0	8.9	.	.	.	.	.	.
3	380790	24JUL91	2	22.0	8.9	.	.	.	.	.	.
4	380790	24JUL91	3	22.0	8.9	.	.	.	.	.	.
5	380790	24JUL91	4	21.8	4.8	547	212	194	32	0.045	2.16
6	380790	24JUL91	5	19.0	0.6	.	.	.	.	.	.
7	380790	24JUL91	6	17.1	0.3	.	.	.	.	.	.
8	380790	24JUL91	7	14.7	0.9	.	.	.	.	.	.
9	380790	24JUL91	8	14.0	1.2	659	310	378	0	3.740	5.12
10	380790	13AUG91	0	22.0	10.6	522	210	157	49	0.042	2.16
11	380790	13AUG91	1	21.5	10.8	.	.	.	.	.	.
12	380790	13AUG91	2	21.5	10.6	.	.	.	.	.	.
13	380790	13AUG91	3	20.0	4.0	.	.	.	.	.	.
14	380790	13AUG91	4	19.0	0.9	532	211	194	31	0.266	1.46
15	380790	13AUG91	5	18.5	0.6	.	.	.	.	.	.
16	380790	13AUG91	6	16.0	0.6	.	.	.	.	.	.
17	380790	13AUG91	7	14.5	0.6	.	.	.	.	.	.
18	380790	13AUG91	8	13.5	0.6	609	291	355	0	3.470	4.64
19	380790	12FEB92	0	2.0	4.3	.	.	.	.	.	.
20	380790	12FEB92	1	4.0	1.4	604	230	281	0	0.877	2.81
21	380790	12FEB92	2	4.0	1.4	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.004	0.530	0.476	211	44.4	24.3	31.3	12.6	0.145	0.204	6.7	31	278
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.004	0.553	0.475	227	48.4	25.7	34.7	13.0	0.048	0.306	6.5	73	329
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.008	3.050	2.670	246	56.3	25.6	33.4	14.3	0.096	7.510	6.7	22	345
10	0.004	0.567	0.506	222	47.4	25.2	35.2	14.6	0.038	0.276	7.0	64	320
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.011	0.585	0.570	221	47.4	25.0	34.7	13.9	0.053	0.416	6.4	64	318
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.009	2.210	2.090	241	55.0	25.2	33.5	14.4	0.069	5.410	6.4	46	355
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.084	0.653	0.526	216	45.9	24.7	36.9	12.2	0.094	0.786	7.6	82	348
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380790	12FEB92	3	3.5	1.3	.	.	.	.	.	.
23	380790	12FEB92	4	3.5	1.2	668	257	304	5	0.826	2.66
24	380790	12FEB92	5	3.5	1.2	.	.	.	.	.	.
25	380790	12FEB92	6	3.5	1.0	.	.	.	.	.	.
26	380790	12FEB92	7	4.0	1.0	680	268	327	0	1.140	3.14
27	380790	12FEB92	8	4.2	1.0	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.018	0.678	0.569	247	52.7	27.9	41.9	14.3	0.139	0.890	8.5	93	393
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	.	.	.	.	.	.	.	.	.	.	.	.	.
26	0.004	0.839	0.725	251	53.6	28.5	42.0	14.6	0.156	1.090	8.6	90	398
27	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380760	24JUL91	0.00000	22.0	8.5	1316	412	405	48	0.051	2.28
2	380760	24JUL91	1.00000	22.0	8.2	1316	411	404	48	0.053	2.54
3	380760	24JUL91	2.00000	22.0	5.4	1320	412	405	48	0.043	2.59
4	380760	24JUL91	0.00000	22.0	9.3	1360	423	402	56	0.034	2.99
5	380760	24JUL91	1.00000	22.0	9.3	1360	423	403	56	0.016	2.23
6	380760	24JUL91	2.20000	22.0	8.0	1343	423	405	55	0.018	2.04
7	380760	24AUG91	0.00000	0.0	8.6	2060	600	710	11	0.075	2.18
8	380760	24AUG91	1.00000	3.0	8.8	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.005	1.70	1.38	393	70.9	52.4	146	44.0	1.860	1.380	38.3	268	867
2	.008	1.78	1.25	430	78.4	56.8	166	50.6	2.260	1.480	38.2	256	893
3	.010	1.77	1.36	432	78.1	57.5	164	50.0	2.070	1.530	38.3	266	901
4	.005	1.49	1.45	388	70.7	51.3	153	44.3	0.901	0.987	39.9	301	914
5	.006	1.49	1.32	367	67.2	48.4	148	42.5	0.929	0.959	39.5	299	899
6	.008	1.52	1.34	362	66.1	47.7	144	40.5	0.872	0.942	40.2	292	885
7	.017	1.87	1.83	538	99.5	70.2	235	55.9	0.181	0.133	60.2	486	1370
8	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380795	23JUL91	0	25.0	11.2	500	182	178	22	0.034	2.48
2	380795	23JUL91	1	25.0	11.2	.	.	.	.	.	.
3	380795	23JUL91	2	24.8	10.6	.	.	.	.	.	.
4	380795	23JUL91	3	24.8	10.5	.	.	.	.	.	.
5	380795	23JUL91	4	24.5	9.2	.	.	.	.	.	.
6	380795	23JUL91	5	24.0	8.6	496	182	185	18	0.038	1.53
7	380795	23JUL91	6	24.0	8.4	.	.	.	.	.	.
8	380795	23JUL91	7	23.0	3.0	.	.	.	.	.	.
9	380795	23JUL91	8	22.5	2.2	.	.	.	.	.	.
10	380795	23JUL91	9	21.5	1.2	.	.	.	.	.	.
11	380795	23JUL91	10	21.0	1.2	531	199	243	0	0.703	2.57
12	380795	23JUL91	10	21.0	1.2	531	199	243	0	0.703	2.57
13	380795	12AUG91	0	23.0	10.4	490	178	179	19	0.255	1.04
14	380795	12AUG91	1	22.7	10.2	.	.	.	.	.	.
15	380795	12AUG91	2	22.0	8.6	.	.	.	.	.	.
16	380795	12AUG91	3	21.5	6.4	.	.	.	.	.	.
17	380795	12AUG91	4	21.3	5.0	.	.	.	.	.	.
18	380795	12AUG91	5	21.0	4.4	491	177	206	5	0.114	1.10
19	380795	12AUG91	6	21.0	4.0	.	.	.	.	.	.
20	380795	12AUG91	7	20.8	1.9	.	.	.	.	.	.
21	380795	12AUG91	8	20.5	0.9	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.004	0.131	0.061	202	38.2	26.0	23.7	15.9	0.098	0.052	18.8	63	295
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.007	0.101	0.087	202	38.5	25.8	23.2	15.9	0.111	0.060	18.8	57	288
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.006	0.516	0.504	218	41.9	27.4	24.6	17.0	0.189	1.470	18.8	55	304
12	0.006	0.516	0.504	218	41.9	27.4	24.6	17.0	0.189	1.470	18.8	55	304
13	0.005	0.089	0.069	208	39.1	26.7	23.0	15.8	0.105	0.034	19.0	57	288
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.020	0.093	0.093	197	37.6	25.0	22.0	14.9	0.112	0.047	18.5	55	279
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380795	12AUG91	9	20.3	0.4	.	.	.	.	.	.
23	380795	12AUG91	10	20.3	0.4	515	188	229	0	0.604	1.82
24	380795	12FEB92	0	2.0	7.6	.	.	.	.	.	.
25	380795	12FEB92	1	3.5	7.3	606	208	254	0	0.281	1.61
26	380795	12FEB92	2	3.5	6.9	.	.	.	.	.	.
27	380795	12FEB92	3	3.8	6.4	.	.	.	.	.	.
28	380795	12FEB92	4	4.0	5.7	.	.	.	.	.	.
29	380795	12FEB92	5	4.0	5.1	616	211	258	0	0.430	1.54
30	380795	12FEB92	6	4.0	4.8	.	.	.	.	.	.
31	380795	12FEB92	7	4.0	4.7	.	.	.	.	.	.
32	380795	12FEB92	8	4.0	4.6	.	.	.	.	.	.
33	380795	12FEB92	9	4.0	4.6	606	211	258	0	0.477	1.82
34	380795	12FEB92	10	4.0	3.4	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.010	0.220	0.173	196	37.1	25.2	21.2	14.3	0.278	0.693	18.5	53	282
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.388	0.096	0.093	242	45.7	31.0	28.3	15.9	0.031	0.302	21.2	75	342
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	0.410	0.122	0.111	237	45.4	30.1	28.2	15.7	0.056	0.503	21.0	76	343
30	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.
33	0.412	0.138	0.124	238	45.2	30.4	27.8	14.9	0.089	0.541	21.8	70	337
34	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381335	09JUL91	0.00000	23.2	6.9	704	268	281	23	0.077	2.06
2	381335	09JUL91	1.00000	22.0	6.6	689	269	292	18	0.107	1.95
3	381335	09JUL91	2.00000	21.0	5.9	701	269	286	21	0.107	1.87
4	381335	09JUL91	2.20000	21.0	3.5	.	.	.	.	.	.
5	381335	01AUG91	0.00000	24.5	8.4	718	275	259	38	0.030	2.41
6	381335	01AUG91	1.00000	.	.	700	275	264	35	0.036	2.62
7	381335	01AUG91	2.00000	24.0	8.1	716	274	259	37	0.020	2.57
8	381335	31JAN92	0.00000	0.0	3.2	.	.	.	.	.	.
9	381335	31JAN92	1.00000	0.5	3.2	936	399	487	0	0.098	1.17
10	381335	31JAN92	2.00000	3.0	0.8	1020	426	467	26	0.615	3.86

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.008	0.091	0.048	276	26.5	50.9	34.8	7.9	0.068	0.047	7.7	101	390
2	0.009	0.125	0.045	280	27.3	51.4	36.0	7.9	0.086	0.055	7.6	104	396
3	0.005	0.102	0.055	278	26.8	51.3	34.5	7.7	0.066	0.052	7.7	102	392
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.005	0.089	0.039	288	27.5	53.3	40.6	9.6	0.010	0.034	8.8	87	392
6	0.006	0.089	0.044	306	26.9	58.0	39.9	9.6	0.071	0.036	8.4	105	413
7	0.003	0.088	0.040	292	26.4	54.9	38.3	8.8	0.030	0.033	8.1	89	390
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.097	0.101	0.024	421	74.9	56.8	41.1	6.6	1.210	0.990	10.3	130	560
10	0.006	0.090	0.034	458	42.2	85.6	61.8	13.1	0.180	0.177	13.4	177	649

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381270	30JUL91	0	22.0	7.8	778	207	240	6	0.000	1.09
2	381270	30JUL91	1	22.0	7.5	.	.	.	.	.	.
3	381270	30JUL91	2	22.0	7.4	.	.	.	.	.	.
4	381270	30JUL91	3	22.0	7.4	.	.	.	.	.	.
5	381270	30JUL91	4	22.0	6.4	.	.	.	.	.	.
6	381270	30JUL91	5	20.5	1.0	.	.	.	.	.	.
7	381270	30JUL91	6	16.5	0.8	818	218	266	0	0.014	1.41
8	381270	30JUL91	7	13.5	0.8	.	.	.	.	.	.
9	381270	30JUL91	8	11.0	0.8	.	.	.	.	.	.
10	381270	30JUL91	9	9.5	0.8	.	.	.	.	.	.
11	381270	30JUL91	10	8.5	0.7	.	.	.	.	.	.
12	381270	30JUL91	11	8.0	0.7	.	.	.	.	.	.
13	381270	30JUL91	12	7.0	0.7	845	235	287	0	0.806	2.71
14	381270	27AUG91	0	24.0	8.0	809	210	238	9	0.012	1.14
15	381270	27AUG91	1	23.5	7.7	.	.	.	.	.	.
16	381270	27AUG91	2	23.0	7.0	.	.	.	.	.	.
17	381270	27AUG91	3	22.5	7.0	.	.	.	.	.	.
18	381270	27AUG91	4	22.0	6.5	.	.	.	.	.	.
19	381270	27AUG91	5	20.0	0.5	.	.	.	.	.	.
20	381270	27AUG91	6	18.0	0.5	834	219	268	0	0.131	1.30
21	381270	27AUG91	7	15.0	0.4	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.006	0.279	0.264	305	69.9	31.7	67.8	11.1	0.041	0.106	17.6	196	518
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.006	0.444	0.437	297	67.7	31.0	67.4	11.1	0.051	2.970	19.0	211	538
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.003	0.951	0.933	331	76.1	34.1	73.6	11.7	0.188	4.620	23.0	226	586
14	0.007	0.280	0.278	298	68.2	31.0	68.3	10.9	0.059	0.140	17.9	174	497
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.017	0.409	0.409	300	68.7	31.1	68.0	10.6	0.076	2.210	18.2	180	509
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381270	27AUG91	8	11.5	0.4	.	.	.	.	.	.
23	381270	27AUG91	9	10.0	0.4	.	.	.	.	.	.
24	381270	27AUG91	10	9.0	0.4	.	.	.	.	.	.
25	381270	27AUG91	11	8.5	0.4	.	.	.	.	.	.
26	381270	27AUG91	12	8.5	0.4	926	249	304	0	0.997	2.89
27	381270	26FEB92	0	0.0	13.4	.	.	.	.	.	.
28	381270	26FEB92	1	1.0	13.3	931	259	279	18	0.037	1.53
29	381270	26FEB92	2	2.0	11.8	.	.	.	.	.	.
30	381270	26FEB92	3	2.0	11.6	.	.	.	.	.	.
31	381270	26FEB92	4	2.0	11.4	.	.	.	.	.	.
32	381270	26FEB92	5	2.5	6.5	.	.	.	.	.	.
33	381270	26FEB92	6	2.8	3.8	952	247	302	0	0.023	1.25
34	381270	26FEB92	7	3.0	2.8	.	.	.	.	.	.
35	381270	26FEB92	8	3.0	1.4	.	.	.	.	.	.
36	381270	26FEB92	9	3.0	1.0	.	.	.	.	.	.
37	381270	26FEB92	10	3.0	1.0	.	.	.	.	.	.
38	381270	26FEB92	11	3.5	0.9	1039	277	338	0	0.693	1.96
39	381270	26FEB92	12	4.0	0.9	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	.	.	.	.	.	.	.	.	.	.	.	.	.
26	0.004	1.000	1.020	328	73.6	35.0	75.7	11.1	0.094	5.230	20.9	206	572
27	.	.	.	.	.	.	.	.	.	.	.	.	.
28	0.000	0.255	0.244	357	82.1	36.8	74.9	10.7	0.041	1.140	21.8	188	570
29	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.
33	0.153	0.320	0.304	358	83.3	36.4	75.6	10.7	0.072	1.660	21.7	230	606
34	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.
38	0.000	0.813	0.762	393	92.2	39.6	83.9	11.4	0.199	3.190	24.0	257	675
39	.	.	.	.	.	.	.	.	.	.	.	.	.

1991-1992 Water Quality Data
MCGREGOR DAM

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380820	16JUL91	0.0	23.5	15.0	552	147	141	19	0.023	5.24
2	380820	16JUL91	1.0	23.5	15.0	.	.	.	.	.	.
3	380820	16JUL91	2.0	23.3	15.0	.	.	.	.	.	.
4	380820	16JUL91	3.0	21.8	8.8	.	.	.	.	.	.
5	380820	16JUL91	4.0	20.5	6.2	593	174	178	17	0.119	2.09
6	380820	16JUL91	5.0	20.0	4.0	.	.	.	.	.	.
7	380820	16JUL91	6.0	19.0	1.2	.	.	.	.	.	.
8	380820	16JUL91	7.0	18.5	1.2	.	.	.	.	.	.
9	380820	16JUL91	8.0	18.0	1.2	631	196	239	0	0.465	2.35
10	380820	06AUG91	0.0	19.3	8.1	550	152	129	28	0.029	3.96
11	380820	06AUG91	1.0	19.3	8.0	.	.	.	.	.	.
12	380820	06AUG91	2.0	19.3	8.0	.	.	.	.	.	.
13	380820	06AUG91	3.0	19.3	8.0	.	.	.	.	.	.
14	380820	06AUG91	4.0	19.3	7.3	549	151	136	24	0.022	3.95
15	380820	06AUG91	5.0	19.2	7.9	.	.	.	.	.	.
16	380820	06AUG91	6.0	19.2	7.9	.	.	.	.	.	.
17	380820	06AUG91	7.0	19.2	7.8	.	.	.	.	.	.
18	380820	06AUG91	8.0	17.0	1.3	676	259	316	0	3.320	4.96
19	380820	06AUG91	8.5	16.5	1.0	.	.	.	.	.	.
20	380820	22JAN92	0.0	0.0	6.8	.	.	.	.	.	.
21	380820	22JAN92	1.0	3.0	3.6	692	191	233	0	0.266	2.03

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.003	0.203	0.026	245	34.9	38.3	18.2	15.2	0.061	0.066	10.3	111	316
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.017	0.134	0.113	260	43.7	36.6	17.3	14.3	0.081	0.186	10.6	132	359
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.005	0.358	0.324	280	49.4	38.1	17.8	15.3	0.126	0.921	10.4	127	376
10	0.004	0.261	0.142	243	37.8	36.0	16.7	14.7	0.042	0.166	12.7	122	331
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.001	0.255	0.161	263	40.7	39.1	19.6	16.0	0.063	0.194	12.7	122	341
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.019	1.180	1.150	310	56.8	40.9	19.7	15.9	0.117	3.790	13.0	102	404
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	0.015	0.116	0.084	309	50.6	44.4	21.3	15.5	0.150	0.692	12.0	154	413

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380820	22JAN92	2.0	3.5	3.2	.	.	.	.	.	.
23	380820	22JAN92	3.0	3.5	3.0	.	.	.	.	.	.
24	380820	22JAN92	4.0	3.5	2.0	688	192	235	0	0.288	1.94
25	380820	22JAN92	5.0	3.5	2.7	.	.	.	.	.	.
26	380820	22JAN92	6.0	4.0	1.4	.	.	.	.	.	.
27	380820	22JAN92	7.0	4.5	1.0	694	202	247	0	0.598	2.01

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	0.014	0.110	0.088	309	50.0	44.8	21.4	15.0	0.161	0.726	11.7	154	413
25	.	.	.	.	.	.	.	.	.	.	.	.	.
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	0.003	0.320	0.239	331	53.3	48.1	22.6	16.2	0.567	1.080	11.9	153	427

1991-1992 Water Quality Data
NIEUSMA DAM

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381330	25JUL91	0.00000	23.0	8.0	396.	203	112	67	0.072	2.29
2	381330	25JUL91	1.00000	23.0	8.0						
3	381330	25JUL91	2.00000	22.5	7.8	397.	204	131	58	0.029	2.07
4	381330	25JUL91	3.50000	22.0	7.6	.	.	.	.	.	.
5	381330	25JUL91	4.00000	21.5	3.4	393.	205	116	66	0.042	1.75
6	381330	14AUG91	0.20000	21.3	8.6	364.	188	89	69	0.042	1.48
7	381330	14AUG91	1.00000	21.0	8.7						
8	381330	14AUG91	2.00000	21.0	8.8	368.	188	89	69	0.000	1.25
9	381330	14AUG91	3.00000	20.5	4.2						
10	381330	14AUG91	4.00000	20.0	1.3	363.	188	87	70	0.058	1.61
11	381330	11FEB92	0.00000	0.5	15.0	.	.	.	.	.	.
12	381330	11FEB92	1.00000	4.0	15.0	378.	161	99	48	0.163	1.91
13	381330	11FEB92	2.00000	4.0	9.6						
14	381330	11FEB92	3.00000	5.0	2.0	463.	211	217	20	0.633	2.45
15	381330	11FEB92	3.50000	5.3	1.0						

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.012	0.517	0.422	158	37.7	15.4	20.6	23.4	0.081	0.240	8.8	2	230
2													
3	0.014	0.519	0.443	158	37.9	15.4	20.7	23.3	0.111	0.264	9.1	0	229
4	.	.	.	.	.	.	.	.	.	.			
5	0.011	0.514	0.458	155	37.0	15.1	20.0	22.7	0.102	0.253	9.0	0	227
6	0.004	0.531	0.470	158	37.8	15.4	24.3	24.5	0.091	0.129	9.2	1	225
7													
8	0.007	0.516	0.452	154	36.9	15.0	23.6	23.8	0.101	0.131	9.5	4	226
9													
10	0.006	0.515	0.476	142	34.3	13.7	22.1	22.2	0.102	0.123	9.3	1	215
11	.	.	.							.			
12	0.005	0.935	0.702	100	22.5	10.6	28.8	21.3	0.043	0.038	11.5	16	207
13													
14	0.000	1.780	1.880	148	35.7	14.3	32.0	22.4	0.061	0.685	13.1	12	156
15													

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381345	10JUL91	0	22.1	8.1	1915	584	593	59	0.260	2.29
2	381345	10JUL91	1	22.1	8.0	.	.	.	.	.	.
3	381345	10JUL91	2	22.0	7.8	.	.	.	.	.	.
4	381345	10JUL91	3	22.0	7.3	.	.	.	.	.	.
5	381345	10JUL91	4	21.8	7.0	1894	583	596	57	0.326	2.08
6	381345	10JUL91	5	21.0	5.1	.	.	.	.	.	.
7	381345	10JUL91	6	20.7	4.0	.	.	.	.	.	.
8	381345	10JUL91	7	20.3	1.2	1900	585	604	54	0.479	1.24
9	381345	31JUL91	0	21.5	8.6	1946	592	574	73	0.042	2.03
10	381345	31JUL91	1	21.5	8.6	.	.	.	.	.	.
11	381345	31JUL91	2	21.5	8.6	.	.	.	.	.	.
12	381345	31JUL91	3	21.5	8.4	.	.	.	.	.	.
13	381345	31JUL91	4	21.3	8.3	1926	591	573	73	0.013	1.61
14	381345	31JUL91	5	21.0	8.3	.	.	.	.	.	.
15	381345	31JUL91	6	21.0	8.0	.	.	.	.	.	.
16	381345	31JUL91	7	21.0	6.6	1880	592	581	70	0.071	2.06
17	381345	21AUG91	0	26.5	7.7	1877	590	556	81	0.001	1.86
18	381345	21AUG91	1	25.0	8.0	.	.	.	.	.	.
19	381345	21AUG91	2	24.0	8.1	.	.	.	.	.	.
20	381345	21AUG91	3	23.5	7.8	.	.	.	.	.	.
21	381345	21AUG91	4	23.0	6.7	1875	590	555	81	0.004	2.74

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.022	0.052	0.032	445	9.95	102	222	21.1	0.036	0.018	11.1	470	1190
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.021	0.057	0.039	544	12.0	125	246	22.4	0.079	0.025	11.0	455	1220
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.019	0.091	0.064	586	12.7	120	236	22.4	0.104	0.061	10.9	465	1220
9	0.011	0.049	0.031	532	11.9	122	244	22.5	0.039	0.017	11.7	535	1300
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.011	0.053	0.022	545	12.1	125	249	23.5	0.043	0.018	11.6	487	1260
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.011	0.063	0.021	525	12.4	120	241	22.6	0.063	0.018	11.6	485	1250
17	0.001	0.045	0.027	548	11.7	126	264	24.0	0.044	0.018	12.3	494	1290
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	0.000	0.061	0.031	565	12.1	130	268	23.9	0.060	0.023	12.0	480	1280

NORTH CARLSON LAKE

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381345	21AUG91	5	23.0	5.2	.	.	.	.	.	.
23	381345	21AUG91	6	22.5	3.2	.	.	.	.	.	.
24	381345	21AUG91	7	22.5	1.6	1874	594	581	71	0.023	3.30
25	381345	30JAN92	0	0.0	7.3	.	.	.	.	.	.
26	381345	30JAN92	1	1.0	7.0	2290	749	764	74	0.567	3.10
27	381345	30JAN92	2	2.0	6.8	.	.	.	.	.	.
28	381345	30JAN92	3	2.0	6.4	.	.	.	.	.	.
29	381345	30JAN92	4	2.0	6.8	2300	754	776	71	0.592	3.37
30	381345	30JAN92	5	2.0	6.2	.	.	.	.	.	.
31	381345	30JAN92	6	2.5	6.0	.	.	.	.	.	.
32	381345	30JAN92	7	2.5	4.0	2310	759	782	71	0.682	3.38

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	0.000	0.111	0.029	559	12.9	128	262	22.9	0.070	0.052	11.8	456	1250
25	.	.	.	.	.	.	.	.	.	.	.	.	.
26	0.324	0.044	0.031	662	14.8	152	299	27.7	0.045	0.015	14.5	653	1610
27	.	.	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	0.139	0.048	0.028	672	15.5	154	318	28.9	0.047	0.024	14.3	644	1630
30	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.
32	0.156	0.043	0.049	682	16.2	156	318	28.9	0.072	0.030	14.4	655	1640

1991-1992 Water Quality Data
NORTHGATE DAM

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380845	17JUL91	0	24.5	6.6	481	203	229	9	0.167	2.66
2	380845	17JUL91	1	23.0	6.8	.	.	.	.	.	.
3	380845	17JUL91	2	23.0	6.8	.	.	.	.	.	.
4	380845	17JUL91	3	23.0	6.8	477	203	225	11	0.172	2.59
5	380845	17JUL91	4	23.0	6.0	.	.	.	.	.	.
6	380845	17JUL91	5	22.0	2.8	.	.	.	.	.	.
7	380845	17JUL91	6	20.5	0.6	482	204	235	7	0.199	2.61
8	380845	07AUG91	0	18.5	7.3	468	194	227	5	0.029	2.19
9	380845	07AUG91	1	18.3	7.0	.	.	.	.	.	.
10	380845	07AUG91	2	18.3	7.0	.	.	.	.	.	.
11	380845	07AUG91	3	18.2	6.9	464	196	227	6	0.004	2.08
12	380845	07AUG91	4	18.0	6.3	.	.	.	.	.	.
13	380845	07AUG91	5	18.0	5.3	.	.	.	.	.	.
14	380845	07AUG91	6	18.0	1.1	465	196	239	0	0.083	2.12
15	380845	21JAN92	0	0.5	12.4	.	.	.	.	.	.
16	380845	21JAN92	1	2.5	12.4	591	256	313	0	0.598	3.01
17	380845	21JAN92	2	3.0	11.6	.	.	.	.	.	.
18	380845	21JAN92	3	3.0	10.0	597	256	313	0	0.643	3.04
19	380845	21JAN92	4	3.5	5.8	.	.	.	.	.	.
20	380845	21JAN92	5	4.0	4.0	589	260	317	0	0.799	2.81
21	380845	21JAN92	6	5.5	3.2	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.035	0.249	0.217	148	29.7	18.0	25.3	17.1	0.183	0.370	10.1	32	254
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.038	0.235	0.225	146	29.6	17.6	24.2	16.5	0.188	0.352	10.1	31	251
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.037	0.296	0.258	152	30.6	18.3	25.2	17.4	0.274	0.470	10.1	3	227
8	0.045	0.224	0.182	171	34.1	20.9	30.0	19.9	0.168	0.275	12.5	26	260
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.042	0.247	0.205	171	33.7	21.2	30.2	20.4	0.180	0.278	12.3	5	241
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.042	0.239	0.193	170	34.0	20.6	30.0	19.4	0.195	0.279	12.4	30	264
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.010	0.386	0.202	212	40.6	26.9	35.8	21.7	0.547	1.140	12.8	58	350
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.009	0.380	0.236	215	41.3	27.2	35.9	21.8	0.597	1.140	12.3	41	334
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.008	0.484	0.197	206	40.1	25.8	34.5	20.6	1.060	1.200	12.4	38	328
21	.	.	.	.	.	.	.	.	.	.	.	.	.

PHEASANT LAKE

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381125	24JUL91	0.00000	23.5	6.6	448	138	169	0	0.297	1.65
2	381125	24JUL91	1.00000	23.5	6.3						
3	381125	24JUL91	2.00000	23.5	6.3	.	.	.	.	.	.
4	381125	24JUL91	3.00000	23.5	6.3	443	138	169	0	0.281	1.87
5	381125	24JUL91	4.00000	23.5	6.3						
6	381125	24JUL91	5.00000	23.5	4.4	437	138	169	0	0.287	1.58
7	381125	13AUG91	0.00000	23.0	6.4	461	148	181	0	0.121	1.60
8	381125	13AUG91	1.00000	22.0	6.1	.	.	.	.	.	.
9	381125	13AUG91	2.00000	21.5	5.7						
10	381125	13AUG91	3.00000	21.2	5.3	461	148	181	0	0.175	1.40
11	381125	13AUG91	4.00000	20.7	4.1	.	.	.	.	.	.
12	381125	13AUG91	5.00000	20.5	0.8	464	148	181	0	0.232	1.51
13	381125	12FEB92	0.00000	0.5	14.8						
14	381125	12FEB92	1.00000	1.5	14.8	674	228 .	268	. 5	0.067	1.28
15	381125	12FEB92	2.00000	2.0	14.7						
16	381125	12FEB92	3.00000	3.0	14.6	646	227	265	6	0.078	1.41
17	381125	12FEB92	4.00000	3.0	14.6						
18	381125	12FEB92	5.00000	4.0	14.6	656	232	267	8	0.078	1.33

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.325	0.780	0.783	130	29.4	13.7	35.5	11.7	1.080	1.180	17.3	61	252
2													
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.319	0.802	0.748	127	28.6	13.5	34.3	11.1	1.140	1.160	17.1	59	247
5													
6	0.316	0.774	0.758	126	28.6	13.3	33.7	11.1	1.160	1.140	17.1	59	246
7	0.260	0.751	0.726	136	31.3	14.1	38.7	12.9	0.333	1.150	18.3	57	261
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9													
10	0.261	0.762	0.734	140	32.1	14.5	39.3	12.8	0.391	1.160	17.8	57	263
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.260	0.766	0.762	138	31.6	14.4	38.7	12.5	0.463	1.240	17.7	58	262
13													
14	0.034	0.432	0.384	206	47.7	21.0	56.7	15.8	0.036	0.144	26.5	88	393
15													
16	0.029	0.501	0.351	198	45.9	20.3	56.2	15.2	0.029	0.138	25.4	90	390
17													
18	0.027	0.501	0.367	214	50.4	21.3	62.0	17.7	0.038	0.157	26.8	88	406

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381090	10JUL91	0.0	21.5	9.1	2080	669	512	150	0.000	1.93
2	381090	10JUL91	1.0	21.5	9.2	.	.	.	.	.	.
3	381090	10JUL91	2.0	21.0	8.5	.	.	.	.	.	.
4	381090	10JUL91	3.0	20.5	8.6	.	.	.	.	.	.
5	381090	10JUL91	4.0	20.5	7.8	2070	671	516	149	0.029	1.42
6	381090	10JUL91	5.0	20.0	7.2	.	.	.	.	.	.
7	381090	10JUL91	6.0	20.0	5.2	.	.	.	.	.	.
8	381090	10JUL91	7.0	19.0	4.8	.	.	.	.	.	.
9	381090	10JUL91	8.0	18.5	2.6	.	.	.	.	.	.
10	381090	10JUL91	9.0	17.0	2.6	2130	672	560	128	0.171	1.52
11	381090	31JUL91	0.0	21.5	8.1	2050	675	517	151	0.023	1.61
12	381090	31JUL91	1.0	21.5	8.1	.	.	.	.	.	.
13	381090	31JUL91	2.0	21.5	8.3	.	.	.	.	.	.
14	381090	31JUL91	3.0	21.5	8.0	.	.	.	.	.	.
15	381090	31JUL91	4.0	21.5	7.9	2090	674	520	149	0.014	1.54
16	381090	31JUL91	5.0	21.5	7.9	.	.	.	.	.	.
17	381090	31JUL91	6.0	21.5	7.9	.	.	.	.	.	.
18	381090	31JUL91	7.0	21.3	7.3	.	.	.	.	.	.
19	381090	31JUL91	8.0	21.2	6.3	.	.	.	.	.	.
20	381090	31JUL91	9.0	19.5	1.0	2150	673	555	131	0.013	2.57
21	381090	21AUG91	0.0	24.0	8.5	2030	667	511	149	0.000	2.42

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.005	0.038	0.026	925	9.6	219	135	41.2	0.075	0.012	31.9	597	1440
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.003	0.035	0.022	938	9.9	222	141	41.8	0.031	0.017	31.2	583	1430
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.001	0.042	0.027	922	9.8	218	137	40.8	0.027	0.059	31.1	586	1430
11	0.007	0.027	0.019	955	8.3	227	139	40.5	0.023	0.021	33.0	606	1460
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.007	0.037	0.016	976	8.5	232	148	39.5	0.000	0.022	32.9	604	1470
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.005	0.048	0.012	1010	10.0	240	148	40.6	0.168	0.048	32.6	591	1470
21	0.005	0.031	0.019	1030	8.4	244	153	42.0	0.022	0.020	35.7	562	1450

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381090	21AUG91	1.0	23.0	9.0	.	.	.	.	.	.
23	381090	21AUG91	2.0	22.0	9.0	.	.	.	.	.	.
24	381090	21AUG91	3.0	22.0	8.6	.	.	.	.	.	.
25	381090	21AUG91	4.0	21.5	7.4	2040	664	512	147	0.020	1.87
26	381090	21AUG91	5.0	21.5	6.6	.	.	.	.	.	.
27	381090	21AUG91	6.0	21.0	5.5	.	.	.	.	.	.
28	381090	21AUG91	7.0	21.0	2.6	.	.	.	.	.	.
29	381090	21AUG91	8.0	20.5	0.7	.	.	.	.	.	.
30	381090	21AUG91	9.0	20.0	0.4	2050	664	536	135	0.056	2.35
31	381090	30JAN92	0.0	0.0	2.8	.	.	.	.	.	.
32	381090	30JAN92	1.0	1.5	3.4	2470	845	781	123	0.143	2.58
33	381090	30JAN92	2.0	2.0	3.4	.	.	.	.	.	.
34	381090	30JAN92	3.0	2.0	3.1	.	.	.	.	.	.
35	381090	30JAN92	4.0	1.5	2.4	2530	871	760	149	0.107	2.76
36	381090	30JAN92	5.0	2.0	1.4	.	.	.	.	.	.
37	381090	30JAN92	6.0	2.0	1.4	.	.	.	.	.	.
38	381090	30JAN92	7.0	2.0	0.7	.	.	.	.	.	.
39	381090	30JAN92	8.0	2.0	0.6	2600	896	846	122	0.114	2.58
40	381090	30JAN92	8.5	2.5	0.5	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.007	0.028	0.020	1000	8.8	238	152	43.0	0.078	0.033	34.6	551	1430
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.
30	0.009	0.037	0.022	1060	9.1	251	165	45.4	0.038	0.044	32.4	587	1490
31	.	.	.	.	.	.	.	.	.	.	.	.	.
32	0.011	0.038	0.011	1170	15.2	276	171	47.4	0.036	0.087	39.4	794	1850
33	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.
35	0.039	0.035	0.024	1210	14.7	285	174	49.2	0.023	0.057	40.5	871	1960
36	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.
39	0.053	0.035	0.026	1250	14.9	295	182	50.0	0.023	0.099	42.3	825	1950
40	.	.	.	.	.	.	.	.	.	.	.	.	.

1991-1992 Water Quality Data
SHORT CREEK DAM

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380905	17JUL91	0	24.3	13.5	773	254	251	29	0.032	2.68
2	380905	17JUL91	1	24.0	13.1	.	.	.	.	.	.
3	380905	17JUL91	2	22.5	9.1	.	.	.	.	.	.
4	380905	17JUL91	3	21.5	7.4	784	256	280	16	0.069	1.26
5	380905	17JUL91	4	20.5	5.1	.	.	.	.	.	.
6	380905	17JUL91	5	19.8	4.0	.	.	.	.	.	.
7	380905	17JUL91	6	19.3	2.3	.	.	.	.	.	.
8	380905	17JUL91	7	18.5	1.1	788	262	320	0	0.332	2.53
9	380905	07AUG91	0	19.2	8.1	761	254	280	15	0.161	2.10
10	380905	07AUG91	1	19.2	7.8	.	.	.	.	.	.
11	380905	07AUG91	2	19.2	7.8	.	.	.	.	.	.
12	380905	07AUG91	3	19.2	7.8	755	256	276	18	0.150	2.32
13	380905	07AUG91	4	19.2	7.8	.	.	.	.	.	.
14	380905	07AUG91	5	19.2	7.8	.	.	.	.	.	.
15	380905	07AUG91	6	19.0	7.3	.	.	.	.	.	.
16	380905	07AUG91	7	19.0	7.2	752	255	281	15	0.198	2.28
17	380905	22JAN92	0	0.5	3.9	.	.	.	.	.	.
18	380905	22JAN92	1	3.0	3.0	966	329	402	0	0.757	2.42
19	380905	22JAN92	2	3.3	2.3	.	.	.	.	.	.
20	380905	22JAN92	3	3.3	2.1	958	329	400	1	0.770	2.12
21	380905	22JAN92	4	3.5	2.1	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.004	0.170	0.052	165	34.9	18.9	102.0	16.6	0.093	0.026	14.9	126	466
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.012	0.117	0.094	155	33.1	17.6	95.4	15.1	0.295	0.043	15.5	131	462
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.032	0.270	0.181	164	35.0	18.7	100.0	15.5	1.260	0.271	16.0	146	489
9	0.024	0.169	0.128	168	36.0	18.9	106.0	16.3	0.312	0.101	18.8	122	471
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.014	0.175	0.129	167	34.7	19.4	110.0	17.4	0.294	0.105	19.0	123	477
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.019	0.200	0.133	188	41.6	20.4	113.0	17.7	0.774	0.144	18.8	122	487
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.054	0.259	0.240	207	42.9	24.3	132.0	19.2	0.130	0.387	19.6	158	594
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.054	0.256	0.230	207	42.7	24.4	131.0	19.3	0.161	0.368	20.1	158	594
21	.	.	.	.	.	.	.	.	.	.	.	.	.

SHORT CREEK DAM

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380905	22JAN92	5	4.0	1.5	959	332	405	0	0.821	2.30

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.046	0.396	0.285	205	42.7	23.8	128.0	18.5	0.662	0.407	20.8	156	589

SHORT CREEK DAM

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380905	17JUL91	0	24.3	13.5	773	254	251	29	0.032	2.68
2	380905	17JUL91	1	24.0	13.1	.	.	.	.	.	.
3	380905	17JUL91	2	22.5	9.1	.	.	.	.	.	.
4	380905	17JUL91	3	21.5	7.4	784	256	280	16	0.069	1.26
5	380905	17JUL91	4	20.5	5.1	.	.	.	.	.	.
6	380905	17JUL91	5	19.8	4.0	.	.	.	.	.	.
7	380905	17JUL91	6	19.3	2.3	.	.	.	.	.	.
8	380905	17JUL91	7	18.5	1.1	788	262	320	0	0.332	2.53
9	380905	07AUG91	0	19.2	8.1	761	254	280	15	0.161	2.10
10	380905	07AUG91	1	19.2	7.8	.	.	.	.	.	.
11	380905	07AUG91	2	19.2	7.8	.	.	.	.	.	.
12	380905	07AUG91	3	19.2	7.8	755	256	276	18	0.150	2.32
13	380905	07AUG91	4	19.2	7.8	.	.	.	.	.	.
14	380905	07AUG91	5	19.2	7.8	.	.	.	.	.	.
15	380905	07AUG91	6	19.0	7.3	.	.	.	.	.	.
16	380905	07AUG91	7	19.0	7.2	752	255	281	15	0.198	2.28
17	380905	22JAN92	0	0.5	3.9	.	.	.	.	.	.
18	380905	22JAN92	1	3.0	3.0	966	329	402	0	0.757	2.42
19	380905	22JAN92	2	3.3	2.3	.	.	.	.	.	.
20	380905	22JAN92	3	3.3	2.1	958	329	400	1	0.770	2.12
21	380905	22JAN92	4	3.5	2.1	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.004	0.170	0.052	165	34.9	18.9	102.0	16.6	0.093	0.026	14.9	126	466
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.012	0.117	0.094	155	33.1	17.6	95.4	15.1	0.295	0.043	15.5	131	462
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.032	0.270	0.181	164	35.0	18.7	100.0	15.5	1.260	0.271	16.0	146	489
9	0.024	0.169	0.128	168	36.0	18.9	106.0	16.3	0.312	0.101	18.8	122	471
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.014	0.175	0.129	167	34.7	19.4	110.0	17.4	0.294	0.105	19.0	123	477
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.019	0.200	0.133	188	41.6	20.4	113.0	17.7	0.774	0.144	18.8	122	487
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.054	0.259	0.240	207	42.9	24.3	132.0	19.2	0.130	0.387	19.6	158	594
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.054	0.256	0.230	207	42.7	24.4	131.0	19.3	0.161	0.368	20.1	158	594
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380905	22JAN92	5	4.0	1.5	959	332	405	0	0.821	2.30

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.046	0.396	0.285	205	42.7	23.8	128.0	18.5	0.662	0.407	20.8	156	589

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380531	18JAN91	1	.	.	1479	238	281	5	0.143	1.86
2	380531	18JAN91	3	.	.	1495	238	281	5	0.135	1.92
3	380531	18JAN91	5	.	.	1522	241	294	0	0.170	1.85
4	380531	07MAY91	1	.	.	1288	203	222	13	0.030	1.36
5	380531	07MAY91	3	.	.	1227	204	223	13	0.028	1.29
6	380531	07MAY91	4	.	.	1249	203	224	12	0.039	1.52
7	380531	06JUN91	1	.	.	1226	207	214	19	0.088	2.34
8	380531	06JUN91	3	.	.	1228	207	214	19	0.053	1.65
9	380531	06JUN91	5	.	.	1229	209	221	17	0.055	1.64
10	380531	26JUL91	0	23.0	8.8	.	.	.	.	.	.
11	380531	26JUL91	1	23.0	8.6	1250	200	210	17	0.074	2.08
12	380531	26JUL91	2	23.0	8.4	.	.	.	.	.	.
13	380531	26JUL91	3	23.0	8.6	1250	200	210	17	0.050	1.81
14	380531	26JUL91	4	23.0	9.2	.	.	.	.	.	.
15	380531	26JUL91	5	22.0	3.8	1252	201	211	17	0.079	1.78
16	380531	26AUG91	0	24.0	11.6	1320	223	215	28	0.067	4.11
17	380531	26AUG91	1	24.0	11.6	.	.	.	.	.	.
18	380531	26AUG91	2	24.0	11.0	.	.	.	.	.	.
19	380531	26AUG91	3	23.5	10.2	1325	223	217	27	0.049	3.35
20	380531	26AUG91	4	23.5	9.2	.	.	.	.	.	.
21	380531	26AUG91	5	22.5	3.8	1329	224	229	22	0.271	1.97

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.029	0.032	.	545	74.5	87.1	141.0	23.1	0.062	0.232	34.1	495	998
2	0.028	0.063	.	546	76.0	86.6	138.0	23.5	0.029	0.231	34.3	493	995
3	0.034	0.039	.	536	74.5	85.1	135.0	22.3	0.039	0.299	34.7	495	991
4	0.016	0.051	.	422	61.2	65.3	110.0	17.5	0.041	0.043	29.3	441	847
5	0.009	0.061	.	424	62.8	64.8	113.0	18.5	0.041	0.052	29.0	427	838
6	0.005	0.053	.	428	63.5	65.5	113.0	18.3	0.053	0.056	29.4	430	842
7	0.007	0.066	.	427	62.7	65.6	107.0	18.7	0.150	0.288	28.7	390	797
8	0.007	0.096	.	438	64.5	67.3	107.0	18.9	0.090	0.294	28.5	394	805
9	0.008	0.092	.	424	64.4	63.8	105.0	18.4	0.530	0.367	28.7	390	796
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.006	0.119	0.107	435	66.3	65.5	99.1	17.6	0.164	0.302	29.0	423	821
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.004	0.145	0.085	452	70.1	67.3	102.0	18.2	0.053	0.310	29.0	427	834
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.004	0.131	0.084	453	69.1	68.1	104.0	18.3	0.045	0.337	28.9	425	834
16	0.000	0.271	0.101	493	77.2	73.0	117.0	19.6	0.094	0.265	27.5	427	875
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	0.000	0.193	0.098	509	77.3	76.8	117.0	19.8	0.045	0.262	28.6	440	893
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	0.000	0.201	0.137	511	79.4	75.9	114.0	19.1	0.106	0.469	29.4	429	882

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380531	27FEB92	0	0.0	3.8	.	.	.	.	.	.
23	380531	27FEB92	1	1.0	3.0	1583	259	316	0	0.925	2.48
24	380531	27FEB92	2	2.8	2.3	.	.	.	.	.	.
25	380531	27FEB92	3	3.0	2.0	1583	261	319	0	1.010	2.44
26	380531	27FEB92	4	3.0	1.8	.	.	.	.	.	.
27	380531	27FEB92	5	4.0	1.2	1570	261	319	0	0.997	2.37

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.095	0.116	0.038	563	87.6	83.6	129.0	20.6	0.194	0.746	37.0	581	1090
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.116	0.138	0.096	557	86.3	83.0	129.0	20.4	0.193	0.800	37.1	584	1100
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	0.093	0.119	0.081	568	88.6	84.3	134.0	21.0	0.230	0.829	37.7	582	1100

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380520	09JUL91	0	24.0	11.2	448	173	175	18	0.001	1.53
2	380520	09JUL91	1	22.0	12.2	.	.	.	.	.	.
3	380520	09JUL91	2	21.0	10.0	.	.	.	.	.	.
4	380520	09JUL91	3	21.0	9.2	460	176	213	1	0.158	1.05
5	380520	09JUL91	4	21.0	6.2	.	.	.	.	.	.
6	380520	09JUL91	5	19.0	0.2	.	.	.	.	.	.
7	380520	09JUL91	6	18.0	0.3	468	186	227	0	0.442	1.32
8	380520	01AUG91	0	22.5	9.0	457	171	187	11	0.026	1.83
9	380520	01AUG91	1	22.1	9.1	.	.	.	.	.	.
10	380520	01AUG91	2	22.1	9.0	.	.	.	.	.	.
11	380520	01AUG91	3	22.0	8.6	454	171	187	11	0.026	1.79
12	380520	01AUG91	4	21.8	7.0	.	.	.	.	.	.
13	380520	01AUG91	5	21.5	4.0	.	.	.	.	.	.
14	380520	01AUG91	6	21.0	1.3	463	172	210	0	0.234	1.81
15	380520	31JAN92	0	0.5	9.3	.	.	.	.	.	.
16	380520	31JAN92	1	2.0	9.0	553	229	279	0	0.301	1.16
17	380520	31JAN92	2	2.5	8.6	.	.	.	.	.	.
18	380520	31JAN92	3	2.5	8.5	552	229	279	0	0.342	1.23
19	380520	31JAN92	4	2.5	7.8	.	.	.	.	.	.
20	380520	31JAN92	5	2.5	7.7	.	.	.	.	.	.
21	380520	31JAN92	6	3.5	1.6	556	230	281	0	0.374	1.26

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.004	0.073	0.014	203	30.5	30.8	18.7	4.3	0.023	0.085	4.9	34	227
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.006	0.064	0.017	189	29.1	28.2	17.7	3.7	0.046	0.125	4.6	49	238
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.010	0.086	0.021	218	34.6	31.9	19.9	4.5	0.045	1.120	4.7	52	259
8	0.007	0.068	0.025	177	25.7	27.5	17.8	4.5	0.021	0.167	5.3	52	236
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.005	0.058	0.023	187	27.6	28.6	18.2	4.6	0.003	0.179	5.0	30	217
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.004	0.050	0.023	187	27.8	28.5	18.1	4.8	0.000	0.446	5.0	47	235
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.012	0.036	0.020	251	44.5	33.9	19.2	4.0	0.047	0.142	6.3	69	314
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.007	0.038	0.022	248	44.4	33.3	18.7	4.3	0.056	0.263	6.4	68	313
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	0.007	0.030	0.029	256	46.2	34.1	19.4	3.9	0.072	0.377	6.0	0	248

1991-1992 Water Quality Data
VELVA SPORTSMAN'S DAM

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381350	10JUL91	0.00000	21.5	8.8	1316	318	356	16	0.026	0.600
2	381350	10JUL91	1.00000	21.5	9.0	.	.	.	.	.	.
3	381350	10JUL91	2.00000	21.2	9.1	.	.	.	.	.	.
4	381350	10JUL91	3.00000	19.3	2.9	.	.	.	.	.	.
5	381350	10JUL91	4.00000	18.5	0.5	1344	329	402	0.0	0.013	0.660
6	381350	10JUL91	5.00000	17.5	0.2	.	.	.	.	.	.
7	381350	10JUL91	6.00000	14.5	0.1	.	.	.	.	.	.
8	381350	10JUL91	7.00000	12.5	1.0						
9	381350	10JUL91	7.50000	12.0	2.6	1420	459	561	0.0	2.080	2.780
10	381350	30JUL91	0.00000	21.5	10.4	.	.	.	.	.	.
11	381350	30JUL91	1.00000	21.5	10.4	1368	315	379	3.0	0.000	0.820
12	381350	30JUL91	2.00000	21.5	10.4	.	.	.	.	.	.
13	381350	30JUL91	3.00000	21.0	10.0	.	.	.	.	.	.
14	381350	30JUL91	4.00000	19.5	3.6	1312	318	388	0.0	0.021	1.210
15	381350	30JUL91	5.00000	17.5	1.6	.	.	.	.	.	.
16	381350	30JUL91	6.00000	14.0	1.0	.	.	.	.	.	.
17	381350	30JUL91	7.00000	13.0	0.8	1288	373	455	0.0	1.610	1.610
18	381350	22AUG91	0.00000	21.0	11.5	.	.	.	.	.	.
19	381350	22AUG91	1.00000	21.0	11.9	1241	301	333	17.0	0.000	1.150
20	381350	22AUG91	2.00000	19.3	7.0	.	.	.	.	.	.
21	381350	22AUG91	3.00000	18.7	3.8	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.004	0.034	0.021	474	78.9	67.2	84.8	7.30	0.61	0.033	2.5	387	819
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.004	0.048	0.019	479	82.6	66.3	87.2	8.26	0.056	0.096	2.6	382	828
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.000	0.539	0.490	517	93.8	68.7	92.3	8.65	0.166	1.51	10.8	312	863
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.004	0.044	0.016	491	80.1	70.6	93.2	8.30	0.000	0.058	2.6	400	844
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.004	0.066	0.011	539	90.2	76.1	103	8.48	0.157	0.096	2.7	404	876
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	0.036	0.361	0.353	570	102	76.6	101	9.17	0.298	1.410	4.8	376	894
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	0.015	0.064	0.024	488	79.8	70.2	92.2	7.53	0.005	0.089	2.5	420	864
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381350	22AUG91	4.00000	18.3	1.0	1263	306	374	0	0.000	1.01
23	381350	22AUG91	5.00000	17.0	0.8	.	.	.	.	.	.
24	381350	22AUG91	6.00000	13.8	0.7	.	.	.	.	.	.
25	381350	22AUG91	7.00000	12.8	0.6	.	.	.	.	.	.
26	381350	22AUG91	7.50000	12.2	0.6	1310	441	539	0	3.800	6.70
27	381350	30JAN92	0.00000	0.0	12.7	.	.	.	.	.	.
28	381350	30JAN92	1.00000	2.5	15.0	1390	385	470	0	0.029	0.76
29	381350	30JAN92	2.00000	3.5	15.0	.	.	.	.	.	.
30	381350	30JAN92	3.00000	3.5	12.5	.	.	.	.	.	.
31	381350	30JAN92	4.00000	3.5	6.8	1415	388	474	0	0.203	1.57
32	381350	30JAN92	5.00000	3.5	5.6	.	.	.	.	.	.
33	381350	30JAN92	6.00000	3.5	2.2	.	.	.	.	.	.
34	381350	30JAN92	7.00000	4.0	0.8	1427	405	495	0	0.648	1.98
35	381350	30JAN92	7.30000	4.0	0.6	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.000	0.053	0.026	527	86.4	75.5	98.0	8.12	0.062	0.124	2.1	377	831
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	.	.	.	.	.	.	.	.	.	.	.	.	.
26	0.200	0.624	0.579	51	98.6	74.0	98.3	8.56	0.140	1.560	2.7	380	928
27	.	.	.	.	.	.	.	.	.	.	.	.	.
28	1.300	0.027	0.017	595	113	75.9	96.5	8.8	0.045	0.050	3.4	398	927
29	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.
31	0.700	0.035	0.017	606	113	78.6	103.0	9.0	0.048	0.163	3.4	437	978
32	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.
34	0.313	0.049	0.020	582	109	75.1	97.3	8.6	0.122	0.634	4.2	446	984
35	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381325	14MAY91	1.0	.	.	1807	505	511	52	0.022	2.63
2	381325	14MAY91	5.0	.	.	1796	506	543	37	0.253	2.19
3	381325	25JUL91	0.0	25.0	13.5	1973	536	341	154	0.019	3.15
4	381325	25JUL91	1.0	23.0	9.8						
5	381325	25JUL91	2.0	22.0	8.4	1946	535	362	143	0.053	3.92
6	381325	25JUL91	3.0	22.0	8.0	.	.	.	.	.	.
7	381325	25JUL91	4.0	22.0	3.8	1959	536	394	128	0.115	3.45
8	381325	14AUG91	0.0	22.0	12.2	1926	529	333	154	0.000	3.86
9	381325	14AUG91	1.0	21.7	12.6	.	.	.	.	.	.
10	381325	14AUG91	2.0	21.2	11.5	.	.	.	.	.	.
11	381325	14AUG91	3.0	21.1	11.0	1929	529	339	151	0.008	3.46
12	381325	14AUG91	4.0	21.0	10.5	.	.	.	.	.	.
13	381325	14AUG91	5.0	21.0	1.0	1942	528	347	146	0.026	3.33
14	381325	03JAN92	0.0	1.5	16.8						
15	381325	03JAN92	1.0	3.0	16.4	2250	609	534	103	0.045	3.46
16	381325	03JAN92	2.0	3.0	6.4	.	.	.	.	.	.
17	381325	03JAN92	3.0	3.0	1.2						
18	381325	03JAN92	4.0	3.8	0.8	2320	610	556	93	0.042	3.08
19	381325	03JAN92	4.5	4.5	0.5						

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.015	0.648		285	49.3	39.2	367	22.0	0.126	0.040	13.0	523	1320
2	0.043	0.792	.	261	45.0	36.0	339	19.7	0.145	0.081	13.6	497	1250
3	0.002	1.080	0.781	290	45.4	43.0	414	22.6	0.062	0.061	13.7	480	1340
4													
5	0.006	0.970	0.784	296	47.0	43.4	413	24.0	0.069	0.070	13.4	462	1320
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.008	1.020	0.764	290	46.5	42.3	422	23.5	0.081	0.071	13.3	470	1340
8	0.003	0.887	0.698	230	35.7	34.1	343	20.3	0.173	0.056	14.3	515	1280
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.010	0.899	0.698	221	33.9	33.1	330	19.2	0.181	0.059	14.2	508	1260
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.005	0.873	0.715	219	33.6	32.9	331	18.1	0.417	0.067	14.2	496	1240
14													
15	0.031	0.737	0.607	261	38.7	39.9	457	22.3	0.093	0.041	20.2	709	1650
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17													
18	0.050	0.760	0.580	255	37.9	39.0	448	21.8	0.084	0.041	20.1	705	1640
19													

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381255	29JUL91	0.0	21.8	7.2	878	249	296	4	0.198	2.01
2	381255	29JUL91	1.0	21.8	7.1	.	.	.	.	.	.
3	381255	29JUL91	2.0	21.3	6.3	.	.	.	.	.	.
4	381255	29JUL91	3.0	21.1	6.1	883	249	288	8	0.211	2.07
5	381255	29JUL91	4.0	21.0	5.9	.	.	.	.	.	.
6	381255	29JUL91	5.0	21.0	5.7	.	.	.	.	.	.
7	381255	29JUL91	6.0	20.8	3.3	866	249	296	4	0.296	1.92
8	381255	27AUG91	0.0	23.0	6.2	943	251	304	1	0.425	1.86
9	381255	27AUG91	1.0	23.0	6.2	.	.	.	.	.	.
10	381255	27AUG91	2.0	22.7	6.0	.	.	.	.	.	.
11	381255	27AUG91	3.0	22.7	5.8	927	248	287	8	0.414	2.12
12	381255	27AUG91	4.0	22.0	4.5	.	.	.	.	.	.
13	381255	27AUG91	5.0	22.0	3.6	.	.	.	.	.	.
14	381255	27AUG91	6.0	22.0	1.8	939	253	309	0	0.666	2.60
15	381255	27AUG91	6.5	22.0	0.8	.	.	.	.	.	.
16	381255	26FEB92	0.0	0.0	8.5	.	.	.	.	.	.
17	381255	26FEB92	1.0	1.0	8.2	1082	303	370	0	0.030	1.85
18	381255	26FEB92	2.0	2.5	7.2	.	.	.	.	.	.
19	381255	26FEB92	3.0	2.8	6.8	1076	301	367	0	0.034	1.69
20	381255	26FEB92	4.0	3.0	4.2	.	.	.	.	.	.
21	381255	26FEB92	5.0	3.2	3.7	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	0.031	0.462	0.458	307	67.7	33.4	79.1	10.1	0.082	0.952	27.7	211	579
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.033	0.464	0.445	307	66.5	34.1	78.9	10.5	0.079	0.981	27.7	210	578
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.031	0.491	0.485	315	68.8	34.8	81.5	11.0	0.131	1.110	27.6	197	571
8	0.093	0.530	0.496	324	69.4	36.5	81.8	10.0	0.063	0.896	27.2	200	576
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.066	0.493	0.482	317	67.8	35.8	80.7	10.1	0.078	0.925	26.6	198	568
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.061	0.617	0.584	313	67.4	35.1	79.2	9.8	0.375	1.280	26.9	200	571
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	0.461	0.378	0.357	369	80.3	40.8	94.3	11.1	0.054	0.703	31.3	245	685
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	0.470	0.423	0.352	366	79.9	40.3	93.3	10.6	0.090	0.702	30.9	244	680
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381255	26FEB92	6.0	3.5	3.0	1082	305	372	0	0.193	2.71
23	381255	26FEB92	6.5	3.5	2.4	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (ug/L)	MANGANESE (ug/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.391	0.457	0.385	368	80.5	40.6	92.3	10.8	0.171	1.210	31.3	234	673
23	.	.	.	.	.	.	.	.	.	.	.	.	.

Appendix B

1991-1992 Macrophyte Maps (On Request)

Appendix C

1991-1992 Phytoplankton Data (On Request)

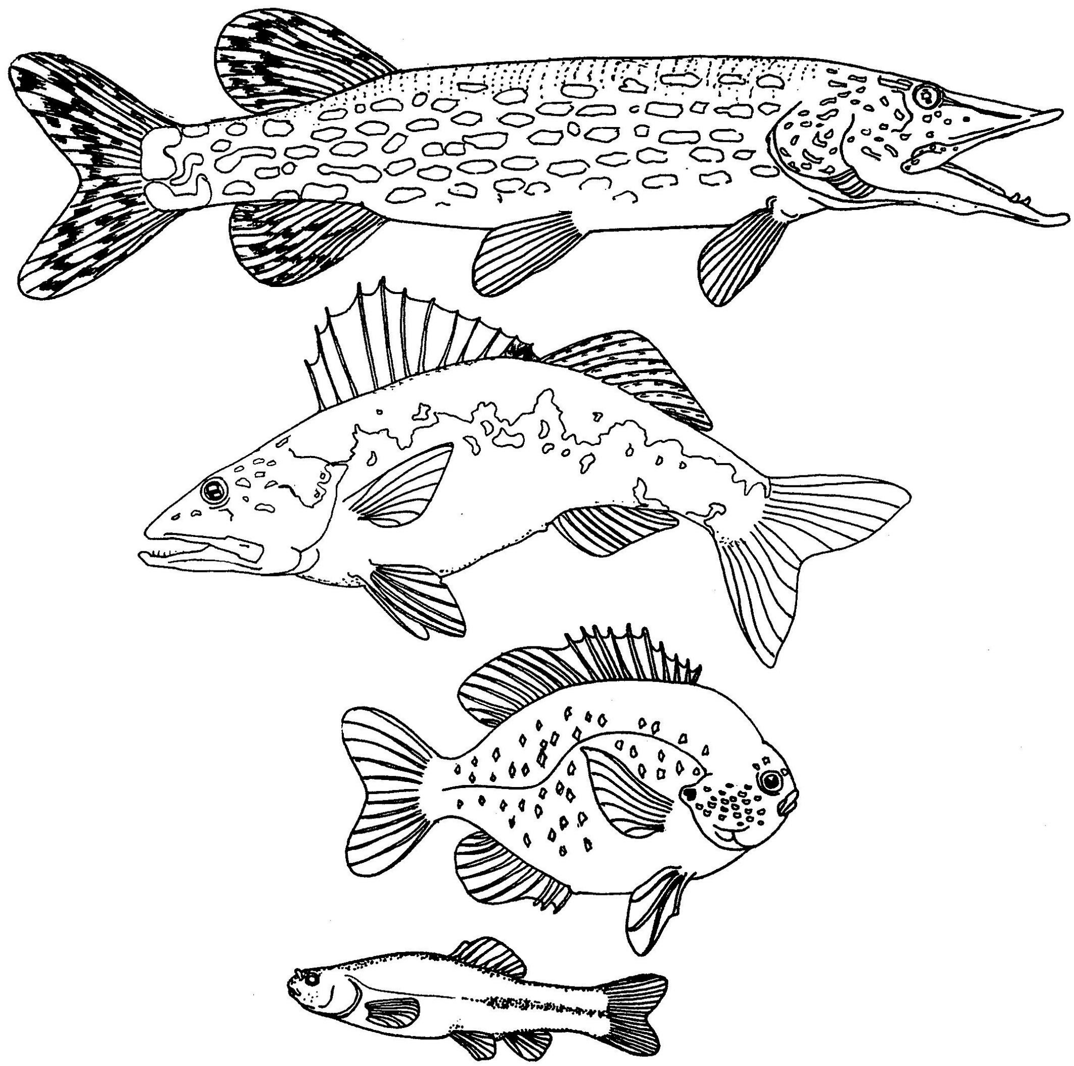
Appendix D

1991-1992 Sediment Contaminant Data (On Request)

Appendix E

1991-1992 Whole Fish Contaminants Data (On Request)

1992-1993 LAKES & RESERVOIRS



LIST OF 1992-1993 ASSESSED LAKES

ALKALI LAKE

SARGENT COUNTY

Peter N. Wax

Alkali Lake is a small natural lake located in central Sargent County, North Dakota. This natural waterbody lies on the northern edge of the Prairie Coteau physiographic region in southeastern North Dakota. Alkali Lake has a surface area of 104 acres, a maximum depth of 11 feet and an average depth of 6.4 feet. Physically Alkali Lake has a meandering shoreline with one small island near its center (Figure 1).

Topography of Alkali Lake's watershed is gently rolling uplands interspersed with multiple small potholes and integrated drainages. Land use within the watershed is nearly an even mixture of agricultural cropland and agricultural livestock production. Soils are predominantly sandy, relatively fertile and susceptible to both wind and water erosion. Alkali Lake's watershed encompasses approximately 759 surface acres.

Alkali Lake is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated biota" (NDSDHCL, 1991). Alkali Lake is managed by the NDG&F through annual fish community assessments and fish stockings. In recent years the stocking regiment has included fish tolerant to low dissolved oxygen conditions (i.e., northern pike).

Historically Alkali Lake's fishery has been managed for trout and many cool and warm water fishes. The fishery on Alkali Lake can be described as erratic due to multiple winter kills, eradications and promiscuous stockings of undesirable fish species such as carp and bullhead. The present fishery on Alkali Lake is dependent on the number of years it can survive without suffering a winterkill.

Access to Alkali Lake is good from state and county roads. Public facilities on Alkali Lake include a boat ramp and vault toilet. Fishing pressure on Alkali Lake is generally low due to heavy macrophyte infestations.

Water Quality

Water quality samples were collected from Alkali Lake twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 381360, Figure 1). Water column samples were collected for analysis at two separate depths, one meter and two meters.

During the summer sampling of 1992 and winter of 1993, Alkali Lake was not thermally stratified (Figure 2). At the times of sampling, dissolved oxygen concentrations were adequate to maintain aquatic life (Figure 3).

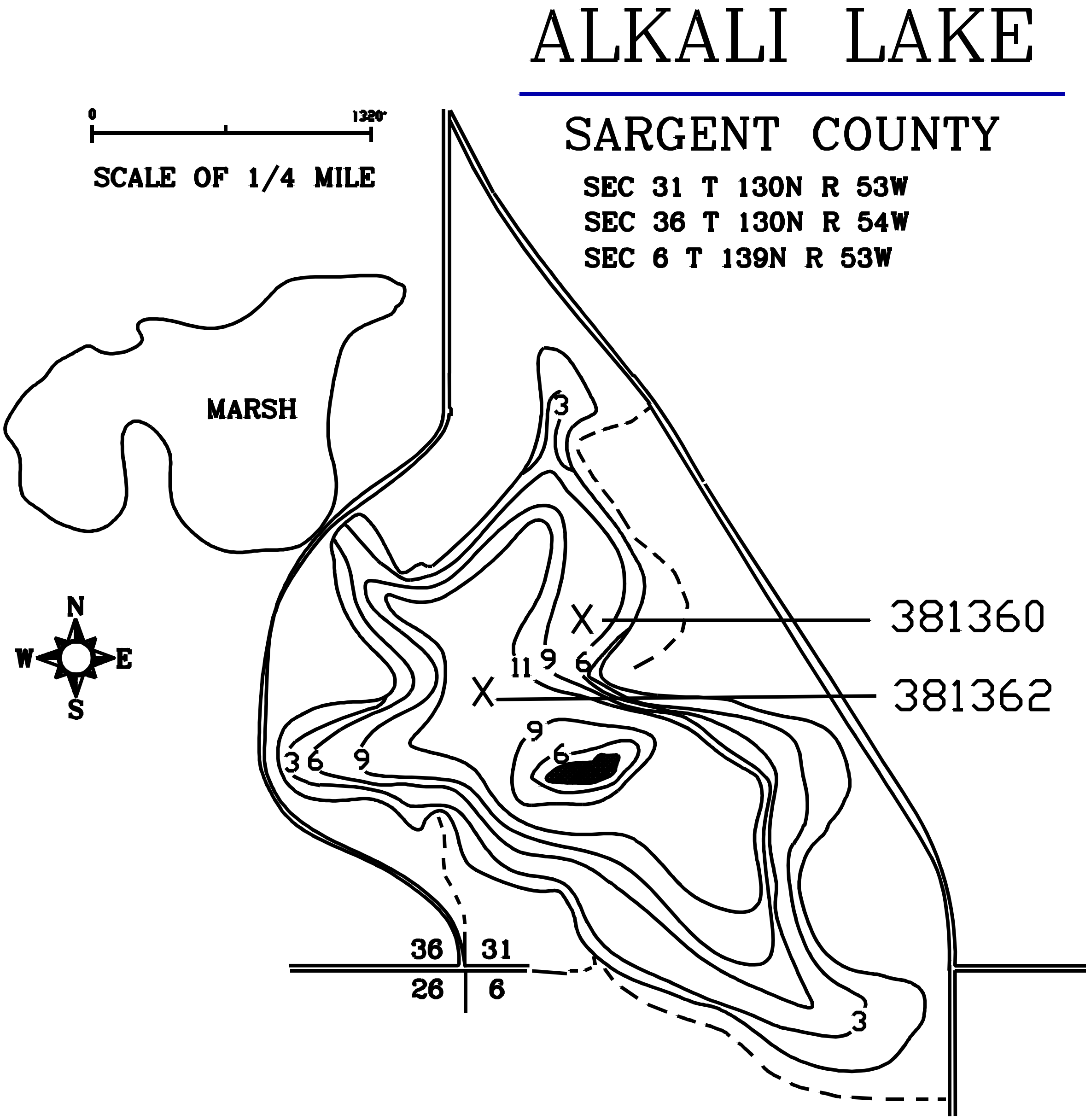


Figure 1. Morphometric map of Alkali Lake.

Alkali Lake, as its name would imply, is a highly buffered waterbody with a volume-weighted mean concentration for total alkalinity as $CaCO_3$ of 943.0 mg L^{-1}. The dominant anion in the water column was sulfate, followed by bicarbonates and chlorides. Sulfates, bicarbonates and chloride had volume-weighted mean concentrations of 3,259, 516 and 678 mg L^{-1}, respectively. Alkali Lake contained relatively high concentrations of total hardness as calcium and total dissolved solids. Weighted-volume mean concentrations of total hardness and total dissolved solids was 1,077 and 7,886 mg L^{-1}.

Total phosphate as P concentrations ranged between 0.036 mg L^{-1} and 0.139 mg L^{-1}, with a volume-weighted mean concentration of 0.108 mg L^{-1}. The nitrate plus nitrite as N concentrations ranged between 0.00 and 0.181 mg L^{-1}, with a volume-weighted mean concentration of 0.061 mg L^{-1}. The ratios between total phosphate as P and nitrate + nitrite as N concentrations of 1.8:1 indicate Alkali Lake is nitrogen limited. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 19, 1992 and March 2, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Alkali Lake		1982-1991	
Total Dissolved Solids	7477	mg L^{-1}	1209	mg L^{-1}
Conductivity	9830	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	1072	mg L^{-1}	488	mg L^{-1}
Sulfates	3317	mg L^{-1}	592	mg L^{-1}
Chloride	674	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.106	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.065	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	942	mg L^{-1}	296	mg L^{-1}
Ammonia	0.071	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.84	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	815	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Alkali Lake as part of the LWQA project. The survey was conducted on July 29, 1992.

At the time of the macrophyte survey, only one submergent and 2 emergent macrophyte species were identified on Alkali Lake. Approximately 20 percent of the lake's surface area contained aquatic vegetation. Nearly 100 percent of the lake's surface area to a depth of approximately two feet contained solid stands of sago pondweed Potamogeton pectinatus accompanied by a narrow intermittent band of cattails Typha spp. and bulrush Scripus spp.. A map depicting the areal extent of macrophyte coverage on Alkali Lake is contained in Appendix B.

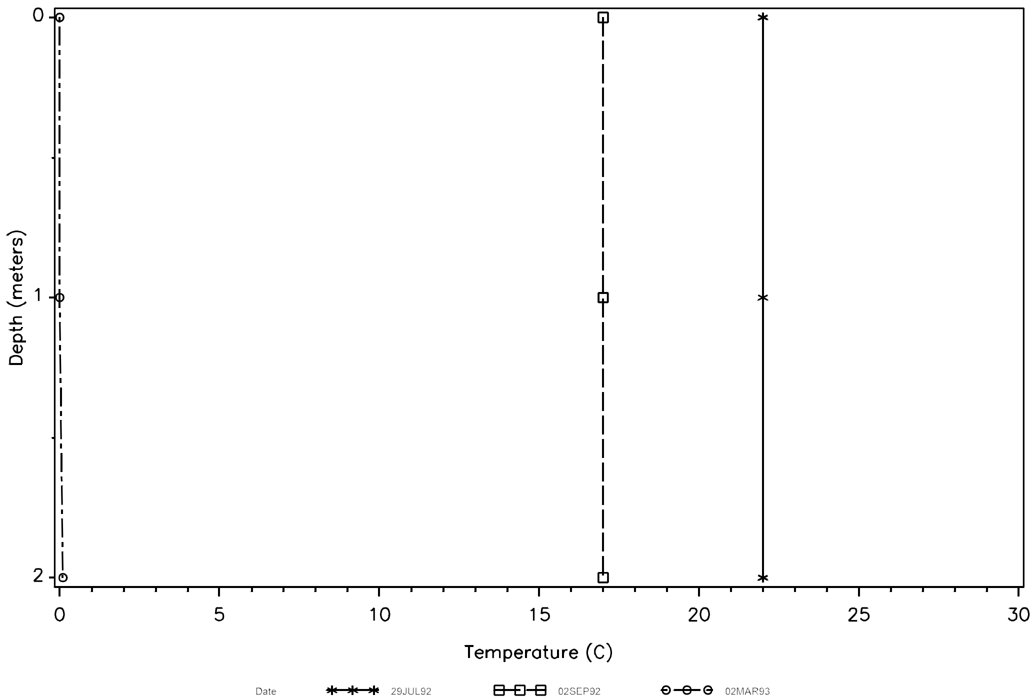


Figure 2. Temperature profile for Alkali Lake.

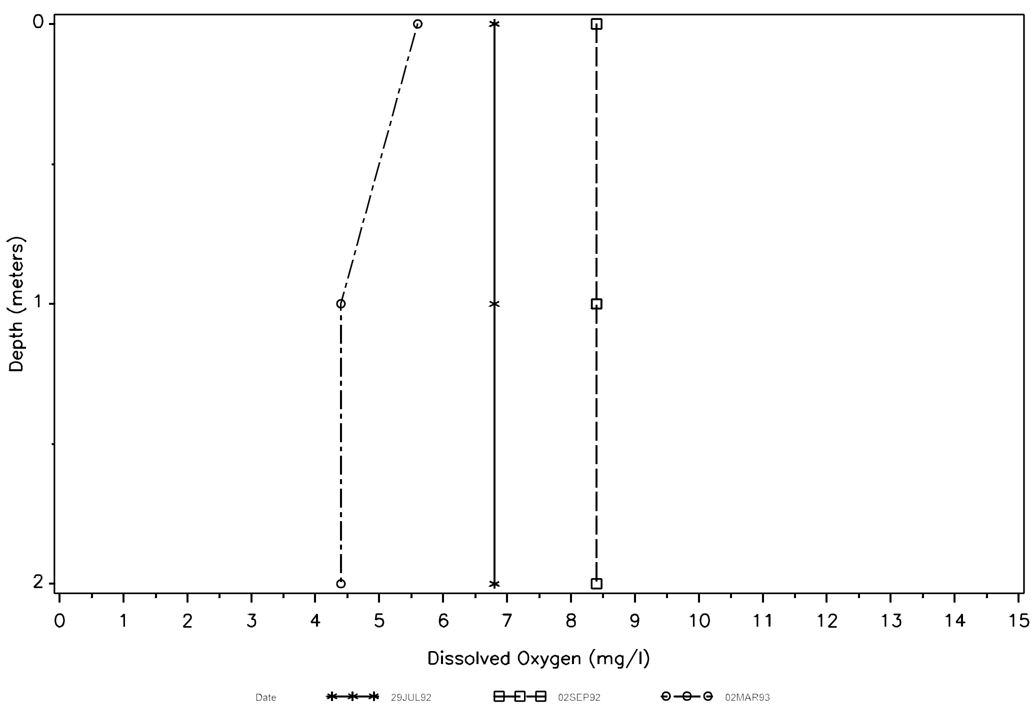


Figure 3. Oxygen profile for Alkali Lake.

Phytoplankton

Alkali Lake's phytoplankton community was sampled two times during the summer of 1992. The phytoplankton community on Alkali Lake was represented by five divisions and 11 genera. The divisions represented were Bacillariophyta, Chlorophyta, Cryptophyta, Cyanophyta and Euglenophyta. The dominant phytoplankton division by density was the blue-green algae Cyanophyta, with a mean density of 27,876 representing a dominance of 1.5-fold over all other divisions combined. In order of descending abundance were the divisions Bacillariophyta, Chlorophyta, Cryptophyta and Euglenophyta.

Alkali Lake's phytoplankton community by volume was dominated by the division Bacillariophyta, with a mean volume of 14,931,243 cubic micrometers per milliliter. In order of next most abundant was the division Cryptophyta, with a mean volume of 126,000 micrometer per milliliter, followed by Cyanophyta, Euglenophyta and Chlorophyta. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Lake data collected during the summer of 1992 defined Alkali Lake as hypereutrophic. The three primary water quality indicators; chlorophyll-a concentrations, total phosphate as P concentrations and secchi disk transparency do not completely agree in defining Alkali Lake's trophic condition. Total phosphate as P collected at the surface during the summer of 1992 had a mean concentration of 86 $\mu g\ L^{-1}$. This concentration suggests a hypereutrophic lake condition. Chlorophyll-a concentrations of 12 $\mu g\ L^{-1}$ and a secchi disk depth average of 1.9 meters suggest a borderline mesotrophic to eutrophic lake condition. Combining these three indicators would suggest a eutrophic lake condition. However, ancillary information such as frequent fish kills, frequent nuisance algal blooms and large macrophyte biomass suggest a hypereutrophic condition. When weighing all of these indicators, both chemical and physical, a hypereutrophic lake status was assigned to Alkali Lake.

Sediment Analysis

Sediments were collected from Alkali Lake and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381360) and the littoral zone (Site 381362) (Figure 1).

Sediment samples collected from Alkali Lake had detectable levels of all trace elements tested for, except for mercury and selenium in the littoral and deepest area sediments. Reported concentrations of trace elements in the sediments collected from Alkali Lake were compared to the median concentrations reported for all lakes assessed in the LWQA project. In general, the reported concentrations of trace elements in the littoral area sediments were near the median concentrations reported for all lakes sampled during the LWQA project. The exceptions were arsenic and cadmium which were near the 75th percentile and lead which was below the 25th percentile.

As with the littoral sediment samples, the deepest area sediment contained trace element concentrations that were generally near or below the median concentration for all sediments samples collected from deep areas during the LWQA project with the exception of lead which was below the 25th percentile. Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Alkali Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Walleye were the only fish species collected for contaminant analysis from Alkali Lake in 1992. The walleye sample collected was composed of two walleye, with a mean length of 35 centimeters and a mean weight of 403 grams.
In order to evaluate the fish tissue data for Alkali Lake, the results were compared to all piscivores assessed in the LWQA project. Reported trace element concentrations in the fish sample collected from Alkali Lake were generally below the 25th percentile, with the exceptions of chromium and lead, which were near or equal to the 75th percentile at 0.287 and 0.61 $\mu g\ g^{-1}$, respectively.

Detectable pesticide residues in the walleye sample collected from Alkali Lake included DDE, dieldrin and trifluralin. DDE is a degradation product of the insecticide DDT and can produce biological effects similar to the parent compound when available to the environment. Dieldrin is an agricultural insecticide that can be extremely toxic to aquatic invertebrate and vertebrate populations. Trifluralin, commonly known as treflan, is an agricultural pre-emergent herbicide. DDT and dieldrin were both removed from agricultural use in the early 1970s due to their potentially harmful effects on the environment.

The DDE concentration reported in the walleye sample collected from Alkali Lake of 0.011 $\mu g\ g^{-1}$ is above the median concentration of 0.009, but below the 75th percentile of 0.018 $\mu g\ g^{-1}$. The reported concentration of dieldrin in the walleye sample of 0.002 $\mu g\ g^{-1}$ is above the median concentration of 0.001, but below the 75th percentile of 0.003 $\mu g\ g^{-1}$. The reported concentrations of trifluralin of 0.005 is equal to the 75th percentile. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Alkali Lake's contributing watershed has a combined surface area of 759 acres, located on the northern edge of the Prairie Coteau in Sargent County, North Dakota. The Prairie Coteau is a glacial erosion remnant of the Wisconsin Age. The surrounding landscape is characterized by rolling hills, valleys and small potholes. Soils are predominantly excessively drained, built from gravely, sandy, glacial materials. Nonpoint source pollution from the surrounding watershed accounts for 100 percent of the nutrient loadings and pollution discharges to Alkali Lake.

Land use within the Alkali Lake watershed is 75 percent agricultural, with 58 percent actively cultivated. The remaining 42 percent is in low density urban development, haylands, pasture, Conservation Reserve Program (CRP) and wildlife management (Table 2). According to the information provided by the Sargent County Soil Conservation District, 80 percent of the cultivated lands and 85 percent of all the remaining lands within the Alkali Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Alkali Lake watershed, the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of over 4 tons per acre, which takes into account the untreated portions of the watershed, approximately 3,082 tons of soil are lost from the watershed annually. Assuming a conservative delivery rate of 10 to 15 percent, between 308 and 462 tons of soil reaches Alkali Lake annually. Other sources of nonpoint source pollution discharges to Alkali Lake other than soil erosion from agricultural fields are livestock water and feeding in the immediate upstream drainage and construction activities.

Table 2. Land use in the Alkali Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	58.0	88
Rangeland	9.2	85
Hayland	0.0	0
CRP	0.0	100
Wet/Wild[1]	24.5	N/A
Other	8.3	N/A
Farmsteads	0[3]	N/A
Feedlots[2]	0[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

ARNEGARD DAM

MCKENZIE COUNTY

Peter N. Wax

Arnegard Dam has a surface acreage of 23.9 acres, a maximum depth of 22 feet and an average depth of 8.5 feet (Figure 1). The dam lies across the main stem of Timber Creek approximately 3 miles northeast of Arnegard, North Dakota. Timber Creek is a tributary of the Missouri River.

Arnegard Dam was built for water based recreation in 1934 by the Civilian Conservation Corp (CCC). In 1967 the dam was reconstructed and raised by the State Water Commission (SWC), the McKenzie County Park Board, McKenzie County and the NDG&F. The 1967 dam is now owned by the McKenzie County Water Resource District.

Arnegard Dam and contributing watershed lie on the Missouri Slope Upland physiographic region of North Dakota. The Missouri Slope Uplands are composed primarily of rolling to hilly uplands, except in the badland areas and near prominent buttes. Slopes are generally gentle with maximum relief ranging from 300 to 500 feet. Land use within the Arnegard Dam watershed is primarily agricultural, predominantly in small grain production.

Arnegard Dam is classified as a marginal fishery, "Waters capable of supporting a fishery on a seasonal basis" (NDSDHCL 1991). The impoundment is managed by the NDG&F through annual fish community assessments and fish stockings. In recent years, the stocking regiment has included northern pike and yellow perch. A fish community assessment conducted in 1991 by the NDG&F captured black bullhead, golden shiner, white sucker, northern pike and yellow perch.

Arnegard Dam's fishery is dependent on the number of years it can survive between winterkills. Pike and perch stocked periodically show good growth rates and high productivity between severe winters. Heavy algal blooms and dense mats of submerged aquatic vegetation are historically prevalent on Arnegard Dam. At this time there are no recreational facilities available at Arnegard Dam.

Water Quality

Water quality samples were collected from Arnegard Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380650, Figure 1). Water column samples were collected for analysis at three separate depths on July 14, 1992 and two separate depths on August 10, 1992, and February 17, 1993.

During the summer of 1992 Arnegard Dam was not thermally stratified at either of the two sample periods (Figure 2). During these time periods, dissolved oxygen concentrations were adequate to maintain aquatic life (Figure 3). Samples collected during the winter of 1992 again showed a water column that had not developed thermal stratification (Figure 2). Oxygen concentrations at this time ranged from 3.6 mg L^{-1} near the surface to 0.1 mg L^{-1} near the bottom.

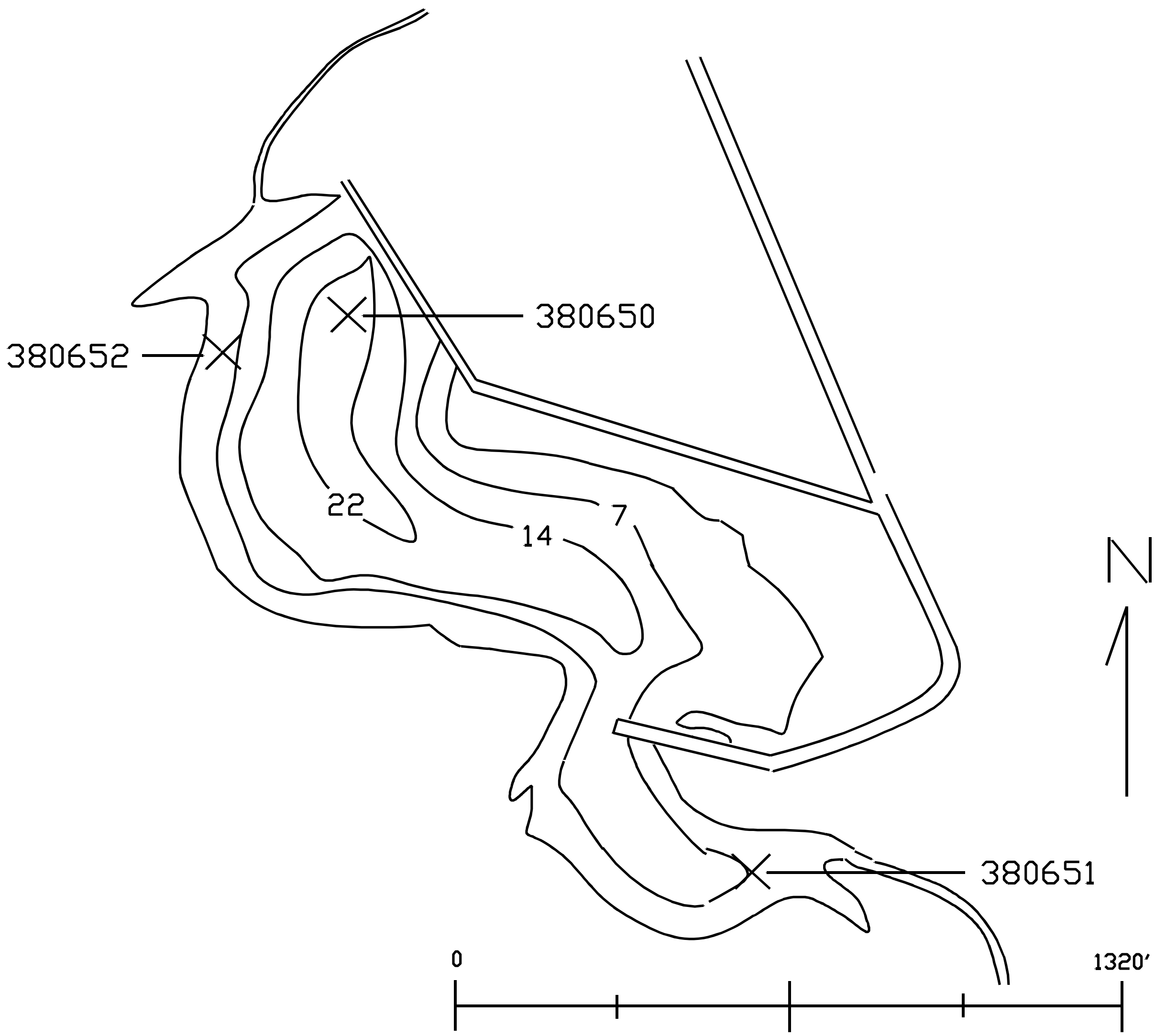


Figure 1. Morphometric map for Arnegard Dam.

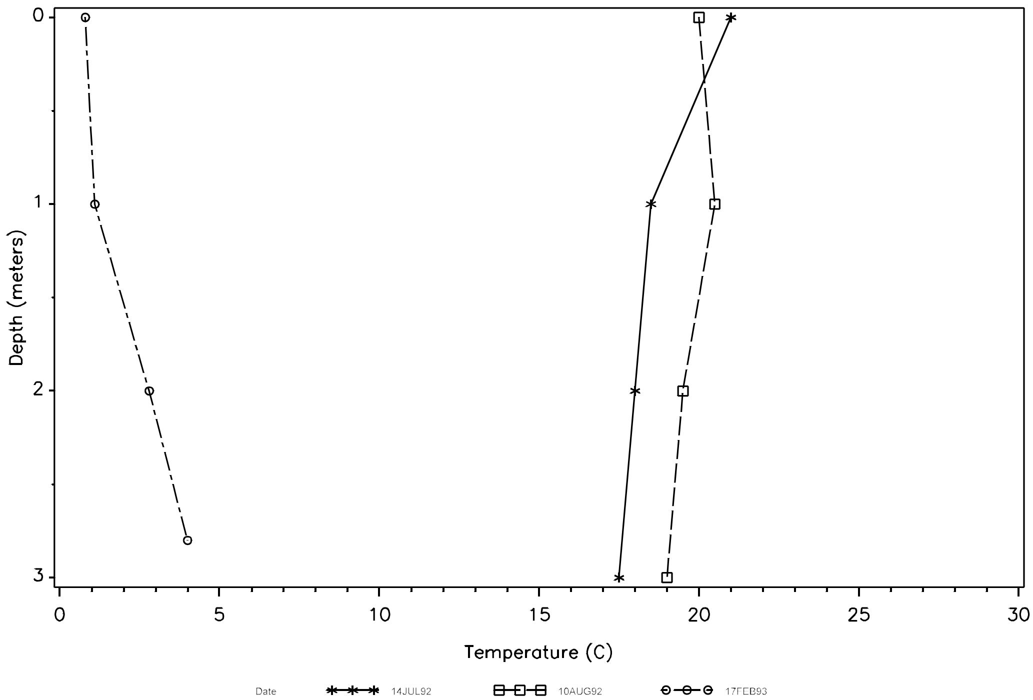


Figure 2. Temperature profile for Arnegard Dam.

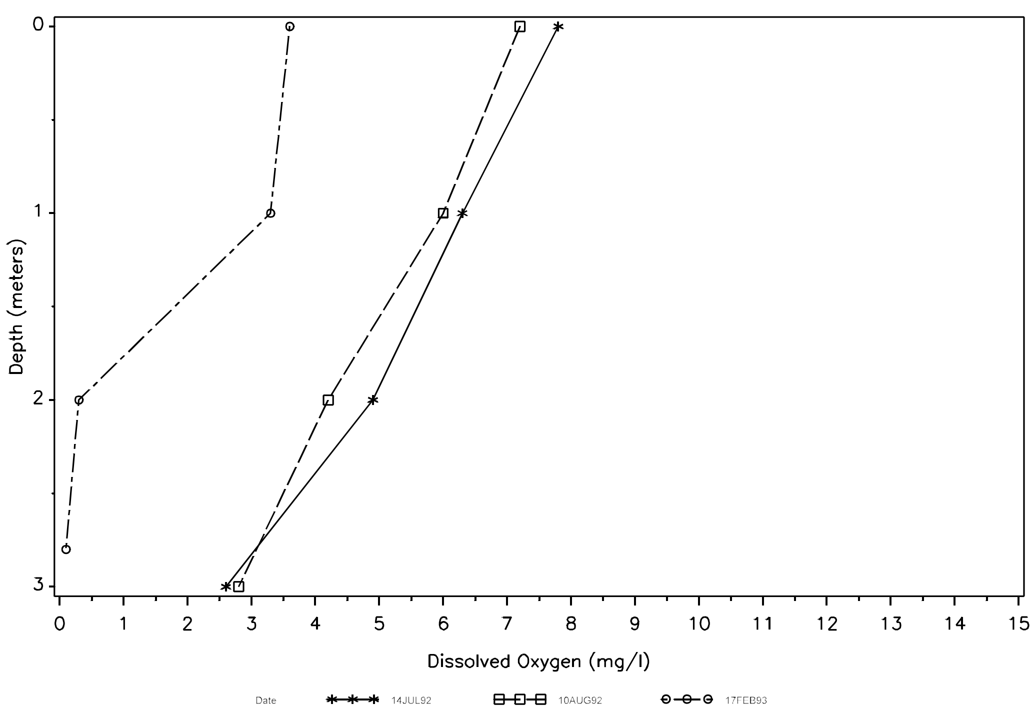


Figure 3. Oxygen profile for Arnegard Dam.

Arnegard Dam is a well-buffered waterbody. Total alkalinity as $CaCO_3$ had a volume-weighted mean concentrations of was 462 mg L^{-1} (Table 1). The dominant anions in the water column were sulfates and bicarbonates. Sulfate concentrations ranged between 171 and 322 mg L^{-1}, with a volume-weighted mean of 216 mg L^{-1}. Bicarbonates ranged from 371 to 810 mg L^{-1}, with a weighted volume mean of 524 mg L^{-1} (Table 1).

The volume-weighted mean concentrations of total phosphate as P was 0.165 mg L^{-1}, exceeding the state's target concentration of 0.020 mg L^{-1} on all occasions sampled. Nitrate plus nitrite as N concentrations had a volume-weighted mean of 0.009 mg L^{-1} and was below the state's target concentration of 0.25 mg L^{-1} on all occasions sampled. The ratios of total phosphate as P and nitrate plus nitrite as N of 18:1 suggest Arnegard Dam is severely nitrogen limited (Table 1). A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 14, 1992 and February 17, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Arnegard Dam		1982-1991	
Total Dissolved Solids	784	mg L^{-1}	1209	mg L^{-1}
Conductivity	1175	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	334	mg L^{-1}	488	mg L^{-1}
Sulfates	216	mg L^{-1}	592	mg L^{-1}
Chloride	7	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.165	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.009	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	462	mg L^{-1}	296	mg L^{-1}
Ammonia	0.075	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.12	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	524	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Arnegard Dam as part of the LWQA project. The survey was conducted on July 14, 1992.

At the time of the macrophyte survey, Arnegard Dam had abundant macrophytes which occupied nearly 25 percent of the lake's surface area. Nearly 100 percent of the lake's surface area to a depth of approximately seven feet was occupied by mixed stands of water milfoil Myriophyllum spp. and sago pondweed Potamogeton pectinatus. A ring of cattails Typha spp. occupied approximately 90 percent of the shoreline to a depth of two feet. A map depicting the areal extent of macrophyte coverage on Arnegard Dam is contained in Appendix B.

Phytoplankton

Arnegard Dam's phytoplankton community was sampled two times during the summer of 1992. Arnegard Dam's phytoplankton community was diverse, with representation from seven divisions and 32 genera. The Arnegard Dam phytoplankton community by density was dominated by green algae, Chlorophyta, during both sample periods. The domination by the green algae, Chlorophyta, was significant, as its population was larger by 14 fold than all other divisions combined. Other divisions represented in descending order of dominance were Chrysophyta, Bacillariophyta, Cyanophyta, Euglenophyta and Pyrrophyta.

An examination of the phytoplankton community on Arnegard Dam by volume shows Chrysophyta as the dominant division. The difference in the phytoplankton community from volume to density is due to the size of individual organisms. The organism Dinopryan divergens in the division Chrysophyta is very large in comparison to many of the other phytoplankton present in Arnegard Dam. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

An examination of all the data available during the LWQA project suggests Arnegard Dam is a eutrophic reservoir. This assessment was reached by combining both ancillary and water quality data. The secchi disk transparency and chlorophyll-a concentrations suggest Arnegard Dam as borderline mesotrophic to eutrophic. The relatively high concentrations of summer surface total phosphate as P concentrations of 116 and 35 $\mu g\ L^{-1}$ indicate Arnegard Dam is hypereutrophic. Ancillary data such as historical fish kills, large macrophyte biomass, frequent nuisance algal blooms and a history of low dissolved oxygen under ice cover conditions suggest a hypereutrophic lake condition. All parameters combined indicate Arnegard Dam is eutrophic.

Sediment Analysis

Sediments were collected from Arnegard Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 380650), the littoral zone (Site 380652) and the inlet (Site 380651) (Figure 1).

Sediments collected from Arnegard Dam show detectable levels of all trace elements tested for, except mercury in the deepest and inlet sediments and selenium in the inlet area sediments. Reported trace element concentrations in the sediments at each sample location within Arnegard Dam were compared to the median concentrations reported for all lakes assessed in the LWQA project. In general, the reported trace element concentrations in the sediments collected from Arnegard Dam were high, often exceeding the 75th percentile concentrations reported for the LWQA project. The exceptions were the selenium concentrations in all sediment samples collected from Arnegard Dam and lead in the inlet and littoral area sediments which were near or below the 25th percentile.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Arnegard Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Northern pike and white suckers were collected for contaminant analysis from Arnegard Dam. The northern pike sample consisted of four fish with a mean length of 62.5 centimeters and a mean weight of 1,628 grams. The white sucker sample collected was a composite of five fish with a mean length of 43.2 centimeters and a mean weight of 1,150 grams.

In order to evaluate the fish tissue data for Arnegard Dam, the results for each fish sample was compared to that group for all lakes assessed in the LWQA project. Trace element concentrations in the fish samples collected from Arnegard Dam were in general near or below the median concentrations for all fish analyzed during the LWQA project. The exception was the reported concentrations of zinc in the northern pike sampled of 47.4 $\mu g\ g^{-1}$ that was approximately equal to the 75th percentile.

Detectable pesticide residues in the fish samples collected from Arnegard Dam was limited to DDE. DDE is a degradation project of the insecticide DDT which can produce biological effects similar to the parent compound. The DDE concentrations reported were below the median concentrations for all fish sampled in the LWQA project at 0.004 $\mu g\ g^{-1}$ for the northern pike sample and 0.005 $\mu g\ g^{-1}$ for the white sucker sample. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Arnegard Dam's watershed lies on the Missouri Slope Upland physiographic regions of North Dakota. Arnegard Dam's watershed is a rather classic example of the Missouri Slope Uplands as it is composed primarily of rolling to hilly uplands except in the badland areas and near prominent buttes. The watershed itself covers 12,023 acres and contributes from nonpoint pollution sources 100 percent of the nutrient discharges and pollution loadings to Arnegard Dam.

Land use within the Arnegard Dam watershed is 97 percent agricultural, with 63.8 percent actively cultivated. The remaining 34.2 percent of the watershed is in low density urban development, haylands, pasture, Conservation Reserve Program (CRP), roads, farms and concentrated livestock feeding areas (Table 2).

According to the information provided by the McKenzie County Soil Conservation District, approximately 64 percent of all the cultivated lands and between 8 and 17 percent of all the remaining lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

Table 2. Land use in the Arnegard Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	63.8	64
Rangeland	17.5	17
Hayland	7.5	8
CRP	8.5	100
Wet/Wild[1]	0.0	N/A
Other	1.4	N/A
Farmsteads	23[3]	N/A
Feedlots[2]	7[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

It is estimated that within the Arnegard Dam watershed the average "T" value is three to five tons per acre. Based on an average soil loss of over nine tons per acre, which takes into account the untreated portions of the watershed, approximately 111,552 tons of soil are lost annual from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 11,155 and 16,732 tons of soil are delivered to Arnegard Dam annually. Other sources of nonpoint source pollution affecting Arnegard Dam are from the seven concentrated livestock feeding areas, road construction and low density urban development within the watershed.

BALTA DAM

PIERCE COUNTY

Peter N. Wax

Balta Dam is a small, narrow reservoir immediately south of the town of Balta in Pierce County, North Dakota. Balta Dam was built under the Works Project Administration in the early 1930s. The spillway eventually washed out and in 1961, the entire dam was rebuilt by the NDG&F and the State Water Commission (SWC). The impoundment presently encompasses 108 surface acres with a maximum depth of 17 feet and a mean depth of 7.9 feet (Figure 1). During the LWQA project no depths greater than 12.5 feet were located.

Balta Dam's watershed lies on the eastern edge of the Missouri Coteau. A physiographic region characterized by regular patterns of hills and shallow depressions. Topography is rolling with shifts in relief of up to 300 feet, but primarily ranging from 50 to 80 feet. Soils in this region are generally formed from rocky gravel or sandy glacial till and are moderately to well drained. Balta Dam has a very large watershed to lake size ratio of 251:1. Land use in the region is primarily agricultural.

Balta Dam is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Balta Dam by annually assessing the fish community by test netting and stock accordingly. In recent years the stocking regiment has included northern pike and walleye. Fish community assessments conducted by the NDG&F in 1990 captured both northern pike and walleye in reasonable numbers and good sizes.

Recreational use on Balta Dam is regulated by fishing success. The Balta Wildlife Club has developed facilities on the south shore of the lake that include a picnic area, toilets and a boat ramp.

Water Quality

Water quality samples were collected from Balta Dam two times during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380975, Figure 1). Water column samples were collected for analysis at two discrete depths. One at approximately a meter depth and the second between 3 and 3.5 meters of depth.

Balta Dam had developed weak thermal stratification between two and three meters on July 21, 1992 however Balta Dam was not thermally stratified on either August 17, 1992, or March 3, 1993 (Figure 2). Dissolved oxygen concentrations during the summer of 1992 were adequate to maintain aquatic life with concentrations ranging between 19.9 mg L^{-1} at the surface to 3.6 mg L^{-1} at the bottom in July and 13.6 mg L^{-1} at the surface and 1.2 mg L^{-1} at the bottom in August (Figure 3). Dissolved oxygen concentrations on the March 3, 1993, ranged between 1.2 mg L^{-1} at the surface to 0.1 mg L^{-1} near the bottom (Figure 3).

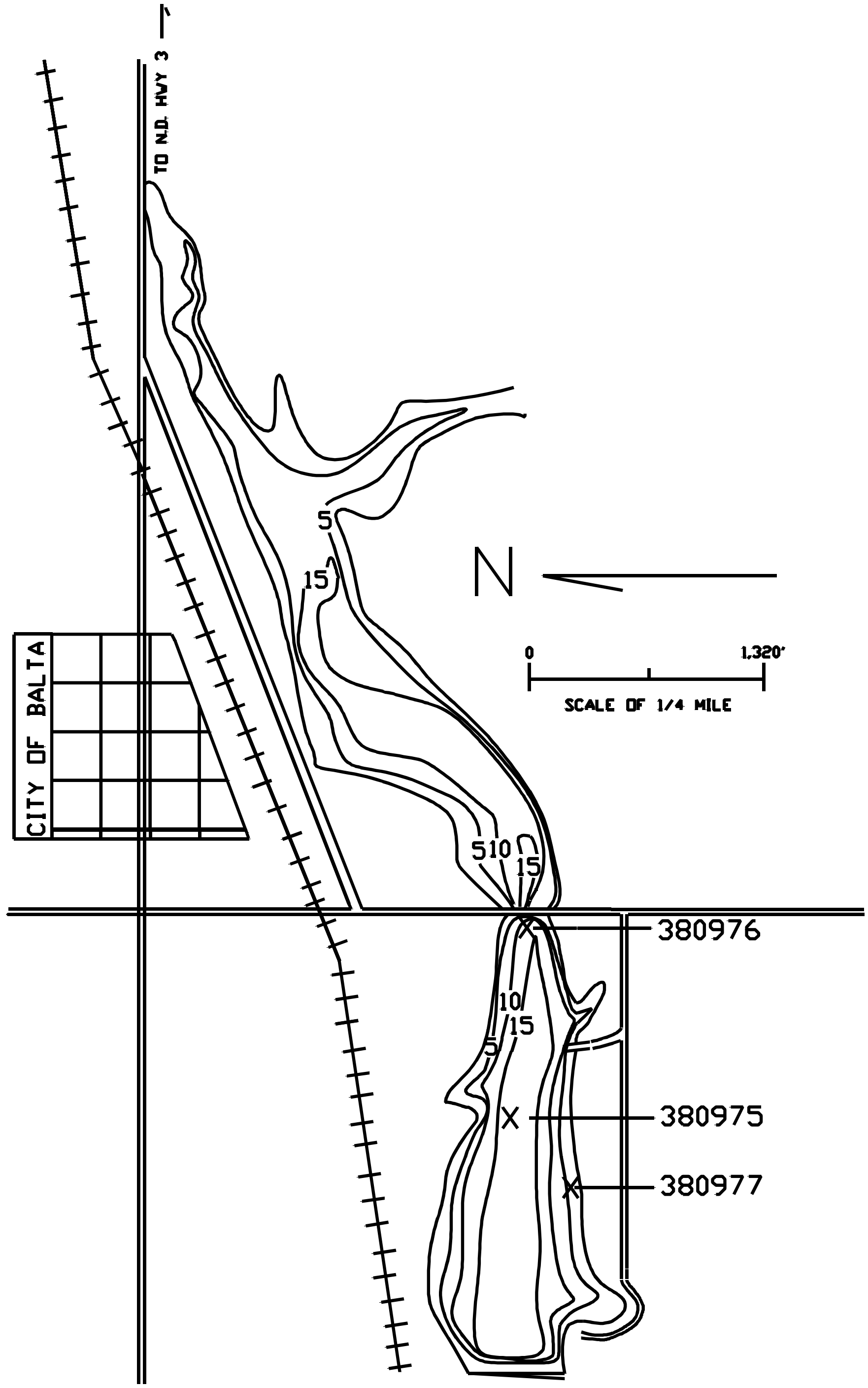


Figure 1. Morphometric map of Balta Dam.

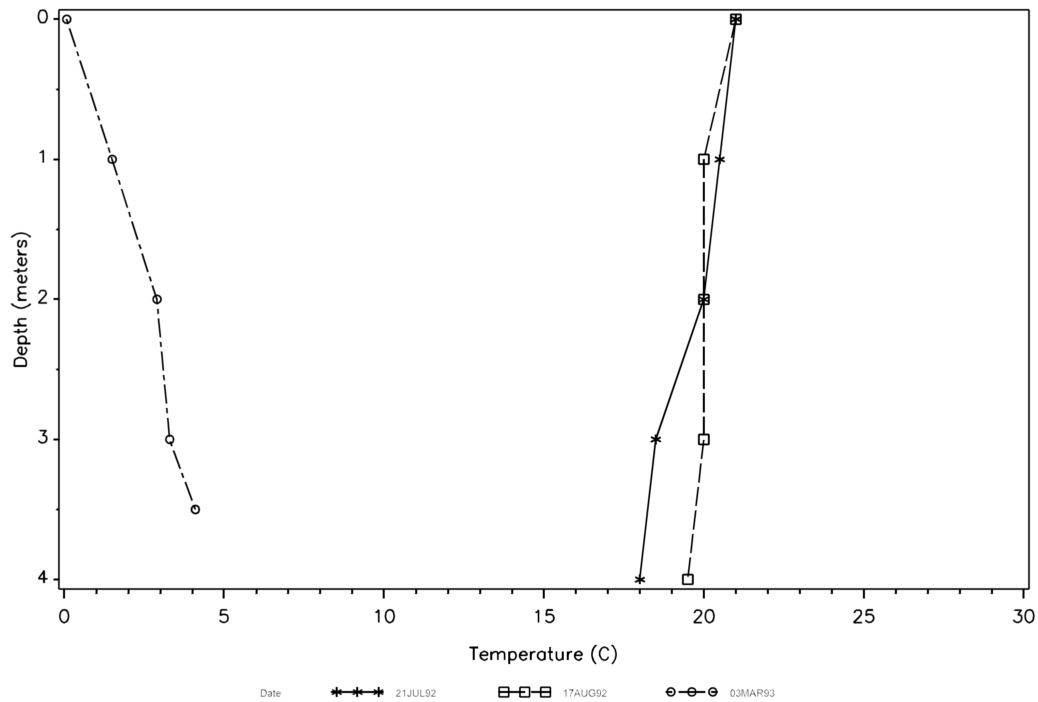


Figure 2. Temperature profile for Balta Dam.

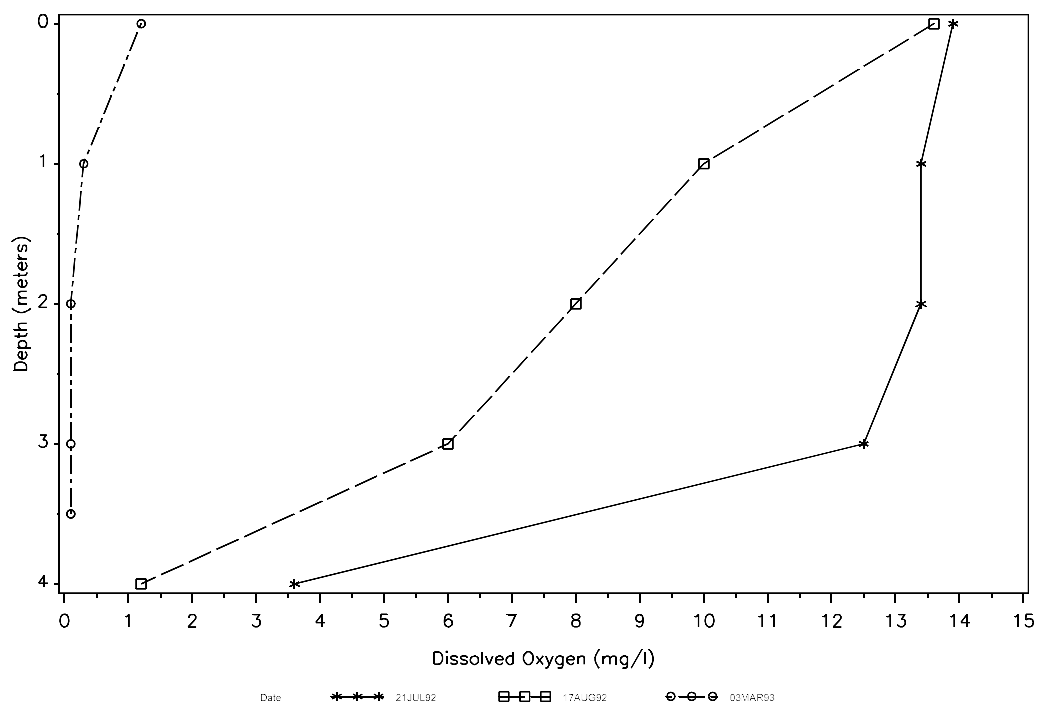


Figure 3. Oxygen profile for Balta Dam.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 21, 1992 and March 3, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Balta Dam		1982-1991	
Total Dissolved Solids	590	mg L^{-1}	1209	mg L^{-1}
Conductivity	918	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	173	mg L^{-1}	488	mg L^{-1}
Sulfates	145	mg L^{-1}	592	mg L^{-1}
Chloride	11.0	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.195	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.003	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	356	mg L^{-1}	296	mg L^{-1}
Ammonia	0.315	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.67	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	382	mg L^{-1}	326	mg L^{-1}

The volume-weighted mean concentration for total alkalinity as $CaCO_3$ was 356 mg L^{-1}, indicating Balta Dam is a well-buffered waterbody (Table 1). Concentrations of total dissolved solids, hardness as calcium, and conductivity were lower than the state's long-term average and lower than most other lakes sampled during the LWQA project (Table 1).

The dominant anions in Balta Dam's water column were sulfates and bicarbonates. Sulfate concentrations ranged from 120 to 199 mg L^{-1} with a volume-weighted mean of 145 mg L^{-1}. Bicarbonates concentrations ranged from 308 to 588 mg L^{-1} with a volume-weighted mean of 582 mg L^{-1} (Table 1).

The volume-weighted mean concentrations of the nutrients total phosphate as P and nitrate + nitrite as N concentrations were 0.195 mg L^{-1} and 0.003 mg L^{-1}, respectively. The ratios between these two nutrients of 65:1 suggest a nitrogen-limited lake condition. Nitrogen-limited implies the supply of nitrogen limits primary production within a lake body. However, on Balta Dam this condition does not limit primary production but instead favors nitrogen fixing organisms such as some species of blue-green algae.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Balta Dam as part of the LWQA project. The survey was conducted on July 21, 1991.
At the time of the macrophyte survey approximately 15 percent of Balta Dam's surface area had aquatic vegetation.

Nearly 100 percent of the lake's surface area on the eastern edge of the lake to a depth of seven feet had solid stands of sago pondweed Potamogeton pectinatus or mixed stands of Potamogeton pectinatus and water milfoil Myriophyllum spp.. Cattails Typha spp. line nearly 100 percent of Balta Dam's shoreline to a depth of two feet extending approximately ten meters out from the shoreline. A map depicting the macrophyte areal coverage on Balta Dam is contained in Appendix B.

Phytoplankton

Balta Dam's phytoplankton community was sampled two times during the summer of 1991. During these sample times the phytoplankton community was represented by five divisions and 68 genera. The largest contributors by density were the blue-green algae, Cyanophyta, with 27 genera represented. In order of next most abundant the divisions represented were Chlorophyta, Bacillariophyta, Cryptophyta and Pyrrophyta. The blue-green algae's domination of the phytoplankton community by density was quite significant with a mean density of 5,359,188 cells mL^{-1}, representing a 14 fold dominance over all other divisions combined.

The phytoplankton community on Balta Dam by volume did not show the same dominance by the blue-green algae Cyanophyta as by density. By volume the dominant division was Chlorophyta with a mean volume of 2,583,307 $\mu m\ L^{-1}$. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Lake water quality assessment data collected during the summer of 1992 indicate Balta Dam is hypereutrophic. The three primary indicators used in making this assessment secchi disk transparency, chlorophyll-a concentrations and summer surface total phosphate as P concentrations all indicating Balta Dam is hypereutrophic. Chlorophyll-a concentrations ranged between 14 and 22 $\mu g\ L^{-1}$, summer surface total phosphate as P concentrations ranged between 199 and 177 $\mu g\ L^{-1}$, and secchi disk depth transparency readings were between 0.3 and 0.4 meters. Collaborating ancillary information supporting a hypereutrophic lake assessment is a large macrophyte biomass, frequent nuisance algal blooms and low dissolved oxygen concentrations below the hypolimnion and under ice cover conditions.

Sediment Analysis

Sediments were collected from Balta Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 380975), the littoral zone (Site 380977) and the inlet (Site 380976) (Figure 1). Sediment samples collected from Balta Dam show detectable levels of all trace elements tested for except mercury in the inlet, littoral and deepest areas of the lake and selenium in the inlet and deepest areas. Reported trace element concentrations at each sample location within Balta Dam were compared to the median concentrations reported for all lakes assessed in the LWQA project.

The reported trace element concentrations in the sediment samples collected from Balta Dam can be divided into two groups. The first group would be the deepest and littoral area sediments which had concentrations that were generally below the median and 25th percentile concentrations. The second group would be the sediments collected from the inlet area which again were generally below the median and 25th percentile, with the exceptions of zinc, chromium and arsenic which were near or above the 75th percentile for sediments analyzed during the LWQA project. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Balta Dam on June 6, 1992. A single walleye sample was collected composed of five fish with an average length of 45.8 centimeters and an average weight of 1,148 grams.

In order to evaluate the fish tissue data for Balta Dam the results for each fish group was compared to that group for all lakes assessed in the LWQA project. Of the trace elements tested for in the walleye sample collected from Balta Dam, copper, arsenic and cadmium were below detectable limits. The reported concentrations of the detectable trace elements in the walleye sample collected from Balta Dam in general were near or below the 25th percentile for all fish samples collected in the LWQA project. The exceptions were the reported concentrations for barium and selenium that were slightly above the reported median concentrations.

The only detectable pesticide residues found in the walleye sample collected from Balta Dam was trifluralin. Trifluralin is an agricultural pre-emergent herbicide commonly known as treflan. Treflan has a 96-hour LC50 for bluegill of 58 $\mu g\ g^{-1}$ (Johnson and Finley, 1980).

The reported concentration of trifluralin in the walleye sample from Balta Dam was 0.008 $\mu g\ g^{-1}$. The concentration of 0.008 $\mu g\ g^{-1}$ is above the 75th percentile for all piscivores analyzed in the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Balta Dam and its contributing watershed has a combined surface area of 27,133 acres located on the glaciated plains in Pierce County, North Dakota. The surrounding landscape is characterized by rolling hills and valleys. Soils are predominantly well drained to excessively well drained, built from gravely, sandy, glacial materials. Nonpoint source pollution from the surrounding watershed accounts for all the nutrient loadings and pollution discharges to Balta Dam.

Land use within the Balta Dam watershed is 91 percent agricultural, with 70.8 percent actively cultivated. The remaining 29 percent is in low density urban development, haylands, pasture, Conservation Reserve Program (CRP), wetlands and wildlife management (Table 2). According to the information provided by the Pierce County Soil Conservation District, 80 percent of the cultivated lands and between 30 and 85 percent of all the remaining lands within the watershed are adequately treated against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequate treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Balta Dam watershed, the average "T" value is three to five tons per acre. Based on an average soil loss of just under three tons per acre, which takes into account all land uses and practices currently employed, approximately 77,392 tons of soil are lost from the watershed annually. Assuming a conservative delivery rate of 10 to 15 percent between 7,739 and 11,069 tons of soil are deposited in Balta Dam annually.

Other sources of nonpoint source pollution discharged to Balta Dam are from cattle feeding and watering in the immediate upstream drainage, the 13 concentrated livestock feedings areas and storm water runoff from the city of Balta. These sources have the capabilities to contribute a significant percentage of Balta Dam's annual nutrient and may be some of the most significant sources due to their proximity to the immediate drainage.

Table 2. Land use in the Balta Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	70.8	80
Rangeland	13.1	30
Hayland	5.0	75
CRP	1.9	N/A
Wet/Wild[1]	5.6	N/A
Other	2.2	N/A
Farmsteads	33.0[3]	N/A
Feedlots[2]	13.0[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

BAUKOL-NOONAN DAM

DIVIDE COUNTY

Peter N. Wax

Baukol-Noonan Dam is an abandoned coal mine that lies in the path of the west branch of Short Creek in Divide County, North Dakota, near the community of Noonan. Baukol-Noonan Mine operated between 1929 and 1950 before the current reclamation laws were in effect. The Baukol-Noonan Mines were donated to the NDG&F on June 8, 1983. Initial fish stockings occurred in 1983 on three depressions within the abandoned mines with relatively good survival rates. In 1986 a dam was created at the outlet of the largest of two of these depressions creating Baukol-Noonan Dam.

Baukol-Noonan Dam is a rectangularly-shaped, relatively deep waterbody, with a single rectangular shaped island on the east bank (Figure 1). It is a relatively small, yet deep reservoir with a surface area of 15.3 acres and a maximum depth of approximately 30 feet (Figure 1).

Topography of Baukol-Noonan Dam's watershed is a mixture of prereclamation spoils of clays and gravels, and relatively level undisturbed prairie and croplands. Land use within the watershed is nearly 100 percent agricultural. Soils in this region vary significantly, but are generally formed from medium to coarse textured sandy or clayey loamy glacial till. Soils are moderately erodible and moderately well drained. Annual precipitation in the watershed is between 15 and 18 inches a year with considerable variations between years.

The NDG&F manage Baukol-Noonan Dam by annually assessing the fish community through test netting operations and stock accordingly. In recent years, stockings have included both rainbow trout and brown trout, with a single stocking of walleye in 1991. Fish community assessments conducted by the NDG&F on July 9, 1991, captured in order of most abundant yellow perch and rainbow trout.

Access to Baukol-Noonan Dam is good from state and county roads. The last mile or so can be difficult during the winter and times of heavy precipitation. Facilities at Baukol-Noonan Dam are a picnic area which includes shelters, toilets and a boat ramp. Public use at Baukol-Noonan Dam is moderate to light depending on the season and the productiveness of the fishing.

Water Quality

Water quality samples were collected from Baukol-Noonan Dam two times during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 381320). During each sample visit water column samples were collected for analysis at three separate depths.

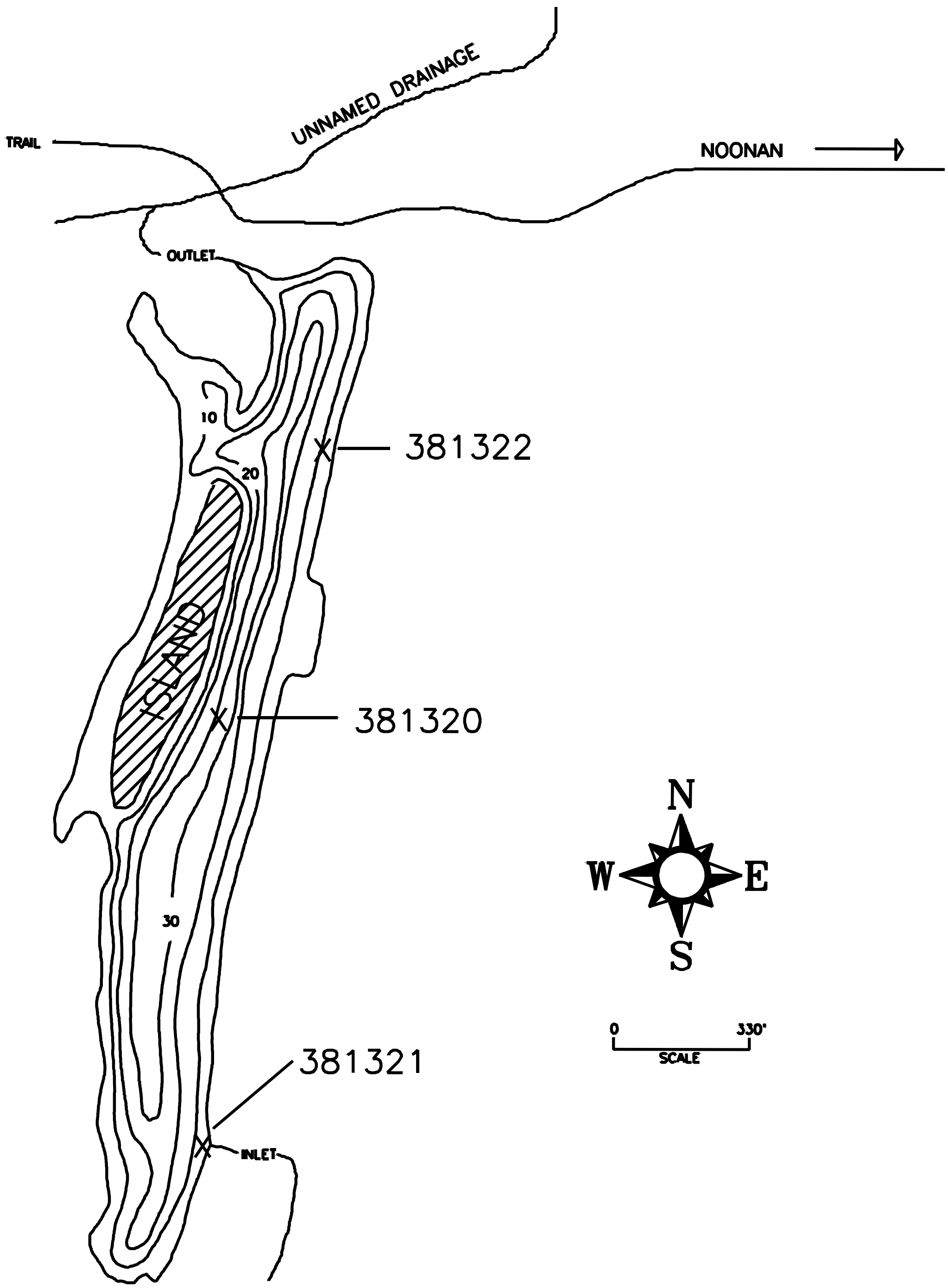


Figure 1. Morphometric map of Baukol-Noonan Dam.

On the sample date of July 14, 1992, Baukol-Noonan Dam was thermally stratified between 2 and 4 meters of depth, on August 12, 1992, Baukol-Noonan Dam was thermally stratified between 7 and 8 meters of depth and on January 23, 1993, Baukol-Noonan had not developed thermal stratification (Figure 2). Dissolved oxygen concentrations at all three sample times was near saturation to within 1 meter of the bottom or the depth of thermal stratification (Figure 3).

Baukol-Noonan Dam is a well-buffered waterbody with total alkalinity as $CaCO_3$ concentrations ranging between 307 and 374 mg L^{-1} and a volume-weighted mean of 329 mg L^{-1} (Table 1). The dominant anions in the water column were sulfates and bicarbonates. Sulfate concentrations ranged from 963 to 1350 mg L^{-1} with a volume-weighted mean of 1069 mg L^{-1}. Bicarbonate concentrations ranged from 324 to 414 mg L^{-1} with a volume-weighted mean of 356 mg L^{-1} (Table 1).

The nutrients total phosphate as P and nitrate + nitrite as N concentrations were relatively low in comparison to the state's long-term average and most lakes sampled during the LWQA project. Total phosphate as P concentrations ranged between 0.000 mg L^{-1} and 0.031 mg L^{-1} with a volume-weighted mean of 0.009 mg L^{-1} (Table 1). Nitrate + nitrite as N concentrations ranged between 0.010 and 0.099 mg L^{-1} with a volume-weighted mean of 0.026 mg L^{-1} (Table 1). The relatively low concentrations of these nutrients reward the reservoir with a relatively clear water column indicated with secchi disk transparency averaging nearly 2 meters.

The ratios of total phosphate as P and nitrate + nitrite as N concentrations ranged from 1:34 to 1:1.2 with a volume-weighted mean ratio of 1:3. These ratios suggest that at least during certain times of the year and particularly at depths within the photic zone Baukol-Noonan Dam is phosphorus limited.

A lake is generally considered phosphorus limited when the ratio of phosphorus to nitrogen is approximately 1:15. When the phosphorus to nitrogen ratio is less than 1:15, nitrogen is probably the limiting nutrient (EPA-440/5-81-003, 1980).

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 14, 1992 and February 23, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Baukol-Noonan Dam		1982-1991	
Total Dissolved Solids	2060	mg L^{-1}	1209	mg L^{-1}
Conductivity	2834	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	311	mg L^{-1}	488	mg L^{-1}
Sulfates	1169	mg L^{-1}	592	mg L^{-1}
Chloride	37	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.009	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.026	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	329	mg L^{-1}	296	mg L^{-1}
Ammonia	0.029	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	0.903	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	356	mg L^{-1}	326	mg L^{-1}

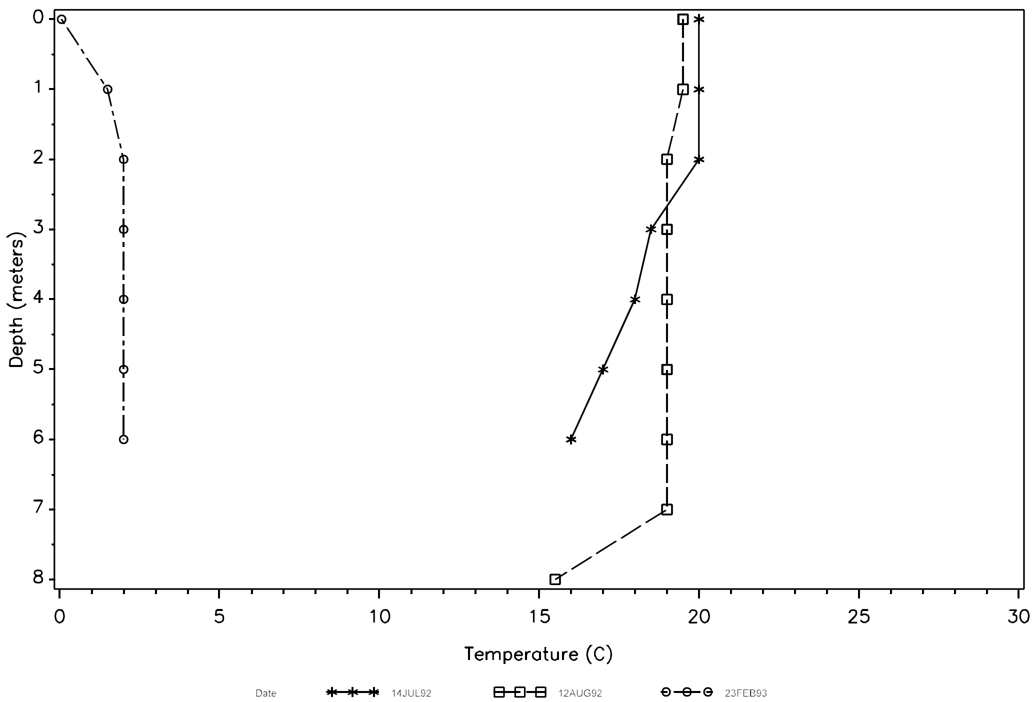


Figure 2. Temperature profile for Baukol-Noonan Dam.

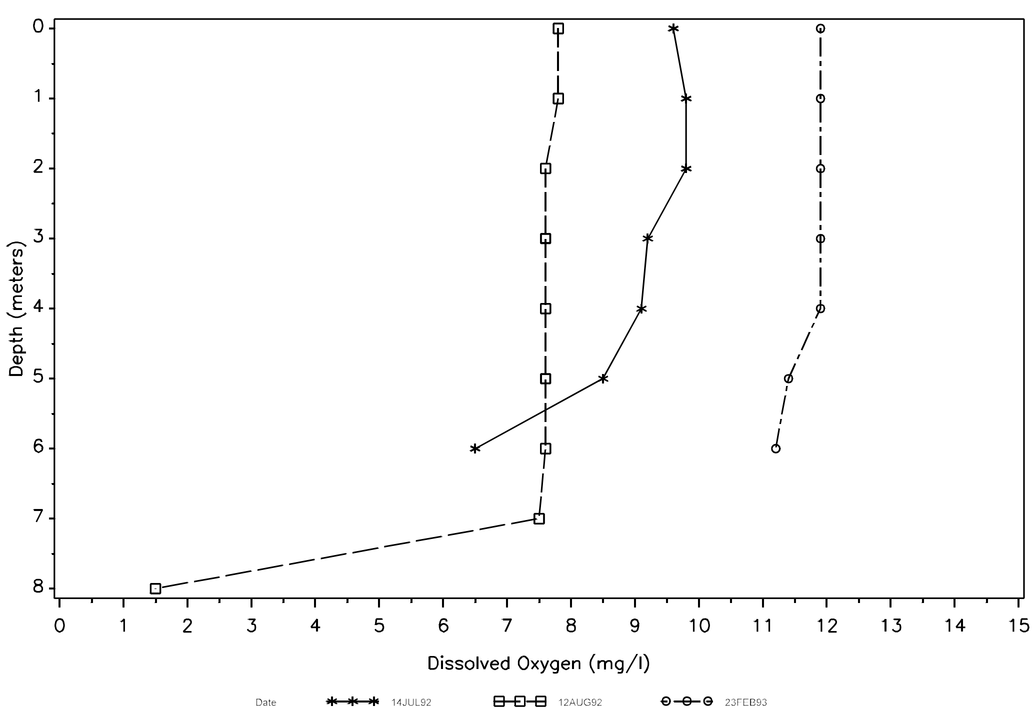


Figure 3. Oxygen profile for Baukol-Noonan Dam.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Baukol-Noonan Dam as part of the LWQA project. The survey was conducted on July 14, 1992.

At the time of the macrophyte survey, sparse stands of water milfoil Myriophyllum spp. and sago pondweed Potamogeton pectinatus were present on Baukol-Noonan Dam to a depth of approximately ten feet. The shore line had sparse stands of cattails Typha spp., bulrush Scirpus spp. and arrowhead Sagittaria spp. A map depicting the macrophyte areal coverage on Baukol-Noonan Dam is contained in Appendix B.

Phytoplankton

Baukol-Noonan Dam's phytoplankton community was sampled two times during the summer of 1992. Baukol-Noonan Dam's phytoplankton community during the two sample periods had representation from six divisions and 16 genera. Divisions represented in order of descending dominance were Chlorophyta, Cyanophyta, Cryptophyta, Chrysophyta, Bacillariophyta and Pyrrophyta. The community structure by density was dominated by the division Chlorophyta, which had a mean density of 10,899 cells mL^{-1}, dominating all other groups by 2.2 fold.

Baukol-Noonan Dam's phytoplankton community by volume was dominated by the division Pyrrophyta, followed by the divisions Chrysophyta, Cryptophyta, Chlorophyta, Bacillariophyta and Cyanophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

LWQA data collected during 1992 indicates Baukol-Noonan Dam is a mesotrophic waterbody, bordering on eutrophic. Primary water quality indicators of this condition are summer surface total phosphorus as P concentrations ranging between nondetectable to 23 $\mu g\ L^{-1}$ and secchi disk transparencies of 1.5 and 2.4 meters. Supporting ancillary information of a mesotrophic lake conditions are a diverse low density phytoplankton population dominated by algal species other than Cyanophyta, no history of fish kills and a low macrophyte biomass.

Sediment Analysis

Sediments were collected from Baukol-Noonan Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381320), the littoral area of the lake (Site 381322) and the inlet area of the lake (Site 381321) (Figure 1).

Sediment samples collected from Baukol-Noonan Dam show detectable levels of all trace elements tested for, except for mercury in the deepest and inlet area sediments. Reported concentrations of trace elements at each sample location within Baukol-Noonan Dam were compared to the median concentrations reported for all lakes assessed in the LWQA project. In general, reported trace element concentrations in the deepest and inlet areas had reported concentrations that were near or below the median for all lake sediment samples collected during the LWQA project. The exceptions were the recorded chromium concentrations which were near or at the 75th percentile. The littoral area sediments, however, contained reported concentrations of trace elements that were near or above the 75th percentile for all lake sediments collected during the LWQA project.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Baukol-Noonan Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

A walleye sample was collected for contaminant analysis from Baukol-Noonan Dam on August 13, 1992. The walleye sample was composed of four walleye with an average length of 21 centimeters and an average weight of 145 grams.

In order to evaluate the fish tissue data for Baukol-Noonan Dam the results from the walleye sample was compared to all piscivore samples collected during the LWQA project. In general, trace elements concentrations reported in the fish sample collected from Baukol-Noonan Dam were near or below the median concentrations for all fish collected in the LWQA project. The only reported element concentration that deviated from this trend was selenium. The selenium concentration of 0.370 $\mu g\ g^{1}$ exceeded the 75th percentile for all piscivores sampled during the LWQA project.

The detectable pesticide residues in the walleye sample collected from Baukol-Noonan Dam included DDT, DDE and trifluralin. DDT is an agricultural insecticide that was banned in the United States in the early 1970s. DDE is a degradation product of the insecticide DDT and can produce biological effects similar to parent compound. Trifluralin, commonly known as treflan, is a selective preemergent herbicide.

The reported DDT concentration in the walleye sample collected from Baukol-Noonan Dam was 0.002 $\mu g\ g^{1}$ representing a concentration equal to the 75th percentile for all piscivore samples. The reported DDE concentration of 0.003 $\mu g\ g^{1}$ in the walleye sample collected from Baukol-Noonan Dam was below the 75th percentile of 0.005 $\mu g\ g^{-1}$. The trifluralin concentration of 0.003 $\mu g\ g^{1}$ is between the 25th and median concentration of 0.002 and 0.005 $\mu g\ g^{1}$ reported for all piscivore samples collected during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Baukol-Noonan Dam and its contributing watershed has a combined surface area of 1,130 acres located on the Glaciated Plains physiographic region of North Dakota in west central Divide County. The undisturbed portions of the watershed are characterized by gently rolling hills and valleys. Soils are predominantly well drained built from gravely, sandy, glacial materials. Nonpoint source pollution from the surrounding watershed accounts for all the nutrient loadings and pollution discharges to Baukol-Noonan Dam.

Land use within the Baukol-Noonan Dam watershed is 53.7 percent agricultural, with 42.6 percent actively cultivated. The remaining 11.1 acres of agricultural lands are in hay production and conservation reserve program (CRP). Four hundred twenty-five acres or 36.7 percent of the Baukol-Noonan watershed are abandoned coal mine spoils.

According to the information provided by the Divide County Soil Conservation District, 90 percent of the cultivated lands and nearly 100 percent of the remaining agricultural lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Baukol-Noonan Dam watershed the average "T" value is three to five tons per acre.

Based on an average soil loss of slightly over two tons per acre, which takes into account all the land uses and corresponding treatments, approximately 2,528 tons of soil are lost from the watershed annually. Assuming a conservative delivery rate of 10 to 15 percent, between 253 and 549 tons of soil are delivered to Baukol-Noonan Dam annually from agricultural sources. No soil loss estimates are available for the abandoned coal mine spoils within the watershed. However, it is assumed that a significant load of sediments are delivered from this region.

Table 2. Land use in the Baukol-Noonan Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	42.5	90
Coal Mine Spoils	37.6	10
Hayland	1.8	100
CRP	9.3	100
Wet/Wild[1]	7.2	N/A
Other	1.3	N/A
Farmsteads	0[3]	N/A
Feedlots[2]	0[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

BEAVER LAKE

LOGAN COUNTY

Peter N. Wax

Beaver Lake is located on Beaver Creek in central Logan County, North Dakota. It is a enhanced natural wetland on the Glaciated Plains physiographic region of North Dakota. Beaver Lake has a maximum depth of 7 feet and a mean depth of 5.6 feet (Figure 1).

The topography of Beaver Lake's watershed is characterized by rolling hills and valleys, integrated drainages and multiple potholes typifying the northern prairie pothole region. Land use is nearly 100 percent agricultural with a relatively even mixture of agricultural croplands and livestock rangeland. Average precipitation in the region ranges between 15 and 20 inches.

Beaver Lake is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Beaver Lake by annually assessing the fish community through test netting operations and stock accordingly. Due to Beaver Lake's shallow maximum depth and rapid oxygen depletion under ice cover conditions the stocking regimen has been directed towards species tolerant of low dissolved oxygen conditions.

In recent years, the stocking regimen has included yellow perch and northern pike. A fish community assessment conducted on July 11, 1991 by the NDG&F, captured in order of most abundant fathead minnows, common carp, black bullhead, northern pike, white sucker and yellow perch. Fishery management activities historically have also included commercial fishing.

Approximately 15 percent of Beaver Lake shoreline is publicly owned. This area of the lake has been developed by the North Dakota State Parks and Recreation. Facilities within the Beaver Lake State Park include camping with electrical hookups, showers, flush toilets, boat ramp and security. Public use at Beaver Lake state park is light to moderate depending on the season and productivity of the fishery.

Considerable public interest has been generated over the water quality and general physical conditions of Beaver Lake. In the past, several attempts have been made to rectify many of the problems associated with the hypereutrophic condition of Beaver Lake. In 1983, the NDSDHCL listed eight alternatives for improving Beaver Lake: 1) aeration/artificial circulation, 2) dilution/ flushing, 3) nutrient precipitation/inactivation, 4) lake level draw-down, 5) sediment covering, 6) sediment removal (dredging), 7) macrophyte harvesting, and 8) biological controls (herbivorous fish/biomanipulation).

Water Quality

Water quality samples were collected from Beaver Lake two times during the summer of 1992 and once during the winter of 1993. Samples were collected at one samplesite located in the deepest area

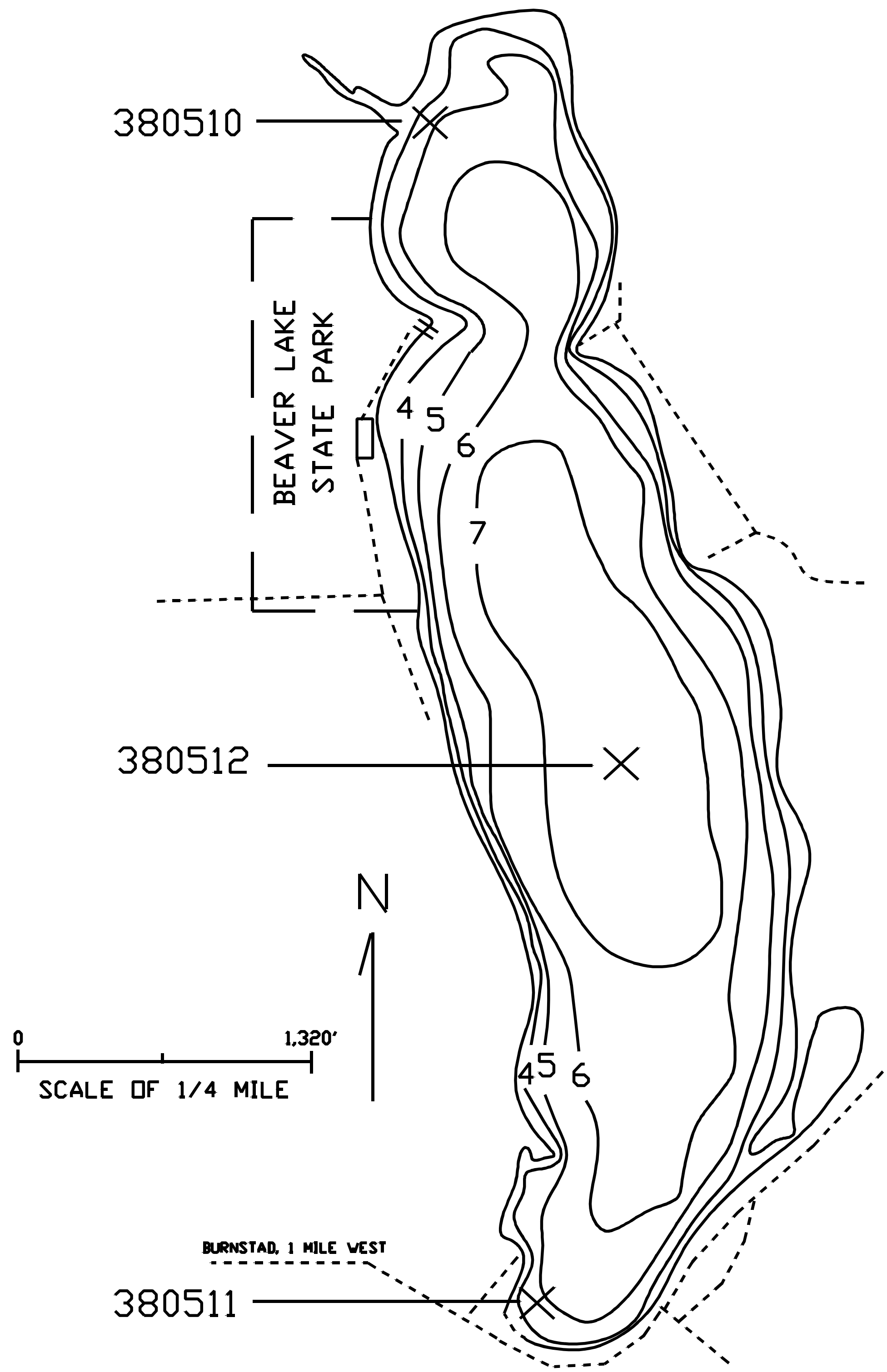


Figure 1. Morphometric map of Beaver Lake.

of the lake (Site 380512, Figure 1). Water column samples were collected for analysis at two separate depths of 1 and 2 meters depth below the lake surface.

During the LWQA project thermal stratification was not documented on Beaver Lake (Figure 2). Dissolved oxygen concentrations were between 3.4 mg L^{-1} near the bottom and 8.5 mg L^{-1} at the surface on July 28, 1992 and between 14.2 mg L^{-1} near the bottom and +15 mg L^{-1} on August 31, 1992. During winter sampling on March 1, 1993, dissolved oxygen concentrations were quite low with a less than detectable reading near the bottom and a 1.3 mg L^{-1} reading at the surface.

Assessment data collected during the LWQA project on Beaver Lake described a lake with high primary productivity resulting from excessive nitrogen and phosphorus. Nitrogen concentrations ranged between nondetectable to 0.013 mg L^{-1} with a volume-weighted mean concentration of 0.007 mg L^{-1} while total phosphorus as P concentrations ranged between 0.282 and 0.74 mg L^{-1} with a weighted-volume mean concentration of 0.437 mg L^{-1}. Ammonia concentrations ranged from 0.013 and 0.734 mg L^{-1} with a volume-weighted mean concentration of 0.383 mg L^{-1} (Table 1). The ratios of phosphorus and nitrogen indicate Beaver Lake is nitrogen limited. However, primary production is not limited by a lack of nitrogen as nitrogen is available to the lake system through atmospheric deposition, wind-induced suspension of sediments and transport of nitrogen from the watershed.

Concentrations of total dissolved solids, hardness as calcium and conductivity in Beaver Lake were lower than the State's long-term averages and lower than approximately half the lakes sampled during the LWQA project. Beaver Lake also was a well-buffered lake with a volume-weighted mean concentration for total alkalinity as $CaCO_3$ of 539 mg L^{-1} (Table 1).

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 28, 1992 and March 1, 1993 and long-term averages for all North Dakota lake data collected by the NDSHD&CL between January 1, 1982 and December 31, 1991.

Parameter	Beaver Lake		1982-1991	
Total Dissolved Solids	786	mg L^{-1}	1209	mg L^{-1}
Conductivity	1194	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	330	mg L^{-1}	488	mg L^{-1}
Sulfates	198	mg L^{-1}	592	mg L^{-1}
Chloride	24.	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.349	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.006	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	539	mg L^{-1}	296	mg L^{-1}
Ammonia	0.351	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	3.83	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	539	mg L^{-1}	326	mg L^{-1}

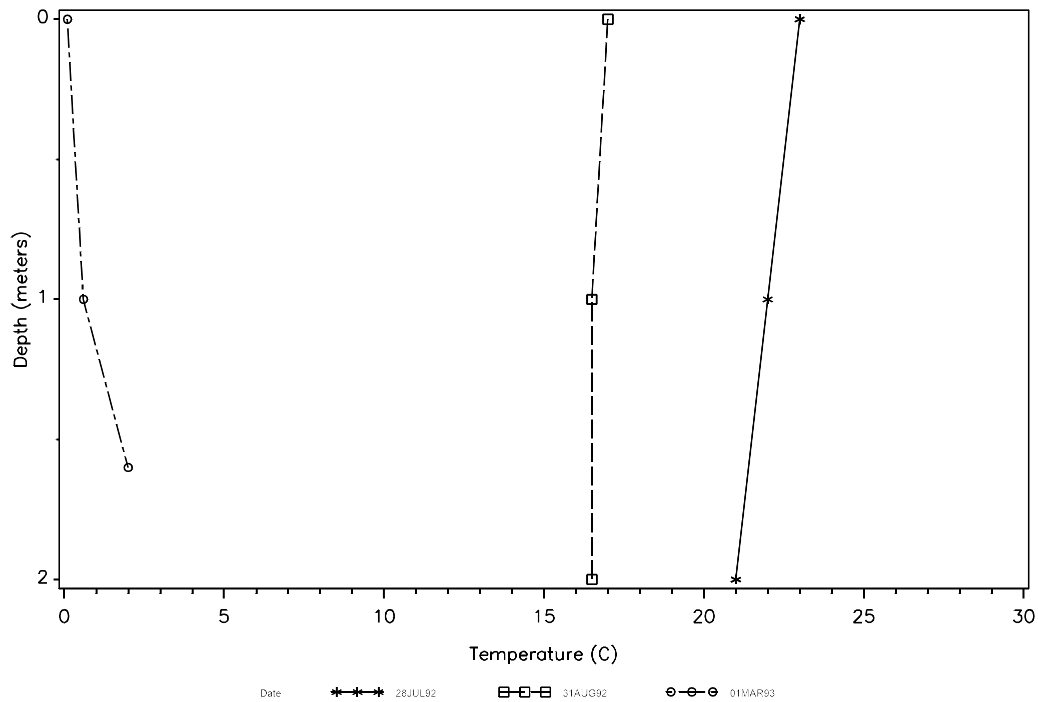


Figure 2. Temperature profile for Beaver Lake.

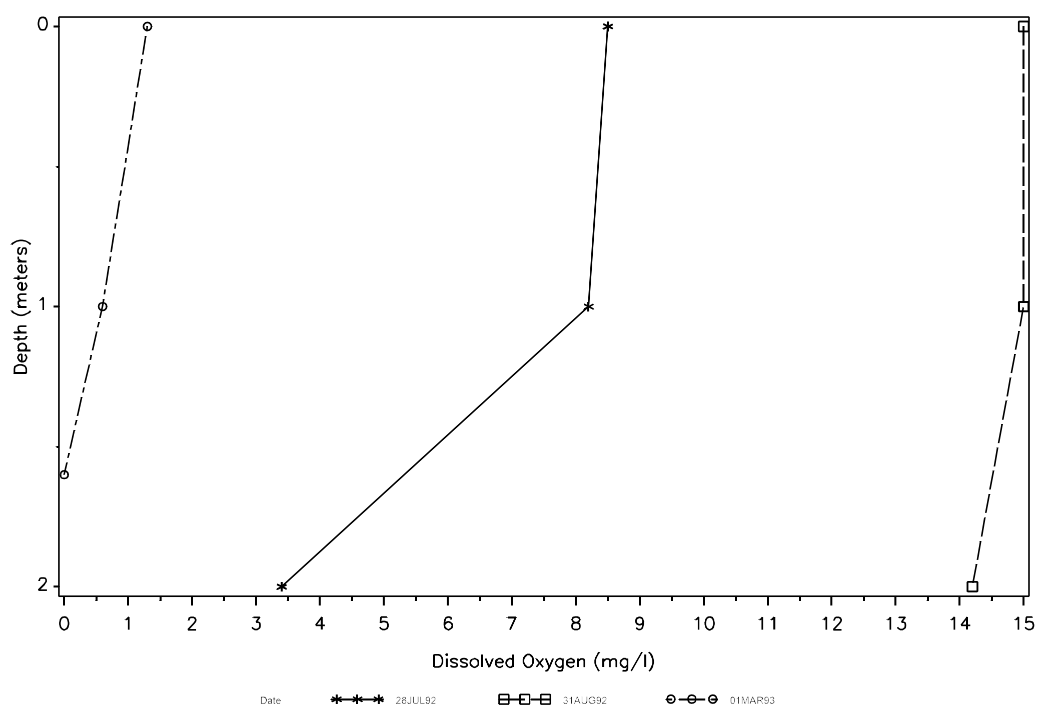


Figure 3. Oxygen profile for Beaver Lake.

The dominant anions in Beaver Lake's water column were sulfates and bicarbon-ates. Sulfates ranged between 137 and 303 mg L^{-1} with a volume-weighted mean concentration of 198 mg L^{-1}. Bicarbonate concentrations ranged between 392 and 814 mg L^{-1} with a weighted-volume mean concentration of 539 mg L^{-1} (Table 1). A complete list of water quality sample data is contained in Appendix A.

Aquatic Vegetation

A qualitative survey of Beaver Lake's macrophyte community was conducted on July 28, 1992. At the time of the macrophyte survey, approximately 20 percent of the shoreline to a maximum distance of 20 meters contained emergent and submergent vegetation. The only submergent aquatic plant identified on Beaver Lake was sago pondweed, Potamogeton pectinatus. The shoreline in the southern quarter of the lake had nearly a solid cover of cattails, Typha spp. and bulrush, Scirpus spp. The remainder of the lake's shoreline has intermittent stands of both cattails and bulrush. The lack of a more substantial macrophyte population on Beaver Lake is probably due to the large carp population and poor water clarity. A map depicting the areal extent of macrophyte coverage on Beaver Lake is contained in Appendix B.

Phytoplankton

Beaver Lake's phytoplankton community was sampled two times during the summer of 1992. During the two sample periods the phytoplankton community on Beaver Lake was represented by 5 orders and 49 genera. The phytoplankton community was dominated, in species diversity and volume, by the algal division Chlorophyta. However, by density the phytoplankton population was dominated by the blue-green algae, Cyanophyta. Other phytoplankton divisions repre-sented in descending order of dominance by density were the Bacillariophyta, Cryptophyta and Euglenophyta. A complete listing of the phytoplankton data collected on Beaver Lake in 1992 is contained in Appendix C.

Trophic Status

Data collected during the LWQA project found Beaver Lake to be hypereutrophic. The assessment was based primarily on surface summer total phosphate as P concentrations and secchi disk depth transparency measurements in combination with ancillary information such as frequent fish kills, phytoplankton composition and low dissolved oxygen concentrations.

Sediment Analysis

Sediments were collected from Beaver Lake and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 380512), the littoral area (Site 380511) and the inlet (380510), (Figure 1).

Sediment samples collected from Beaver Lake showed detectable levels of all trace elements tested for except mercury and selenium. Trace element concentrations at each sample location within Beaver Lake were compared to the median concentrations reported for all lakes assessed in the LWQA project. All reported trace element concentrations in the sediments collected from Beaver Lake were near or below the 25th percentile reported during the LWQA project.

Concentrations of selected pesticides and PCBs in the sediments collected from Beaver Lake were below the detection limits. A complete listing of sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Beaver Lake on June 25, 1992. Two samples were collected, one composed of four northern pike with an average length of 62 centimeters and an average weight of 1,712 grams and one composed of three carp with a mean length of 73.7 centimeters and 5,333 grams. The northern pike collected will represent the piscivore group and the carp collected the bottom feeder group.

In order to evaluate the fish tissue data for Beaver Lake the results for each fish sample was compared to all corresponding samples collected during the LWQA project. Reported trace element concentrations in the fish samples collected from Beaver Lake were generally near or below the 25th percentile for all fish collected during the LWQA project. The exceptions were the reported zinc and barium concentrations for both the bottom feeder and piscivore samples and the cadmium concentrations in the carp sample collected which were near or above the 75th percentile for all fish samples collected during the LWQA project.

Detectable pesticide residues in the walleye and carp samples collected from Beaver Lake included BHC-Alpha, DDD, DDE and Trifluralin. BHC-Alpha an organic compound known as Benzene Hexachloride. Benzene Hexachloride is an ingred-ient used in a number of agricultural pesticides. BHC-Alpha can be toxic to aquatic invertebrates and vertebrates in concentrations above 9 $\mu g\ L^{-1}$. DDD and DDE are breakdown derivatives of the agricultural insecticide DDT. The use of DDT was terminated in 1973 due to its detrimental effects on the environment. DDD and DDE can produce similar biological effects as the parent compound when available to the environment. Trifluralin, commonly known as treflan, is an agricultural preemergent herbicide.

The carp sample collected from Beaver Lake contained all of the above mentioned organic compounds. The reported concentrations of BHC-Alpha in the carp sample of 0.002 $\mu g\ g^{-1}$ was nearly equal to the 99th percentile for all samples collected during the LWQA project. BHC-Alpha showed up in very few samples which accounts for this relatively high percentile even though the concentration is relatively low. The concentrations of DDD and DDE of 0.005 and 0.001 $\mu g\ g^{-1}$ respectively, represent approximately the median concentrations reported in all bottom feeder samples collected during the LWQA project. The concentration of 0.002 $\mu g\ g^{-1}$ reported for trifluralin in the carp sample collected from Beaver Lake is just slightly above the 25th percentile for all samples collected during the LWQA project.

The northern pike sample collected from Beaver Lake contained detectable levels of DDD and DDE. The concentrations of DDE and DDD of 0.003 and 0.008 $\mu g\ g^{-1}$ are approximately equal to the median for all piscivore samples collected during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Beaver Lake with its contributing watershed has a combined surface area of 29,030 acres located on the Glaciated Plains physiographic region in Logan County, North Dakota. The surrounding landscape is characterized by rolling hills and valleys. Soils are predominately well drained, built from sandy gravelly glacial material. Nonpoint source pollution from the surrounding watershed accounts for nearly 100 percent of the nutrient loadings and pollution discharges to Beaver Lake.

Land use within the Beaver Lake watershed is 94.4 percent agricultural with 36 percent actively cultivated. The remaining 60 percent is in low density urban development, haylands, pasture, conservation reserve program (CRP) and wildlife or recreational management (Table 2).

According to the information provided by the Logan County Soil Conservation District 60 percent of the cultivated lands and between 40 and 60 percent of the remaining lands within the Beaver Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Beaver Lake watershed the average "T" value is 3 to 5 tons per acre. Based on a conservative estimated soil loss of 3 to 4 tons per acre which takes into account all current land treatments and practices approximately 112,615 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent between 11,262 and 16,892 tons of soil are delivered to Beaver Lake annually.

Table 2. Land use in the Beaver Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	35.9	62
Rangeland	29	49
Hayland	14.8	60
CRP	14.7	100
Wet/Wild[1]	4.3	N/A
Other	0.4	N/A
Farmsteads	36[3]	N/A
Feedlots[2]	36[3]	10

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

Other sources of nonpoint source pollution discharges to Beaver Lake are from the 36 concentrated livestock feeding areas within the watershed and the low density urban developments along its shore. These sources are possibly the most significant source due to their closeness to the water edge and their abilities to discharge large quantities of concentrated nutrients and sediments during runoff events.

BRADDOCK DAM

EMMONS COUNTY

Peter N. Wax

Braddock Dam is located in Emmons County on the Missouri Coteau physiographic region in south central North Dakota. Braddock Dam was originally constructed in 1939 under the Works Project Administration (WPA). The dam created a reservoir of nearly 70 acres with a mean depth of 6 feet and a maximum depth of 15 feet (Figure 1).

Braddock Dam's watershed encompasses 38,015 acres of the Missouri Coteau, and is characterized by rolling hills, valleys and integrated drainages typifying the northern prairie pothole region. Land use is over 90 percent agricultural with over 85 percent actively cultivated. Soils are generally moderately well drained formed from glacial till.

Braddock Dam is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated biota" (NDSDHCL, 1991). The NDG&F manage Braddock Dam by annually assessing the fish community through test netting operations and stock accordingly. In recent years, the stocking regimen has included a variety of fish tolerant of low dissolved oxygen conditions. Previous stockings have included northern pike, large mouth bass, walleye, bluegill, crappie and yellow perch. Black bullheads have historically dominated the fish community on Braddock Dam.

Public facilities at Braddock Dam include a boat ramp, picnic area and toilet facilities. Public use on Braddock Dam is sporadic depending on the productivity of the fishery.

Water Quality

Water quality samples were collected from Braddock Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 381365, Figure 1). Water column samples were collected for analysis at two separate depths of 1 meter and between 2.5 and 5 meters.

During the summer sampling of 1992, Braddock Dam was thermally stratified between 1 and 3 meters depth on July 28, 1992, yet not thermally stratified on August 31, 1992 (Figure 2). Dissolved oxygen concentrations during these times were between 10.3 and 8.9 mg L^{-1} at the surface and between 7.4 and 2.5 mg L^{-1} near the bottom (Figure 3). During the winter of 1993 Braddock Dam was thermally stratified between 1 and 2 meters of depth (Figure 2). Dissolved oxygen concentrations at this time were between 0.7 mg L^{-1} near the bottom and 3.0 mg L^{-1} near the surface (Figure 3).

Water quality samples collected during the LWQA project described Braddock Dam as a well-buffered waterbody with concentrations of total alkalinity as $CaCO_3$ ranging between 264 and 449 mg L^{-1} with a volume-weighted mean concentration

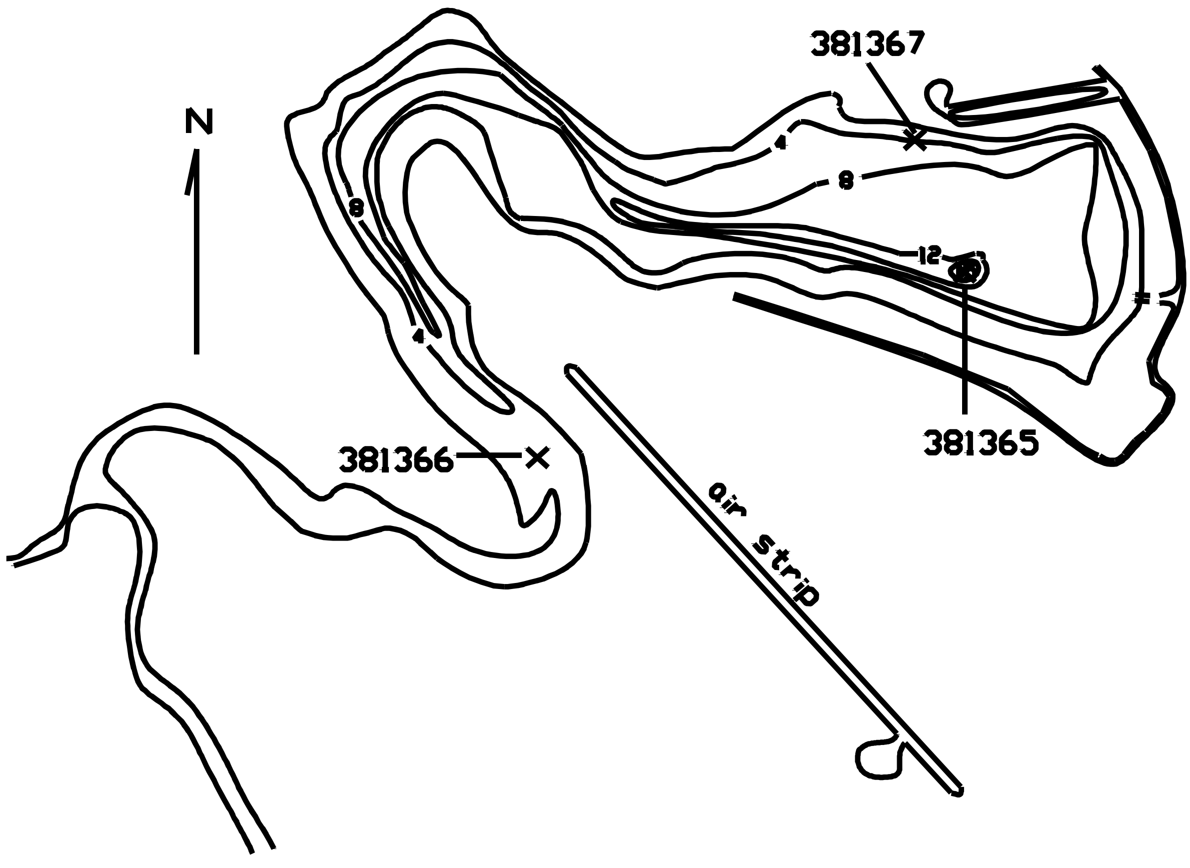


Figure 1. Morphometric map of Braddock Dam.

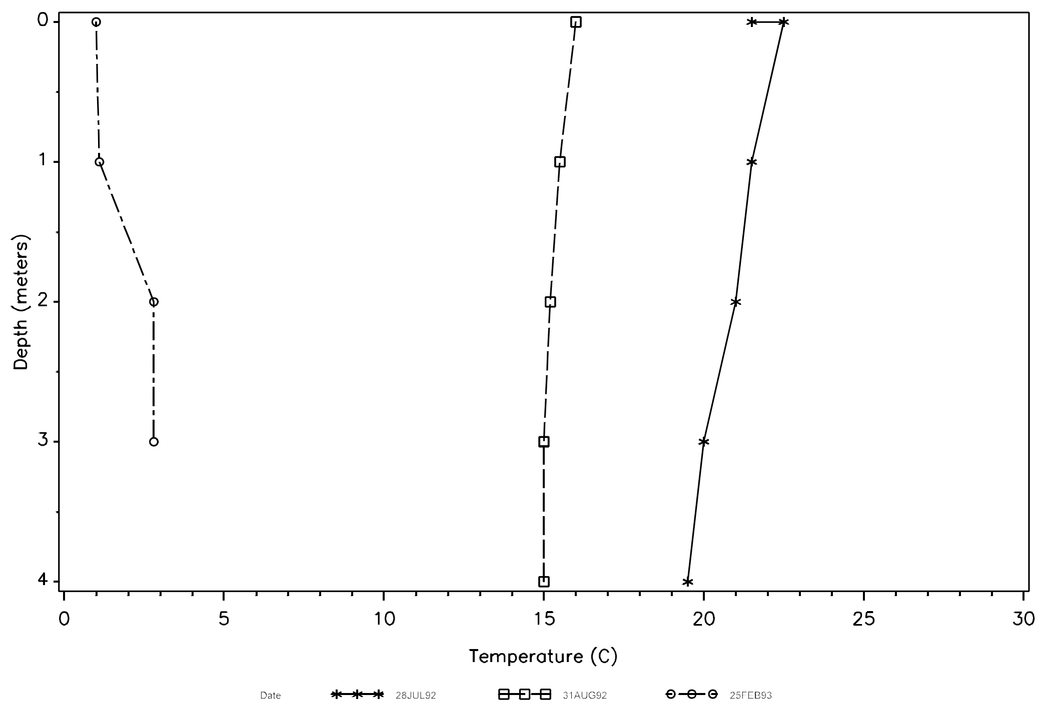


Figure 2. Temperature profile for Braddock Dam.

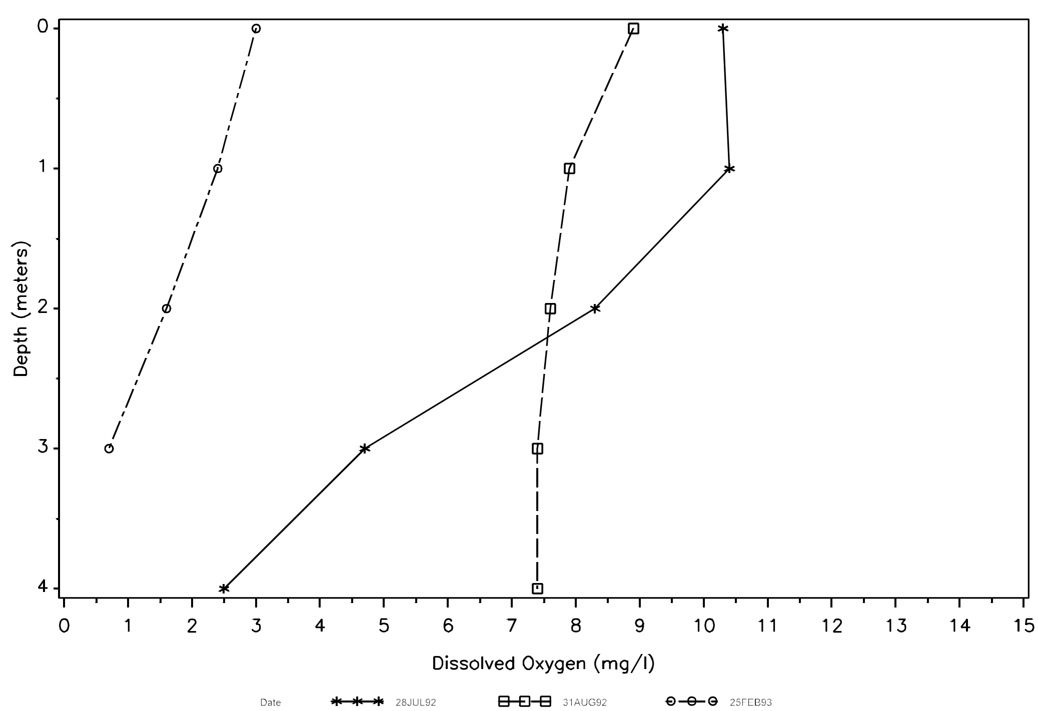


Figure 3. Oxygen profile for Braddock Dam.

of 329 mg L^{-1}. The dominant anions in water column were sulfates and bicarbonates. Sulfates ranged between 194 and 301 mg L^{-1} with a volume-weighted mean concentration of 237 mg L^{-1} and bicarbonates ranged between 214 and 548 mg L^{-1} with a volume-weighted mean concentration of 347 mg L^{-1} (Table 1).

Braddock Dam is a highly productive waterbody with total phosphate as P concentrations ranging between 0.163 and 0.368 mg L^{-1} with a volume-weighted mean concentrations of 0.281 mg L^{-1}. The ratios between phosphorus and nitrogen suggest Braddock Dam is a nitrogen limited waterbody. Nitrogen limited generally refers to a waterbody where primary production is limited by the available supply of nitrogen. However, on Braddock Dam, nitrogen fixing organism such as some species of blue-green algae are favored due to the over abundance of phosphorus. A complete listing of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 28, 1992 and February 25, 1993 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Braddock Dam		1982-1991	
Total Dissolved Solids	689	mg L^{-1}	1209	mg L^{-1}
Conductivity	1048	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as calcium	196	mg L^{-1}	488	mg L^{-1}
Sulfates	237	mg L^{-1}	592	mg L^{-1}
Chloride	6.7	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.281	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.021	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	329	mg L^{-1}	296	mg L^{-1}
Ammonia	0.368	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.35	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	347	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Braddock Dam on July 28, 1992. At the time of the macrophyte survey approximately 80 percent of Braddock Dam surface area had submergent aquatic vegetation and approximately 70 to 80 percent of the shoreline was ringed with emergent vegetation. The submergent aquatic vegetation was composed of approximately 80 percent water milfoil Myriophyllum spp., 10 percent coontail Ceratophyllum demersum and 10 percent leafy pondweed Potamogeton foliosus. Other species of submergent aquatic vegetation found on Braddock Dam were sago pondweed Potamogeton pectinatus and curlyleaf pondweed Potamogeton crispus.

Braddock Dam's shoreline was interspersed with emergent macrophytes which occupied 70 to 80 percent of the shoreline in concentrations of approximately 70 percent cattails Typha spp. and 30 percent bulrush Scirpus spp. A map depicting the areal extent of macrophyte coverage on Braddock Dam is contained in Appendix B.

Phytoplankton

Braddock Dam's phytoplankton community was sampled two times during the summer of 1992. At the time of sampling, Braddock Dam's phytoplankton community was represented by 5 divisions and 51 genera. The largest contributor in terms of density were the green algae Chlorophyta with 29 genera present. Mean density of the green algae for the two samples collected was of 21,009 cells mL^{-1}. The next most abundant division was Cyanophyta, followed by Euglenophyta, Cryptophyta and Bacillariophyta.

At the time of the assessment, mean phytoplankton concentrations by volume were dominated by the division Cryptophyta, followed by Bacillariophyta, Chlorophyta, Cyanophyta and Euglenophyta. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Braddock Dam is assessed as hypereutrophic, based on data collected during the LWQA project. Primary indicators used in making this assessment were secchi disk depth transparency, chlorophyll-a concentrations and total phosphate as P concentrations. Secchi disk transparencies ranged between 0.5 and 1.2 meters, chlorophyll-a concentrations ranged between 14 and 22 $\mu g\ L^{-1}$ and summer surface total phosphate as P concentrations ranged between 293 and 368 $\mu g\ L^{-1}$, all indicating a hypereutrophic lake condition. Ancillary information which collaborates a hypereutrophic assessment were frequent nuisance algae blooms, large macrophyte biomass and low dissolved oxygen concentrations throughout the winter.

Sediment Analysis

Sediments were collected from Braddock Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381365), the littoral area of the lake (Site 381367) and the inlet area of the lake (Site 381366) (Figure 1).

Sediment samples collected from Braddock Dam contained detectable concentra-tions of all trace elements tested for with the exception of mercury in all samples and selenium in the inlet and deepest area samples. Reported trace element concentrations within the sediments collected from Braddock Dam can be divided into two groups. Group one would be trace element concentrations reported in the deepest and inlet area sediments which were very low and the sediments from the littoral area which had reported concentrations near the median.

Concentrations of selected pesticides and PCBs were below detection limits for all sediment samples collected from Braddock Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Braddock Dam on June 16, 1992. Walleye and white suckers were collected, representing the piscivore and bottom feeder groups respectively. The walleye sample collected was composed of three fish with an average length of 57.7 centimeters and an average weight of 2,140 grams. The white sucker sample was composed of three fish with an average length of 50.7 centimeters and an average weight of 1,583 grams.

To evaluate the fish tissue data for Braddock Dam the results for each fish group was compared to that group for all lakes assessed in LWQA project. Reported trace element concentrations in the walleye sample collected from Braddock Dam were generally near or slightly below the median concentrations for all piscivores collected during the LWQA project. The exception was the reported mercury concentration of 0.68 $\mu g\ g^{-1}$, which is above the 75th percentile.

Reported trace element concentrations in the white sucker sample collected from Braddock Dam were also generally near or slightly below the median concentrations for all fish collected during the LWQA project. The exceptions were the reported concentrations of zinc and barium which are near or above the 75th percentile for all bottom feeders collected during the LWQA project. Detectable pesticide residues in the fish samples collected from Braddock Dam included BHC-Alpha, DDD, DDE, DDT, Dieldrin and Trifluralin. BHC-Alpha is an agricultural pesticide which can have adverse effects on the aquatic, invertebrate and vertebrate population in concentrations as low as 9 $\mu g\ g^{-1}$. DDT is an agricultural insecticide which was removed from public use in 1973 due to its adverse effects on the environment. DDD and DDE are breakdown derivatives of DDT and can behave similarly to the parent compound when available to the ecosystem. Dieldrin is also an agricultural insecticide which like DDT was banned in 1973 due to its detrimental effects on the environment. Trifluralin, commonly known as treflan, is a selective preemergent herbicide (Johnson and Finley, 1980).

The walleye sample from Braddock Dam contained concentrations of all the above mentioned pesticides. All of the concentrations reported were near or above the 75th percentile with the exception of trifluralin which was near the median. The white sucker sample collected from Braddock Dam contained only DDD, DDE and trifluralin. The concentrations of the organic compounds in the white sucker sample were near the median concentrations for all bottom feeders sampled during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Braddock Dam with its contributing watershed has a combined surface area of 38,015 acres located on the Missouri Coteau physiographic region in Emmons County, North Dakota. The Missouri Coteau is a glacial erosion remnant of the Wisconsin Age. The surrounding landscape is characterized by rolling hills and valleys. Soils are predominately well drained, built from gravelly, sandy glacial materials. Nonpoint source pollution from the surrounding watershed accounts for nearly 100 percent of the nutrient loading and pollution discharges to Braddock Dam.

Land use within the Braddock Dam watershed is 96.2 percent agricultural with 86.6 percent actively cultivated. The remaining 13.4 percent of the watershed is in low density urban development, haylands, pasture, Conservation Reserve Program (CRP) and wildlife management (Table 2).

According to the information provided by the Emmons County Soil Conservation District, 75 percent of the cultivated lands and between 70 and 90 percent of the remaining lands within the Braddock Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Braddock Dam watershed the average "T" value is 3 to 5 tons per acre. Based on a conservative average soil loss of 2 to 3 tons per acre, approximately 102,164 tons of soil is lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 10,216 and 15,324 tons of soil are delivered to Braddock Dam annually.

Other sources of nonpoint source pollution discharges to Braddock Dam are from the 13 concentrated livestock feeding areas, construction activities and the city of Braddock. These sources due to their close proximity to the lake and immediate drainage have the potential to be significant sources of nonpoint source pollution discharges to Braddock Dam.

Table 2. Land use in the Braddock Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	86.6	75
Rangeland	6.5	70
Hayland	2.3	90
CRP	0.8	100
Wet/Wild[1]	0.1	N/A
Other	1.6	N/A
Farmsteads	45[3]	N/A
Feedlots[2]	13[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represents the number of farms and concentrated livestock feeding areas within the contributing watershed.

CARBURY DAM

BOTTINEAU COUNTY

Peter N. Wax

Carbury Dam is a narrow impoundment covering 130 acres with a maximum depth of 25 feet and an average depth of 9 feet (Figure 1). The dam is located five miles west and four miles north of the city of Bottineau in Bottineau County, North Dakota.

Carbury Dam is one of two flood control structure dams built as part of the boundary creek watershed project. The project was authorized on August 31, 1966, under the authority of the Watershed Protection and Flood Prevention Act. Construction began in June 1981 and was completed in 1982.

Carbury Dam is a small, multi-purpose structure designed to provide flood water storage, recreation and wildlife enhancement. Recreation opportunities presently available include boating, fishing, hiking, swimming, camping, and picnicking. Carbury Dam is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Carbury Dam by annually assessing the fish community through test netting operations and stock accordingly.

Since 1988, the NDG&F has stocked primarily rainbow trout in Carbury Dam, with two stockings of smallmouth bass in 1988 and 1991 and a single stocking of bluegill in 1990. A fish community assessment conducted by the NDG&F in 1990 captured in order of most abundant yellow perch, rainbow trout, smallmouth bass and a single bluegill.

Approximately 30 percent of Carbury Dam's shore line is publicly owned. Public facilities include camping platforms, picnic shelters, vault toilets and a boat ramp. In recent years, the unmanaged yellow perch has been the principle fishery on Carbury Dam. Public use on Carbury Dam is variable, depending on the productivity of the fishery.

Water Quality

Water quality samples were collected on Carbury Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at the deepest area of the lake (Site 381200, Figure 1). Water column samples were collected for analysis at three separate depths of 1 meter, 3 meters and 6 meters in July, 1 meter, 4 meters and 6 meters in August and 1 meter, 3 meters and 5.5 meters in March.

During the summer sampling of 1992, Carbury Dam was not thermally stratified on July 21, 1992, however, thermal stratification was occurring between the depths of 4 and 5 meters on August 18, 1992 (Figure 2). During these time periods, dissolved oxygen concentrations ranged between 1.2 mg L^{-1} near the bottom to 7.1 mg L^{-1} near the surface with adequate concentrations of dissolved oxygen to

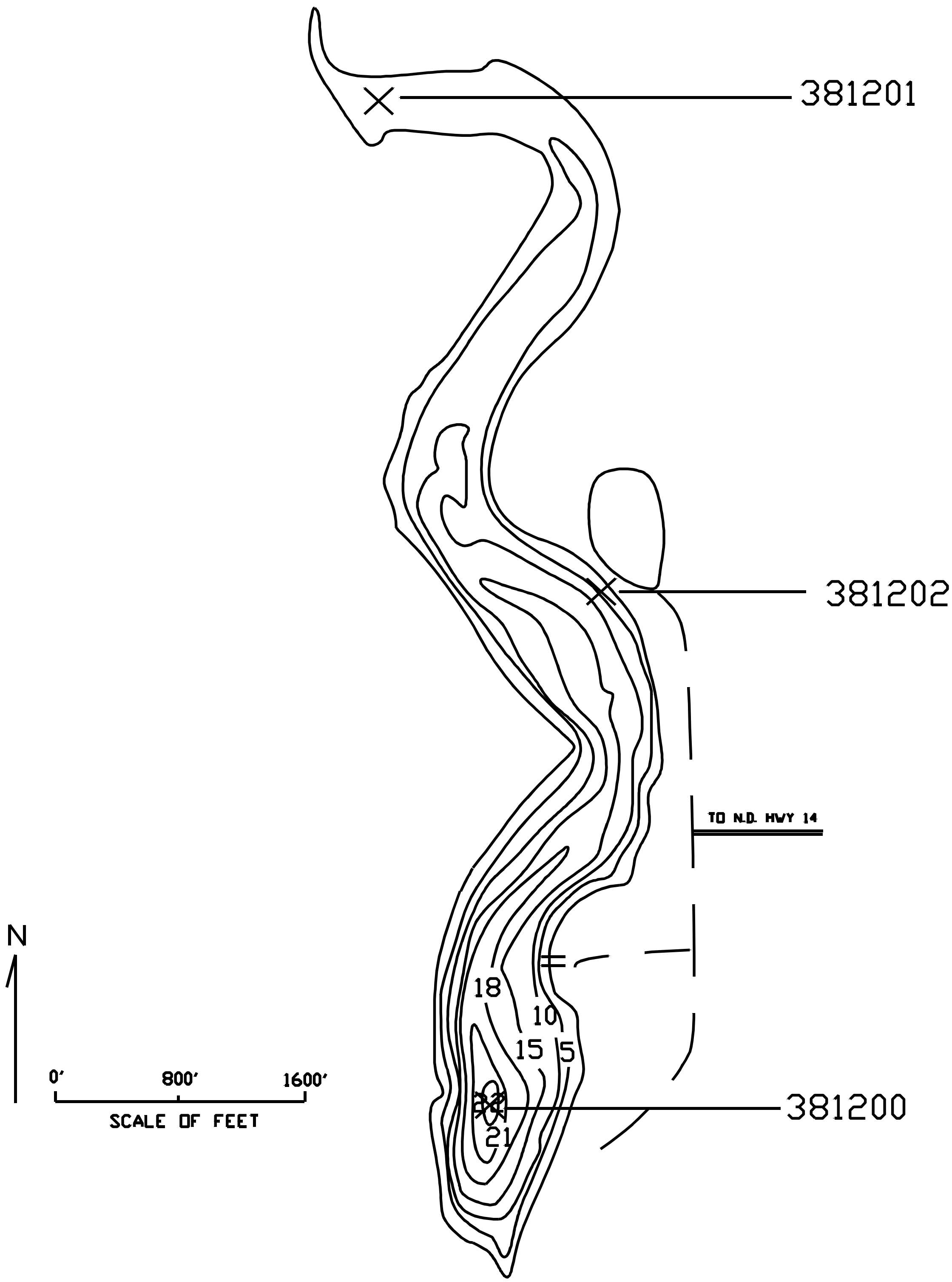


Figure 1. Morphometric map of Carbury Dam.

maintain aquatic life (Figure 3). In March Carbury Dam's water column was thermally stratified between two and three meters of depth (Figure 2). Dissolved oxygen concentrations at this time were between 0.1 mg L^{-1} to 2.3 mg L^{-1} (Figure 3).

During the LWQA project concentrations of total dissolved solids, hardness as calcium and conductivity in Carbury Dam were lower than the state's long-term average (Table 1). The dominant anions in the water column were sulfates and bicarbonates. Sulfates and bicarbonates had volume-weighted mean concentrations of 312 and 426 µg L^{-1}, respectively (Table 1). LWQA water quality data shows Carbury Dam as a well-buffered waterbody. Total alkalinity as $CaCO^3$ has a volume-weighted mean concentration of 367 mg L^{-1} (Table 1).

Total phosphate as P concentrations had a volume-weighted mean concentration of 0.329 mg L^{-1}, exceeding the state's long-term average and the state's target concentration of 0.25 mg L^{-1}. The ratio of total phosphate as P and nitrate + nitrite as N of 23.5:1 suggests Carbury Dam is nitrogen limited.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 24, 1992 and March 3, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Carbury Dam		1982-1991	
Total Dissolved Solids	806	mg L^{-1}	1209	mg L^{-1}
Conductivity	1226	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	356	mg L^{-1}	488	mg L^{-1}
Sulfates	312	mg L^{-1}	592	mg L^{-1}
Chloride	11	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.329	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.014	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	367	mg L^{-1}	296	mg L^{-1}
Ammonia	0.640	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	3.07	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	426	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Carbury Dam as part of the LWQA project. The survey was conducted on July 24, 1992. At the time of the macrophyte survey, approximately 20 percent of Carbury Dam's surface area had aquatic vegetation. Nearly 100 percent of the lake's surface area to a depth of approximately seven feet had sago pondweed Potamogeton pectinatus with small patches extending to a depth of nearly ten feet. A narrow band of cattails Typha spp. lined nearly 100 percent of Carbury Dam's shoreline to a depth of two feet. A map depicting the areal extent of macrophyte coverage on Carbury Dam is contained in Appendix B.

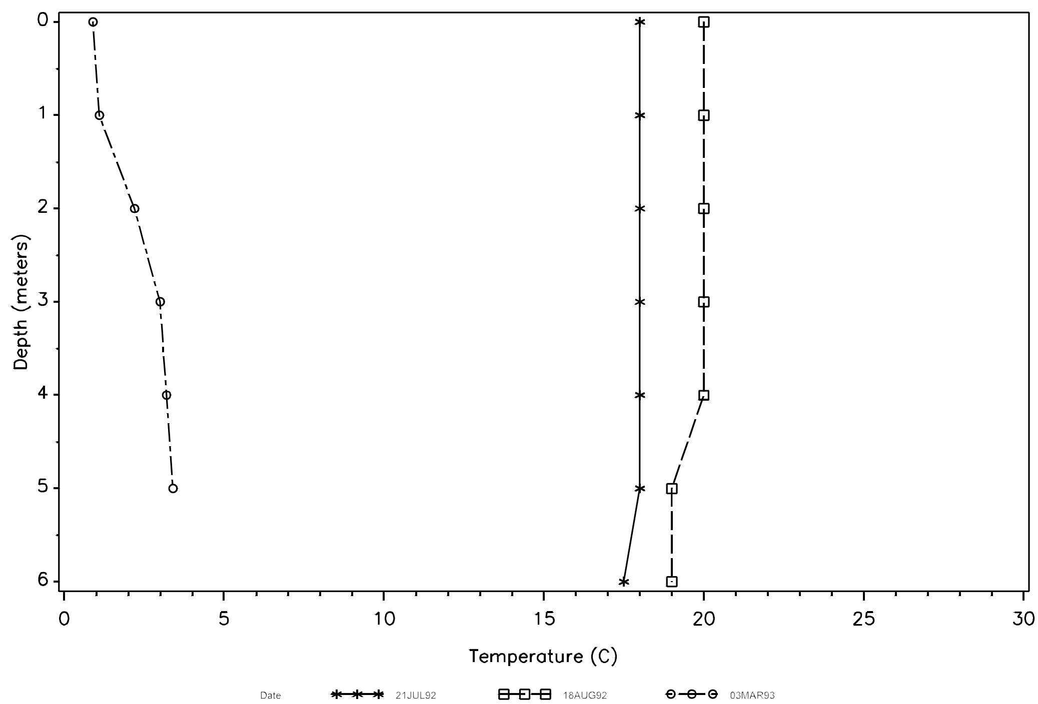


Figure 2. Temperature profile for Carbury Dam.

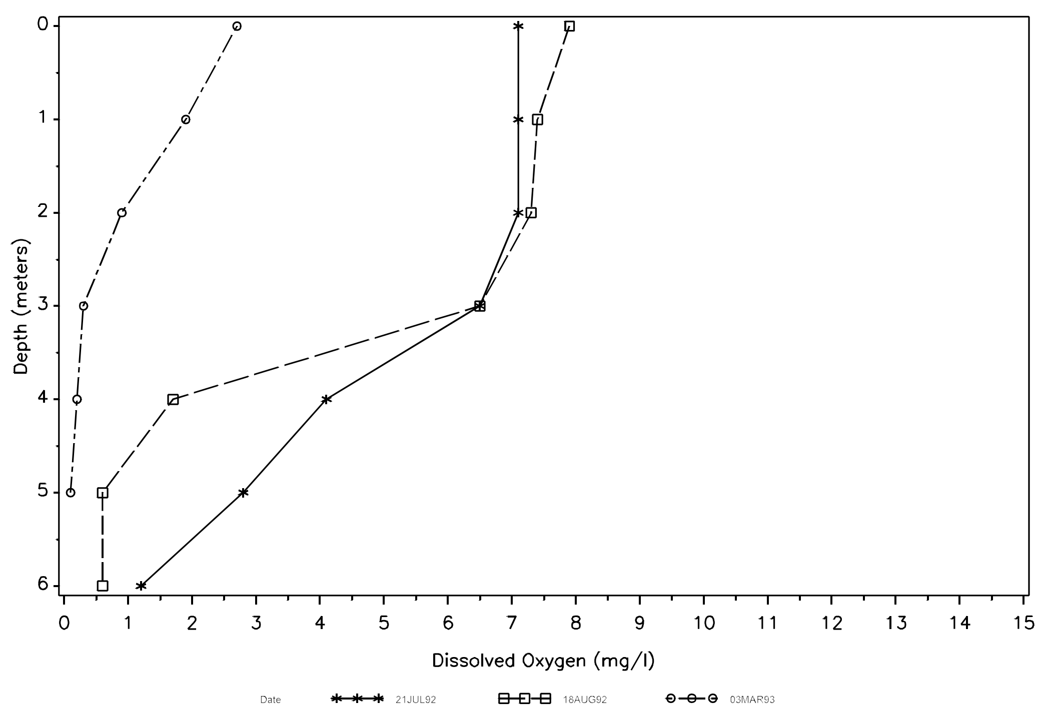


Figure 3. Oxygen profile for Carbury Dam.

Phytoplankton

Carbury Dam's phytoplankton community was sampled two times during the summer of 1992. At the sample times Carbury Dam's had representation from five divisions and 15 genera. The largest contributors to the phytoplankton community by density were the blue-green algae, Cyanophyta, with 21 general represented. Mean density of the two samples collected during the summer of 1992 for the division Cyanophyta was 494,836 cells mL^{-1}, representing a dominance of over four fold the next most abundant division Chlorophyta. Other divisions represented in descending order of dominance by density were Cryptophyta, Bacillariophyta and Euglenophyta.

At the time of the LWQA assessment, mean phytoplankton concentrations by volume were also dominated by the blue-green algae, Cyanophyta. Blue-green algae occupied over 50 percent of the community by volume. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA project defined Carbury Dam as hypereutrophic. The three primary indicators secchi disk depth transparency, chlorophyll-a concentrations and summer surface total phosphate as P concentrations agree quite well, all indicating a hypereutrophic condition. Secchi disk depth transparency at both sample times was 0.4 meters, chlorophyll-a concentrations ranged between 69 and 73 $\mu g\ L^{-1}$ and total phosphorus as P concentrations ranged between 87 and 92 $\mu g\ L^{-1}$. Supporting ancillary data of a hypereutrophic assessment are low dissolved oxygen concentrations under ice cover conditions, a large macrophyte biomass and a large phytoplankton community dominated by blue-green algae species.

Sediment Analysis

Sediments were collected from Carbury Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381200), the littoral zone (Site 381202) and the inlet (Site 381201) (Figure 1).

Sediment samples collected from Carbury Dam had detectable levels of all trace elements tested for with the exception of mercury in all areas and selenium in the inlet and deepest areas. Concentrations of trace elements in the sediments at each sample location within Carbury Dam were compared to the median concentrations reported for all lakes assessed in the LWQA project.

In general, the reported trace element concentrations in the inlet sediments collected from Carbury Dam were near or below the 25th percentile for all inlet samples collected during the LWQA project. Reported concentrations of trace elements in the littoral sediment samples were generally near or below the median concentrations reported with the exceptions of copper, zinc and chromium, which were near or exceeded the 75th percentile. The deepest area sediments collected from Carbury Dam contained reported concentrations of trace elements that were near or below the median concentrations for all sediment samples collected from the deepest areas during the LWQA project.

Reported concentrations of selected pesticides and PCB's were below detectable limits for all sediment samples collected from Carbury Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Carbury Dam on June 10, 1992. Rainbow trout were the only species collected, representing the piscivore group. The sample collected was a composite of three rainbow trout with an average length of 46.3 centimeters and an average weight of 1,443 grams. In order to evaluate the fish tissue data for Carbury Dam, the results for each fish group was compared to that group for all lakes assessed in the LWQA project.

Reported trace element concentrations high enough to be detected in the fish sample collected from Carbury Dam included copper, zinc, barium, chromium and selenium. Of these elements, all but chromium, which was below the 25th percentile, were approximately the same as the median concentrations reported for all piscivore sampled during the LWQA project.

Detectable pesticide residues in the rainbow trout sample collected from Carbury Dam included BHC-Alpha, lindane, DDE, triallate and trifluralin. The BHC-Alpha, also known as benzene hexachloride, is an agricultural insecticide. BHC-Alpha can have significant environmental impacts on invertebrate and vertebrate populations in concentrations as low as 9 $\mu g\ L^{-1}$. Lindane is an agricultural insecticide very similar to BHC-Alpha. DDE is a degradation byproduct of the insecticide DDT. Triallate, commonly known as Fargo, is an agricultural preemergent herbicide. Trifluralin, commonly known as Treflan, is also a preemergent selective herbicide (Johnson and Finley 1980).

The concentrations of BHC-Alpha and lindane of 0.002 and 0.004 $\mu g\ g^{-1}$ reported in the trout sample are above the 75th percentile for all piscivores sampled during the LWQA project. The reported concentrations of DDE, triallate and trifluralin were also above the 75th percentile at 0.026, 0.011 and 0.024 $\mu g\ L^{-1}$, respectively. A complete listing of the whole fish analysis results is provided in Appendix E.

Watershed

Carbury Dam with its contributing watershed has a surface area of 11,520 acres. Approximately 85 percent of the watershed lies on the Glaciated Plains physiographic region with nearly 15 percent extending into the Turtle Mountains. The majority of the watershed is nearly level to gently rolling, interspersed by well defined drainages and forested areas. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to Carbury Dam.

Land use within the Carbury Dam watershed is 89.1 percent agricultural, with 36.5 percent actively cultivated. The remaining 63.5 percent of the watershed is in low density urban development, haylands, pasture, woodlands, Conservation Reserve Program (CRP) and wildlife management (Table 2). According to the information provided by the Bottineau County Soil Conservation District, 72 percent of the cultivated lands and 50 to 65 percent of all the remaining lands within the Carbury Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Carbury Dam watershed the average "T" value is three to five tons per acre. Based on an average soil loss of nearly two tons per acre, which takes into account all current land uses and practices approximately 21,290 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent between 2,129 and 3,194 tons of soil are delivered to Carbury Dam annually.

Runoff from concentrated livestock feeding areas and the town of Carbury are other sources of nonpoint source pollution discharges within the watershed. These sources have the capability to contribute nutrients and sediments to the lake and may be the most significant source due to their proximity to the actual drainage area and ability to deliver a highly concentrated loading.

Table 2. Land use in the Carbury Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	36.5	72
Rangeland	10.9	50
Hayland	5.8	65
Woodlands	25.6	N/A
CRP	10.3	100
Wet/Wild[1]	6.6	N/A
Other	3.0	N/A
Farmsteads	14[3]	N/A
Feedlots[2]	1[3]	50

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

CLEAR WATER LAKE

MOUNTRAIL COUNTY

Peter N. Wax

Clear Water Lake is a natural lake located on the Prairie Coteau physiographic region in Mountrail County, North Dakota. Clear Water Lake is a rather classic Coteau lake in that it is formed through glacial action, is rather bowl-shaped in cross section, contains an intricate shoreline and has a small watershed. Clear Water Lake has a surface acreage of 132.3, a maximum depth of 15 feet, and an average depth of 8.1 feet (Figure 1).

The topography of the surrounding area is characterized by irregular patterns of hills and shallow depressions. Topography is rolling which shifts in relief of up to 300 feet but primarily ranging between 50 to 80 feet. Soils in this region are generally formed from rocky, gravelly or sandy glacial till and are moderately well drained. Slopes range from nearly level to steep with average slope between 2 and 9 percent. Average precipitation in the region is 15 to 18 inches with major variations common between years. Land use in Clear Water Lake watershed is predominantly in beef cattle production with approximately 20 percent in agricultural croplands.

Clear Water Lake is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated biota" (NDSDHCL, 1991). In recent years, due to the drought, Clear Water Lake has averaged 5 feet below full pool with maximum fluctuations of nearly 10 feet. During the LWQA project, water levels were approximately 8 feet below full pool and it is questionable at the time winter samples were collected that any fish were present within the lake.
The NDG&F manage Clear Water Lake by annually assessing the fish community through test netting operations and stock accordingly. In recent years, the stocking regimen has been suspended due to the low water levels and low dissolved oxygen concentrations created by the recent drought. Historically, the NDG&F has stocked northern pike, walleye, yellow perch and occasionally bluegills in Clear Water Lake.

Clear Water Lake is mostly publicly owned with a number of permanent and semipermanent residences lining the western shore. Access to Clear Water Lake is good year around. Public recreational facilities include a picnic area, vault toilets, swim beach and a boat launching area. Public use on Clear Water Lake fluctuates significantly from heavy to light, depending on the productivity of the fishery.

Water Quality

Water quality samples were collected from Clear Water Lake two times during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 381355) and (Figure 1). Water column samples were collected for analysis at two separate depths of 1 meter and approximately 2.5 meters.

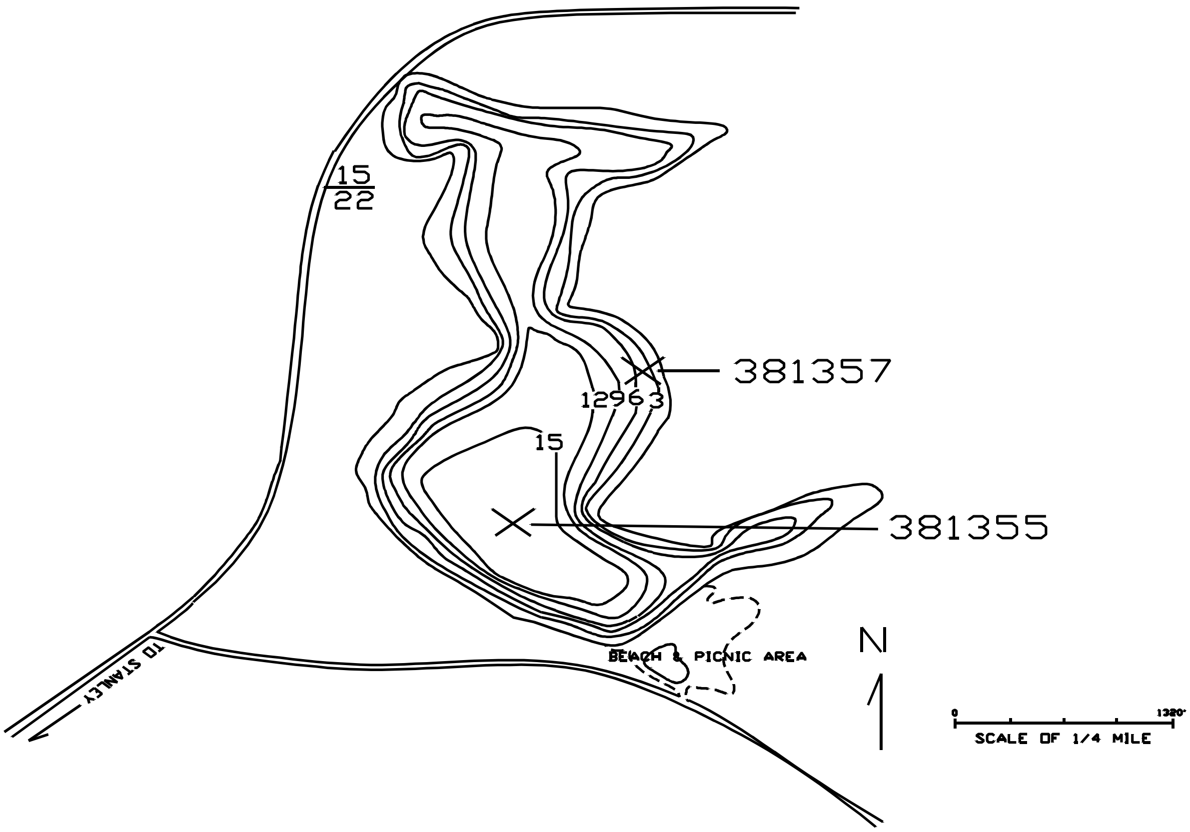


Figure 1. Morphometric map of Clear Water Lake.

During the summer sampling of 1992 Clear Water Lake was not thermally stratified (Figure 2). At the time of sampling, dissolved oxygen concentra-tions ranged between 4.1 mg L^{-1} near the bottom to 7 mg L^{-1} at the surface (Figure 3). Samples collected on January 22, 1993, again showed Clear Water Lake's water column was not thermally stratified (Figure 2) with dissolved oxygen concentrations ranging from 0.1 mg L^{-1} to 1.5 mg L^{-1} (Figure 3).

Water quality data collected on Clear Water Lake during the LWQA project show Clear Water Lake as a well-buffered, alkaline waterbody containing relatively high concentrations of total dissolved solids and hardness as calcium. The volume-weighted mean concentrations of total alkalinity as $CaCO_3$ was 1,868 mg L^{-1}, total hardness as calcium was 1,406 mg L^{-1} and total dissolved solids was 2,618 mg L^{-1}. The dominant anions in water column were bicarbonates and sulfates. Bicarbonates and sulfates had volume-weighted mean concentrations of 1,684 and 533 mg L^{-1}, respectively.

Clear Water Lake during the period sampled had relatively high concentrations of the nutrients, total phosphate as P and nitrate + nitrite as N. The volume-weighted means for these two parameters were 0.56 and 0.073 µg g^{-1}, respectively (Table 1). A complete list of the water quality sample data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 15, 1992 and January 22, 1993 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Clear Water Lake		1982-1991	
Total Dissolved Solids	2618	mg L^{-1}	1209	mg L^{-1}
Conductivity	3531	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	1406	mg L^{-1}	488	mg L^{-1}
Sulfates	533	mg L^{-1}	592	mg L^{-1}
Chloride	70	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.056	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.073	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	1868	mg L^{-1}	296	mg L^{-1}
Ammonia	0.666	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	4.77	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	1684	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Clear Water Lake on July 15, 1992. At the time of the survey no aquatic vegetation was present on Clear Water Lake. Dry dead cattails were found a significant distance from the shoreline. It is assumed that survival and reproduction of the emergent and submergent macrophyte community has been minimal in recent years due to declining water levels.

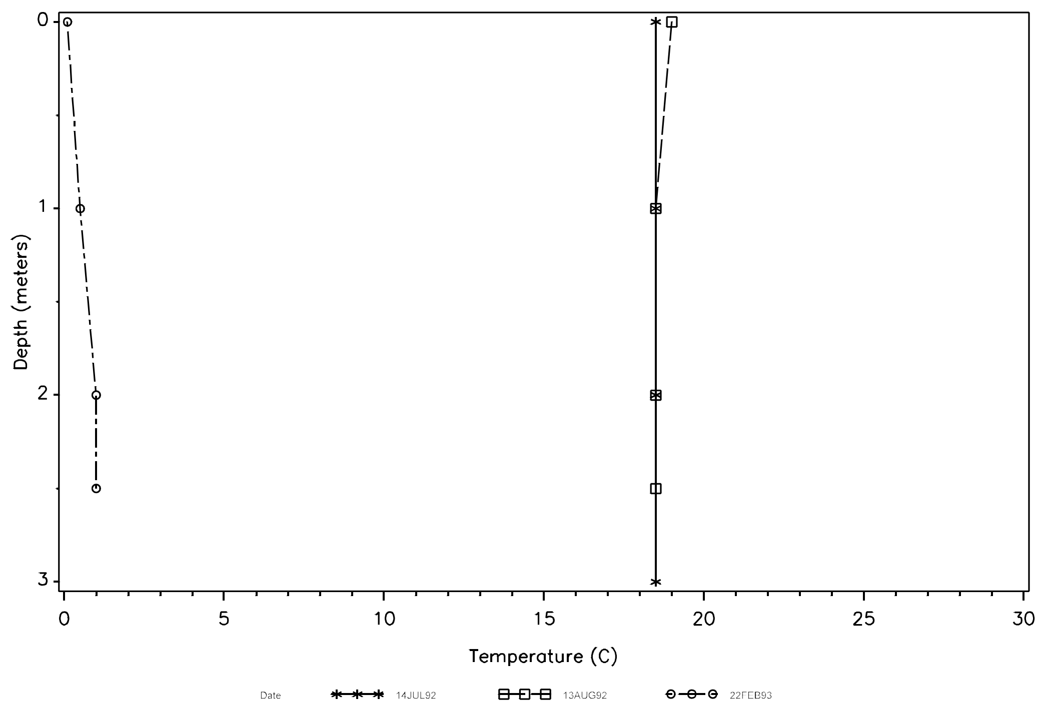


Figure 2: Temperature profile for Clear Water Lake.

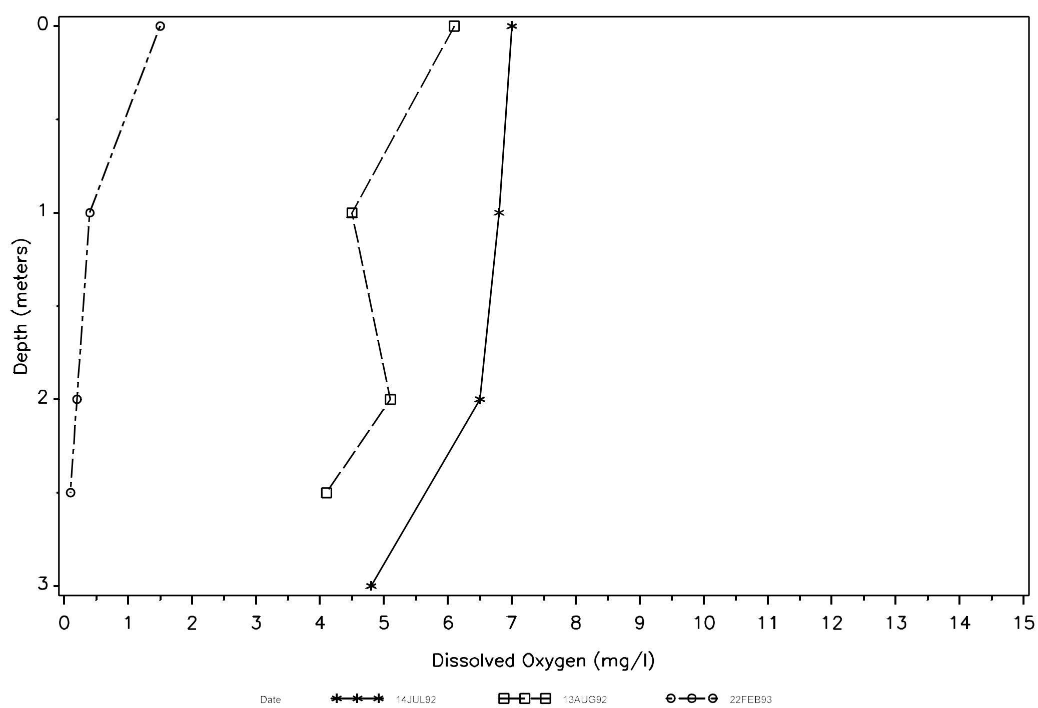


Figure 3. Oxygen profile for Clear Water Lake.

Phytoplankton

Clear Water Lake's phytoplankton community was sampled two times during the summer of 1992. At the time of sampling, Clear Water Lake's phytoplankton community was represented by 5 divisions and 10 genera. The largest contributors to the phytoplankton community by density was the division Cryptophyta, with a single genera Chromontas acuta. Mean density of the two samples collected during the summer of 1992 for the division Cryptophyta was 1,890 cells mL^{-1}, representing a population structure of equal portions between the division Cryptophyta and all other divisions combined. Other divisions present on Clear Water Lake in order of descending dominance were Cyanophyta, Chlorophyta, Bacillariophyta and Euglenophyta.

At the time of the assessment, mean phytoplankton concentrations by volume were dominated by the division Bacillariophyta. In descending order of volume other divisions represented were Chlorophyta, Cryptophyta, Euglenophyta and Cyanophyta. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected on Clear Water Lake during the LWQA project indicate Clear Water Lake is eutrophic. This assessment is based primarily on a secchi disk depth transparency average of 2.3 meters and summer surface total phosphate as P concentrations of 81 and 25 $\mu g\ L^{-1}$. Supporting ancillary information of a eutrophic lake condition are low dissolved oxygen concentrations under ice cover conditions and a history of fish kills.

Sediment Analysis

Sediments were collected from Clear Water Lake and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381355) and the littoral area of the lake (Site 381357) (Figure 1).

Sediment samples collected from Clear Water Lake showed detectable levels of all trace elements tested for except mercury and selenium in the littoral area sediments. Reported trace element concentrations in the sediments collected from each location within Clear Water Lake were compared to the 25th percentile, median and 75th percentile concentrations reported for all lakes assessed in the LWQA project. In general, the reported trace element concentrations in the sediments were below the median with most of them below the 25th percentile for all sediments analyzed during the LWQA project. The only exceptions were the reported copper concentrations in the littoral sediments and the barium concentrations in the deepest area which were near the median concentrations for all lake sediments analyzed during the LWQA project.

Reported concentrations of selected organic compounds and PCBs were below detectable limits for all sediment samples collected from Clear Water Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Clear Water Lake on August 13, 1992. A single northern pike was captured to represent the piscivore group with a length of 56 centimeters and a weight of 1,050 grams. Three white suckers were captured representing a bottom feeder sample with a mean length of 42 centimeters and a mean weight of 917 grams.

Concentrations of mercury, arsenic, cadmium and lead were below the detectable limits in both fish samples collected from Clear Water Lake. In general detectable trace element concentrations in the sample were above the 75th percentile for all piscivore samples collected during the LWQA project, with the exception of copper which was below the 25th percentile. The white sucker sample collected from Clear Water Lake in general had reported concentrations that were above the median with zinc and barium exceeding the 75th percentile.
Detectable pesticide residues in the fish samples collected from Clear Water Lake included DDD and DDE. DDD and DDE are breakdown derivatives of the agricultural insecticide DDT and can produce biological effects similar to the parent compound when available to the environment. The reported concentrations of DDD and DDE in the white sucker and northern pike samples collected from Clear Water Lake were near or above the 75th percentile for all fish samples collected during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Clear Water Lake with its contributing watershed has a combined surface area of 3,940 acres located on the Missouri Coteau physiographic region in Mountrail County, North Dakota. The Missouri Coteau is a glacial erosion remnant of the Wisconsin Age. The surrounding landscape is characterized by rolling hills and valleys, indicative of the prairie pothole region of North American. Soils are predominately excessively drained, built from gravelly, sandy glacial materials which are highly susceptible to wind and water erosion. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loadings and pollution discharges to Clear Water Lake.
Land use within the Clear Water Lake watershed is nearly 90 percent agricultural with 20.3 percent actively cultivated. The remaining 79.7 percent of the watershed is in low density urban development, haylands, pasture, conservation reserve program (CRP), wildlife and wetland management (Table 2).

According to the information provided by the Mountrail County Soil Conservation District, 50 percent of the cultivated lands and between 57 and 90 percent of all other lands within the Clear Water Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). It is estimated that within the Clear Water Lake watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of just over 2 tons per acre, which takes into account all land treatment and land uses within the watershed, approximately 8,333 tons of soil is lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 833 and 1,250 tons of soil are delivered to Clear Water Lake annually.

Other sources of nonpoint source pollution discharges to Clear Water Lake are from the numerous seasonal and semipermanent lake residences that lie in the western shore and cattle feeding and watering in the immediate drainage. These pollution sources possibly are the most significant within the watershed due to their ability to deliver a highly concentrated load of nutrients and sediments during runoff event.

Table 2. Land use in the Clear Water Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	20.3	50
Rangeland	56.7	70
Hayland	2.5	90
CRP	8.9	100
Wet/Wild[1]	10.4	N/A
Other	0.8	N/A
Farmsteads	3[3]	N/A
Feedlots[2]	0[3]	0[3]

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

CROWN BUTTE DAM

MORTON COUNTY

Peter N. Wax

Crown Butte Dam is a small impoundment on a tributary to the Heart River just west and slightly north of the city of Mandan in Morton County, North Dakota. The impoundment has a surface area of 31 acres, a maximum depth of 31 feet and a mean depth of 12.4 feet (Figure 1).

The topography of Crown Butte Dam's watershed is a classic characterization of the Coteau Slope physiographic region of North Dakota. Glacial deposits in the region are thin and discontinuous with remnants of unglaciated topography present. Soils in this region are predominantly silty and loamy and moderately well to well drained. Soils are generally fertile, easily worked and highly susceptible to both wind and water erosion. Annual precipitation ranges from 14 to 17 inches. Land use in the Crown Butte dam watershed is primarily agricultural.

Crown Butte Dam is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated biota" (NDSDHCL, 1991). The NDG&F manage Crown Butte Dam by annually assessing the fish community by test netting and stocking accordingly.

In recent years, stockings have mainly been rainbow trout with additional plants of largemouth bass, brown trout and walleye. Test netting operations conducted in the early summer of 1991 by the NDG&F captured in order of most abundant bluegills, fathead minnows, black bullhead, rainbow trout and white suckers.

Public facilities at Crown Butte Dam include a boat ramp and associated parking, toilets, picnic shelters and camping. Crown Butte Dam is popular with children of the local area due to the abundant bluegill population. Public use on Crown Butte Dam at times is heavy, depending on the productivity of the fishing.

Water Quality

Water quality data was collected from Crown Butte Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 381130, Figure 1). Water column samples were collected for analysis at three separate depths on each sampling date.

On July 20, 1992, Crown Butte Dam was thermally stratified between 1 and 3 meters however, on September 4, 1992, Crown Butte Dam was not thermally stratified (Figure 2). During sampling dissolved oxygen concentrations were near saturation to a depth of three meters and were adequate to maintain aquatic life (Figure 3). Samples collected during the winter of 1992 showed

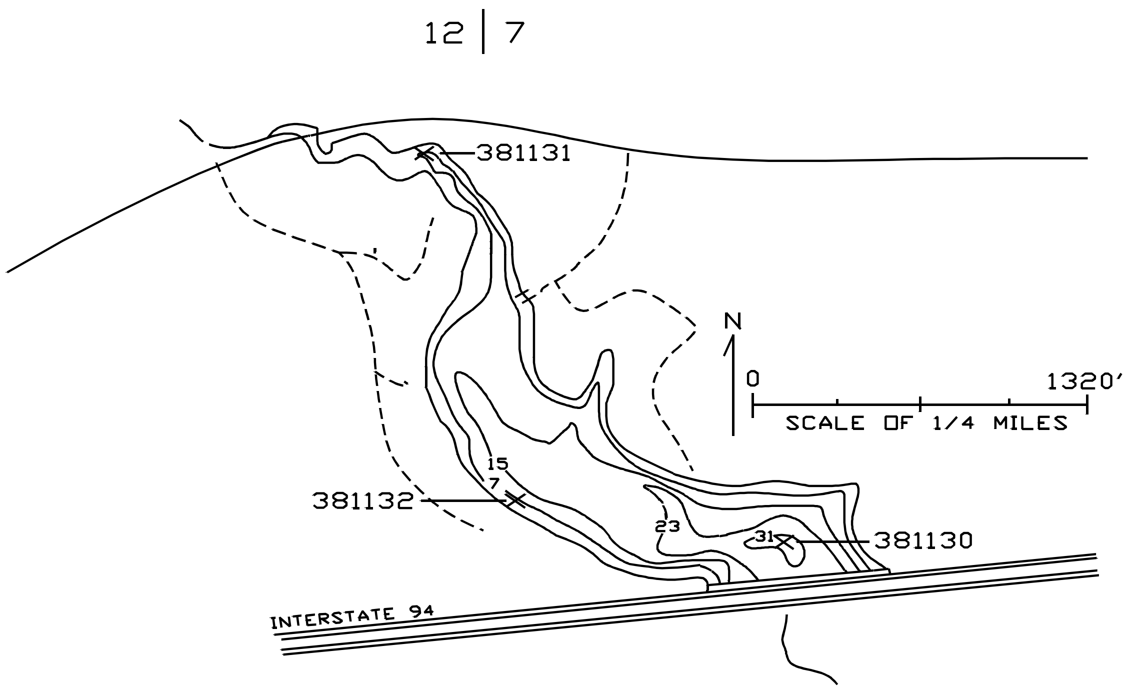


Figure 1. Morphometric map of Crown Butte Dam.

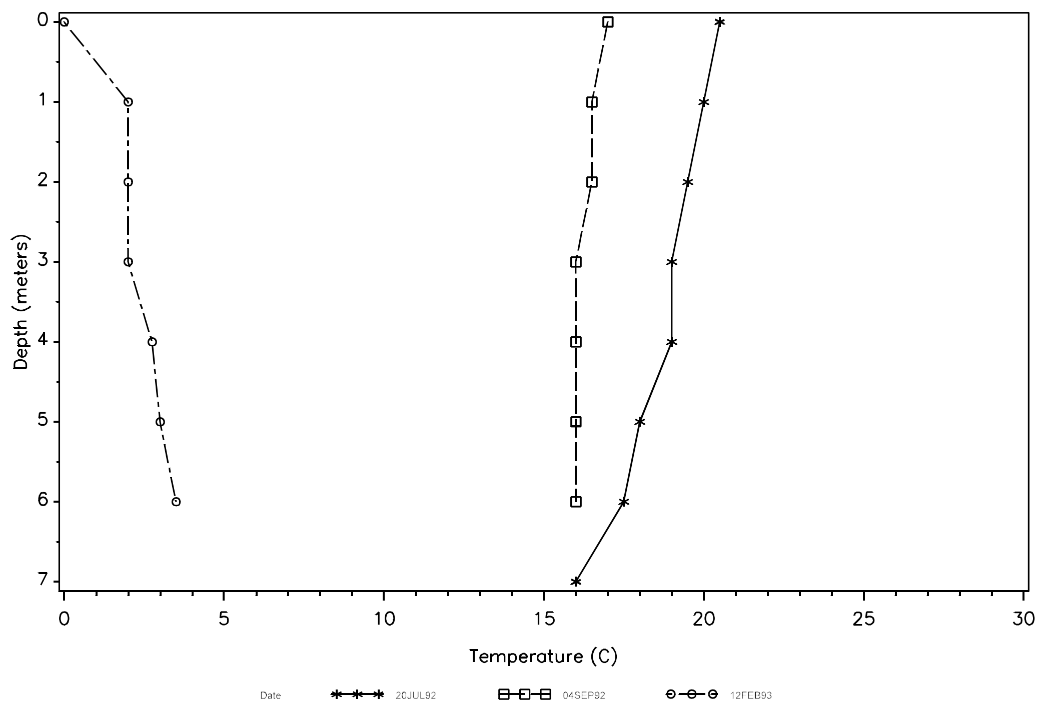


Figure 2. Temperature profile for Crown Butte Dam.

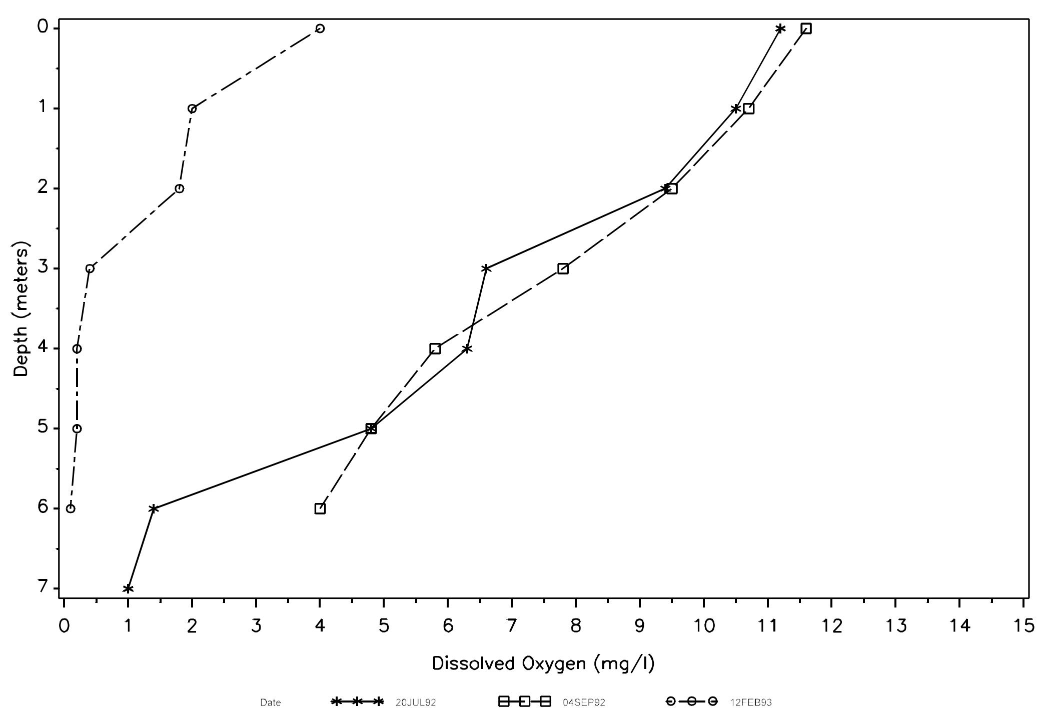


Figure 3. Oxygen profile for Crown Butte Dam.

Crown Butte Dam had developed thermal stratification at approximately four meters of depth (Figure 2). Dissolved oxygen concentrations at this time were low, ranging between 0.1 and 4.0 mg L^{-1} (Figure 3).

Water quality data collected during the LWQA project showed Crown Butte Dam as a highly-buffered waterbody. Total alkalinity as $CaCO_3$ had a volume-weighted mean concentrations of 454 mg L^{-1} (Table 1). Sulfates and bicarbonates were the dominant anions in the water column, with volume-weighted mean concentra-tions of 320 and 453 mg L^{-1}, respectively (Table 1). Concentrations of total dissolved solids, total hardness as calcium, and conductivity were all below the state's long-term average with volume-weighted mean concentrations of 927, 300 and 1,376 mg L^{-1}, respectively (Table 1).

Total phosphate as P concentrations had a volume-weighted mean of 0.965 mg L^{-1}, exceeding the state's target concentration of 0.25 mg L^{-1} on all occasions sampled. Nitrate + nitrite as N volume-weighted mean concentration was 0.019 mg L^{-1}, with concentrations ranging between 0.012 to 0.714 mg L^{-1}. The ratios between total phosphate as P and nitrate + nitrite as N suggest Crown Butte Dam is nitrogen limited. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 20, 1992 and February 12, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Crown Butte Dam		1982-1991	
Total Dissolved Solids	927	mg L^{-1}	1209	mg L^{-1}
Conductivity	1376	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	300	mg L^{-1}	488	mg L^{-1}
Sulfates	320	mg L^{-1}	592	mg L^{-1}
Chloride	17	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.965	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.019	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	454	mg L^{-1}	296	mg L^{-1}
Ammonia	0.258	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	4.63	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	453	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Crown Butte Dam as part of the LWQA project. The survey was conducted on July 20, 1992. At the time of the macrophyte survey, approximately 25 percent of Crown Butte Dam's surface area had aquatic vegetation. Nearly 100 percent of the lake's surface area to a depth of five feet had either sago pondweed Potamogeton pectinatus, water milfoil Myriophyllum spp., coontail Ceratophyllum demersum and cattails Typha spp., or a combination of all four. Also identified interspersed sparsely with the sago pondweed was a low density population of curlyleaf pondweed Potamogeton crispus. A map depicting the areal extent of macrophyte coverage on Crown Butte Dam is contained in Appendix B.

Phytoplankton

Crown Butte Dam's phytoplankton community was sampled two times during the summer of 1992. At the time of assessment, Crown Butte Dam's phytoplankton community was represented by six divisions and 26 genera. The largest contributors to the community by density was the division Cyanophyta with 8 genera represented. Mean density of the Cyanophyta for the two samples collected during the summer of 1992 was 178,071 cells mL^{-1}, representing a dominance of 5.5 fold over all other divisions combined. Other divisions represented in order of descending dominance by density were Chlorophyta, Pyrrophyta, Cryptophyta, Bacillariophyta and Euglenophyta.

At the time of the LWQA assessment, mean phytoplankton concentrations by volume did not reflect the blue-green algae, Cyanophyta dominance as by density. By volume the dominant divisions were Pyrrophyta, Chlorophyta, Bacillariophyta, Cyanophyta, Euglenophyta and Cryptophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA project defined Crown Butte Dam as hypereutrophic. Primary water quality indicators were shallow average secchi disk depth transparency of 0.75 meters, a chlorophyll-a concentrations of 30 $\mu g\ L^{-1}$ and high concentrations of summer surface total phosphate as P concentrations which ranged between 348 to 396 $\mu g\ L^{-1}$. Supporting ancillary information is a large macrophyte biomass, domination of the algal community by density by blue-green algae, rapid depletion of dissolved oxygen concentrations below the hypolimnion and during ice cover and history of fish kills.

Sediment Analysis

Sediments were collected from Crown Butte Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381130), the littoral zone (Site 381132) and the inlet (Site 381131) (Figure 1).

Sediment samples collected from Crown Butte Dam showed detectable levels of all trace elements tested for except mercury and selenium. Reported trace element concentrations in the sediments collected at each location within Crown Butte Dam were compared to the median concentrations reported for all lakes assessed in the LWQA project.

In general, reported trace element concentrations in the deepest and littoral area sediments were near the median concentrations for all lakes sampled. The exceptions were reported barium concentrations in the deepest area and arsenic in the deepest and littoral areas of the lake, which were near or above the 75th percentile for all sediment samples collected during the LWQA project. The inlet area sediments collected from Crown Butte Dam had reported concentrations of trace elements that were near or above the 75th percentile for all inlet sediments collected during the LWQA project. The reported barium concentration from the inlet area sediments was the maximum concentration reported for the LWQA project at 104 $\mu g\ g^{-1}$. Concentrations of selected pesticides and PCBs were below detectable limits for all samples collected from Crown Butte Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Crown Butte Dam on June 4, 1992. Two fish samples were collected from Crown Butte Dam. The first sample was composed of five rainbow trout, with an average length of 25.8 centimeters and an average weight of 156 grams and the second sample was composed of 5 bullheads with an average length of 25.4 centimeters and an average weight of 270 grams.

To evaluate the fish data for Crown Butte Dam the results for each fish sample was compared to all lakes assessed in the LWQA project. The trout sample collected from Crown Butte Dam contained detectable concentrations of all trace elements analyzed for, with the exception of cadmium, chromium and mercury. In general, the detectible trace element had reported concentrations that were near or below the median concentration. The exceptions were reported concentrations of selenium and barium of 0.34 and 3.07 $\mu g\ g^{-1}$, which are near and above the 75th percentile for all piscivores sampled during the LWQA project.

The bullhead sample collected from Crown Butte Dam contained detectable concentrations of all trace elements tested for with the exception of copper, mercury and chromium. Nearly all of the detectable elements within the bullhead sample from Crown Butte Dam had reported concentrations at or above the 75th percentile, with the reported concentration of barium being the highest concentration reported during the LWQA project. The exceptions were the reported concentrations of arsenic and lead which were equal to or below the 25th percentile for all bottom feeders analyzed during the LWQA project.

Detectable pesticide residues in the rainbow trout and bullhead samples collected from Crown Butte Dam were limited to DDE. DDE is a degradation byproduct of the insecticide DDT and can produce biological effects similar to the parent compound when available to the environment. The reported concentrations of DDE in the rainbow trout and bullhead samples collected from Crown Butte Dam were 0.004 and 0.003 $\mu g\ g^{-1}$, respectively. These concentrations represent concentrations which are below the 25th percentile for all bottom feeders and piscivore samples collected during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Crown Butte Dam, with its contributing watershed, has a surface area of 4,170 acres, located on the Missouri Slope physiographic region in Morton County, North Dakota. The Missouri Slope region of North Dakota is characterized by regular patterns of hills and shallow depressions. Topography is rolling, with shifts in relief of up to 300 feet but rarely exceeding 50 to 80 feet. The soils in this region are generally formed from rocky, gravelly or sandy glacial till and are moderately well to well drained. Slopes range from nearly level to steep with average slopes between 2 and 9 percent. The area is highly erodible when poor land management is employed. Normal annual precipitation ranges from 15 to 18 inches with major variations common from year to year. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to Crown Butte Dam.

Land use within the Crown Butte Dam watershed is 96 percent agricultural with 45.6 percent actively cultivated. The remaining 54 percent of the watershed is in low density urban development, haylands, pasture, Conservation Reserve Program (CRP) and wildlife management (Table 2). According to the information provided by the Morton County Soil Conservation District, 70 percent of the cultivated lands and between 75 and 80 percent of all the remaining lands within the Crown Butte Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Crown Butte Dam watershed the average "T" value is three to five tons per acre. Based on an average soil loss of five to six tons per acre, approximately 23,250 tons of soil are lost annually from the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 2,325 and 3,488 tons of soil are delivered to Crown Butte Dam annually. Other sources of nonpoint source pollution discharges to Crown Butte Dam than wind and water erosion are from concentrated livestock feeding areas and construction activities within the watershed.

Table 2. Land use in the Crown Butte Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	46.6	70
Rangeland	30.0	75
Hayland	14.8	80
CRP	14.7	40
Wet/Wild[1]	0.96	80
Other	1.9	80
Farmsteads	12[3]	N/A
Feedlots[2]	3[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the watershed.

DEAD COLT CREEK DAM

RANSOM COUNTY

Peter N. Wax

Dead Colt Creek Dam is located on a tributary to the Sheyenne River in Ransom County, North Dakota. The reservoir was built in 1983 and filled the following spring. It is a multipurpose dam built for flood protection and recreation. Dead Colt Creek Dam has a surface area of 113 acres and a maximum depth of 18.3 feet (Figure 1).

The topography of the surrounding area is characterized by regular patterns of hills and shallow depressions. Soils in the watershed are formed from rocky, gravelly or sandy glacial till and are moderately well drained. Slopes range from nearly level to steep with average slopes between 2 and 9 percent. Average precipitation in the region is 15 to 18 inches with major variations common between years. Land use in the Dead Colt Creek Dam watershed is predominantly in small grains and row crops with a small percentage in livestock production.

Dead Colt Creek Dam is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated biota" (NDSDHCL, 1991). The NDG&F manage Dead Colt Creek Dam through annual assessments of the fish community and stock accordingly.

Fisheries management began on Dead Colt Creek Dam in 1983 with complete chemical eradication of the reservoir and upstream drainage. Initial stockings the following spring were rainbow trout and crappie. Stockings of small and largemouth bass, catfish and walleye followed in subsequent years. Historically, the rainbow trout fishery on Dead Colt Creek Dam has been erratic, experiencing occasional fish kills with the warm water fishery being very productive.

In recent years the stocking regiment has included smallmouth bass, channel catfish and walleye. The last rainbow trout stocking occurred in 1988. A fish community assessments conducted by the NDG&F in 1991 captured in order of most abundance black bullheads, bluegill, black crappie and walleye.

One hundred percent of Dead Colt Creek Dam is publicly owned. Public facilities at Dead Colt Creek Dam are excellent and include a boat ramp, parking, toilets, picnic grounds and camping areas. Public use on Dead Colt Creek Dam initially was very high, but in recent years has declined to moderate or low due to a lack of a stable fishery.

Water Quality

Water quality samples were collected from Dead Colt Creek Dam two times during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380340, Figure 1).

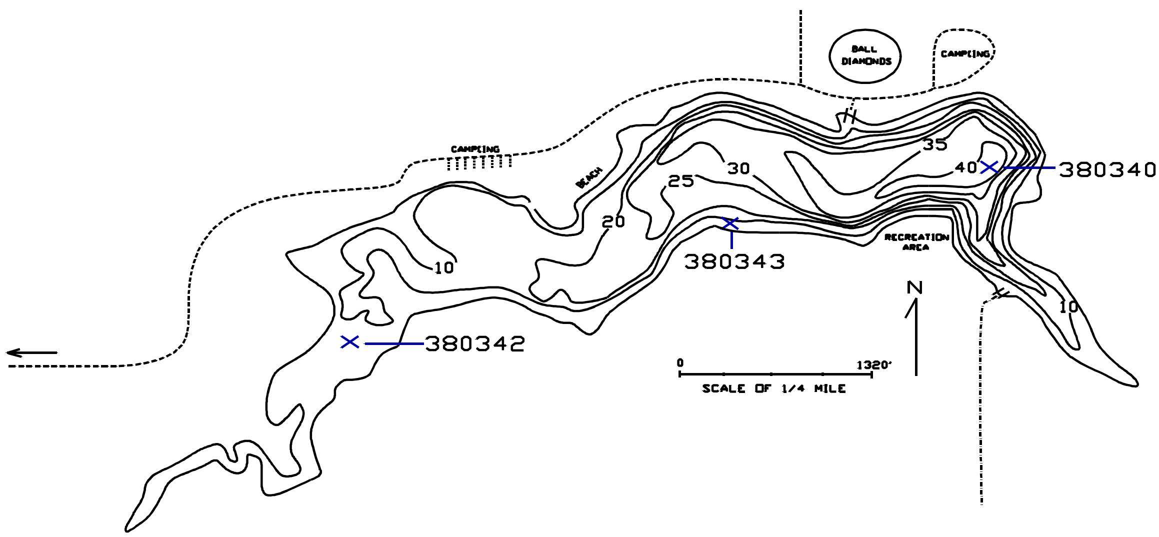


Figure 1. Morphometric map of Dead Colt Creek Dam.

Water column samples were collected for analysis at three separate depths of 1, 5 and 10 meters during summer sampling and 1, 5 and 9 meters during winter sampling.

During the summer sampling of 1992 Dead Colt Creek Dam was thermally stratified on July 29, 1992 between 5 and 7 meters of depth and between 6 and 7 meters on September 1, 1992 (Figure 2). Dissolved oxygen concentrations on the July sample date were between 0.4 mg L^{-1} near the bottom to 10.6 mg L^{-1} at the surface. In September, dissolved oxygen concentrations were between 0.2 mg L^{-1} near the bottom and 5.2 mg L^{-1} at the surface (Figure 3). Water column samples collected on March 2, 1993 showed weak thermal stratification occurring between 4 and 6 meters of depth (Figure 1) with dissolved oxygen concentrations ranging between 0.1 mg L^{-1} and 7.6 mg L^{-1} (Figure 3).

Water quality samples collected during the LWQA project on Dead Colt Creek Dam described a well buffered waterbody with a volume-weighted mean for total alkalinity as $CaC0_3$ of 179 mg L^{-1} (Table 1). The dominant anions in the water column were bicarbonates and sulfates, with volume-weighted mean concentra-tions of 211 and 119 mg L^{-1}, respectively (Table 1). Volume-weighted mean concentrations of the parameters total hardness as calcium and total dissolved solids describe a waterbody with relatively fresh water when compared to the long-term averages for the state of North Dakota (Table 1).

Dead Colt Creek Dam had relatively high concentrations of the nutrients total phosphate as P and nitrate + nitrite as N with volume-weighted mean concentra-tions of 0.196 mg L^{-1} and 0.161 mg L^{-1} respectively. The ratios between total phosphate as P and nitrate + nitrite as N of 1.2:1 indicate Dead Colt Creek is nitrogen limited. However, under these conditions true nitrogen limitation is not occurring but instead a situation is created that favors nitrogen fixing organism such as some species of blue-green algae. A complete listing of all LWQA water quality data is contained in Appendix A.

Aquatic Vegetation

A qualitative survey of the macrophyte community on Dead Colt Creek Dam was conducted on July 29, 1992. At the time of the survey approximately 25 percent of Dead Colt Creek Dam's surface area to a depth of nearly 10 feet had submergent aquatic vegetation. In the upper (inlet) third of Dead Colt Creek Dam submergent aquatic vegetation present was coontail Ceratophyllum demersum, curlyleaf pondweed Potamogeton crispus and sago pondweed Potamogeton pectinatus in concentrations of approximately 50 percent curlyleaf, 30 percent coontail, and 20 percent sago pondweed.

In the center third of the lake the same species were found in concentrations of approximately 80 percent curlyleaf, 10 percent coontail and 10 percent sago pondweed. The lower third of the lake contained only curlyleaf and sago pondweed in concentrations of approximately 80 percent curlyleaf and 20 percent sago pondweed. The emergent macrophytes present on Dead Colt Creek Dam was a narrow intermittent band cattails Typha spp. A map depicting the areal extent of macrophyte coverage on Dead Colt Creek Dam is contained in Appendix B.

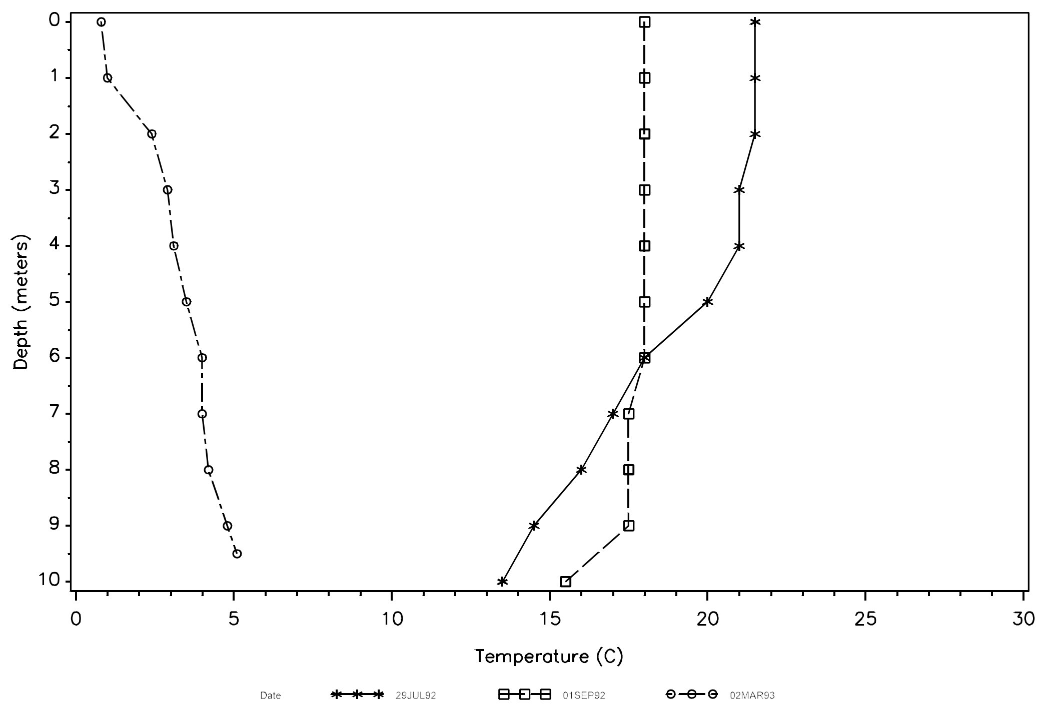


Figure 2. Temperature profile for Dead Colt Creek Dam.

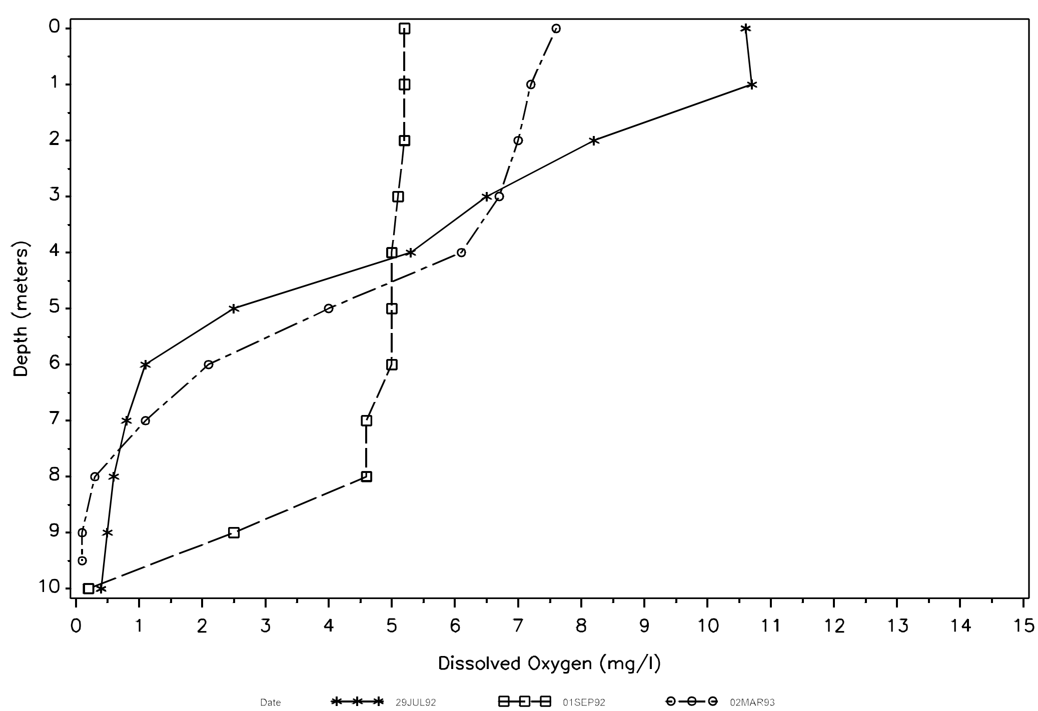


Figure 3. Oxygen profile for Dead Colt Creek Dam.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 29, 1992 and March 2, 1993 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Dead Colt Creek Dam		1982-1991	
Total Dissolved Solids	365	mg L^{-1}	1209	mg L^{-1}
Conductivity	603	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	214	mg L^{-1}	488	mg L^{-1}
Sulfates	119	mg L^{-1}	592	mg L^{-1}
Chloride	19	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.196	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.161	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	179	mg L^{-1}	296	mg L^{-1}
Ammonia	0.660	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.85	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	211	mg L^{-1}	326	mg L^{-1}

Phytoplankton

Dead Colt Creek Dam's phytoplankton community was sampled two times during the summer of 1992. At the time of the assessment Dead Colt Creek Dam's phytoplankton community had representation from 3 divisions and 13 genera. The largest contributor by density to the phytoplankton community was the blue-green algae Cyanophyta, with 6 genera represented. Mean density of the two samples collected during the summer of 1992 was 99,911 cells mL^{-1}, representing a dominance of 67 fold over the other two divisions combined.

At the time of the assessment, mean phytoplankton concentrations by volume were also dominated by blue-green algae Cyanophyta. Blue-green algae occupied over 96 percent of the community by volume. The division Cryptophyta followed with a little over 3 percent of the community by volume and the remainder was composed of Chlorophyta. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA project identified Dead Colt Creek as hypereutrophic. Primary indicators were secchi disk transparency depths ranging between 1.2 and 2.1 meters, chlorophyll-a concentrations of 4 and 1 $\mu g\ L^{-1}$ and summer surface total phosphate as P concentrations of 66 and 223 $\mu g\ L^{-1}$.

Supporting ancillary information of a hypereutrophic assessment are Dead Colt Creek Dam's phytoplankton community which is dominated by blue-green algae, rapid dissolved oxygen depletion within the hypolimnion, large macrophyte biomass, frequent nuisance algae blooms and a history of fish kills. A complete summary of the LWQA water quality data is contained in Appendix A.

Sediment Analysis

Sediments were collected from Dead Colt Creek Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 380340), the littoral zone (Site 380343) and the inlet (Site 380342) (Figure 1).

Sediment samples collected from Dead Colt Creek Dam contained detectable levels of all trace elements tested for except for selenium in the deepest and inlet area sediments and mercury in all areas. Reported trace element concentrations in the sediments collected at each location within Dead Colt Creek Dam were compared to the median concentration reported for all lakes assessed in the LWQA project. In general, trace element concentrations in the sediments were near or below the median concentrations for all lakes sampled during the LWQA project. The only exception was the cadmium concentrations in the littoral area sediments.

Concentrations of selected organic compounds (pesticides) were below detectable limits for all sediment samples collected from Dead Colt Creek Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Dead Colt Creek Dam on July 2, 1992. A black bullhead sample composed of 5 fish with an average length of 22.8 centimeters and an average weight of 218 grams and a largemouth bass sample composed of 4 fish with a mean length of 40 centimeters and a mean weight of 1,037 grams were collected.

To evaluate the fish tissue data for Dead Colt Creek Dam the results for each fish sample was compared to all corresponding samples assessed in LWQA project. Trace element concentrations in the black bullhead sample collected from Dead Colt Creek Dam in general were near or slightly below the median concentrations for all bottom feeders sampled during the LWQA project. The exception was the cadmium concentration of 0.008 $\mu g\ g^{-1}$ which exceeded the 75th percentile.

The largemouth bass sample collected from Dead Colt Creek Dam had reported trace element concentrations which varied significantly between parameters. The reported concentrations of copper, zinc, arsenic and lead were all equal to or below the 25th percentile for all piscivore samples collected during the LWQA project. However, the reported concentrations of barium, chromium, cadmium and mercury exceeded the median concentration with reported concentrations of barium, chromium and cadmium exceeding the 75th percentile.
Detectable pesticide residues in the fish samples collected from Dead Colt Creek Dam included DDE, DDD, dieldrin and nonachlor. All four of these organic compounds are either agricultural pesticides or by-products of pesticides that were removed from use in the early 1970's due to their negative impacts upon the environment. DDE and DDD are both degradation by-products of the agricultural insecticide DDT and can produce similar biological effects as the parent compound when available to the environment. Dieldrin is an agricultural insecticide that has been shown to prevent daphne from completing metamorphosis to adulthood at concentrations as low as 5.6 $\mu g\ L^{-1}$ and was lethal on 50 percent of largemouth bass and walleye during a 96-hour exposure at

concentrations of 1.5 and 2.9 μg L^{-1} respectively. The chemical nonachlor is a major ingredient in technical chlordane. Very little data is available on its biological effects on the environment, however, it is known to be quite persistent (Johnson and Finley 1980).

The black bullhead sample collected from Dead Colt Creek Dam contained DDE, DDD and dieldrin. The DDE concentration of 0.005 μg g^{-1} was just slightly greater than the 25th percentile the DDD concentration of 0.003 was slightly higher than the median concentration for all bottom feeders and the concentration of dieldrin of 0.005 is equal to the maximum concentration reported for any bottom feeder analyzed during the LWQA project.

The largemouth bass sample collected from Dead Colt Creek Dam contained con-centrations of DDE and nonachlor. The concentration of DDE at 0.008 μg g^{-1} was less than the median concentration for all piscivores sampled during the LWQA project, however, the concentration of nonachlor at 0.002 μg g^{-1} was approximately equal to the 75th percentile. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Dead Colt Creek Dam with its contributing watershed has a combined surface area of 41,400 acres located on the Glaciated Plains in Ransom County, North Dakota. This physiographic region of North Dakota is characterized by rolling glaciated plains with many small potholes and integrated drainages. Soils are moderately erodible and generally well drained. Annual precipitation is between 15 and 20 inches with considerable variation between years. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loadings and pollution discharges to Dead Colt Creek Dam.

Land use within the Dead Colt Creek Dam watershed is nearly 97 percent agricultural with 82.1 percent actively cultivated. The remaining 17 percent is in low density urban development, haylands, pasture, conservation reserve program (CRP), wetland and wildlife areas (Table 2).

According to the information provided by the Ransom County Soil Conservation District, 50 percent of the cultivated lands and between 60 and 75 percent of all the remaining lands within the Dead Colt Creek Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Dead Colt Creek Dam watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of 4 to 5 tons per acre, which takes into account all land treatment and land uses within the watershed, approximately 176,460 tons of soil is lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 17,646 and 26,469 tons of soil are delivered to Dead Colt Creek Dam annually. Other sources of nonpoint source pollution discharges to Dead Colt Creek Dam are from concentrated livestock feeding and watering in the immediate drainage and construction activities within the watershed. These sources can have the capabilities to contribute a significant percentage of the annual nutrient and sediment load to Dead Colt Creek Dam.

Table 2. Land use in the Dead Colt Creek Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	82.1	50
Rangeland	8.1	90
Hayland	6.0	90
CRP	1.0	100
Wet/Wild[1]	2.7	N/A
Other	0.3	N/A
Farmsteads	68[3]	N/A
Feedlots[2]	20[3]	100

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

FORDVILLE DAM

GRAND FORKS COUNTY

Peter N. Wax

Fordville Dam is located on the south branch of the Forest River two miles southeast of Fordville in Grand Forks County, North Dakota. Fordville Dam is a multi-purpose structure built for flood protection, recreation and wildlife benefits. The dam was completed in 1981 and filled the following spring to a maximum depth of 25 feet, a mean depth of 10.5 feet and a surface area of 197 acres (Figure 1).

Topography of the surrounding area is level with very gradual changes in relief and slopes rarely exceeding two percent. In general, soils are moderately erodible with good moisture retention. Annual rainfall in this region is between 19 and 21 inches. Land use is primarily agricultural, consisting of small grain and row crop production.

Fordville Dam is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Fordville Dam by annually assessing the fish community by test netting and stock accordingly.

Initial fisheries management by the NDG&F began in October 1977 with a complete eradication of all fish within Fordville Dam and the upstream drainage. Eradication was followed with stockings of northern pike, walleye, largemouth bass, crappie and bluegill. In recent years the stocking regiment has been restricted to walleye and northern pike. Test netting operations conducted on June 19, 1990 by the NDG&F captured in order of most abundance black bullheads, yellow perch, white suckers, walleye, crappie, bluegill and northern pike.

Recreational uses on Fordville Dam include fishing, boating, hiking, swimming and picnicking. The entire recreational area of Fordville Dam is nearly 900 acres. The Grand Forks and Walsh County Management Boards are primary managers of the recreational area in conjunction with the NDG&F. Facilities at Fordville Dam include a picnic area, outdoor toilets, boat ramp and associated parking. Use on Fordville Dam is heavy to moderate depending on the productivity of the fishery.

Water Quality

Water quality samples were collected from Fordville Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at a single sample site located in the deepest area of the lake (Site 381240, Figure 1). Water column samples were collected for analysis at three separate depths on each sample date. Water column samples were collected at depths of 1 meter, between 3 and 4 meters and between 6 and 7 meters.

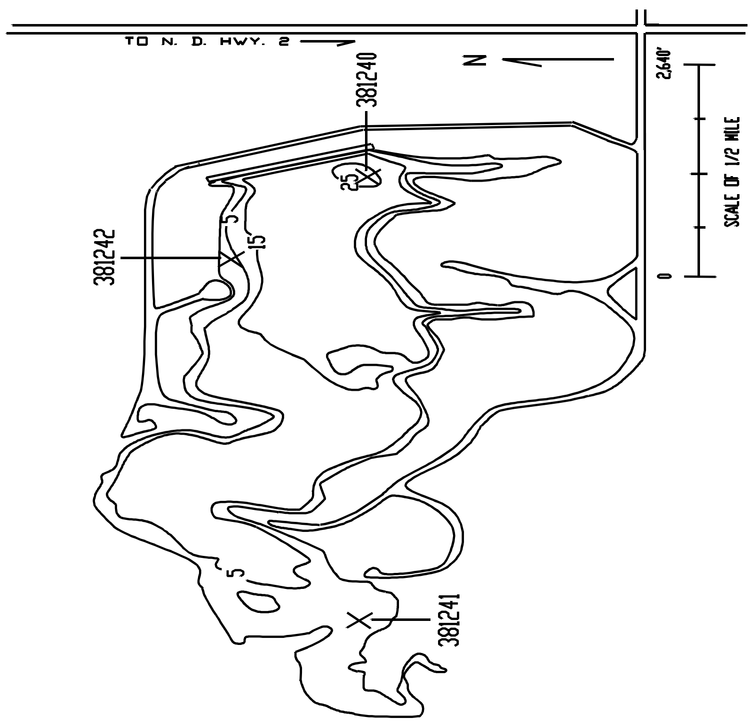


Figure 1. Morphometric map of Fordville Dam.

During the summer of 1992, Fordville Dam was weakly thermally stratified between one and two meters of depth on July 22, and between three and four meters of depth on August 19 (Figure 2). During sampling, dissolved oxygen concentrations were at or near saturation to the depth of thermal stratifi-cation with rapid depletion below (Figure 3). Samples collected on March 11, 1993, show Fordville Dam without thermal stratification occurring and dissolved oxygen concentrations ranging from nondetectable near the bottom to 5.0 mg L^{-1} at the surface (Figure 2, Figure 3).

During the LWQA project, concentrations of total dissolved solids, hardness as calcium and conductivity were lower than the long-term average for North Dakota lakes and lower than most other lakes sampled during this period (Table 1). The volume-weighted mean concentration of total alkalinity as $CaCO_3$ of 227 mg L^{-1} indicate Fordville Dam is a well-buffered waterbody. The dominant anions in the water column were bicarbonates and sulfates with volume-weighted means of 236 and 117 mg L^{-1}, respectively.

During the LWQA project Fordville Dam had abundant supplies of the primary nutrients total phosphate as P and nitrate + nitrite as N. Volume-weighted mean concentrations of total phosphate as P and nitrate + nitrite as N were 0.298 and 0.109 mg L^{-1}, respectively. The ratio of total phosphate as P and nitrate + nitrite as N of 2.7:1 indicates Fordville Dam is nitrogen limited. True nitrogen limitation does not exist on Fordville Dam, but rather, there is an overabundance of phosphorus in the water column. Under these conditions, certain nitrogen fixing species such as some blue-green algae are favored. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 22, 1992 and March 11, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Fordville Dam		1982-1991	
Total Dissolved Solids	395	mg L^{-1}	1209	mg L^{-1}
Conductivity	652	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	269	mg L^{-1}	488	mg L^{-1}
Sulfates	117	mg L^{-1}	592	mg L^{-1}
Chloride	11	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.298	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.109	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	227	mg L^{-1}	296	mg L^{-1}
Ammonia	0.250	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.117	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	236	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Fordville Dam as part of the LWQA project. The survey was conducted on July 22, 1992.

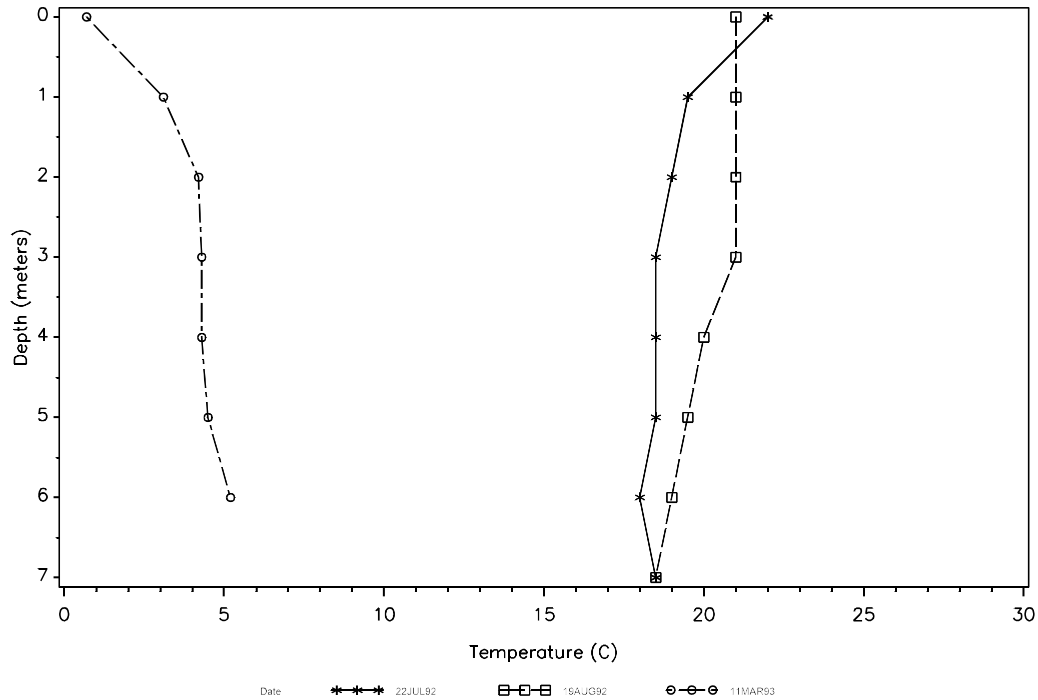


Figure 2. Temperature profile for Fordville Dam.

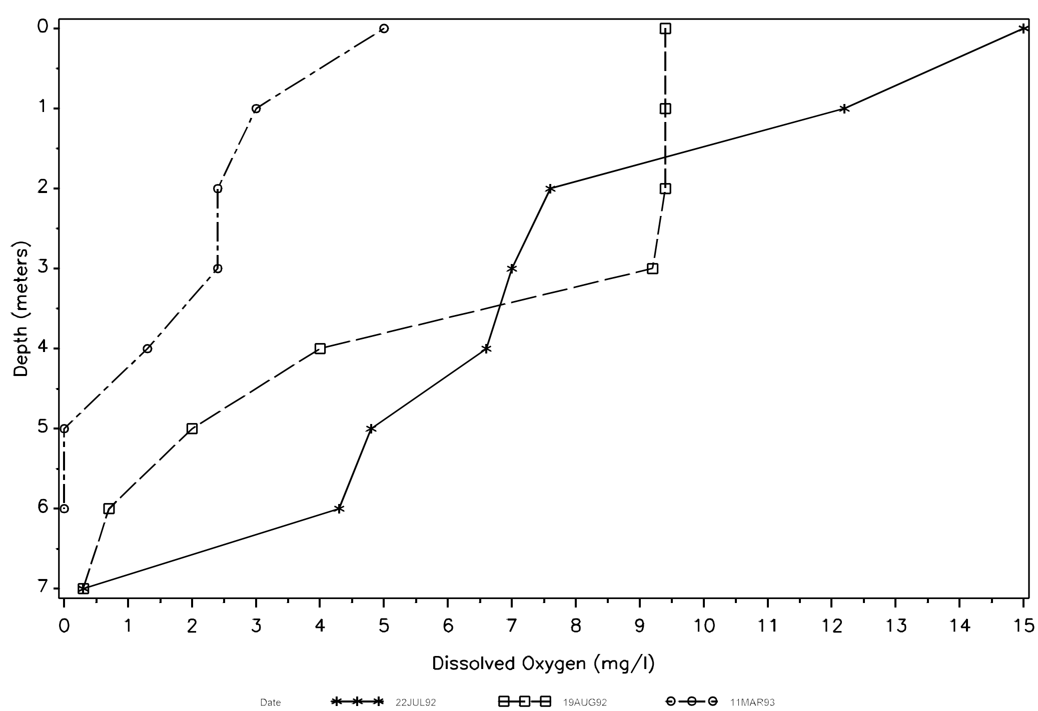


Figure 3. Oxygen profile for Fordville Dam.

At the time of the macrophyte survey, approximately 20 percent of Fordville Dam's surface area had aquatic vegetation. Nearly 100 percent of the lake's surface area to a depth of five feet had either sago pondweed Potamogeton pectinatus, american elodea Elodea canadensis, coontail Ceratophyllum demersum, cattails Typha spp. and bulrush Scirpus spp or a combination of two or more. The lower third of the lake was void of emergent macrophyte vegetation, however, there were mixed stands of sago pondweed, coontail, and elodea. The upper two thirds of the lake contained either mixed stands of sago pondweed and elodea or pure stands of sago. The bulrush and cattails were located in the inlet and bay areas of Fordville Dam. A map depicting the areal extent of macrophyte coverage on Fordville Dam is contained in Appendix B.

Phytoplankton

Fordville Dam's phytoplankton community was sampled two times during the summer of 1992. At the time of the assessment, Fordville Dam's phytoplankton community was one of the least diverse sampled during the LWQA project, with representation from only three divisions and seven genera. The largest contributors by density were the blue-green algae Cyanophyta with three genera present. Mean density of the blue-green algae population for the two samples collected was 243,407 cells per mL^{-1}, representing a dominance 120 fold over the other two divisions combined.

At the time of the assessment, mean phytoplankton concentrations by volume were also dominated by blue-green algae, Cyanophyta. Blue-green algae occupied over 90 percent of the algal communities volume. The division, Crypothyta, followed with a little over 8 percent and the remainder was composed of Chlorophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA project defined Fordville Dam as hypereutrophic. Primary water quality indicators used to define the trophic condition of Fordville Dam were secchi disk transparency depth, chlorophyll-a concentrations and summer surface total phosphate as P concentrations with averages of 1.4 meters, 31 $\mu g\ L^{-1}$ and 25 $\mu g\ L^{-1}$, respectively. Ancillary data collaborated the trophic assessment of hypereutrophic on Fordville Dam. Ancillary data included a large macrophyte biomass, rapid oxygen depletion below the hypolimnion and under ice cover conditions, frequent nuisance algal blooms and a relatively monotypic phytoplankton population dominated by blue-green algae species.

Sediment Analysis

Sediments were collected from Fordville Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381240), the littoral zone (Site 381242) and the inlet (Site 381241) (Figure 1).

Sediment samples collected from Fordville Dam showed detectable levels of all trace elements tested for, except for selenium and mercury in the littoral and inlet areas. Reported concentrations of trace elements in the sediments collected from Fordville Dam were compared to the concentrations reported for all lakes assessed in the LWQA project.

Reported trace element concentrations in the littoral sediments collected from Fordville Dam in general were near or below the 25th percentile for all sediment samples collected in the LWQA project. The exceptions were barium and arsenic, which were near the median concentrations reported.

The reported concentrations of trace elements in the inlet sediments collected from Fordville Dam were near the medians for all inlet sediment samples collected during the LWQA project. The only exception was the reported arsenic concentration which was near the 75th percentile.

In general, the deepest area sediments collected from Fordville Dam had reported concentrations of trace elements that were near or slightly above the median. The exceptions were the reported zinc, arsenic, cadmium and mercury concentrations which all were near or exceeding the 75th percentile for all deepest area sediments collected during the LWQA project.

Concentrations of selected organic compounds (pesticides) and PCBs were below detectable limits for all sediment samples collected from Fordville Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected from Fordville Dam for contaminant analysis on June 17, 1992. A composite sample of two walleyes were collected, with a mean length of 51 centimeters and a mean weight of 1,380 grams and a composite sample of five white suckers were collected with a mean length of 51.5 centimeters and a mean weight of 1,798 grams. The walleyes collected will represent a piscivore sample and the white suckers a bottom feeder sample.

Trace element concentrations reported in the fish samples collected from Fordville Dam were generally below or near the median concentrations for all fish collected during the LWQA project. The exceptions were the reported barium, zinc and selenium concentrations in the white sucker sample and the reported barium, selenium and mercury concentrations in the piscivore sample which were above the 75th percentile.

Detectable pesticide residues in the fish samples collected from Fordville Dam were DDT, DDE, DDD and dieldrin. DDT is an agricultural insecticide which was removed from agricultural use in 1973 due to its harmful affect on the environment. DDE and DDD are both breakdown derivatives of DDT and can behave similarly to the parent compound when exposed to the environment. Dieldrin is also an agricultural insecticide that was removed from use the same year as DDT due to its potential harmful effects on the environment.

The walleye sample collected from Fordville Dam contained concentrations of DDT, DDE, DDD and dieldrin in concentrations of 0.003, 0.023, 0.004, and 0.002 $\mu g\ g^{-1}$, respectively. These concentrations are either equal to or exceeding the 75th percentile for all piscivore samples collected during the LWQA project.

The white sucker sample collected from Fordville Dam contained only DDE and DDD. The concentrations reported were 0.019 and 0.005 $\mu g\ g^{-1}$, respectively. The DDE concentration was slightly above the 75th percentile for all bottom feeders collected during the LWQA project while the DDD concentration was slightly below. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Fordville Dam with its contributing watershed has a combined surface area of 25,560 acres located in the Red River Valley in eastern Grand Forks County, North Dakota. The physiographic region known as the Red River Valley was formed through sedimentation of glacial Lake Agassiz. It is extremely level, with only gradual changes in topography. Soils of the watershed are deep and highly fertile, with slopes rarely exceeding two percent. In general, soils are moderately erodible, with good moisture retention. Annual rainfall in the watershed is between 19 and 21 inches. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loadings and pollution discharges to Fordville Dam.

Land use within the Fordville Dam watershed is approximately 90 percent agri-cultural with 79 percent actively cultivated. The remaining 21 percent of the watershed is in low density urban development, haylands, pasture, Conservation Reserve Program (CRP), woodlands and wetlands (Table 2). According to the information provided by the Grand Forks County Soil Conservation District, 60 percent of the cultivated lands and approximately 70 percent of all the remaining lands in the Fordville Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

Table 2. Land use in the Fordville Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	79.0	60
Rangeland	1.5	70
Hayland	4.0	70
CRP	5.6	100
Woodlands	2.2	N/A
Wet/Wild[1]	2.3	N/A
Other	5.1	N/A
Farmsteads	15[3]	N/A
Feedlots[2]	1[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

It is estimated that within the Fordville Dam watershed, the average "T" value is three to five tons per acre. Based on an average soil loss of nearly five tons per acre, which takes into account all current land treatments and practices, approximately 126,798 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 12,680 and 19,019 tons of soil are delivered to Fordville Dam annually.

Other sources of nonpoint source pollution discharges to Fordville Dam are cattle feeding and watering in the immediate drainage and a single concentrated livestock feeding area. These sources have the capabilities to contribute nutrients to the lake and may be a significant source due to their proximity to the water's edge.

FROELICH DAM

SIOUX COUNTY

Peter N. Wax

Froelich Dam is a small impoundment on a unnamed tributary to the Cannonball River in Sioux County, North Dakota. The dam and watershed lie on the transitional area between the Coteau Slope and Missouri Slope Upland physiographic regions of North Dakota. At full pool the reservoir has a surface area of 176.4 acres, a maximum depth of 36 feet and an average depth of 13 feet (Figure 1). Froelich Dam was completed in 1962, but failed to fill until 1964.

Froelich Dam's watershed is relatively small extending over 4,160 acres of predominantly rangeland. The topography of the area is composed primarily of rolling to hilly uplands. Slopes are generally gentle with relief ranging from 300 to 500 feet. This region has well-defined drainages in the form of intermittent and perennial streams. Few surficial aquifers exist in the watershed other than along stream drainages. Soils are moderately shallow to shallow, formed from weathered, loamy glacial till or soft bedrock. Generally, soils are moderately fertile to fertile, well drained and susceptible to wind and water erosion. Average precipitation ranges from 14 to 16 inches, with 80 to 90 percent of the annual precipitation occurring between April and September.

Approximately 90 percent of Froelich Dam's watershed is either owned by the NDG&F or has a public flood easement upon it. All of the non-NDG&F portion of the lake is currently grazed. The northwest side of the dam is devoted to public use and wildlife management, with very limited permitted grazing.

Public access to Froelich Dam is reasonable during the summer months and is almost unattainable in winters after heavy snows. Public facilities on Froelich Dam are limited to a boat ramp and associated parking, a small area for picnicking and toilets. Recreational use on Froelich Dam historically has fluctuated significantly from heavy during times of good fishing to nearly nonexistent in times when the fishing is poor.

Froelich Dam is classified as a cool water fishery "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL 1991). The NDG&F manage Froelich Dam by annually assessing the fish community by test netting and stock accordingly.

In recent years, the stocking regiment has included rainbow trout, walleye, and largemouth bass. Historically, Froelich Dam has been an excellent rainbow trout fishery, with fish in the five to six pound range common.

Water Quality

Water quality samples were collected from Froelich Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380730, Figure 1). Water column samples were collected for analysis at three discrete depths, 1 meter, 4 meters and between 6 and 8 meters.

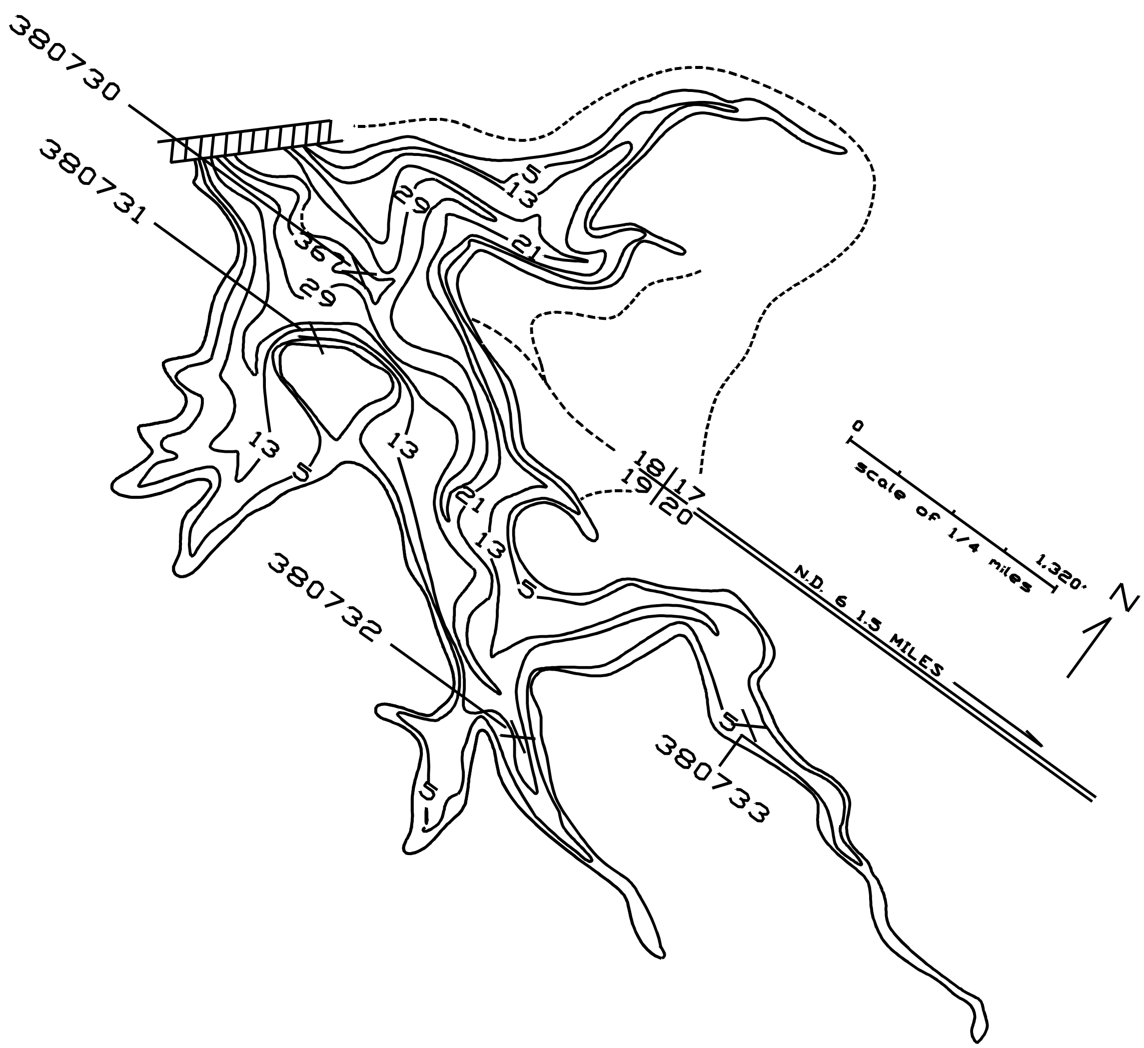


Figure 1. Morphometric map of Froelich Dam.

During summer sampling of 1992, Froelich Dam was weakly thermally stratified on July 9, at a depth of 2 to 4 meters and not thermally stratified on August 6 (Figure 2). Dissolved oxygen concentrations ranged between 1.7 and
7.9 mg L^{-1} on July 9 and between 1.2 and 6.2 mg L^{-1} on August 6 (Figure 3). Samples collected on January 12, 1993 showed Froelich Dam weakly stratified between 4 and 5 meters of depth. Dissolved oxygen concentrations at this time were between 4.4 and 7.6 above the thermocline with rapid depletion to nearly zero below the thermocline (Figure 2, Figure 3).

Water quality data collected during the LWQA project indicates Froelich Dam is a well-buffered waterbody. Total alkalinity as $CaCO_3$ had a volume-weighted mean concentration of 331 mg L^{-1} (Table 1). Concentrations of total dissolved solids, hardness as calcium, and conductivity were lower than the state's long-term average and lower than most other lakes sampled during the LWQA project (Table 1). The dominant anions in the water column were bicarbonates and sulfates, with volume-weighted mean concentrations of 373 and 21 mg L^{-1}, respectively (Table 1).

The primary nutrients total phosphate as P and nitrate + nitrite as N had volume-weighted mean concentrations of 0.356 and 0.074 mg L^{-1}, respectively. The phosphorus to nitrogen ratio of 4.8:1, indicates Froelich Dam is a nitrogen limited waterbody. Under these conditions, nitrogen fixing organisms such as some blue-green algae species are favored. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 7, 1992 and January 12, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Froelich Dam		1982-1991	
Total Dissolved Solids	385	mg L^{-1}	1209	mg L^{-1}
Conductivity	644	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	61	mg L^{-1}	488	mg L^{-1}
Sulfates	21	mg L^{-1}	592	mg L^{-1}
Chloride	5	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.356	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.074	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	331	mg L^{-1}	296	mg L^{-1}
Ammonia	0.253	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	3.02	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	373	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Froelich Dam as part of the LWQA project. The survey was conducted on July 7, 1992. At the time of the macrophyte survey submergent aquatic vegetation present was sago pondweed Potamogeton pectinatus and curlyleaf pondweed Potamogeton crispus. The mixture of submergent aquatic vegetation varied from less than

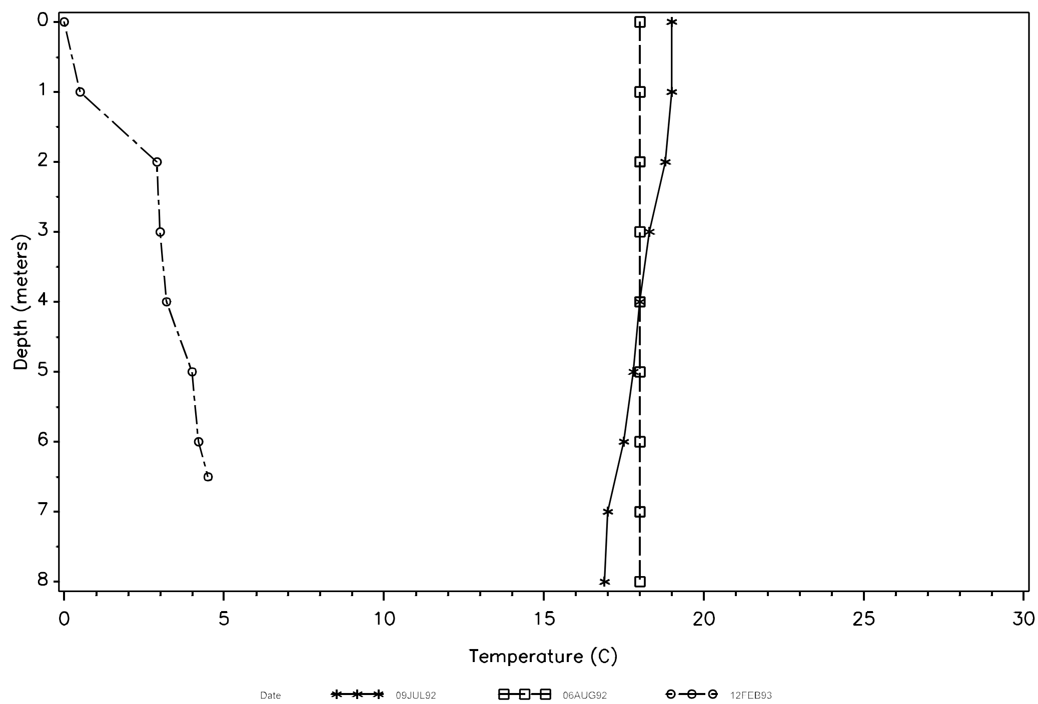


Figure 2. Temperature profile for Froelich Dam.

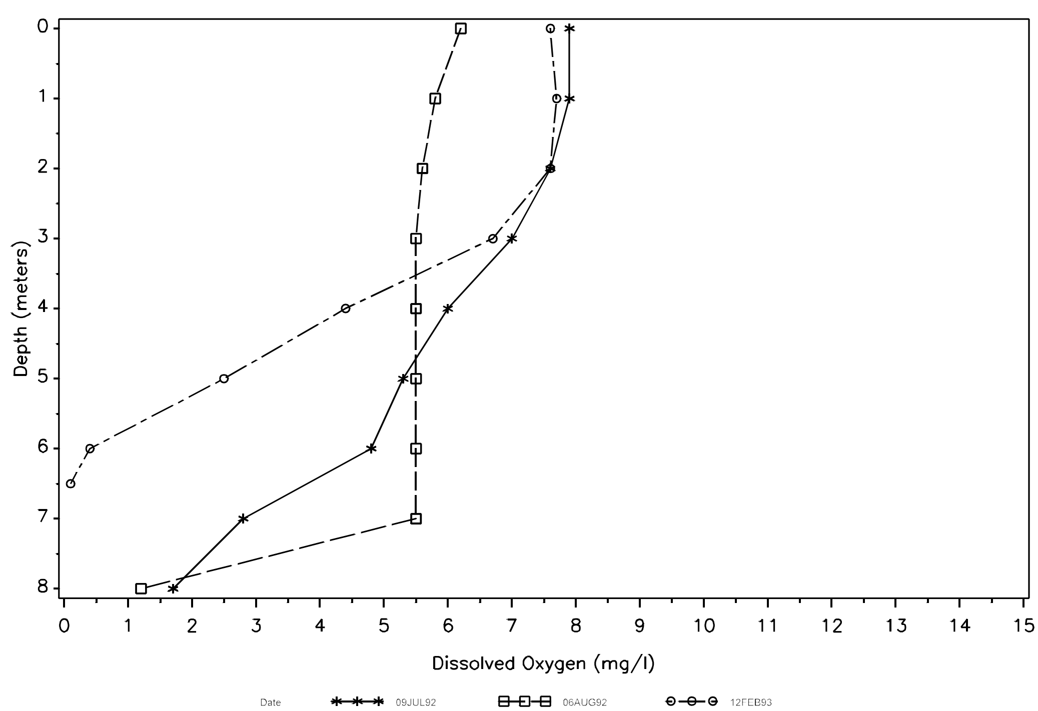


Figure 3. Oxygen profile for Froelich Dam.

one percent curlyleaf to up to 20 percent curlyleaf with the remainder composed of sago pondweed. Also located in small interspersed patches throughout the lake were cattails Typha spp., bulrush Scirpus spp. and arrowhead Sagittaria spp. The submergent aquatic vegetation occupied approximately 25 percent of the surface area on Froelich Dam to a depth of five feet. A map depicting the areal extent of macrophyte coverage on Froelich Dam is contained in Appendix B.

Phytoplankton

Froelich Dam's phytoplankton community was sampled two times during the summer of 1992. Froelich Dam's phytoplankton community is relatively undiverse, with representation from only three divisions and ten genera. The largest contributors to the community by density are the blue-green algae, Cyanophyta, with five genera represented. Mean density of the blue-green algae for the two samples collected during the summer of 1992 was 46,685 cells mL^{-1} representing a dominance of 31 fold over all other divisions combined.

At the time of the LWQA sampling mean phytoplankton concentrations by volume were also dominated by blue-green algae, Cyanophyta. Blue-green algae dominated by volume all other divisions combined by nearly ten fold. The other orders represented were (Cryptophyta) and (Chlorophyta). A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA project indicates Froelich Dam is eutrophic. Primary water quality indicators used in making this assessment were a secchi disk depth transparency average of 1.4 meters, a chlorophyll-a concentration of 1 $\mu g\ L^{-1}$ and summer surface total phosphate as P concentra-tions of 261 and 285 $\mu g\ L^{-1}$. Collaborating ancillary information was rapid oxygen depletion below the hypolimnion and under ice cover conditions and frequent nuisance algal blooms.

Of note is that Froelich Dam was nearly 10 feet below full pool at the time of assessment. Some of the current and historical data collected and researched, such as, secchi disk depth transparency, no history of fish kills and low frequency of nuisance algal blooms are more indicative of a mesotrophic condition then a eutrophic condition.

Sediment Analysis

Sediments were collected from Froelich Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected from the deepest area of the lake (Site 380730), the littoral zone (Site 380731) and the two inlet areas of the lake (Sites 380732 and 380733) (Figure 1).

Sediment samples collected from Froelich Dam had detectable levels of all trace elements tested for except mercury. Trace element concentrations in the sediments collected from Froelich Dam were compared to the concentrations reported for all lakes assessed in the LWQA project. In general, the sediments collected from the inlets of Froelich Dam contained reported concentrations that were near the median concentrations for all inlet sediment samples collected during the LWQA project. The exceptions were the reported arsenic and selenium concentrations, which were below the 25th percentile and the reported concentrations of zinc and copper, which were near or above the 75th percentile. Sediment samples collected from Froelich Dam's littoral area contained reported concentrations of trace elements that were near the median for copper, zinc, barium and lead, below the 25th percentile for arsenic and cadmium and above the 75th percentile for chromium and selenium. The deep area sediments collected from Froelich Dam contain reported concentrations of barium, chromium, selenium and lead which were near or slightly above the reported median, above the 75th percentile for copper, zinc and cadmium and below the 25th percentile for arsenic.

Concentrations of selected pesticides and PCBs were below detectable limits for all samples collected from Froelich Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected from Froelich Dam for contaminant analysis on June 17, 1992. A sample composed of four northern pike representing the piscivore group with an average length of 70.2 centimeters and an average weight of 2,645 grams was collected.

In order to evaluate the fish tissue data for Froelich Dam the results for the fish sample was compared to all piscivores assessed in the LWQA project. Trace element concentrations in the northern pike sample collected from Froelich Dam contained reported concentrations that were either near the 25th percentile or near the 75th percentile. Copper, chromium, arsenic, cadmium, lead and mercury were all equal to or below the 25th percentile while barium, zinc and selenium were all equal to or above the 75th percentile.

Detectable pesticide residues in the northern pike sample collected from Froelich Dam included DDT, DDE, and DDD. DDT is an agricultural insecticide which was banned in the early 1970s due to its harmful effects on the environment. DDE and DDD are both breakdown derivatives of DDT that can exhibit similar behaviors to the parent compound when exposed to the environment.

The concentrations of DDT, DDE and DDD in the northern pike sample and were 0.002, 0.016, and 0.003 $\mu g\ g^{-1}$, respectively. The DDT concentration is above the 75th percentile reported for all piscivore samples collected during the LWQA project while the concentrations of DDE and DDD are both slightly above the medians. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Froelich Dam and its contributing watershed has a combined surface area of 4,160 acres, located near the transitional area between the Missouri Slope Upland and Coteau Slope physiographic regions of North Dakota. Soils in the watershed are moderately deep to shallow, formed from weathered loamy glacial till or soft bedrock. In general, the soils are moderately fertile to fertile, well drained and susceptible to wind and water erosion. Average precipitation in the watershed ranges from 14 to 16 inches, with 80 to 90 percent of the annual precipitation occurring between April and September. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to Froelich Dam.

Land use within the Froelich Dam watershed is 98.5 percent agricultural, with 22 percent actively cultivated and 70.6 percent in some kind of livestock related activity. The remaining small portion of the watershed is in wildlife and wetland management, farms and roads. There are two farms within the Froelich Dam watershed and two concentrated livestock feeding areas (Table 2).

Table 2. Land use in the Froelich Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	22	75
Rangeland	61.3	100
Hayland	9.3	100
CRP	0.0	0.0
Wet/Wild[1]	5.3	N/A
Other	0.7	N/A
Farmsteads	2[3]	N/A
Feedlots[2]	2[3]	0.0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

According to the information provided by the Sioux County Soil Conservation District, 75 percent of the cultivated lands and 100 percent of all the remaining agricultural lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Froelich Dam watershed, the average "T" value is three to five tons per acre. Based on an average soil loss of 1.3 tons per acre, which assumes 100 percent treatment on all rangeland, approximately 5,877 tons of soil are lost from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 588 and 882 tons of soil are delivered to Froelich Dam annually.

Other nonpoint source pollution discharges to Froelich Dam are from cattle feeding and watering along its shores and runoff from the farms and concentrated livestock feeding areas. These sources have the capabilities to contribute a significant percentage of Froelich Dam's annual nutrient and sediment load due to their ability to discharge a large concentrated load and their close proximities to the waters edge.

HEINRICH-MARTIN DAM

LAMOURE COUNTY

Peter N. Wax

Heinrich-Martin Dam is a small reservoir on the Glaciated Plains in north central LaMoure County, North Dakota. It is located on a unnamed tributary to the James River approximately 1/2 mile southeast of the town of Adrian. Heinrich-Martin Dam has a surface area of 11 acres, a maximum depth of 28 feet and an average depth of 12.2 feet (Figure 1).

Heinrich-Martin's watershed is characterized by rolling to hilly glaciated plains with many small potholes and integrated drainages. The irregular patterns of hills and valleys overlie a relatively deep deposit of glacial till.

Heinrich-Martin Dam is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonid fishes and marginal growth of salmonid fishes and associated aquatic biota (NDSDHCL, 1991). The North Dakota Game and Fish Department (NDG&F) manage Heinrich-Martin Dam by annually assessing the fish community by test netting and stocking accordingly.

The initial fishery on Heinrich-Martin Dam began in 1969 with the introduction of rainbow trout, bluegill and smallmouth bass. Due to promiscuous introduction of black bullheads and subsequent domination of the fish community, Heinrich-Martin Dam was chemically eradicated in 1978. Following eradication, the NDG&F stocked smallmouth bass, largemouth bass, bluegill and rainbow trout in 1984 and 1985.

Presently Heinrich-Martin Dam is managed as a largemouth bass and bluegill fishery. Recent stockings conducted in 1989, 1990 and 1991 included catfish and largemouth bass. The bluegill population on Heinrich-Martin is very strong and bluegill from Heinrich-Martin are used for brood stock around the state. Test netting operations conducted on June 27, 1991, captured in order of most abundant bluegills and largemouth bass.

Public access to Heinrich-Martin Dam is good during both winter and summer. Public facilities at Heinrich-Martin Dam include a boat ramp, toilets, picnic area and swim beach. The excellent facilities are maintained by the local public. Recreational use on Heinrich-Martin Dam is high, both summer and winter.

Water Quality

Water quality samples were collected from Heinrich-Martin Dam twice during the summer of 1992 and once during the winter of 1993. Water quality samples were collected at one sample site located in the deepest area of the lake (Site 380750, Figure 1). Water column samples were collected for analysis at three discrete depths.

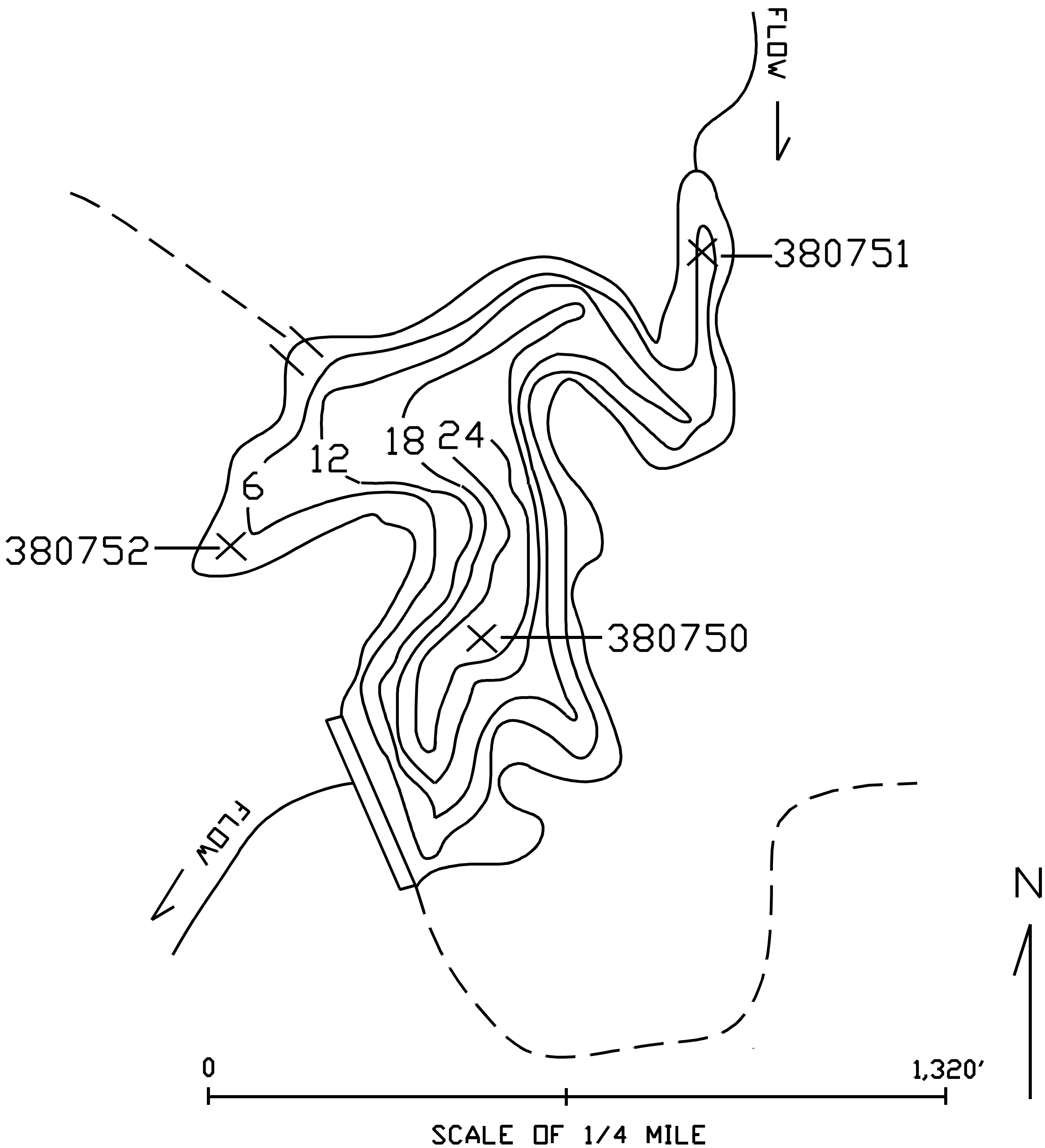


Figure 1. Morphometric map of Heinrich-Martin Dam.

On July 27, 1991, Heinrich-Martin Dam was thermally stratified between three and four meters depth and on September 1, between six and seven meters (Figure 2). At these times dissolved oxygen concentrations were near saturation above the thermocline but experienced rapid declined below (Figure 3). Samples collected in the winter of 1993 on March 2 showed Heinrich-Martin was thermally stratified between three and four meters of depth with oxygen concentrations ranging from 2.2 to 4.5 mg L^{-1} above thermal stratification and 0.15 to 1.0 below (Figure 2, Figure 3).

Water quality data collected during the LWQA project on Heinrich-Martin Dam describe a reservoir with good water quality when compared to many other lakes sampled during the LWQA project. Concentrations of total dissolved solids, hardness as calcium, conductivity and ammonia were below the long-term average for North Dakota waters with volume-weighted mean concentrations of 146, 109, 257 and 0.191 mg L^{-1} respectively (Table 1).

Heinrich-Martin Dam is a relatively well-buffered waterbody with a volume-weighted mean concentration of total alkalinity as $CaCO^3$ of 131 mg L^{-1} (Table 1). The dominant anions in the water column were bicarbonates and sulfates with volume-weighted means of 156 and 13 mg L^{-1}, respectively (Table 1).

Total phosphate as P concentrations ranged from nondetectable to 0.183 mg L^{-1}, with a volume-weighted mean of 0.066 mg L^{-1}. Nitrate + nitrite as N concentrations ranged between nondetectable to 0.08 mg L^{-1}, with a volume-weighted mean of 0.033 mg L^{-1}. The ratio between total dissolved phosphorus and nitrate + nitrite as N combined with ammonia ranged between 1:5.3 to 1:10.8 with an average of 1:8 mg L^{-1}. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 27, 1992 and March 2, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Heinrich-Martin Dam		1982-1991	
Total Dissolved Solids	146	mg L^{-1}	1209	mg L^{-1}
Conductivity	257	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	109	mg L^{-1}	488	mg L^{-1}
Sulfates	13	mg L^{-1}	592	mg L^{-1}
Chloride	2	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.066	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.033	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	131	mg L^{-1}	296	mg L^{-1}
Ammonia	0.191	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.33	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	156	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Heinrich-Martin Dam as part of the LWQA project. The survey was conducted on July 27, 1992.

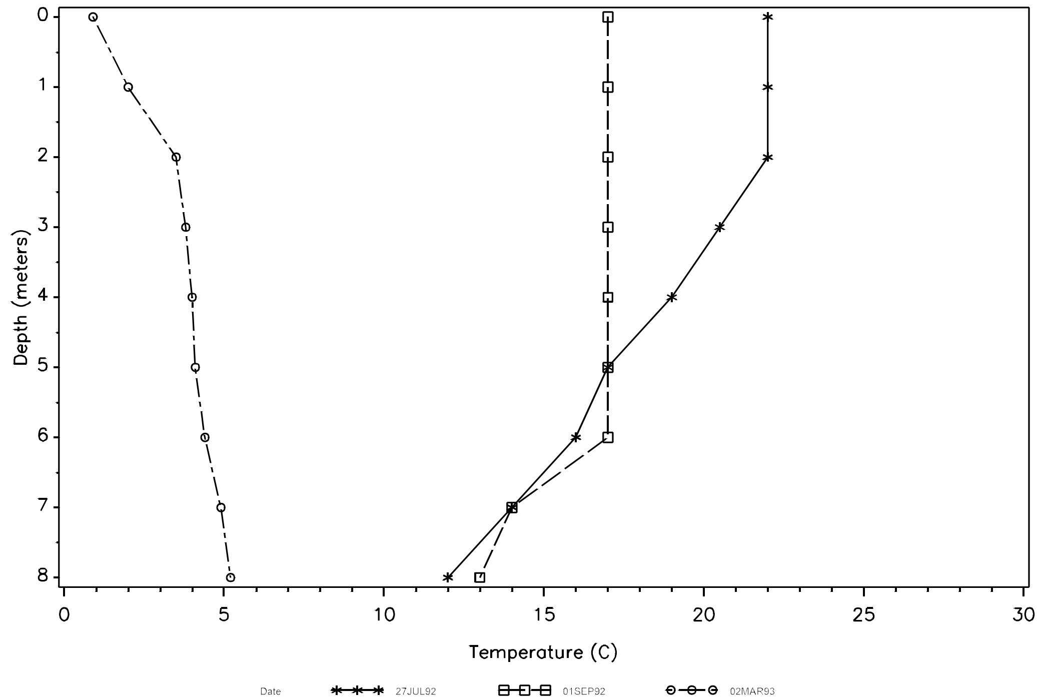


Figure 2. Temperature profile for Heinrich-Martin Dam.

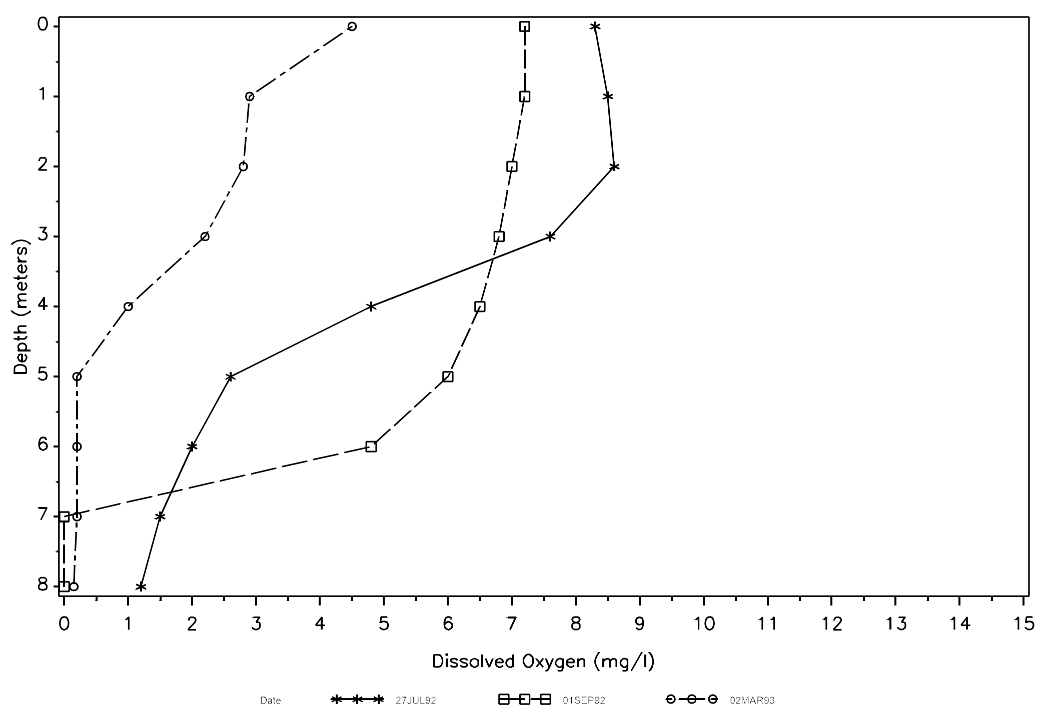


Figure 3. Oxygen profile for Heinrich-Martin Dam.

At the time of the macrophyte survey, Heinrich-Martin Dam had dense mats of submergent aquatic vegetation to a depth of nearly 12 feet. The macrophyte community was composed of coontail Ceratophyllum demersum, water milfoil Myriophyllum spp. and leafy pondweed Potamogeton foliosus. A heavy ring of cattails Typha spp. completely lined 100 percent of the shoreline around Heinrich-Martin Dam. A map depicting the areal extent of macrophyte coverage on Heinrich-Martin Dam is contained in Appendix B.

Phytoplankton

Heinrich-Martin Dam's phytoplankton community was sampled two times during the LWQA project. At the time of sampling, Heinrich-Martin Dam's phytoplankton community was one of the most diverse sampled during the LWQA project with representation from seven divisions and 39 genera. The largest contributors to the phytoplankton community by density were the blue-green algae, Cyanophyta, with a density of 31,967 cells mL^{-1}. The density of blue-green algae species was 3.6 fold greater than all other divisions combined. Other divisions represented in descending order of dominance were Chlorophyta, Chrysophyta, Cryptophyta, Bacillariophyta, Euglenophyta and Pyrrophyta.

The phytoplankton community on Heinrich-Martin Dam by volume was much more evenly distributed with the division Cryptophyta dominating. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA project on Heinrich-Martin Dam defined Heinrich-Martin as mesotrophic. During the summer of 1992, secchi disk depth transparency averaged 2.2 meters, chlorophyll-a concentrations averaged 9 $\mu g\ L^{-1}$ and surface summer total phosphate as P concentrations averaged 46 $\mu g\ L^{-1}$. Supporting ancillary information of a mesotrophic assessment for Heinrich-Martin Dam is a low frequency of nuisance algal blooms, diverse phytoplankton community, diverse medium density macrophyte community and no history of fish kills.

Sediment Analysis

Sediments were collected from Heinrich-Martin Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 380750), the littoral zone (Site 380752) and the inlet (Site 380751) (Figure 1).

Sediment samples collected from Heinrich-Martin Dam had detectable levels of all trace elements tested for with the exception of mercury in all areas and selenium in the deepest and inlet areas. Trace element concentrations in the sediments collected from Heinrich-Martin Dam were compared to concentrations reported for all lakes assessed in the LWQA project.

The reported concentrations of copper, barium, arsenic and selenium in littoral area sediments collected from Heinrich-Martin Dam were all near the median concentration reported for all littoral samples collected during the LWQA project, while the concentrations of zinc, chromium, cadmium and lead were all near or above the 75th percentile. Sediments collected from the inlet area of Heinrich-Martin Dam had reported trace element concentrations that were near or above the 75th percentile for copper, zinc and barium, yet near or below the median for chromium, arsenic, selenium, cadmium and lead. The reported concentrations of trace elements in the deepest area sediments were all equal to or above the 75th percentile, with the exceptions of selenium and lead which were near the median.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Heinrich-Martin Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Heinrich-Martin Dam on July 2, 1992. An insectivore sample was collected composed of four bluegill with an average length of 8.2 centimeters and an average weight of 145 grams and a piscivore sample composed of four largemouth bass with an average length of 34 centimeters and an average weight of 582 grams.

In order to evaluate the fish tissue data for Heinrich-Martin Dam the results for each fish group was compared to that group for all lakes assessed in the LWQA project. In general, trace element concentrations in both fish samples collected from Heinrich-Martin Dam were near or below the median with the majority close to or below the 25th percentile. The exceptions were the reported zinc and barium concentrations in the bluegills collected and barium in the largemouth bass that were equal to or exceeding the 75th percentile.

Detectable pesticide residues in the fish samples collected from Heinrich-Martin Dam included DDE, DDD and trifluralin. DDE and DDD are both breakdown derivatives of the agricultural insecticide DDT. DDT has been banned since the early 1970s due to its ability to harm the environment. DDE and DDD have the potential to behave similarly to the parent compound DDT when available to the environment. Trifluralin, commonly known as treflan, is an agricultural preemergent herbicide commonly used with rice and lentils.

The bluegill sample collected from Heinrich-Martin Dam contained reported concentrations of DDD and trifluralin of 0.002 and 0.003 $\mu g\ g^{1}$. These concentrations represent approximately the median concentrations reported for all insectivores analyzed during the LWQA project. The largemouth bass sample collected from Heinrich-Martin Dam contained DDE and trifluralin in concentrations of 0.003 and 0.002 $\mu g\ g^{1}$, respectively. The DDE concentration was below the 25th percentile for all piscivore samples collected during the LWQA project, while the trifluralin concentration was near the median. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Heinrich-Martin Dam, with its contributing watershed has a combined surface area of 3,933 acres located on the glaciated plains in LaMoure County, North Dakota. The watershed is characterized by rolling to hilly glaciated plains with many small potholes and integrated drainages. The regular pattern of hills and valleys overlie a relatively deep deposit of glacial till.

Soils in this region are generally formed from medium to coarse textured sandy or clayey, loamy glacial till. Soils are moderately erodible and moderately to well drained. Annual precipitation is between 15 and 20 inches, with considerable variation between years. Topography is rolling to hilly, with maximum shifts in elevation of 300 feet with few shifts exceeding 100 feet. Nonpoint source pollution accounts for 100 percent of the pollution discharges and nutrient loadings to Heinrich-Martin Dam.

Land use within the Heinrich-Martin Dam watershed is 95 percent agricultural, with 76.3 percent actively cultivated. The remaining 23.7 percent is in low density urban development, haylands, pasture, conservation reserve program (CRP), farms and roads (Table 2). According to the information provided by the LaMoure County Soil Conservation District, 80 percent of the cultivated lands and nearly all of the remaining lands within the Heinrich-Martin watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Heinrich-Martin Dam watershed, approximately 16,740 tons of soil are lost annually. This is based on an average soil loss of 4.25 tons per acre, which takes into account all current land uses and practices within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 1,674 and 2,511 tons of soil are delivered to Heinrich-Martin Dam annually.

Within the Heinrich-Martin watershed are eight farms and one concentrated livestock feeding area. These areas and construction within the watershed have the potential to contribute a significant nonpoint source pollution load to Heinrich-Martin Dam. The proximity of these areas to actual drainages determine the significance of any potential impacts these areas will have on the reservoir.

Table 2. Land use in the Heinrich-Martin Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	76.3	80
Rangeland	5.5	80
Hayland	1.2	90
CRP	11.8	100
Wet/Wild[1]	1.5	N/A
Other	2.8	N/A
Farmsteads	8.0[3]	N/A
Feedlots[2]	1.0[3]	0.0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

HIDDENWOOD LAKE

WARD COUNTY

Peter N. Wax

Hiddenwood Lake is a small impoundment on Hiddenwood National Wildlife Refuge located approximately seven miles south of Makoti in the southwest corner of Ward County, North Dakota. The dam was completed in the mid-1970s and filled in the late 1970s to a maximum depth of 18 feet with a surface area of 115.2 acres (Figure 1). The dam itself is a farm-to-market road lying across a coulee in the Missouri River drainage.

Hiddenwood Lake is a rather picturesque reservoir located on the Missouri Coteau. The Missouri Coteau physiographic region is characterized by regular patterns of hills and shallow depressions. Topography is rolling with shifts in relief of up to 300 feet, but rarely exceeding 50 to 80 feet. Soils in the watershed are generally formed from rocky, gravelly, or sandy glacial material and are moderately to well drained. The watershed's sandy soils and steeper slopes are highly erodible. Normal precipitation ranges between 15 and 18 inches per year, with variations of over five inches common. Land use in the watershed is predominantly agricultural, with the majority of the lands being in small grain production.

Hiddenwood Lake is not classified by NDSDHCL and has had very limited water quality data collected on it over the years. The NDG&F manage Hiddenwood Lake by annually assessing the fish community by test netting and stock accordingly.

Initial fishery management by the NDG&F on Hiddenwood lake was stockings of rainbow trout in 1980 to establish a fishery, however, test netting operations conducted the following spring recovered no rainbow trout. Yellow perch were introduced in 1982 followed by northern pike, bluegill and walleye. Freshwater scuds Gammarus were stocked in 1985 to improve Hiddenwood Lake's forage base.

In recent years the stocking regiment has included northern pike, yellow perch, bluegill, fathead minnows, walleye and black crappie. Test netting operations conducted by the NDG&F on May 31, 1991, captured in order of abundance yellow perch, bluegill and northern pike. Only small numbers of any fish were captured on Hiddenwood Lake at this time, however, the fish captured did indicate good growth rates.

Public use on Hiddenwood Lake is relatively light, with moderate fishing pressure during summer and light to moderate pressure during the winter months. Public facilities at Hiddenwood Lake, completed and maintained by Makoti Sportsmans Club, are a swim beach, picnic area, boat dock, toilets, a large building for indoor functions and a concrete plank boat ramp.

Water Quality

Water quality samples were collected from Hiddenwood Lake twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample

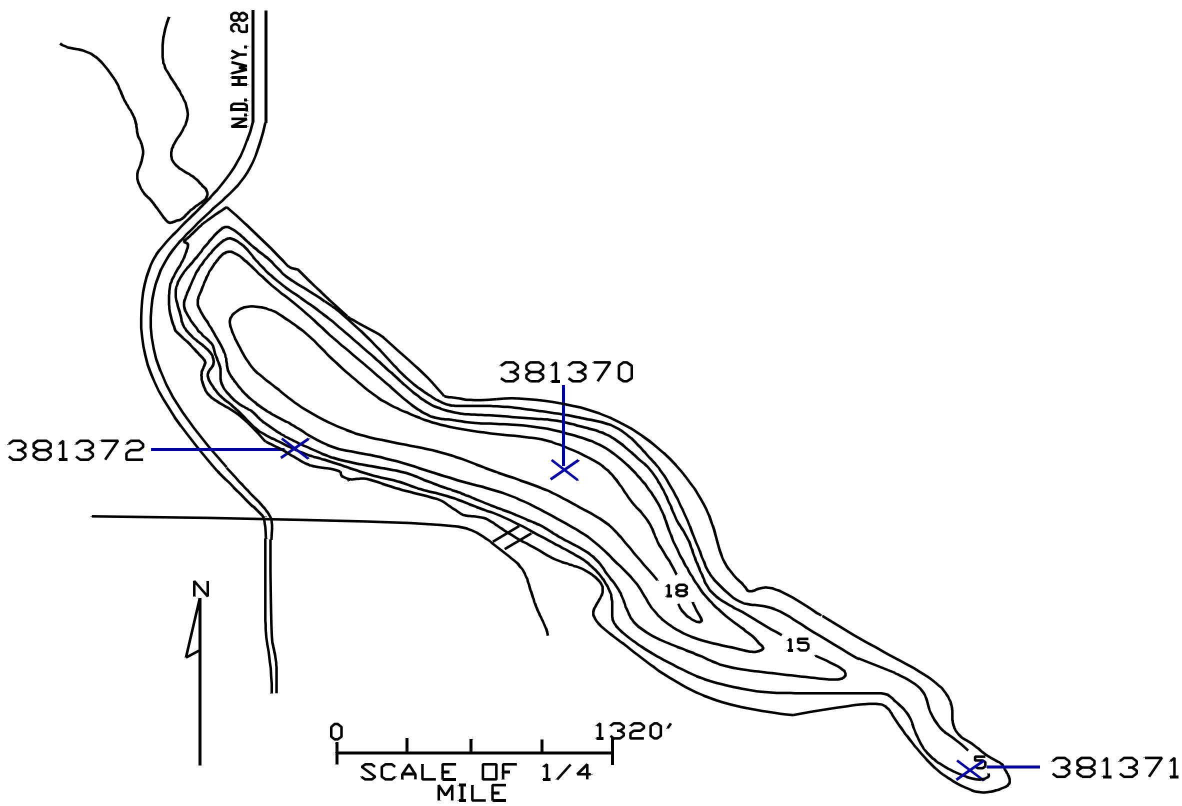


Figure 1. Morphometric map of Hiddenwood Lake.

site located in the deepest area of the lake (Site 381370, Figure 1). Water column samples were collected for analysis at three separate depths in July and August of 1992, and two separate depths in January of 1993.

When samples were collected during the summer of 1992, Hiddenwood Lake was not thermally stratified and had oxygen concentrations that were near saturation throughout the entire water column (Figure 2, Figure 3). On January 18, 1993, Hiddenwood Lake was thermally stratified between two and three meters of depth (Figure 2). Dissolved oxygen concentrations at this time were between 7.1 and 7.9 mg L^{-1} above the thermocline and 0.5 to 5.0 mg L^{-1} below the thermocline (Figure 3).

Concentrations of total dissolved solids, hardness as calcium and conductivity were lower than the long-term North Dakota average (Table 1). Concentrations of total alkalinity as $CaCO_3$ ranged between 359 and 467 mg L^{-1}, with a volume-weighted mean concentration of 387 mg L^{-1}, describing a well-buffered waterbody. The dominant anions in the water column were bicarbonates and sulfates. Bicarbonates ranged between 356 and 521 mg L^{-1}, with a weighted-volume mean of 398 and sulfates ranged between 165 and 242 mg L^{-1}, with a volume-weighted mean of 190 mg L^{-1} (Table 1).

The primary nutrients total phosphate as P and nitrate + nitrite as N had weighted-volume means of 0.068 and 0.005 mg L^{-1}, respectively. The ratios of total phosphate as P and nitrate + nitrite as N concentrations was 13.6:1, indicating Hiddenwood Lake is nitrogen limited. A lake is generally considered nitrogen limited when the ratios between phosphorus and nitrogen are less than 1:15. Actual nitrogen limitation does not exist on Hiddenwood Lake, but rather an overabundance of phosphorus is present which favors nitrogen fixing organisms such as certain blue-green algal species. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 16, 1992 and January 18, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Hiddenwood Lake		1982-1991	
Total Dissolved Solids	633	mg L^{-1}	1209	mg L^{-1}
Conductivity	994	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	472	mg L^{-1}	488	mg L^{-1}
Sulfates	190	mg L^{-1}	592	mg L^{-1}
Chloride	13	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.068	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.005	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	387	mg L^{-1}	296	mg L^{-1}
Ammonia	0.187	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.49	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	398	mg L^{-1}	326	mg L^{-1}

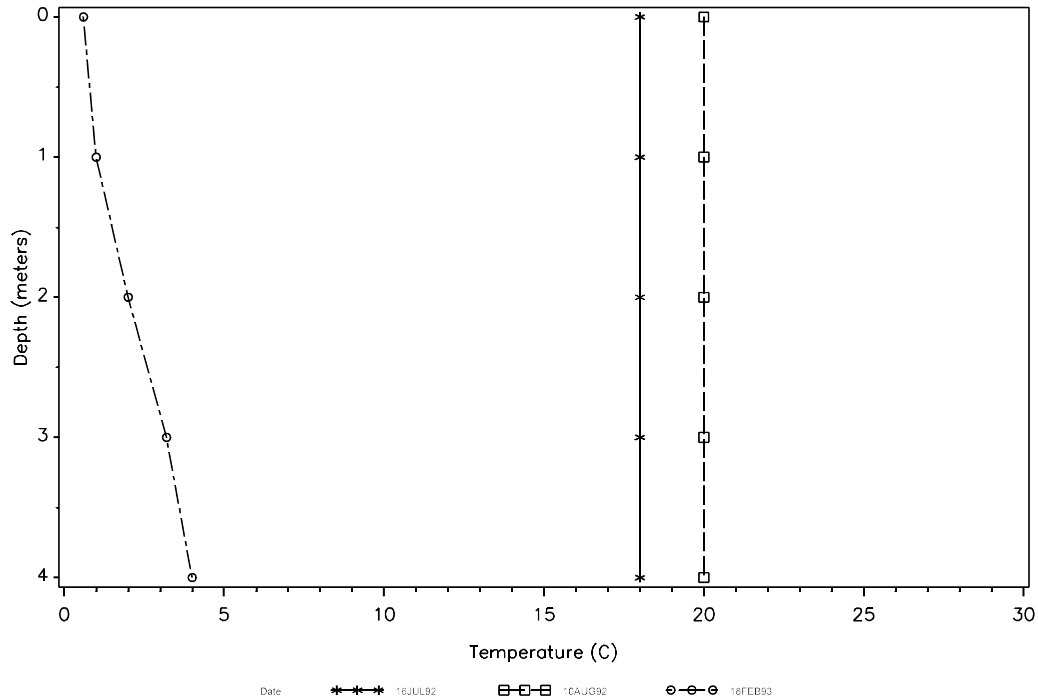


Figure 2. Temperature profile for Hiddenwood Lake.

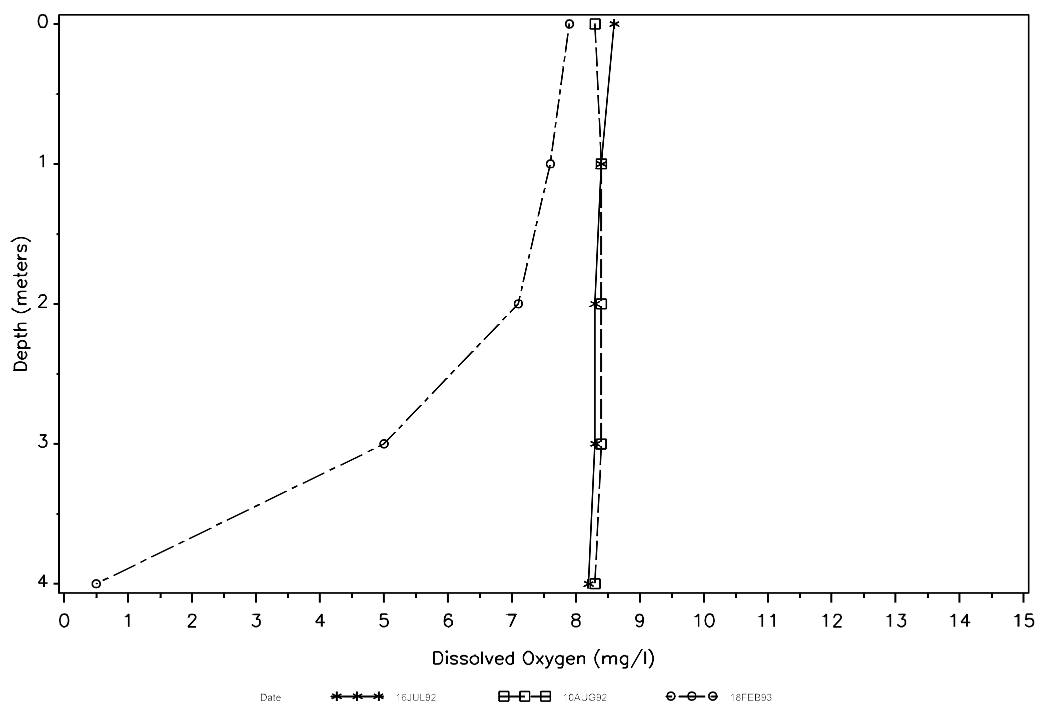


Figure 3. Oxygen profile for Hiddenwood Lake.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Hiddenwood Lake as part of the LWQA project. The survey was conducted on July 16, 1992.

At the time of the macrophyte survey, approximately 10 percent of Hiddenwood Lake's surface area had aquatic vegetation. Nearly 100 percent of the lake's surface area to a depth of approximately four feet had mixed growths of sago pondweed Potamogeton pectinatus and coontail Ceratophyllum demersum. The inlet area of the lake and in scattered patches along the shore were stands of arrowhead Sagittaria spp. and cattails Typha spp. A single specimen of green parrots feather Myriophyllum pinnatum was identified near the boat ramp on August 10, 1992. A macrophyte map depicting the population and areal extent on Hiddenwood Lake is contained in Appendix B.

Phytoplankton

Hiddenwood Lake's phytoplankton community was sampled two times during the summer of 1992. At the time of sampling, Hiddenwood Lake's phytoplankton community was represented by five divisions and 17 genera. The largest contributors to the phytoplankton community by density were the blue-green algae, Cyanophyta with three genera represented. Mean density of the blue-green algae for the two samples collected in the summer of 1992 was 86,828 cells mL^{-1} representing a 22 fold dominance over all the other divisions combined. Other divisions represented in descending dominance were Bacillariophyta, Cryptophyta, Chlorophyta and Pyrrophyta.

The phytoplankton community on Hiddenwood Lake by volume was much more evenly distributed than by density with the divisions Pyrrophyta, Cryptophyta and Bacillariophyta occupying approximately 80 percent of the community. The remaining 20 percent of the community in approximately equal proportions was occupied by Chlorophyta and Cyanophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Data collected during the LWQA project identified Hiddenwood Lake is mesotrophic. Primary water quality indicators used in making this assessment was secchi disk depth transparency readings of 1.3 and 1.9 meters, chlorophyll-a concentrations of 7 and 8 $\mu g\ L^{-1}$ and summer surface total phosphate as P concentrations of 24 and 55 $\mu g\ L^{-1}$. Ancillary information supporting a mesotrophic lake condition are infrequent nuisance algal blooms, moderate macrophyte biomass, good dissolved oxygen conditions throughout the year and no history of fish kills.

Sediment Analysis

Sediments were collected from Hiddenwood Lake and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381370) and the littoral zone (Site 381372) (Figure 1).

Sediments collected from Hiddenwood Lake show detectable levels of all trace elements tested for except mercury in the deepest area sediments. Reported trace element concentrations in the sediments collected from Hiddenwood Lake were compared to all trace element concentrations reported during the LWQA project. In general, reported trace element concentrations in the sediments collected from the deepest area of Hiddenwood Lake were near or below the median concentrations reported for all deep area sediments analyzed during the LWQA project. The only exception was barium which exceeded the 75th percentile.

In general the reported concentrations of trace elements in the sediments collected from the littoral area within Hiddenwood Lake exceeded the 75th percentile with the reported concentrations of copper and chromium being equal to the maximum concentrations reported. The only exception was the selenium concentrations which were below the 25th percentile for all littoral area sediment analyzed during the LWQA project.

Concentrations of selected pesticides and PCB's were below detectable limits. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Hiddenwood Lake on July 12, 1992. Northern pike were the only species collected representing the piscivore group. The northern pike sample collected was a composite of four fish with an average length of 73.4 centimeters and an average weight of 2,530 grams.

In order to evaluate the fish tissue data for Hiddenwood Lake the results were compared to all piscivore samples collected during the LWQA project. The northern pike sample collected from Hiddenwood Lake contained detectable levels of all trace elements tested for with the exception of arsenic. Of the detectable trace elements in the northern pike sample collected from Hiddenwood Lake all were near or below the median with the exception of zinc, barium and selenium which were above the 75th percentile.

Detectable pesticide residue in the northern pike sample collected from Hiddenwood Lake was DDE. DDE is a degenerate by-product of the insecticide DDT which can produce biological effects similar to the parent compound. DDT was banned in 1973 due to its ability to harm the environment.

The northern pike sample contained 0.004 $\mu g\ g^{-1}$ of DDE. The concentration of 0.004 $\mu g\ g^{-1}$ is below the 25th percentile of all piscivore samples analyzed during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Hiddenwood Lake, with its contributing watershed, has a combined surface area of 13,240 acres located on the Missouri Coteau physiographic region in southwestern Ward County, North Dakota. Hiddenwood Lake's watershed is characterized by irregular patterns of hills and shallow depressions. Soils in the watershed are generally formed from rocky, gravelly or sandy glacial till and are moderately to well drained. Slopes range from nearly level to steep, with average slopes ranging between one and six percent. The area is highly erodible when poor land management is employed on the sandier soils and steeper slopes. Annual precipitation normally ranges from 15 to 18 inches. Nonpoint source pollution from the contributing watershed accounts for all of the nutrient loading and pollution discharges to Hiddenwood Lake.

Land use within the Hiddenwood Lake watershed is 87.6 percent agricultural, with 83.5 percent actively cultivated. The remaining 16.5 percent of the watershed is in low density urban development, haylands, pasture and wildlife management (Table 2). According to the information provided by the Ward County Soil Conservation District, 75 percent of all agricultural lands within Hiddenwood Lake's watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Hiddenwood Lake watershed, the average "T" value is three to five tons per acre. Based on an average soil loss of 3.3 tons per acre, which takes into account all land uses and land treatment, approximately 44,200 tons of soil are lost annually from within the Hiddenwood Lake watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 4,420 and 6,630 tons of soil are delivered to Hiddenwood Lake annually.

Table 2. Land use in the Hiddenwood Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	83.5	75
Rangeland	3.2	75
Hayland	0.9	75
CRP	0.0	0.0
Wet/Wild[1]	10.2	N/A
Other	1.5	N/A
Farmsteads	12[3]	N/A
Feedlots[2]	0[3]	0.0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

KOTA-RAY DAM

WILLIAMS COUNTY

Peter N. Wax

Kota-Ray Dam is located on the Missouri Coteau eight miles south of Ray in south eastern Williams County, North Dakota. It lies on Nelson Creek approximately 4 miles upstream of the Missouri River floodplain. Kota-Ray Dam was first constructed in 1933 by the Civilian Conservation Corp and rebuilt in 1959 by the State Water Commission, the NDG&F and Williams County when the dam was raised to accommodate a roadbed. Currently, Kota-Ray Dam has a surface area of 29.5 acres, a maximum of depth of 32 feet and an average depth of 11.4 feet (Figure 1).

Kota-Ray Dam is owned by the community Park Board of Ray. Public facilities at Kota-Ray Dam are managed by the Ray Wildlife Club. Kota-Ray's water rights belong to the NDG&F. Public facilities at Kota-Ray Dam occupy approximately 4 percent of the shoreline and include a boat ramp, camping and picnicking areas, drinking water and toilets. Public use on Kota-Ray Dam is moderate to heavy depending on the productivity of the fishery.

Kota-Ray Dam's 4,810 acre watershed consists primarily of hills and steep drainages leading to the Missouri River floodplain. Land use is approximately an even mixture of agricultural croplands and livestock production.

Kota-Ray Dam is classified as a cold water fishery, "Waters capable of supporting growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Kota-Ray Dam by annually assessing the fish community by test netting and stock accordingly.

The initial management of the fishery on Kota-Ray Dam began in 1959 with the introduction of rainbow trout. Promiscuous introductions of perch eventually necessitated eradication of the fish community in 1966 followed by restocking of trout in 1967. In recent years the stocking regiment has included rainbow trout, bluegill and walleye. Test netting operations conducted on May 21, 1991, by the NDG&F captured in order of most abundant white suckers, rainbow trout, walleye and bluegill.

Water Quality

Water quality samples were collected from Kota-Ray Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380785, Figure 1). Water column samples were collected for analysis at three discrete depths of 1 meter, 4 meters and 7 meters.

During the summer sampling of 1992, Kota-Ray Dam was thermally stratified on July 13 between 4 and 5 meters of depth with dissolved oxygen concentrations ranging between 6.6 and 8.8 mg L^{-1} above the thermocline and 1.1 to 4.4 mg L^{-1} below (Figure 2, Figure 3). On the August 11 sample date Kota-Ray Dam was not thermally stratified and had dissolved oxygen concentrations of 1.0 mg L^{-1} near the bottom to 7.8 mg L^{-1} near the surface (Figure 2, Figure 3).

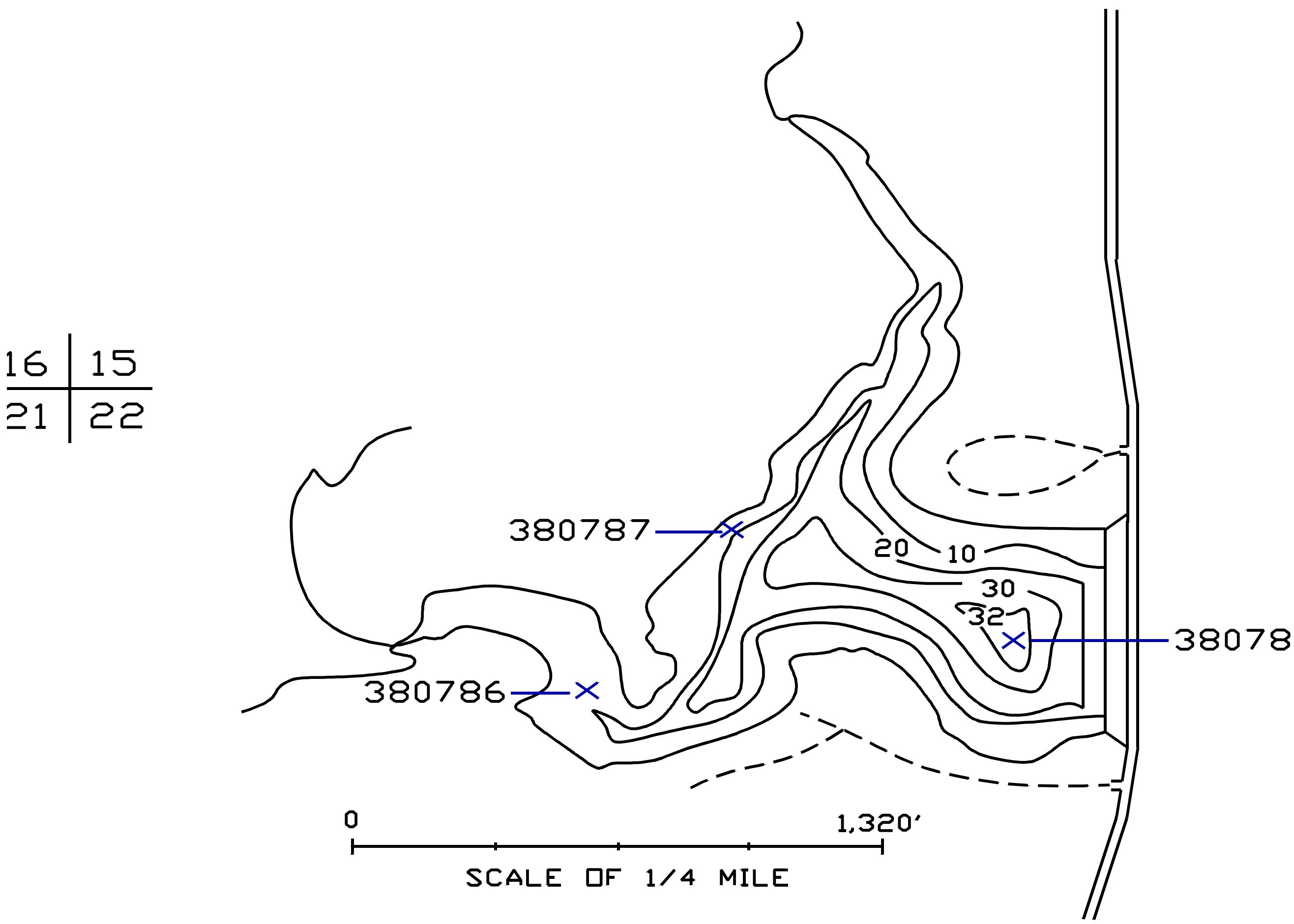


Figure 1. Morphometric map for Kota-Ray Dam.

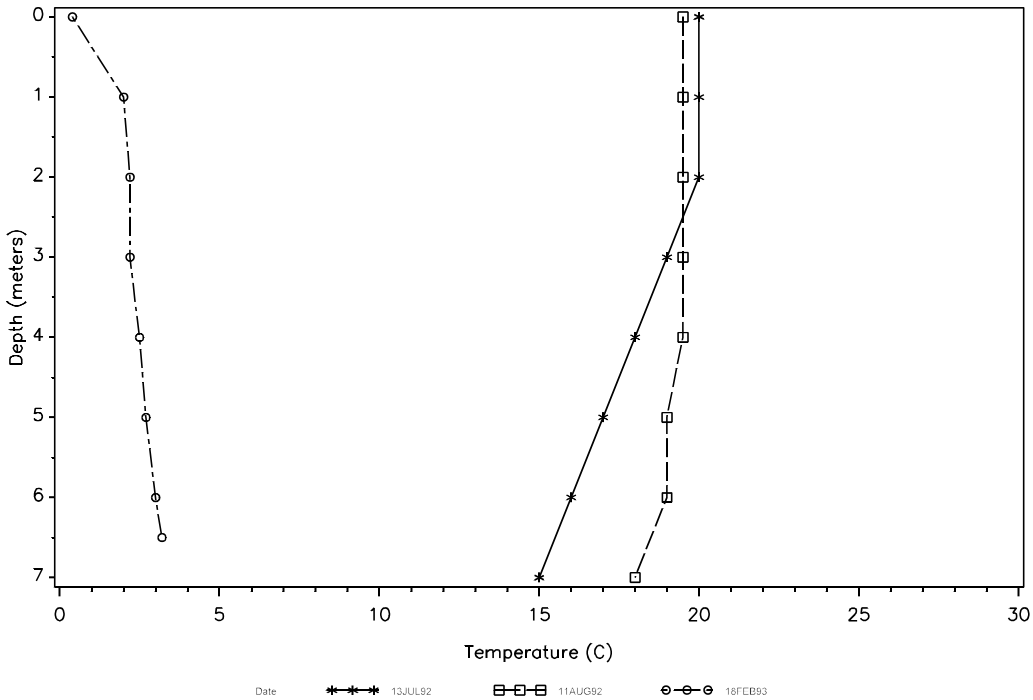


Figure 2. Temperature profile for Kota-Ray Dam.

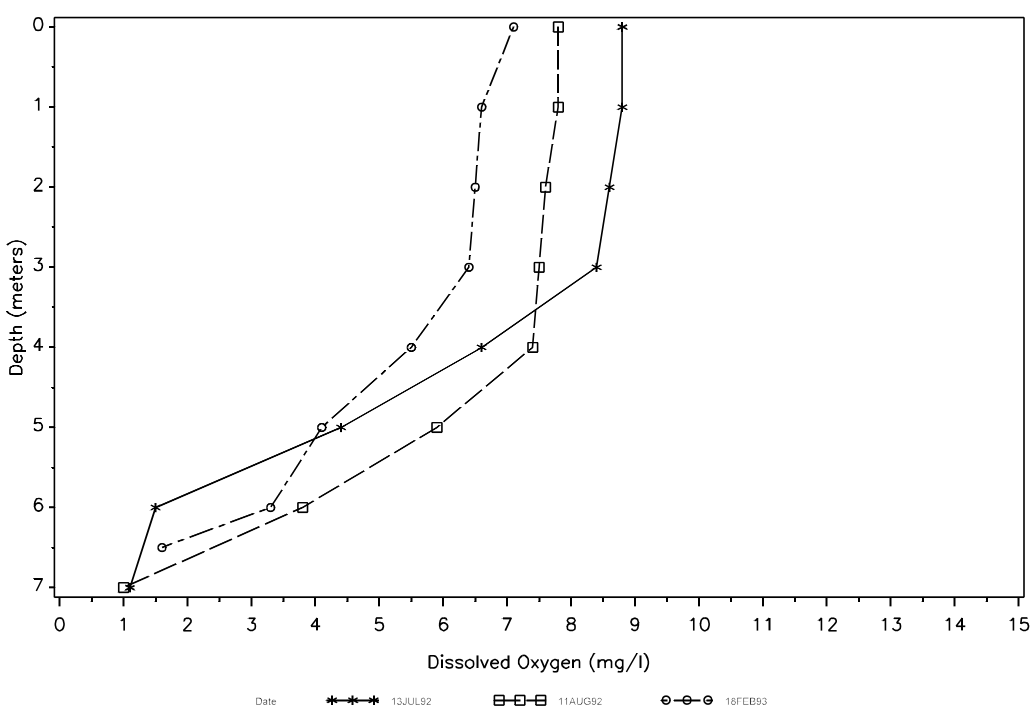


Figure 3. Oxygen profile for Kota-Ray Dam.

Samples collected on January 18, 1993, showed Kota-Ray Dam had not developed thermal stratification with dissolved oxygen concentrations ranging between 1.6 mg L^{-1} near the bottom to 7.1 mg L^{-1} at the surface (Figure 2, Figure 3). During all three sampling visits, dissolved oxygen concentrations in Kota-Ray Dam were adequate to maintain aquatic life.

Water quality data show Kota-Ray Dam as containing concentrations of total dissolved solids, hardness as calcium and conductivity that were below the state's long-term average (Table 1). Concentrations of total alkalinity as $CaCO_3$ ranged between 422 and 547 mg L^{-1}, with a volume-weighted mean of 465 mg L^{-1} describing a well buffered waterbody. The dominant anions in the water column were sulfates and bicarbonates. Sulfates ranged between 197 and 325 mg L^{-1}, with a volume-weighted mean of 244 mg L^{-1} while bicarbonates ranged between 470 and 657 mg L^{-1}, with a volume-weighted mean of 542 mg L^{-1} (Table 1).

Kota-Ray Dam contained relatively high concentrations of the primary nutrient total phosphate as P and nitrate + nitrite as N. Total phosphate as P concentrations ranged between nondetectable to 0.128 mg L^{-1} with a volume-weighted mean of 0.052. Nitrate + nitrite as N concentrations ranged between nondetectable to 0.014 mg L^{-1} with a volume-weighted mean of 0.018 mg L^{-1}. Volume-weighted mean concentration ratios of total phosphate as P and nitrate + nitrite as N of 2.8:1 suggest Kota-Ray Dam is nitrogen limited. A complete list of LWQA water quality sample data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 14, 1992 and January 18, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Kota-Ray Dam		1982-1991	
Total Dissolved Solids	779	mg L^{-1}	1209	mg L^{-1}
Conductivity	1191	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	464	mg L^{-1}	488	mg L^{-1}
Sulfates	244	mg L^{-1}	592	mg L^{-1}
Chloride	4	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.052	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.018	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	465	mg L^{-1}	296	mg L^{-1}
Ammonia	0.131	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	0.769	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	542	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Kota-Ray Dam as part of the LWQA project. The survey was conducted on August 16, 1993.

At the time of the macrophyte survey, approximately 20 percent of Kota-Ray Dam's surface area had aquatic vegetation. Nearly 85 percent of the shoreline to a depth of two to five feet contained mixed stands of cattails Typha spp., bulrush Scirpus spp., common reeds Phragmities spp., coontail Ceratophyllum demersum and water buttercup Rananculus spp. Small stands of arrowhead Sagittaria spp., narrowleaf waterplantain Alisma spp., marestail Hippuris vulgaris and sago pondweed Potamogeton pectinatus were also present in scattered patches along the shoreline. A map depicting the areal extent of macrophyte coverage on Kota-Ray Dam is contained in Appendix B.

Phytoplankton

Kota-Ray Dam's phytoplankton community was sampled two times during the summer of 1992. During sampling, Kota-Ray Dam's phytoplankton community was represented by 7 divisions and 33 genera. The largest contributors to the phytoplankton population by density were the blue-green algae Cyanophyta, with a density of 14,469 cells mL^{-1}. The numerical dominance by the blue-green algae species over the other divisions present was quite dramatic at nearly 12 fold. Other divisions represented in descending order of numerical dominance were Chlorophyta, Cryptophyta, Chrystophyta, Bacillariophyta, Pyrrophyta and Euglenophyta.

The division Pyrrophyta occupied the largest volume of the phytoplankton community, with a volume of 3,901,742 μm^3 mL^{-1}. The other divisions represented in descending order of volume occupied were Cyanophyta, Chlorophyta, Bacillariophyta, Chrystophyta, Euglenophyta and Cryptophyta. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected from Kota-Ray Dam during the LWQA project defines Kota-Ray as mesotrophic. Primary water quality indications of a mesotrophic assessment are secchi disk depth transparencies ranging between 1.8 and 2.2 meters, a chlorophyll-a concentration of 5 μg L^{-1} and summer surface total phosphate as P concentrations ranging between 6 and 7 μg L^{-1}. All these primary indicators agree quite well and suggest that Kota-Ray Dam is mesotrophic.

Supporting ancillary information is adequate dissolved oxygen concentrations throughout the water column in summer and winter, a relatively diverse phytoplankton population, low frequency of nuisance algae blooms, low macrophytes biomass and no recorded fish kills.

Sediment Analysis

Sediments were collected from Kota-Ray Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 380785), the littoral zone (Site 380787) and the inlet area of the lake (Site 380786), (Figure 1).

Sediment samples collected from Kota-Ray Dam showed detectable levels of all trace elements tested for with the exception of mercury in all sediments collected and selenium in the inlet area and littoral area sediments. Reported trace element concentrations in the sediments collected from Kota-Ray Dam were compared to the reported concentrations for all lake sediments collected during the LWQA project.

Trace elements above the detection limits in the deep and littoral area sediments collected from Kota-Ray Dam were generally near or above the 75th percentile reported for all sediments collected during the LWQA project. The exceptions were the reported concentrations of selenium in both the deepest and littoral areas of the lake and cadmium in the littoral area sediments.

The inlet area sediments collected from Kota-Ray Dam contained reported concentrations of trace elements that were near the median and 25th percentiles with the exception of chromium which was above the 75th percentile.

Concentrations of PCBs and pesticides were all below detectable limits in the sediments collected from Kota-Ray Dam. A complete listing of the sediment analysis is contained in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Kota-Ray Dam on June 9, 1992. Walleyes were collected representing the piscivore group and white suckers representing the bottom feeding group. The walleye sample was composed of 3 fish with a mean length of 36.7 centimeters and a mean weight of 600 grams. The white sucker sample was composed of 5 fish with a mean length of 44.4 centimeters and a mean weight of 890 grams.

In order to evaluate the fish tissue data for Kota-Ray Dam, the results for each fish sample was compared to all samples collected during the LWQA project. In general, trace element concentrations in both fish samples collected from Kota-Ray Dam were near or below the median for all fish analyzed during the LWQA project. The exceptions were the reported chromium concentrations in the walleye and white sucker samples and the reported lead concentrations in the walleye sample which were near or above the 75th percentile.

Detectable pesticide residues in the fish samples collected from Kota-Ray Dam included DDE and triallate. DDE is a degradation by-product of the agri-cultural insecticide DDT. DDT was banned in 1973 due to its environmental health risk. Triallate, commonly known as Far-go is an agricultural preemergent herbicide, commonly used in North Dakota.

The walleye sample collected from Kota-Ray Dam contained DDE and the white sucker contained both DDE and triallate. The walleye sample contained 0.008 $\mu g\ g^{-1}$ DDE representing a concentration below the median for all piscivore samples collected in the LWQA project. The white sucker sample contained concentrations of DDE and triallate of 0.002 and 0.004 $\mu g\ g^{-1}$. The DDE concentration of 0.002 is below the 25th percentile for all bottom feeders collected during the LWQA project while the triallate concentration of 0.004 $\mu g\ g^{-1}$ is equal to the median. A complete listing of the fish contaminant data is available in Appendix E.

Watershed

Kota-Ray Dam with its contributing watershed has a combined surface area of 4,810 acres located on the Missouri Coteau in southeastern Williams County, North Dakota. Kota-Ray Dam is located on the Missouri Coteau just north of the Missouri River flood plain. This region in North Dakota is characterized by steep hilly drainages, and is primarily in livestock production.

Soils in the Kota-Ray watershed vary significantly but are generally formed from median to course textured sandy and clayey loamy glacial till. Soils are erodible and well drained. Annual precipitation within the Kota-Ray watershed is between 15 and 20 inches a year. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loadings and pollution discharges to Kota-Ray Dam.

Land use within the Kota-Ray Dam watershed is nearly 98 percent agricultural with 41.4 percent actively cultivated and the remaining 56.9 percent either in some type of livestock production or Conservation Reserve Program (CRP). The remaining 2 percent of the watershed is in low density urban develops, transportation and wildlife management (Table 2).

According to the information provided by the Williams County Soil Conservation District, 80 percent of the cultivated lands and between 90 and 100 percent of all the remaining lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Kota-Ray Dam watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of 2 to 3 tons per acre, which takes into account all land practices and treatments, approximately 12,708 tons of soil is lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 1,271 and 1,908 tons of soil are delivered to Kota-Ray Dam annually.

Other sources of nonpoint source pollution discharges to Kota-Ray Dam are from cattle feeding and watering along the immediate upstream drainage and concentrated livestock feeding areas. These sources can have the capabilities to contribute a significant percentage of Kota-Ray's annual nutrients and may be the largest degradation source due to their proximity to the waters edge.

Table 2. Land use in the Kota-Ray Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	41.4	80
Rangeland	53.8	90
Hayland	3.1	100
CRP	0.0	0.0
Wet/Wild[1]	1.0	N/A
Other	0.2	N/A
Farmsteads	2	N/A
Feedlots[2]	1	00

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

LAKE ELSIE

RICHLAND COUNTY

Peter N. Wax

Lake Elsie is located approximately 1.5 miles southeast of the town of Hankinson in eastern Richland County, North Dakota. Lake Elsie is a natural lake with a surface area of 260.5 acres, a maximum depth of 20 feet and an average depth of 9 feet (Figure 1).

Lake Elsie and its contributing watershed lie on the physiographic region known as the Prairie Coteau. The Prairie Coteau is an area characterized by glacial terminal moraines near the southeastern corner of North Dakota. Soils of the region are in complex patterns ranging from fairly well drained to well drained. Soils in this region are generally sandy. The surface layers overlie a deep deposit of glacial sands and gravels. The majority of slopes range between six and nine percent and are moderately erodible. Annual rainfall in this region of the state ranges between 16 and 21 inches. Land use is predominantly agricultural. The watershed is a mixture of pastures and cultivated fields. Other natural resources within the watershed are sand and gravel deposits. Due to the formation events of this area Lake Elsie is well connected to a surficial aquifer.

Lake Elsie is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Lake Elsie by annually assessing the fish community by test netting and stock accordingly.

In recent years the stocking regiment has included walleye, largemouth bass, northern pike and bluegill. Historically the fishery on Lake Elsie has been excellent with the largemouth bass naturally reproducing and sustaining a sport fishery second to none in the state of North Dakota. Early in the 1970s, with the construction of Interstate Highway 29, Lake Elsie's fishery began to deteriorate.

The construction of Highway 29 and the need for gravel created a gravel pit on the southwestern edge of Lake Elsie. The silt load coming from this gravel pit has been attributed to the degradation of the fishery. Reproduction at this time seems to have dropped off significantly as has the aquatic macrophyte population. It is assumed the continuous layers of silt blankets the bottom causing a reduction in the fishery and an increased in the eutrophication of the lake.

Public use on Lake Elsie is heavy at times with the majority of use occurring in mid summer and winter. Nearly 100 percent of the shore line surrounding Lake Elsie has had some sort of development on it over the last ten years.

Water Quality

Water quality samples were collected from Lake Elsie twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 381710, Figure 1). Water

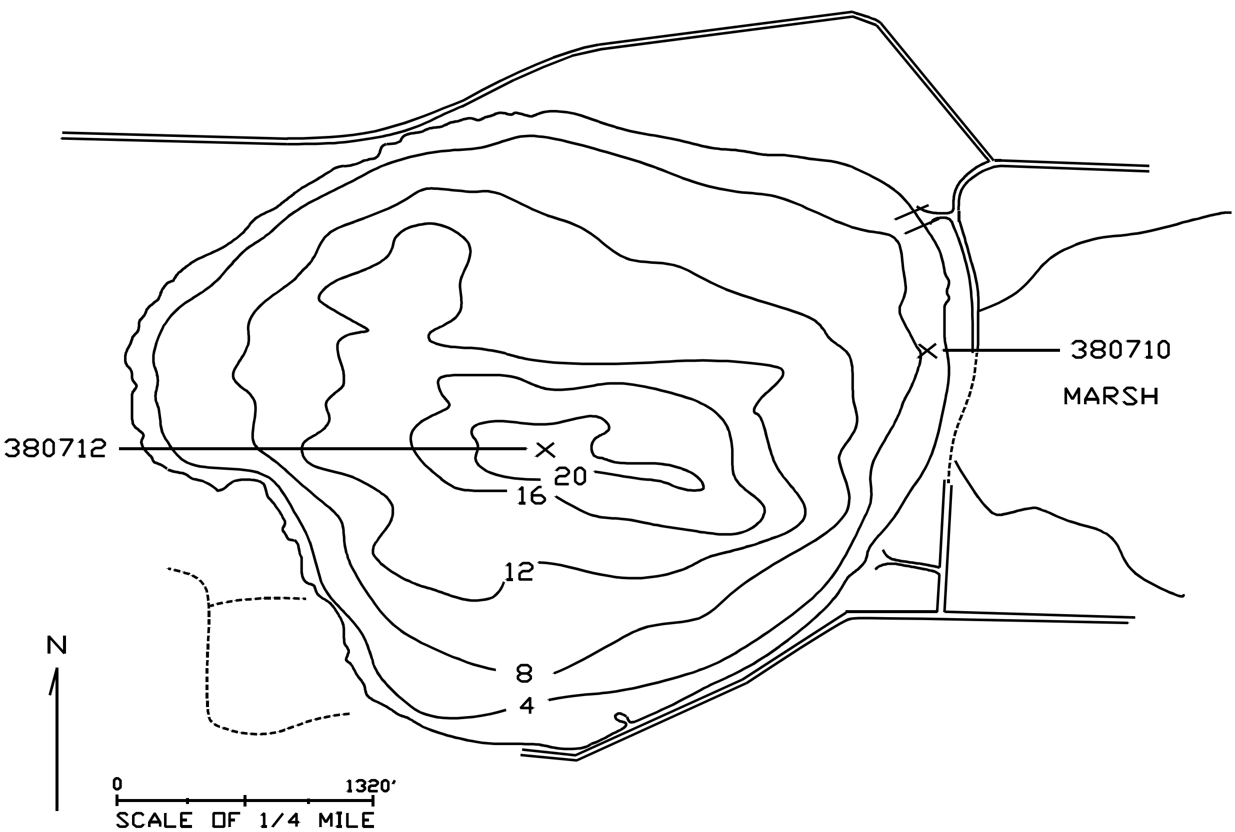


Figure 1. Morphometric map for Lake Elsie.

column samples were collected for analysis at three discrete depths on each sampling visit. During the summer sampling of 1992 Lake Elsie was thermally stratified on July 29, 1992 at approximately three meters of depth. On September 2, 1991 the water column was weakly thermally stratified at approximately four meters depth. During both summer sample visits, dissolved oxygen concentrations were adequate to maintain aquatic life (Figure 3). On March 2, 1993 Lake Elsie's water column was void of thermal stratification (Figure 2). Dissolved oxygen concentrations ranged from 2.4 mg L^{-1} near the bottom to 5.0 mg L^{-1} at the surface (Figure 3).

Concentrations of total dissolved solids, hardness as calcium and conductivity during the LWQA project on Lake Elsie were lower than the state's long-term average and lower than most other lakes sampled during the LWQA project (Table 1). Total alkalinity as $CaCO_3$ had a volume-weighted mean concentration of 212 mg L^{-1} indicating Lake Elsie is a well-buffered waterbody. The dominant anions in the water column were bicarbonates and sulfates with volume-weighted mean concentrations of 251 and 475 mg L^{-1}, respectively (Table 1).

Concentrations of total phosphorus as P ranged between 0.047 and 0.84 mg L^{-1} with a volume-weighted mean of 0.052 mg L^{-1}. Nitrate + nitrite as N concentrations ranged between 0.042 and 1.49 mg L^{-1}, with a volume-weighted mean of 0.056 mg L^{-1}. The ratios between total phosphorus as P and nitrate + nitrite as N is approximately 1:1. However, with the addition of ammonia as N concentrations added to the interpretation a total phosphorus to available nitrogen comes much closer to 1: 10 indicating the primary nutrients are near equilibrium.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 29, 1992 and September 2, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Lake Elsie		1982-1991	
Total Dissolved Solids	862	mg L^{-1}	1209	mg L^{-1}
Conductivity	1268	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	634	mg L^{-1}	488	mg L^{-1}
Sulfates	475	mg L^{-1}	592	mg L^{-1}
Chloride	12	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.052	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.056	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	212	mg L^{-1}	296	mg L^{-1}
Ammonia	0.405	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.63	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	251	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Lake Elsie on July 29, 1992. At the time of the macrophyte survey aquatic submergent and emergent vegetation identified on Lake Elsie included sago pondweed Potamogeton pectinatus and bulrush Scirpus spp. Macrophytes populations were sparse and intermittent (Appendix B).

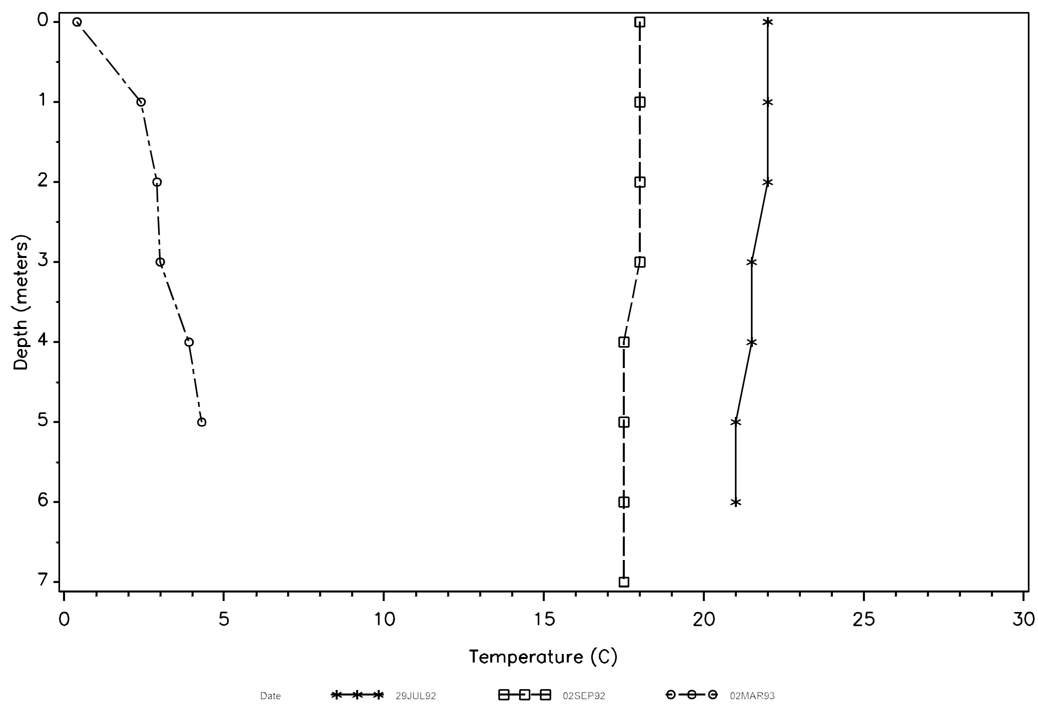


Figure 2. Temperature profile for Lake Elsie.

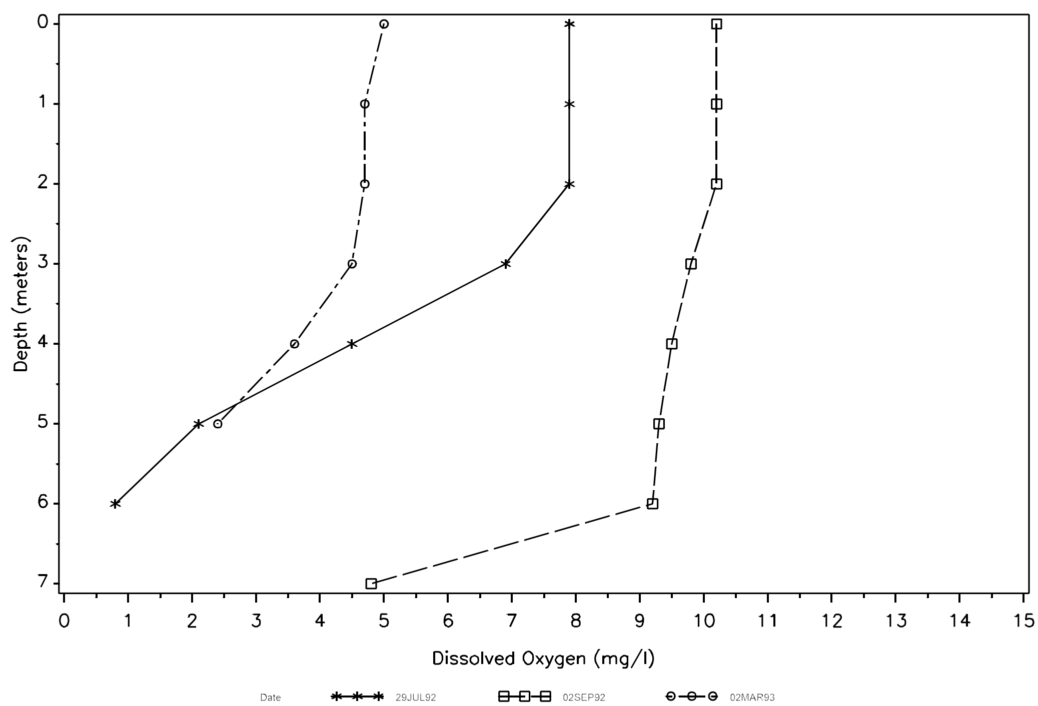


Figure 3. Oxygen profile for Lake Elsie.

Phytoplankton

Lake Elsie's phytoplankton community was sampled two times during the summer of 1992. At the time of assessments Lake Elsie's phytoplankton community was represented by five divisions and 45 genera. The largest contributors to the phytoplankton community by density were the blue-green algae, Cyanophyta, with 12 genera present. Mean density of the two samples collected during the summer of 1992 for blue-green algae was 620,634 cell mL^{-1} representing a dominance of nine fold over all other divisions combined. Other divisions represented in descending order of dominance were Chlorophyta, Cryptophyta, Bacillariophyta and Pyrrophyta.

At the time of the assessment mean phytoplankton concentrations by volume were not dominated by the division Cyanophyta, but rather Pyrrophyta. This shift in community structure by volume is due to the large size of the genera in the division Pyrrophyta. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA project indicate Lake Elsie is mesotrophic. Water quality indicators used in making this assessment were secchi disk depth transparencies that averaged nearly 0.8 meters, chlorophyll-a concentrations of 7 and 21 $\mu g\ L^{-1}$ and summer surface total phosphate as P concentrations of 47 and 51 $\mu g\ L^{-1}$. These indicators agree quite well suggesting Lake Elsie is mesotrophic.

Collaborating ancillary information used in making this assessment was Lake Elsie's history of an excellent fishery, infrequent nuisance algal blooms, lack of large macrophyte biomass, adequate dissolved oxygen below the hypolimnion and under ice cover conditions and no history of fish kills.

Sediment Analysis

Sediments were collected from Lake Elsie and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected in the deepest area of the lake (Site 380710) and the littoral area of the lake (Site 380712) (Figure 1).
Sediment samples collected from Lake Elsie show detectable levels of all trace elements tested for except mercury and selenium. The reported concentrations of trace elements in the sediments collected from Lake Elsie were some of the lowest reported for the LWQA project. The only exception was the reported arsenic concentrations which was near the median concentration reported for all sediments collected during the LWQA project. Concentrations of selected organic compounds and PCBs were below detectable limits for all sediment samples collected from Lake Elsie. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Lake Elsie on June 30, 1992. A walleye and a white sucker sample were collected to represent the piscivore and bottom feeder groups respectively. The walleye sample was composed of two fish with an average length of 61 centimeters and an average weight of 2,650 grams. The white sucker sample was composed of four fish with an average length of 40.8 centimeters and an average weight of 924 grams.

To evaluate the fish tissue data for Lake Elsie the results for each fish group was compared to that group for all fish assessed in the LWQA project. Trace element concentrations in the fish samples collected from Lake Elsie were generally near or below the 25th percentile reported for all fish samples collected during the LWQA project. The exception was the lead concentration in the walleye sample collected that was slightly above the median concentration reported for all piscivores sampled.

Detectable pesticide residues in the fish samples collected from Lake Elsie included BHC-Alpha, DDT, DDE, DDD, dieldrin, nonachlor and trifluralin. BHC-Alpha is a metabolite found in benzene hexachloride and lindane, both agricultural insecticides. DDT is an agricultural insecticide that was banned in the early 1970s due to the potential environmental risks associated with its use. DDE and DDD are both breakdown derivatives of the parent compound DDT and can behave similarly when available to the environment. Dieldrin is also an agricultural insecticide that like DDT was banned in the early 1970's due to it's destructive effect upon the environment. Nonachlor is a primary ingredient in technical chlordane, an agricultural insecticide that like DDT and dieldrin was removed from agricultural use due to its detrimental effect on the environment. Trifluralin, commonly known as treflan, is an agricultural preemergent herbicide commonly used in agricultural crop production in North Dakota.

Reported concentration of all these organic compounds in the walleye sample collected from Lake Elsie were above the 75th percentile for all piscivores sampled during the LWQA project. The reported concentrations of BHC-Alpha, dieldrin and nonachlor were the maximum concentrations reported during the LWQA project. Pesticide residues in the white suckers collected from Lake Elsie were DDT, DDE and DDD. The concentrations reported exceeded or were equal to the 75th percentile for all bottom feeders sampled during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Lake Elsie and its contributing watershed has a combined surface area of 4,529 acres located on the prairie coteau in western Richland County, North Dakota. This area of North Dakota is characterized by gently rolling hills and valleys with slopes generally between one and six percent. Soils are predominantly well drained, built from sandy, gravelly, glacial materials. Nonpoint source pollution from the surrounding watershed accounts for all the nutrient loadings and pollution discharges to Lake Elsie.

Land use within Lake Elsie watershed is 67 percent agricultural, with 52 percent actively cultivated. The remaining acres in the watershed are in wetland and wildlife management, pasture, haylands, Conservation Reserve Program (CRP) and low density urban development (Table 2). According to the information provided by the Richland County Soil Conservation

District, 80 percent of the cultivated lands and 90 percent of all the remaining agricultural lands within the Lake Elsie watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Lake Elsie watershed, the average "T" value is three to five tons per acre. Based on an average soil loss of just under three tons per acre, which takes into account all land uses and treatments within the watershed, approximately 13,227 tons of soil are lost from the watershed annually. Assuming a conservative delivery rate of 10 to 15 percent, between 1,322 and 1,984 tons of soil are delivered to Lake Elsie annually. These figures do not take into account the untreated portions of the sand and gravel operation just adjacent to Lake Elsie. The sand and gravel pit combined with uncontrolled concentrated livestock feeding and watering areas, construction activities and new developments along its shores are probably contributing a significant percentage of Lake Elsie's annual nutrient and sediment load.

Table 2. Land use in the Lake Elsie watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	52.0	80
Rangeland	8.1	90
Hayland	6.0	90
CRP	1.0	100
Wet/Wild[1]	25.9	N/A
Other	4.8	N/A
Farmsteads	10.0[3]	N/A
Feedlots[2]	5.0[3]	60

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

LAKE ISABEL

KIDDER COUNTY

Peter N. Wax

Lake Isabel is a pothole lake located near the community of Dawson in south central Kidder County on the Glaciated Plains physiographic region of North Dakota. The lake is a rather classic glacial pothole in that it is small and bowl shaped. Lake Isabel has a surface area of 806 acres, a maximum depth of 8 feet and an average depth of 6.5 feet. Slade National Wildlife Refuge borders Lake Isabel's northeast shore.

The topography of Lake Isabel's watershed is composed of gently rolling hills and valleys with many small potholes and integrated drainages. Their regular pattern of hills and valleys overlie a relatively deep deposit of glacial till. Soils in the watershed are predominantly moderately erodible and moderate to well drained. Annual precipitation is between 15 and 20 inches. Principle land use in Lake Isabel's watershed is agricultural with a predominant number of acres in small grain production.

Lake Isabel is classified as a warm water fishery "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Lake Isabel by annually assessing the fish community by test netting and stock accordingly.

In recent years the NDG&F stocking regiment has included yellow perch, northern pike and walleye. The fishery on Lake Isabel receives a significant amount of pressure from the occupants of the seasonal and permanent homes along its shore. Test netting operations conducted on July 3, 1991 by the NDG&F captured northern pike and fathead minnows.

Approximately two thirds of Lake Isabel's shoreline is privately owned. Nearly 100 percent of this area is developed with summer and permanent lake homes. Public access on Lake Isabel is limited to two picnic areas and a single boat ramp provided on the refuge side of the lake.

Water Quality

Water quality samples were collected from Lake Isabel two times during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380340, Figure 1). Water column samples were collected for analysis at two separate depths.

Water quality samples collected in July and August indicate Lake Isabel does not thermally stratify for any length of time (Figure 2). This is probably due to its shallowness allowing constant wind mixing. At the time of summer sample collection dissolved oxygen concentrations were between 9.0 and 10.5 mg L^{-1}, and adequate to maintain aquatic life (Figure 3).

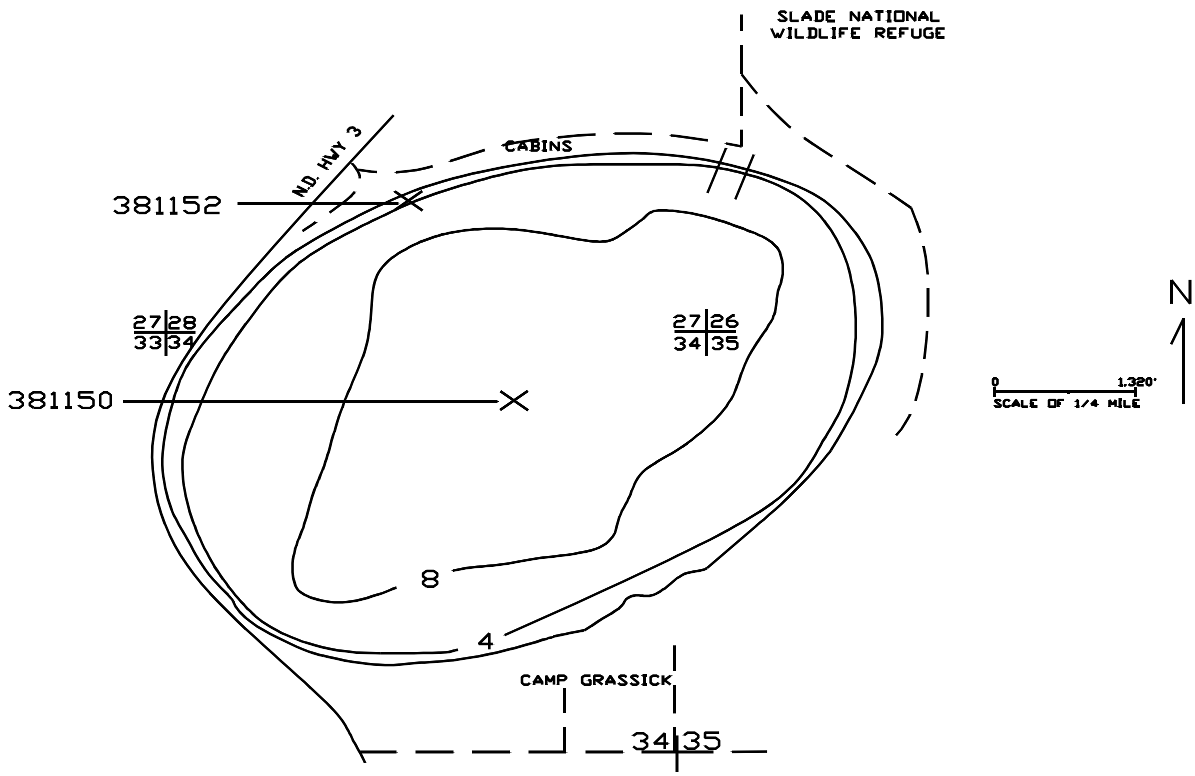


Figure 1. Morphometric map of Lake Isabel.

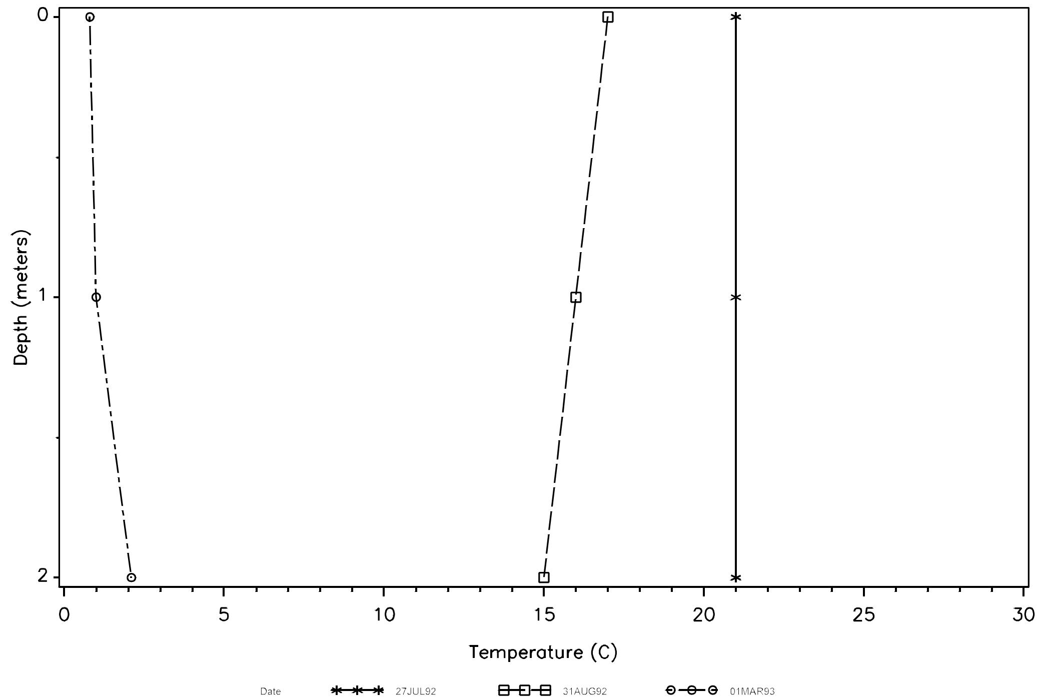


Figure 2. Temperature profile for Lake Isabel.

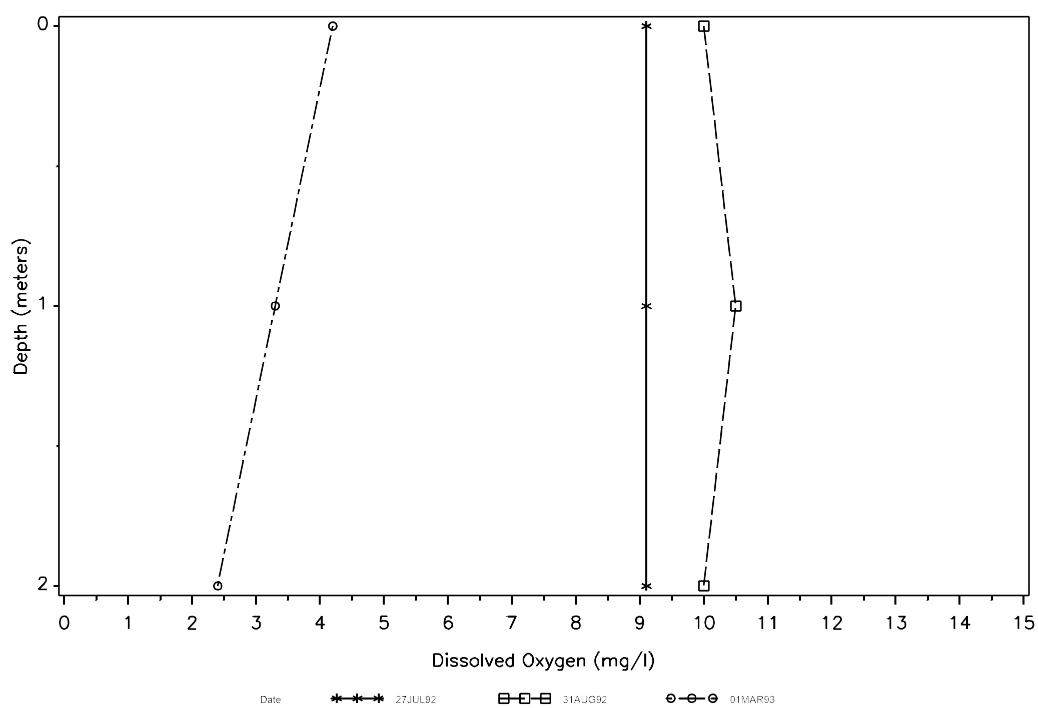


Figure 3. Oxygen profile for Lake Isabel.

Water quality samples collected on March 1, 1993 again showed Lake Isabel water column not thermally stratified with dissolved oxygen concentrations ranging between 2.4 mg L^{-1} near the bottom and 4.2 mg L^{-1} at the surface (Figure 2, Figure 3).

Concentrations of total dissolved solids, hardness as calcium and conductivity in Lake Isabel exceeded the states long-term average and had volume-weighted mean concentrations of 2,231, 745, and 3,142 mg L^{-1} respectively. Lake Isabel is an extremely well-buffered waterbody with total alkalinity concentrations ranging between 1,070 and 1,570 mg L^{-1} with a volume weighted mean of 1,255 mg L^{-1} (Table 1). Bicarbonates and sulfates were the dominant anions in the water column followed by chlorides. Volume-weighted means for these three parameters were 984, 674, and 55 mg L^{-1} respectively.

Total phosphate as P concentrations ranged between 0.089 and 0.108 mg L^{-1} with a volume-weighted mean of 0.098 mg L^{-1}, exceeding the state's target concentra-tion of 0.025 mg L^{-1} on all occasions sampled. Nitrate + nitrite as N concentrations ranged between nondetectable to 0.107 mg L^{-1} with a volume-weighted mean of 0.036 mg L^{-1} (Table 2). The ratio of total phosphate and nitrate + nitrite of approximately 3:1 suggest Lake Isabel is a nitrogen limited waterbody. Under these condition primary producers which can affix nitrogen, such as some types of blue-green algae, are favored. A complete list of water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 29, 1992 and March 2, 1993 and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Lake Isabel		1982-1991	
Total Dissolved Solids	2230	mg L^{-1}	1209	mg L^{-1}
Conductivity	3142	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	745	mg L^{-1}	488	mg L^{-1}
Sulfates	674	mg L^{-1}	592	mg L^{-1}
Chloride	54	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.098	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.036	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	1255	mg L^{-1}	296	mg L^{-1}
Ammonia	0.057	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.77	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	984	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Lake Isabel as part of the LWQA project. The survey was conducted on July 27, 1992.

At the time of the macrophyte survey the only aquatic vegetation identified on Lake Isabel was bulrush, Scirpus spp. The bulrush lined between 70 and 80 percent of the southern shoreline of the lake and was exposed in patches throughout the shallow southern portions of the lake. A map depicting the areal extent of macrophyte coverage on Lake Isabel is contained in Appendix B.

Phytoplankton

Lake Isabel's phytoplankton community was sampled two times during the summer of 1992. During these periods Lake Isabel's phytoplankton community was represented by 3 divisions and 22 genera. The largest contributors to the phytoplankton community by density were the blue-green algae, Cyanophyta, with 3 genera present. Mean density of blue-green algae species for the two samples collected during the summer of 1992 was 11,410,125 cell mL^{-1}, representing a dominance 681 fold over all other divisions combined. Other divisions identified were Chlorophyta and Pyrrophyta.

The blue-green algae's domination of the phytoplankton community was evident when viewing the community by volume also. Mean phytoplankton densities by volume of the two samples collected during 1992 was 40,022,035 μm^3 mL^{-1}, representing a volumetric dominance of 11.5 fold and occupying 92 percent of the total phytoplankton community by volume. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Water quality assessment data collected on Lake Isabel in 1992 indicate it is hypereutrophic. This assessment is primarily based on a secchi disk depth transparency average of 0.23 meters, a chlorophyll-a concentration average of 6 μg L^{-1} and summer surface total phosphate as P average of 99 μg L^{-1}. Supporting ancillary information of a hypereutrophic lake condition are frequent nuisance algal blooms, rapid oxygen depletion under ice covered conditions and shallowness of the water-body.

Sediment Analysis

Sediments were collected from Lake Isabel and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381150) and the littoral area of the lake (Site 381152), (Figure 1).

Sediment samples collected from Lake Isabel had detectable levels of all trace elements tested for except selenium and mercury. Reported concentrations of trace elements in the sediments collected from Lake Isabel were compared to the concentrations reported for all lakes assessed in the LWQA project. In general, the reported trace element concentrations in the sediments collected from Lake Isabel were near the 25th percentile with some being the lowest concentrations reported for the LWQA project. The exceptions were the reported concentrations of chromium in the deepest area sediments and arsenic in the littoral area sediments. The chromium concentration of 0.425 μg g^{-1} in the deepest area sediments was the highest concentration reported during the LWQA project while the arsenic concentration from the littoral area was near the median.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Lake Isabel. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

With help from the NDG&F, Fish were collected from Lake Isabel on June 24, 1992. Northern pike were the only fish collected representing the piscivore group. The northern pike sample was a composite of 5 fish with a mean length of 57.6 centimeters and a mean weight of 1,220 grams.

To evaluate the fish tissue data for Lake Isabel the results were compared to the reported concentration of all piscivore samples collected during the LWQA project. The northern pike sample collected from Lake Isabel contained detectible concentrations of all trace elements analyzed for with the exception of copper and cadmium. The reported trace element concentrations of mercury, arsenic, copper and chromium were all near or below the 25th percentile reported for all piscivores. The concentrations of zinc and barium were equal to or above the 75th percentile and the reported concentrations of selenium and lead were near the median reported for all piscivore samples collected during the LWQA project.

Detectable pesticide residues in the northern pike sample collected from Lake Isabel contained DDE, DDD and trifluralin. DDE and DDD are both breakdown derivatives of the agricultural insecticide DDT. DDT was removed from use in 1973 due to its harmfull effect on the environment. Trifluralin, commonly known as treflan is an agricultural preemergent herbicide commonly used in North Dakota.

The reported concentration of 0.006 $\mu g\ g^{-1}$ of DDE was equal to the 25th percentile for all piscivore samples analyzed during the LWQA project while the concentration of 0.002 $\mu g\ g^{-1}$ of DDD was near the median. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Lake Isabel with its contributing watershed has a surface area of 51,885 acres located on the Glaciated Plains physiographic region in Kidder County, North Dakota. The watershed is characterized by gently rolling to hilly glaciated plains with many small potholes and integrated drainages. The irregular patterns of hills and valleys caused by glacial thrusting and sedimentation overlie relatively deep deposits of glacial till. Soils in the watershed are generally formed from medium to course textured sandy or clayey loamy glacial till. Soils are moderately erodible and moderately to well drained. Annual precipitation is between 15 and 20 inches in the Lake Isabel watershed. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loadings and pollution discharges to Lake Isabel.

Land use within the Lake Isabel watershed is nearly 85 percent agricultural with 15.8 percent actively cultivated. The remaining 69.7 percent of the agricultural lands within the watershed are in some type of livestock related production, conservation reserve program (CRP), wildlife management, roads and low density urban developments. (Table 2).

According to the information provided by the Kidder County Soil Conservation District, 80 percent of the cultivated lands and between 60 and 75 percent of the remaining agricultural lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Lake Isabel watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of 1.5 tons per acre, which takes into account all land uses and treatments approximately 80,227 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 8,023 and 12,034 tons of soil are delivered to Lake Isabel annually.

Other significant sources of nonpoint source pollution discharges to Lake Isabel are from the 29 concentrated livestock feeding areas in the watershed, construction activities within the watershed and the low density urban developments along its shores. These sources in particular the low density urban developments have the capabilities to contribute a significant portion of Lake Isabel's annual nutrient budget due to their close proximity to the waters edge. Pollution contributions can be delivered through surface runoff and ground seepage of inadequate waste disposal systems.

Table 2. Land use in the Lake Isabel watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	15.8	80
Rangeland	44.4	60
Hayland	25.3	75
CRP	3.7	100
Wet/Wild[1]	7.2	N/A
Other	2.1	N/A
Farmsteads	38[3]	N/A
Feedlots[2]	29[3]	50

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

LAKE METIGOSHE

BOTTINEAU COUNTY

Peter N. Wax

Lake Metigoshe is a natural lake located in the scenic Turtle Mountains on the North Dakota-Manitoba border approximately 13 miles north of Bottineau, North Dakota. It is a relatively large lake covering 1,641 surface acres with a maximum depth at full pool of 22 feet and an average depth of 9.3 to 10.9 feet (Figure 1). Lake Metigoshe is one of the largest lakes within the Turtle Mountains an area which is composed of hills, intricate drainages and small closed basins. The landscape is covered with brush and hardwoods and is home to many species of animals uncommon to most of North Dakota such as the rough grouse, moose, elk, lynx, bobcat, common loon and snowshoe hare.

Lake Metigoshe has a very intricate shoreline with four main islands located throughout the waterbody and a narrow area which divides Lake Metigoshe into two lakes (Figure 1). Twenty-two acres of the northern half of Lake Metigoshe extends into Manitoba, Canada (Figure 2). Lake Metigoshe is approximately 90 percent under private ownership. The north half of the lake has approximately 600 lake cabins, two resorts and a state park. The south half has approximately 450 lake cabins, three resorts and one picnic area (Figure 3).

Due to the size and intricate pattern of Lake Metigoshe for purposes of the LWQA project the lake has been divided into three basins. The first of these basins lies above the narrows and will be referred to as Lake Metigoshe North and includes the portions that extend into Manitoba, Canada (Figure 2). The second two basins assessed are south of the narrows. These will be referred to as Lake Metigoshe Center and Lake Metigoshe South (Figure 3).

Lake Metigoshe's watershed encompasses approximately 37,000 acres of which 14,068 lie below the Manitoba-North Dakota border. The watershed is characterized by rolling hills with relief above the prairie between 300 and 500 feet. The land- scape is covered with brush and hardwoods. The Turtle Mountains were probably formed by sedimentation of collapsed superglaciers.

Soils in the Turtle Mountain region are relatively shallow, moderately fertile, and well drained. The majority of slopes range between six and nine percent. Annual rainfall in the Turtle Mountains is between 15 and 18 inches. Land use is primarily agricultural. The Turtle Mountains are an area of significant recreational value to the state of North Dakota.

Lake Metigoshe has been the subject of many research projects and lake studies. A sewage collection system has been installed to eliminate sewage inflows into Lake Metigoshe.

Lake Metigoshe is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonid fishes and marginal growth of salmonid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Lake Metigoshe by assessing the fish community through test netting operations, fish stockings and biomanipulations.

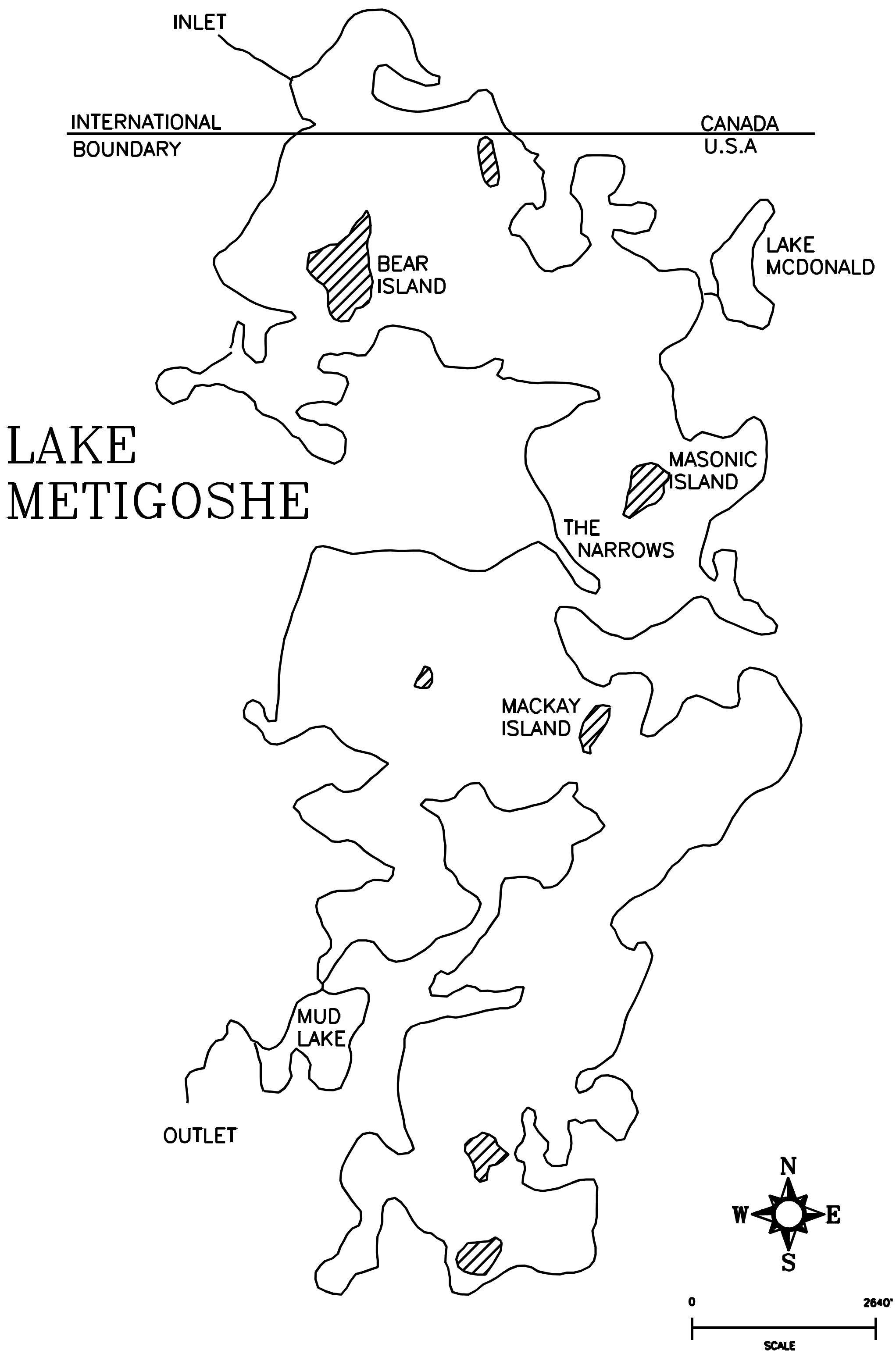


Figure 1. Map of Lake Metigoshe.

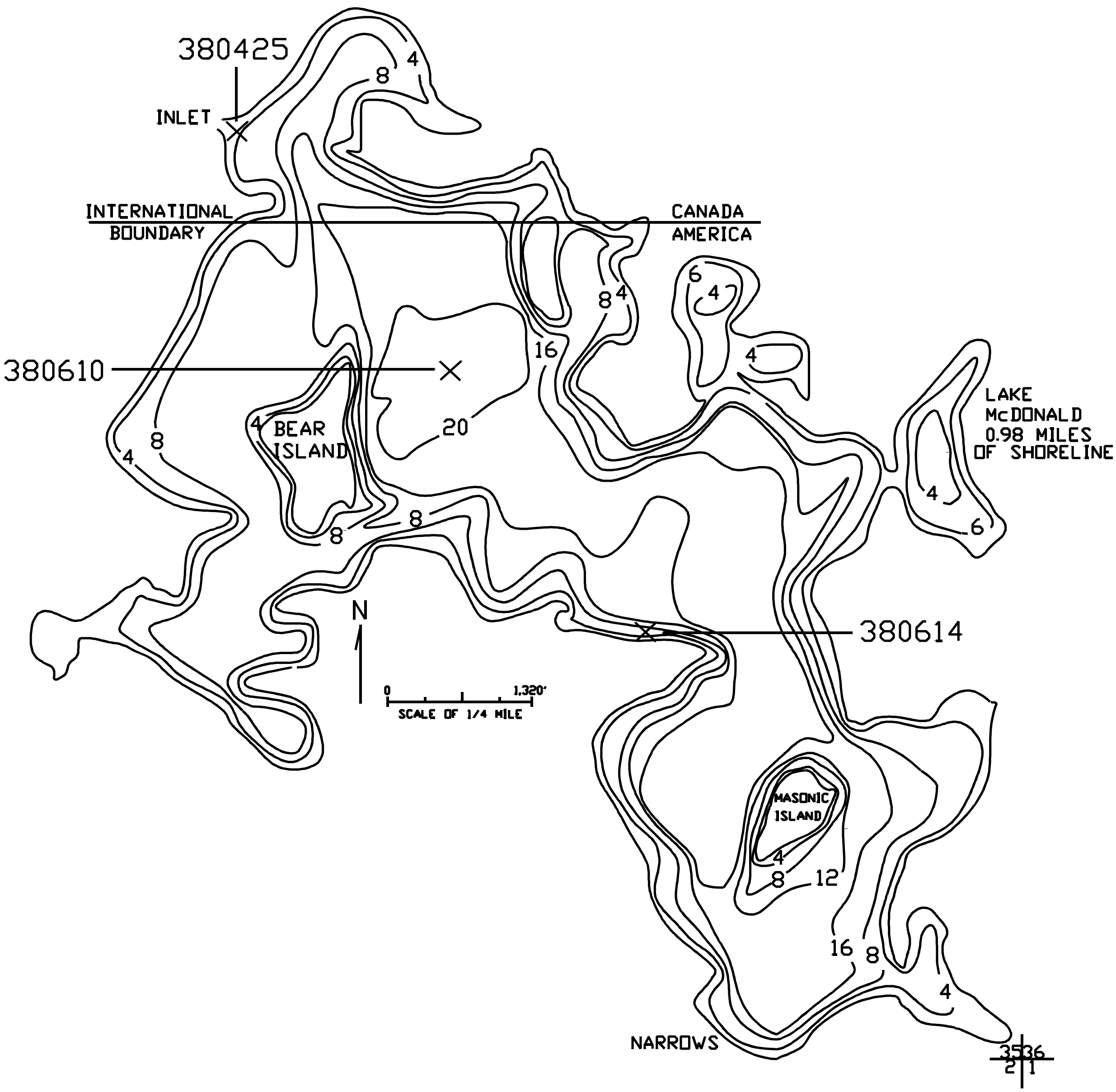


Figure 2. Morphometric map of Lake Metigoshe North.

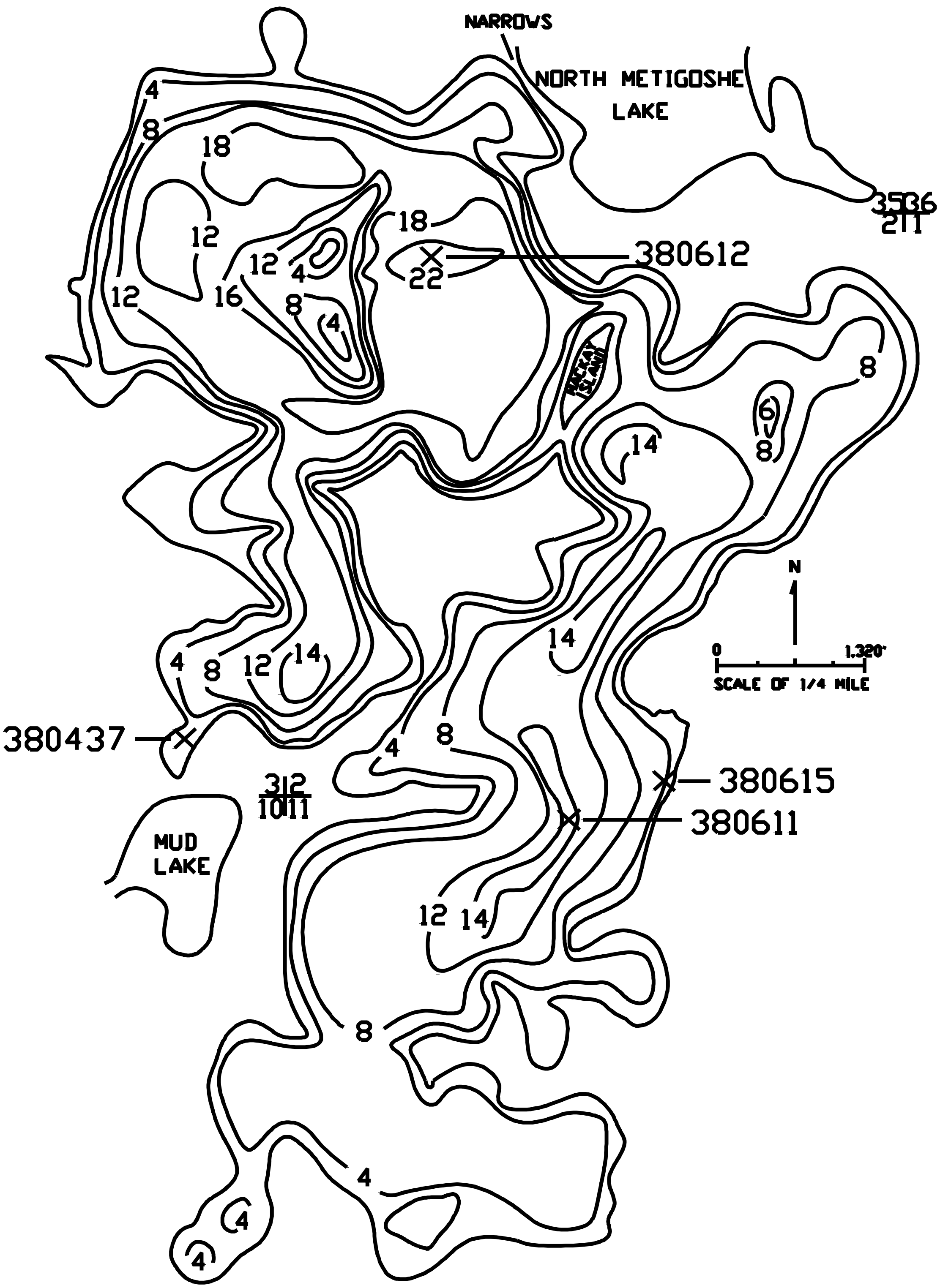


Figure 3. Morphometric map of Lake Metigoshe Center and Lake Metigoshe South.

Fishery records for Lake Metigoshe begin in 1959 at which time a stunted yellow perch and black bullhead population was present. At this time projects were initiated to partially eradicate these species. The stunted yellow perch and bullhead problem has continued to this day. Historically a limited commercial fishery was established in an attempt to help control their numbers, however, this also was unsuccessful.

Lake Metigoshe's sport fishery has been unstable with the primary sport fish sought after being yellow perch and walleye. In the winter of 1979-80 a severe winter kill occurred as a result of low water levels and low dissolved oxygen concentrations. Test nettings in 1980 indicated that it was not a 100 percent kill with the black bullhead, yellow perch, northern pike and walleye collected in the capture nets.

The stocking regiment on Lake Metigoshe since 1988 has included northern pike, walleye, bluegill, pure muskies and fathead minnows. Test nettings conducted in August of 1991 captured in order of most abundant, black bullheads, yellow perch, northern pike and walleye.

Recreational use on Lake Metigoshe is heavy year-round. Activities at the lake include all types of water-based recreation, hiking, camping, bicycling, ice skating and snowmobiling. Public facilities on Lake Metigoshe include a state park, two picnic areas, boat ramps and associated parking, hiking trails, resorts, convenience stores and gas stations.

Water Quality

Water quality samples were collected from Lake Metigoshe twice during the summer of 1992 and once during the winter of 1993. Samples were collected from three sample sites located in the deepest area of each basin (Site 380612, Site 380610, and Site 380611) (Figure 1, Figure 2 and Figure 3). Water column samples were collected for analysis at three separate depths, one meter, three meters and five meters in Lake Metigoshe North; one meter, three meters and five meters in Lake Metigoshe Center; and one meter, two meters and between three and five meters in Lake Metigoshe South.

During the summer sampling of 1992 all areas sampled within Lake Metigoshe did not thermally stratify (Figure 4, Figure 5 and Figure 6). At the time of sampling dissolved oxygen concentrations were near stratification to within one meter of the bottom. Near the bottom, however, dissolved oxygen concentrations dropped to as low as 3.2 mg L^{-1} (Figure 7, Figure 8 and Figure 9). During winter sampling Lake Metigoshe Center was not thermally stratified, however, both Lake Metigoshe South and Lake Metigoshe North experienced weak thermal stratification between two and three meters of depth (Figure 4, Figure 5 and Figure 6). Dissolved oxygen concentrations throughout the winter for all three basins were relatively low with concentrations ranging from 0.2 mg L^{-1} near the bottom to 3.9 near the surface (Figure 7, Figure 8 and Figure 9).

Water quality data collected from the three sites during the LWQA project on Lake Metigoshe showed all three basins had similar water quality. All three basins were well buffered with the volume-weighted means for total alkalinity

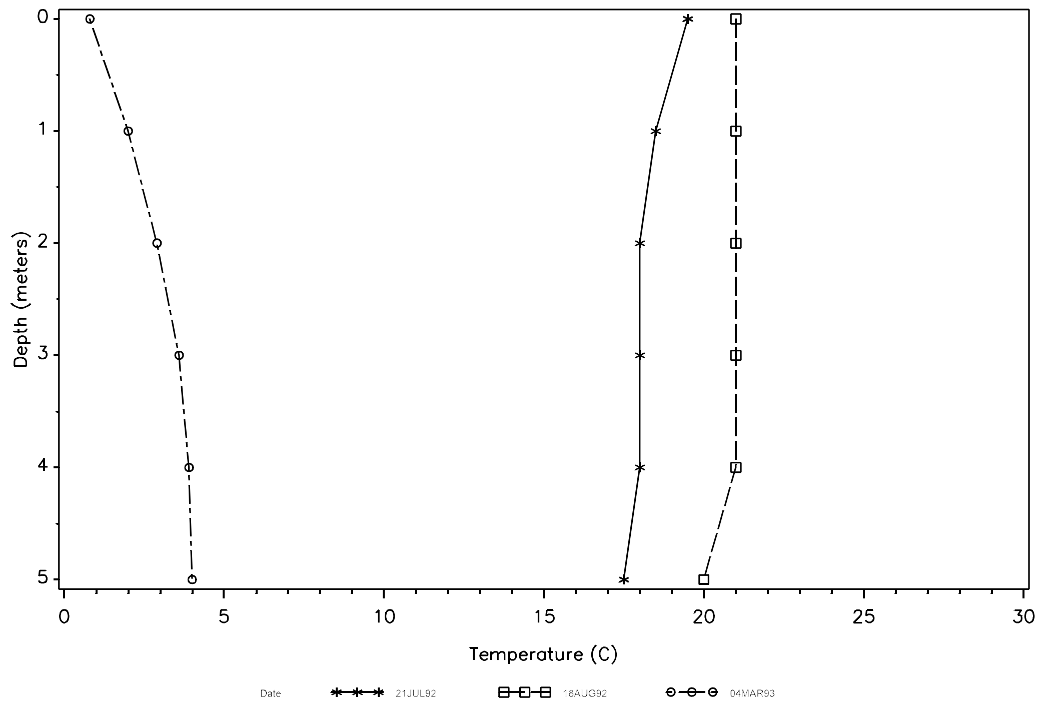


Figure 4. Temperature profile for Lake Metigoshe Center.

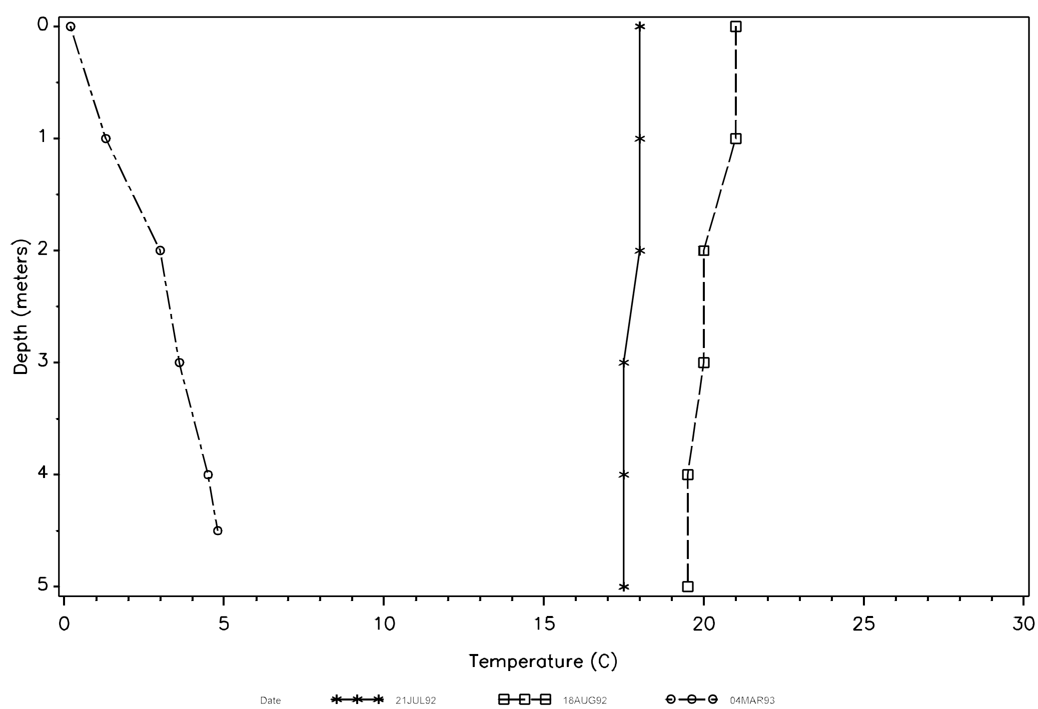


Figure 5. Temperature profile for Lake Metigoshe North.

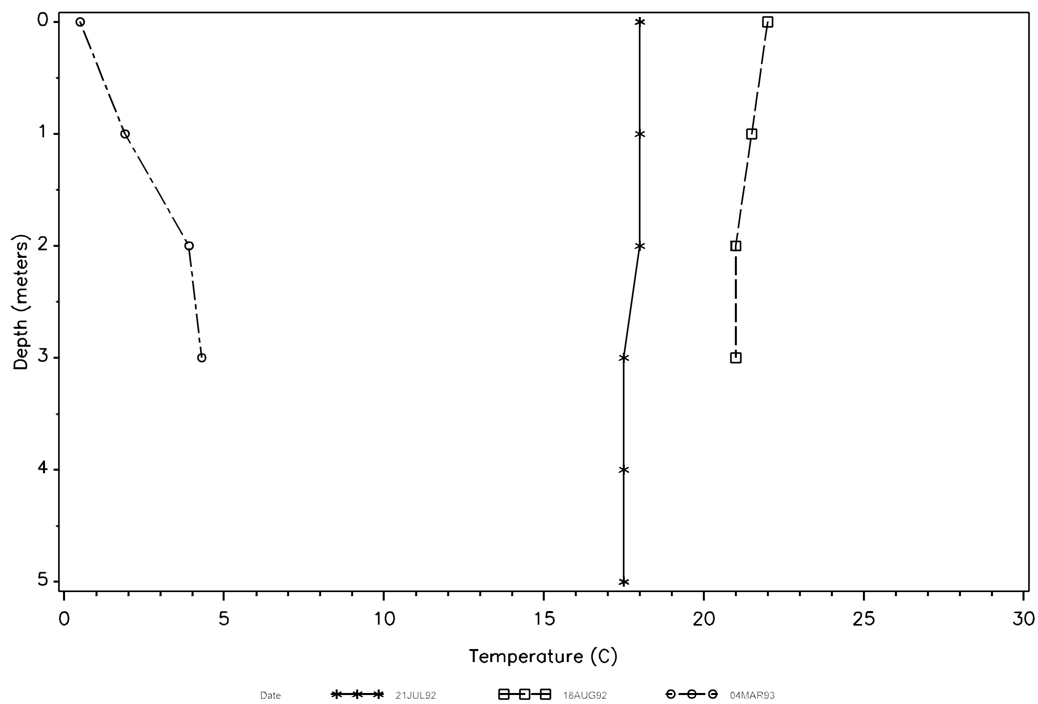


Figure 6. Temperature profile for Lake Metigoshe South.

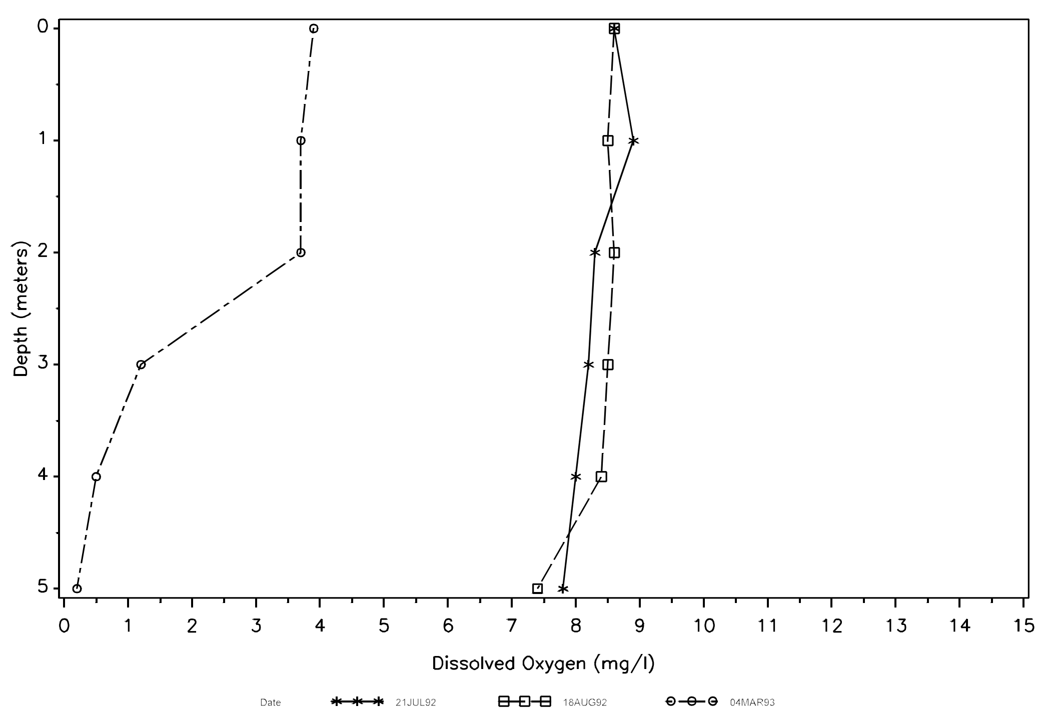


Figure 7. Oxygen profile for Lake Metigoshe Center.

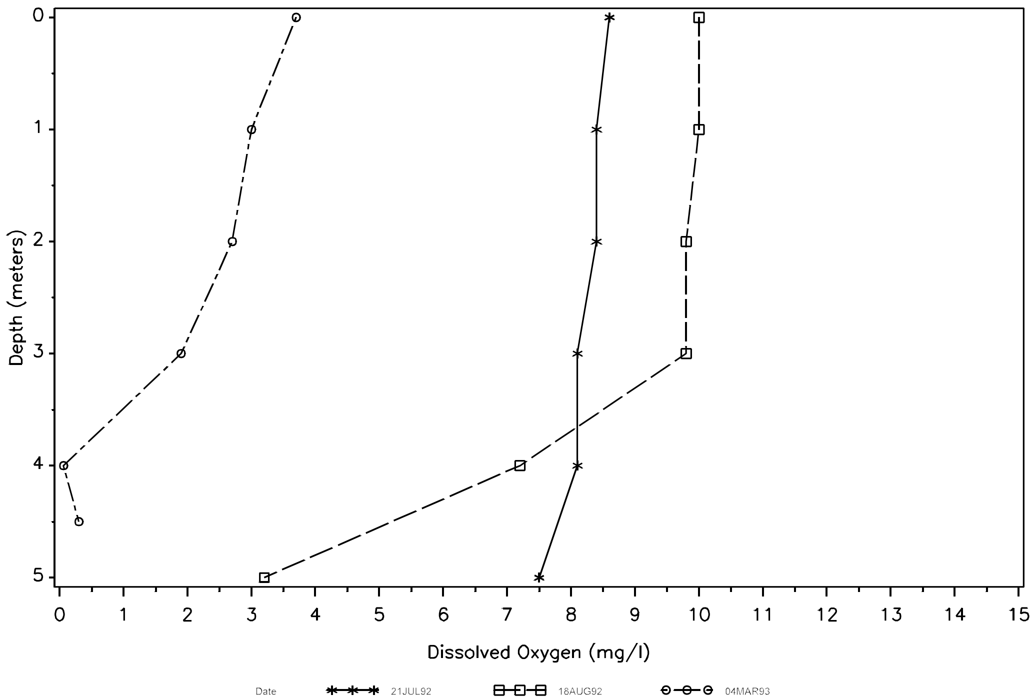


Figure 8. Oxygen profile for Lake Metigoshe North.

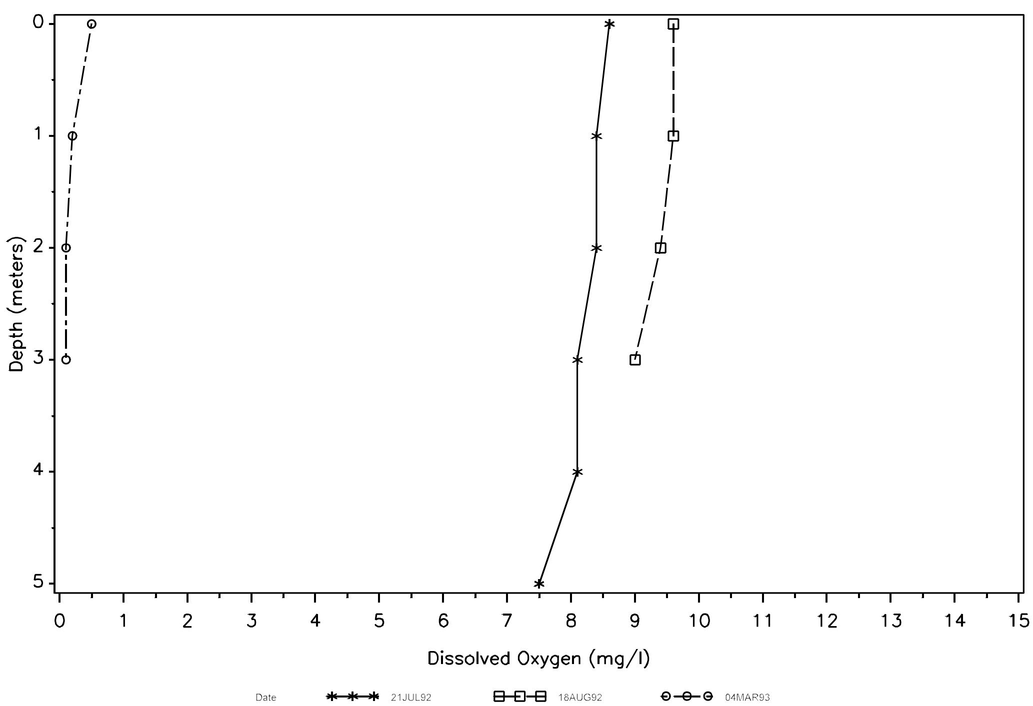


Figure 9. Oxygen profile for Lake Metigoshe South.

as $CaCO_3$ concentrations varying by less than 20 mg L^{-1}. Volume-weighted mean concentrations of Total Alkalinity as $CaCO_3$ was 315 mg L^{-1} for Lake Metigoshe South, 304 mg L^{-1} for Lake Metigoshe Center and 325 mg L^{-1} for Lake Metigoshe North.

The dominant anions in the water column of all three basins were sulfates and bicarbonates. Bicarbonate concentrations ranged between 301 mg L^{-1} to 338 mg L^{-1} and sulfates ranged between 45 and 47 mg L^{-1}. Concentrations of total dissolved solids, hardness as calcium and conductivity for all three basins was below the North Dakota long-term average with volume-weighted mean concentrations of 358, 331 and 618 mg L^{-1} for Lake Metigoshe South, Center and North, respectively (Tables 1, 2 and 3).

The nutrients total phosphate as P and nitrate + nitrite as N were very similar at the Lake Metigoshe South and Lake Metigoshe Center sample sites, yet were considerably lower at the Lake Metigoshe North site. Total phosphate as P and nitrate + nitrite as N volume-weighted mean concentrations in Lake Metigoshe Center were 0.039 and 0.023 mg L^{-1} respectively. In the Lake Metigoshe South the volume-weighted means were 0.036 and 0.008 mg L^{-1}, respectively. Of note the ratios between these two nutrients would suggest both Lake Metigoshe Center and Lake Metigoshe South are nitrogen limited. As with most North Dakota waters, nitrogen limited does not prevent primary production within the waterbodies but favors nitrogen-fixing organisms such as certain blue-green algae species.

Total phosphate as P concentrations and total nitrate + nitrite as N con-centrations in Lake Metigoshe North had volume-weighted mean concentrations of 0.012 and 0.035 mg L^{-1}. The ratios of total phosphate as P and nitrogen combined with ammonia of 1:11.9 indicate Lake Metigoshe North is a phosphorus-limited waterbody (Table 1, Table 2 and Table 3). A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 21, 1992 and February 4, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Lake Metigoshe (North)		1982-1991	
Total Dissolved Solids	362	mg L^{-1}	1209	mg L^{-1}
Conductivity	640	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	329	mg L^{-1}	488	mg L^{-1}
Sulfates	46	mg L^{-1}	592	mg L^{-1}
Chloride	7	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.012	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.035	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	325	mg L^{-1}	296	mg L^{-1}
Ammonia	0.108	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.85	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	338	mg L^{-1}	326	mg L^{-1}

Table 2. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 21, 1992 and February 4, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Lake Metigoshe (Center)		1982-1991	
Total Dissolved Solids	348	mg L^{-1}	1209	mg L^{-1}
Conductivity	617	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	321	mg L^{-1}	488	mg L^{-1}
Sulfates	417	mg L^{-1}	592	mg L^{-1}
Chloride	6	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.039	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.023	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	304	mg L^{-1}	296	mg L^{-1}
Ammonia	0.037	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.47	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	335	mg L^{-1}	326	mg L^{-1}

Table 3. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 21, 1992 and February 4, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Lake Metigoshe (South)		1982-1991	
Total Dissolved Solids	359	mg L^{-1}	1209	mg L^{-1}
Conductivity	614	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	338	mg L^{-1}	488	mg L^{-1}
Sulfates	45	mg L^{-1}	592	mg L^{-1}
Chloride	7	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.036	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.008	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	315	mg L^{-1}	296	mg L^{-1}
Ammonia	0.127	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.71	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	301	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Lake Metigoshe as part of the LWQA project. The survey was conducted on July 21, 1992.

Emergent macrophyte vegetation identified on Lake Metigoshe included bulrush Scirpus spp. and cattails Typha spp. The dominance between these two species varied between locations within the lake.

Submergent macrophyte vegetation identified on Lake Metigoshe included sago pondweed Potomogeton pectinatus, water milfoil Myriophyllum spp., curly leaf pondweed Potomogeton crispus, american pondweed Potomogeton americanus and coontail Ceratophyllum demersum. The dominant submergent was sago pondweed followed by water milfoil and american pondweed. Submergent macrophyte vegetation extended to approximately eight feet of depth. A map depicting the areal extent of macrophyte coverage in Lake Metigoshe is contained in Appendix B.

Phytoplankton

Lake Metigoshe's phytoplankton community was sampled at all three basins twice during the summer of 1992. The phytoplankton community at Lake Metigoshe North was represented by five divisions and 55 genera. The largest contributors to the phytoplankton community by numerical density and volume were the divisions Cyanophyta and Cryptophyta. Other divisions represented in descending order of numerical dominance were Chlorophyta, Cryptophyta, Bacillariophyta and Chrysophyta.

The phytoplankton community in Lake Metigoshe South was represented by five divisions and 46 genera. The largest contributors to the phytoplankton community in numbers were the divisions, Cyanophyta, and by volume, Cryptophyta. Other divisions represented in order of descending numerical dominance were Cryptophyta, Chlorophyta, Bacillariophyta and Chrysophyta.

The phytoplankton community in Lake Metigoshe Center was the least diverse of the three sample locations, with representation from four divisions and 27 genera. As in Lake Metigoshe South and North the dominant species by numerical density was the division Cyanophyta. Other divisions represented in descending order of dominance by numerical density were Chlorophyta, Cryptophyta and Bacillariophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA project on Lake Metigoshe, combined with ancillary information define Lake Metigoshe as presently eutrophic. Water quality data used to make this assessment was secchi disk depth transparency, summer surface total phosphate as P concentrations and chlorophyll-a concentrations. These water quality parameters indicate Lake Metigoshe North is mesotrophic bordering on eutrophic, while Lake Metigoshe South and Center are firmly eutrophic. When combining the water quality data with ancillary information such as a large macrophyte biomass, frequent nuisance algal blooms, low dissolved oxygen conditions under ice cover conditions and below the hypolimnion, and frequent history of fish kills it becomes apparent Lake Metigoshe South, Center and North are eutrophic.

Sediment Analysis

Sediments were collected from Lake Metigoshe and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest areas of Lake Metigoshe South, Lake Metigoshe North and Lake Metigoshe Center, the inlet area of Lake Metigoshe North and the outlet area of Lake Metigoshe South (Figure 2, Figure 3).

Sediment samples collected from Lake Metigoshe show detectable levels of all trace elements tested for, except mercury and selenium. Reported concentrations of trace elements in the sediments collected from Lake Metigoshe were compared to the concentrations reported for all lakes assessed in the LWQA project. In general, the reported trace element concentrations in the sediments collected from Lake Metigoshe were generally lower than the 25th percentile for all sediment samples collected during the LWQA project. The exception was the reported chromium concentration in the deepest area sediments collected from Lake Metigoshe South which approached the median concentration for all sediments sampled collected during the LWQA project.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Lake Metigoshe. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Lake Metigoshe on July 11, 1992. Black bullheads and northern pikes were collected representing a bottom feeder and a piscivore sample respectively. The black bullhead sample was composed of five fish with a mean length of 21.6 centimeters and a mean weight of 172 grams. The northern pike sample was composed of two fish with a mean length of 87.5 centimeters and a mean weight of 4,235 grams.

In order to evaluate the fish tissue data for Lake Metigoshe the results for each fish sample was compared to all corresponding fish samples collected during the LWQA project. Reported trace element concentrations in the black bullhead sample collected from Lake Metigoshe in general contained concentrations that were near or below the 25th percentile for all bottom feeders sampled during the LWQA project. The exceptions were the zinc and barium concentrations which exceeded the 75th percentile. The northern pike sample had reported concentrations of trace elements that were near or above the median with the reported concentrations of cadmium, mercury and zinc exceeding the 75th percentile for all piscivores sampled during the LWQA project.

Detectable pesticide residues in the fish samples collected from Lake Metigoshe included DDE and DDD. DDE and DDD are both degradation byproducts of the insecticide DDT and can produce biological effects similar to the parent compound. DDT has been removed from use since 1973 due to its potential environmental risks.

The black bullhead sample collected form Lake Metigoshe contained DDD and DDE in concentrations which approximated the median for all bottom feeders analyzed during the LWQA project. The northern pike sample contained just DDE in concentrations that were just slightly above the median concentration for all piscivores sampled during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Lake Metigoshe, with its contributing watershed, has a combined surface area of 37,000 acres located in the Turtle Mountain region of north central North Dakota and southwestern Manitoba, Canada. The Turtle Mountain physiographic region, which comprises the majority of Lake Metigoshe's watershed, is significantly different in appearance than most of the North Dakota landscape. The relief of the Turtle Mountains reaches between 300 and 500 feet above the glacial plains which surround it. Topography of the region is hilly with many integrated drainages and small closed basins. The landscape is covered with brush and hardwoods. The Turtle Mountains were probably formed by sedimentation of collapsed superglaciers.

Soils in Lake Metigoshe's watershed are relative shallow, moderately fertile and well drained. The majority of slopes range between six and nine percent. Annual precipitation in the Lake Metigoshe watershed is between 15 and 18 inches. The Turtle Mountains are an area of significant recreational value to the state of North Dakota. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loadings and pollution discharges to Lake Metigoshe.

Land use within the Lake Metigoshe watershed is 43.1 percent agricultural with 14.1 percent actively cultivated, 19.4 percent in rangeland, 8.5 percent in haylands and 1.1 percent in Conservation Reserve Program (CRP). Between 65 and 100 percent of all agricultural lands within the Lake Metigoshe watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). Of the remaining 56 percent of the watershed, 28.3 percent is in woodlands, 25.1 percent in wildlife/ woodland and wetland management, 2.8 percent in low density urban development and transportation. There are 18 farms and four concentrated livestock feeding areas within the watershed (Table 2).

Table 4. Land use in the Lake Metigoshe watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	14.1	65
Rangeland	19.4	90
Hayland	8.5	90
CRP	1.1	100
Woodlands	28.3	N/A
Wet/Wild[1]	25.1	N/A
Other	2.8	N/A
Farmsteads	18[3]	N/A
Feedlots[2]	4[3]	50

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

According to the information provided by the Bottineau County Soil Conservation District, 65 percent of the cultivated lands, 90 percent of the range and haylands, and nearly 100 percent of all CRP lands within the Lake Metigoshe watershed are "adequately treated" against soil loss. Based on an average soil loss of approximately 1.4 tons per acre, which takes into account all land uses and treatments within the watershed, approximately 16,007 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 1,601 and 2,401 tons of soil are delivered to Lake Metigoshe annually.

Cattle feeding and watering in and near Lake Metigoshe also contribute nutrients and solids to the lake. However, aside from the agricultural erosion, probably the most significant nutrient loading delivered to Lake Metigoshe comes from shoreline developments and construction activities within the watershed. These sources contribute fertilizer, pesticide, sediments and pollutants almost unchecked into the Lake Metigoshe due to their close proximity to the waters edge.

LAKE TSCHIDA

GRANT COUNTY

Peter N. Wax

Lake Tschida is a Bureau of Reclamation project built in 1948-49 as an irrigation storage reservoir. The reservoir is located approximately 17 miles south of Glen Ullin on the Heart River in central Grant County. The reservoir and contributing watershed lie on the Missouri Slope Uplands physiographic region of North Dakota. The Missouri Slope Uplands are composed primarily of rolling hills and uplands. Lake Tschida covers approximately 5,018 acres, with a maximum depth of 64 feet and an average depth of 27.9 feet (Figure 1).

The watershed surrounding Lake Tschida is primarily in small grain and livestock production. Soils in the watershed are moderately fertile to fertile, well drained and susceptible to wind and water erosion. Annual precipitation ranges from 14 to 16 inches, with between 80 and 90 percent of the precipitation occurring between April and September. Other industries within the Heart River drainage include coal and oil exploration.

Lake Tschida is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Lake Tschida by annually assessing the fish community by test netting and stock accordingly.

In recent years, the stocking regiment has included northern pike, walleye, yellow perch, bluegill, smallmouth bass and pure musky. Test netting operations conducted in August 1991 by the NDG&F captured black crappie, yellow perch, bluegill, bullhead, smallmouth bass, river carp sucker, walleye, spottail shiner, white suckers, carp, orange spotted sunfish, white bass, channel catfish, fathead minnow, greater red ears, largemouth bass, spottail shiner and common goldeye. As evident by the number of species captured, Lake Tschida is a highly diverse sport fishery.

Lake Tschida receives heavy recreational use. Recreational facilities include five public use areas containing boat ramps, rest rooms and drinking water. Private developments along Lake Tschida include over 116 cabins and 122 trailers located primarily on the north and south shores. Also adjacent to Lake Tschida are hundreds of acres of additional lands under management by the NDG&F for hunting and general leisure.

Water Quality

Water quality samples were collected from Lake Tschida twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380950, Figure 1). Water column samples were collected for analysis at three separate depths of 1 meter, 5 meters and 11 meters during July and August and 1 meter, 6 meters and 11.5 meters in January 1993.

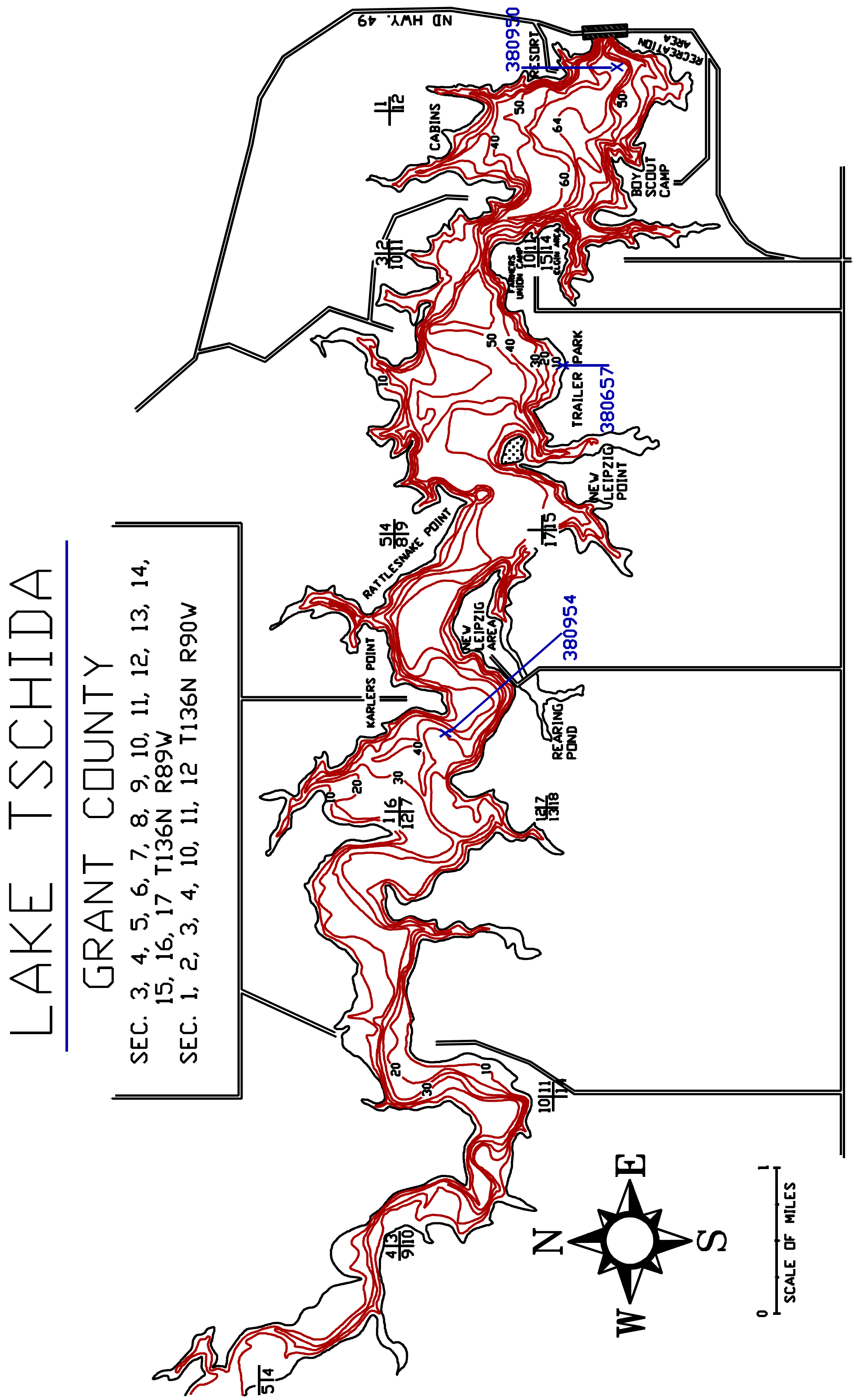


Figure 1. Morphometric map of Lake Tschida.

At the time summer samples were collected in 1992 Lake Tschida was not thermally stratified on either July 8 or August 5 (Figure 2). Dissolved oxygen concentrations on the July sample date were between 8.2 and 9.8 mg L^{-1} and between 7.1 and 6.5 mg L^{-1} in August (Figure 3). Lake Tschida was also not thermally stratified on January 16, 1993. Dissolved oxygen concentrations at this time were between 6.2 and 12.1 mg L^{-1} (Figure 2, Figure 3).

Water quality data collected during the LWQA project shows Lake Tschida as a well-buffered waterbody with total alkalinity as $CaCO_3$ concentrations ranging between 295 and 406 mg L^{-1}, with a volume-weighted mean of 324 mg L^{-1} (Table 1). Concentrations of total dissolved solids, total hardness as calcium and conductivity were similar to the North Dakota long-term average, with volume-weighted mean concentrations of 1,100, 325 and 1,652 mg L^{-1} (Table 1).

The dominant anions in the water column were bicarbonates and sulfates. Bicarbonates ranged between 307 and 496 mg L^{-1}, with a volume-weighted mean of 359 mg L^{-1} while sulfates ranged between 446 and 649 mg L^{-1}, with a volume-weighted mean of 513 mg L^{-1}. These concentrations compare well to the North Dakota long-term average (Table 1).

Total phosphate as P concentrations and nitrate + nitrite as N concentrations were found in good quantities with a ratio of approximately 1:1. Total phosphate as P concentrations ranged between 0.038 to 0.155 mg L^{-1}, with a volume-weighted mean concentration of 0.074, while nitrate + nitrite as N concentrations ranged between 0.012 and 0.261 mg L^{-1}, with a volume-weighed mean concentration of 0.076 mg L^{-1}. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 8, 1992 and January 16, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Lake Tschida		1982-1991	
Total Dissolved Solids	1100	mg L^{-1}	1209	mg L^{-1}
Conductivity	1652	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	325	mg L^{-1}	488	mg L^{-1}
Sulfates	513	mg L^{-1}	592	mg L^{-1}
Chloride	18	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.074	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.076	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	324	mg L^{-1}	296	mg L^{-1}
Ammonia	0.164	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.87	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	359	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Lake Tschida as part of the LWQA project. The survey was conducted on July 8, 1992. Possibly due to the low water levels experienced on Lake Tschida caused by the recent drought, no aquatic vegetation was found on Lake Tschida at the time of the assessment.

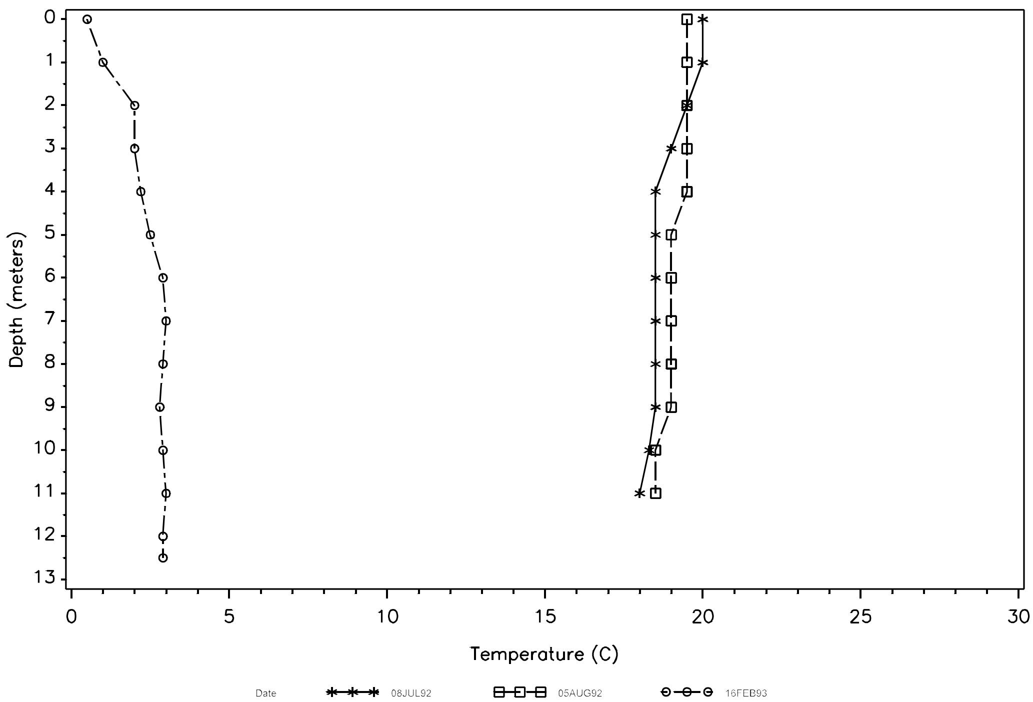


Figure 2. Temperature profile for Lake Tschida.

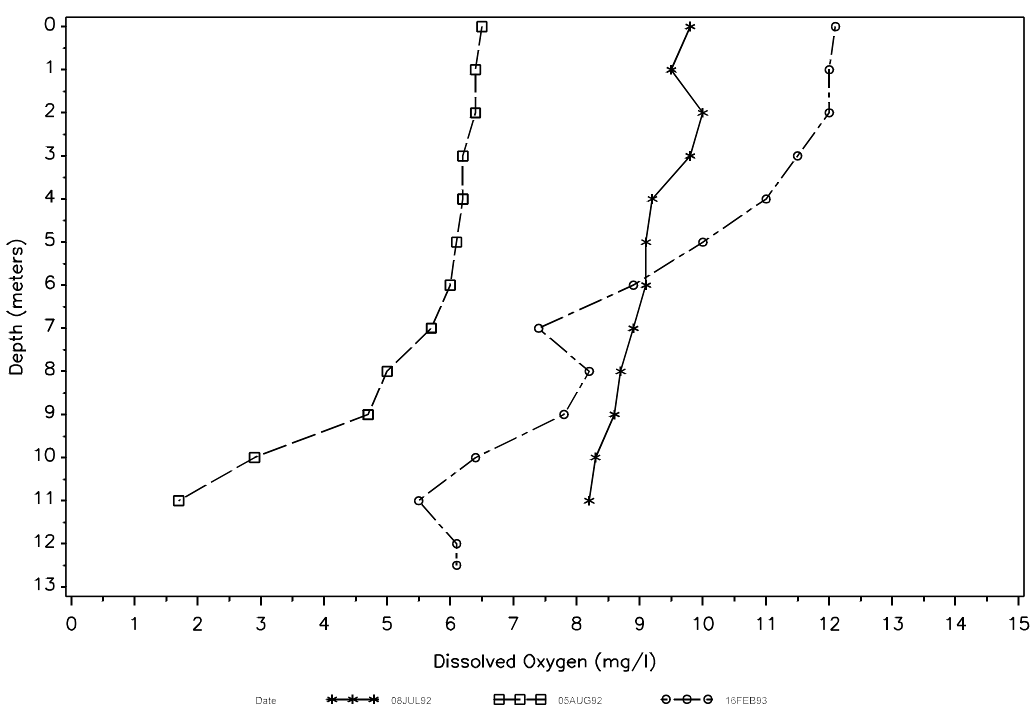


Figure 3. Oxygen profile for Lake Tschida.

Phytoplankton

Lake Tschida's phytoplankton community was sampled two times during the summer of 1992. The two samples collected contained representation from four divisions and nine genera. The largest contributors to the phytoplankton community by numerical density were the blue-green algae, Cyanophyta, with four general present. Mean numerical density of blue-green algae for the two samples collected during the summer of 1992 was 137,473 cells per milliliter, representing a dominance of 76 fold over all other divisions combined. Other divisions represented in the phytoplankton community in descending order of numerical dominance were Chlorophyta, Cryptophyta and Bacillariophyta.

The phytoplankton community by volume was also dominated by blue-green algae, Cyanophyta. Blue-green algae occupied over 99 percent of the phytoplankton community by volume, which is a 145 fold dominance over all other divisions combined. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA project indicate Lake Tschida is eutrophic. This assessment is based on primarily three indicators, secchi disk transparency depth, chlorophyll-a concentrations and summer surface total phosphate as P concentrations. Secchi disk depth transparency averaged 1.2 meters during the summer of 1992, chlorophyll-a concentrations averaged 52 $\mu g\ L^{-1}$ and summer surface total phosphate as P concentrations averaged 64 $\mu g\ L^{-1}$. Supporting ancillary information of a eutrophic assessment include frequent nuisance algal blooms and a phytoplankton community dominated by blue-green algal species.

Sediment Analysis

Sediments were collected from Lake Tschida and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of Lake Tschida (Site 380950), the littoral zone (Site 380955) and the inlet (Site 380954) (Figure 1).

Sediment samples collected from Lake Tschida contained detectable levels of all trace elements tested for with the exceptions of mercury in the deepest and littoral sediments and selenium in the inlet area sediments. Reported trace element concentrations in the sediment samples collected from Lake Tschida were compared to the reported concentrations for all lakes assessed in the LWQA project. In general, trace element concentrations were near or above the 75th percentile for all lakes sampled while below the maximum reported. The exceptions were mercury, selenium and chromium in the inlet area sediments, and chromium and selenium in the deepest area sediments which were near or below the median.

Reported concentrations of selected pesticides and PCBs were below detectable limits for all samples collected from Lake Tschida. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Lake Tschida in 1991 and 1992. White bass, channel catfish, common carp, white suckers, yellow perch and walleye have been collected and analyzed primarily for the trace element mercury with some samples having complete analysis performed on them for selected trace elements, PCBs and pesticides. These fish were not analyzed as whole fish composites, but as skin-on-fillet composites to correlate with mercury contaminate data already in existence for Lake Tschida.

Presently, Lake Tschida has a consumption advisory in effect due to mercury concentrations in the flesh of fish collected during 1991 and 1992. Of the skin-on-fillets collected from Lake Tschida, two walleye samples, a carp sample and a channel catfish sample composed of a minimum of one fish and a maximum of five have been tested for trace elements, PCBs and selected pesticides.

In general, reported trace element concentrations in the skin-on-fillet samples analyzed from Lake Tschida were near or below the 25th percentile when compared to concentrations reported for whole fish analyzed in the LWQA project. The exceptions were the selenium and mercury concentrations which were above the median and close to the 75th percentile. Comparisons of whole fish and skin-on-fillet data is questionable as certain elements concentrate in the meat of fish while others concentrate in the fatty tissues.

Detectable pesticide residues found in the skin-on-fillets collected from Lake Tschida were DDD and DDE. DDD and DDE are both breakdown derivatives of the agricultural insecticide DDT. DDT was banned in 1973 because of its harmful effect on the environment. Concentrations of DDE and DDD were found in only about half of the fillets analyzed and were near or below the median concentration all whole fish analyzed during the LWQA project. A complete listing of the contaminant results is provided in Appendix E.

Watershed

Lake Tschida and its contributing watershed has a combined surface area of 995,102 acres located on the Missouri Slope Uplands in portions of Grant, Hettinger, Morton and Stark Counties, North Dakota. The watershed is composed primarily of rolling to hilly uplands except in badlands areas and near prominent buttes. Slopes are generally gentle with reliefs ranging from a maximum of 300 feet to a minimum of 50 feet, with few exceeding 100 feet. Drainages are generally well defined in the form of intermittent and perennial streams. Few surficial aquifers exist in the Lake Tschida watershed other than along stream drainages.

Soils in the Lake Tschida watershed are moderately deep to shallow, formed from weathered, loamy glacial till or soft bedrock. In general, soils are moderately fertile to fertile, well drained and susceptible to wind and water erosion.

Average precipitation in the Lake Tschida watershed ranges from 14 to 16 inches, with between 80 and 90 percent of the annual precipitation occurring between April and September.

A small percentage of the Lake Tschida watershed is composed of badlands. Badlands are eroded formations composed of buttes and steeply eroded drainages. Soils are generally thin, formed from sandy and clayey materials. Badland areas are highly susceptible to wind and water erosion.

Land use within the Lake Tschida watershed is approximately 95 percent agricultural, with 47 percent actively cultivated. The remaining 38 percent of agricultural lands are either in pastures, haylands or concentrated feeding areas. The five percent of the watershed that is not in agricultural use is in wetland and wildlife management, roads and small urban developments (Table 2).

Table 2. Land use in the Lake Tschida watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	47.0	45-70
Rangeland	28.2	60-95
Hayland	12.8	65-97
CRP	6.4	100
Wet/Wild[1]	1.1	N/A
Other	2.9	N/A
Farmsteads	886[3]	N/A
Feedlots[2]	791[3]	42-50

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

According to the information provided by the Grant, Hettinger and Stark County Soil Conservation Districts, between 45 and 70 percent of the cultivated lands and between 60 and 90 percent of all the remaining agricultural lands within the Lake Tschida watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Lake Tschida watershed, the average "T" value is three to five tons per acre. Based on an average soil loss of just over four tons per acre, which takes into account all land uses and treatments, approximately 4,078,158 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 407,816 and 611,723 tons of soil are delivered to Lake Tschida annually.

Within the Lake Tschida watershed, there are three small rural municipalities, one point source discharge at the city of Gladstone, 886 farms and 791 concentrated livestock feeding areas. The city of Gladstone has a discharge permit with the NDSDHCL-NDPDES. Due to the regulations imposed upon this release site and the distance the discharge location is from the reservoir, it poses only a minimal threat to the water quality of Lake Tschida. However, the concentrated livestock feeding areas, construction and other activities within the watershed do pose a significant risk due to their ability to deliver a huge combined load of nutrients and sediments.

LAKE WILLIAMS

KIDDER COUNTY

Peter N. Wax

Lake Williams is located in northeastern Kidder County on the Glaciated Plains physiographic region of North Dakota. Lake Williams typifies the characteristics of a natural North Dakota glacial lake in that it is relatively small and bowl-shaped. Lake Williams has a maximum depth of 20 feet, a mean depth of 9.6 feet and a surface area of 154.6 acres (Figure 1).

Lake William's watershed of 1,075 acres is dominated by nearly level to undulating topography with slopes ranging from three to six percent. Soils are moderately well drained formed from glacial till. The watershed is predominantly integrated closed drainages typifying the characteristics of the northern prairie pothole region.

Land use within the Lake Williams watershed is primarily agricultural, with less than ten percent currently cultivated and greater than 50 percent in virgin sod. Lake Williams has a 7:1 watershed to lake size ratio, a relatively small amount of cultivated acres within it's watershed and presently is a mesotrophic waterbody.

Lake Williams is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonid fishes and marginal growth of salmoniod fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Lake Williams fishery by annually assessing the fish community through test netting operations and stock accordingly.

Historically, the fishery on Lake Williams has included stockings of rainbow trout, however, due to heavy predations by northern pike and walleye the trout fishery was slowly phased out until the present-day fishery was established. In recent years the stocking regiment has included largemouth bass, walleye and northern pike. A fish community assessment conducted by the NDG&F on July 2, 1991 captured in order of most abundant, yellow perch, walleye and northern pike. Past stockings have also included muskellunge, bluegill, crappie and tiger musky.
Lake Williams is a well buffered waterbody which generally does not thermally stratify or weakly stratifies and has never suffered a fish kill. Water clarity on the lake is generally good with few nuisance algal blooms recorded.

Public use on Lake Williams is seasonal with the majority of fishing pressure occurring during the winter months. Public facilities on Lake Williams include a recreational area, boat ramp, toilets and associated parking.

Water Quality

Water quality samples were collected from Lake Williams twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380970, Figure 1). Water column samples were collected for analysis at three discrete depths during each sample period.

During the summer of 1992 Lake Williams did not develop thermal stratification on either of the two sample occasions (Figure 2). During these time periods, dissolved oxygen concentrations were at or near saturation to within one meter of the lake's bottom and were adequate to maintain all manner of aquatic life (Figure 3). Samples collected on March 1, 1993, showed Lake Williams's water column as weakly thermally stratified between five and six meters of depth (Figure 2). Dissolved oxygen concentrations at this time were between 0.6 and 0.9 mg L^{-1} below the thermocline, and between 5.7 and 9.2 mg L^{-1} above (Figure 3).

Water quality samples collected from Lake Williams during the LWQA project describe Lake Williams as a mesotrophic waterbody that is well buffered and relatively high in mineral and total dissolved solids. The dominant anions in the water column were bicarbonates and sulfates. The concentrations of bicarbonates ranged between 290 and 470 mg L^{-1} with a volume-weighted mean of 343 mg L^{-1}, while sulfates ranged between 89 and 125 mg L^{-1} with a volume-weighted mean of 104 mg L^{-1} (Table 1). Volume-weighted mean concentrations for total dissolved solids, hardness as calcium, and conductivity were 475, 396, and 786 mg L^{-1} respectively and are lower than the state's long-term average (Table 1).

The nutrients total phosphate as P and nitrate + nitrite as N had volume-weighted mean concentrations of 0.049 and 0.022 mg L^{-1}, respectively. Total Phosphate as P concentrations ranged between 0.01 and 0.113 mg L^{-1} exceeding the state's target concentration of 0.02 mg L^{-1} in all but sample collected at the surface. Nitrate + nitrite as N concentrations ranged between nondetectable to 0.06 mg L^{-1} never exceeding the state's maximum target concentration of 0.25 mg L^{-1}. The ratios of total dissolved phosphate as P and nitrate + nitrite as N and ammonia of 1:1.5 indicate Lake Williams is nitrogen limited (Table 1).

The relatively small amount of actively and historically cultivated acres within Lake Williams watershed probable account for its better then average water quality. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 24, 1992 and March 1, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Lake Williams		1982-1991	
Total Dissolved Solids	475	mg L^{-1}	1209	mg L^{-1}
Conductivity	786	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	396	mg L^{-1}	488	mg L^{-1}
Sulfates	104	mg L^{-1}	592	mg L^{-1}
Chloride	10	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.049	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.022	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	352	mg L^{-1}	296	mg L^{-1}
Ammonia	0.051	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.09	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	343	mg L^{-1}	326	mg L^{-1}

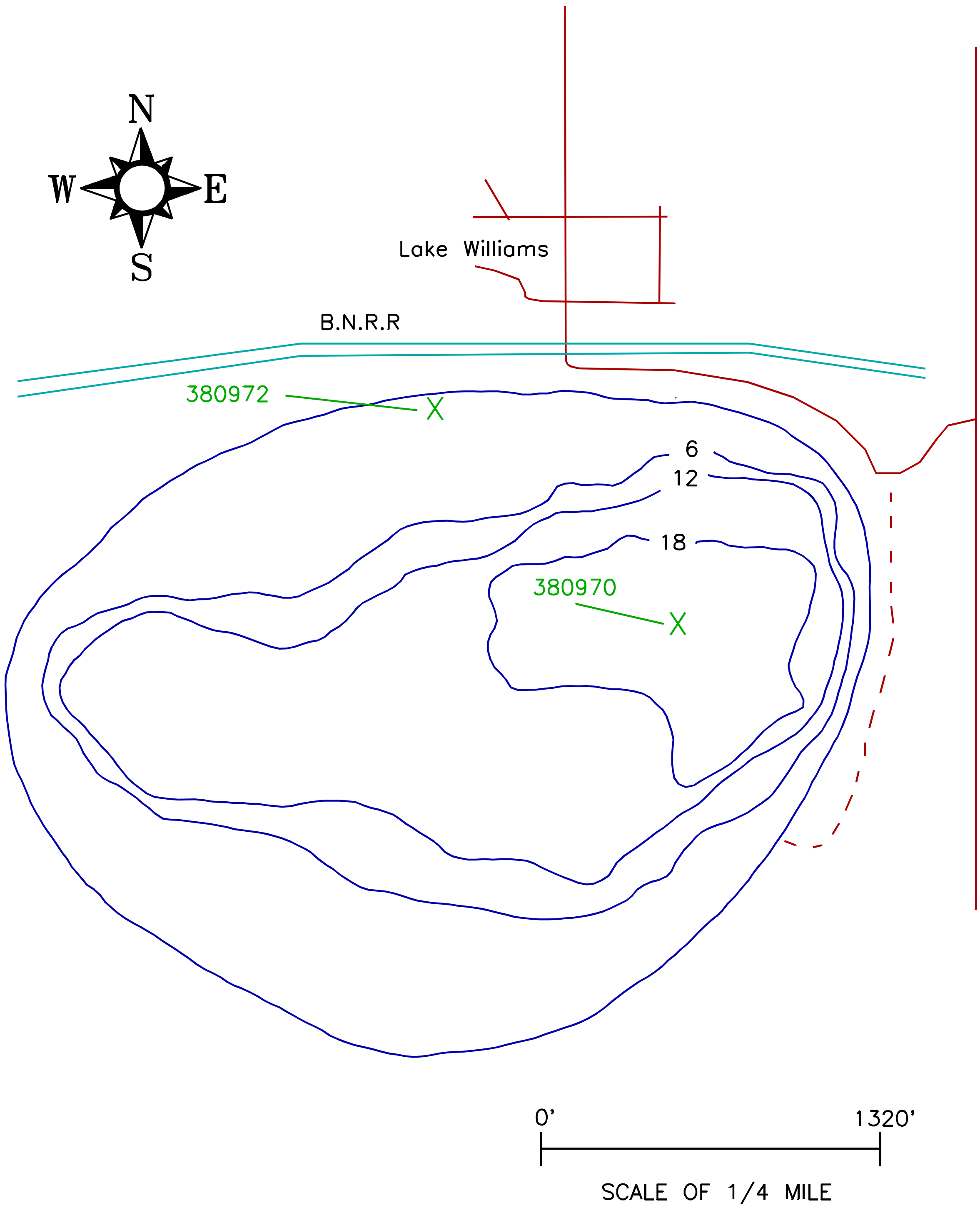


Figure 1. Morphometric map of Lake Williams.

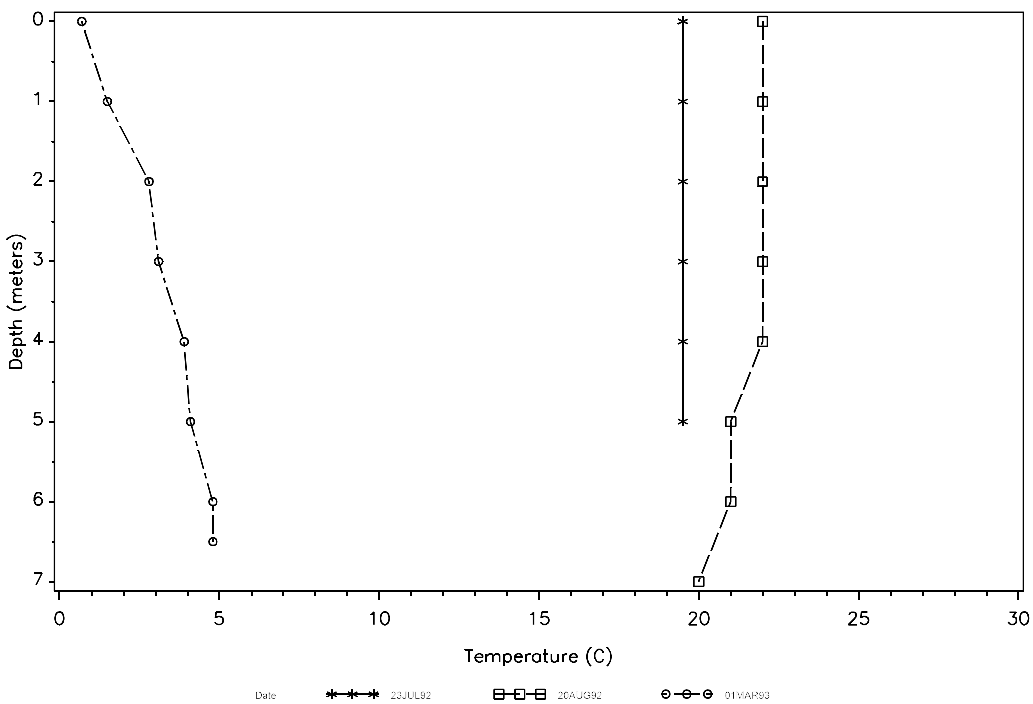


Figure 2. Temperature profile for Lake Williams.

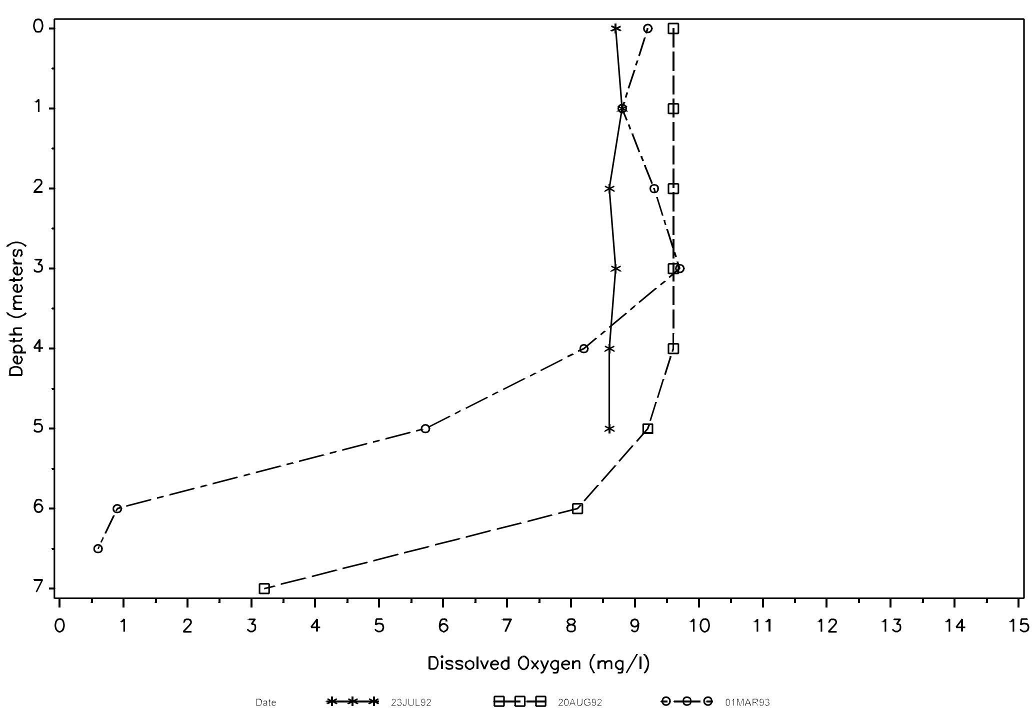


Figure 3. Oxygen profile for Lake Williams.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Lake Williams as part of the LWQA project. The survey was conducted on July 24, 1992.

At the time of the macrophyte survey approximately 20 percent of Lake Williams's surface area had aquatic vegetation. Nearly 100 percent of the lake's surface area to a depth of two to four feet had a mixed stand of sago pondweed Potomogeton pectinatus, curlyleaf pondweed Potomogeton crispus and water milfoil Myriophyllum spp. The mixed stands of sago pondweed, curlyleaf and water milfoil were in concentrations of approximately 90 percent sago pondweed and 10 percent curlyleaf pondweed and water milfoil. The western side of Lake Williams also contained a large patch of 100 percent sago pondweed which extended out to a depth of nearly seven feet. The only emergent macrophyte identified on Lake Williams was bulrush Scirpus spp. which extended to a depth of approximately two feet and was located in a intermittent ring that surrounded the entire lakeshore. A map depicting the areal extent of macrophyte coverage on Lake Williams is contained in Appendix B.

Phytoplankton

Lake Williams's phytoplankton community was sampled two times during the summer of 1992. At the time of sampling Lake Williams's phytoplankton community was represented by six divisions and 42 genera. The largest contributors to the phytoplankton community by numerical density were the blue-green algae, Cyanophyta, with 14 genera present. The blue-green algae mean numerical density for the two samples collected during the summer of 1992 was 94,798 cell mL^{-1} representing a dominance of nearly eight fold over all other orders combined. Other divisions represented in descending order of dominance were Cryptophyta, Chlorophyta, Pyrrophyta, Bacillariophyta and Chrysophyta.

At the time of the assessment mean phytoplankton concentrations by volume were much more evenly distributed with the division Pyrrophyta occupying the largest volume followed by the divisions Cryptophyta, Chlorophyta, Cyanophyta, Bacillariophyta and Chrysophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Lake Williams is presently mesotrophic. Principle water quality indicators used in defining the trophic condition on Lake Williams were secchi disk depth transparency, chlorophyll-a concentrations and summer surface total phosphate as P concentrations. Secchi disk depth transparencies ranged between 1.7 and 2.2 meters, chlorophyll-a concentrations ranged between 4 and 8 $\mu g\ L^{-1}$ and summer surface total phosphate as P concentrations ranged between 19 and 65 $\mu g\ L^{-1}$. These principle indicators all agreed quite well, defining Lake Williams as mesotrophic. Supporting ancillary information of a mesotrophic lake condition are infrequent nuisance algal blooms, good dissolved oxygen concentrations throughout the year, low macrophyte biomass and no history of fish kills.

Sediment Analysis

Sediments were collected from Lake Williams and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area the lake (Site 380970) and the littoral zone (Site 380972) (Figure 1).

Sediment samples collected from Lake Williams show detectable levels of all trace elements tested for with the exception of selenium and mercury. Reported trace element concentrations in the sediment samples collected from Lake Williams were compared to the concentrations reported for all lakes assessed in the LWQA project.

In general, reported trace element concentrations in the sediments collected from Lake Williams were near or below the 25th percentile for all sediments collected during the LWQA project. The only exceptions were the reported barium and arsenic concentrations which were above the median and above the 75th percentile, respectively.

Concentrations of selected organic compounds and PCBs were below detectable limits for all sediment samples collected from Lake Williams. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Lake Williams on June 23, 1992. Walleyes and black bullheads were collected representing the piscivore and bottom feeder groups. The walleye sample was composed of two fish with a mean length of 46.5 centimeters and a mean weight of 1,038 grams. The black bullhead sample was composed of five fish with a mean length of 28.2 centimeters and a mean weight of 368 grams.

In order to evaluate the fish tissue data for Lake Williams the results for each fish group was compared to that group for all lakes assessed in the LWQA project. Both whole fish samples collected from Lake Williams had detectable levels of all trace elements tested for with the exception of copper, arsenic and cadmium. In general, reported trace element concentrations in the black bullhead and walleye samples collected from Lake Williams had concentrations that were near or below the median for all bottom feeders and piscivores sampled during the LWQA project. The exceptions were the barium concentration in the black bullhead sample and the chromium and cadmium concentrations in the walleye samples which either equaled or exceeded the 75th percentile.

Detectable pesticide residues found in the black bullhead sample collected from Lake Williams included DDE. Detectable pesticide residues found in the walleye sample collected from Lake Williams included DDT, DDE, DDD, dieldrin and trifluralin. DDD and DDE are both degradation byproducts of the insecticide DDT and can behave similarly to the parent compound when exposed to the environment. DDT is an agricultural insecticide which was removed from use in 1973 due to the environmental degradation associated with its use. Dieldrin, like DDT, is an agricultural insecticide

which was removed from use at approximately the same time as DDT and for similar environmental concerns. Trifluralin is a selective preemergent herbicide, commonly known as treflan.
The black bullhead sample collected from Lake Williams contained a reported concentration of DDE of 0.002 $\mu g\ g^{-1}$, which is below the 25th percentile for all bottom feeders analyzed during the LWQA project. The walleye sample collected from Lake williams contained concentrations of DDT, DDE, DDD, dieldrin and trifluralin of 0.004, 0.029, 0.009, 0.002 and 0.004 $\mu g\ g^{-1}$, respectively. These concentrations are either equal to or above the 75th percentile for all piscivores sampled during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Lake Williams with its contributing watershed has a combined surface area of 1,075 acres located on the Glaciated Plains physiographic region in Kidder County, North Dakota. The watershed is characterized by rolling to hilly glaciated plains with many small potholes and integrated drainages. The irregular patterns of hills and valleys caused by glacial thrusting and sedimentation overlie a relatively deep deposit of glacial till.

Soils in Lake Williams watershed are generally formed from medium to coarse textured sandy or clayey, loamy, glacial till. Soils are predominantly moderately erodible and moderately to well drained. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to Lake Williams.

Land use within the Lake Williams watershed is 63 percent agricultural with 10.5 percent actively cultivated, 13 percent in livestock production, 20.8 percent in haylands and 18.6 percent in Conservation Reserve Program (CRP). The remaining 37 percent of the watershed is in woodlands, wetlands, wildlife management, towns and transportation routes. There is only one farmstead within the watershed and no concentrated livestock feeding areas (Table 2).

Table 2. Land use in the Lake Williams watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	10.5	80
Rangeland	13.0	60
Hayland	20.8	75
CRP	18.6	100
Wet/Wild[1]	0.5	N/A
Other	16.6	N/A
Farmsteads	1	N/A
Feedlots[2]	0	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

According to the information provided by the Kidder County Soil Conservation District 80 percent of the cultivated lands and between 60 and 100 percent of the remaining agricultural lands within the Lake Williams watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Lake Williams watershed, the average "T" value is three to five tons per acre. Based on an estimated average soil loss of approximately 0.85 tons per acre, which takes into account all land practices and treatments currently employed within the watershed, approximately 919 tons of soil are lost from within the watershed annually. Assuming a conservative delivery rate of 10 to 15 percent, between 92 and 138 tons of soil are delivered to Lake Williams annually. Other sources of nonpoint source pollution discharges to Lake Williams are from cattle feeding and watering in it and the immediate watershed, the town of Lake Williams and any construction or development activities along its shores.

LARIMORE DAM

GRAND FORKS COUNTY

Peter N. Wax

Larimore Dam is a multi-purpose structure located on the Upper Turtle River watershed in Grand Forks County, North Dakota. It is one of seven flood water control structures along the Upper Turtle River watershed. Larimore Dam was built to provide flood protection, and support a sport fishery and water-based recreation. Larimore Dam has a surface area of 155.6 acres, a maximum of depth of 35 feet and a mean depth of 12 feet (Figure 1).

Larimore Dam's watershed lies on the western edge of the Red River Valley physiographic region in northeastern North Dakota extending westward onto the Lake Agassiz beach. This area of North Dakota is one of the most fertile agricultural areas in the United States.

Topography of Larimore Dam's watershed is level with very gradual changes in relief. Soils of the watershed are generally deep, highly fertile with slopes rarely exceeding 2 percent. Soils are moderately erodible with good moisture retention. Annual rainfall in the Larimore Dam drainage is between 19 and 21 inches annually. Land use within the watershed approaches 99 percent in small grain and row crop production.

Larimore Dam is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Larimore Dam by annually assessing the fish community by test netting and stock accordingly.

Initial fisheries management on Larimore Dam began in 1979 immediately following the dam completion in 1978 with stockings of rainbow trout followed by walleyes in 1981 and bluegills in 1982. Over the last five years the NDG&F have stocked Larimore Dam with walleye, rainbow trout and brown trout. In all, the NDG&F Department manages Larimore Dam as a walleye, trout and bluegill fishery. Recently, no additional plants have been needed to support the bluegill population as it has been stable through natural reproduction. Test netting operations conducted on June 26, 1990 by the NDG&F captured in order of most abundant bluegills, black bullheads, white suckers and walleye.

Public use facilities on Larimore Dam include toilets, picnic areas with shelters, swim beach, camping and boat ramp. Supported recreational activities at Larimore Dam include boating, swimming, camping, nature hiking, ice skating and picnicking. The excellent facilities on Larimore Dam are maintained by the Larimore Park Board. Public use on Larimore Dam at times is very heavy with many users from Grand Forks and Grand Forks Air Force Base as well as the surrounding community.

Water Quality

Water quality samples were collected from Larimore Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380250, Figure 1). Water

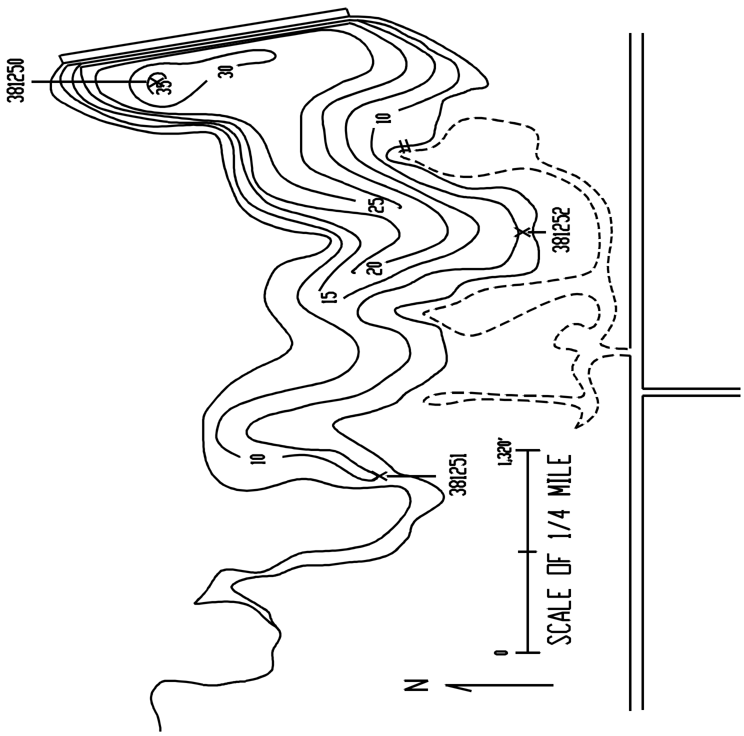


Figure 1. Morphometric map of Larimore Dam.

column samples were collected for analysis at three discreet depths of 1 meter, 5 meters and 9 meters during July and August 1992 and 1 meter, 4 meters and 8 meters in March 1993.

On the July sampling date Larimore Dam was thermally stratified between 4 and 5 meters of depth and between 5 and 6 meters on the August date (Figure 2). During these time periods dissolved oxygen concentrations were at or near saturation to the depth of thermal stratification with rapid oxygen depletion below (Figure 3). Samples collected in March of 1993 showed Larimore Dam's water column as not thermally stratified with dissolved oxygen concentrations ranging between 1.8 mg L^{-1} near the bottom to 7.8 mg L^{-1} one meter below the surface (Figure 2, Figure 3).

Concentrations of total dissolved solids, hardness as calcium and conductivity during the LWQA project on Larimore Dam were lower than North Dakota's long-term average with volume-weighted mean concentrations of 437, 329 and 697 mg L^{-1} respectively (Table 1). Water quality analysis also showed Larimore Dam as a well buffered waterbody with total alkalinity as $CaCO_3$ concentrations ranging between 151 and 318 mg L^{-1} with a volume-weighted mean of 239 mg L^{-1} (Table 1).

Bicarbonates and sulfates were the dominant anions in the water column. Volume-weighted means for bicarbonates and sulfates were 266 and 125 mg L^{-1} respectively (Table 1).

Volume-weighted mean concentrations for total phosphate as P and nitrate + nitrite as N were 0.091 and 0.070 mg L^{-1} respectively (Table 1). The ratios of these two nutrients suggest that Larimore Dam is nitrogen limited which favors nitrogen fixing organisms such as certain blue-green algae species. A complete list of LWQA water quality sample data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 22, 1992 and March 11, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Larimore Dam		1982-1991	
Total Dissolved Solids	431	mg L^{-1}	1209	mg L^{-1}
Conductivity	697	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	329	mg L^{-1}	488	mg L^{-1}
Sulfates	125	mg L^{-1}	592	mg L^{-1}
Chloride	26	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.091	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.070	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	239	mg L^{-1}	296	mg L^{-1}
Ammonia	0.209	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	0.868	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	266	mg L^{-1}	326	mg L^{-1}

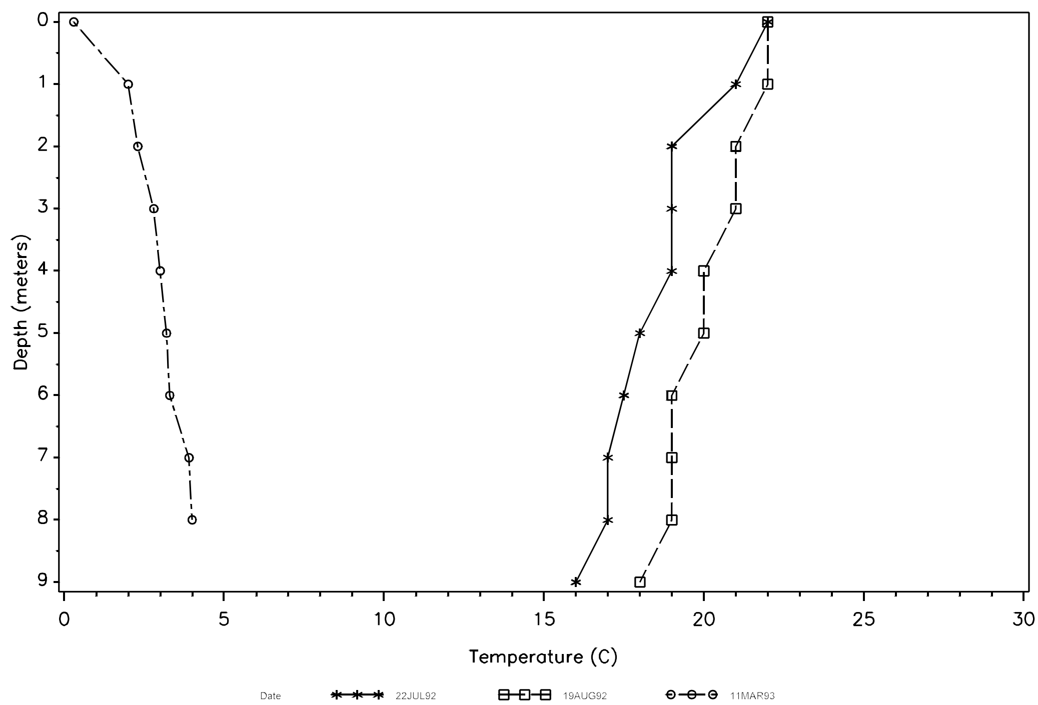


Figure 2. Temperature profile for Larimore Dam.

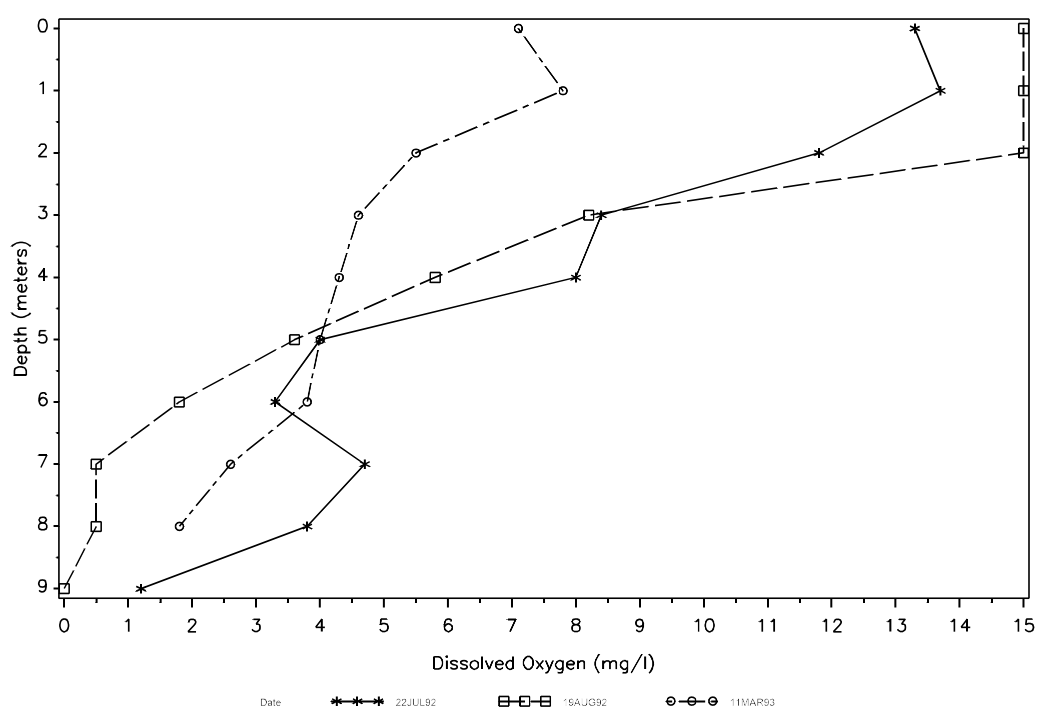


Figure 3. Oxygen profile for Larimore Dam.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Larimore Dam as part of the LWQA project. The survey was conducted on July 22, 1992. At the time of the macrophyte survey approximately 20 percent of Larimore Dam's surface area had aquatic vegetation. Nearly 100 percent of the lake's surface area to a depth of 3 feet had mixed stands of sago pondweed Potamogeton pectinatus and coontail Ceratophyllum demersum. Also lining approximately 10 percent of the shore in scattered patches and nearly solid throughout the inlet area were cattails Typha spp. and small patches of American pondweed Potamogeton americanus in the inlet area. The mix stands throughout the main body of Larimore Dam of sago pondweed and coontail were in a ratio of approximately 90 percent sago pondweed and 10 percent coontail. A map depicting the areal extent of macrophyte coverage on Larimore Dam is contained in Appendix B.

Phytoplankton

Larimore Dam's phytoplankton community was sampled two times during the summer of 1992. Larimore Dam's phytoplankton community was represented by 4 divisions and 8 genera. The largest contributors to the phytoplankton community by density were the blue-green algae, Cyanophyta, with 2 genera present. Blue-green algae mean densities for the two samples collected during the summer of 1992 was 170,813 cell mL^{-1} representing a dominance of 11 fold over all other divisions present. Other divisions represented in order of decreasing dominance by density were Chlorophyta, Bacillariophyta and Cryptophyta.

The division Bacillariophyta occupied the largest volume of the phytoplankton community during the summer of 1992 followed by Cyanophyta, Cryptophyta and Chlorophyta. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Water quality assessment data collected during the LWQA project defined Larimore Dam as eutrophic. Primary water quality indicators used to make this assessment were secchi disk depth transparency average of 1.45 meters, chlorophyll-a concentrations of 12 and 39 $\mu g\ L^{-1}$ and summer surface total phosphate as P concentrations of 46 and 64 $\mu g\ L^{-1}$. These indicators define Larimore Dam as eutrophic. Supporting ancillary information of a eutrophic assessment is rapid depletion of dissolved oxygen concentrations below the hypolimnion, a relatively large macrophyte biomass and relatively frequent nuisance algae blooms.

Sediment Analysis

Sediments were collected from Larimore Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381250), the littoral zone (Site 381252) and the inlet (Site 381251) (Figure 1).

The sediment samples collected from Larimore Dam showed detectable levels of all trace elements tested for except mercury and selenium in the deepest and littoral area sediments. Reported concentrations of trace elements in the sediments collected from Larimore Dam were compared to the reported concentrations for all lake sediments collected during the LWQA project. In general, trace element concentrations were near or slightly below the median concentrations for all lakes sampled during the LWQA project. The exceptions were the arsenic and cadmium concentrations which were near or above the 75th percentile.

Concentrations of pesticides and PCBs were below detectable limits for all sediment samples collected from Larimore Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Larimore Dam on June 17, 1992. White suckers were the only species collected representing the bottom feeder group. The white sucker sample collected from Larimore Dam was composed of 5 fish with a mean weight of 1,510 grams and a mean length of 50 centimeters.

In order to evaluate the fish tissue data for Larimore Dam the results for the bottom feeder sample was compared to that group for all lakes assessed in LWQA project. Trace element concentrations in the fish sample collected from Larimore Dam were generally near or significantly lower than the median concentrations for all bottom feeders analyzed during the LWQA project. The exception was the reported selenium concentration of 0.49 $\mu g\ g^{-1}$ which was above the 75th percentile.

Detectable pesticide residues in the white sucker sample collected from Larimore Dam included DDE and DDD. DDE and DDD are both degradation by-products of the insecticide DDT and can produce biological effects similar to the parent compound when available to the environment.

DDD and DDE concentrations reported in the white sucker sample collected from Larimore Dam were equal to or above the 75th percentile at 0.006 and 0.017 $\mu g\ g^{-1}$. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Larimore Dam with its contributing watershed has a combined surface area of 41,344 acres located on the Red River Valley in Grand Forks County, North Dakota. The Red River Valley is extremely level with gradual changes in topography. Soils within Larimore Dam's watershed are primarily deep, highly fertile with slopes rarely exceeding 2 percent. Generally, soils are moderately erodible with good moisture retention capabilities. Annual rainfall within the Larimore Dam watershed is between 19 and 21 inches annually. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loadings and pollution discharges to Larimore Dam.

Land use within the Larimore Dam watershed is nearly 92 percent agricultural with 83 percent actively cultivated. The remaining 17 percent is in low density urban development, haylands, pasture, Conservation Reserve Program (CRP), wetland and wildlife management (Table 2).

According to the information provided by the Grand Forks County Soil Conservation District, 60 percent of the cultivated lands and approximately 60 percent of all remaining agricultural lands within the Larimore Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Larimore Dam watershed the average "T" value is 3 to 5 tons per acre. Based on an average soil loss of approximately 5 tons per acre, which takes into account all land treatments and practices presently employed within the watershed, approximately 212,935 tons of soil is lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 21,293 and 31,940 tons of soil are delivered to Larimore Dam annually.

Other sources of nonpoint source pollution discharges to Larimore Dam are from concentrated livestock feeding areas, cattle feeding and watering in the immediate upstream drainage, construction activities within the watershed and urban development near its shores. These sources have the capability to contribute a large portion of the annual nutrient and sediment load to Larimore Dam and cause significant degradation due to their close proximities to the immediate drainage and lakeshore.

Table 2. Land use in the Larimore Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	83	60
Rangeland	1.5	60
Hayland	1.9	60
CRP	4.9	100
Wet/Wild[1]	2.7	N/A
Other	5.3	N/A
Farmsteads	59[3]	N/A
Feedlots[2]	10[3]	50

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

MCVILLE DAM

NELSON COUNTY

Peter N. Wax

McVille Dam is a small reservoir located on McVille Coulee, a small drainage to the Sheyenne River in Nelson County, North Dakota. The reservoir was constructed through the cooperative efforts of the State Water Commission, the Nelson County Park Board and the North Dakota Game and Fish Department (NDG&F). The reservoir created has a surface area of 33.4 acres, a maximum depth of 20 feet and a mean depth of 11.8 feet (Figure 1).

McVille Dam and contributing watershed lie on the Glaciated Plains physiographic region in northeastern North Dakota. The watershed is characterized by rolling to hilly glaciated plains with many small potholes and integrated drainages. The regular pattern of hills and valley caused by glacial thrusting and sedimentation overlie a relatively deep deposit of glacial till. The Sheyenne River, which McVille Coulee drains to, is one of the three main river drainages within this region of North Dakota.

McVille Dam is classified as a cold water fishery, "Waters capable of supporting growth of salmonid fishes and associated biota" (NDSDHCL, 1991). McVille Dam is managed by the NDG&F by annually assessing the fish community through test netting and stock accordingly.

The initial fishery on McVille Dam created by the NDG&F in 1962 was rainbow trout. The reservoir opened to fishing in 1963 with excellent results until 1969 when a complete winter kill occurred. The lake was again restocked in 1971 with rainbow trout with annual maintenance stockings made until 1978 when again a severe winter kill occurred. Yellow perch were introduced some time between 1970 and 1976 and quickly become a management problem necessitating eradication of the lake in October of 1979. In 1981 rainbow trout were once again introduced and the lake closed to angling until 1982. In 1983 bluegill were stocked into the lake followed by smallmouth bass in 1984 and 1985.

Presently, the stocking regiment includes walleye, northern pike, largemouth bass and rainbow trout. Test netting operations conducted in 1990 captured in order of most abundant yellow perch, bluegill, northern pike and walleye. McVille Dam is located within the city limits of McVille. Public facilities on McVille Dam include a concrete boat ramp, swimming area, picnic area, toilets and camping. Public use on McVille Dam is heavy to moderate during all four seasons of the year.

Water Quality

Water quality samples were collected from McVille Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 381075, Figure 1). Water column samples were collected for analysis at three separate depths of one meter, between three and four meters and six meters.

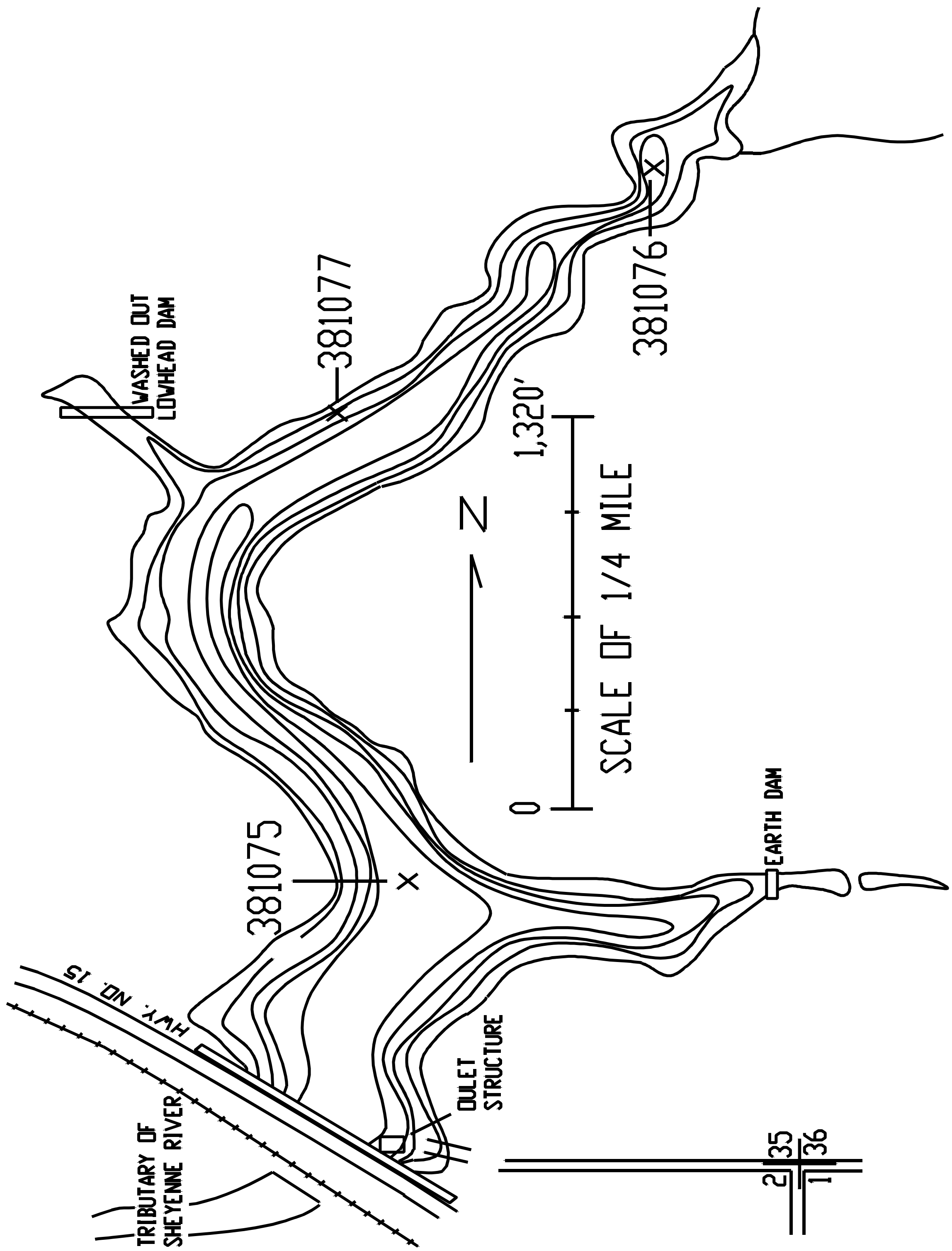


Figure 1. Morphometric map of McVille Dam.

McVille Dam developed thermal stratification between two and three meters of depth on July 22, however no thermally stratification was present on August 19 (Figure 2). Dissolved oxygen concentrations on July 22, 1992 were near saturation to the depth of stratification and between 1.2 to 0.8 mg L^{-1} below (Figure 3). On August 19, 1992, dissolved oxygen concentrations were between 3.2 mg L^{-1} at the surface falling to 0.4 mg L^{-1} near the bottom (Figure 3). Water quality samples collected during the winter of 1993 on February 10 again showed McVille Dam's water column as not thermally stratified with dissolved oxygen concentrations ranging between 0.2 mg L^{-1} near the bottom to 4.0 mg L^{-1} at the surface (Figure 2, Figure 3).

Concentrations of total dissolved solids, hardness as calcium and conductivity were lower than the long-term average for all North Dakota lakes sampled between January 1, 1982 and December 31, 1991 with volume-weighted means of 650, 391, and 1,007 mg L^{-1} respectively (Table 1). Water quality samples collected during the LWQA project indicated McVille Dam is a well-buffered water body, with total alkalinity as $CaCO_3$ concentrations ranging between 238 and 325 mg L^{-1} and having a volume-weighted mean of 272 mg L^{-1} (Table 1). Dominant anions in the water column were sulfates and bicarbonates with volume-weighted means of 265 and 318 mg L^{-1} respectively (Table 1).

Volume-weighted mean concentrations of the primary nutrients total phosphate as P and nitrate + nitrite as N concentrations were 0.198 mg L^{-1} and 0.032 mg L^{-1} respectively. The total phosphate as P concentrations while below the North Dakota long-term average did exceed the state's target concentrations of 0.020 on all occasions sampled, while nitrate + nitrite as N concentrations exceeded the state's target concentration of 0.25 mg L^{-1} on approximately half of the samples collected. The ratios between total phosphate as P and nitrate + nitrite as N of 6.2:1 suggest McVille Dam is nitrogen limited. Under these conditions, organisms which can affix free nitrogen such as some species of blue-green algae are favored. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between August 18, 1992 and February 10, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	McVille Dam		1982-1991	
Total Dissolved Solids	650	mg L^{-1}	1209	mg L^{-1}
Conductivity	1007	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	391	mg L^{-1}	488	mg L^{-1}
Sulfates	265	mg L^{-1}	592	mg L^{-1}
Chloride	17	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.198	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.032	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	272	mg L^{-1}	296	mg L^{-1}
Ammonia	0.274	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.49	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	318	mg L^{-1}	326	mg L^{-1}

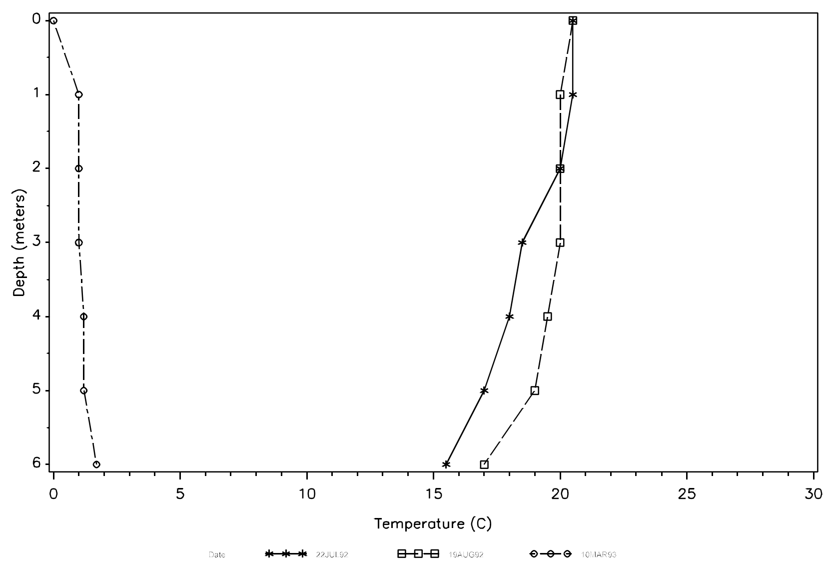


Figure 2. Temperature profile for McVille Dam.

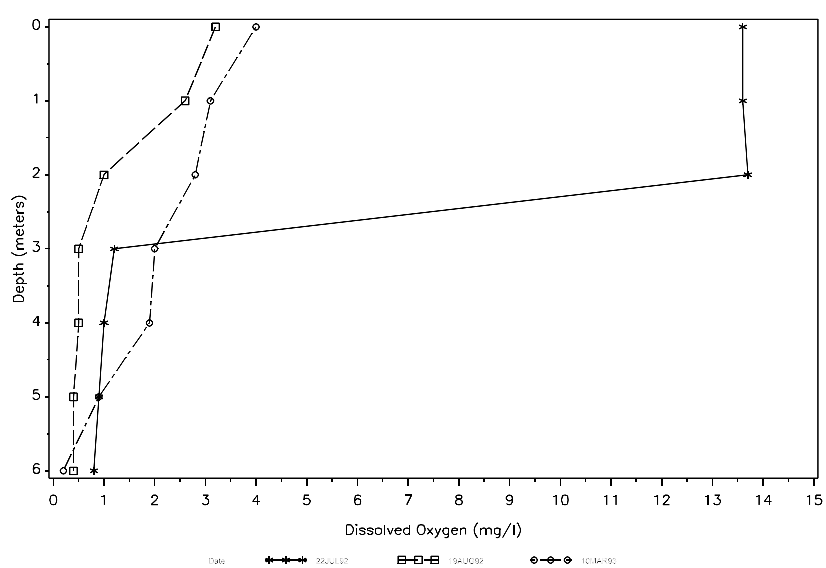


Figure 3. Oxygen profile for McVille Dam.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on McVille Dam as part of the LWQA project. The survey was conducted on July 22, 1992.

At the time of the macrophyte survey approximately 20 percent of McVille Dam's surface area had aquatic vegetation. The dominant submergent macrophyte species present during the LWQA project was sago pondweed, Potamogeton pectinatus. Sago pondweed occupied nearly 100 percent of the lake surface area to a depth of 5 feet. Cattails, Typha spp. were the dominant emergent macrophyte occupying approximately 80 percent of the shoreline. Other macrophytes identified were water milfoil Myriophyllum spp., arrowhead Sagittaria spp. and duckweed Lemna minor. A map depicting the areal extent of macrophyte coverage on McVille Dam is contained in Appendix B.

Phytoplankton

McVille Dam's phytoplankton community was sampled two times during the summer of 1992. At the time of assessment McVille Dam's phytoplankton community was diverse with representation from seven divisions and 26 genera. The largest contributors by numerical density to the phytoplankton community were by the blue-green algae, Cyanophyta, with nine genera present. Mean density of the two samples for blue-green algae collected during the summer of 1992 was 29,403 cell mL^{-1} representing a numerical dominance of more than three fold over all other divisions combined. Other divisions represented in descending order of numerical dominance were Chlorophyta, Cryptophyta, Bacillariophyta, Pyrrophyta, Chrystophyta and Euglenophyta.

At the time of the assessment mean phytoplankton concentrations by volume were dominated by the division, Pyrrophyta, with two genera represented and a mean volume of 13,000,000 $\mu m^3 \ mL^{-1}$. This domination of the phytoplankton community by volume is due to the large size of the species Glenodinium gymnodinium. A complete listing of the phytoplankton data collected during the LWQA project is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA from McVille Dam combined with ancillary data indicate McVille Dam presently is hypereutrophic. This assessment is based primarily on the three water quality indicators summer surface total phosphate as P concentrations, chlorophyll-a concentrations and secchi disk depth transparency. Total phosphate as P concentrations ranged between 181 and 291 $\mu g \ L^{-1}$, chlorophyll-a concentrations ranged between 11 and 17 $\mu g \ L^{-1}$ and secchi disk depth transparency averaged 1.25 meters. Supporting ancillary information of a hypereutrophic lake condition are frequent nuisance algal blooms, large macrophyte biomass, rapid dissolved oxygen depletion below the hypolimnion and a history of fish kills.

Sediment Analysis

Sediments were collected from McVille Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381075), the inlet area (Site 381076) and the littoral area (Site 381007) (Figure 1).

Sediment samples collected from McVille Dam contain detectable levels of all trace elements tested for except mercury. Reported concentrations of trace elements in the sediments collected from McVille Dam were compared to the concentrations reported for all lakes assessed in the LWQA project.

In general, reported trace element concentrations in the inlet and deepest areas of McVille Dam were very similar, with most parameters being near or below the 25th percentile for all sediment samples assessed during the LWQA project. The exceptions were the reported chromium concentration which was near the median and selenium which was above the 75th percentile. Reported concentrations of trace elements in littoral area sediments again were near or below the median concentrations for all littoral sediment samples analyzed during the LWQA with the exceptions of barium and chromium which were near and above the 75th percentile respectively.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from McVille Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from McVille Dam on June 22, 1992. Bluegill and northern pike were collected for contaminant analysis representing the insectivore and piscivore groups respectively. The bluegill sample was composed of five fish with a mean length of 22 centimeters and a mean weigh of 334 grams. The northern pike sample was composed of a single fish with a length of 75 centimeters and a weight of 2,950 grams.

The bluegill sample collected from McVille Dam contained detectable levels of all trace elements tested for except for copper, arsenic, cadmium and mercury. In general, reported trace element concentrations of those above the detection limit were near or below the median with the exceptions of selenium and chromium which were near or above the 75th percentile. Of note, is the chromium concentrations reported in the bluegill sample collected from McVille Dam which was the highest reported for any insectivores during the LWQA project.

The northern pike collected from McVille Dam contained detectable levels of all trace elements analyzed for with the exception of cadmium, lead and arsenic. Of the elements in concentrations great enough to be detectable, most were between the median and 25th percentile. The only exception was the zinc concentration which was above the 75th percentile. None of the reported trace element concentrations in the fish samples collected from McVille Dam during the LWQA project would warrant a fish flesh consumption advisory.

Detectable pesticide residues in the bluegill sample collected from McVille Dam included DDE and DDD. The northern pike collected from McVille Dam contained detectable pesticide residues of DDT, DDE, DDD, dieldrin, nonachlor and trifluralin. DDD and DDE are degenerate byproducts of the insecticides DDT.

DDT was removed from use in the early 1970s due to its negative effect upon the environmental. Nonachlor is a principal ingredient in technical chlordane, an agricultural insecticide. Dieldrin, like chlordane and DDT, is an agricultural insecticide which was removed from agricultural use at approximately the same time as DDT and for similar reasons. Trifluralin, commonly known as Treflan, is an agricultural selective preemergency herbicide.

The bluegill sample contained reported concentrations of DDD and DDE of 0.006 and 0.013 $\mu g\ g^{-1}$. When compared to all insectivore data collected during the LWQA project these concentrations are above the 75th percentile. The northern pike sampled collected from McVille Dam contained DDT, DDE, DDD, dialdrin, nonachlor and trifluralin in concentrations of 0.003, 0.076, 0.034, 0.002, 0.01 and 0.006 $\mu g\ g^{-1}$. When comparing all piscivore data collected during the LWQA project these concentrations are equal to or above the 75th percentile for all piscivores analyzed. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

McVille Dam with its contributing watershed has a combined surface area of 11,500 acres located on the Glaciated Plains physiographic region in Nelson County, North Dakota. Topography of the watershed is rolling to hilly with maximum shifts in elevation of approximately 150 feet. Soils in the watershed are formed from medium to coarse textured sandy or clayey loamy till. Soils are predominantly erodible and well drained. Annual precipitation is between 15 and 20 inches with considerable variation between years. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loadings and pollution discharges to McVille Dam.

Land use within the McVille Dam watershed is 95.9 percent agricultural with 77.6 percent actively cultivated and the remaining 4 percent in low density urban development and transportation (Table 2). According to the information provided by the Nelson County Soil Conservation District 70 percent of the cultivated lands and nearly 100 percent of all the remaining lands within the McVille Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the McVille Dam watershed the average "T" value is three to five tons per acre. Based on an average soil loss of 4.3 tons per acre, which takes into account current land treatments and practices approximately 49,060 tons of soil are lost from the watershed annually. Assuming a conservative delivery rate of 10 to 15 percent, between 4,906 and 7,359 tons of soil are delivered to McVille Dam annually.

Other sources of nonpoint source pollution affecting McVille Dam other than erosion from agricultural fields are from cattle feeding and watering in the immediate drainage, low density urban development and the community of McVille. These sources have the capabilities to contribute a significant percentage of McVille Dam's annual nutrient and sediment load due to their close proximities to the water.

Table 2. Land use in the McVille Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	77.6	70
Rangeland	1.7	100
Hayland	4.6	100
CRP	10.6	100
Wet/Wild[1]	3.3	N/A
Other	1.5	N/A
Farmsteads	11[3]	N/A
Feedlots[2]	0[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

MIRROR LAKE
ADAMS COUNTY
Peter N. Wax

Mirror Lake was built in 1907 to provide steam locomotive water for the Chicago, Milwaukee, St. Paul and Pacific Railroad Company. At the time, Hettinger was little more than a whistle stop but growing rapidly with its residents quickly adopting Mirror Lake as a haven for recreation. The breaking of the prairie sod in the 1920s and the severe droughts in the 1930s contributed sediment and nutrients to the shallow lake. The return to normal precipitation in the early 1940s encouraged recreation once more and by 1946 a city park was developed on the lake's north shore.

By the late 1950s frequent winter kills reduced the game fish population. Subsequently, black bullheads achieved a competitive advantage and dominated the lake. In 1980 the city of Hettinger with the NDSDHCL entered into a cooperative agreement with the EPA for a phase 1 diagnostic and feasibility study to determine corrective measures. A study of the lake was begun that same year with the alternative of breaching the dam and physically removing bottom sediments appearing to be the most feasible restoration project.

Excavation started in October of 1983 and upon its completion changed Mirror Lake from a lake with a surface area of 63 acres, a maximum depth of 9 feet and a mean depth of 4.5 feet, to a lake of 63.3 acres, with a maximum depth of 18 feet and a mean depth of 8 feet (Figure 1).

Mirror Lake is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated biota" (NDSDHCL, 1991). The NDG&F manage Mirror Lake by annually assessing the fish community through test nettings and stock accordingly.

From 1988 through 1991 the NDG&F stocking regiment has included rainbow trout and walleye. Fish community assessments conducted by the NDG&F on July 19, 1991 captured in order of most abundant black bullhead, bluegill, white sucker, rainbow trout, walleye, northern pike, largemouth bass, black crappie, yellow perch, green sunfish and channel catfish. As is evident from the capture records Mirror Lake is a diverse sport fishery.

Presently, nearly 100 percent of Mirror Lake's shoreline is publicly owned. Public facilities include a boat ramp and associated parking, picnic and fishing areas around the shore, walking trails and a city park with toilets, swim beach and playground. Public use on Mirror Lake is heavy even though large growths of macrophytes in the littoral zone make shore fishing difficult at times. One of the reasons Mirror Lake remains popular with the area residents is due to the abundant panfish, largemouth bass and trout.

Water Quality

Water quality samples were collected from Mirror Lake twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample

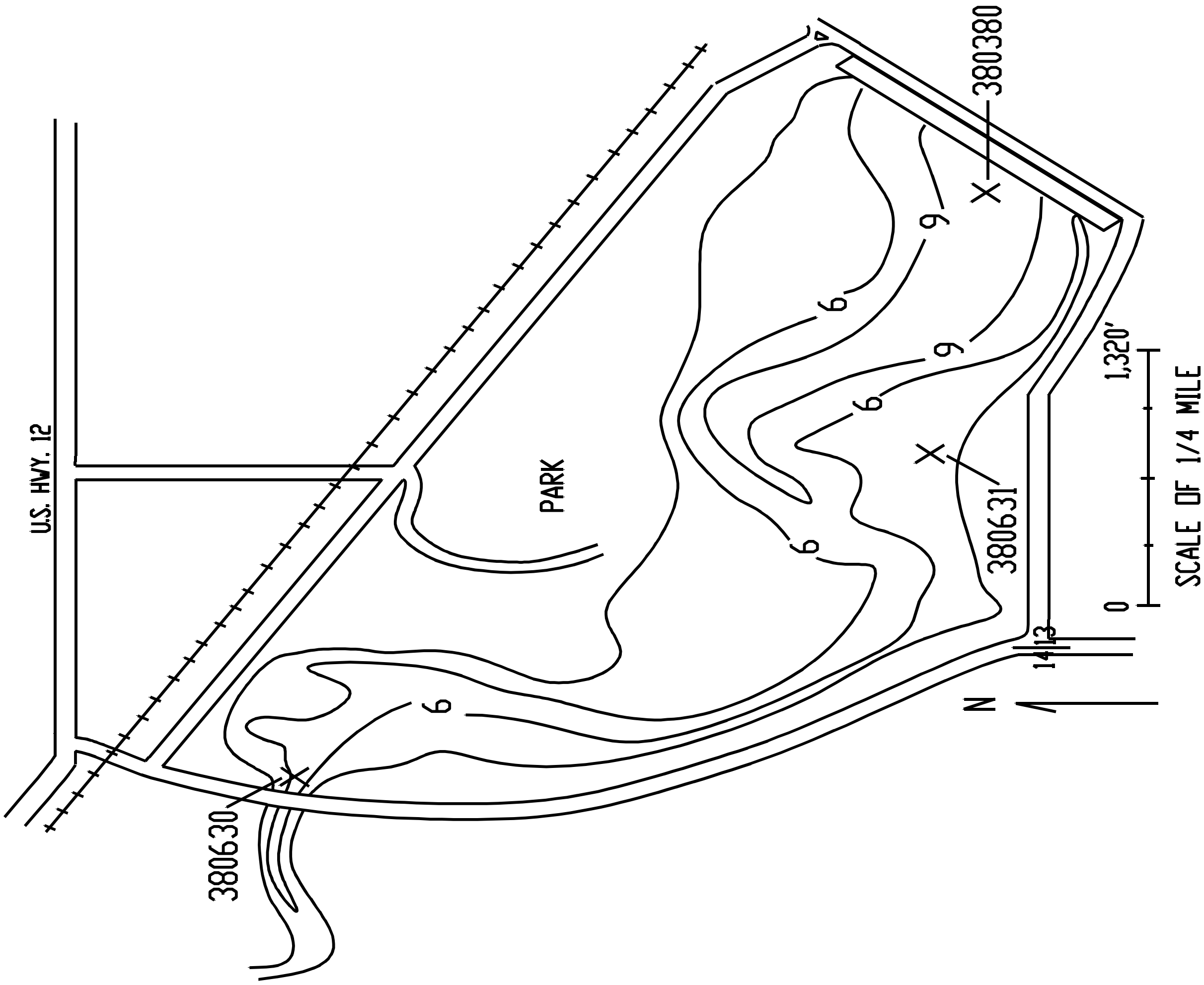


Figure 1. Morphometric map of Mirror Lake.

site located in the deepest area of the lake (Site 380630, Figure 1). Water column samples were collected for analysis at three separate depths during the summer of 1992 and two separate depths during winter of 1993.

During the summer sampling of 1992 Mirror Lake did not thermally stratify (Figure 2). At the time of sampling dissolved oxygen concentrations ranged between 6.0 and 8.6 mg L^{-1} on July 8, 1992 and between 6.3 and 7.3 mg L^{-1} on August 5, 1992 (Figure 3). During winter sampling on January 17, 1993, the water column on Mirror Lake was thermally stratified between two and three meters of depth (Figure 2). Dissolved oxygen concentrations were near saturation to the depth of stratification and between 7.2 and 8.5 mg L^{-1} below (Figure 3).

Concentrations of total dissolved solids, hardness as calcium and conductivity during the LWQA project on Mirror Lake were relatively high yet below the state's long-term average with volume-weighted mean concentrations of 755, 314 and 1,168 mg L^{-1} respectively (Table 1). Water quality data collected during the LWQA project indicates Mirror Lake is a well buffered waterbody with total alkalinity as $CaCO_3$ concentrations ranging between 221 and 323 mg L^{-1} with a volume-weighted mean of 252 mg L^{-1}. The dominant anions in the water column were bicarbonates and sulfates. Bicarbonates ranged between 242 and 366 mg L^{-1} with a volume-weighted mean of 277 mg L^{-1} and sulfates ranged between 291 and 501 mg L^{-1} with a volume-weighted mean of 352 mg L^{-1} (Table 1).

The volume-weighted mean concentrations of the primary nutrients total phosphate as P and nitrate + nitrite as N concentrations were 0.094 and 0.008 mg L^{-1}, respectively (Table 1). The ratios between total phosphate as P and nitrate + nitrite as N of 11.8:1 indicate Mirror Lake is nitrogen limited. Under these conditions nitrogen fixing organisms such as some blue-green algal species are favored. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 8, 1992 and January 17, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Mirror Lake		1982-1991	
Total Dissolved Solids	755	mg L^{-1}	1209	mg L^{-1}
Conductivity	1168	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	314	mg L^{-1}	488	mg L^{-1}
Sulfates	352	mg L^{-1}	592	mg L^{-1}
Chloride	14	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.094	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.008	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	252	mg L^{-1}	296	mg L^{-1}
Ammonia	0.007	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.15	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	277	mg L^{-1}	326	mg L^{-1}

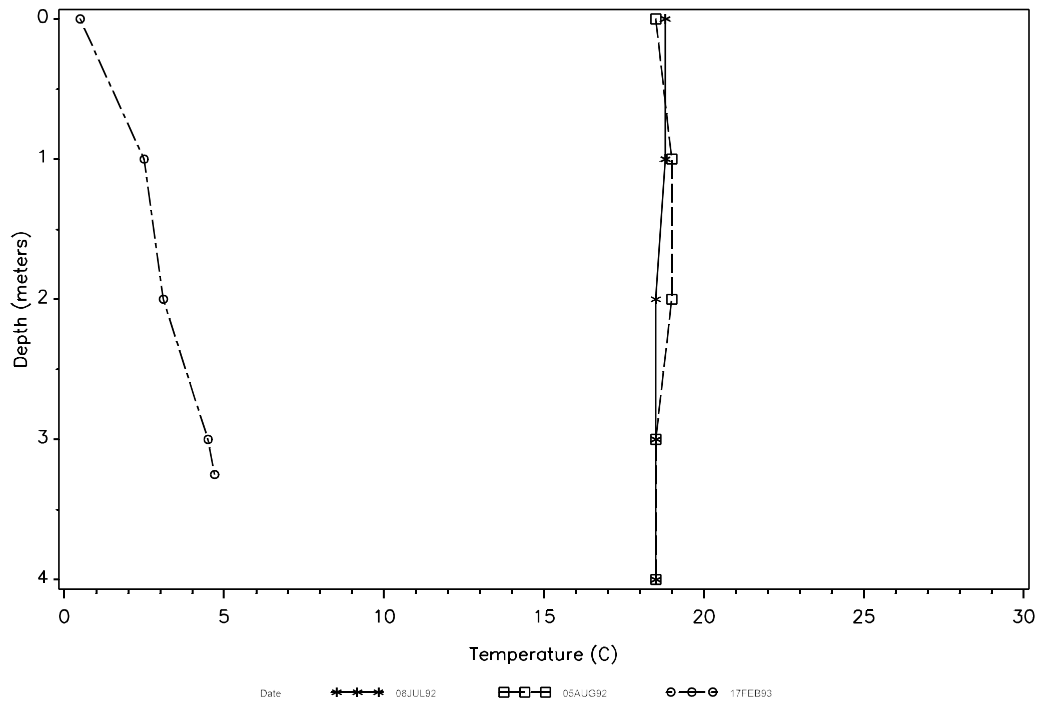


Figure 2. Temperature profile for Mirror Lake.

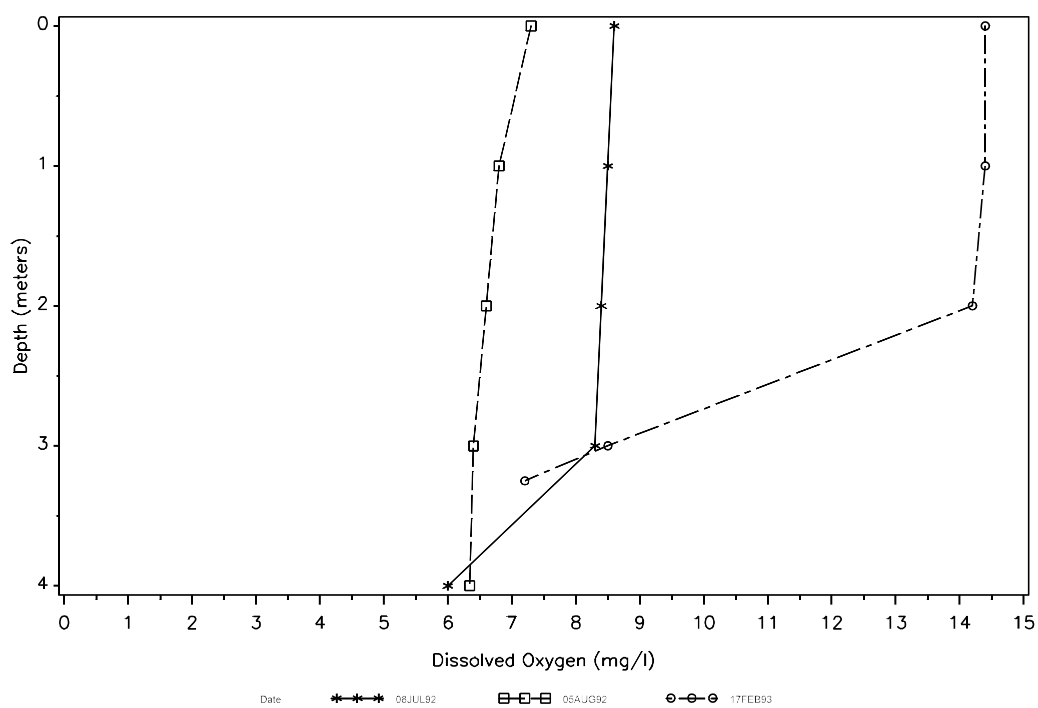


Figure 3. Oxygen profile for Mirror Lake.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Mirror Lake as part of the LWQA project on July 8, 1992. At the time of the macrophyte survey approximately 20 percent of Mirror Lake's surface area had aquatic vegetation. Nearly 100 percent of the lake's surface area to a depth of approximately six feet had either sago pondweed Potamogeton pectinatus, water milfoil Myriophyllum spp., cattails Typha spp., bulrush Scirpus spp., curlyleaf pondweed Potamogeton crispus, coontail Ceratophyllum demersum or a combination of three or more. Also, identified in sparse numbers were duckweed Lemna minor and arrowhead Sagittaria spp. The dominant submergent macrophyte throughout the entire lake was water milfoil making up nearly 90 percent of the total submergent macrophyte community. Cattails were the dominant emergent macrophyte in the inlet regions of the lake with bulrush dominating the north and south shores. A map depicting the areal extent of macrophyte coverage on Mirror Lake is contained in Appendix B.

Phytoplankton

Mirror Lake's phytoplankton community was sampled two times during the summer of 1992. During the two sample periods Mirror Lake's phytoplankton community was represented by six divisions and 24 genera. The largest contributors to the phytoplankton community by number were the blue-green algae, Cyanophyta, with ten genera represented. The blue-green algae's mean numerical density for the two samples collected during the summer of 1992 was 93,681 cell mL^{-1} representing a dominance of three fold over all other divisions combined. Other divisions represented in order of decreasing numerical dominance were Chlorophyta, Cryptophyta, Bacillariophyta, Euglenophyta and Pyrrophyta.

At the time of the assessment mean phytoplankton concentrations by volume were more evenly distributed with the phytoplankton community dominated by the division Bacillariophyta. The division Bacillariophyta by volume did not dominant the phytoplankton community so severely as Cyanophyta did by numerical density. Bacillariophyta had a mean volume of 2,536,123 μm^3 mL^{-1} representing a dominance of two fold over its nearest competitor. The other divisions in order of decreasing volume were Cryptophyta, Chlorophyta, Cyanophyta, Euglenophyta and Pyrrophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Data collected during the LWQA project identifies Mirror Lakes present condition as eutrophic. Primary water quality indicators of a eutrophic condition on Mirror Lake are summer surface total phosphate as P concentrations of 46 and 62 μg L^{-1}, chlorophyll-a concentrations of 4 and 9 μg L^{-1} and secchi disk depth transparency which averaged one meter. Supporting ancillary information of a eutrophic assessment on Mirror Lake include a large macrophyte biomass. Of note is that presently Mirror Lake is not experiencing the hypereutrophic symptoms it had previously exhibited such as; frequent nuisance algal blooms, odor problems, fish kills and poor water clarity. This can be attributed to the local community and their dedication to reverse some of man's negative impacts upon the environment.

Sediment Analysis

Sediments were collected from Mirror Lake and analyzed for trace elements, PCBs and selected pesticides during the LWQA project. Sediments were collected at the deepest area of the lake (Site 380631), the littoral zone (Site 380632) and the inlet (Site 380380) (Figure 1).

Sediment samples collected from Mirror Lake show detectable levels of all trace elements tested for except for mercury in the inlet and deepest areas of the lake. Reported concentrations of trace elements from each sample location within Mirror Lake were compared to the reported concentrations for all lakes assessed in the LWQA project.

In general, trace element concentrations were near or above the 75th percentile for all lakes sampled, while below the maximum concentrations. The exceptions were the reported concentrations of cadmium in the deepest area sediments and the reported concentrations of selenium in the littoral and inlet areas which were between the median and 25th percentile.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Mirror Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Mirror Lake on May 21, 1992. White suckers were the only species collected representing the bottom feeder group. The white sucker sample was composed of three fish with a mean length of 44 centimeters and a mean weight of 1,250 grams.

In order to evaluate the fish tissue data for Mirror Lake the results from the white sucker sample was compared to all bottom feeders collected during the LWQA project. The reported concentrations of copper, zinc, barium, chromium, arsenic and mercury in the white sucker sample were equal to or below the median while the reported concentrations of selenium, cadmium and lead were all above the 75th percentile.

Detectable contaminant residues in the white sucker sample collected from Mirror Lake included DDT, DDE, DDD, dieldrin and PCBs. DDD and DDE are breakdown derivatives of the agricultural insecticide DDT and have the ability to produce similar biological effects as the parent compound when available to the environment. DDT is an agricultural pesticide which was removed from use in 1973 due to its negative environmental impact. Dieldrin, like DDT, is an agricultural insecticide that was removed from use at approximately the same time and for similar environmental concerns. PCBs are generally considered industrial wastes commonly used in electrical and dielectric fluids.

The concentrations of DDE, DDD and dieldrin were all above the 75th percentile for all bottom feeder analyzed during the LWQA project. The concentration of DDT of 0.004 was above the 75th percentile and equal to the maximum concentration reported during the LWQA project. The concentration of PCBs of 0.02 $\mu g\ g^{-1}$ is also above the 75th percentile for all PCB concentrations reported during the LWQA project but below the maximum reported concentration of 0.046 $\mu g\ g^{-1}$. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Mirror Lake, with its contributing watershed has a combined surface area of 45,568 acres located on the Missouri Slope Uplands in Adams County, North Dakota. The watershed is composed primarily of rolling to hilly uplands. Slopes are gentle with relief ranging from 50 to 150 feet. Some areas have either never been glaciated or were glaciated so long ago as to have no glacial evidence remaining. The watershed, unlike the Glaciated Plains or the Missouri Coteau physiographic regions of North Dakota has well defined drainages in the form of intermittent streams. Few surficial aquifers exist within the watershed other than along stream drainages.

Soils within the watershed are moderately deep to shallow, formed from weathered, loamy, glacial till or soft bedrock. In general, soils are fertile, well drained and susceptible to wind and water erosion. Normal annual precipitation ranges from 14 to 16 inches with between 80 and 90 percent occurring between April and September. Nonpoint source pollution from the surrounding watershed accounts for all the nutrient loadings and pollution discharges to Mirror Lake.

Land use within the Mirror Lake watershed is 95.2 percent agricultural, with 42.8 percent actively cultivated, 25 percent in rangeland, 18.2 percent in hay production, 8.8 percent in Conservation Reserve Programs (CRP) and 0.4 percent in farmsteads. The remaining 4.8 percent is in low density urban development and transportation (Table 2).

Table 2. Land use in the Mirror Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	42.8	60
Rangeland	25.0	50
Hayland	18.2	60
CRP	8.8	100
Wet/Wild[1]	0.1	N/A
Other	4.8	N/A
Farmsteads	32[3]	N/A
Feedlots[2]	11[3]	80

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

According to the information provided by the Adams County Soil Conservation District, 60 percent of the cultivated lands and between 50 and 60 percent of all remaining agricultural lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Mirror Lake watershed, the average soil loss is 4.6 tons per acre, which takes into account all land practices and treatments presently being employed. Based on this estimation, approximately 207,900 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 20,790 and 31,185 tons of soil are delivered to Mirror Lake annually.

Other sources of nonpoint source pollution discharges to Mirror Lake are from cattle feeding and watering in the immediate upstream drainage, concentrated livestock feeding areas and the community of Hettinger. These sources have the capabilities to contribute a significant percentage of the annual nutrient budget to Mirror Lake due to their close proximity to the immediate drainages and lakes edge, and their ability to release concentrated amounts of nutrient during snowmelt and runoff events.

NORTH LEMMON LAKE

ADAMS COUNTY

Peter N. Wax

North Lemmon Lake is a small reservoir on a tributary to Cedar Creek in southeastern Adams County, North Dakota. The reservoir is located approximately four miles north of Lemmon, South Dakota with its watershed extending in a southerly direction onto the Missouri Slope Uplands of North Dakota. North Lemmon Lake has a surface area of 55 acres, a maximum depth of 33 feet and an mean depth of 13.2 feet (Figure 1).

The surrounding watershed is characterized by sandstone buttes and rolling hills. Soils within the watershed are moderately deep to shallow formed from weathered loamy glacial till or soft sandstone bedrock. Generally, soils are fertile, well drained and susceptible to wind and water erosion. Average precipitation within the watershed ranges from 14 to 16 inches with between 80 and 90 percent of the annual precipitation occurring between April and September. Principal land use is agricultural predominating in livestock and small grain production.

Approximately 20 percent of North Lemmon Lake's watershed is composed of badlands. Badlands are eroded formations composed of buttes and deeply eroded drainages. Soils in these regions are generally thin formed from sandy and clayey materials. Badland areas within North Lemmon Lake's watershed are highly susceptible to wind and water erosion.

North Lemmon Lake is classified as a cold water fishery, "Waters capable of supporting growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage North Lemmon Lake by annually assessing the fish community through test netting and stocking accordingly.

In recent years, the stocking regiment on North Lemmon Lake has included rainbow and brown trout. In years past the stocking regiment has also included largemouth bass. Test netting operations conducted on July 19, 1991 by the NDG&F captured rainbow trout, green sunfish, largemouth and smallmouth bass.

One hundred percent of North Lemmon Lake is owned and managed by the NDG&F. The shoreline and the immediate area surrounding North Lemmon Lake is managed for wildlife. Facilities at North Lemmon Lake include a boat ramp, parking and a picnic area. Public use on North Lemmon Lake is dependent upon the productivity of the fishery, varying from relatively heavy to very light.

Water Quality

Water quality samples were collected from North Lemmon Lake once during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380850, Figure 1). Water column samples were collected for analysis at three separate depths of one meter, between two and four meters, and between four and six meters.

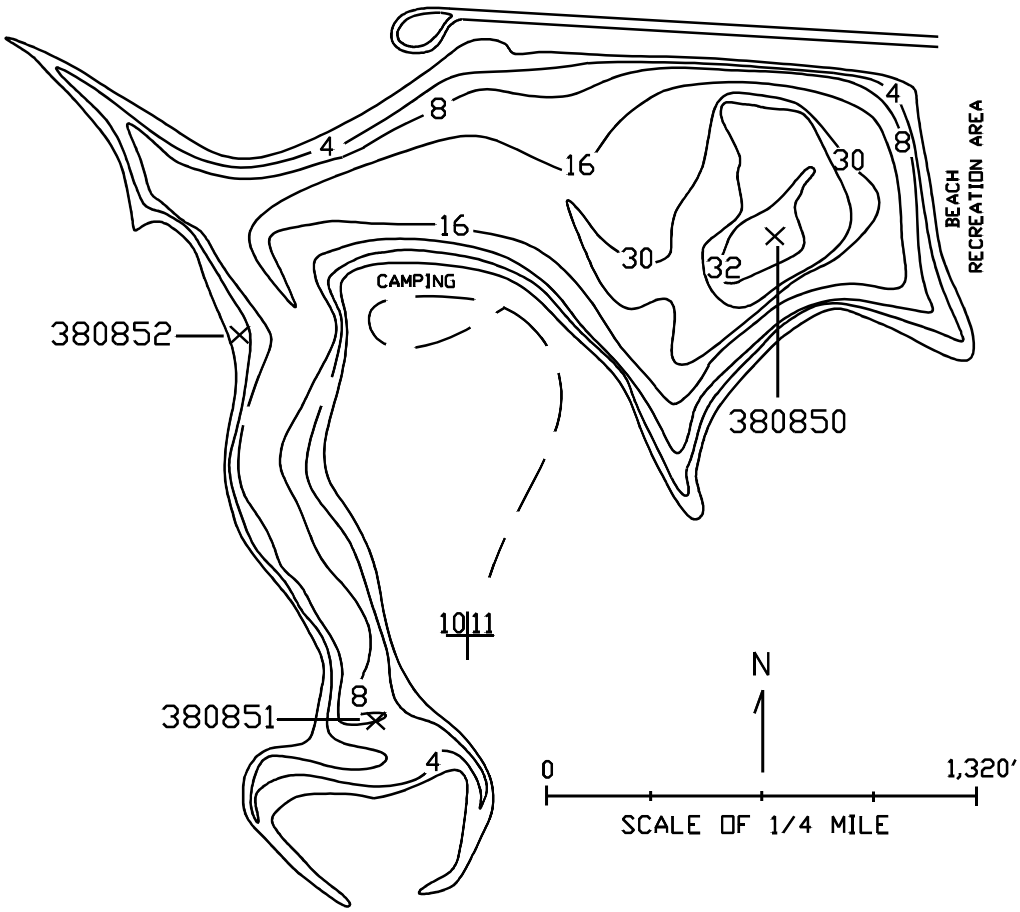


Figure 1. Morphometric map of North Lemmon Lake.

On August 18, 1992 North Lemmon Lake was not thermally stratified (Figure 2). Dissolved oxygen concentrations ranged between 8.2 mg L^{-1} near the surface to 3.0 mg L^{-1} near the bottom (Figure 3). On January 16, 1993 North Lemmon Lake was weakly thermally stratified between three and four meters of depth (Figure 2). Dissolved oxygen concentrations in the epilimnion range between 7.2 and 12.8 mg L^{-1} and between 0.1 and 2.1 mg L^{-1} in the hypolimnion (Figure 3).

Water quality data collected during the LWQA project on North Lemmon Lake describe a waterbody that is well buffered. Total alkalinity as $CaCO_3$ had a volume-weighted mean concentrations of 337 mg L^{-1} and ranged between 294 and 379 mg L^{-1}. North Lemmon Lake also had relatively high concentrations of total dissolved solids, total hardness as calcium and conductivity with volume-weighted mean concentrations of 356, 279, and 589 mg L^{-1}, respectively. While these concentrations are relatively high, they are below the state's long-term average (Table 1).

The dominant anions in the water column were bicarbonates and sulfates with volume-weighted mean concentrations of 307 and 14 mg L^{-1} followed by chlorides at 8 mg L^{-1}. The primary nutrients in the water column total phosphate as P and nitrate plus nitrite as N had volume-weighted mean concentrations of 0.062 and 0.002 mg L^{-1}, respectively. The ratios between these two nutrients suggest North Lemmon Lake is nitrogen limited. Under these conditions nitrogen fixing organisms, such as certain blue-green algal species, are favored.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between August 18, 1992 and January 16, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	North Lemmon Lake		1982-1991	
Total Dissolved Solids	356	mg L^{-1}	1209	mg L^{-1}
Conductivity	589	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	379	mg L^{-1}	488	mg L^{-1}
Sulfates	14	mg L^{-1}	592	mg L^{-1}
Chloride	8.0	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.062	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.002	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	337	mg L^{-1}	296	mg L^{-1}
Ammonia	0.145	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	0.41	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	307	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on North Lemmon Lake as part of the LWQA project. The survey was conducted on August 18, 1992.

At the time of the macrophyte survey approximately 45 percent of North Lemmon Lake's surface area had aquatic vegetation. Nearly 100 percent of the lake's surface area to the depth of eight feet had either sago pondweed Potamogeton pectinatus, coontail Ceratophyllum demersum, water milfoil Myriophyllum spp.,

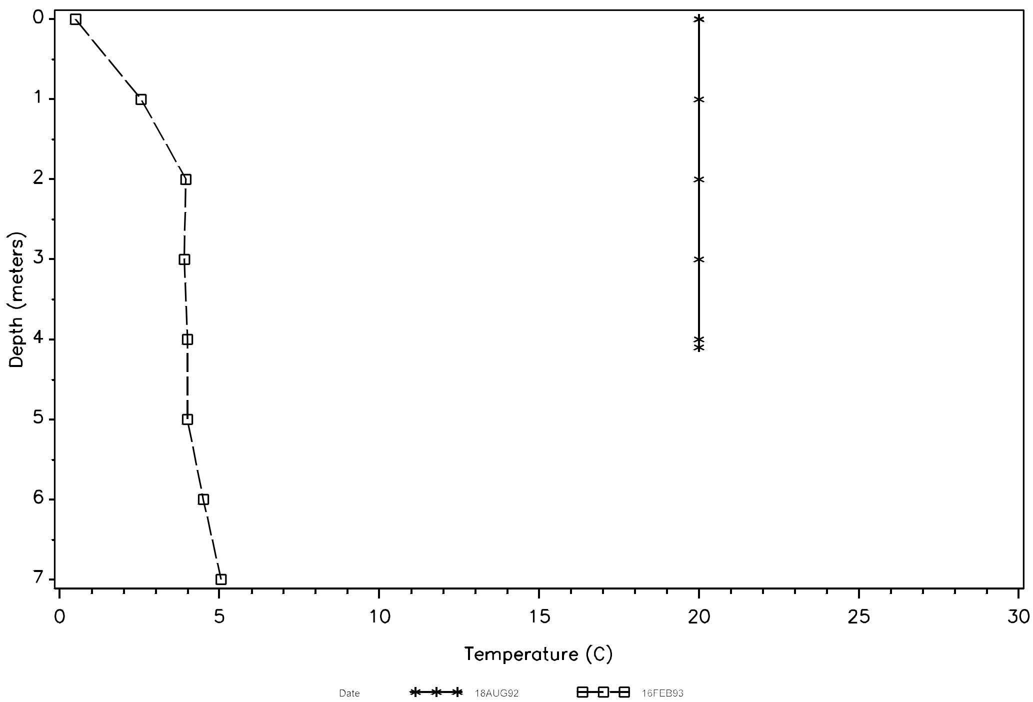


Figure 2. Temperature profile for North Lemmon Lake.

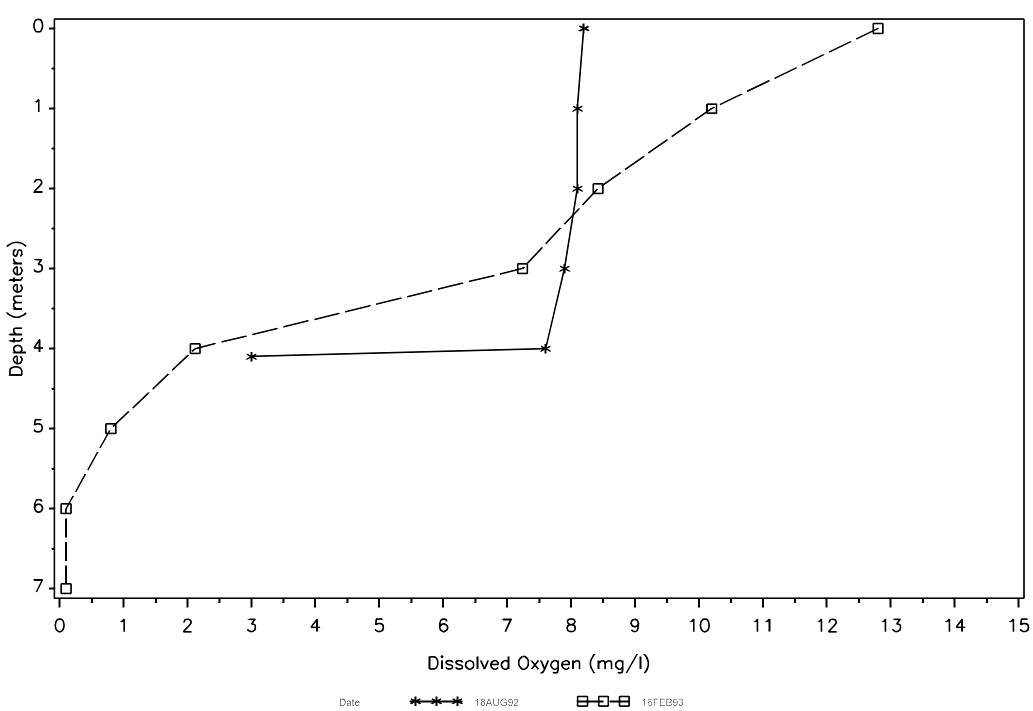


Figure 3. Oxygen profile for North Lemmon Lake.

leafy pondweed Potamogeton foliosus, clasping leaf pondweed Potamogeton richardsonii or a combination of three or more. The only emergent macrophyte vegetation was a sparse stand of bulrush Scirpus spp. between the boat ramp and the dam. A map depicting the macrophyte coverage on North Lemmon Lake is contained in Appendix B.

Phytoplankton

North Lemmon Lake's phytoplankton community was sampled a single time during the summer of 1992. At the time the sample was collected North Lemmon Lake's phytoplankton community was represented by five divisions and 24 genera. The largest contributors to the phytoplankton community by numerical density were the blue-green algae Cyanophyta, with 14 genera present. Blue-green algae on August 18 had a numerical density of 40,369 cell mL^{-1} dominating all other divisions combined by 11 fold.

At the time of assessment phytoplankton concentrations by volume were dominated by the division Pyrrophyta by nearly twofold. The next most abundant division on volume was the blue-green algae, Cyanophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected in 1992 on North Lemmon Lake identify North Lemmon Lake as mesotrophic. Primary water quality indicators are, summer surface total phosphate as P concentrations of 14 $\mu g\ L^{-1}$, chlorophyll-a concentrations of 12 $\mu g\ L^{-1}$ and a secchi disk depth transparency of 2.4 meters. Ancillary information used in defining North Lemmon Lakes trophic status was no record of any fish kills, adequate dissolved oxygen concentrations throughout the summer and above the hypolimnion during the winter, infrequenct nuisance algal blooms and a diverse phytoplankton population.

During the LWQA project North Lemmon Lake received a relatively small amount of water quality sampling. This data might have been collected at a time of minimal internal cycling or at a time when the lake was experiencing a period of unusual clarity. The assessment of mesotrophic based on water quality data is somewhat elevated when we look at the ancillary information which is more indicative of a eutrophic lake condition. It is possible that a more aggressive sampling program might have defined North Lemmon Lake as eutrophic.

Watershed

North Lemmon Lake with its contributing watershed and combined surface area of 3,516 acres is located on the Missouri Slope Uplands in Adams County, North Dakota. North Lemmon Lake's watershed is composed primarily of rolling to hilly uplands with small areas of badlands near prominent buttes. Slopes generally
are gentle with the relief ranging from 50 to 150 feet. The watershed has well defined drainages in the form of intermittent streams. No shallow aquifers exist in the watershed other than in buried sand deposits along stream drainages.

Soils in the North Lemmon Lake watershed are moderately deep to shallow, formed from weathered glacial till or soft bedrock. In general, soils are fertile, well drained and susceptible to wind and water erosion. Average precipitation in the watershed ranges from 14 to 16 inches with between 80 and 90 percent of the annual precipitation occurring between April and September. Principal land use is agricultural predominating in small grain and livestock production.

Approximately ten percent of the North Lemmon Lake's watershed is composed of badlands. The badlands are located to the east of North Lemmon Lake. The badlands are eroded formations composed of buttes and steeply eroded drainages. Soils in this region are generally thin, formed from sandy and clayey materials. The badland regions are highly susceptible to wind and water erosion. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to North Lemmon Lake.

Land use within North Lemmon Lake watershed is 96.1 percent agricultural with 27.6 percent actively cultivated, 31.2 percent in range, 20.5 percent in haylands and 16.8 percent in Conservation Reserve Programs (CRP) (Table 2). The remaining 3.9 percent of the watershed is in wetland and wildlife management, transportation, farms and concentrated feeding areas (Table 2).

Table 2. Land use in the North Lemmon Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	27.6	90
Rangeland	31.2	50
Hayland	20.5	70
CRP	16.8	100
Wet/Wild[1]	1.1	N/A
Other	1.4	N/A
Farmsteads	5[3]	N/A
Feedlots[2]	2[3]	100

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within

According to the information provided by the Adams County Soil Conservation District 90 percent of the cultivated lands and between 50 and 100 percent of all the remaining lands within the North Lemmon Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the North Lemmon Lake watershed the average "T" value is three to five tons per acre. Based on an average soil loss of 2.7 tons per acre, which takes into account all current land practices, approximately 9,578 tons of soil are lost annually from within the North Lemmon Lake watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 958 and 1,437 tons of soil reaches North Lemmon Lake annually.

Other nonpoint source pollution discharges to North Lemmon Lake are from cattle feeding and watering in the lake and immediate drainage, concentrated feeding areas within the drainage, low density urban development and construction. These sources have the capabilities to contribute a significant amount of nutrients and sediments to the lake. They are also possibly the largest degradation source due to their ability to release highly concentrated loads during runoff and snowmelt events.

ODLAND DAM

GOLDEN VALLEY COUNTY

Peter N. Wax

Odland Dam was created in 1936 by damming Little Beaver Creek approximately eight miles north of the city of Beach in Golden Valley County, North Dakota. Since the original damming, a concrete spillway has been added and the dam raised an additional 18 inches. Presently, Odland Dam covers 108 surface acres, with a maximum depth of 16 feet and an average depth of 7.9 feet (Figure 1).

Topography of the Odland Dam watershed is characterized by rolling to hilly uplands with a few badland areas and buttes. Slopes are generally gentle with reliefs rarely exceeding 150 feet. Soils in the watershed are moderately deep to shallow, formed from weathered, loamy glacial till or soft bedrock. Soils are moderately fertile to fertile, well drained and susceptible to wind and water erosion. Average precipitation ranges from 14 to 16 inches, within between 80 and 90 percent of the annual precipitation occurring between April and September. Principal land uses are small grain and livestock production.

Odland Dam is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). Odland Dam is managed by the North Dakota Game and Fish Department (NDG&F). The NDG&F manage Odland Dam by annually assessing the fish community by test netting and stock accordingly.

In 1961, Odland Dam was chemically eradicated to remove an overabundant population of black bullhead and golden shiners and even though the chemical eradication was not 100 percent complete an excellent trout fishery was established. Additional fish species stocked in the following years included walleye, yellow perch and largemouth bass. The yellow perch fishery between 1960 and 1970 was excellent but has declined since that time. The stocking regiment between 1988 and 1990 included northern pike, yellow perch and bluegills. A fish community assessment conducted by the NDG&F on May 17, 1991 captured in order of most abundant northern pike, yellow perch, fathead minnows and white suckers.

One hundred percent of Odland Dam's shoreline is privately owned. Public facilities include a boat ramp and access roads. Public use on Odland Dam is variable depending on the productivity of the fishery. Fishing can be difficult from midsummer until ice over due to heavy macrophyte growths in the littoral zone.

Water Quality

Water quality samples were collected from Odland Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380860, Figure 1). Water column samples were collected for analysis at three separate depths of 1 meter, 2 meters and 4 meters.

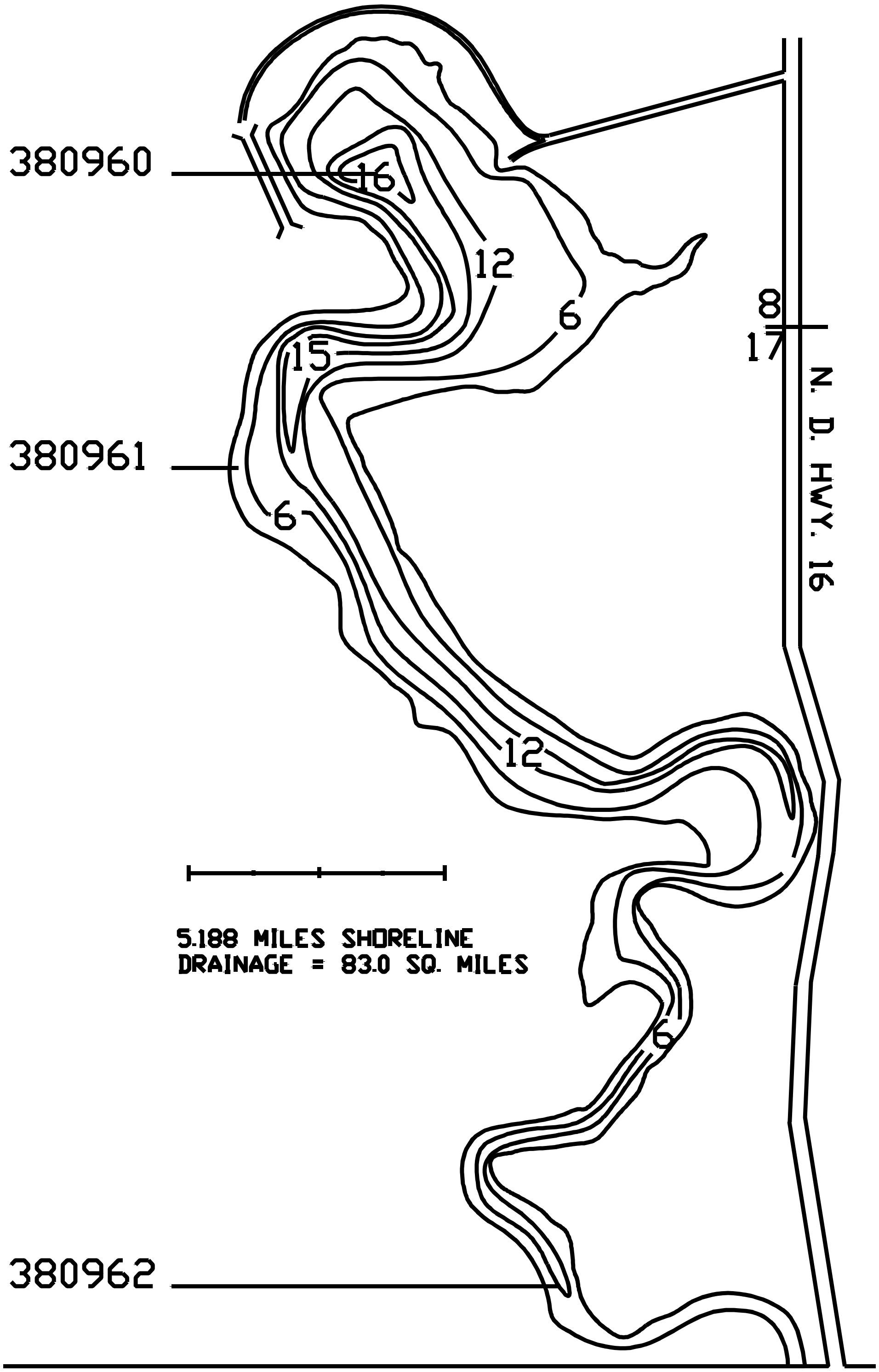


Figure 1. Morphometric map of Odland Dam.

Samples collected on Odland Dam during the summer of 1992 did not document thermal stratification (Figure 2). Dissolved oxygen concentrations were sufficient at the times of summer sampling to maintain aquatic life. Dissolved oxygen concentrations ranged between 3.5 and 8.9 mg L^{-1} on July 7, 1992 and 8.9 and 9.3 mg L^{-1} on August 4, 1992 (Figure 3). Water quality samples collected during the winter on January 17, 1993 showed Odland Dam was weakly thermally stratified between 2 and 3 meters of depth. Dissolved oxygen concentration ranged between 6.2 and 9.2 mg L^{-1} above the thermal stratification and 0.1 to 0.3 mg L^{-1} below (Figure 2, Figure 3).

Concentrations of total dissolved solids, hardness as calcium and conductivity were above the state's long-term average with volume-weighted mean concentrations of 3,789, 1,396 and 4,564 mg L^{-1} respectively (Table 1). Odland Dam is a well buffered waterbody with a volume-weighted mean concentration of total alkalinity as $CaCO_3$ of 485 mg L^{-1} (Table 1). The dominant anions in the water column were sulfates, followed by bicarbonates and chlorides. The volume-weighted mean concentration for sulfates, bicarbonates and chlorides was 2,341, 549 and 54 mg L^{-1} respectively (Table 1).

The volume-weighted mean concentrations for the nutrients total phosphate as P and nitrate + nitrite as N were 0.202 mg L^{-1} and 0.044 mg L^{-1} (Table 1). The ratios between total phosphate as P and nitrate + nitrite as N of 1.6:1 indicate Odland Dam is nitrogen limited. Under these conditions nitrogen fixing organisms such as some blue-green algal species are favored. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 7, 1992 and February 7, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Odland Dam		1982-1991	
Total Dissolved Solids	3789	mg L^{-1}	1209	mg L^{-1}
Conductivity	4564	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	1396	mg L^{-1}	488	mg L^{-1}
Sulfates	2341	mg L^{-1}	592	mg L^{-1}
Chloride	54	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.202	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.044	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	485	mg L^{-1}	296	mg L^{-1}
Ammonia	0.069	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.99	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	549	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community on Odland Dam was conducted on July 7, 1992. At the time of the macrophyte survey, the dominant submergent macrophyte was sago pondweed Potamogeton pectinatus which occupied nearly 100 percent of the surface area to a depth of approximately four feet, with small patches of curly leaf pondweed Potamogeton crispus extending to depths of nearly 11 feet.

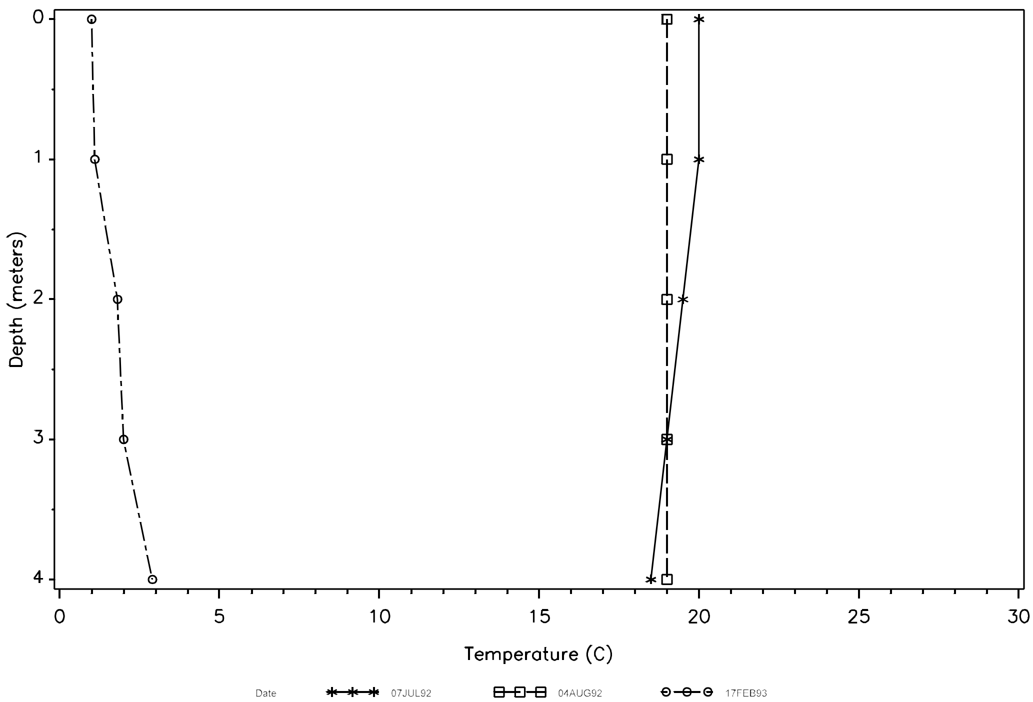


Figure 2. Temperature profile for Odland Dam.

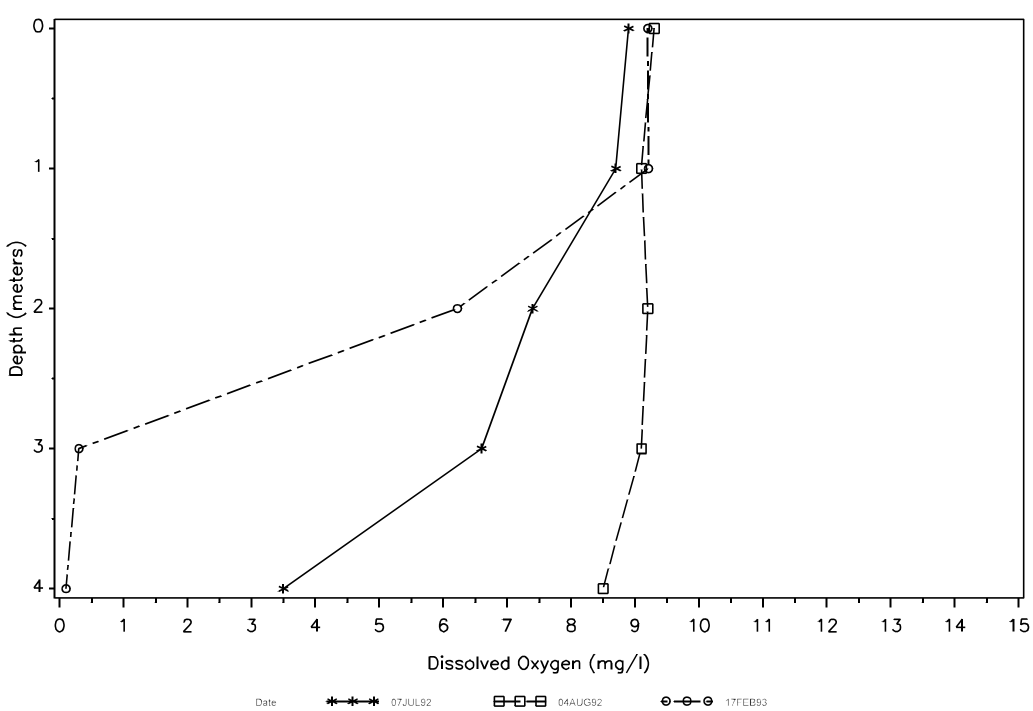


Figure 3. Oxygen profile for Odland Dam.

The dominant emergent macrophyte was bulrush Scirpus spp., which lined nearly the entire shore with small patches of cattails Typha spp. intermittently dispersed throughout. A map depicting the areal extent of macrophyte coverage on Odland Dam is contained in Appendix B.

Phytoplankton

Odland Dam's phytoplankton community was sampled two times during the summer of 1992. The samples collected had representation from four divisions and 26 genera. The largest contributors to the phytoplankton community by density in number was the division, Chlorophyta, with 13 genera present. Mean density of Chlorophyta collected during the summer of 1992 was 110,361 cell mL^{-1} representing a dominance of threefold over all other divisions combined. Other divisions identified in order of descending numerical dominance were Cyanophyta, Cryptophyta and Bacillariophyta.

At the time of the assessments, mean phytoplankton concentrations by volume were much more evenly distributed. The division Cyanophyta occupying the largest amount of volume followed by Cryptophyta, Chlorophyta and Bacillariophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Odland Dam in the summer of 1992 was eutrophic. Primary water quality indicators of a eutrophic condition on Odland Dam were summer surface total phosphate as P concentrations of 136 and 274 $\mu g\ L^{-1}$, chlorophyll-a concentrations of 3 and 12 $\mu g\ L^{-1}$ and secchi disk depth transparency readings of 1 and 2.3 meters. Supporting ancillary data of a eutrophic assessment are a large macrophyte biomass, frequent nuisance algal blooms, history of low dissolved oxygen concentrations and fish kills.

Sediment Analysis

Sediments were collected from Odland Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 380960), the littoral zone (Site 380961) and the inlet (Site 380862), (Figure 1).

Sediment samples collected from Odland Dam show detectable levels of all trace elements tested for except for selenium and mercury. Reported concentrations of trace elements in the sediments collected from Odland Dam were compared to the reported concentrations for all lakes assessed in the LWQA project.

Reported concentrations of trace elements in the deepest and inlet areas sediments from Odland Dam were very similar. The reported concentrations of copper, zinc, barium, cadmium and lead were all above the median for all sediment samples collected during the LWQA project. Detectible trace elements in the deepest and inlet areas of Odland Dam were near or below the 25th percentile. The littoral area sediment sample collected from Odland Dam contained reported concentrations that were all near or above the 75th percentile with the exceptions of selenium and mercury which were nondetectable.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Odland Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected from Odland Dam for contaminant analysis on May 27, 1992. Northern pike were the only species collected, representing the piscivore group. The northern pike sample was composed of five fish with a mean length of 51.6 centimeters and a mean weight of 2,250 grams.

In order to evaluate the fish tissue data for Odland Dam the results of the northern pike sample was compared to all piscivore samples assessed in the LWQA project. Trace element concentrations in the northern pike sample collected from Odland Dam were mostly above the median with barium, selenium and cadmium approaching or exceeding the 75th percentile for all piscivores sampled during the LWQA project. The exceptions were the reported concentrations of arsenic and lead that were approximately equal to the 25th percentile.

Detectable pesticide residues in the northern pike sampled collected from Odland Dam include DDT and DDE. DDE is a degradation byproduct of the insecticide DDT and can produces biological effects similar to the parent compound. DDT is an agricultural insecticide which was discontinued from agricultural use in 1973 due to its negative impact on the environment.

The DDT concentration found in the northern pike sampled collected from Odland Dam was 0.003 $\mu g\ g^{-1}$ and exceeded the 75 percentile concentration for all LWQA piscivores. The DDE concentration of 0.007 $\mu g\ g^{-1}$ was just slightly above the 25 percentile concentration for all piscivores sampled during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Odland Dam and its contributing watershed has a combined surface area of 60,800 acres located on the Missouri Slope Uplands in Golden Valley County, North Dakota. The watershed is composed primarily of rolling to hilly uplands. Slopes are generally gentle with relief rarely exceeding 50 feet. The region's drainages are generally well defined in the form of intermittent and perennial streams. Few surficial aquifers exist within the watershed other than along stream drainages.

Soils within the watershed are moderately deep to shallow, formed from weathered, loamy glacial till or soft bedrock. In general, soils are moderately fertile to fertile, well drained and susceptible to wind and water erosion. Average precipitation ranges from 14 to 16 inches, with between 80 and 90 percent of the annual precipitation occurring between April and September. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loadings and pollution discharges to Odland Dam.

Land use within the Odland Dam watershed is 98.5 percent agricultural, with 82.5 percent actively cultivated. The remaining 17.5 percent of the watershed is in rangelands, haylands, Conservation Reserve Program (CRP), wildlife and wetland management, and transportation. Also within the watershed occupying approximately 1.2 percent of the total acreage are 40 farms and seven concentrated livestock feeding areas (Table 2).

According to the information provided by the Golden Valley County Soil Conservation District, 95 percent of all the cultivated lands and between 75 and 100 percent of all the remaining agricultural lands within the Odland Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

Based on an average soil loss of approximately 2.6 tons per acre, which takes into account current land uses and land practices, approximately 161,930 tons of soil are lost from within the watershed annually. Assuming a conservative delivery rate of 10 to 15 percent, between 16,193 and 24,289 tons of soil are delivered to Odland Dam annually.

Other sources of nonpoint source pollution discharges to Odland Dam are from cattle feeding and watering in it and the immediate drainage, runoff from the seven concentrated livestock feeding areas, road construction and low density urban development. These sources have the capabilities to contribute a significant percentage of the annual nutrient and sediment load to Odland Dam due to their ability to deliver a highly concentrated load during snowmelt and storm events.

Table 2. Land use in the Odland Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	82.5	95
Rangeland	9.2	75
Hayland	0.3	90
CRP	5.3	100
Wet/Wild[1]	0.2	N/A
Other	1.6	N/A
Farmsteads	40[3]	N/A
Feedlots[2]	7[3]	15

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

PATTERSON DAM

STARK COUNTY

Peter N. Wax

Patterson Lake was constructed in 1949-50 by the Bureau of Reclamation as a multi-purpose reservoir to supply potable water for the city of Dickinson, irrigation, downstream flood protection and water based recreation. The rolled earthen structure dams the Heart River approximately one mile southwest of the town of Dickinson impounding 649.6 surface acres with a maximum depth of 27 feet and an average depth of 8.8 feet (Figure 1).

The original impoundment when surveyed in 1954 impounded 819 acres and had a maximum depth of 32 feet. The loss of depth and storage is the result of sedimentation carried by the Heart River. Erosion within the watershed is severe and compounded through inadequate conservation practices on cultivated and grazed agricultural lands. Topography of Patterson Lake's watershed is composed primarily of rolling to hilly uplands except in badland areas and near prominent buttes. Slopes are gentle, with reliefs ranging from 300 to 500 feet, but rarely exceeding 150 feet. This region, unlike many portions of the rest of North Dakota, has well-defined drainages in the form of intermittent and perennial streams. Few surficial aquifers exist in the watershed other than along stream drainages. Approximately 20 percent of this region is composed of badlands. Badlands are eroded formation composed of buttes and steeply eroded drainages. Soils are generally thin in badland areas, formed from sandy and clayey material. Badland areas within the watershed are highly susceptible to wind and water erosion.

Patterson Lake is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated biota" (NDSDHCL, 1991). The NDG&F manage the fishery on Patterson Lake by annually assessing the fish community through test netting operations and stock accordingly.

Initial fishery management by the NDG&F began after dam closure in 1949-50. In 1958, Patterson Lake was chemically eradicated to remove undesirable fish species. The NDG&F estimated the eradication attempt was 98 percent successful. Intensive management efforts followed but resulted in only a marginal warm-water fishery.

Major factors suppressing the fishery were poor water quality and undesirable fluctuations in the water levels resulting in a lack of food organisms. The reservoir is typically turbid, a result of the fine clayey materials which are carried as a sediment load in the Heart River.

In recent years the stocking regiment by the NDG&F has included northern pike, walleye, yellow perch, bluegill, smallmouth bass, largemouth bass, and channel catfish. A fish community assessment conducted by the NDG&F on August 1 and 2, 1991 captured a multitude of fish species including black crappie, bluegill, white sucker, black bullhead, common carp, walleye, yellow perch, northern pike and channel catfish.

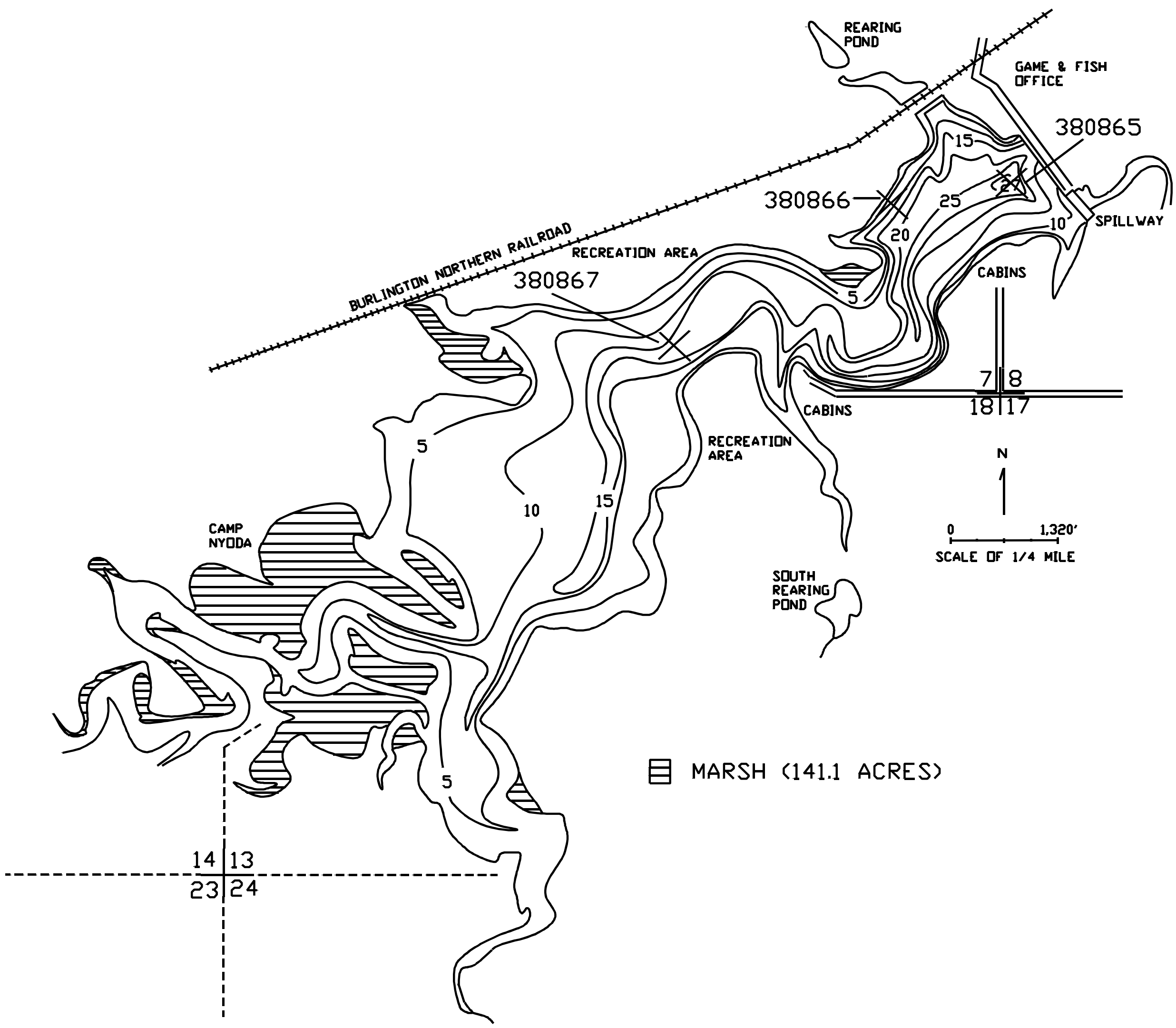


Figure 1. Morphometric map of Patterson Dam.

Public facilities on Patterson Lake developed on Bureau of Reclamation lands, include picnic areas with drinking water and shelters, a public swim beach, three boat ramps and associated parking, and toilets. Approximately 25 percent of Patterson Lake's shoreline has designated areas for private summer and permanent cabins. At this time, approximately 30 private cabins have been constructed on these designated areas. Also, along the shores of Patterson Lake are a campfire girls camp and a boy scout camp with archery and trapshooting ranges.

Future fisheries management and recreational potential for Patterson Lake presently is in jeopardy due to declining water quality. Public concern for the water quality and general health of Patterson Lake is high in the local community. A grassroots movement secured tentative approval of an EPA Section 319 grant for fiscal year 1992 to implement conservation practices within the watershed. This project had the potential to preserve and restore some of the recreational and water quality benefits to Patterson Lake. Unfortunately, local sponsors were unable to commit the required matching funds and the project was never realized.

Water Quality

Water quality samples were collected from Patterson Lake twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380865, Figure 1). Water column samples were collected for analysis at three discrete depths. The sample depths were 1 meter, 2.5 meters and 5 meters during the summer of 1992 and 1 meter, 3 meters and 4 meters during the winter of 1993.

During the summer sampling of 1992, Patterson Lake was weakly thermally stratified between two and three meters on July 7 and between three and four meters on August 4 (Figure 2). Dissolved oxygen concentrations ranged between 6.2 mg L^{-1} near the bottom to 11.5 mg L^{-1} at the surface on July 7 and between 4.5 mg L^{-1} near the bottom to 6.6 mg L^{-1} at the surface on August 4 (Figure 3). Winter samples collected on Patterson Lake on February 17, 1993, showed Patterson Lake thermally stratified between two and three meters of depth (Figure 2). At the time of sampling dissolved oxygen concentrations were between 6.9 and 8.1 mg L^{-1} above the thermocline and nondetectable to 0.3 mg L^{-1} below (Figure 3).

Water quality data collected during the LWQA project shows Patterson Lake as a well-buffered waterbody with concentrations of total alkalinity as $CaCo_3$ ranging between 356 and 577 mg L^{-1} with a volume-weighted mean concentration of 426
mg L^{-1}. Concentrations of total dissolved solids and conductivity exceeded the state's long-term averages with volume-weighted mean concentrations of 1,655 and 2,370 mg L^{-1}, respectively (Table 1). Total hardness as calcium concentrations were slightly below the state's long-term average, with a volume-weighted mean concentration of 302 mg L^{-1} (Table 1). The dominant anions in the water column were sulfates and bicarbonates, with volume-weighted mean concentrations of 822 and 470 mg L^{-1} respectively (Table 1).

During the LWQA project Patterson Lake's water column contained relatively high concentrations of the two primary nutrients total phosphate as P and total nitrate + nitrite as N. Total phosphate as P concentrations ranged between 0.18 and 0.639 mg L^{-1}, exceeding the state's target concentration of 0.02 mg L^{-1} on all

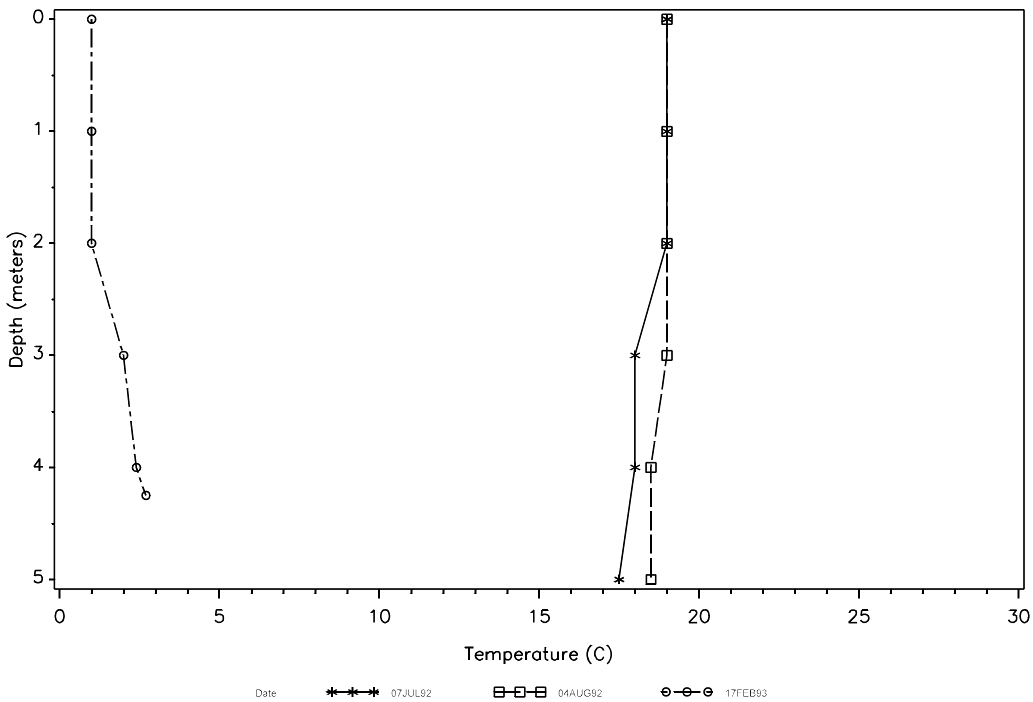


Figure 2. Temperature profile for Patterson Lake.

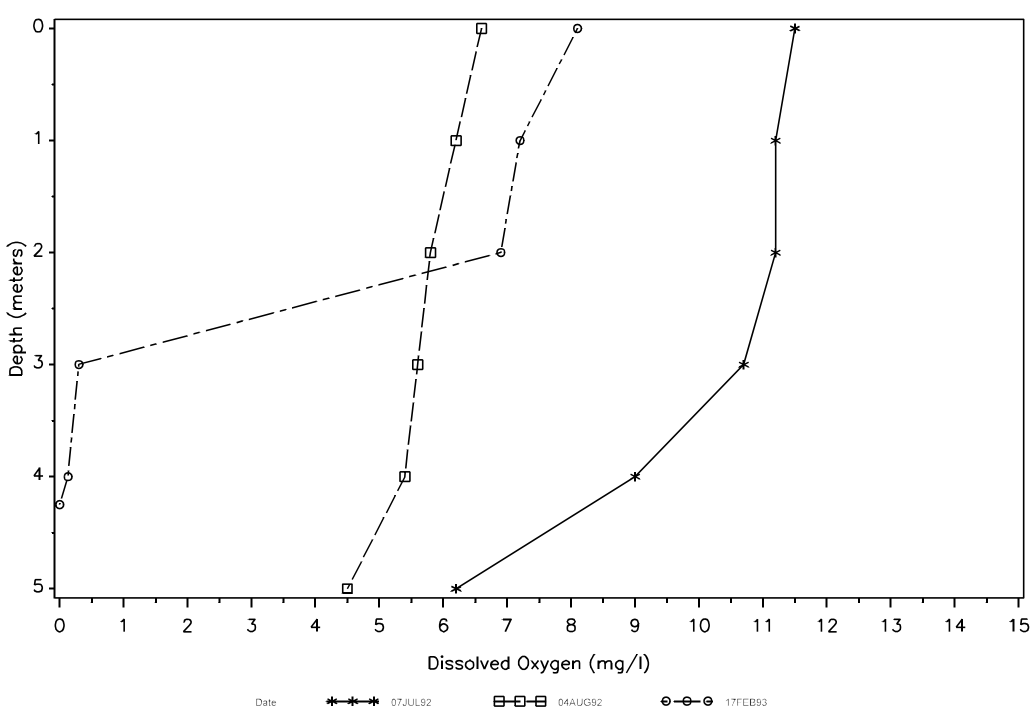


Figure 3. Oxygen profile for Patterson Lake.

occasions sampled. Nitrate + nitrite as N concentrations ranged between nondetectable to 0.26 mg L^{-1}, being under the state's target concentration of 0.25 mg L^{-1} in all but a single sample. The ratios of total phosphate as P and nitrate + nitrite as N of 4.6:1 indicate Patterson Lake is nitrogen limited. Under these conditions primary producers which can affix nitrogen, such as, some species of blue-green algae are favored.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 7, 1992 and February 17, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Patterson Lake		1982-1991	
Total Dissolved Solids	1655	mg L^{-1}	1209	mg L^{-1}
Conductivity	2370	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	302	mg L^{-1}	488	mg L^{-1}
Sulfates	822	mg L^{-1}	592	mg L^{-1}
Chloride	21	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.350	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.075	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	426	mg L^{-1}	296	mg L^{-1}
Ammonia	0.212	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.41	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	470	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Patterson Lake as part of the LWQA project on July 7, 1992. At the time of the assessment no submergent macrophyte vegetation was identified on Patterson Lake. Due to the low water levels Patterson Lake has experienced during the recent drought much of the shallow inlet area was not accessible by boat. However, on observation from shore, stands of dead bulrush Scirpus and cattails Typha spp. were noted. A map depicting the lack of macrophyte coverage on Patterson Lake is contained in Appendix B.

Phytoplankton

Patterson Lake's phytoplankton community was sampled twice during the summer of 1992. At the time of the assessment Patterson Lake's phytoplankton community had representation from five divisions and 62 genera. The largest contributors to the phytoplankton community by numerical density were the blue-green algae, Cyanophyta, followed by the divisions Chlorophyta and Bacillariophyta. The largest genera diversity was in the division Chlorophyta, with 42 genera present. Other divisions present in the sample were Cryptophyta, and Euglenophyta.

At the time of the LWQA assessment mean phytoplankton concentrations by volume were more evenly distributed, with the division Chlorophyta occupying the largest volume. The other divisions present in descending order of volume occupied were Cyanophyta, Bacillariophyta, Cryptophyta and Euglenophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA project defined Patterson Lake as hypereutrophic. This assessment is based on summer surface total phosphate as P concentrations, chlorophyll-a concentrations and secchi disk depth transparency. These parameters agreed quite well, all indicating Patterson Lake is hypereutrophic. Surface summer total phosphate as P concentrations ranged between 187 and 364 $\mu g\ L^{-1}$, chlorophyll-a concentrations ranged between 24 and 68 $\mu g\ L^{-1}$ and secchi disk depths never exceeded 0.3 meters. Supporting ancillary information of a hypereutrophic assessment are frequent nuisance algal blooms, poor fishery productivity, and rapid oxygen depletion below the hypolimnion and under ice cover conditions.

Sediment Analysis

Sediments were collected from Patterson Lake and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 380865), the littoral zone (Site 380866) and the inlet (Site 380867, Figure 1).

Sediment samples collected from Patterson Lake had detectable levels of all trace elements tested for, except mercury. Reported concentrations of trace elements in the sediments collected from Patterson Lake were compared to the reported concentrations for all lakes assessed in the LWQA project.

In general, the trace element concentrations in the sediments collected from Patterson Lake were relatively high, ranging from approximately the median to above the 75th percentile. The exceptions were mercury which was nondetectable and selenium which was equal to or below the 25th percentile. Of note were the reported concentrations of copper in the deepest and inlet area sediments which were the highest reported concentrations for the entire LWQA project.

Concentrations of selected pesticides and PCBs were below detectable limits for all samples collected from Patterson Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Patterson Lake on July 7, 1992. A walleye and white sucker sample was collected representing the piscivore and bottom feeders groups, respectively. The walleye sample was composed of two fish with a mean length of 61 centimeters and a mean weight of 2,250 grams. The white sucker sample collected was a composite of five fish with a mean length of 42 centimeters and a mean weight of 748 grams.

In order to evaluate the fish tissue data for Patterson Lake the results for each sample was compared to that all corresponding samples assessed in the LWQA project. Trace element concentrations in the walleye sample collected from Patterson Lake were generally near or below the median concentration for all piscivores samples assessed. The exceptions were barium and mercury, which were slightly below and above the 75th percentile respectively.

The white sucker sample collected from Patterson Lake had reported trace element concentrations which were similar to the walleye sample. Reported trace element concentrations were generally near or below the median with the exception of barium. None of the trace element concentrations were high enough to warrant a consumption advisory, however, the reported concentration of 0.61 $\mu g\ L^{-1}$ for mercury in the walleye sample is high enough to warrant further investigations.

Detectable contaminant residues in the walleye sampled collected from Patterson Lake included DDT, DDE, DDD, dieldrin, trifluralin and PCBs. The white sucker sample collected from Patterson Lake contained only DDE and DDD. DDE and DDD are both breakdown derivatives of the agricultural insecticide DDT. DDT is an agricultural insecticide which was banned in 1973 due to its adverse effects upon the environment. Dieldrin, like DDT, is an agricultural insecticide, which was removed from agricultural use at approximately the same time and for similar reasons. Trifluralin, commonly known as treflan, is a selective, preemergent herbicide, commonly used in North Dakota. PCBs are generally considered industrial wastes, used in industrial manufacturing and dielectric fluids.

The walleye sample contained reported concentrations of DDT, DDE, DDD, dieldrin and PCBs that were equal to or above the 75th percentile for all piscivores sampled during the LWQA project. Of note is the reported concentration of 0.008 $\mu g\ g^{1}$ for DDT, which was the highest concentration reported during the LWQA project. The reported concentration of trifluralin in the walleye sampled collected from Patterson Lake was equal to the median concentration for all piscivores sampled during the LWQA project.

The white sucker sampled collected from Patterson Lake contained reported concentrations of DDE and DDD that were slightly below and above the reported 75th percentile for all bottom feeders collected during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Patterson Lake with its contributing watershed has a combined surface area of 272,960 acres located on the Missouri Slope Upland physiographic regions in Stark County, North Dakota. The watershed is composed primarily of rolling to hilly uplands, except in the badland areas and near prominent buttes. Slopes generally are gentle, with the relief ranging from 300 to 500 feet, but seldom exceeding 400 feet. Some areas have either never been glaciated or were glaciated so long ago as to have no glacial evidence remaining. This region, unlike the glaciated plains and Missouri Coteau regions of North Dakota, have well-defined drainages in the form of intermittent and perennial streams. Few surficial aquifers exist in this area, other than along stream drainages.

Soils in the Patterson Lake watershed are moderately deep to shallow, formed from weathered loamy glacial till or soft bedrock. Generally, soils are moderately fertile to fertile, well drained and susceptible to wind and water erosion. Annual average precipitation ranges from 14 to 16 inches with between 80 and 90 percent of the precipitation occurring between April and September. Principal land is small grain and livestock production. Other industries within the area and watershed include oil and coal exploration.

Approximately 20 percent of the region is composed of badlands. Badlands are eroded formations composed of buttes and steeply eroded drainages. Soils are generally thin, formed from sandy and clayey material. Badland areas are highly susceptible to wind and water erosion. Nonpoint source pollution from the surrounding watershed accounts for all of the sediment and nutrient loadings and pollution discharges to Patterson Lake.

Land use within the Patterson Lake watershed is 96.7 percent agricultural, with 45.4 percent actively cultivated, 29.3 percent in pasture, 13.3 percent in hay production, 6.7 percent in Conservation Reserve Program (CRP), 1.7 percent in farmsteads and 0.3 percent in woodlands. The remainder of the watershed is in wetland and wildlife management, transportation, and low density urban development (Table 2).

Table 2. Land use in the Patterson Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	45.4	50
Rangeland	29.3	60
Hayland	13.3	80
CRP	6.7	100
Woodlands	0.3	0
Wet/Wild[1]	0.8	N/A
Other	2.4	N/A
Farmsteads	234	N/A
Feedlots[2]	234	50

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

According to the information provided by the Stark County Soil Conservation District, 50 percent of all cultivated lands and between 60 and 100 percent of all the remaining agricultural lands within the Patterson Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

Based on an average soil loss of approximately four tons per acre, which takes into account all land treatments and practices currently active within the watershed, approximately 1,094,658 tons of soil are lost from the watershed annually. Assuming a conservative delivery rate of 10 to 15 percent, between 109,466 and 164,199 tons of soil are delivered to Patterson Lake annually.

Other sources of nonpoint source pollution discharge to Patterson Lake are from the cattle feeding and watering in it and the immediate upstream drainage, concentrated livestock feeding areas and low density urban development along its shores. These sources have the capabilities to contribute a significant percentage of the annual nutrient load to Patterson Lake due to their close proximities to the waters edge.

RED WILLOW LAKE

GRIGGS COUNTY

Peter N. Wax

Red Willow Lake is located in Griggs County, on the Glaciated Plains in northeastern North Dakota. Red Willow Lake is a natural lake with a surface area of 130 acres, a maximum depth of 22 feet and a mean depth of approximately 10 feet (Figure 1).

Red Willow Lake has a watershed of 5,760 acres. The watershed lies primarily to the south, west and east of the lake. Topography of the watershed is composed of a regular pattern of hills and valleys caused by glacial thrusting and sedimen-tation overlying a deep deposit of glacial till. The outlet to Red Willow Lake is to the north and at times of heavy precipitation or snow melt, outflows from Red Willow Lake travel in a northerly direction to the Sheyenne River. Principal land uses in the Red Willow Lake watershed is agricultural, predominating in livestock production.

Red Willow Lake is classified as a warm water fishery "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). NDG&F manage Red Willow Lake by annually assessing the fish community through test netting operations and stock accordingly.

Fisheries management by the NDG&F began as early as 1943 with eradication of an overabundant perch population. Subsequent management has included chemical and physical observations, stocking of a variety of fish species, biomanipulation and chemical eradication. Red Willow Lake does not have a history of frequent fish kills, however, partial and near complete fish kills have occurred occasionally since management records have been kept on Red Willow Lake. The most recent record of a substantial fish kill occurred in 1967.

In recent years, the stocking regiment by the NDG&F have included walleye, largemouth bass, pure musky and rainbow trout. A fish community assessment conducted by the NDG&F on August 1, 1991, captured in order of most abundant yellow perch, bluegill and walleye.

Red Willow Lake is 100 percent publicly owned. Nearly 100 percent of Red Willow Lake's shoreline has some type of development upon it including approximately 100 lake homes, a church camp and a small resort facility. Water-based recreation on Red Willow Lake is heavy, even though after mid-summer, dense submergent vegetation makes boating and fishing difficult. There is very limited public access to Red Willow Lake.

Water Quality

Water quality samples were collected from Red Willow Lake twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380500, Figure 1). Water column samples were collected for analysis at three separate depths of one meter, between three and four meters, and six meters.

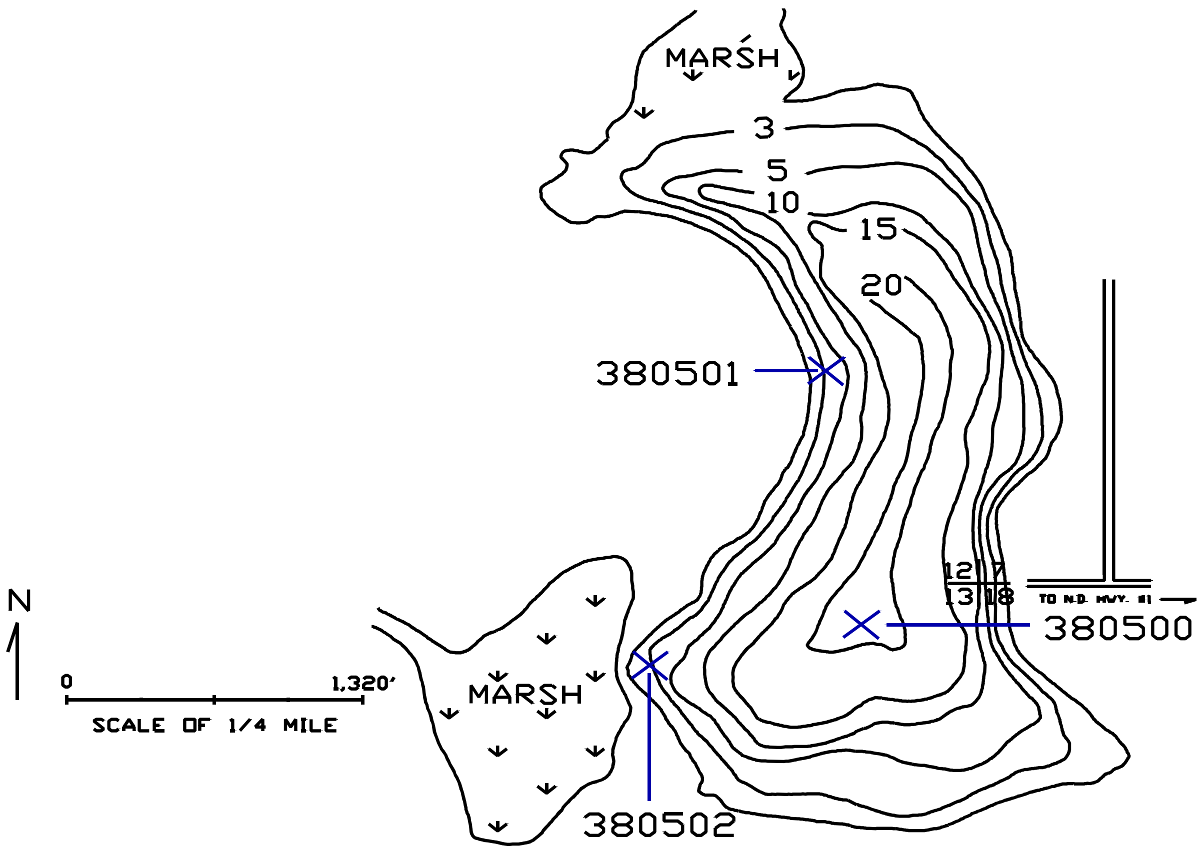


Figure 1. Morphometric map of Red Willow Lake.

During the summer of 1992 Red Willow Lake was weakly thermally stratified between three and four meters on August 19 and at approximately four meters on July 22 (Figure 2). During sampling, dissolved oxygen concentrations were at or near saturation to the depth of stratification with rapid depletion of dissolved oxygen concentrations below (Figure 3). Samples collected on March 10, 1993, showed Red Willow Lake thermally stratified at approximately two meters of depth with dissolved oxygen concentrations ranging between 0.4 and 0.9 mg L^{-1} below the thermocline and 2.2 to 4.9 mg L^{-1} above (Figure 2, Figure 3).

Water quality data collected during the LWQA project on Red Willow Lake describe a waterbody with relatively good water quality. Concentrations of total dissolved solids, hardness as calcium and conductivity were significantly lower than the North Dakota long-term average and lower than most other lakes sampled during the LWQA project (Table 1). Volume-weighted mean concentrations for total dissolved solids, hardness as calcium and conductivity were 342, 278 and 574 mg L^{-1}, respectively (Table 1). Red Willow Lake is a relatively well-buffered waterbody with a volume-weighted mean concentration of total alkalinity of $CaCO_3$ at 218 mg L^{-1}. The dominant anions in the water column were bicarbonates and sulfates, followed by chlorides with volume-weighted means of 237, 93, and 6 mg L^{-1}, respectively (Table 1).

Total phosphate as P and nitrate + nitrate as N had volume-weighted means of 0.068 and 0.032 mg L^{-1} (Table 1). Total phosphate as P concentrations ranged between 0.035 and 0.098 mg L^{-1} exceeding the state's target concentration of 0.020 mg L^{-1} on all occasions sampled. Nitrate + nitrite as N concentrations ranged between 0.00 and 0.095 mg L^{-1}, and was below the state's target concentration of 0.25 mg L^{-1} on all occasions sampled. The ratios between total phosphate as P and nitrate + nitrite as N of approximately 2:1 indicate Red Willow Lake is nitrogen limited. Under these conditions nitrogen-fixing organisms such as some blue-green algae species are favored. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 22, 1992 and March 10, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Red Willow Lake		1982-1991	
Total Dissolved Solids	342	mg L^{-1}	1209	mg L^{-1}
Conductivity	574	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	278	mg L^{-1}	488	mg L^{-1}
Sulfates	93	mg L^{-1}	592	mg L^{-1}
Chloride	6	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.068	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.032	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	218	mg L^{-1}	296	mg L^{-1}
Ammonia	0.071	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.23	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	237	mg L^{-1}	326	mg L^{-1}

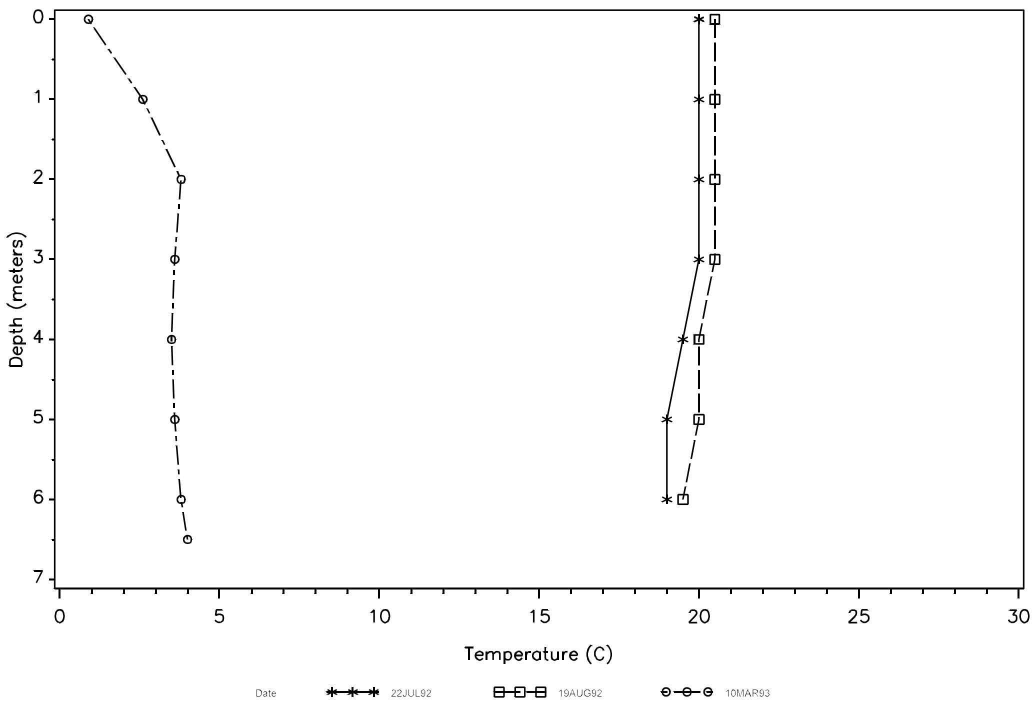


Figure 2. Temperature profile for Red Willow Lake.

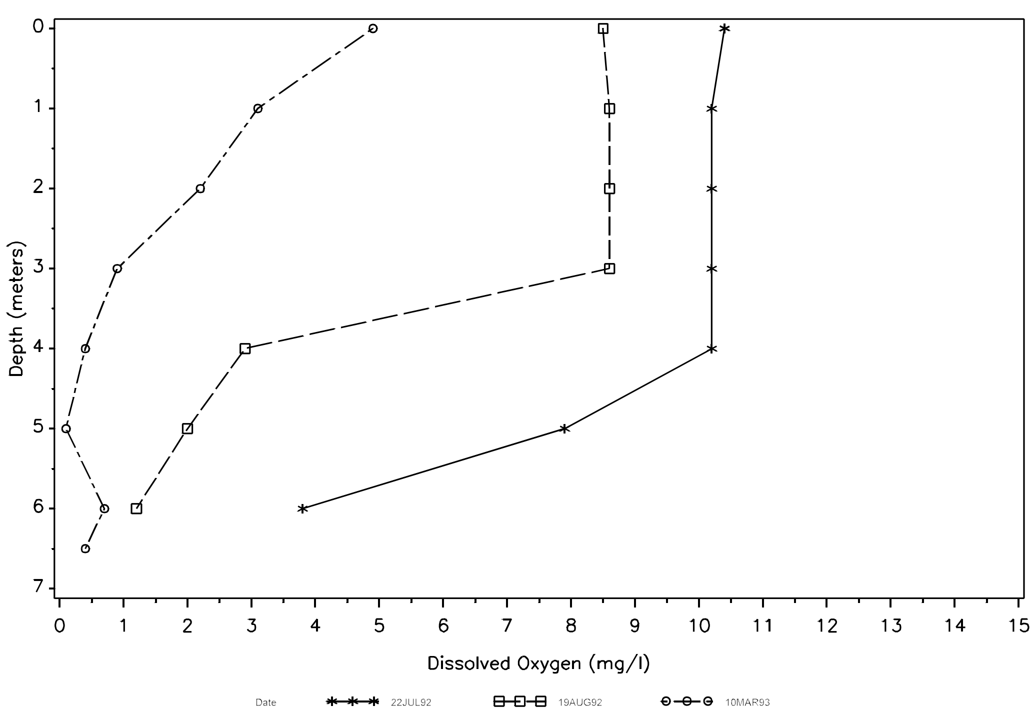


Figure 3. Oxygen profile for Red Willow Lake.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Red Willow Lake on July 22, 1992. At the time of the macrophyte survey approximately 25 percent of Red Willow Lake's surface area had aquatic vegetation. The dominant submergent macrophytes on Red Willow Lake were water milfoil, Myriophyllum spp. and sago pondweed, Potamogeton pectinatus. These two species occupied nearly 100 percent of the shoreline to a depth of approximately four feet. The only other submergent macrophyte identified was curlyleaf pondweed Potamogeton crispus.

Emergent macrophyte vegetation on Red Willow Lake included both cattails Typha spp. and bulrush Scirpus spp. Emergent macrophytes were found intermittently along the entire shoreline. Also identified during the macrophyte survey on Red Willow Lake were large mats of Chara an advanced form of algae. The Chara occupied major portions of the lake bottom from a depth of four to six feet. A map depicting the areal extent of macrophyte coverage on Red Willow Lake is contained in Appendix B.

Phytoplankton

Red Willow Lake's phytoplankton community was sampled two times during the LWQA project. At the time of the assessment Red Willow Lake's phytoplankton community was represented by six divisions and 52 genera. The largest contributors to the phytoplankton community by numerical density were the blue-green algae, Cyanophyta, with 22 genera represented. Mean density of the blue-green algae population for the two samples collected in the summer of 1992 was 260,879 cell mL^{-1}, representing a dominance of approximately 13 fold over all other divisions combined. Other divisions present in the samples in descending order of numerical density were Chlorophyta, Cryptophyta, Bacillariophyta, Chrysophyta and Pyrrophyta.

At the time of assessment mean phytoplankton concentrations by volume were also dominated by blue-green algae, Cyanophyta. The blue-green algae occupied approximately 25th percent of the phytoplankton community by volume. In order of descending volume the other divisions present were Bacillariophyta, Cryptophyta, Pyrrophyta, Chlorophyta and Chrysophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Red Willow Lake presently is a eutrophic waterbody. Primary indicators used to define Red Willow Lake's trophic status were summer surface total phosphate as P concentrations of 41 and 95 $\mu g\ L^{-1}$, chlorophyll-a concentrations of 8 and 6 $\mu g\ L^{-1}$ and secchi disk depth transparencies of 1.9 and 2 meters. These three primary water quality indicators define Red Willow Lake is mesotrophic bordering on eutrophic. However, the ancillary information such as large macrophyte biomass, frequent nuisance algal blooms, rapid oxygen depletion below the hypolimnion and under ice cover conditions and history of multiple fish kills are systematic of a hypereutrophic waterbody. In combination, the water quality data and ancillary information define a eutrophic lake status.

The water chemistry of Red Willow Lake is similar to or better then many mesotrophic waterbodies on the Glaciated Plains physiographic region of North Dakota. The most likely reason for Red Willow Lake to have water quality of a mesotrophic lake and exhibit physical characteristics of hypereutrophic waterbody is due to nonpoint source pollution discharges from the low density urban development on its shores. This developed area is negatively impacting the lake substantially as runoff carries pesticides, herbicides and general lawn wastes. Redwillow lake also is well connected to a surficial aguifer. This aquifer acts as a conduit for human wastes to enter the waterbody from leaking or inadequate drainfields, holding tanks or pit toilets.

Sediment Analysis

Sediments were collected from Red Willow Lake and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 380500), the littoral zone (Site 380501) and the inlet (Site 380502) (Figure 1).

Sediment samples collected from Red Willow Lake show detectable levels of all trace elements tested for except mercury and selenium. Reported concentrations of trace elements in the sediments collected from Red Willow Lake were compared to the reported concentrations for all lakes assessed in the LWQA project. In general, reported trace element concentrations in the sediments collected from Red Willow Lake were some of the lowest reported during the LWQA project with the majority of them being below the 25th percentile. The only exception was the reported concentration of arsenic in the deepest area sediments of 2.78 $\mu g\ g^{-1}$, which exceeded the 75th percentile for all deep area sediments collected during the LWQA project.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Red Willow Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Red Willow Lake on June 22, 1992. Walleye were the only species collected representing the piscivore group. The walleye sample collected from Red Willow Lake was composed of four fish with a mean length of 43 centimeters and a mean weight of 862 grams.

In order to evaluate the fish tissue data for Red Willow Lake the results for each fish sample was compared to that group for all lakes assessed in the LWQA project. Trace element concentrations in the fish samples collected from Red Willow Lake were generally near or below the 25th percentile and were some of the lowest concentrations reported during the LWQA project. The only exception was the mercury concentration of 0.2 $\mu g\ g^{-1}$ which approximates the median for all piscivores sampled during the LWQA project.

Detectable pesticide residues in the walleye sample collected from Red Willow Lake included DDT, DDE and DDD. DDE and DDD are both breakdown degradation by-products of the insecticide DDT and can produce biological effects similar to the parent compound. DDT is an agricultural insecticide that was removed from use in 1973 due to its harmful effect on the environment.

Concentrations of DDT, DDE and DDD reported in the walleye sample from Red Willow Lake were 0.004, 0.273, and 0.004 $\mu g\ g^{-1}$. All three of these concentrations exceed the 75th percentile while the

DDE concentration was the highest reported for any piscivore during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Red Willow Lake with its contributing watershed has a combined surface area of 5,760 acres located on the Glaciated Plains in Griggs County, North Dakota. The watershed is characterized by rolling to hilly glaciated plains with many small potholes and integrated drainages. The watershed is composed of a regular pattern of hills and valleys, caused by glacial thrusting and sedimentation overlying the relatively deep deposit of glacial till. Soils in the watershed vary significantly, but are generally formed from median to coarse textured sandy or clayey loamy glacial till. Soils are moderately erodible and moderately to well drained. Annual precipitation within the Red Willow Lake watershed is between 18 and 20 inches. Nonpoint source pollution from the surrounding watershed accounts for all of nutrient loading and pollutant discharges to Red Willow Lake.

Land use within the Red Willow Lake watershed is 88.6 percent agricultural with 17.4 percent actively cultivated, 52.1 percent grazed, 8.7 percent in haylands and 10.4 percent in Conservation Reserve Program (CRP). The remaining 11.4 percent of the watershed is in woodlands, wetlands, wildlife management, transportation, farms and low density urban development of which nearly 100 percent lies directly on the banks of Red Willow Lake (Table 2).

Table 2. Land use in the Red Willow Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	17.4	69
Rangeland	52.1	50
Hayland	8.7	50
CRP	10.4	100
Woodland	5.2	N/A
Wet/Wild[1]	5.6	N/A
Other	0.2	N/A
Farmsteads	3[3]	N/A
Feedlots[2]	2[3]	0.0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

According to the information provided by the Griggs County Soil Conservation District, 65 percent of the cultivated lands and between 50 and 100 percent of all the remaining agricultural lands are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

Based on an average soil loss of approximately 3.2 tons per acre, which takes into account all land practices and uses within the watershed, approximately 18,550 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 1,855 and 2,782 tons of soil reaches Red Willow Lake annually.

Sources of nonpoint source pollution discharges to Red Willow Lake other than agricultural wind and water erosion are from cattle feeding and watering in it and the immediate upstream drainage, poorly designed waste treatment systems for the approximately 100 recreational homes on its shore, fertilizer and pesticide runoff from the lawns and construction activities within the watershed. These sources are probably the largest single factor causing increased eutrophication and degradation of Red Willow Lake.

RIVERDALE SPILLWAY POND

MCLEAN COUNTY

Peter N. Wax

Riverdale Spillway Pond is located below the spillway of Garrison Dam in McLean County, North Dakota. It is a rectangular shaped pond created as a stilling basin for the dam's emergency spillway. Riverdale Spillway Pond has a surface area of 95.8 acres, an average depth of 22.4 feet and a maximum depth of nearly 70 feet (Figure 1).

Riverdale Spillway Pond's contributing watershed is relatively small at approximately 500 acres, with the majority of the watershed lying to the east of the pond itself. The watershed is predominantly native grasslands with the city of Riverdale lying at the headwaters. Topography of the watershed is composed of relatively well defined drainages and barren high wall. The watershed-to-lake size ratio for Riverdale Spillway Pond is approximately 5:1. Riverdale Spillway Pond receives most of its annual hydrologic budget from Lake Sakakawea in the form of seepage through the spillway gates.

Riverdale Spillway Pond is classified as a cold water fishery, "Waters capable of supporting growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The North Dakota Game and Fish Department (NDG&F) manage Riverdale Spillway Pond by annually assessing the fish community by test netting and stock accordingly.

Fisheries management began on Riverdale Spillway Pond in 1973 after successful negotiations with the Corps of Engineers. The negotiations included closing the entire east bank to public use due to the high wall hazards and provided for construction of recreational facilities on the west shore. Relatively limited data is available on the initial fishery management on Riverdale Spillway Pond, however, the first test nettings conducted by the NDG&F on the impoundment captured yellow perch, bluegill, crappie, walleye, rainbow trout and northern pike. Over the years, the Riverdale Spillway Pond has received a wide variety of fish including lake trout, rainbow trout, chinook salmon, crappie, bluegill and walleye. Often times, fish left over at the federal Garrison Dam hatchery are stocked into the pond.

In recent years, the stocking regiment by the NDG&F has included northern pike, walleye, sauger, rainbow trout, bluegill and crappie. A fish community assessment conducted on Riverdale Spillway Pond on July 2, 1991, captured in order of most abundant crappie, yellow perch, walleye, bluegill, carp, white suckers, smallmouth bass and freshwater drum. On the west shore of Riverdale Spillway Pond are well-maintained public facilities, accessible from all season roads. Public facilities include a small camping area, poured cement boat ramp, associated parking and toilets. Public use on Riverdale Spillway Pond is light to moderate with ice fishing for perch providing the most utilized fishery.

Nearly 100 percent of Riverdale Spillway Pond's watershed is within an easement refuge. Very little nonpoint source pollution from this area of the watershed is

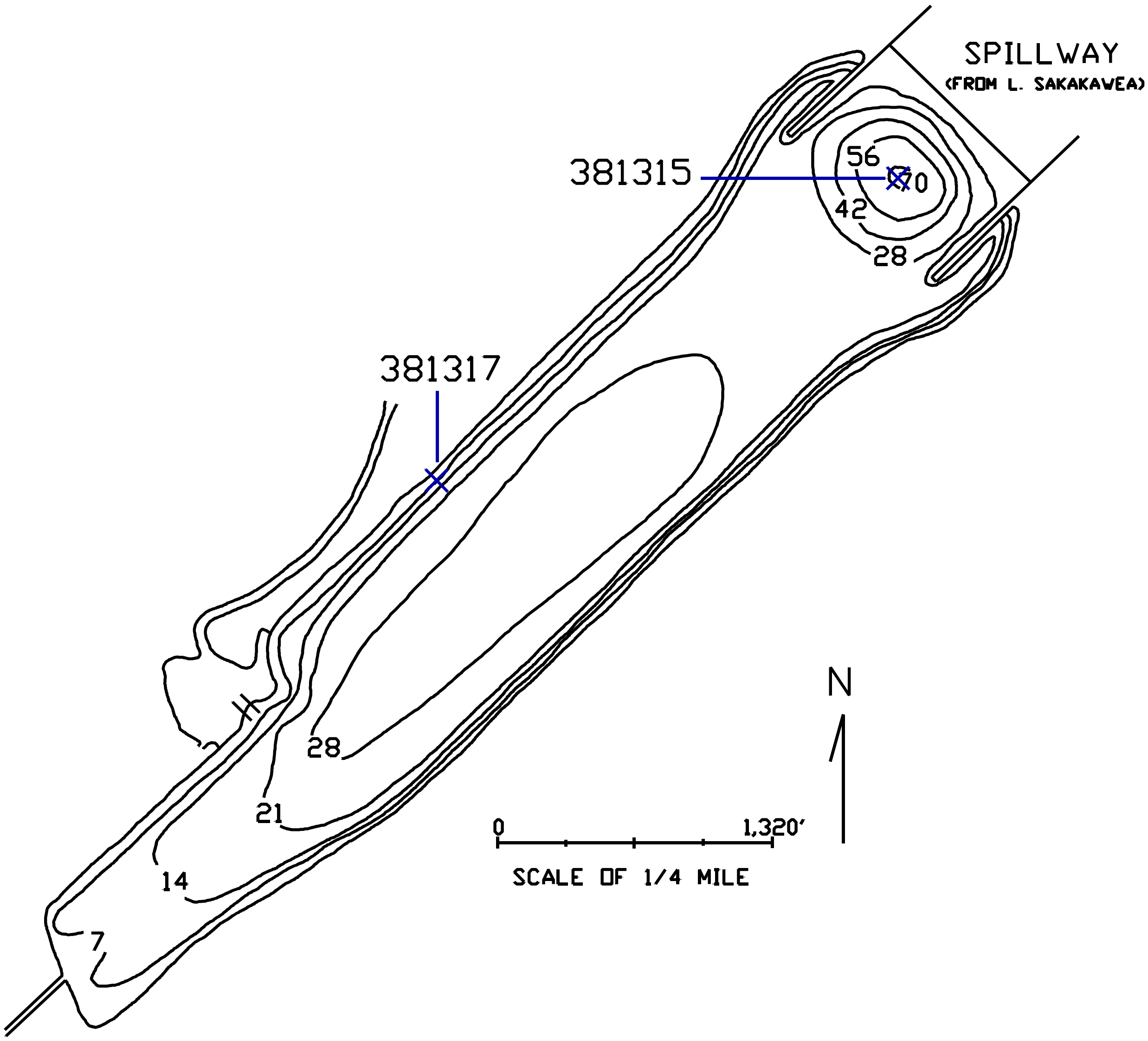


Figure 1. Morphometric map of Riverdale Spillway Pond.

delivered to Riverdale Spillway Pond. However the shoreline, in particular the high wall on the western bank is composed of exposed clay, sand and gravel deposits. These exposed layers are affected by wave action and subsequently are actively eroding.

Water Quality

Water quality samples were collected from Riverdale Spillway Pond twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 381315, Figure 1). Water column samples were collected for analysis at three depths of one meter, ten meters, and between 19 and 20 meters.

During the summer sampling of 1992 Riverdale Spillway Pond was thermally stratified between eight and ten meters of depth on July 20 and August 10 (Figure 2). Dissolved oxygen concentrations during summer sampling were near saturation to the depth of thermal stratification with rapid depletion below (Figure 3). Samples collected on February 22, 1993, showed Riverdale Spillway Pond's water column thermally stratified between a depth of 17 and 18 meters. Dissolved oxygen concentrations ranged between 7.7 and 11.4 mg L^{-1} above the thermocline and 0.0 to 0.2 mg L^{-1} below (Figure 2, Figure 3).

Riverdale Spillway Pond is a well-buffered waterbody. Total alkalinity as $CaCO_3$ concentrations ranged between 227 and 546 mg L^{-1} with a volume-weighted mean concentration of 286 mg L^{-1} (Table 1). Concentrations of total dissolved solids, hardness as calcium, and conductivity were below the state's long-term average with volume-weighted mean concentrations of 708, 207, and 1,107 mg L^{-1}, respectively (Table 1). The dominant anions in the water column were bicarbonates and sulfates. Volume-weighted mean concentrations of bicarbonates and sulfates were 332 mg L^{-1} and 268 mg L^{-1}, respectively (Table 1).

The nutrients total phosphate as P and nitrate + nitrite as N had volume-weighted means of 0.042 and 0.065 mg L^{-1}, respectively. Total phosphate as P concentrations ranged from nondetectable to 0.165 mg L^{-1} exceeding the state's target concentration of 0.02 mg L^{-1} in all but three samples analyzed. Nitrate + nitrite as N concentrations ranged between nondetectable to 0.427 mg L^{-1} exceeding the state's target concentration of 0.25 mg L^{-1} in only a single sample. The ratios of total dissolved phosphorus to nitrate + nitrite as N plus ammonia ranged between 1:3.5 to 1:11 with an average of 1:8.9, indicating Riverdale Spillway Pond is phosphorus limited. A complete list of LWQA water quality data is contained in Appendix A.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Riverdale Spillway Pond on July 20, 1992. At the time of the macrophyte survey Riverdale Spillway Pond contained a very low density population of sago pondweed Potamogeton pectinatus and american pondweed Potamogeton americanus in the northern portions of the waterbody and a sparse intermittent population of cattails Typha spp. lining the shores. A map depicting the areal extent of macrophyte coverage on Riverdale Spillway Pond is contained in Appendix B.

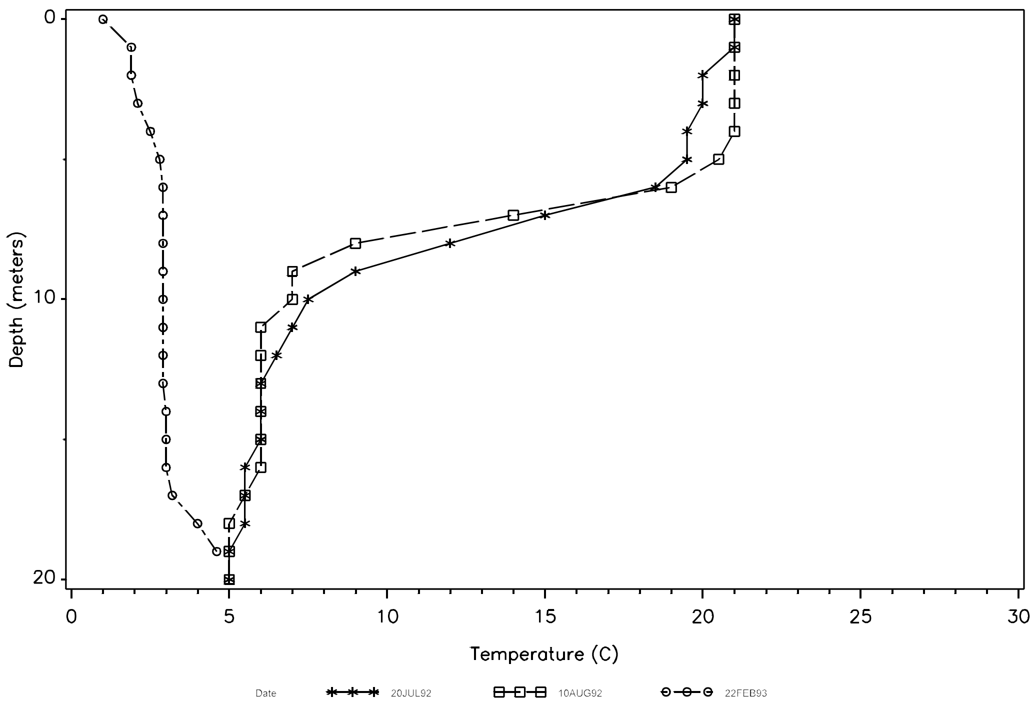


Figure 2. Temperature profile for Riverdale Spillway Pond.

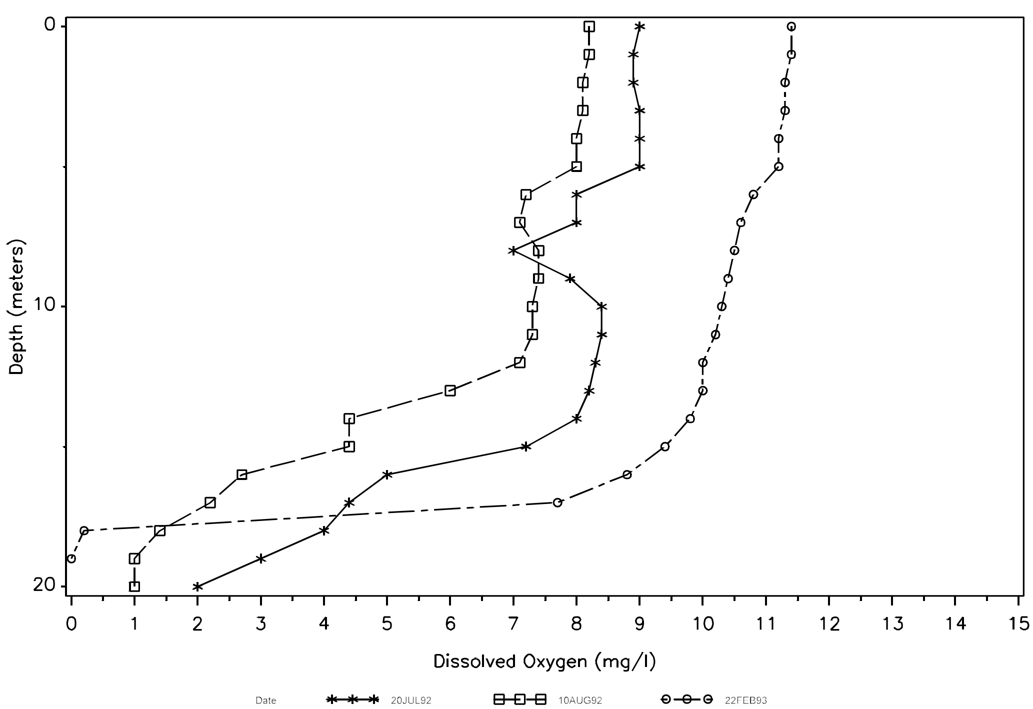


Figure 3. Oxygen profile for Riverdale Spillway Pond.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 20, 1992 and February 22, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Riverdale Spillway Pond		1982-1991	
Total Dissolved Solids	708	mg L^{-1}	1209	mg L^{-1}
Conductivity	1101	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	207	mg L^{-1}	488	mg L^{-1}
Sulfates	268	mg L^{-1}	592	mg L^{-1}
Chloride	17	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.042	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.065	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	286	mg L^{-1}	296	mg L^{-1}
Ammonia	0.157	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	0.547	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	332	mg L^{-1}	326	mg L^{-1}

Phytoplankton

Riverdale Spillway Pond's phytoplankton community was sampled twice during the summer of 1992. The two sample collected contained a phytoplankton community composed of six divisions and 27 genera. The largest contributors to Riverdale Spillway Pond's phytoplankton community by numerical density were the blue-green algae, Cyanophyta. Mean density of the blue-green algae for the two samples collected during the summer of 1992 was 20,368 cell mL^{-1} representing a numerical dominance of approximately two fold over all other divisions combined. Other divisions present in descending number were Chlorophyta, Cryptophyta, Chrysophyta, Bacillariophyta and Pyrrophyta.

At the time of the assessment mean phytoplankton concentrations by volume were more evenly distributed with division Cryptophyta occupying the greatest space. The other divisions present in order of descending volume were Chrysophyta, Bacillariophyta, Chlorophyta, Cyanophyta and Pyrrophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

LWQA data collected during 1991 in combination with ancillary information define Riverdale Spillway Pond is mesotrophic. This assessment was based on secchi disk depth transparencies of 1.8 meters and total phosphate as P concentrations of 57 $\mu g\ L^{-1}$ to less than detectable during the same period. Supporting ancillary information of a mesotrophic lake condition are a low macrophyte biomass, infrequent nuisance algal blooms, relatively diverse phytoplankton population, good dissolved oxygen concentrations throughout entire year and no history of fish kills.

Sediment Analysis

Sediments were collected from Riverdale Spillway Pond and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area the lake (Site 381315) and the littoral area (Site 381317) (Figure 1).

Sediment samples collected from Riverdale Spillway Pond had detectable levels of all trace elements tested for, with the exception of mercury in the deepest area sediments. Reported concentrations of trace elements in the sediments collected from Riverdale Spillway Pond were compared to the concentration reported for all lakes assessed in the LWQA project. In general, reported trace element concentrations in the sediments collected from Riverdale Spillway Pond were higher then average with the reported concentrations of copper and chromium in the deepest area sediments and arsenic, cadmium, barium and lead in the littoral area sediments exceeding the 75th percentile.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Riverdale Spillway Pond. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Riverdale Spillway Pond on July 22, 1992. Walleye and white suckers were collected representing a piscivore and bottom feeder sample, respectively. The walleye sample was composed of four fish with a mean length of 39.2 centimeters and a mean weight of 512 grams. The white sucker sample was composed of a single fish with a mean length of 38 centimeters and a mean weight of 580 grams. In order to evaluate the fish tissue data for Riverdale Spillway Pond the results of each fish sample was compared to all corresponding samples assessed in the LWQA project.

In general, trace element concentrations in the walleye sample collected from Riverdale Spillway Pond were low. The only exceptions were the reported concentrations of selenium and cadmium, which were above the median concentrations yet below the 75th percentile. Reported concentrations of trace elements in the white sucker sample collected from Riverdale Spillway Pond were like the walleye sample in that the majority of concentrations were below the median. The only exception was the reported concentration of selenium, which exceeded the 75th percentile for all bottom feeders sampled during the LWQA project.

Detectable pesticide residues in the walleye sample collected from Riverdale Spillway Pond included DDT, DDE, DDD, dieldrin and nonachlor. DDE and DDD are degradation byproducts of the insecticide DDT and can produce biological effects similar to the parent compound when available to the environment. DDT and dieldrin are agricultural insecticides which were removed from use in the United States due to the environmental risks associated with their use. Nonachlor is a principal ingredient in technical chlordane. Chlordane is an agricultural insecticide which was also removed from use in the early 1970s due to its environmental risk. Concentrations of selected pesticides and PCBs in the white sucker sample collected from Riverdale Spillway Pond were below detectable limits.

The reported concentrations of DDT, dieldrin and nonachlor in the walleye sample collected from Riverdale Spillway Pond were above the 75th percentile for all piscivores sampled during the LWQA project at 0.002, 0.003 and 0.005 $\mu g\ g^{-1}$, respectively. The concentrations of DDE and DDD of 0.007 and 0.003 $\mu g\ g^{-1}$ were
near the median concentrations for all piscivores sampled during this same time period. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Riverdale Spillway Pond with its contributing watershed has a combined surface area of approximately 600 acres located on the edge of the Missouri River flood plain below Garrison Dam in McLean County, North Dakota. The watershed is characterized by rolling hills, intermittent streams and steep high walls where the pond was created. Soils are predominantly well drained, built from gravelly, sandy glacial materials. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to Riverdale Spillway Pond.

Land use within the Riverdale Spillway Pond watershed is approximately 65 percent easement refuge, 21 percent pasture land, 10 percent in urban development, and 2 percent in transportation and recreational development (Table 2). Due to the relatively small watershed and limited exposed acres very little nonpoint source pollution is delivered to Riverdale Spillway Pond. An estimate of the amount of soil loss, based on the current land uses and practice, is approximately 1,008 tons of soil annually. Assuming a conservative delivery rate of 10 to 15 percent, between 101 and 151 tons of soil are delivered to Riverdale Spillway Pond annually. Of the lands which are in easement refuge, approximately two percent are compose of exposed high wall. This area of the watershed is highly susceptible to wind and wave action and is probably the largest source of sedimentation to Riverdale Spillway Pond. This area and storm water runoff from the community of Riverdale and surrounding easement refuge are in effect the only pollution sources to Riverdale Spillway Pond.

Table 2. Land use in the Riverdale Spillway Pond watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Urban development	10	N/A
Native grasses	65	100
Pasture	22.5	100
Food plots	0.5	N/A
Transportation	2[3]	N/A

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

SHEEP CREEK DAM

GRANT COUNTY

Peter N. Wax

Sheep Creek Dam is located on the Missouri Slope Uplands in central Grant County, North Dakota. It is a narrow, winding reservoir on Sheep Creek approximately 1/2 mile upstream from the confluence of Sheep Creek and the Cannonball River. Sheep Creek Dam was constructed by the Bureau of Outdoor Recreation (BOR), the North Dakota Game and Fish Department (NDG&F), the Soil Conservation Service (SCS) and Grant County. It is a multipurpose reservoir built for recreation and flood control. At the time of the LWQA assessment, Sheep Creek Dam was approximately 8 feet below full pool. At full pool, Sheep Creek Dam has a surface area of 84.4 acres, with a maximum depth of 36.5 feet, and an average depth of 14.5 feet (Figure 1).

Topography of Sheep Creek Dam's watershed is composed of rolling to hilly uplands except in badland areas and near prominent buttes. Slopes are gentle with reliefs ranging from 100 to 150 feet. This physiographic region of North Dakota has well-defined drainages in the form of intermittent streams.

Soils in the Sheep Creek Dam watershed are moderately deep to shallow, formed from weathered, loamy glacial till or soft bedrock. Generally, soils are moderately fertile, well drained and highly susceptible to wind and water erosion. Average precipitation within the watershed ranges from 14 to 16 inches with between 80 and 90 percent of the annual precipitation occurring between April and September. Principal land use is small grain and livestock production.
Approximately 5 percent of this region is composed of badlands. Badlands are eroded formations composed of buttes and steeply eroded drainages. Soils in the badland regions of the watershed are generally thin, formed from sandy and clayey materials. Badland areas are readily susceptible to wind and water erosion.

Sheep Creek Dam is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Sheep Creek Dam by annually assessing the fish community by test netting and stock accordingly.

The initial fishery managed on Sheep Creek Dam was rainbow trout. In 1978, the lake was chemically eradicated to remove undesirable fish species. Test netting operations conducted the following spring captured brook stickleback, golden shiner, Iowa darter, silvery minnow and white suckers. In 1980 the NDG&F stocked rainbow trout and smallmouth bass, followed by plants of walleye and bluegill in 1981 and 1984. From this time, even though complete eradication was unsuccessful, an excellent fishery has been maintained on Sheep Creek Dam. Recent stockings by the NDG&F have included smallmouth bass, brown trout, rainbow trout, walleye and northern pike. A fish community assessment conducted by the NDG&F on July 25, 1991, captured in order of most abundant black crappie, bluegill, smallmouth bass, white sucker, green sunfish and walleye.

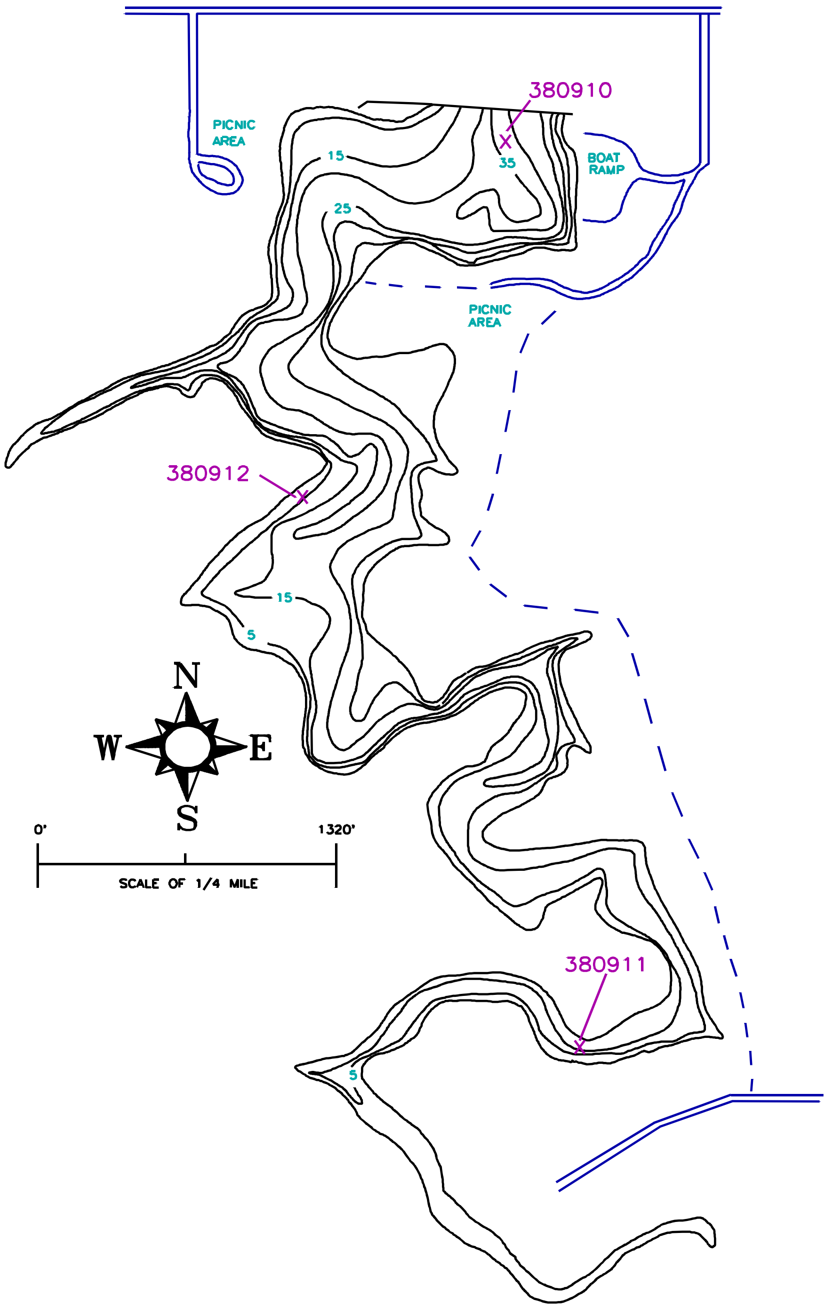


Figure 1. Morphometric map of Sheep Creek.

One hundred percent of Sheep Creek Dam's shoreline is under public easement. Approximately 30 percent of the shoreline in the northern portion of the reservoir is accessible to the public. Excellant and well maintained public facilities at this location include a boat ramp and associated parking, picnic shelters, changing facilities and public toilets. Public use and fishing pressure is heavy to moderate depending on the crappie fishery.

In general, Sheep Creek Dam is a very popular, well-maintained reservoir that has the capabilities to provide recreational opportunities for generations to come. Presently, Sheep Creek Dam is beginning to suffer degradation symptoms typifying a highly fertile and poorly treated watershed. The NDG&F operates a hypolimnetic drawdown on Sheep Creek Dam in conjunction with oxygen and temperature profiles to help manage nutrient availability. Operation of the hypolimnetic drain, however, is treating a symptom and not the illness. If Sheep Creek Dam is to continue supplying the sport fishery and water-based recreation opportunities to the surrounding community, better conservation practices will need to be implemented within the watershed.

Water Quality

Water quality samples were collected from Sheep Creek Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380910, Figure 1). Water column samples were collected for analysis at three separate depths of one meter, four meters and seven meters during the summer, and one meter, three meters and six meters during the winter.

During the summer sampling of 1992, Sheep Creek Dam was thermally stratified between four and five meters on July 8, and at approximately six meters of depth on August 5 (Figure 2). Dissolved oxygen concentrations on the July sample date were near saturation above the thermocline and between 2.4 and 6.4 below. On the August sample date, dissolved oxygen concentrations were again near saturation to the depth of thermal stratification and between 1.4 and 2.0 mg L^{-1} below. On January 16, 1993, Sheep Creek Dam was very weakly thermally stratified between five and six meters of depth with dissolved oxygen concentrations ranging between 1.75 and 3.9 mg L^{-1} above the thermocline and 0.2 to 0.6 mg L^{-1} below (Figure 2, Figure 3).

Concentrations of total dissolved solids, total kjeldahl nitrogen, conductivity and ammonia were all above the state's long-term average with volume-weighted mean concentrations of 1,280, 2.42, 1,898 and 0.55 mg L^{-1}, respectively (Table 1). Sheep Creek Dam is a well-buffered waterbody with a volume-weighted mean concentration of total alkalinity as $CaCO_3$ of 375 mg L^{-1} (Table 1). Sulfates and bicarbonates were the dominant anions in the Sheep Creek Dam's water column. Sulfate concentrations ranged between 528 and 713 mg L^{-1}, with a volume-weighted mean concentration of 617 mg L^{-1} and bicarbonates ranged between 314 and 517 mg L^{-1}, with a volume-weighted mean of 386 mg L^{-1} (Table 1).

Sheep Creek Dam contained abundant amounts of the nutrients total phosphate as P and nitrate + nitrite as N. Total phosphate as P concentrations ranged between 0.179 to 0.709 mg L^{-1} exceeding the state's target concentration of 0.02 mg L^{-1} on all occasions sampled.

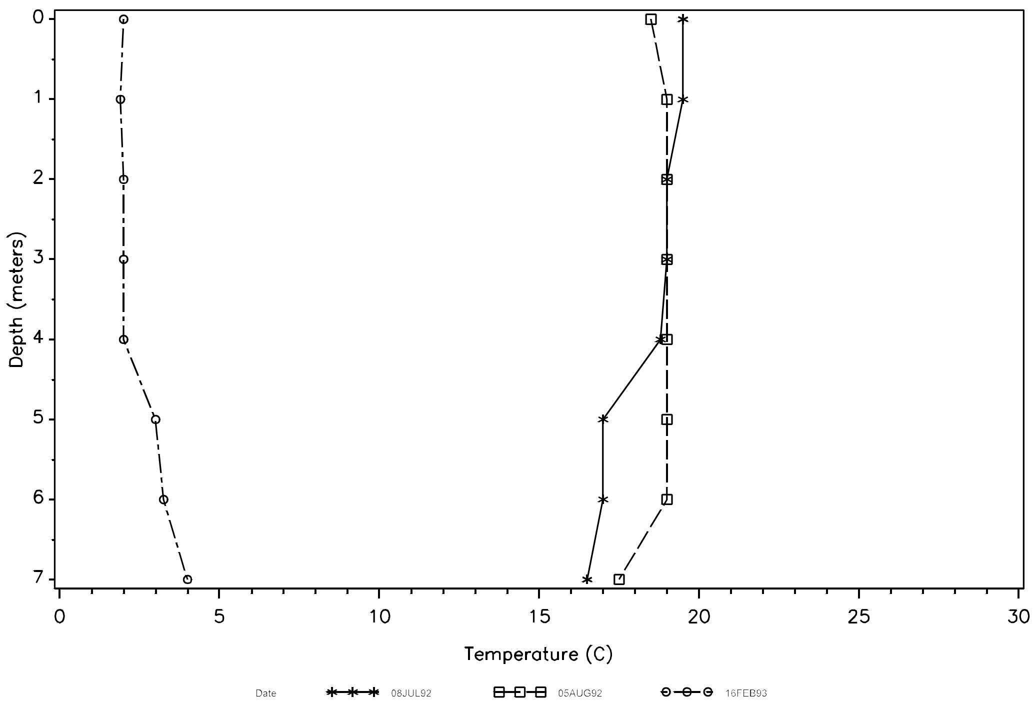


Figure 2. Temperature profile for Sheep Creek Dam.

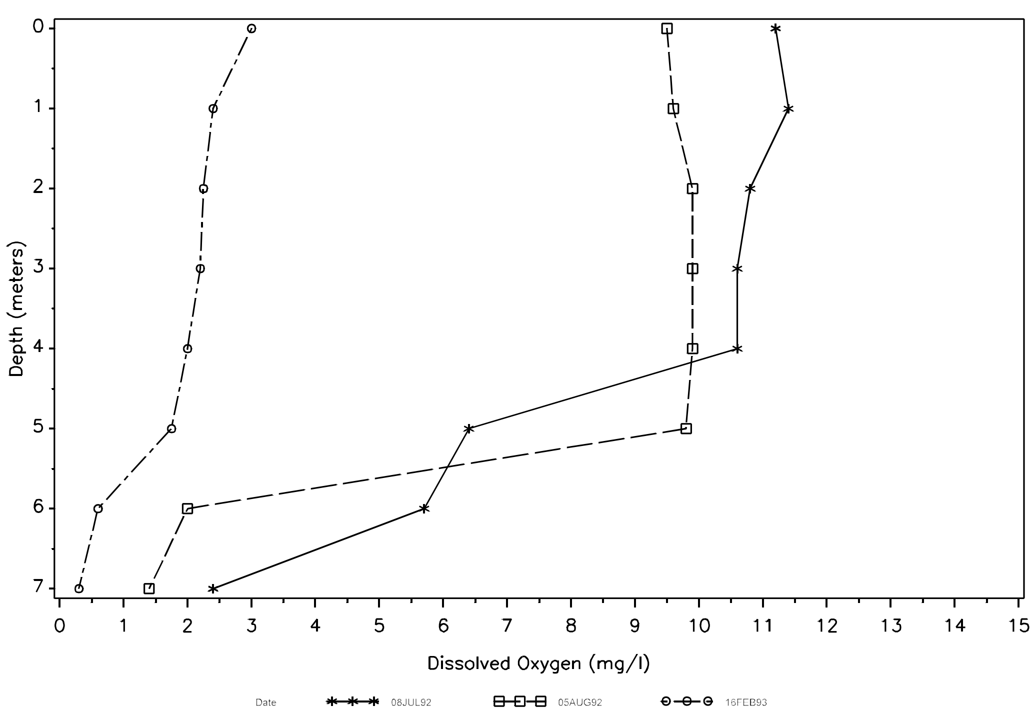


Figure 3. Oxygen profile for Sheep Creek Dam.

Nitrate + nitrite as N concentrations ranged between 0.000 and 0.790 mg L^{-1} exceeding the state's target concentration of 0.25 mg L^{-1} only at the surface on July 8, 1992. The ratio of nitrate + nitrite as N and total phosphate as P of 1:0.94 indicates Sheep Creek Dam is nitrogen limited. Under these conditions, nitrogen fixing organisms such as some species of blue-green algae are favored.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 8, 1992 and February 16, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Sheep Creek Dam		1982-1991	
Total Dissolved Solids	1280	mg L^{-1}	1209	mg L^{-1}
Conductivity	1898	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	365	mg L^{-1}	488	mg L^{-1}
Sulfates	617	mg L^{-1}	592	mg L^{-1}
Chloride	9	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.231	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.247	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	375	mg L^{-1}	296	mg L^{-1}
Ammonia	0.549	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.42	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	386	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Sheep Creek Dam as part of the LWQA project on July 8, 1992. At the time of the macrophyte survey, approximately ten percent of Sheep Creek Dam's surface area had aquatic vegetation. Nearly 100 percent of the lake's surface area to a depth of three to four feet in the southern half of the lake had mixed stands of sago pondweed Potamogeton pectinatus, water milfoil Myriophyllum spp. and curlyleaf pondweed Potamogeton crispus. The population distribution was approximately 90 percent sago pondweed, 5 percent curlyleaf and 5 percent water milfoil.

The northern half of Sheep Creek Dam had a mixed stand of sago pondweed Potamogeton pectinatus and curlyleaf pondweed Potamogeton crispus with a ratio of approximately 50:50. A small population of little duckweed Lemna minor was also present near the dam's face. A map depicting the areal extent of macrophyte coverage on Sheep Creek Dam is contained in Appendix B.

Phytoplankton

Sheep Creek Dam's phytoplankton community was sampled two times during the summer of 1992. At the time of sampling Sheep Creek Dam's phytoplankton community was represented by five divisions and 20 genera. The largest contributors to Sheep Creek Dam's phytoplankton community by numerical density were the blue-green algae, Cyanophyta, with five genera present. Mean density of the blue-green algae population for the two samples collected during the summer of 1992 was 22,649,690 cell mL^{-1}, representing a dominance of 45 fold over all other divisions combined. The most diverse division present was Chlorophyta with ten genera. Other divisions identified in descending order of dominance by numerical density were Cryptophyta, Pyrrophyta and Bacillariophyta.

The division Pyrrophyta by numerical density occupied only one tenth of one percent of the phytoplankton community. However, due to the large size of the single genera presented Ceratuim hirundinella, it occupied the largest amount of volume, followed by Cyanophyta, Cryptophyta, Chlorophyta and Bacillariophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

LWQA data collected on Sheep Creek Dam during the LWQA project defined Sheep Creek Dam as hypereutrophic. Primary water quality data used to make this assessment was summer surface total phosphate as P concentrations of 179 and 211 $\mu g\ L^{-1}$, chlorophyll-a concentrations of 7 and 91 $\mu g\ L^{-1}$ and secchi disk depth transparency readings of 1.0 and 1.4 meters. Supporting ancillary information of a hypereutrophic lake assessment are frequent nuisance algal blooms and rapid oxygen depletion below the hypolimnion and under ice cover conditions.

Sediment Analysis

Sediments were collected from Sheep Creek Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 380910), the inlet (Site 380911) and the littoral zone (Site 380912) (Figure 1).

Sediment samples collected from Sheep Creek Dam had detectable levels of all trace elements tested for with the exception of mercury and cadmium in the deepest area sediments. Reported trace element concentrations in the sediments collected from Sheep Creek Dam were compared the reported concentrations for all lake sediments assessed in the LWQA project.

In general, reported trace element concentrations in the deepest and inlet areas of Sheep Creek Dam were relatively high, with the majority exceeding the 75th percentile for all sediments collected during the LWQA project. The exceptions were the cadmium, mercury and selenium concentrations, which were either nondetectable or near the 25th percentile. The highest reported trace element concentrations in the inlet area sediments were near the median with many near or below the 25th percentile.

Concentrations of pesticides and PCBs were below detectable limits for all sediment samples collected from Sheep Creek Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Sheep Creek Dam on May 28, 1992. Walleye and white suckers were collected representing a piscivore and bottom feeder sample respectively. The walleye sample was composed of three fish with a mean length of 41.3 centimeters and a mean weight of 717 grams. The white sucker sample was composed of five fish with a mean length of 39.6 centimeters and a mean weight of 737 grams.

In order to evaluate the fish tissue data for Sheep Creek Dam the results for each fish sample was compared to all corresponding samples assessed in the LWQA project. Reported trace element concentrations in the fish samples collected from Sheep Creek Dam were all above the detection limits except for copper, in both the walleye and white sucker samples, and cadmium in the walleye sample.

In general, the reported concentrations of trace elements in the walleye sample were below the 25th percentile. The exceptions were the reported concentrations of chromium, arsenic and selenium which were above the 75th percentile for all piscivores sampled during the LWQA project. The reported concentrations of trace elements in the white sucker sample were relatively high with the majority being above the median and many above the 75th percentiles The exceptions were the reported concentration of arsenic and lead which were below the median.

Detectable contaminants in the walleye sample collected from Sheep Creek Dam included DDT, DDE, DDD and PCBs. Detectable pesticide residues in the white sucker sample collected from Sheep Creek Dam included DDE and DDD. DDE and DDD are breakdown derivatives of the agricultural insecticide DDT. DDT was removed for use in 1973 due to the environmental degradation associated with its use. PCBs are generally considered industrial wastes, commonly used in plasticizers and dielectric fluids.

The reported concentrations of DDT and PCBs in the walleye sample were above the 75th percentile with the PCB concentration being equal to the maximum reported concentration of 0.02 $\mu g\ g^{-1}$ for any piscivore sample collected during the LWQA project. Concentrations of DDE and DDD in the walleye and white sucker samples collected from Sheep Creek Dam were above the median yet below the 75th percentile for their prospective groups. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Sheep Creek Dam with its contributing watershed has a combined surface area of 37,827 acres located on the missouri slope uplands in Grant County, North Dakota. The watershed is composed primarily of rolling to hilly uplands except in badland areas and near prominent buttes. Slopes are generally gentle, with the relief ranging from 100 to 150 feet. Drainages within the watershed are generally well defined in the form of intermittent streams. Few surficial aquifers exist within the watershed other than along stream drainages.

Soils within the watershed are moderately deep to shallow, formed from weathered, loamy glacial till or soft bedrock. Generally, soils are moderately fertile to fertile, well drained, and susceptible to wind and water erosion. Annual precipitation ranges from 14 to 16 inches, with 80 to 90 percent of the annual precipitation occurring between April and September.

Approximately five percent of Sheep Creek Dam's watershed is composed of badlands. Badlands are eroded formations composed of buttes and steeply eroded drainages. Soils are generally thin, formed from sandy or clayey material. Badlands areas are highly susceptible to wind and water erosion. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to Sheep Creek Dam.

Land use within the Sheep Creek Dam watershed is 96 percent agricultural with 49.1 percent actively cultivated, 32.8 percent in rangeland, 8.5 percent in haylands and 5.4 percent in Conservation Reserve Program (CRP). The remaining 4 percent of the watershed is in wildlife and wetland management, transportation, low density urban development, and farmsteads. Along with the 29 farmsteads, there are 26 concentrated livestock feeding areas within Sheep Creek Dam's watershed (Table 2).

According to the information provided by the Hettinger and Grant County Soil Conservation Districts between 45 and 80 percent of all cultivated lands within the watershed and between 75 and 100 percent of the remaining agricultural lands within the Sheep Creek Dam watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Sheep Creek Dam watershed the average "T" value is three to five tons per acre. Based on an average soil loss of just over 10 tons per acre, which takes into account all land practices and treatments currently being implemented, approximately 144,443 tons of soil are lost annually from the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 14,444 and 21,666 tons of soil are delivered to Sheep Creek Dam annually.

Other sources of nonpoint source pollution discharges to Sheep Creek Dam are from concentrated livestock feedings areas, construction activities and energy development. These sources have the capabilities to contribute nutrients to the lake and may be the most significant potential source due to their ability to discharge large amounts of nutrients and sediments during snowmelt and runoff events.

Table 2. Land use in the Sheep Creek Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	49.1	45-80
Rangeland	32.8	75-95
Hayland	8.5	65-90
CRP	5.4	100
Wet/Wild[1]	0.7	N/A
Other	2.4	N/A
Farmsteads	29[3]	N/A
Feedlots[2]	26[3]	50

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

SILVER LAKE

SARGENT COUNTY

Peter N. Wax

Silver Lake is located in Sargent County, North Dakota, on a tributary to the Wild Rice River. Silver Lake is a natural lake with an added concrete structure across the outlet to enhance lake levels. With enhancement, Silver Lake has a surface area of 91 acres, a maximum depth of 11 feet and an average depth of 8.6 feet (Figure 1).

Silver Lake's watershed of 130,210 acres lies on the southeastern edge of the Glaciated Plains physiograghic region of North Dakota. Topography of the watershed is gently rolling to rolling, with average slopes rarely exceeding six percent. Soils within the watershed are generally formed from medium to coarse textured sandy or clayey loamy glacial till. Soils are moderately erodible and moderately well drained. Annual precipitation within the Silver Lake watershed is between 15 and 20 inches with considerable variation between years. Land use is primarily livestock and small grain production.

Silver Lake is classified as a cool water fishery, "Waters capable of supporting growth and propagation on nonsalmonoid fishes and marginal growth of salmonoid fishes and associated biota" (NDSDHCL, 1991). The NDG&F manage Silver Lake through population assessments, stockings and habitat manipulations. Fishery management on Silver Lake has always been complicated by an abundance of nongame species. The introduction of nongame species is an annual event through Wild Rice River's flood waters. This situation might be improved and has been considered by the NDG&F through construction of a fish barrier between the river and the lake proper.

In recent years the stocking regiment by the NDG&F has included walleye and northern pike. A fish community assessments conducted by the NDG&F on July 9, 1991, captured in order of most abundant, black bullhead, northern pike, walleye and fathead minnow. Fishing pressure on Silver Lake is variable depending on the productivity of the fishery. Silver Lake has a unstable fishery history due to unreliable water levels and corresponding fish survival rates.

There are excellent and well maintained public facilities on Silver Lake. Public facilities include a public use area with boat ramp, associated parking, picnic shelters and camping. The facilities are maintained by the Sargent County Park Board in cooperation with the lake region improvement association.

Water Quality

Water quality samples were collected from Silver Lake twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 381100) (Figure 1). Water column samples were collected for analysis at two depths of one meter and between two and three meters.

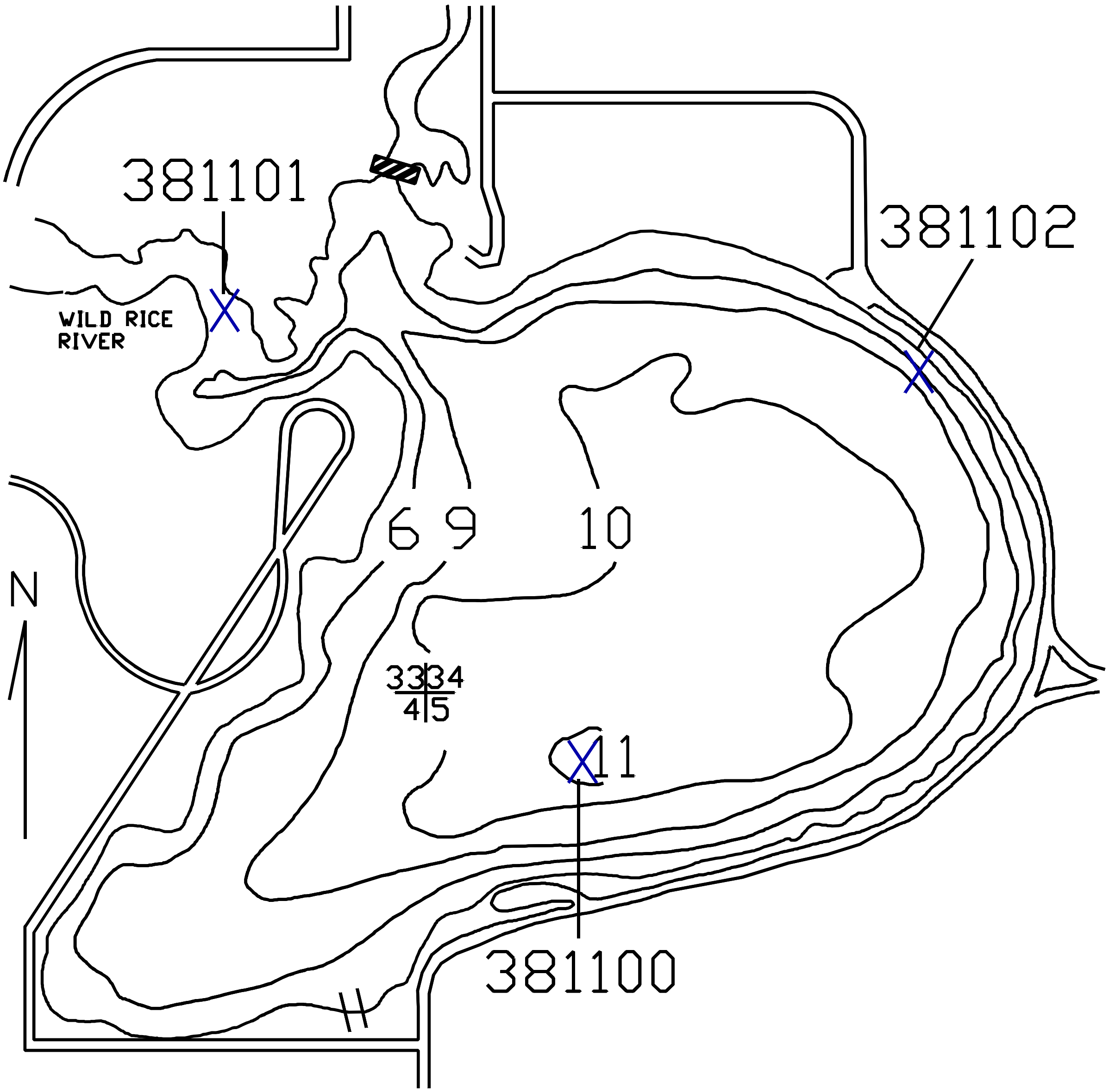


Figure 1. Morphometric map of Silver Lake.

During summer sampling in 1992, Silver Lake did not develop thermal stratification (Figure 2). At the time of sample collection dissolved oxygen concentrations ranged between 3.6 and 8.2 mg L^{-1} on July 29 and between 4.5 and 5.5 mg L^{-1} on August 2 (Figure 3). Winter samples collected on March 2, 1993, showed Silver Lake as thermally stratified at approximately 2 meters of depth, with dissolved oxygen concentrations between 10.4 and 10.6 above the thermocline and 2.3 mg L^{-1} below (Figure 2) (Figure 3).

Concentrations of total dissolved solids, hardness as calcium and conductivity were higher than the North Dakota long-term average and higher than most other lakes sampled during the LWQA project. The volume-weighted mean concentrations of total dissolved solids, hardness as calcium and conductivity were 1,657, 873 and 2,268 mg L^{-1}, respectively (Table 1).

The dominant anions in the water column were sulfates and bicarbonates. Sulfates ranged between 706 and 1,080 mg L^{-1} with a volume-weighted mean of 888 mg L^{-1}. Bicarbonates ranged between 349 to 516 mg L^{-1} with a volume-weighted mean of 410 mg L^{-1}. Silver Lake is a well-buffered waterbody with a volume-weighted mean concentration of total alkalinity as $CaCO_3$ of 338 mg L^{-1} (Table 1).

Concentrations of total phosphate as P ranged between 0.221 and 0.374 mg L^{-1} with a volume-weighted mean of 0.283 mg L^{-1} (Table 1). The volume-weighted mean concentration of 0.283 mg L^{-1} while below the state's long-term average, is above the state's target concentration of 0.02 mg L^{-1} by more than 10 fold. Nitrate + nitrite as N concentrations ranged between nondetectable to 0.108 mg L^{-1} with a volume-weighted mean of 0.058 mg L^{-1}, never exceeding the state's target concentration of 0.25 mg L^{-1} on any occasion sampled. The ratios between total phosphate as P and nitrate + nitrite as N of 4.9:1 suggest Silver Lake is nitrogen limited. Under these conditions primary producer which affix free nitrogen are favored. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 29, 1992 and March 2, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Silver Lake		1982-1991	
Total Dissolved Solids	1657	mg L^{-1}	1209	mg L^{-1}
Conductivity	2268	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	873	mg L^{-1}	488	mg L^{-1}
Sulfates	888	mg L^{-1}	592	mg L^{-1}
Chloride	82	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.283	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.058	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	338	mg L^{-1}	296	mg L^{-1}
Ammonia	0.158	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.39	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	1.657	mg L^{-1}	326	mg L^{-1}

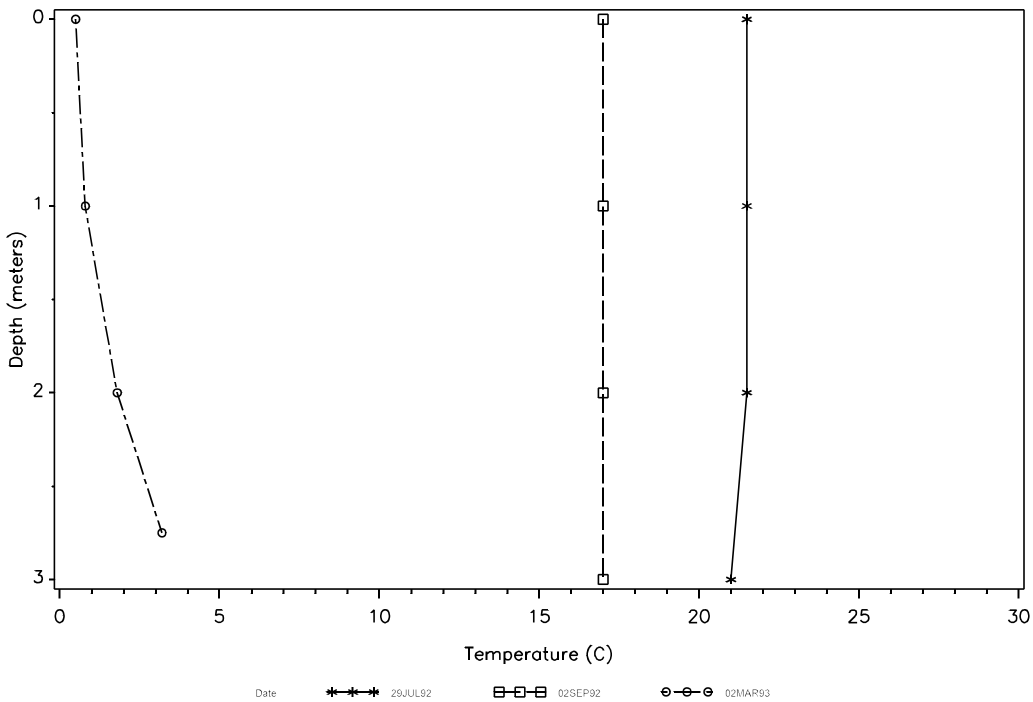


Figure 2. Temperature profile for Silver Lake.

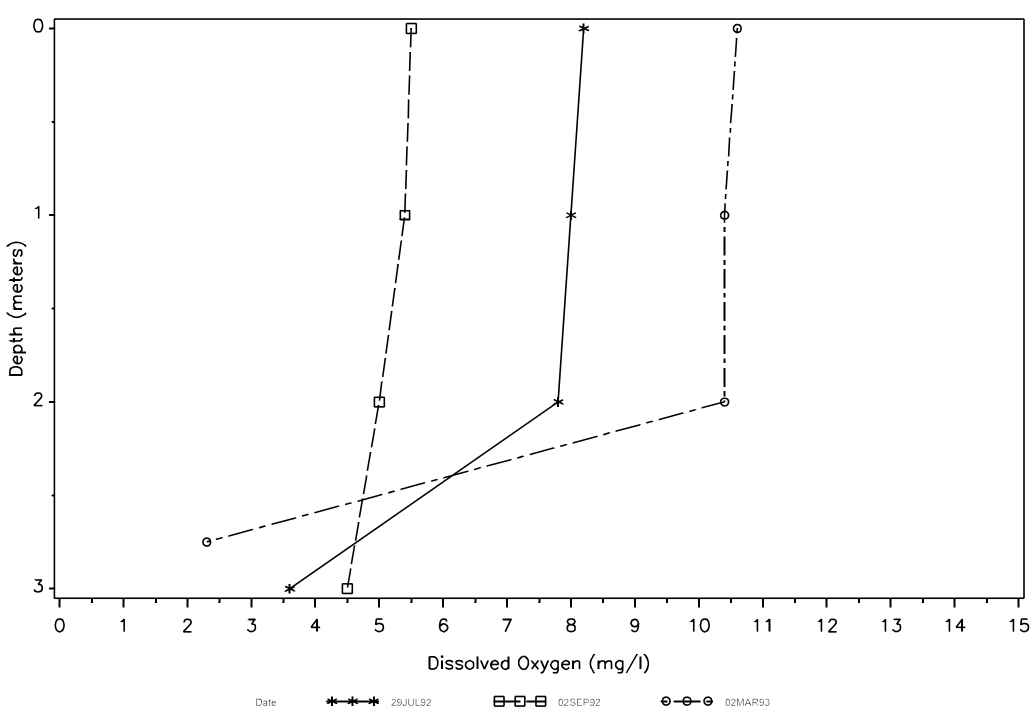


Figure 3. Oxygen profile for Silver Lake.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Silver Lake as part of the LWQA project on July 28, 1992. At the time of the macrophyte survey 100 percent of Silver Lake's shoreline to a depth of approximately three feet had a mixture of cattails Typha spp. and bulrush Scirpus spp. The cattails occupied approximately 98 percent of the emergent plant community with bulrush occupying the remaining 2 percent. Submergent macrophyte vegetation on Silver Lake was very light, with only intermittent patches of sago pondweed Potamogeton pectinatus present. A map depicting the areal extent of macrophyte coverage on Silver Lake is contained in Appendix B.

Phytoplankton

Silver Lake's phytoplankton community was sampled twice during the summer of 1992. The two samples contained a phytoplankton community represented by six divisions and 35 genera. The largest contributors to the phytoplankton community by numerical density were the blue-green algae, Cyanophyta. The Cyanophyta occupied about 51 percent of the community. The next most abundant division was Chlorophyta with approximately 43 percent of the phytoplankton community by number. The remaining 6 percent of the community was composed of Cryptophyta, Bacillariophyta, Euglenophyta and Pyrrophyta.

At the time of the assessment mean phytoplankton concentrations by volume were much more evenly distributed with the division Bacillariophyta occupying the greatest amount of volume. In order of descending volume were Cryptophyta, Chlorophyta, Cyanophyta, Euglenophyta and Pyrrophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Lake water quality assessment data collected during the LWQA project on Silver Lake defined Silver Lake as hypereutrophic. This assessment is based primarily on three water quality parameters, summer surface total phosphate as P concentrations, chlorophyll-a concentrations, and secchi disk depth transparency. During the summer of 1992 surface total phosphate as P concentrations ranged between 221 and 368 $\mu g\ L^{-1}$, chlorophyll-a concentrations ranged between 11 and 26 $\mu g\ L^{-1}$ and secchi disk depth transparencies ranged between 0.6 and 0.8 meters. Supporting ancillary information of a hypereutrophic assessment on Silver Lake include a phytoplankton community dominated by blue-green algal species, frequent nuisance algal blooms, rapid oxygen depletion under ice cover conditions and history of reoccurring fish kills.

Sediment Analysis

Sediments were collected from Silver Lake and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381100), the littoral zone (Site 381102) and the inlet (Site 381101), (Figure 1).

Sediment samples collected from Silver Lake showed detectable levels of all trace elements tested for except selenium in the deepest, inlet and littoral areas and mercury in the inlet and littoral areas.

Reported concentrations of trace elements in the sediments collected from Silver Lake were compared to the reported concentrations for all sediment samples collected during the LWQA project.

Reported concentrations of trace element deepest area sediments collected from Silver Lake contained concentrations that were generally near or below the median concentrations for all sediments collected during the LWQA project. The exceptions were the reported concentrations of cadmium and mercury, which were near and exceeding the 75th percentiles respectively.

Reported trace element concentrations in the inlet area sediments were generally low with the majority being below the 25th percentile. The exceptions were the reported zinc and lead concentrations that exceeded the 75th percentiles for all inlet sediments collected during the LWQA project. Reported trace element concentrations in the littoral area sediments collected from Silver Lake were generally high. Concentrations of copper, zinc, barium, cadmium and lead all exceeded the median with many exceeding the 75th percentiles. The only exception was the reported arsenic concentration that equaled the 25th percentile.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Silver Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Silver Lake on July 1, 1992. Walleyes and black bullheads were collected representing the piscivore and bottom feeders groups, respectively. The walleye sample was composed of five fish with a mean length of 44.6 centimeters and a mean weight of 1,600 grams. The black bullhead sample was composed of five fish with a mean length of 27.6 centimeters and a mean weight of 897 grams.

In order to evaluate the fish tissue data for Silver Lake the results were compared to all corresponding fish samples collected during the LWQA project. The fish samples collected from Silver Lake contained detectible concentrations of all trace elements tested for with the exception of copper, arsenic and cadmium in the bullhead sample, and copper and cadmium in the walleye sample. In general, reported trace element concentrations in both the black bullhead and walleye samples collected from Silver Lake were comparatively low with the majority of the reported concentrations being below the median for all fish samples collected during the LWQA project. The exception was the reported concentrations of mercury in the walleye sample of 0.66 $\mu g\ g^{-1}$. The concentration of mercury of 0.66 $\mu g\ g^{-1}$ indicates the need for further research.

Detectable pesticide residues in the black bullhead sample collected from Silver Lake included DDE and trifluralin. Detectable pesticide residues in the walleye sample collected from Silver Lake include BHC_Alpha, DDE, DDD, dieldrin and trifluralin. BHC_Alpha, also known as benzene hexachloride, is an agricultural insecticide. DDE and DDD are degradation byproducts of the agricultural insecticide DDT and can produce biological effects similar to the parent compound when available to the environment. Dieldrin is an agricultural insecticide that can have adverse effects on aquatic insect communities in very low concentra-tions. Both DDT and dieldrin were banned in the United States in the early 1970s due to their detrimental effects on the environment. Trifluralin is a selective preemergent herbicide commonly known as treflan.

The concentrations of DDE and trifluralin of 0.003 and 0.006 $\mu g\ g^{-1}$ reported in the black bullhead sample collected from Silver Lake are below the 25th and above the 75th percentile respectively. The reported concentrations of BHC_Alpha, dieldrin and trifluralin in the walleye sample exceeded the 75th percentile with concentrations of 0.002, 0.003 and 0.005 $\mu g\ g^{-1}$, respectively. The concentrations of DDE and DDD of 0.006 and 0.002 $\mu g\ g^{-1}$ reported in the walleye sample approximated the 25th and median concentrations. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Silver Lake with its contributing watershed has a combined surface area of 130,210 acres located on the glaciated plains of North Dakota in Sargent County, North Dakota. The watershed is composed primarily of irregular patterns of hills and valleys caused by glacial thrusting and sedimentation overlying a relatively deep deposit of glacial till. Soils within the watershed vary significantly, but are generally formed from medium to coarse textured sandy or clayey, loamy glacial till. Soils are moderately erodible and moderately well drained. Annual precipitation within the Silver Lake watershed is between 18 and 21 inches, with considerable variation between years. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to Silver Lake.

Land use within the Silver Lake watershed is 95 percent agricultural with 55.8 percent actively cultivated, 23.9 percent in rangelands, 9.3 percent in haylands and 5.9 percent in Conservation Reserve Program (CRP). The remaining 5 percent of the watershed is in wildlife and wetland management, transportation, low density urban development and farmsteads. In conjunction with the 144 farmsteads, the Sargent County SCS knows of only one concentrated livestock feeding area (Table 2).

Table 2. Land use in the Silver Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	55.8	80
Rangeland	23.9	75
Hayland	9.3	85
CRP	5.9	100
Wet/Wild[1]	3.0	N/A
Other	0.9	N/A
Farmsteads	144[3]	N/A
Feedlots[2]	1[3]	0.0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.2
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

According to the information provided by the Sargent County Soil Conservation District 80 percent of the cultivated lands and between 75 and 100 percent of all remaining lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T). Based on an average soil loss of four tons per acre, which takes into account all land practices and treatment currently employed in the watershed, approximately 515,051 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 51,505 and 77,258 tons of soil are delivered in Silver Lake annually.

Other sources of nonpoint source pollution discharge to Silver Lake other than wind and water erosion from agricultural fields are the concentrated livestock feeding area, construction activities and fertilizer runoff from the recreation area along the lake's edge.

SKJERMO LAKE

DIVIDE COUNTY

Peter N. Wax

Skjermo Lake is located in northwestern Divide County, near the transitional area between the Missouri Coteau and Glaciated Plains physiographic region of northwestern, North Dakota. Skjermo Lake is a natural lake created by glacial action during the late Wisconsin age. It is a relatively classic glacial lake in that it is small and bowl-shaped. Skjermo Lake has a maximum depth of 19 feet, a mean depth of 9.8 feet with a surface area of 40.3 acres (Figure 1).

Topography of Skjermo Lake's watershed is predominated by rolling to undulating uplands with slopes ranging from 3 to 6 percent. Soils are moderately well drained, formed from glacial till. The watershed is composed of integrated drainages, typifying the characteristics of the northern prairie pothole region.

Skjermo Lake is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The North Dakota Game and Fish Department (NDG&F) manage Skjermo Lake by annually assessing the fish community through test nettings and stock accordingly.

In recent years the stockings have been limited to northern pike. Historical stockings have included largemouth bass, smallmouth bass, bluegill and yellow perch. Fish community assessments conducted by the NDG&F on July 9, 1991, captured in order of most abundant bluegill, yellow perch and northern pike.

Skjermo Lake is 100 percent privately owned with a public access area and facilities at the south end of the lake. Public facilities are maintained by the Fortuna Air Force Station. Public facilities include parking, picnic area and toilets. Public use on Skjermo Lake is generally moderate, however, when the perch fishery is productive, Skjermo Lake receives heavy fishing pressure particularly during the winter months.

Water Quality

Water quality samples were collected from Skjermo Lake twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380915) (Figure 1). Water column samples were collected for analysis at three separate depths on each sampling visit. Samples were collected at 1 meter, between 2.5 to 3 meters and between 4 meters and 5 meters.

During summer sampling of 1992 Skjermo Lake was thermally stratified on July 14, at approximately three meters below the lake's surface (Figure 2). During this time period, dissolved oxygen concentrations were at or near saturation to the depth of thermal stratification and between 0.8 and 4.2 mg L^{-1} below (Figure 3). On August 11, Skjermo Lake's water column was not thermally stratified and had dissolved oxygen concentrations which ranged between 5.0 mg L^{-1} near the bottom

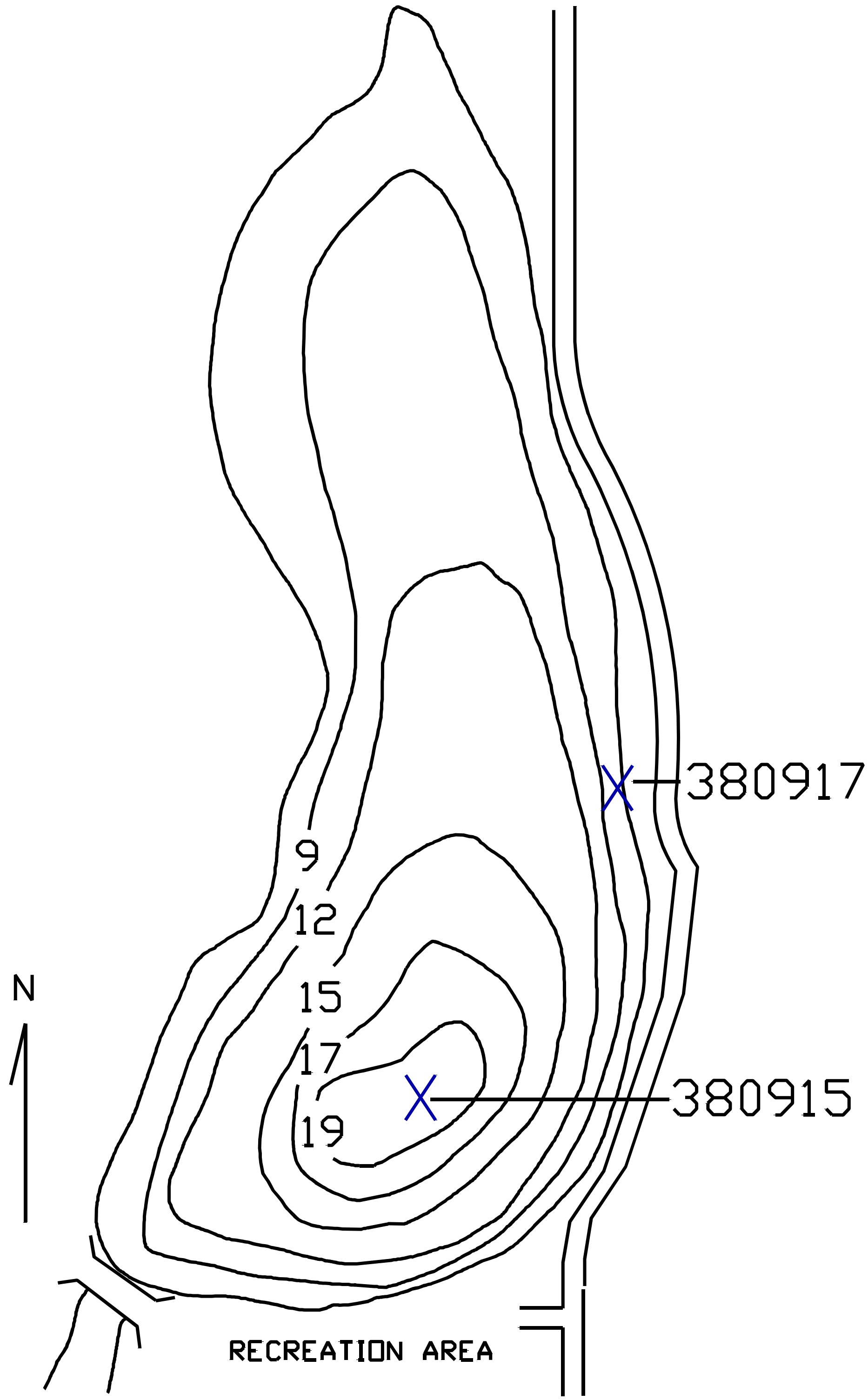


Figure 1. Morphometric map of Skjermo Lake.

to 7.6 mg L^{-1} near the surface (Figure 2, Figure 3). During the winter Skjermo Lake did not thermally stratify and dissolved oxygen concentrations ranged from 1.6 mg L^{-1} near the bottom to 5.3 mg L^{-1} at the surface (Figure 2, Figure 3).

Volume-weighted mean concentrations of total dissolved solids, hardness as calcium and conductivity were 2,353, 1,645, and 2,815 mg L^{-1} exceeding the state's long-term averages on all occasions sampled (Table 1). The dominant anions in the water column were sulfate and bicarbonates. Sulfates ranged between 12,000 and 19,080 mg L^{-1} with a volume-weighted mean of 1,562 mg L^{-1}. Bicarbonates ranged between 145 and 206 mg L^{-1} with a volume-weighted mean of 167 mg L^{-1}. Total alkalinity as $CaCO_3$ concentrations ranged between 119 and 165 mg L^{-1} with a volume-weighted mean of 137 mg L^{-1} (Table 1).

The concentrations of total alkalinity as $CaCO_3$ indicate Skjermo Lake is a well-buffered waterbody. The high concentrations of total dissolved solids, hardness as calcium, and conductivity could be exaggerated due to the recent drought and lower lake levels within Skjermo Lake. It also indicates that Skjermo Lake is closed basin with no way to disgorge, through ground water or surface water discharge, the increasing concentrations of minerals and dissolved solids.

The nutrients total phosphate as P and nitrate + nitrite as N had volume-weighted mean concentrations of 0.031 and 0.123 mg L^{-1}, respectively. The ratios between total phosphate as P and nitrate + nitrite as N of approximately 1:4 indicates Skjermo Lake is nitrogen limited. Under these conditions primary producers which can affix free nitrogen are favored. A complete list of LWQA water quality data is contained in Appendix A.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 14, 1992 and January 24, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Skjermo Lake		1982-1991	
Total Dissolved Solids	2353	mg L^{-1}	1209	mg L^{-1}
Conductivity	2815	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	1645	mg L^{-1}	488	mg L^{-1}
Sulfates	1562	mg L^{-1}	592	mg L^{-1}
Chloride	83	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.031	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.123	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	137	mg L^{-1}	296	mg L^{-1}
Ammonia	0.025	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.57	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	167	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted on Skjermo Lake on July 14, 1992. At the time of the macrophyte survey Skjermo Lake had an intermittent ring of cattails, Typha spp. with an inner ring of bulrush, Scirpus spp. extending to a depth of nearly three feet.

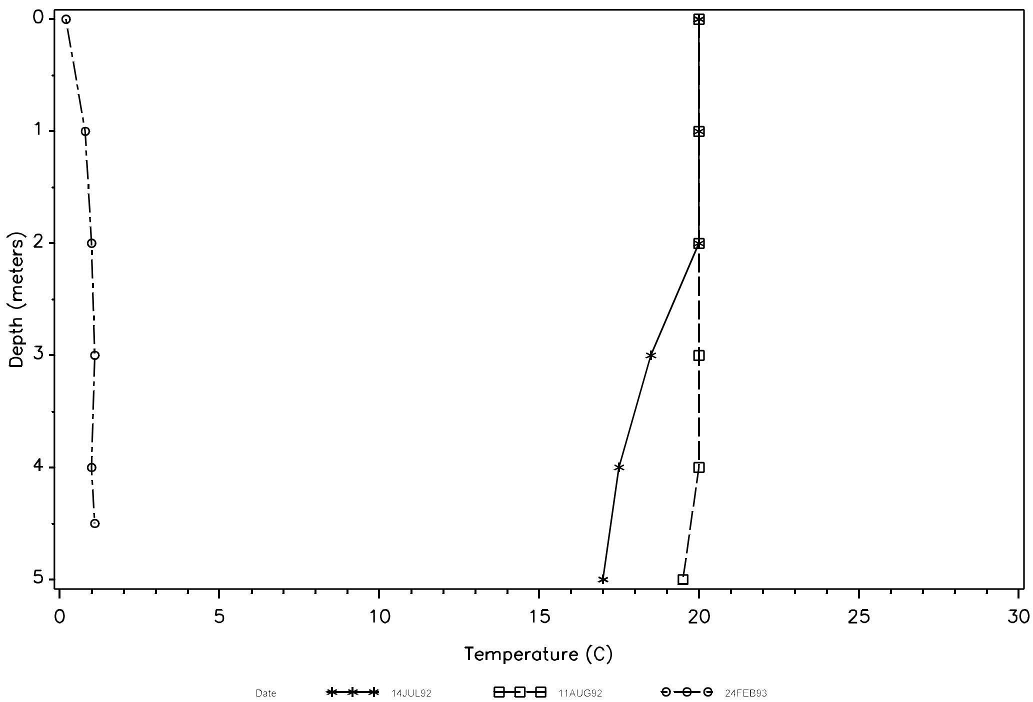


Figure 2. Temperature profile for Skjermo Lake.

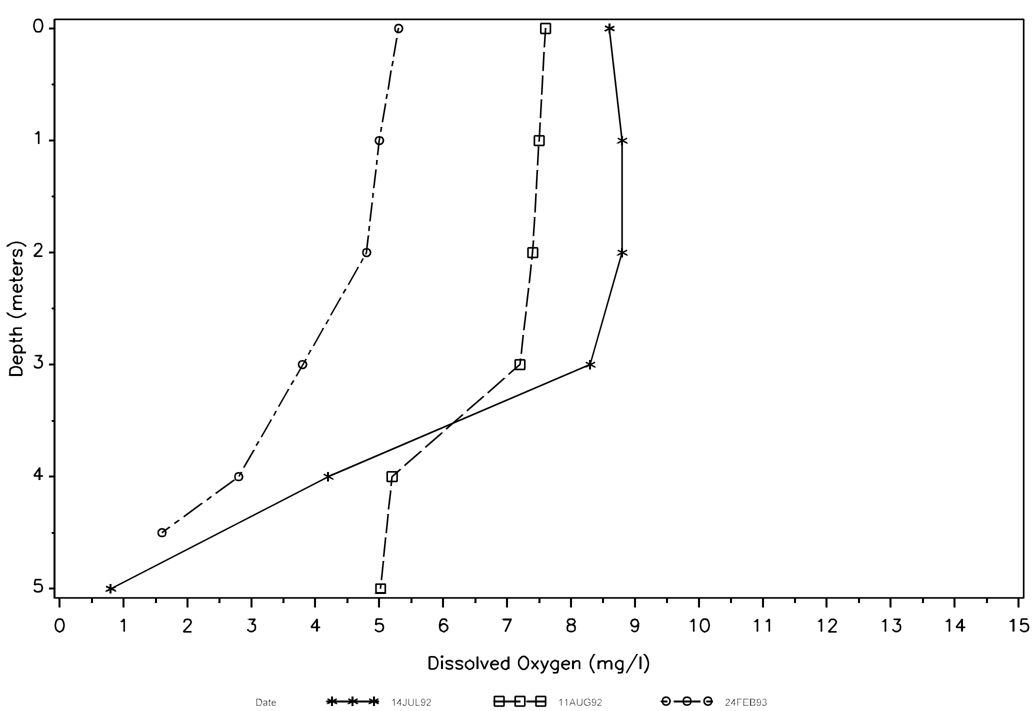


Figure 3. Oxygen profile for Skjermo Lake.

The only submergent macrophyte identified on Skjermo Lake was water milfoil, Myriophyllum spp. which inhabited nearly 100 percent of the entire lake bottom along the transects surveyed. A map depicting the areal extent of macrophyte coverage on Skjermo Lake is contained in Appendix B.

Phytoplankton

Skjermo Lake's phytoplankton community was sampled two times during the summer of 1992. Between the two samples Skjermo Lake's phytoplankton community was represented by six divisions and 27 genera. The largest contributors to Skjermo Lake's phytoplankton community by numerical density were the divisions Cyanophyta, Cryptophyta and Chlorophyta with 4, 3 and 10 genera represented. Mean density of the two samples collected during the summer of 1992 for the divisions Cyanophyta, Cryptophyta and Chlorophyta was 21,376, 20,079 and 17,388 cells mL^{-1}, respectively. Other divisions represented in descending order of numerical density were Bacillariophyta, Chrysophyta and Pyrrophyta.

At the time of the assessment mean phytoplankton concentrations by volume were dominated by the division Cryptophyta. The mean volume of the two samples collected during the summer of 1992 for the division Cryptophyta was
2,525,724 μm^3 mL^{-1}, representing a dominance of 2.7 fold all other divisions combined. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected during the LWQA project defined Skjermo Lake as mesotrophic. The primary water quality indicators of a mesotrophic lake condition are secchi disk depth transparencies readings of 2.0 and 2.1 meters, chlorophyll-a concentrations of 3 and 4 $\mu g\ L^{-1}$ and summer surface total phosphate as P concentrations of 22 and 26 $\mu g\ L^{-1}$. Supporting ancillary information of a mesotrophic assessment for Skjermo Lake was a relatively low macrophyte biomass, infrequent nuisance algal blooms and a diverse phytoplankton community. The only ancillary information suggestive of a higher trophic assessment is a history of fish kills, however, the history of fish kills on Skjermo Lake are probably directly related to drought and the severity of the winters in this area of North Dakota and not its present trophic state.

Sediment Analysis

Sediments were collected from Skjermo Lake and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area the lake (Site 380915) and the littoral zone (Site 380817) (Figure 1).

Sediment samples collected from Skjermo Lake show detectable levels of all trace elements tested for with the exception of mercury. Reported concentrations of trace elements in the sediments collected from Skjermo Lake were compared to the reported concentrations for all lakes assessed in the LWQA project.

In general, reported trace element concentrations were low. All detectible trace element concentrations were below the median with the majority equal to or below the 25th percentile for all sediments analyzed during the LWQA project.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Skjermo Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

A northern pike sample representing the piscivore group was collected from Skjermo Lake on June 11, 1992. The northern pike sample collected from Skjermo Lake was composed of five fish with a mean length of 62.2 centimeters and a mean weight of 1,590 grams.

To evaluate the fish tissue data for Skjermo Lake the results of the northern pike sample was compared to all piscivore samples assessed in the LWQA project. The northern pike sample collected from Skjermo Lake contained detectable levels of all trace elements tested for with the exception of copper and cadmium. In general, reported trace element concentrations in the northern pike sample collected from Skjermo Lake were relatively low with a significant number below the 25th percentile. The exceptions were the reported concentrations of chromium and selenium of 0.502 and 1.04 $\mu g\ L^{-1}$, which exceeded the 75th percentile for all piscivores sampled during the LWQA project.

Detectable pesticide residues in the northern pike sample collected from Skjermo Lake included DDE and trifluralin. DDE is a degradation byproduct of the insecticide DDT and produces biological effects similar to the parent compound when exposed to the environment. Trifluralin, commonly known as treflan, is a selective, preemergent herbicide which is commonly used for small grain production in North Dakota.

The DDE concentration of 0.004 $\mu g\ g^{1}$ in the northern pike sample collected from Skjermo Lake is below the 25th percentile for all piscivores sampled during the LWQA project. The trifluralin concentration of 0.003 $\mu g\ g^{1}$ is between the median and the 75th percentile for all piscivores sampled during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Skjermo Lake with its contributing watershed has a combined surface area of 10,380 acres located on the Missouri Coteau just southeast of the Glaciated Plains in Divide County, North Dakota. The watershed is a glacial erosion remnant of the Wisconsin age. The region is characterized by irregular patterns of hills and shallow depressions. Topography is rolling with shifts in relief of up to 300 feet, but primary ranging between 50 and 80 feet. Soils in the watershed are generally formed from rocky, gravelly, or sandy glacial till and are moderately to well drained. Slopes range from nearly level to steep, with average slopes between two and nine percent. The watershed is highly erodible when poor land management is employed on the sandier soils and steeper slopes. Annual precipitation within the watershed ranges from 15 and 18 inches, with major variations from year to year. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to Skjermo Lake.

Land use within the Skjermo Lake watershed is 83.2 percent agricultural with 53.5 percent actively cultivated, 5.9 percent in pasture, 7.2 percent in haylands, 16.1 percent in Conservation Reserve Program (CRP) and 5 percent in farmsteads. The remaining 16.8 percent of the watershed is in wetland and wildlife management and transportation. Within the watershed there are nine farms and five concentrated livestock feeding areas (Table 2).

According to the information provided by the Divide County Soil Conservation District, 30 percent of the cultivated lands and between 70 and 100 percent of the remaining agricultural lands within the Skjermo Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Skjermo Lake watershed, the average "T" value is three to five tons per acre. Based on an average soil loss of 5.7 tons per acre, which takes into account all land uses and practices presently being employed within the watershed, approximately 59,037 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 5,904 and 8,856 tons of soil are delivered to Skjermo Lake annually. Other sources of nonpoint source pollution discharges to Skjermo Lake are from concentrated livestock feeding areas, livestock feeding and watering in it and the immediate drainage, and construction activities within the watershed.

Table 2. Land use in the Skjermo Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	53.5	30
Rangeland	5.9	70
Hayland	7.2	100
CRP	16.1	100
Wet/Wild[1]	15.7	N/A
Other	0.7	N/A
Farmsteads	9[3]	N/A
Feedlots[2]	5[3]	50

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

SMISHEK LAKE

BURKE COUNTY

Peter N. Wax

Smishek Lake is located in south central Burke County on the Glaciated Plains of North Dakota. Originally Smishek Lake was composed of two waterbodies, known as Smishek and Sedak Lakes. A dam constructed at the southern outlet of Sedak Lake in 1959 by the State Water Commission, the NDG&F and Burke County Water Resource District raised the water levels ten feet, flooding both lakes. The combined waterbodies are known as Smishek Lake. The dam is a rolled earthen structure with a natural grassed spillway. The dam created a single lake with a surface area of 187.5 acres, a maximum depth of 26 feet and a mean depth of 9.6 feet (Figure 1).

Topography of Smishek Lake's watershed is nearly level to undulating with slopes ranging from three to six percent. Soils are moderately well drained, built from glacial till. The watershed is predominantly integrated drainages, typifying the characteristics of the northern prairie pothole region.

Smishek Lake is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Smishek Lake by annually assessing the fish community through test netting and stock accordingly.

In 1963 Smishek Lake was overpopulated with small northern pike. Following chemical eradication in 1964 Smishek Lake was stocked with rainbow trout. High runoff during the spring of 1965 introduced northern pike to Smishek Lake through natural upstream migrations from the White Earth River.

The stocking regiment by the NDG&F in recent years has included walleye, bluegill, northern pike and yellow perch. A fish community assessment conducted by the NDG&F on June 10, 1991 captured in order of most abundant, yellow perch, white suckers, northern pike and bluegill. Recreational use on Smishek Lake is moderate to heavy depending on the productivity to the fishery and the season.

Smishek Lake and dam are owned by the NDG&F with approximately 60 percent of the shoreline in public possession and 40 percent in private ownership and 10 percent developed. The public facilities on Smishek Lake include a boat ramp with associated parking, toilets, drinking water and picnic areas. In general, Smishek Lake is a well-managed waterbody providing the state of North Dakota and in particular the local community with an excellent source of water-based recreational opportunity.

Water Quality

Water quality samples were collected from Smishek Lake twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380920) (Figure 1). Water column samples were collected for analysis at three discrete depths of one meter, four meters, and between six and seven meters.

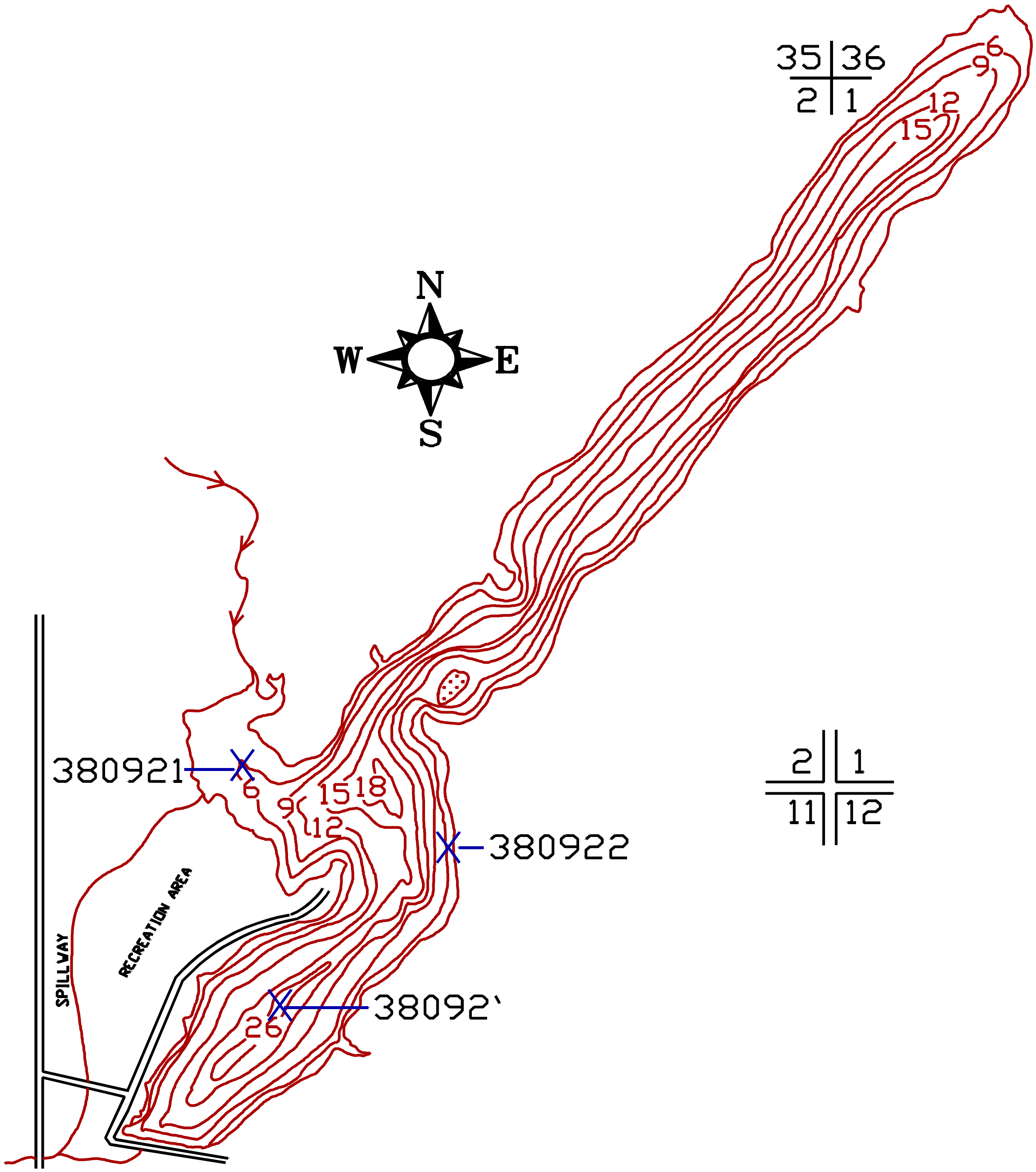


Figure 1. Morphometric map of Smishek Lake.

During the summer sampling of 1992, Smishek Lake was weakly thermally stratified between four and five meters of depth on July 15, with dissolved oxygen concentrations ranging between 7.8 and 8.1 mg L^{-1} above the thermocline, and 0.5 to 5.3 mg L^{-1} below. On August 11, Smishek Lake was not thermally stratified and had dissolved oxygen concentrations ranging between 5.2 mg L^{-1} near the bottom to 9.1 mg L^{-1} at the surface (Figure 2) (Figure 3).

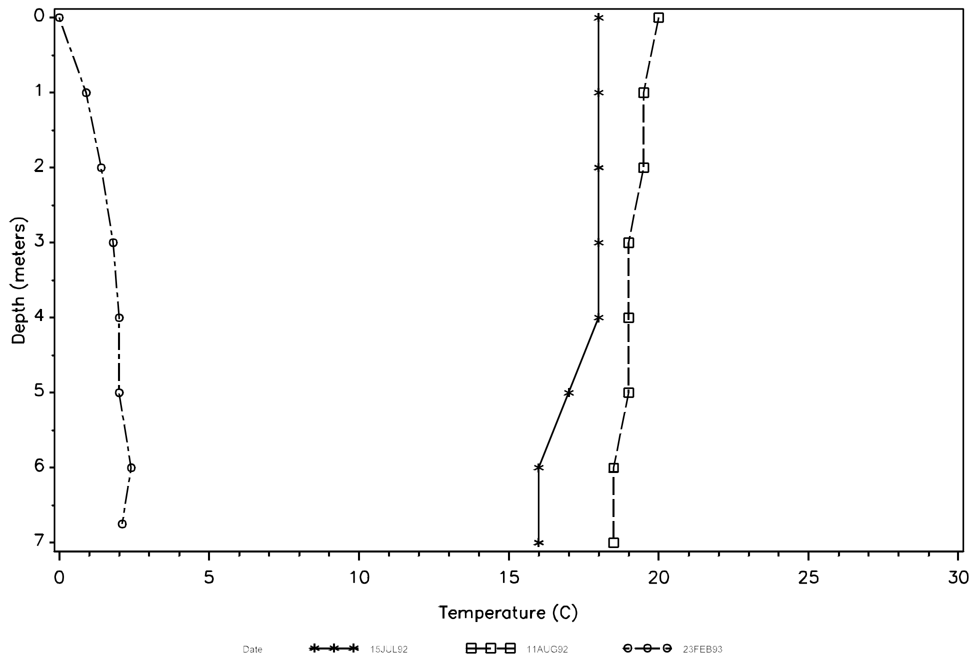


Figure 2. Temperature profile for Smishek Lake.

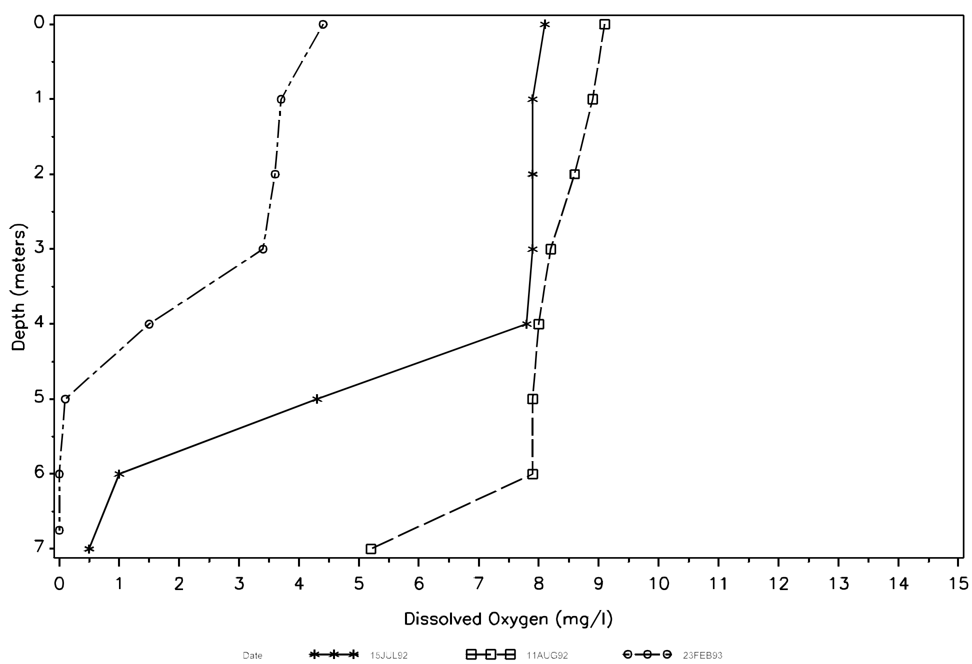


Figure 3. Oxygen profile for Smishek Lake.

During the winter sampling of 1993, Smishek Lake was weakly thermally stratified at approximately four meters of depth (Figure 2). Dissolved oxygen concentrations ranged between 1.5 and 4.5 mg L^{-1} above the thermocline and between 0.0 and 0.05 mg L^{-1} below (Figure 2) (Figure 3).

Water quality data collected during the LWQA project shows Smishek Lake as a well-buffered waterbody. Total alkalinity as $CaCO_3$ concentrations ranged between 377 and 527 mg L^{-1}. The dominant anions in the water column were sulfates and bicarbonates. Sulfates ranged between 452 and 721 mg L^{-1} with a volume-weighted mean concentration of 569 mg L^{-1}, and bicarbonates ranged between 407 and 643
mg L^{-1} with a volume-weighted mean of 482 mg L^{-1} (Table 1). Concentrations of total dissolved solids, hardness as calcium, and conductivity were above the state's long-term average with volume-weighted mean concentrations of 1,233, 440 and 1,858 mg L^{-1}, respectively (Table 1).

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 14, 1992 and January 23, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Smishek Lake		1982-1991	
Total Dissolved Solids	1233	mg L^{-1}	1209	mg L^{-1}
Conductivity	1858	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	440	mg L^{-1}	488	mg L^{-1}
Sulfates	569	mg L^{-1}	592	mg L^{-1}
Chloride	13	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.021	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.019	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	421	mg L^{-1}	296	mg L^{-1}
Ammonia	0.008	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	0.922	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	482	mg L^{-1}	326	mg L^{-1}

Concentrations of the primary nutrients total phosphate as P and nitrate + nitrite as N were relatively low when compared to North Dakota's long-term average (Table 1). Total phosphate as P concentrations ranged between nondetectable to 0.043 mg L^{-1} with volume-weighted mean concentration of 0.021 mg L^{-1}. Nitrate + nitrite as N concentrations ranged between nondetectable to 0.053 mg L^{-1}, with a volume-weighted mean of 0.019 mg L^{-1} (Table 1). The ratios between total phosphate as P and nitrate + nitrite as N varied significantly over the three sample periods and three stratified samples, however, using the volume-weighted mean, the ratio is nearly 1:1. The ratio of 1:1 indicates Smishek Lake is nitrogen limited. Under these conditions, nitrogen fixing organisms, such as certain blue-green algae species, are favored. A complete list of LWQA water quality data is contained in Appendix A.

Aquatic Vegetation

On July 14, 1992, a qualitative survey of the macrophyte community was conducted on Smishek Lake. At the time of the macrophyte survey, very few macrophytes were present in the southern half of Smishek Lake. In the northern half of Smishek Lake, fairly dense, yet, intermittent stands of bulrush Scirpus spp. and cattails Typha spp. were present.

Throughout the remainder of the lake, intermittent sparse populations of cattails Typha spp., sago pondweed Potamogeton pectinatus and coontail Ceratophyllum demersum were present extending to a depth of four feet. A map depicting the areal extent of macrophyte coverage on Smishek Lake is contained in Appendix B.

Phytoplankton

Smishek Lake's phytoplankton community was sampled two times during the summer of 1992. At the time of the assessments, Smishek Lake's phytoplankton community was represented by six divisions and 53 genera. The largest contributors to Smishek Lake's phytoplankton community by numerical density were the blue-green algae, Cyanophyta. Mean density of the blue-green algae for the two samples collected
during the summer of 1992 was 358,056 cell mL^{-1}, representing a numerical dominance of approximately seven fold over all other divisions combined. Other divisions represented in descending order of numerical dominance were Chlorophyta, Cryptophyta, Chrysophyta, Bacillariophyta and Pyrrophyta.

At the time of the assessment mean phytoplankton concentrations by volume were dominated by the division, Cryptophyta. The division Cryptophyta occupied approximately 42 percent of the total volume between the two samples collected during the LWQA project. Other divisions represented in order of descending volume were Pyrrophyta, Cyanophyta, Chlorophyta, Bacillariophyta, and Chrysophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Smishek Lake is presently eutrophic. The primary water quality indicators, chlorophyll-a concentrations, summer surface total phosphate as P concentrations and secchi disk depth transparencies agree quite well, all indicating a eutrophic lake condition. Secchi disk depth transparencies at both sample times were 1.3 meters, chlorophyll-a concentrations ranged between 46 and 54 $\mu g\ L^{-1}$ and summer surface total phosphate as P concentrations ranged between 51 and 57 $\mu g\ L^{-1}$.

Ancillary information available for Smishek Lake indicate a wide range of conditions from mesotrophic to hypereutrophic. Indicators of a mesotrophic status for Smishek Lake are a relatively low macrophyte biomass and no history of fish kills. Ancillary data supportive of a eutrophic or hypereutrophic trophic status are rapid oxygen depletion below the hypolimnion and under ice cover conditions, frequent nuisance algal blooms and a phytoplankton community severely dominated by blue-green algae Cyanophyta.

Sediment Analysis

Sediments were collected from Smishek Lake and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area the lake (Site 380920), the inlet (Site 38092), and the littoral zone (Site 380922) (Figure 1).

Sediments collected from Smishek Lake show detectable levels of all trace elements tested for with the exception of mercury. Reported concentrations of trace elements in the sediments collected from each location within Smishek Lake were compared to the reported concentrations for all lakes assessed in the LWQA project. In general, reported trace element concentrations in the sediments collected from Smishek Lake were low. Nearly all of the reported trace element concentrations were below the 25th percentile with the exception of a few in the inlet area sediments which approached the median concentration.

Concentrations of pesticides and PCBs were below detectable limits for all sediment samples collected from Smishek Lake. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Smishek Lake on June 10, 1992. Northern pike and white suckers were collected, representing the piscivore and bottom feeder groups, respectively. The northern pike sample was composed of five fish with a mean length of 57 centimeters and a mean weight of 1,300 grams. The white sucker sample was composed of five fish, with a mean length of 47.4 centimeters and a mean weight of 2,280 grams.

In order to evaluate the fish tissue data for Smishek Lake the results for each fish sample was compared to all samples collected during in the LWQA project. Trace element concentrations in the northern pike sample collected from Smishek Lake included zinc, barium, chromium, arsenic, selenium and lead. Of the trace elements detected, reported concentrations were generally equal to or below the 25th percentile for all piscivores sampled during the LWQA project. The exceptions were the concentrations of zinc and selenium that equaled and nearly equaled the 75th percentile, respectively.

Trace elements detected in the white sucker sampled collected from Smishek Dam included zinc, barium, chromium, arsenic and selenium. Of these zinc, barium and arsenic were all near or below the median concentrations while chromium and selenium were near and above the 75th percentile.

Detectable pesticide residues in the northern pike sampled collected from Smishek Lake was DDE, while the white sucker sample contained DDE and trifluralin. DDE is a degradation byproduct of the insecticide DDT and can produce biological effects similar to the parent compound. Trifluralin, commonly known as treflan, is a selective, preemergent herbicide commonly used in small grain production.

The DDE concentrations reported for the northern pike and white sucker samples collected from Smishek Lake of 0.005 and 0.003 $\mu g\ g^{-1}$ were both below the 25th percentile for all fish samples collected during the LWQA project. The concentration of trifluralin of 0.002 $\mu g\ g^{-1}$ in the white sucker sample collected from Smishek Lake was slightly above the median for all bottom feeders sampled during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Smishek Lake with its contributing watershed has a combined surface area of 12,220 acres located on the Glaciated Plains physiographic region in Burke County, North Dakota. The watershed is characterized by gently rolling to rolling glaciated plains, with many small potholes and integrated drainages. Soils in the watershed vary significantly, but are generally formed from medium to coarse textured sandy or clayey, loamy, glacial till. Soils are moderately erodible and moderately to well drained. Annual precipitation within the watershed is between 15 and 20 inches. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to Smishek Lake.

Land use within the Smishek Lake watershed is 97 percent agricultural with 43.1 percent actively cropped, 48.4 percent in rangeland, 1.7 percent in hay production and 3.0 percent in Conservation Reserve Program (CRP). The remaining 3 percent of the watershed is in wetland and wildlife management, woodlands, transportation and farmsteads. There are a total of eight farms and two concentrated livestock feeding areas within the Smishek Lake watershed (Table 2).

Table 2. Land use in the Smishek Lake watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	43.1	70
Rangeland	48.4	60
Hayland	1.7	80
CRP	3.0	100
Woodland	0.2	N/A
Wet/Wild[1]	2.2	N/A
Other	0.6	N/A
Farmsteads	8[3]	N/A
Feedlots[2]	2[3]	60

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

According to the information provided by the Burke County Soil Conservation District 70 percent of the cultivated lands and between 60 and 100 percent of the remaining agricultural lands within the Smishek Lake watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Smishek Lake watershed, the average "T" value is three to five tons per acre. Based on an average soil loss of 7.5 tons per acre, which takes into account all land uses and practices currently employed within the watershed approximately 92,078 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 9,208 and 13,812 tons of soil are delivered to Smishek Lake annually.

Other sources of nonpoint source pollution discharges to Smishek Lake are from cattle feeding and watering in it and the immediate drainage, lakeshore development and construction within the watershed. These sources, due to their ability to discharge large concentrated loads of nutrients and sediments may be contributing a significant amount nutrient and sediment to Smishek Lake annually.

SWEET BRIAR DAM

MORTON COUNTY

Peter N. Wax

Sweet Briar Dam is located in Morton County on the Coteau Slope in central North Dakota. Sweet Briar Dam was constructed in 1964 through the efforts of local community, the State Water Commission and the NDG&F. The dam itself is Interstate Highway 94 road bed. At full pool, Sweet Briar Dam covers a surface area of 271 acres, has a maximum depth of 28 feet and a mean depth of 9.5 feet (Figure 1).

Sweet Briar Dam's watershed is characterized by partially glaciated terrain with thin deposits of glacial material. Soils in the watershed are predominantly silty or loamy, well drained, fertile, easily worked and highly susceptible to both wind and water erosion. Annual precipitation ranges between 14 and 17 inches. Land use within the watershed is intensely agricultural. Principal agricultural uses are small grain and livestock production.

Sweet Briar Dam is classified as a warm water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Sweet Briar Dam by annually assessing the fish community through test nettings and stock accordingly.

Approximately 10 years after construction it became apparent that Sweet Briar Dam was experiencing rapid eutrophication due to its highly fertile yet poorly treated watershed. At this juncture, a joint federal and state agency meeting was held and plans were made to design and implement a nonpoint source pollution abatement project. Project implementations included grassed waterways, conservation tillage, terracing, waste containment and diking. The five-year abatement program's success was reflected in the improved fishery experienced during and immediately following implementation. It was hoped that best management practices implemented during the project would be continued after the five-year program. However, this was not the case, and continued degradation has occurred to Sweet Briar Dam since the conclusion of the project.

Fisheries management activities began on Sweet Briar Dam in 1964 with complete eradication of the watershed. The 100,781 acre watershed supplied significant runoff to fill the reservoir in 1965. At this time, the NDG&F stocked bluegill, rainbow trout and walleye. The rainbow trout provided an excellent sport fishery through 1968 receiving very heavy use. In addition, the plants of walleye, bluegill and largemouth bass were doing well and were beginning to replace the rainbow trout. The declining quality of this heavily utilized fishery was the motive behind implementing the watershed project in 1974.

In recent years, the NDG&F stocking regiment has included walleye, bluegill, largemouth bass and smallmouth bass. A fish community assessment conducted on June 13, 1991, by the NDG&F captured in order of most abundant, white suckers,

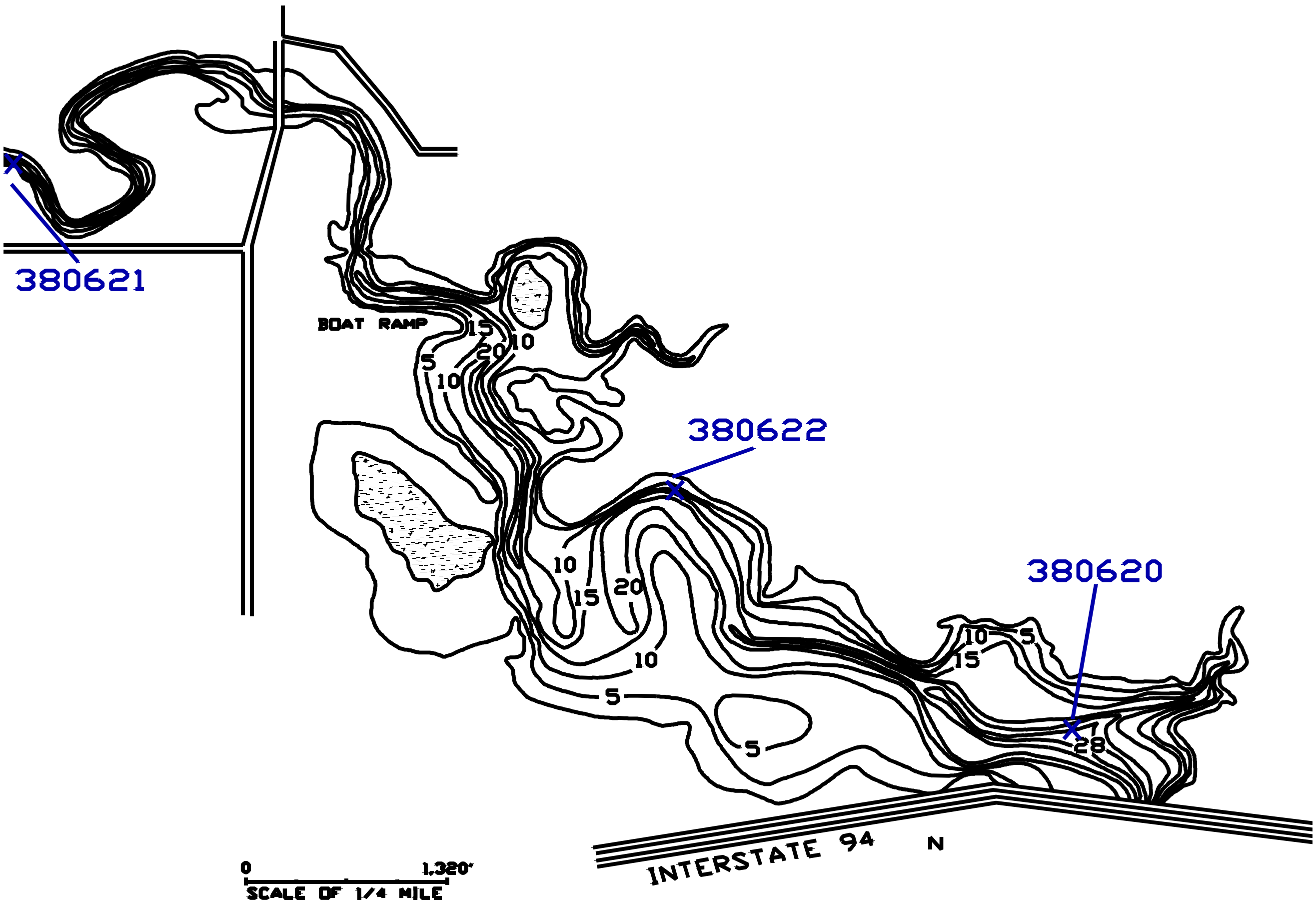


Figure 1. Morphometric map of Sweet Briar Dam.

bluegill, black bullhead, walleye and yellow perch. Though not captured during the survey anglers have reported catching tiger muskies within the last year.

Excellent recreational facilities are available around Sweet Briar Dam. Access is good from paved roads and well maintained gravel accesses. The facilities are maintained by the Morton County Park Board. Facilities available include boat ramps and associated parking, toilets, camping and picnic areas.

Water Quality

Water quality samples were collected from Sweet Briar Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380620) (Figure 1). Water column samples were collected for analysis at three separate depths of one meter, three meters and seven meters during the summer sampling, and one meter, four meters and six meters during the winter sampling.

During the summer sampling of 1992 Sweet Briar Dam did not thermally stratify (Figure 2). Dissolved oxygen concentrations on July 6, ranged between 6.9 mg L^{-1} near the bottom to 8.0 mg L^{-1} at the surface (Figure 3). Dissolved oxygen concentrations on August 4, ranged between 2.5 mg L^{-1} near the bottom and 4.6 mg L^{-1} at the surface (Figure 3).

On February 16, 1993, Sweet Briar Dam was weakly thermally stratified at approximately four meters of depth below the lake's surface (Figure 2). Dissolved oxygen concentrations ranged between 1.4 and 4.2 mg L^{-1} below the thermocline and between 4.2 and 8.0 mg L^{-1} above (Figure 3).

Water quality data collected during the LWQA project indicated Sweet Briar Dam is well buffered. Total alkalinity as $CaCO_3$ had a volume-weighted mean concentration of 362 mg L^{-1} (Table 1). Bicarbonates and sulfates were the dominant anions in the water column with volume-weighted means of 407 and 169 mg L^{-1}, respectively (Table 1). Concentrations of total dissolved solids, hardness as calcium and conductivity were below the state's long-term averages with volume-weighted mean concentrations of 630, 148 and 973 mg L^{-1}, respectively (Table 1).

The primary nutrients total phosphate as P and nitrate + nitrite as N had volume-weighted means of 0.267 and 0.08 mg L^{-1}, respectively. Total phosphate as P concentrations ranged between 0.54 and 0.373 mg L^{-1} exceeding the state's target concentration of 0.02 mg L^{-1} on all occasions sampled. Nitrate + nitrite as N concentrations ranged between 0.006 and 0.237 mg L^{-1} and were below the state's target concentration of 0.25 mg L^{-1} on all occasions sampled. The ratios between total phosphate as P and nitrate + nitrite as N concentrations ranged between 1:1.5 to 62:1, indicating a highly nitrogen limited waterbody. However, primary production on Sweet Briar Dam is not limited by a lack of nitrogen. Under these condition primary producers with the ability to affix free nitrogen are favored. A complete list of LWQA water quality data is contained in Appendix A.

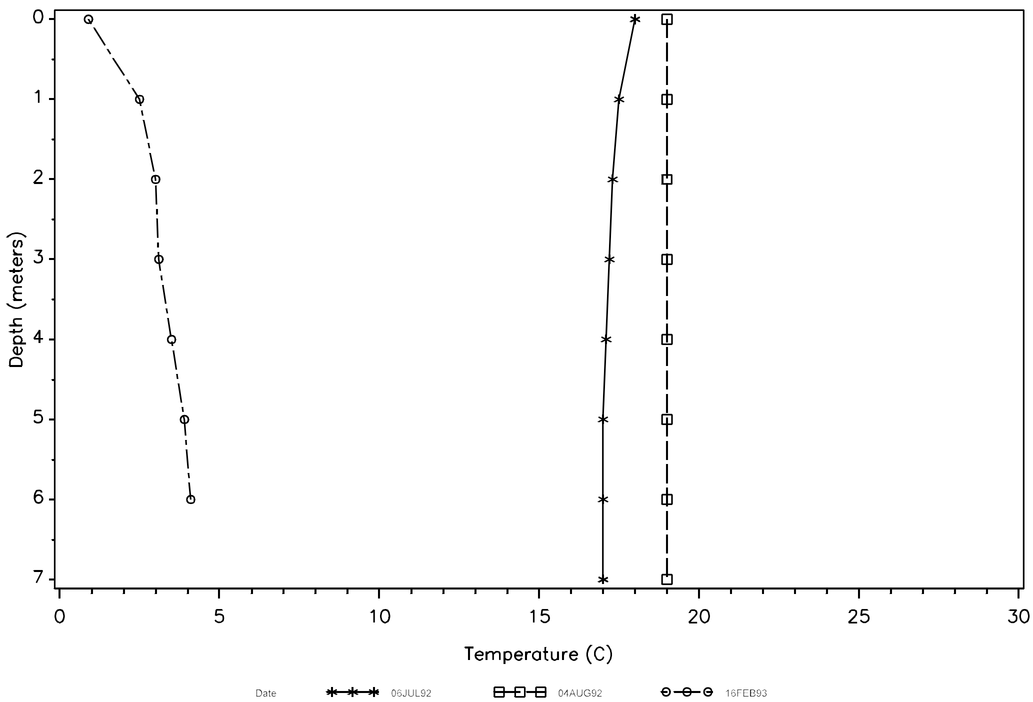


Figure 2. Temperature profile for Sweet Briar Dam.

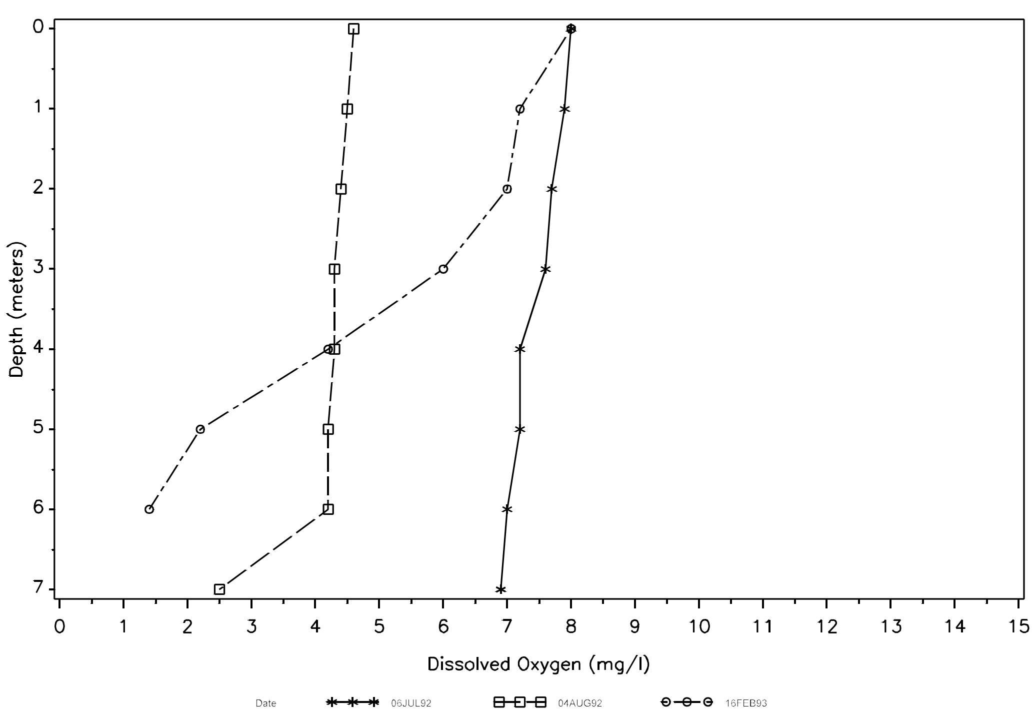


Figure 3. Oxygen profile for Sweet Briar Dam.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 6, 1992 and February 16, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Sweet Briar Dam		1982-1991	
Total Dissolved Solids	630	mg L^{-1}	1209	mg L^{-1}
Conductivity	973	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	148	mg L^{-1}	488	mg L^{-1}
Sulfates	169	mg L^{-1}	592	mg L^{-1}
Chloride	5	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.267	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.080	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	362	mg L^{-1}	296	mg L^{-1}
Ammonia	0.437	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.77	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	407	mg L^{-1}	326	mg L^{-1}

Aquatic Vegetation

On July 6, 1992, a qualitative survey of the macrophyte community was conducted on Sweet Briar Dam as part of the LWQA project. At the time of the macrophyte survey the main body of Sweet Briar Dam was ringed with intermittent patches of cattails Typha spp. to a depth of 2 feet and sago pondweed Potamogeton pectinatus to a depth of approximately six feet. The inlet area of Sweet Briar Dam had nearly a solid ring of cattails Typha spp. with intermittent and sparse populations of sago pondweed Potamogeton pectinatus, curly leaf pondweed Potamogeton crispus and arrowhead Sagittaria spp. A map depicting the areal extent of macrophyte coverage on Sweet Briar Dam is contained in Appendix B.

Phytoplankton

Sweet Briar Dam's phytoplankton community was sampled two times during the summer of 1992. At the time of the assessment Sweet Briar Dam's phytoplankton community was represented by five divisions and 12 genera. The largest contributors to Sweet Briar Dam's phytoplankton community by numerical density were the blue-green algae, Cyanophyta. Mean numerical density of the blue-green algae for the two samples collected during the summer of 1992 was 16,536 cell mL^{-1}, representing a dominance of approximately eight fold over all other divisions combined. Other divisions represented in descending number were Cryptophyta, Chlorophyta, Bacillariophyta and Euglenophyta.

During the assessment mean phytoplankton concentrations by volume were also dominated by the blue-green algae, Cyanophyta. Blue-green algae occupied approximately 59 percent of the phytoplankton community by volume. The division Chlorophyta followed with a little over 31 percent, then Cryptophyta with 9.5 percent and the remainder was composed of Bacillariophyta and Euglenophyta. A complete listing of the phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data combined with ancillary data collected during the summer of 1992 defined Sweet Briar Dam was eutrophic. Primary water quality data used in making this assessment was secchi disk depth transparency readings that ranged between 2.0 and 3.1 meters, a chlorophyll-a concentration of 6 $\mu g\ L^{-1}$, and total phosphate as P concentrations of 85 and 89 $\mu g\ L^{-1}$. Collaborating ancillary data of a eutrophic status is frequent nuisance algal blooms, large macrophyte biomass, a phytoplankton community dominated by Cyanophyta and rapid oxygen depletion under ice cover conditions and below the hypolimnion.

Sediment Analysis

Sediments were collected from Sweet Briar Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area the lake (Site 380620), the inlet (Site 380862) and the littoral zone (Site 380622) (Figure 1).

Sediment samples collected from Sweet Briar Dam show detectable levels of all trace elements tested for with the exception of selenium in the littoral area sediments. Reported concentrations of trace elements in the sediments collected from Sweet Briar Dam were compared to the reported concentrations for all lakes assessed in the LWQA project.

In general, trace element concentrations were comparatively high, with the majority being above the median and 75th percentile for all lake sediments collected during the LWQA project. The exceptions were the reported concentrations of arsenic in the deepest area sediments and selenium in all areas which were below the median concentration.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Sweet Briar Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Sweet Briar Dam on June 4, 1992. Walleye and white sucker samples were collected, representing the piscivore and bottom feeder groups, respectively. The walleye sample collected was composed of one fish with a mean length of 64 centimeters and a mean weight of 2,280 grams. The white sucker sample was composed of five fish with a mean length of 49.8 centimeters and a mean weight of 1,672 grams.

In order to evaluate the fish tissue data for Sweet Briar Dam the results for each fish sample was compared to all corresponding samples assessed in the LWQA project. Reported trace element concentrations in the walleye sample collected from Sweet Briar Dam contained detectable levels of zinc, barium, chromium, arsenic and mercury. Of these, barium exceeded the median concentrations, and selenium and mercury exceeded the 75th percentile.

The white sucker sample collected from Sweet Briar Dam contained detectable levels of all trace elements tested for with the exception of cadmium. In general, trace element concentrations reported for the white sucker sample were near or below the median with the majority being below the 25th percentile. The only exception was the reported concentration of selenium, which exceeded the 75th percentile.

Detectable pesticide residues in the walleye and white sucker samples collected from Sweet Briar Dam included BHC_Alpha, DDE, DDD and lindane. DDD and DDE are degradation byproducts of the insecticide DDT and behave similarly to the parent compound when exposed to the environment. BHC_Alpha and lindane are agricultural insecticides.

The walleye sample collected from Sweet Briar Dam contained DDD and DDE in concentrations that were below the median at 0.006 and 0.002 $\mu g\ g^{-1}$, respectively. The white sucker sample collected from Sweet Briar Dam contained BHC_Alpha, DDD, DDE and lindane. The DDE and DDD concentrations of 0.006 and 0.002 $\mu g\ g^{-1}$ are approximately equal to the median concentration reported for all bottom feeders sampled during the LWQA project. Both BHC_Alpha and lindane had reported concentrations of 0.002 $\mu g\ g^{-1}$ and represent concentrations that are above the 75th percentile. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Sweet Briar Dam with its contributing watershed has a combined surface area of 100,781 acres located in Morton County on the Coteau Slope physiographic region of North Dakota. Sweet Briar Dam's watershed is characterized by partially glaciated terrain separating the recently glaciated areas of North Dakota from the southwestern quarter of the state. Glacial deposits in the watershed are thin and discontinuous with remnants of unglaciated topography present. Soils in the watershed, other than river bottom soils which can be clayey, are predominantly silty or loamy and moderately well to well drained. In general, soils in the watershed are moderately fertile, easily worked and highly susceptible to both wind and water erosion. Annual precipitation within the watershed ranges from 14 to 17 inches. Nonpoint source pollution from the surrounding watershed accounts for all of the nutrient loading and pollution discharges to Sweet Briar Dam.

Land use within the Sweet Briar Dam watershed is 97.3 percent agricultural with 466 percent actively cultivated, 36.3 percent in cattle production, 11.4 percent in hay production, 1.7 percent in conservation reserve program (CRP) and 1.3 percent in farmsteads. The remaining 2.8 percent of the watershed is in wetland and wildlife management, low density urban development and transportation (Table 2).

According to the information provided by the Morton County Soil Conservation District, 50 percent of the cultivated lands and between 65 and 100 percent of the remaining agricultural lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Sweet Briar Dam watershed, the average "T" value is three to five tons per acre. Based on an average soil loss of 5.6 tons per acre, which takes into account all land practices and treatments currently employed within the watershed, it is estimated that 595,802 tons of soil are lost from the watershed annually. Assuming a conservative delivery rate of 10 to 15 percent, between 59,580 and 89,370 tons of soil are delivered to Sweet Briar Dam annually.

Other sources of nonpoint source pollution discharges to Sweet Briar Dam are from cattle feeding and watering in it and the immediate drainage, and the 65 concentrated livestock feeding areas within the watershed. These sources have the capabilities to cause rapid degradation to a waterbody of this size due to their ability to discharge concentrated loads of nutrients and solids.

Table 2. Land use in the Sweet Briar Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	46.6	50
Rangeland	36.3	65
Hayland	17.4	70
CRP	1.7	100
Wet/Wild[1]	0.8	N/A
Other	1.9	N/A
Farmsteads	88[3]	N/A
Feedlots[2]	65[3]	45

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

TOLNA DAM

NELSON COUNTY

Peter N. Wax

Tolna Dam is located in southeastern Nelson County on the eastern edge of the Glaciated Plains of North Dakota. Tolna Dam was created in 1937 under the Works Project Administration by damming a small tributary to the Sheyenne River. Since its original construction in 1937 the dam has undergone numerous repairs and modifications. Presently, the reservoir has a surface area of 147.1 acres with a maximum depth of 21 feet and a mean depth of 12.2 feet (Figure 1). Significant water level fluctuations of two to five feet have been regularly recorded during Tolna Dam's 55 year lifespan.

Tolna Dam's contributing watershed can be characterized by rolling to hilly topography with maximum shifts in elevation of less than 100 feet. Soils in the watershed vary significantly, but generally are formed from medium to coarse textured, sandy or clayey or glacial till. Soils are predominantly moderately erodible and moderately well drained. Annual precipitation is between 15 and 20 inches, with considerable variation between years.

Land use within the watershed is predominantly agricultural. The town of Tolna is the only municipality within the watershed with a population in 1990 of 230 people. The city of Tolna's waste treatment system is the only point source discharge within the watershed. Discharges occur approximately twice a yearly.

Tolna Dam is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage Tolna Dam by annually assessing the fish community by test netting and stock accordingly.

Historical fishery records for Tolna Dam indicate it supported an excellent sport fishery of black crappie between the years of 1942 to 1950. By the year 1955 the black crappie population had become stunted and coexisted with an overabundant population of black bullhead and yellow perch. A severe winter kill in 1955-56 reduced the crappie and perch population but did not severely affect the black bullheads. In 1961 the entire watershed was chemically eradicated by the NDG&F followed by stocking of rainbow trout between 1962 and 1967. Walleye were also introduced during this time period and an excellent fishery was produced from these two species between 1963 to 1970. Promiscuous introductions of yellow perch and black bullhead eventually overpopulated Tolna Dam necessitating a second eradication in 1978. In 1979 rainbow trout, walleye, northern pike, bluegill and black and white crappie were stocked.

Recent stockings by the NDG&F have included walleye, northern pike and black crappie. A fish community assessments conducted by the NDG&F on Tolna Dam on June 27, 1991, captured in order of most abundant, black crappie, walleye, yellow perch, and bullheads. Public use on Tolna Dam is light to heavy

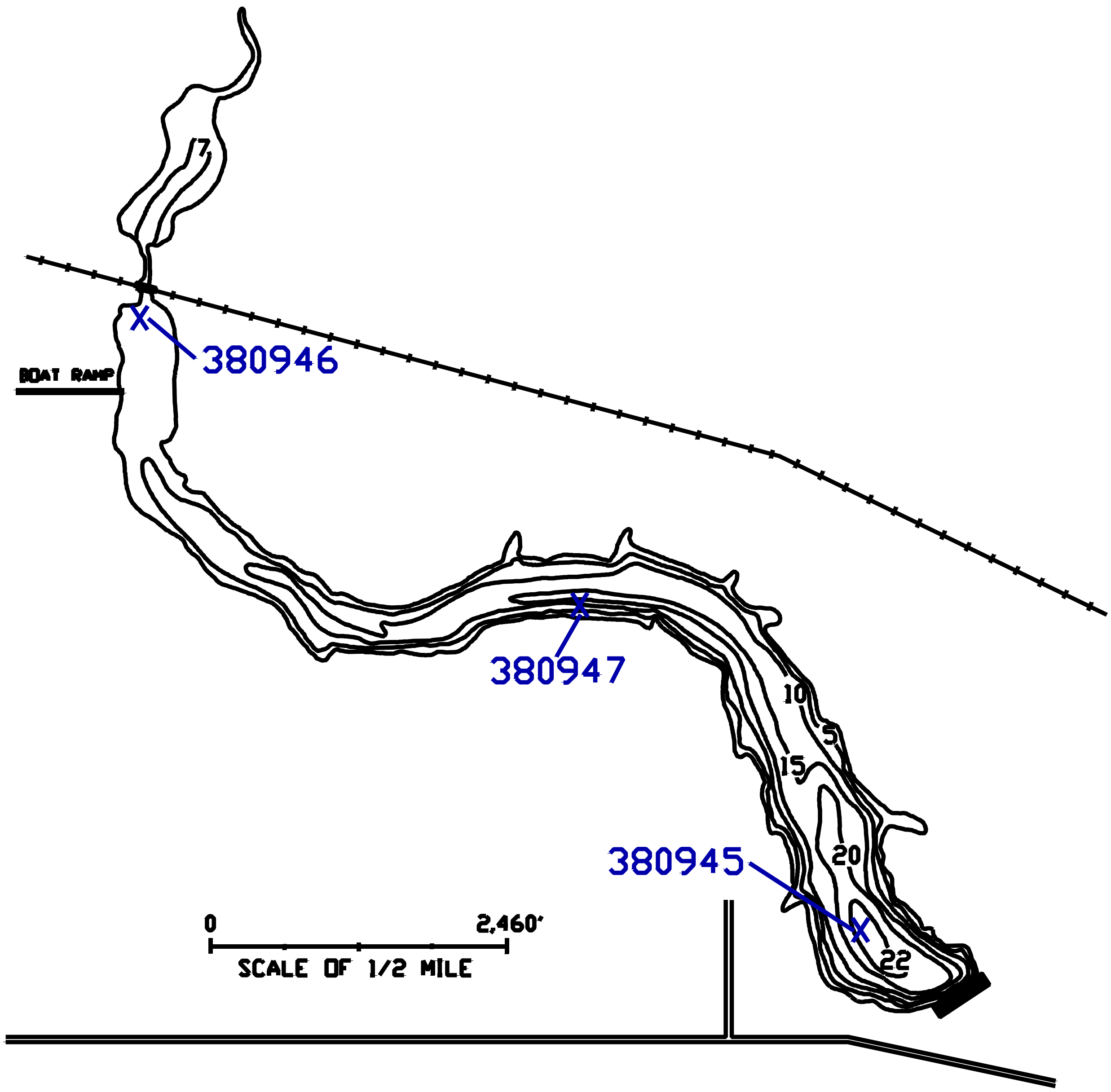


Figure 1. Morphometric map of Tolna Dam.

depending on the productivity of the fishery. Access to Tolna Dam is good from paved and gravel roads. Public facilities on Tolna Dam include two boat ramps, a picnic area and toilets.

Water Quality

Water quality samples were collected from Tolna Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380945) (Figure 1). Water column samples were collected for analysis at three discrete depths of one meter, between three and four meters, and between six and seven meters.

During the summer sampling of 1992 Tolna Dam did not thermally stratified (Figure 2). Dissolved oxygen concentrations ranged between 2.2 and 9.8 mg L^{-1} on July 22 and 0.5 to 7.0 mg L^{-1} on August 19 (Figure 3). Winter samples collected on March 3, 1993, showed Tolna Dam's water column thermally stratified between four and five meters of depth with dissolved oxygen concentrations ranging between 0.2 and 0.3 mg L^{-1} below the thermocline and 1.6 to 5.3 mg L^{-1} above (Figure 2, Figure 3).

Water quality samples collected during the LWQA project describe Tolna Dam as a well buffered waterbody. Total alkalinity as $CaCO_3$ concentrations ranged between 263 and 334 mg L^{-1} and had a volume-weighted mean concentration of 296 mg L^{-1} (Table 1). Concentrations of total dissolved solids, hardness as calcium and conductivity were lower than the state's long-term average with volume-weighted mean concentrations of 242, 296, and 699 mg L^{-1}, respectively (Table 1).

The dominant anions in the water column were bicarbonates and sulfates. Bicarbonates ranged between 254 and 423 mg L^{-1} with a volume-weighted mean of 314 mg L^{-1} while sulfates ranged between 68 and 111 mg L^{-1} with a volume-weighted mean of 84 mg L^{-1} (Table 1).

The primary nutrients total phosphate as P and nitrate + nitrite as N had volume-weighted mean concentrations of 0.199 and 0.099 mg L^{-1}, respectively. The ratio of dissolved phosphorus and nitrate + nitrite as N plus ammonia of approximately 1:1 indicate Tolna Dam is nitrogen limited. Concentrations of total phosphate as P ranged between 0.055 and 0.378 mg L^{-1} exceeding the state's target concentration of 0.02 mg L^{-1} on all occasions sampled. Nitrate + nitrite concentrations ranged between 0.02 and 0.3 mg L^{-1}, exceeding the state's target concentration of 0.25 mg L^{-1} on only the March sample date at 1 and 4 meters of depth. A complete list of LWQA water quality data is contained in Appendix A.

Aquatic Vegetation

A qualitative survey of the macrophyte community on Tolna Dam was conducted on July 22, 1992. At the time of the macrophyte survey approximately 20 percent of Tolna Dam's surface area had aquatic vegetation. Only a sparse populations of emergent vegetation was identified during the survey composed of small patches of bulrush Scirpus spp. and cattails Typha spp.. Submergent vegetation identified included mixed stands of sago pondweed Potamogeton pectinatus, curlyleaf pondweed Potamogeton crispus and water milfoil Myriophyllum spp. which extended to a depth of 6 feet.

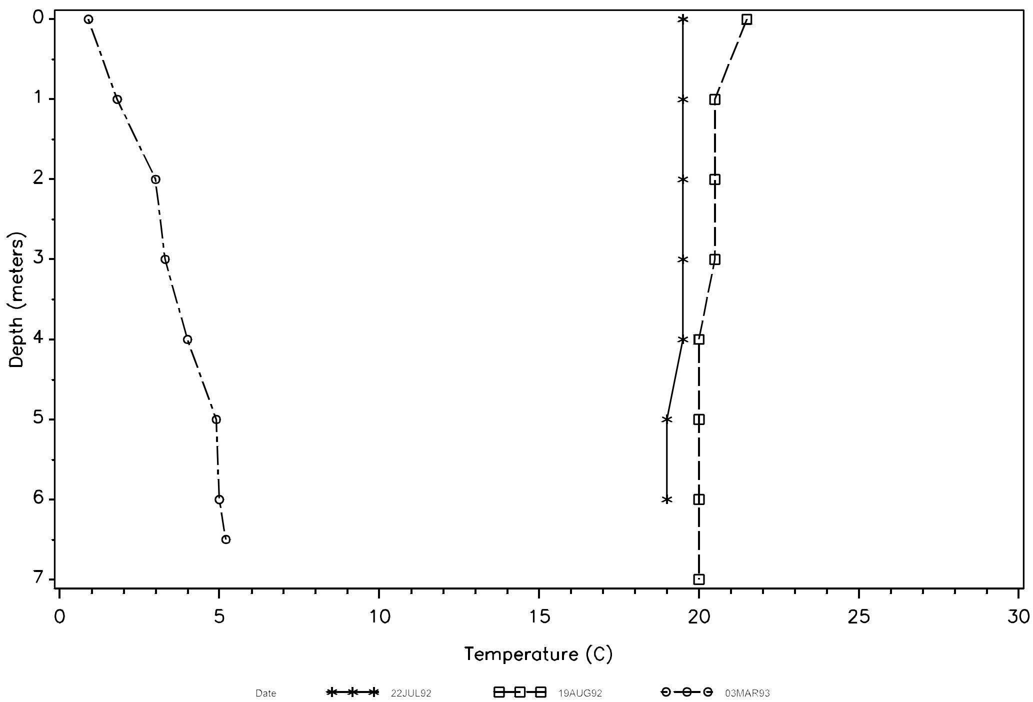


Figure 2. Temperature profile for Tolna Dam.

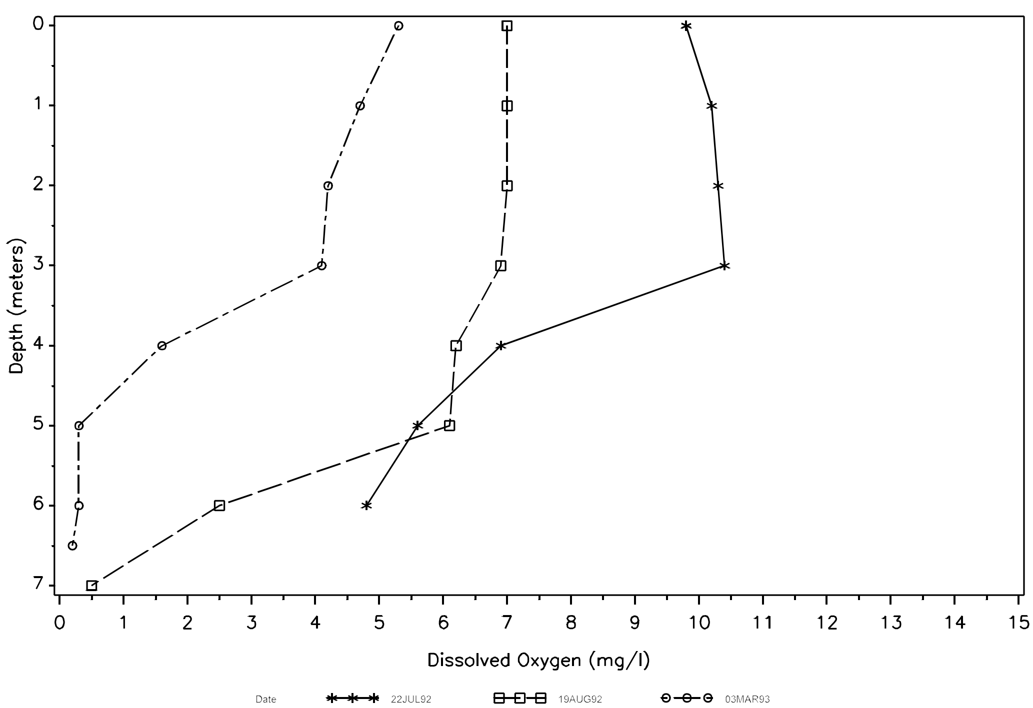


Figure 3. Oxygen profile for Tolna Dam.

The ratios of these mixed stands of submergents was approximately 95 percent sago pondweed and 5 percent curlyleaf and water milfoil. A map depicting the areal extent of macrophyte coverage on Tolna Dam is contained in Appendix B.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 22, 1992 and March 3, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Tolna Dam		1982-1991	
Total Dissolved Solids	422	mg L^{-1}	1209	mg L^{-1}
Conductivity	699	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	296	mg L^{-1}	488	mg L^{-1}
Sulfates	84	mg L^{-1}	592	mg L^{-1}
Chloride	16	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.199	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.099	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	296	mg L^{-1}	296	mg L^{-1}
Ammonia	0.111	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.21	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	314	mg L^{-1}	326	mg L^{-1}

Phytoplankton

Tolna Dam's phytoplankton community was sampled two times during the summer of 1992. The two samples collected from Tolna Dam's showed a phytoplankton community with representation from five divisions and 16 genera. The largest contributor to the phytoplankton community by numerical density were the blue-green algae, Cyanophyta. Mean density of the blue-green algae during the summer of 1992 was 69,321 cell mL^{-1}, representing a numerical dominance of approximately 3.8 fold over all other divisions combined. Other divisions present in descending numbers were Chlorophyta, Cryptophyta, Bacillariophyta and Euglenophyta.

Mean phytoplankton concentrations by volume were dominated by the division Bacillariophyta. The division Bacillariophyta occupied over 60 percent of the community by volume, followed by Cyanophyta with 37 percent and the remaining 3 percent composed of in descending order of volume, Cryptophyta, Chlorophyta and Euglenophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

During the summer of 1992 Tolna Dam was hypereutrophic. This assessment is based on primarily three water quality parameters, secchi disk depth transparency, chlorophyll-a concentrations and summer surface total phosphate as P concentrations. These three parameters agreed quite well and combined with ancillary information such as a large macrophyte biomass, frequent nuisance algal blooms, phytoplankton population dominated by blue-green algae and history of fish kills support the hypereutrophic assessment.

Sediment Analysis

Sediments were collected from Tolna Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected from the deepest area the lake (Site 380945), the inlet (Site 380946) and the littoral zone (Site 380947) (Figure 1).

Sediment samples collected from Tolna Dam show detectable levels of all trace elements tested for, with the exception of mercury in all areas and selenium in the littoral area. Reported trace element concentrations collected from Tolna Dam were compared to the reported concentrations for all lake sediments assessed in the LWQA project.

In general, trace element concentrations were near or below the 25th percentile for all lakes sampled during the LWQA project. The only exceptions were the concentrations of chromium in the deepest and inlet area sediments and the reported barium concentration in the littoral area sediments which exceeded the 75th percentile. Of note is the reported chromium concentration of 16.5 $\mu g\ g^{-1}$ in the inlet sample which was the highest reported during the LWQA project.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from Tolna Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Tolna Dam on June 22, 1992. Walleyes and black bullhead were collected representing the piscivore and bottom feeder groups. The walleye sample consisted of four fish with a mean length of 55.5 centimeters and a mean weight of 1,870 grams. The black bullhead sample was composed of five fish with a mean length of 23.4 centimeters and a mean weight of 194 grams.

In order to evaluate the fish tissue data for Tolna Dam the results for each fish sample was compared to all samples collected during the LWQA project. The walleye sample collected from Tolna Dam contained detectable levels of all trace elements tested for with the exception of copper and arsenic. Of the detectable trace elements, the reported concentrations were generally high. With all except zinc, selenium and lead exceeding the 75th percentile.

The black bullhead sample contained detectable levels of all trace elements tested for except for copper, arsenic, cadmium and mercury. Of the detectable trace elements, all were near or below the median with the majority being below the 25th percentile for all bottom feeders sampled during the LWQA project.

Detectable pesticide residues in the walleye sample collected from Tolna Dam included DDE, DDD, dieldrin, nonachlor, PCBs, triallate and trifluralin. The black bullhead sample collected from Tolna Dam contained detectable levels of only DDE. DDE and DDD are both degradation byproducts of the insecticide DDT. DDT is an agricultural insecticide which was removed from use in the early 1970s due to its harmful effects upon the environment. Dieldrin is also an agricultural insecticide, which like DDT, was pulled from use in the early 1970s. Nonachlor is a primary ingredient in technical chlordane, an agricultural insecticide which, like DDT and dieldrin, is no longer available due to the biological risks associated with its use. PCBs are generally considered industrial wastes, commonly used in plasticizers and dielectric fluids. Triallate and trifluralin are both preemergent selective herbicides, commonly known as Far-Go and Treflan, respectively.

The reported concentration of DDE in the black bullhead sample collected from Tolna Dam was 0.013 $\mu g\ g^{1}$ and is very near the 75th percentile for all bottom feeders analyzed during the LWQA project. Concentrations reported of DDE and DDD in the walleye sample collected from Tolna Dam were above the median, yet below the 75th percentile reported for all piscivores sampled during the LWQA project. The concentrations of dieldrin, nonachlor, PCBs, triallate and trifluralin in the walleye sample collected from Tolna Dam were all equal to or above the 75th percentile concentrations for all piscivores sampled during the LWQA project. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Tolna Dam with its contributing watershed has a combined surface area of 30,720 acres located on the glaciated plains in Nelson County, North Dakota. The watershed is characterized by gently rolling to rolling glaciated plains with well defined small intermittent drainages. The irregular patterns of hills and valleys caused by glacial thrusting and sedimentation overlie a relatively deep deposit of glacial till. Tolna Dam's watershed is located in the Sheyenne drainage one of the three main river drainages in the glaciated plains region of North Dakota.

Soils in this region vary significantly but are generally formed from medium to coarse textured sandy or clayey, loamy glacial till. Soils are predominantly moderately erodible and moderately well drained. Annual precipitation within the watershed varies between 15 and 20 inches.

Nonpoint source pollution from the surrounding watershed accounts for nearly all of the nutrient loading and pollution discharges to Tolna Dam. The city of Tolna's lagoons are the only point source discharge within the watershed. According to the NDSDHCL permit program, the city of Tolna discharges from its lagoon approximately twice yearly.

Land use within the Tolna Dam watershed is 97.6 percent agricultural, with 66.1 percent actively cultivated, 11.0 percent in livestock production, 6.8 percent in hay production, 12.6 percent in conservation reserve program (CRP) and 1.1 percent in farmsteads. The remaining 2.4 percent of the watershed is composed of rural and urban developments, and transportation. The city of Tolna is the only municipality within the watershed. Tolna human population is approximately 230. The watershed also has 25 farms and 8 concentrated livestock feeding areas (Table 2).

According to the information provided by the Nelson County Soil Conservation District, approximately 70 percent of all cultivated lands and nearly 100 percent of all the remaining agricultural lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the Tolna Dam watershed, the average "T" value is three to five tons per acre. Based on an estimated soil loss of just over 4 tons per acre, which takes into account all land practices and treatments currently employed within the watershed, approximately 127,629 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent, between 12,763 and 19,144 tons of soil are delivered to Tolna Dam annually.

Other sources of pollution discharges to Tolna Dam are from the Tolna city lagoon's discharge, cattle feeding and watering in Tolna Dam and the immediate upstream drainage and concentrated livestock feeding areas. These sources have the capability to contribute nutrients to the lake and may be significant sources due to their ability to contribute large concentrated loads during runoff and discharge events.

Table 2. Land use in the Tolna Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	66.1	70
Rangeland	11.0	100
Hayland	6.8	100
CRP	12.6	100
Wet/Wild[1]	0.2	N/A
Other	2.5	N/A
Farmsteads	25[3]	N/A
Feedlots[2]	8[3]	0

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

WARSING DAM

EDDY COUNTY

Peter N. Wax

Warsing Dam is located in northeastern Eddy County on the Glaciated Plains of North Dakota. The reservoir was created in 1961 by damming a tributary to the Sheyenne River approximately 1/2 mile east of the town of Sheyenne, a community of 272 (1990 census). Warsing Dam has a surface area of 53.4 acres, a maximum depth of 28 feet and a mean depth of 11.2 feet (Figure 1).

Warsing Dam's watershed is characterized by rolling to hilly glaciated plains with many small potholes and integrated drainages typifying the characteristics of the northern prairie pothole region. Annual precipitation within the watershed is 15 to 20 inches. Land use is predominantly agricultural, with pastures and cultivated fields creating a checkerboard areal appearence.

Warsing Dam is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL 1991). The North Dakota Game and Fish Department (NDG&F) manage Warsing Dam by annually assessing the fish community through test netting and stock accordingly.

The initial fishery on Warsing Dam began in 1963 after eradication of the reservoir basin and upstream watershed. Following eradication the NDG&F introduced rainbow trout and largemouth bass. Warsing Dam produced an excellent sport fishery between 1963 and 1968, however, by 1969 black bullheads were dominating the fish community. In 1971 the NDG&F for a second time chemically eradicated Warsing Dam. In 1972 walleye and rainbow trout were stocked with subsequent plants of brown trout, largemouth bass and bluegills. Due to heavy predation of the trout by the largemouth bass and walleye trout stockings were terminated in 1976.

The recent stocking regiment by the NDG&F has included walleye and largemouth bass. Fish community assessments conducted by the NDG&F on July 13, 1991 captured in order of most abundant black bullhead, yellow perch, bluegill, walleye and largemouth bass. Presently recreational use on Warsing Dam is dominated by ice fishermen in the pursuit of yellow perch.

Shortly after its construction Warsing Dam experienced water quality degradation systematic of excessive nutrient loading from it's poorly treated watershed, cattle feeding and watering in it and the city of Sheyenne's lagoon releases. Presently, the city of Sheyenne lagoon system is no longer contributing to the degradation of Warsing Dam, as they have not discharged since 1975. However, siltation and other nonpoint source pollutants are still being discharged to Warsing Dam from the watershed, and cattle feeding and grazing along its north shore.

Public facilities at Warsing Dam are excellent, maintained by the city of Sheyenne. Public facilities include the Ollie Dion Memorial Park with boat ramps, picnic areas, camping areas, shelters and toilets.

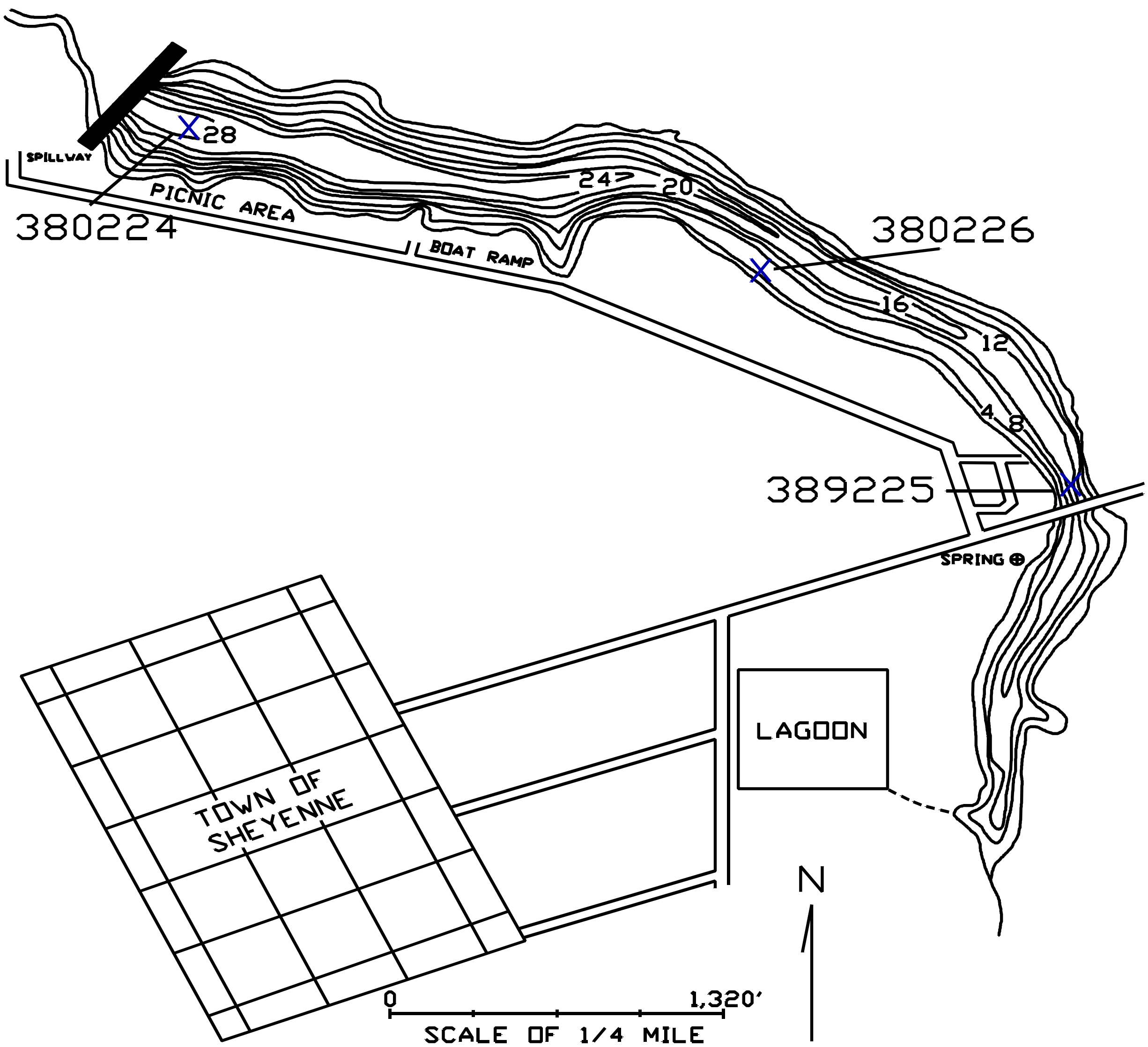


Figure 1. Morphometric map of Warsing Dam.

Water Quality

Water quality samples were collected from Warsing Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 381375) (Figure 1). Water column samples were collected for analysis at three discrete depths of 1 meter, between 3 and 4 meters, and between 5.5 and 6 meters.

During the summer sampling of 1992 Warsing Dam was not thermally stratified on July 22, and had dissolved oxygen concentrations ranging between 1.6 near the bottom to 8.4 mg L^{-1} at the surface. On August 19, Warsing Dam was weakly thermally stratified between three and four meters of depth with dissolved oxygen concentrations ranging between 0.6 and 1.3 mg L^{-1} below the thermocline and 4.7 to 11.4 above (Figure 2) (Figure 3). Samples collected on January 10, 1993, showed Warsing Dam's water column as weakly thermally stratified at approximately three meters of depth. Dissolved oxygen concentrations ranged between 0.3 and 1.8 mg L^{-1} below the thermocline and 1.8 to 4.2 mg L^{-1} above (Figure 2, Figure 3).

Concentrations of total dissolved solids, hardness as calcium and conductivity were lower than the state's long-term average with volume-weighted mean concentrations of 546, 267, and 926 mg L^{-1}, respectively (Table 1). LWQA water quality data indicate Warsing Dam is a well-buffered water body. Concentrations of total alkalinity as $CaCO_3$ ranged between 273 and 351 mg L^{-1} with volume-weighted mean concentration of 298 mg L^{-1} (Table 1).

The dominant anions in the water column were bicarbonates and sulfates. Bicarbonate concentrations ranged between 266 and 429 mg L^{-1} with volume-weighted mean concentration of 327 mg L^{-1}. Sulfates ranged between 109 and 137 mg L^{-1}, with volume-weighted concentration mean of 119 mg L^{-1} (Table 1).

The primary nutrients total phosphate as P, and nitrate + nitrite as N had volume-weighted mean concentrations of 0.144 and 0.099 mg L^{-1}, respectively (Table 1). Total phosphate as P concentrations ranged between 0.105 and 0.331, exceeding the state's target concentration of 0.02 mg L^{-1} on all occasions sampled. Nitrate + nitrite as N concentrations ranged between nondetectable to 0.269 mg L^{-1} and was under the state's target concentration of 0.25 mg L^{-1} in all but three samples. The ratios between total dissolved phosphorus and nitrate + nitrite as N combined and ammonia of 1:2.7 indicate Warsing Dam is nitrogen limited. Warsing Dam's primary production, however, is not limited by the lack of nitrogen. Under these conditions nitrogen fixing organisms such as some species of blue-green algae are favored. A complete list of LWQA water quality data is contained in Appendix A.

Aquatic Vegetation

On July 22, 1992, a qualitative survey of the macrophyte community was conducted on Warsing Dam as part of the LWQA project. At the time of the macrophyte survey 100 percent of Warsing Dam shoreline had a ring of cattails Typha spp. extending to a depth of approximately four feet. Sub mergent macrophyte vegetation present on Warsing Dam included sago pondweed Potamogeton pectinatus, extending to a depth of approximately five feet, water milfoil Myriophyllum spp., extending to a depth of approximately four feet and coontail Ceratophyllum demersum, extending

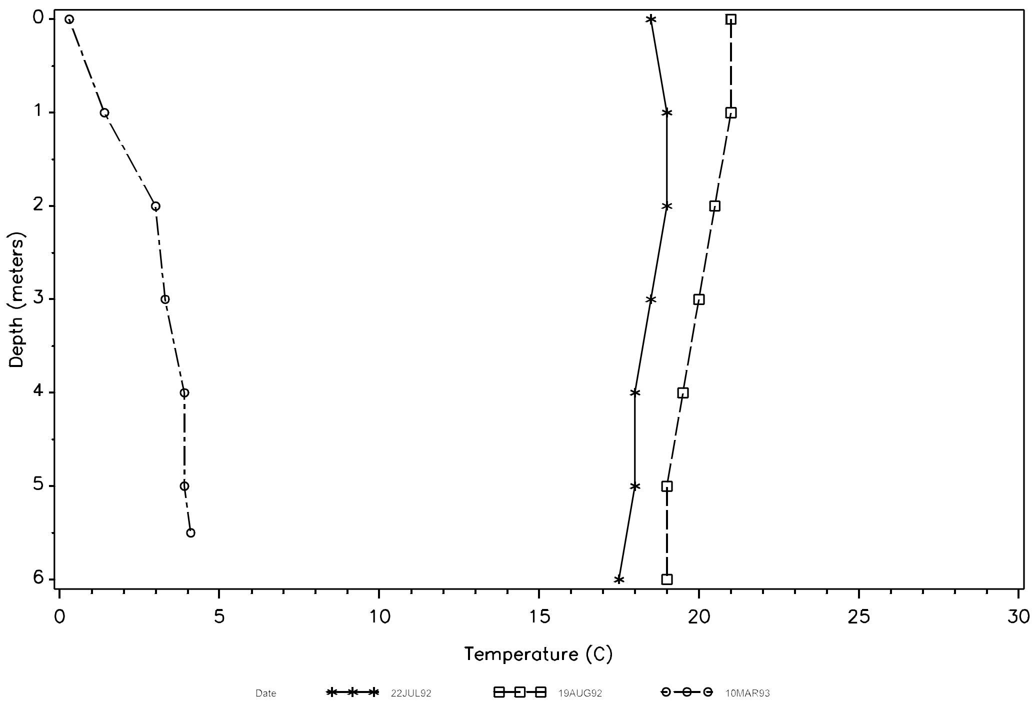


Figure 2. Temperature profile for Warsing Dam.

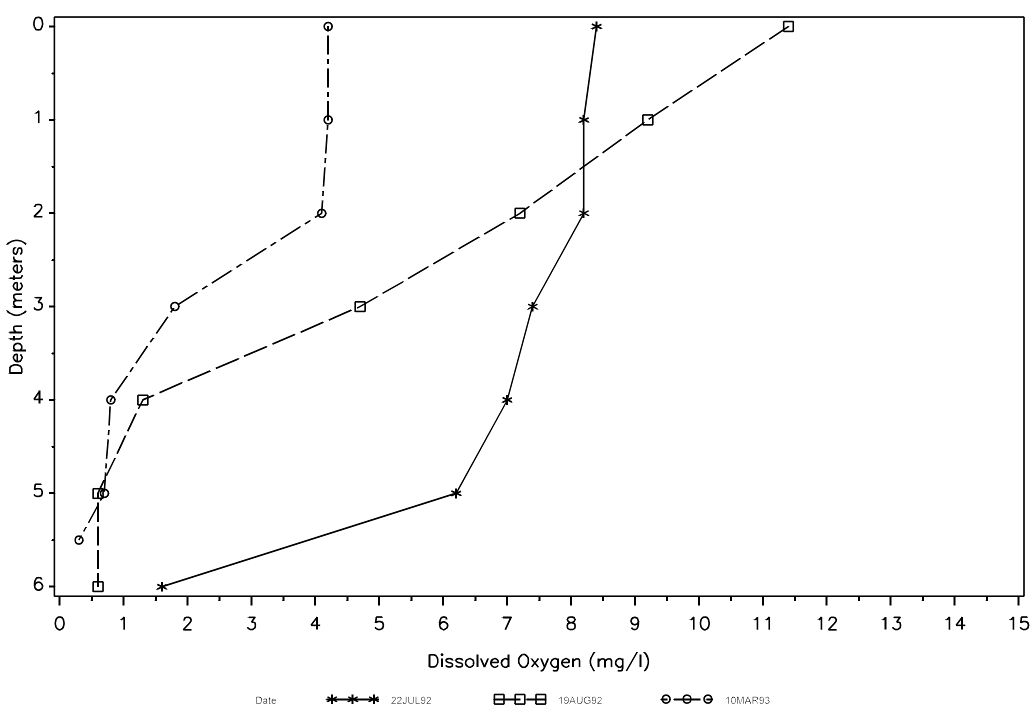


Figure 3. Oxygen profile for Warsing Dam.

to a depth of approximately four feet. Density of the three submergent macrophytes identified was approximately 80 percent sago pondweed, 10 percent water milfoil and 10 percent coontail. A map depicting the areal extent coverage of macrophytes on Warsing Dam is contained in Appendix B.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 22, 1992 and March 10, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	Warsing Dam		1982-1991	
Total Dissolved Solids	546	mg L^{-1}	1209	mg L^{-1}
Conductivity	926	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	267	mg L^{-1}	488	mg L^{-1}
Sulfates	119	mg L^{-1}	592	mg L^{-1}
Chloride	62	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.144	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.099	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	298	mg L^{-1}	296	mg L^{-1}
Ammonia	0.170	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	1.49	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	327	mg L^{-1}	326	mg L^{-1}

Phytoplankton

Warsing Dam's phytoplankton community was sampled two times during the summer of 1992. The combined samples identified five phytoplankton divisions and 17 genera. The largest contributors to the phytoplankton community by numerical density were the blue-green algae, Cyanophyta. Blue-green algae mean density for the two samples collected was 120,165 cell mL^{-1}, representing a numerical dominance of nearly 30 fold over all other divisions combined. Other divisions present in descending numbers were Cryptophyta, Chlorophyta, Bacillariophyta and Pyrrophyta.

At the time of the assessment mean phytoplankton concentrations by volume were also dominated by the division Cyanophyta. Blue-green algae occupied just under 75 percent of the community by volume. The division Cryptophyta followed with a little over 15 percent and the remainder of the community was composed of Bacillariophyta, Pyrrophyta and Chlorophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

Water quality data collected on Warsing Dam during the LWQA project defines Warsing Dam is hypereutrophic. Primary water quality data used to define Warsing Dams trophic status was secchi disk depth transparencies of 1.1 to 2.4 meters, chlorophyll-a concentrations of 6 and 29 µg L^{-1} and summer surface total phosphate as P concentrations of 107 and 181 µmg L^{-1}. The assessment of hypereutrophic is collaborated by ancillary information such as rapid oxygen depletion below the hypolimnion and under ice cover conditions, large macrophyte biomass, frequent nuisance algal blooms and a phytoplankton community dominated by blue-green algae species.

Sediment Analysis

Sediments were collected from Warsing Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area of the lake (Site 381375), the inlet (Site 381376) and the littoral zone (Site 381377) (Figure 1).

Sediment samples collected from Warsing Dam contained detectable levels of all trace elements tested for with the exception of selenium in the deepest and inlet area sediments, and mercury in all areas. Reported trace element concentrations in the sediments collected from Warsing Dam were compared to the reported concentrations for all lakes assessed in the LWQA project.

In general, reported trace element concentrations were near or below the median concentrations for sediments collected during the LWQA project with a many below the 25th percentile. The only exceptions were the reported concentrations of chromium in the inlet area sediments, and barium and selenium in the littoral area sediments. These concentrations all exceeded the 75th percentile for all lakes assessed in the LWQA project.

Concentrations of selected organic compounds and PCBs were below detectable limits in all sediment samples collected from Warsing Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from Warsing Dam on June 23, 1993. Bluegill were the only species collected, representing the insectivore group. The bluegill sample was composed of five fish with a mean length of 19 centimeters and a mean weight of 218 grams, or approximately 1/2 pounds.

To evaluate the fish tissue data for Warsing Dam the results for the bluegill sample was compared to all insectivores samples assessed in the LWQA project. The bluegill sample collected from Warsing Dam had detectable levels of all trace element concentrations tested for with the exceptions of cadmium and mercury. Of the trace elements detected, in general, the reported concentrations were below the median with a significant number below the 25th percentile. The only exception was the concentration of selenium, which was slightly above the median concentration at 0.31 $\mu g\ g^{-1}$.

Detectable pesticide residues in the bluegill sample collected from Warsing Dam was limited to DDE. DDE is a degradation byproduct of the insecticide DDT, which can produce biological effects similar to the parent compound when available to the environment.

The DDE concentrations reported in the bluegill sample collected from Warsing Dam of 0.002 $\mu g\ g^{-1}$ is below the 25th percentile of 0.003 $\mu g\ g^{-1}$ for all insectivores sampled during the LWQA project. Concentrations of PCBs in the bluegill sample collected from Warsing Dam were below detectable levels. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

Warsing Dam with its contributing watershed has a combined surface area of 8,360 acres located on the Glaciated Plains physiographic region in Eddy County, North Dakota. The watershed is characterized by gently rolling to rolling glaciated plains, with many small potholes and intermittent drainages. The watershed itself is a tributary to the Sheyenne River. The Sheyenne River is one of three main river basins within the Glaciated Plains of North Dakota. The regular patterns of hills and valleys within the watershed overlie a relatively deep deposit of glacial till.

Soils within the watershed are generally formed from coarse textured sandy or clayey, loamy glacial till. Soils are moderately erodible and moderately well drained. Annual precipitation is between 15 and 20 inches a year, with considerable variations between years. Nonpoint source pollution from the surrounding watershed accounts for nearly all of the nutrient loadings and pollution discharges to Warsing Dam.

Land use within the Warsing Dam watershed is approximately 75 percent agricultural with 45.7 percent actively cultivated, 17.6 percent in livestock production, 14.0 percent in haylands and 7.5 percent in Conservation Reserve Program (CRP). The remaining 25 percent of the watershed is in woodlands, wetlands, wildlife management, transportation, farms and concentrated livestock feeding areas (Table 2). The community of Sheyenne which has a population of 272, ten farms, one feedlot and the Ollie Dion Memorial Park are the only developments within the watershed.

Table 2. Land use in the Warsing Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	45.7	60
Rangeland	7.6	90
Hayland	14.0	90
CRP	7.5	100
Woodlands	0.1	N/A
Wet/Wild[1]	2.9	N/A
Other	2.6	N/A
Farmsteads	10[3]	N/A
Feedlots[2]	1[3]	100

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

According to the information provided by the Eddy County Soil Conservation District 60 percent of the cultivated lands and between 90 and 100 percent of all the remaining lands within the watershed are "adequately treated" against soil loss. Based on an average soil loss of approximately six tons per acre, which takes into account all land practices and treatments currently being employed in the watershed, approximately 49,975 tons of soil are lost annually from within the watershed. Assuming a conservative delivery rate of 10 to 15 percent between 4,977 and 7,496 tons of soil are delivered to Warsing Dam annually.

Other sources of nonpoint source pollution discharges to Warsing Dam are from the city of Sheyenne, concentrated livestock feeding areas, cattle feeding and watering in it, road construction and any other developments which occur along its banks. These sources have the capabilities to contribute nutrients and sediments to the lake and possible are a significant source due to their ability to produce a concentrated highly fertile load during snowmelt and storm events.

WHITE EARTH DAM

MOUNTRAIL COUNTY

Peter N. Wax

White Earth Dam is located on the Missouri Coteau in central Mountrail County, North Dakota. It was constructed in 1970 for recreation through the combined efforts of the Mountrail Water Resource District, the North Dakota State Water Commission, the Bureau of Outdoor Recreation, the North Dakota Game and Fish Department (NDG&F) and the Federal Disaster Administration. The dam creating the reservoir lies across the White Earth River in the picturesque White Earth Valley. The valley is a classic example of the missouri river drainage with hardwood coulees topped with rolling prairies, abounding in native flora and fauna. The dam itself is a rolled earthen structure, creating an impoundment of 174 acres, with a maximum depth of 25 feet and a mean depth of 9.4 feet (Figure 1).

White Earth Dam is classified as a cool water fishery, "Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota" (NDSDHCL, 1991). The NDG&F manage White Earth Dam by annually assessing the fish community through test netting and stock accordingly.

Initial fisheries management by the NDG&F began after the reservoir filled in 1979 with the stockings of northern pike, walleye, bluegill, yellow perch and crappie. Subsequent test nettings indicated the adult perch survived but failed to reproduce. Of the other species stocked the only recorded reproduction was by the northern pike. The current stocking regiment by the NDG&F for White Earth Dam includes northern pike, bluegill and walleye.

White Earth Dam is 100 percent publicly controlled under a wildlife easement. Public access to the waterbody is good from county roads. Public access on White Earth Dam include a recreational use area on the southwest shore, which has facilities for camping, picnicking with shelters, boating, associated parking, and toilets. These excellent facilities are maintained by the Mountrail Park Board.

The reservoir itself is narrow, long and winding with an intricate shoreline. The original river channel provides the deepest areas within the waterbody (Figure 1). Public use on White Earth Dam is light to moderate depending on the productivity of the fishery. Heavy macrophyte growth and frequent nuisance algal blooms inhibit shore fishing, however, White Earth Dam remains popular with the locals. White Earth Dam receives its primary use from the community of White Earth, which lies approximately six miles downstream from the reservoir and the rural farming community within a 50-mile radius.

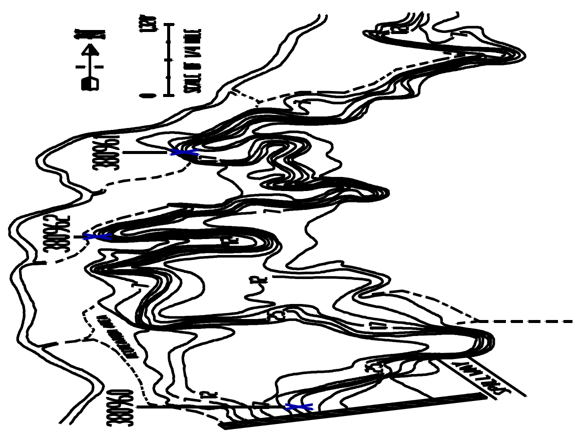


Figure 1. Morphometric map of White Earth Dam.

Water Quality

Water quality samples were collected from White Earth Dam twice during the summer of 1992 and once during the winter of 1993. Samples were collected at one sample site located in the deepest area of the lake (Site 380960, Figure 1). Water column samples were collected for analysis at three discrete depths of one meter, three meters and six meters.

During 1992 summer sampling White Earth Dam was weakly thermally stratified between five and six meters of depth on July 15, however, developed no thermal stratification on August 13 (Figure 2). Dissolved oxygen concentrations on the July sample date ranged between 2.3 and 3.2 mg L^{-1} below the thermocline to between 7.0 to 7.5 mg L^{-1} above. Dissolved oxygen concentrations on August 13 ranged between 4.8 and 7.5 mg L^{-1} (Figure 3). Samples collected on February 23, 1993, again showed White Earth Dam's water column as not thermally stratified with dissolved oxygen concentrations ranging between 1.3 and 3.6 mg L^{-1} (Figure 2, Figure 3).

Concentrations of total dissolved solids, hardness as calcium and conductivity were higher than the state's long-term average with volume-weighted mean concentrations of 2,280, 558 and 3,126 mg L^{-1}, respectively (Table 1). Sulfates and bicarbonates were the dominant anions in the water column. Sulfates ranged between 828 and 1,250 mg L^{-1} while bicarbonates ranged between 733 to 1,060 mg L^{-1}. Concentrations of total alkalinity as $CaCO_3$ ranged between 719 and 996 mg L^{-1} with a volume-weighted mean of 850 mg L^{-1} describing a well buffered waterbody (Table 1).

The nutrients total phosphate as P and nitrate + nitrite as N had volume-weighted means of 0.248 and 0.068 mg L^{-1}, respectively (Table 1). Total phosphate as P concentrations ranged between 0.216 and 0.301 mg L^{-1}, exceeding the state's maximum target concentration of 0.02 mg L^{-1} in all samples collected. The nitrate + nitrite as N concentrations ranged between 0.019 and 0.173 mg L^{-1}, remaining below the state's target concentration of 0.25 mg L^{-1} on all occasions sampled.

Table 1. Average volume-weighted mean concentrations for selected water quality parameters sampled between July 15, 1992 and February 23, 1993, and long-term averages for all North Dakota lake data collected by the NDSDHCL between January 1, 1982 and December 31, 1991.

Parameter	White Earth Dam		1982-1991	
Total Dissolved Solids	2280	mg L^{-1}	1209	mg L^{-1}
Conductivity	3126	umhos cm^{-1}	1604	umhos cm^{-1}
Hardness as Calcium	558	mg L^{-1}	488	mg L^{-1}
Sulfates	1020	mg L^{-1}	592	mg L^{-1}
Chloride	21	mg L^{-1}	81	mg L^{-1}
Total Phosphate as P	0.248	mg L^{-1}	0.248	mg L^{-1}
Nitrate + Nitrite as N	0.068	mg L^{-1}	0.069	mg L^{-1}
Total Alkalinity	813	mg L^{-1}	296	mg L^{-1}
Ammonia	0.124	mg L^{-1}	0.347	mg L^{-1}
Total Kjeldahl Nitrogen	2.04	mg L^{-1}	2.34	mg L^{-1}
Bicarbonate	850	mg L^{-1}	326	mg L^{-1}

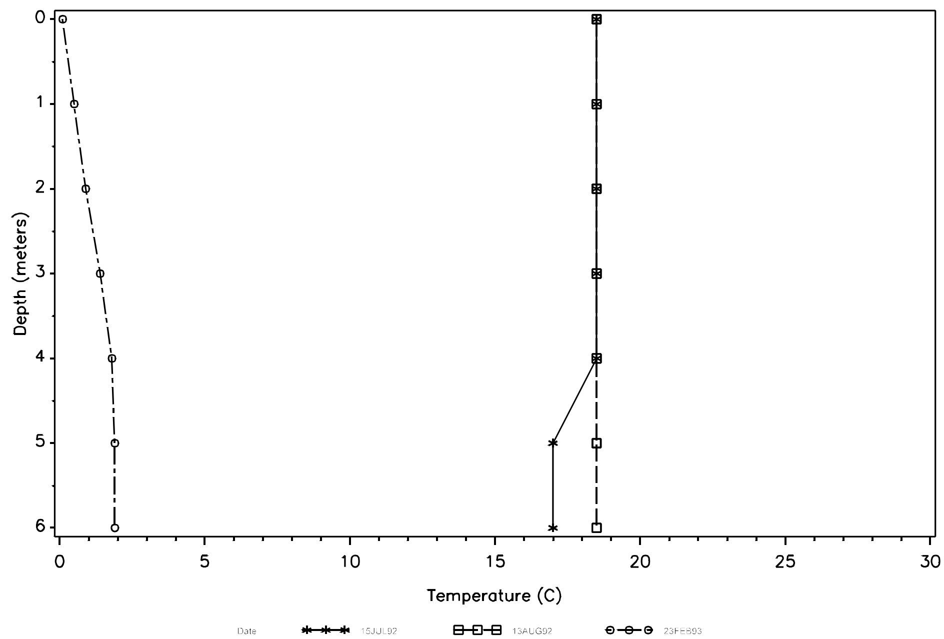


Figure 2. Temperature profile for White Earth Dam.

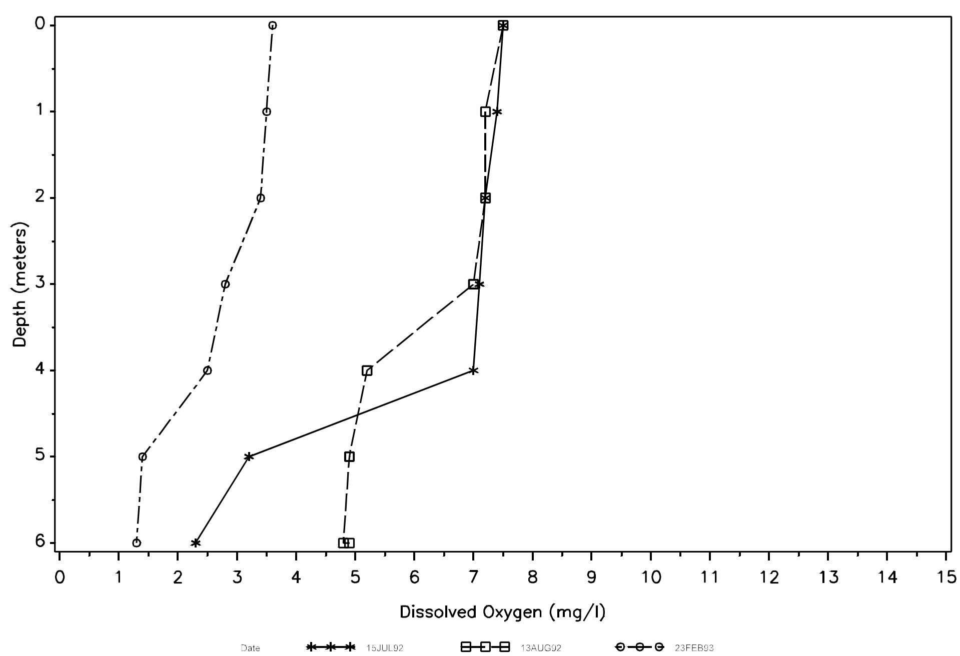


Figure 3. Oxygen profile for White Earth Dam.

The ratios between total dissolved phosphorus and nitrate + nitrite as N combined with ammonia was 1.2:1, indicating White Earth Dam is nitrogen limited. Under these conditions, organisms with the ability to affix free nitrogen, such as certain blue-green algae species, are favored. A complete list of LWQA water quality data is contained in Appendix A.

Aquatic Vegetation

A qualitative survey of the macrophyte community was conducted for White Earth Dam on July 15, 1992. At the time of the macrophyte survey White Earth Dam was ringed by cattails Typha spp. and bulrush Scirpus to a depth of approximately three feet. The ring of cattails and bulrush was sparse and at times intermittent.

Submergent macrophytes identified on White Earth Dam included sago pondweed Potamogeton pectinatus, water milfoil Myriophyllum spp. and coontail Ceratophyllum demersum to a depth of approximately four feet. The dominant submergent macrophyte was sago pondweed occupying approximately 80 percent of the community, with only sparse intermittent patches of water milfoil and coontail. A map depicting the areal extent of macrophyte coverage on White Earth Dam is contained in Appendix B.

Phytoplankton

White Earth Dam's phytoplankton community was sampled two times during the summer of 1992. White Earth Dam's phytoplankton community during the two sample periods was represented by five divisions and 16 genera. The largest contributors to the phytoplankton community in numerical density was the division Chlorophyta with eight genera present. Mean density of the two samples collected for the division Chlorophyta was 70,752 cell mL^{-1}, representing a numerical dominance of approximately 31 fold over all other divisions combined. Other divisions represented in descending number were Cyanophyta, Chrysophyta, Bacillariophyta, and Pyrrophyta.

At the time of the assessment, mean phytoplankton concentrations by volume were dominated by the division Pyrrophyta, which occupied approximately 39 percent of the phytoplankton community by volume, followed by the divisions Bacillariophyta with 34 percent, Chlorophyta with 19 percent and the remainder composed of Chrysophyta and Cyanophyta. A complete listing of phytoplankton data is contained in Appendix C.

Trophic Status

At the time of the LWQA project, White Earth Dam was eutrophic. This assessment is based primarily on the three water quality indicators, secchi disk depth transparency, chlorophyll-a concentrations and summer surface total phosphate as P concentrations.

Secchi disk depth transparencies ranged between 1 and 1.3 meters, chlorophyll-a concentrations at both sample times was 3 $\mu g\ L^{-1}$ and summer surface total phosphate as P concentrations ranged between 216 and 227 $\mu g\ L^{-1}$. Collaborating ancillary information of a eutrophic assessment was frequent nuisance algal blooms and rapid dissolved oxygen depletion under ice cover conditions and below the hypolimnion.

Sediment Analysis

Sediments were collected from White Earth Dam and analyzed for trace elements, PCBs and selected pesticides. Sediments were collected at the deepest area the lake (Site 380960), the inlet (Site 380961) and the littoral zone (Site 380962) (Figure 1).

Sediment samples collected from White Earth Dam show detectable levels of all trace elements tested for with the exception of mercury. Reported trace element concentrations in the sediments collected from White Earth Dam were compared to the reported concentrations for all sediment samples collected during the LWQA project.

In general, reported trace element concentrations in the sediments collected from White Earth Dam were relatively high with the majority being near or above the 75th percentiles reported during the LWQA project. The exceptions were the reported concentrations of arsenic in the deepest and inlet area sediments, selenium in the inlet and littoral sediments, cadmium in the deepest and littoral area sediments and lead in the deepest and littoral area sediments, which were below the median concentrations reported for all sediment samples analyzed during the LWQA project.

Concentrations of selected pesticides and PCBs were below detectable limits for all sediment samples collected from White Earth Dam. A complete listing of the sediment results is provided in Appendix D.

Whole Fish Analysis

Fish were collected for contaminant analysis from White Earth Dam on June 10, 1992. Northern pike and white suckers were collected, representing the piscivore and bottom feeder groups respectively. The northern pike sample was composed of three fish with a mean length of 60 centimeters and a mean weight of 1,383 grams. The white sucker sample was composed of four fish with a mean length of 45 centimeters and a mean weight of 1,013 grams.

In order to evaluate the fish tissue data for White Earth Dam the results for each fish sample was compared to its all corresponding samples assessed in the LWQA project. Trace element concentrations detected in the northern pike sample were zinc, barium, selenium and mercury. Of these, zinc and selenium were equal to or above the 75th percentile, mercury was approximately equal to the median and barium was below the 25th percentile.

The white sucker sample collected contained detectable levels of all trace elements analyzed for with the exception of cadmium. The concentrations of copper, chromium, arsenic and mercury reported in the white sucker sample were equal to or below the 25th percentile for all bottom feeders sampled, while the concentrations of lead, selenium and zinc were equal to or above the 75th percentile. The only concentration reported that was near the median was that of barium.

Detectable contaminant residues in the northern pike sample collected from White Earth Dam included DDE, triallate and trifluralin, while the white sucker sample contained only DDE and trifluralin. DDE is a degradation byproduct of the insecticide DDT and can produce biological effects similar to the parent compound when available to the environment. Triallate and trifluralin are both selective preemergent herbicides, commonly known as Far-go herbicide and Treflan, respectively.

The concentrations of DDE in the northern pike and white sucker samples collected from White Earth Dam were equal to or below the 25th percentile for all fish samples collected during the LWQA project. The concentrations of triallate in the northern pike sample was above the 75th percentile for all piscivores sampled. The concentrations of trifluralin in both the northern pike and white sucker samples was above the median, but below the 75th percentile. Concentrations of PCBs were below detectable levels for all fish samples collected from White Earth Dam. A complete listing of the fish tissue results is provided in Appendix E.

Watershed

White Earth Dam with its contributing watershed has a combined surface area of 155,360 acres located on the Missouri Coteau in Mountrail County, North Dakota. Topography of the watershed varies from hilly to level, with poorly defined drainages. The topography immediately above the White Earth River flood plain is hilly, well drained with steep slopes. Post glacial stream deposited sediments of various depths overlie the bedrock below the embankments. Bedrock within the watershed is of the tertiary system, Ft. Union group composed of the Sentinel Butte and Tongue River formations. These are generally nonsolidified to slightly cemented silts, sands and clays, with some lignite seams. These formations outcrop within the steeper areas of the watershed in near vertical exposures and exhibit slump topography. The Coal Harbor formation of glacial drift overlies the entire area with the exception of the stream valley.

Of White Earth Dam's 155,360 acre watershed approximately 53,600 is located above Powers Lake, Fish Lake, Smishek Lake and a swamping area downstream of these lakes is only partially or noncontributing. The contributing watershed below these areas covers approximately 101,760 acres. Nonpoint source pollution from the contributing regions of the watershed accounts for nearly all of the nutrients and pollutants discharged to White Earth Dam.

Land use within the White Earth Dam watershed is 96 percent agricultural with 68.5 percent actively cultivated, 20.6 percent in cattle production, 4.5 percent in hay production and 2.3 percent in Conservation Reserve Program (CRP). The remainder of the watershed is composed of woodlands, small lakes and wetlands, wildlife management, transportation and farms (Table 2). Within the watershed there are 58 farms, 3 concentrated livestock feeding areas and the community of Powers Lake, which lies outside the primary contributing area of the watershed.

According to the information provided by the Mountrail County Soil Conservation District 62 percent of the cultivated lands and between 80 and 100 percent of all the remaining agricultural lands within the watershed are "adequately treated" against soil loss. It should be noted that "adequately treated" still allows erosion or soil loss to occur. The definition of "adequately treated" is that amount of land treatment necessary to achieve the soil loss tolerance (T).

It is estimated that within the White Earth Dam watershed, the average "T" value is three to five tons per acre. Based on an average soil loss of approximately four tons per acre, which takes into account all land treatments and practices currently employed within the watershed, approximately 645,930 tons of soil are lost from watershed annually, and 4,230,081 tons from the contributing regions of the watershed. Assuming a conservative delivery rate of 10 to 15 percent from the principal contributing areas of the watershed, between 42,308 and 63,462 tons of soil are delivered to White Earth Dam annually.

Other sources of nonpoint source pollution discharges to White Earth Dam are from the cattle feeding and watering in it, concentrated livestock feeding areas and construction activities within the watershed. These sources have the capabilities to contribute a significant nutrient load to White Earth Dam due to their ability to produce a concentrated and highly fertile discharge.

Table 2. Land use in the White Earth Dam watershed.

Land use	Percent of total Watershed Acreage	Percent Adequately Treated
Cropland	68.5	62
Rangeland	20.6	80
Hayland	4.5	85
CRP	2.3	100
Woodlands	1.3	N/A
Wet/Wild[1]	1.8	N/A
Other	0.8	N/A
Farmsteads	58[3]	N/A
Feedlots[2]	3[3]	100

[1]Wet/Wild are wildlife management areas, wetlands and lakes.
[2]Feedlots are areas where livestock are concentrated to be fed.
[3]Represent the number of farms and concentrated livestock feeding areas within the contributing watershed.

Appendix A

1992-1993 LWQA Water Quality Data

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381360	29JUL92	0.0	22.0	6.8	.	.	.	.	.	.
2	381360	29JUL92	0.5	22.0	6.8	8898.0	851	671	181	0.128	2.48
3	381360	29JUL92	1.0	22.0	6.8	.	.	.	.	.	.
4	381360	29JUL92	2.0	22.0	6.8	8848.0	852	674	180	0.036	2.08
5	381360	02SEP92	0.0	17.0	8.4	.	.	.	.	.	.
6	381360	02SEP92	0.5	17.0	8.4	9132.0	864	744	153	0.007	2.78
7	381360	02SEP92	1.0	17.0	8.4	.	.	.	.	.	.
8	381360	02SEP92	2.0	17.0	8.4	9132.0	863	736	156	0.001	2.63
9	381360	02MAR93	0.0	0.0	5.6	.	.	.	.	.	.
10	381360	02MAR93	1.0	0.0	4.4	11460.0	1110	1030	161	0.077	3.26
11	381360	02MAR93	2.0	0.1	4.4	11500.0	1120	1040	160	0.097	3.28

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.015	0.081	0.075	1040	19.3	241	2030	84.9	0.382	0.035	916	2960	6760
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.007	0.108	0.051	1010	18.8	233	2000	78.3	0.064	0.043	939	2940	6720
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.000	0.098	0.042	1000	23.1	229	2170	69.8	0.000	0.020	981	3110	7100
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.000	0.122	0.036	945	22.5	216	2000	66.6	0.000	0.010	980	3080	9880
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.181	0.139	0.096	1180	38.0	264	2380	80.8	0.052	0.026	126	3880	8570
11	0.162	0.101	0.094	1280	40.8	286	2570	85.8	0.059	0.032	126	3560	8470

Arnegard Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380650	14JUL92	0.0	21.0	7.8	.	.	.	.	.	.
2	380650	14JUL92	0.5	21.0	7.8	995.8	362	371	35	0.000	0.67
3	380650	14JUL92	1.0	18.5	6.3	.	.	.	.	.	.
4	380650	14JUL92	2.0	18.0	4.9	997.8	361	372	34	0.000	0.88
5	380650	14JUL92	3.0	17.5	2.6	998.8	364	386	29	0.000	0.74
6	380650	10AUG92	0.0	20.0	7.2	.	.	.	.	.	.
7	380650	10AUG92	0.5	20.0	7.2	1055.0	407	454	21	0.015	1.40
8	380650	10AUG92	1.0	20.5	6.0	.	.	.	.	.	.
9	380650	10AUG92	1.5	.	.	1035.0	402	448	21	0.013	1.47
10	380650	10AUG92	2.0	19.5	4.2	.	.	.	.	.	.
11	380650	10AUG92	3.0	19.0	2.8	1055.0	407	456	20	0.014	1.24
12	380650	17FEB93	0.0	0.8	3.6	.	.	.	.	.	.
13	380650	17FEB93	1.0	1.1	3.3	1565.0	663	810	0	0.250	1.31
14	380650	17FEB93	2.0	2.8	0.3	.	.	.	.	.	.
15	380650	17FEB93	2.5	.	.	1554.0	661	807	0	0.244	1.07
16	380650	17FEB93	2.8	4.0	0.1	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.021	0.116	0.113	247	24.9	45.0	148	6.7	0.066	0.040	5.0	176	623
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.006	0.114	0.095	240	24.0	43.7	141	5.7	0.069	0.043	5.6	181	618
5	0.009	0.157	0.120	243	24.8	44.1	144	6.4	0.177	0.109	6.5	178	623
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.014	0.135	0.144	266	28.9	47.2	164	7.1	0.157	0.081	6.6	175	673
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.000	0.169	0.142	267	28.7	47.4	162	6.5	0.158	0.083	7.3	171	665
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.000	0.176	0.135	265	28.5	47.0	159	6.0	0.178	0.090	8.1	175	668
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.000	0.250	0.117	536	87.3	77.1	239	9.1	0.158	0.805	10.5	322	1140
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.000	0.225	0.126	528	84.6	76.9	243	9.3	0.182	0.741	10.0	305	1130
16	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380975	21JUL92	0.0	21.0	13.9	.	.	.	.	.	.
2	380975	21JUL92	0.5	21.0	13.9	804.6	312	308	36	0.011	2.78
3	380975	21JUL92	1.0	20.5	13.4	.	.	.	.	.	.
4	380975	21JUL92	2.0	20.0	13.4	.	.	.	.	.	.
5	380975	21JUL92	3.0	18.5	12.5	.	.	.	.	.	.
6	380975	21JUL92	4.0	18.0	3.6	808.6	314	320	31	0.035	2.80
7	380975	17AUG92	0.0	21.0	13.6	.	.	.	.	.	.
8	380975	17AUG92	0.5	21.0	13.6	796.8	306	288	42	0.067	3.53
9	380975	17AUG92	1.0	20.0	10.0	.	.	.	.	.	.
10	380975	17AUG92	2.0	20.0	8.0	798.8	308	307	34	0.082	2.45
11	380975	17AUG92	3.0	20.0	6.0	.	.	.	.	.	.
12	380975	17AUG92	4.0	19.5	1.2	795.8	307	310	32	0.110	3.90
13	380975	03MAR93	0.0	0.1	1.2	.	.	.	.	.	.
14	380975	03MAR93	1.0	1.5	0.3	1221.0	479	585	0	0.994	1.24
15	380975	03MAR93	2.0	2.9	0.1	.	.	.	.	.	.
16	380975	03MAR93	3.0	3.3	0.1	1225.0	482	588	0	0.983	3.39
17	380975	03MAR93	3.5	4.1	0.1	.	.	.	.	.	.
18	380975	03MAR93	3.5	4.1	0.1	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.009	0.199	0.023	166	28.6	22.9	136	9.8	0.105	0.171	9.6	126	521
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.010	0.186	0.040	164	28.5	22.6	132	9.1	0.155	0.236	9.6	126	516
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.000	0.177	0.048	151	20.6	24.1	144	9.3	0.067	0.123	9.0	121	512
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.000	0.144	0.042	148	20.5	23.6	145	9.1	0.114	0.128	9.2	127	520
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.000	0.148	0.037	144	20.1	22.8	137	8.7	0.115	0.130	9.7	120	503
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.000	0.269	0.194	218	31.6	33.7	209	11.8	0.371	0.418	15.8	197	787
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.000	0.185	0.198	219	30.8	34.6	196	11.6	0.347	0.432	15.8	199	777
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.

Baukol Noonan Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381320	14JUL92	0.0	20.0	9.6	.	.	.	.	.	.
2	381320	14JUL92	0.5	20.0	9.6	2637.0	308	327	24	0.000	0.60
3	381320	14JUL92	1.0	20.0	9.8	.	.	.	.	.	.
4	381320	14JUL92	2.0	20.0	9.8	.	.	.	.	.	.
5	381320	14JUL92	3.0	18.5	9.2	2657.0	307	324	25	0.000	0.76
6	381320	14JUL92	4.0	18.0	9.1	.	.	.	.	.	.
7	381320	14JUL92	5.0	17.0	8.5	.	.	.	.	.	.
8	381320	14JUL92	6.0	16.0	6.5	2647.0	307	336	19	0.000	0.87
9	381320	12AUG92	0.0	19.5	7.8	.	.	.	.	.	.
10	381320	12AUG92	0.5	19.5	7.8	2726.0	310	323	27	0.067	0.88
11	381320	12AUG92	1.0	19.5	7.8	.	.	.	.	.	.
12	381320	12AUG92	2.0	19.0	7.6	.	.	.	.	.	.
13	381320	12AUG92	3.0	19.0	7.6	.	.	.	.	.	.
14	381320	12AUG92	4.0	19.0	7.6	2716.0	309	326	25	0.030	1.07
15	381320	12AUG92	5.0	19.0	7.6	.	.	.	.	.	.
16	381320	12AUG92	6.0	19.0	7.6	.	.	.	.	.	.
17	381320	12AUG92	7.0	19.0	7.5	.	.	.	.	.	.
18	381320	12AUG92	8.0	15.5	1.5	2676.0	308	352	12	0.170	0.97
19	381320	23FEB93	0.0	0.1	11.9	.	.	.	.	.	.
20	381320	23FEB93	1.0	1.5	11.9	3137.0	368	409	20	0.007	1.06
21	381320	23FEB93	2.0	2.0	11.9	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.031	0.021	0.000	312	51.2	44.7	540	11.7	0.096	0.011	34.1	976	1840
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.009	0.023	0.000	305	50.0	43.7	528	11.0	0.114	0.012	34.4	966	1820
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.099	0.031	0.000	295	49.6	41.5	519	10.9	0.101	0.052	35.3	963	1800
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.033	0.000	0.026	308	49.6	44.6	556	11.6	0.215	0.017	34.5	1190	2070
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.034	0.000	0.019	286	46.6	41.2	520	11.0	0.165	0.018	35.6	1200	2040
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.015	0.000	0.043	308	51.1	43.7	554	11.9	0.188	0.387	34.6	1240	2120
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.007	0.000	0.021	324	51.1	47.8	582	11.6	0.073	0.009	39.2	1350	2300
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381320	23FEB93	3.0	2.0	11.9	3157.0	374	414	21	0.005	1.21
23	381320	23FEB93	4.0	2.0	11.9	.	.	.	.	.	.
24	381320	23FEB93	5.0	2.0	11.4	.	.	.	.	.	.
25	381320	23FEB93	6.0	2.0	11.2	3168.0	372	414	20	0.007	1.17

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.010	0.000	0.036	312	48.9	46.2	557	11.4	0.142	0.009	45.2	1310	2240
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.011	0.023	0.032	315	49.6	46.3	559	11.6	0.072	0.008	44.4	1300	2230

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380512	28JUL92	0.0	23.0	8.5	.	.	.	.	.	.
2	380512	28JUL92	0.5	23.0	8.5	928.8	396	394	44	0.539	1.81
3	380512	28JUL92	1.0	22.0	8.2	.	.	.	.	.	.
4	380512	28JUL92	2.0	21.0	3.4	917.8	396	392	45	0.053	1.68
5	380512	31AUG92	0.0	17.0	15.0	.	.	.	.	.	.
6	380512	31AUG92	0.5	17.0	15.0	975.9	404	414	39	0.013	4.82
7	380512	31AUG92	1.0	16.5	15.0	.	.	.	.	.	.
8	380512	31AUG92	2.0	16.5	14.2	968.8	412	420	41	0.021	4.68
9	380512	01MAR93	0.0	0.1	1.3	.	.	.	.	.	.
10	380512	01MAR93	1.0	0.6	0.6	1679.0	667	814	0	0.711	4.85
11	380512	01MAR93	1.6	2.0	0.0	.	.	.	.	.	.
12	380512	01MAR93	2.0	.	.	1685.0	650	794	0	0.734	5.11

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.008	0.282	0.082	281	32.2	48.8	125	24.9	0.471	0.464	21.5	137	627
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.007	0.285	0.065	291	33.8	50.1	129	25.4	0.500	0.475	21.5	140	638
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.000	0.439	0.054	268	30.3	46.7	120	23.8	0.384	0.481	21.4	158	643
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.000	0.459	0.039	261	29.6	45.5	118	22.6	0.488	0.542	22.3	178	664
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.006	0.574	0.417	451	49.7	79.5	200	30.2	0.235	0.736	35.8	279	1080
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.013	0.568	0.411	427	47.2	75.0	189	27.8	0.146	0.687	36.8	303	1070

Braddock Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381365	28JUL92	0.0	21.5	10.3	.	.	.	.	.	.
2	381365	28JUL92	0.5	21.5	10.3	872.8	264	214	53	0.993	0.87
3	381365	28JUL92	1.0	21.5	10.4	.	.	.	.	.	.
4	381365	28JUL92	2.0	21.0	8.3	.	.	.	.	.	.
5	381365	28JUL92	3.0	20.0	4.7	.	.	.	.	.	.
6	381365	28JUL92	4.0	19.5	2.5	873.8	264	227	47	0.232	0.72
7	381365	31AUG92	0.0	16.0	8.9	.	.	.	.	.	.
8	381365	31AUG92	0.5	16.0	8.9	936.5	275	279	28	0.125	2.08
9	381365	31AUG92	1.0	15.5	7.9	.	.	.	.	.	.
10	381365	31AUG92	2.0	15.2	7.6	.	.	.	.	.	.
11	381365	31AUG92	3.0	15.0	7.4	.	.	.	.	.	.
12	381365	31AUG92	4.0	15.0	7.4	935.5	278	280	29	0.160	1.87
13	381365	25FEB93	0.0	1.0	3.0	.	.	.	.	.	.
14	381365	25FEB93	1.0	1.1	2.4	1332.0	446	544	0	0.163	1.20
15	381365	25FEB93	2.0	2.8	1.6	.	.	.	.	.	.
16	381365	25FEB93	2.5	.	.	1347.0	449	548	0	0.164	1.20
17	381365	25FEB93	3.0	2.8	0.7	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.006	0.293	0.245	154	24.6	22.4	156	10.5	0.095	0.053	6.7	194	573
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.010	0.357	0.301	145	24.0	20.7	146	9.7	0.126	0.079	6.1	209	574
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.024	0.368	0.259	145	25.7	19.7	161	10.3	0.397	0.062	5.3	216	603
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.024	0.358	0.248	148	25.6	20.4	151	9.9	0.390	0.061	5.1	210	589
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.032	0.169	0.148	280	59.4	32.0	199	11.9	0.081	0.364	8.6	301	880
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.034	0.163	0.137	328	68.3	38.2	238	14.0	0.072	0.310	7.4	297	933
17	.	.	.	.	.	.	.	.	.	.	.	.	.

Carbury Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381200	21JUL92	0.0	18.0	7.1	.	.	.	.	.	.
2	381200	21JUL92	0.5	18.0	7.1	1088.0	314	337	23	0.012	2.45
3	381200	21JUL92	1.0	18.0	7.1	.	.	.	.	.	.
4	381200	21JUL92	2.0	18.0	7.1	.	.	.	.	.	.
5	381200	21JUL92	3.0	18.0	6.5	1087.0	314	339	22	0.012	1.91
6	381200	21JUL92	4.0	18.0	4.1	.	.	.	.	.	.
7	381200	21JUL92	5.0	18.0	2.8	.	.	.	.	.	.
8	381200	21JUL92	6.0	17.5	1.2	1095.0	317	348	19	0.307	2.63
9	381200	18AUG92	0.0	20.0	7.9	.	.	.	.	.	.
10	381200	18AUG92	0.5	20.0	7.9	1109.0	333	372	17	1.610	2.78
11	381200	18AUG92	1.0	20.0	7.4	.	.	.	.	.	.
12	381200	18AUG92	2.0	20.0	7.3	.	.	.	.	.	.
13	381200	18AUG92	3.0	20.0	6.5	.	.	.	.	.	.
14	381200	18AUG92	4.0	20.0	1.7	1117.0	333	399	4	0.199	3.00
15	381200	18AUG92	5.0	19.0	0.6	.	.	.	.	.	.
16	381200	18AUG92	6.0	19.0	0.6	1109.0	333	406	0	0.631	2.43
17	381200	03MAR93	0.0	0.9	2.7	.	.	.	.	.	.
18	381200	03MAR93	1.0	1.1	1.9	1479.0	455	556	0	0.689	4.29
19	381200	03MAR93	2.0	2.2	0.9	.	.	.	.	.	.
20	381200	03MAR93	3.0	3.0	0.3	1466.0	446	544	0	0.764	3.76
21	381200	03MAR93	4.0	3.2	0.2	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.006	0.321	0.104	337	46.4	53.6	131	16.3	0.090	0.341	9.9	271	717
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.045	0.312	0.105	345	47.1	55.2	133	16.6	0.088	0.355	10.3	272	723
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.012	0.336	0.151	325	45.9	51.2	134	16.4	0.214	0.565	10.5	282	730
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.000	0.288	0.157	313	44.2	49.2	127	15.5	0.061	0.345	10.2	300	746
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.007	0.337	0.197	326	46.5	50.9	131	16.0	0.072	0.442	9.6	287	742
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.000	0.315	0.249	305	43.3	47.8	124	15.3	0.069	0.552	9.8	296	736
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.033	0.351	0.217	410	58.0	64.4	158	18.8	0.052	0.330	12.4	361	946
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.019	0.318	0.233	425	59.9	66.9	160	17.1	0.083	1.030	12.6	366	950
21	.	.	.	.	.	.	.	.	.	.	.	.	.

Carbury Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381200	03MAR93	5.0	3.4	0.1	1496.0	471	575	0	1.060	3.87

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.000	0.476	0.455	417	61.1	64.3	165	17.5	0.235	1.280	12.7	384	988

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381355	14JUL92	0.0	18.5	7.0	.	.	.	.	.	.
2	381355	14JUL92	0.5	18.5	7.0	3056.0	1570	1420	244	0.850	3.28
3	381355	14JUL92	1.0	18.5	6.8	.	.	.	.	.	.
4	381355	14JUL92	2.0	18.5	6.5	.	.	.	.	.	.
5	381355	14JUL92	2.5	.	.	3046.0	1570	1420	244	0.871	3.53
6	381355	14JUL92	3.0	18.5	4.8	.	.	.	.	.	.
7	381355	13AUG92	0.0	19.0	6.1	.	.	.	.	.	.
8	381355	13AUG92	0.5	19.0	6.1	3169.0	1640	1500	249	0.515	4.99
9	381355	13AUG92	1.0	18.5	4.5	.	.	.	.	.	.
10	381355	13AUG92	2.0	18.5	5.1	.	.	.	.	.	.
11	381355	13AUG92	2.5	18.5	4.1	3179.0	1650	1510	249	0.533	5.13
12	381355	22FEB93	0.0	0.1	1.5	.	.	.	.	.	.
13	381355	22FEB93	1.0	0.5	0.4	4447.0	2440	2170	399	0.618	5.02
14	381355	22FEB93	2.0	1.0	0.2	.	.	.	.	.	.
15	381355	22FEB93	2.5	1.0	0.1	4142.0	2260	2010	370	0.640	8.52

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.016	0.081	0.063	1250	4.9	301	347	131	0.223	0.025	56.9	423	2210
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.019	0.066	0.053	1210	4.8	292	344	126	0.870	0.026	56.6	425	2180
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.018	0.025	0.051	1330	5.0	319	370	140	0.038	0.017	61.6	470	2350
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.023	0.047	0.066	1330	5.5	320	363	139	0.087	0.210	60.3	530	2410
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.179	0.062	0.075	1680	5.6	405	487	182	0.057	0.027	91.5	703	3340
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.191	0.060	0.042	1560	5.1	377	473	173	0.047	0.026	88.6	650	3130

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381130	20JUL92	0.0	20.5	11.2	.	.	.	.	.	.
2	381130	20JUL92	0.5	20.5	11.2	1240.0	407	348	71	0.012	3.59
3	381130	20JUL92	1.0	20.0	10.5	.	.	.	.	.	.
4	381130	20JUL92	2.0	19.5	9.4	.	.	.	.	.	.
5	381130	20JUL92	3.0	19.0	6.6	1236.0	404	351	70	0.009	3.02
6	381130	20JUL92	4.0	19.0	6.3	.	.	.	.	.	.
7	381130	20JUL92	5.0	18.0	4.8	.	.	.	.	.	.
8	381130	20JUL92	6.0	17.5	1.4	.	.	.	.	.	.
9	381130	20JUL92	7.0	16.0	1.0	1236.0	407	373	61	0.194	1.28
10	381130	04SEP92	0.0	17.0	11.6	.	.	.	.	.	.
11	381130	04SEP92	0.5	17.0	11.6	1290.0	428	396	62	0.210	2.98
12	381130	04SEP92	1.0	16.5	10.7	.	.	.	.	.	.
13	381130	04SEP92	2.0	16.5	9.5	1292.0	428	397	62	0.107	3.31
14	381130	04SEP92	3.0	16.0	7.8	1289.0	428	386	67	0.212	2.44
15	381130	04SEP92	4.0	16.0	5.8	.	.	.	.	.	.
16	381130	04SEP92	5.0	16.0	4.8	.	.	.	.	.	.
17	381130	04SEP92	6.0	16.0	4.0	1294.0	429	402	60	0.047	3.21
18	381130	12FEB93	0.0	0.0	4.0	.	.	.	.	.	.
19	381130	12FEB93	1.0	2.0	2.0	1613.0	531	610	19	0.714	10.80
20	381130	12FEB93	2.0	2.0	1.8	.	.	.	.	.	.
21	381130	12FEB93	3.0	2.0	0.4	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.003	0.366	0.204	280	29.2	50.3	188	24.4	0.133	0.074	14.4	274	823
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.304	0.329	0.209	287	30.2	51.4	197	25.1	0.189	0.085	14.4	275	836
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.039	0.408	0.250	290	31.0	51.6	202	26.6	0.258	0.228	12.7	266	835
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.000	0.458	0.352	270	28.3	48.4	196	24.8	0.150	0.076	15.4	284	854
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.000	0.475	0.306	279	28.3	50.5	200	25.3	0.155	0.075	15.0	282	859
14	0.000	0.379	0.316	320	31.3	58.7	210	27.1	0.189	0.066	14.9	279	878
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	0.000	0.399	0.363	273	26.7	50.1	193	24.1	0.240	0.121	14.9	283	850
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	0.018	3.160	0.114	335	35.1	60.1	226	24.9	0.079	0.165	17.5	423	1110

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381130	12FEB93	4.0	2.8	0.2	.	.	.	.	.	.
23	381130	12FEB93	5.0	3.0	0.2	.	.	.	.	.	.
24	381130	12FEB93	6.0	3.5	0.1	1610.0	537	637	9	0.430	3.31
25	381130	12FEB93	8.0	.	.	1604.0	530	621	13	0.219	2.98

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	0.000	0.339	0.202	405	41.8	73.0	278	31.3	0.168	0.410	18.2	376	1140
25	0.000	0.274	0.125	324	34.1	58.0	221	24.8	0.087	0.224	17.8	394	1070

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380340	29JUL92	0.0	21.5	10.6	.	.	.	.	.	.
2	380340	29JUL92	0.5	21.5	10.6	510.9	140	134	18	0.012	1.19
3	380340	29JUL92	1.0	21.5	10.7	.	.	.	.	.	.
4	380340	29JUL92	2.0	21.5	8.2	.	.	.	.	.	.
5	380340	29JUL92	3.0	21.0	6.5	.	.	.	.	.	.
6	380340	29JUL92	4.0	21.0	5.3	.	.	.	.	.	.
7	380340	29JUL92	5.0	20.0	2.5	515.9	146	162	8	0.278	0.96
8	380340	29JUL92	6.0	18.0	1.1	.	.	.	.	.	.
9	380340	29JUL92	7.0	17.0	0.8	.	.	.	.	.	.
10	380340	29JUL92	8.0	16.0	0.6	.	.	.	.	.	.
11	380340	29JUL92	9.0	14.5	0.5	.	.	.	.	.	.
12	380340	29JUL92	10.0	13.5	0.4	602.8	237	289	0	4.600	6.11
13	380340	01SEP92	0.0	18.0	5.2	.	.	.	.	.	.
14	380340	01SEP92	0.5	18.0	5.2	551.2	160	193	1	0.426	2.94
15	380340	01SEP92	1.0	18.0	5.2	.	.	.	.	.	.
16	380340	01SEP92	2.0	18.0	5.2	.	.	.	.	.	.
17	380340	01SEP92	3.0	18.0	5.1	.	.	.	.	.	.
18	380340	01SEP92	4.0	18.0	5.0	.	.	.	.	.	.
19	380340	01SEP92	5.0	18.0	5.0	.	.	.	.	.	.
20	380340	01SEP92	6.0	18.0	5.0	.	.	.	.	.	.
21	380340	01SEP92	7.0	17.5	4.6	548.1	160	195	0	0.442	1.57

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.005	0.066	0.013	186	33.7	24.7	38.8	10.9	0.037	0.520	17.1	106	315
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.009	0.105	0.074	190	35.5	24.6	38.9	10.7	0.077	0.105	15.7	99	312
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.004	1.030	1.160	230	49.4	25.8	37.8	11.4	0.007	2.490	19.1	78	364
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.011	0.223	0.094	191	37.3	23.8	35.2	10.6	0.116	0.569	15.7	116	335
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.	.
21	0.017	0.157	0.089	188	35.6	24.1	35.0	10.6	0.120	0.544	17.2	121	340

Dead Colt Creek Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380340	01SEP92	8.0	17.5	4.6	.	.	.	.	.	.
23	380340	01SEP92	9.0	17.5	2.5	.	.	.	.	.	.
24	380340	01SEP92	10.0	15.5	0.2	553.2	161	197	0	0.526	0.02
25	380340	02MAR93	0.0	0.8	7.6	.	.	.	.	.	.
26	380340	02MAR93	1.0	1.0	7.2	716.4	210	256	0	0.087	1.24
27	380340	02MAR93	2.0	2.4	7.0	.	.	.	.	.	.
28	380340	02MAR93	3.0	2.9	6.7	.	.	.	.	.	.
29	380340	02MAR93	4.0	3.1	6.1	.	.	.	.	.	.
30	380340	02MAR93	5.0	3.5	4.0	700.2	200	244	0	0.043	1.07
31	380340	02MAR93	6.0	4.0	2.1	.	.	.	.	.	.
32	380340	02MAR93	7.0	4.0	1.1	.	.	.	.	.	.
33	380340	02MAR93	8.0	4.2	0.3	.	.	.	.	.	.
34	380340	02MAR93	9.0	4.8	0.1	743.9	214	261	0	0.323	1.16
35	380340	02MAR93	9.5	5.1	0.1	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	0.200	0.146	0.106	190	36.1	24.2	36.5	10.6	0.133	0.600	17.0	112	333
25	.	.	.	.	.	.	.	.	.	.	.	.	.
26	0.396	0.040	0.040	265	57.3	29.5	47.0	11.6	0.028	0.187	22.7	143	437
27	.	.	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.
30	0.445	0.040	0.057	241	52.5	26.7	41.6	10.6	0.026	0.277	21.9	140	413
31	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.
34	0.416	0.084	0.061	243	54.5	25.9	43.2	10.0	0.172	0.961	23.9	147	433
35	.	.	.	.	.	.	.	.	.	.	.	.	.

Fordville Dam

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OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381240	22JUL92	0.0	22.0	15.0	.	.	.	.	.	.
2	381240	22JUL92	1.0	19.5	12.2	.	.	.	.	.	.
3	381240	22JUL92	2.0	19.0	7.6	.	.	.	.	.	.
4	381240	22JUL92	3.0	18.5	7.0	618.9	209	196	29	0.209	0.83
5	381240	22JUL92	4.0	18.5	6.6	.	.	.	.	.	.
6	381240	22JUL92	5.0	18.5	4.8	.	.	.	.	.	.
7	381240	22JUL92	6.0	18.0	4.3	625.9	212	210	24	0.394	0.86
8	381240	22JUL92	7.0	18.5	0.3	.	.	.	.	.	.
9	381240	19AUG92	0.0	21.0	9.4	.	.	.	.	.	.
10	381240	19AUG92	0.5	21.0	9.4	616.2	214	214	23	0.328	1.87
11	381240	19AUG92	1.0	21.0	9.4	.	.	.	.	.	.
12	381240	19AUG92	2.0	21.0	9.4	.	.	.	.	.	.
13	381240	19AUG92	3.0	21.0	9.2	.	.	.	.	.	.
14	381240	19AUG92	4.0	20.0	4.0	612.2	215	207	27	0.307	2.19
15	381240	19AUG92	5.0	19.5	2.0	.	.	.	.	.	.
16	381240	19AUG92	6.0	19.0	0.7	.	.	.	.	.	.
17	381240	19AUG92	7.0	18.5	0.3	623.3	218	227	19	0.708	1.79
18	381240	11MAR93	0.0	0.7	5.0	.	.	.	.	.	.
19	381240	11MAR93	1.0	3.1	3.0	703.0	249	304	0	0.132	0.59
20	381240	11MAR93	2.0	4.2	2.4	.	.	.	.	.	.
21	381240	11MAR93	3.0	4.3	2.4	751.8	262	320	0	0.068	0.57

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.020	0.376	0.269	261	60.7	26.6	36.5	6.6	0.095	1.070	12.3	111	379
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.020	0.400	0.334	258	60.0	26.3	35.7	6.2	0.097	1.140	12.1	112	380
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.010	0.355	0.372	243	57.4	24.1	33.8	5.5	0.138	0.954	12.0	110	371
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.012	0.375	0.368	259	60.8	25.9	35.6	5.7	0.110	1.010	12.4	119	388
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	0.011	0.502	0.527	251	59.9	24.7	34.5	5.7	0.106	1.170	12.1	117	385
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	0.312	0.156	0.097	289	75.0	24.7	30.0	5.3	0.065	0.695	7.7	117	409
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	0.323	0.189	0.132	292	72.5	27.0	34.6	5.6	0.027	0.798	10.2	133	441

Fordville Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381240	11MAR93	4.0	4.3	1.3	.	.	.	.	.	.
23	381240	11MAR93	5.0	4.5	0.0	.	.	.	.	.	.
24	381240	11MAR93	6.0	5.2	0.0	785.3	273	333	0	0.721	0.69
25	381240	22JUL93	0.5	.	.	598.0	208	164	44	0.011	0.79

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	0.232	0.201	0.152	314	78.2	28.7	36.3	5.3	0.066	1.840	11.4	140	464
25	0.012	0.295	0.214	266	61.9	27.0	36.8	6.8	0.083	1.030	11.8	112	381

Froelich Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380730	09JUL92	0.0	19.0	7.9	.	.	.	.	.	.
2	380730	09JUL92	0.5	19.0	7.9	594.3	307	328	23	0.123	3.20
3	380730	09JUL92	1.0	19.0	7.9	.	.	.	.	.	.
4	380730	09JUL92	2.0	18.8	7.6	.	.	.	.	.	.
5	380730	09JUL92	3.0	18.3	7.0	.	.	.	.	.	.
6	380730	09JUL92	4.0	18.0	6.0	594.3	309	328	24	0.098	2.16
7	380730	09JUL92	5.0	17.8	5.3	.	.	.	.	.	.
8	380730	09JUL92	6.0	17.5	4.8	.	.	.	.	.	.
9	380730	09JUL92	7.0	17.0	2.8	.	.	.	.	.	.
10	380730	09JUL92	8.0	16.9	1.7	592.3	307	330	22	0.136	2.58
11	380730	06AUG92	0.0	18.0	6.2	.	.	.	.	.	.
12	380730	06AUG92	0.5	18.0	6.2	593.3	305	324	24	0.219	2.70
13	380730	06AUG92	1.0	18.0	5.8	.	.	.	.	.	.
14	380730	06AUG92	2.0	18.0	5.6	.	.	.	.	.	.
15	380730	06AUG92	3.0	18.0	5.5	.	.	.	.	.	.
16	380730	06AUG92	4.0	18.0	5.5	593.3	305	323	24	0.145	2.71
17	380730	06AUG92	5.0	18.0	5.5	.	.	.	.	.	.
18	380730	06AUG92	6.0	18.0	5.5	.	.	.	.	.	.
19	380730	06AUG92	7.0	18.0	5.5	.	.	.	.	.	.
20	380730	06AUG92	8.0	18.0	1.2	596.3	306	327	23	0.176	2.70
21	380730	12FEB93	0.0	0.0	7.6	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	DISSOLVED SODIUM (mg/L)	POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.070	0.285	0.199	63	14.5	6.4	129	11.0	0.409	0.080	4.4	16	366
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.088	0.264	0.205	64	14.8	6.5	132	10.7	0.407	0.082	4.7	17	371
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.072	0.267	0.209	67	15.6	6.7	133	11.0	0.419	0.108	4.5	19	374
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.038	0.261	0.218	53	12.1	5.6	117	9.9	0.191	0.055	3.7	17	349
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.039	0.239	0.213	59	13.2	6.2	129	10.9	0.198	0.061	4.2	17	364
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.030	0.262	0.224	56	12.7	5.8	123	10.2	0.230	0.087	4.0	16	356
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380730	12FEB93	1.0	0.5	7.7	738.7	379	463	0	0.349	3.74
23	380730	12FEB93	2.0	2.9	7.6	.	.	.	.	.	.
24	380730	12FEB93	3.0	3.0	6.7	.	.	.	.	.	.
25	380730	12FEB93	4.0	3.2	4.4	735.7	378	461	0	0.345	3.47
26	380730	12FEB93	5.0	4.0	2.5	.	.	.	.	.	.
27	380730	12FEB93	6.0	4.2	0.4	751.9	387	472	0	0.598	3.15
28	380730	12FEB93	6.5	4.5	0.1	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.135	0.647	0.082	62	14.3	6.4	135	10.5	0.189	0.075	5.8	30	430
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.141	0.410	0.094	63	14.6	6.5	138	10.9	0.221	0.075	6.4	30	433
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	0.077	0.407	0.104	64	14.9	6.6	137	10.3	0.211	0.348	5.7	29	436
28	.	.	.	.	.	.	.	.	.	.	.	.	.

Heinrich-Martin Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380750	27JUL92	0.0	22.0	8.3	.	.	.	.	.	.
2	380750	27JUL92	0.5	22.0	8.3	216.8	112	121	8	0.012	1.08
3	380750	27JUL92	1.0	22.0	8.5	.	.	.	.	.	.
4	380750	27JUL92	2.0	22.0	8.6	.	.	.	.	.	.
5	380750	27JUL92	3.0	20.5	7.6	.	.	.	.	.	.
6	380750	27JUL92	4.0	19.0	4.8	219.8	114	139	0	0.014	1.01
7	380750	27JUL92	5.0	17.0	2.6	.	.	.	.	.	.
8	380750	27JUL92	6.0	16.0	2.0	.	.	.	.	.	.
9	380750	27JUL92	7.0	14.0	1.5	.	.	.	.	.	.
10	380750	27JUL92	8.0	12.0	1.2	267.8	136	166	0	0.597	1.80
11	380750	01SEP92	0.0	17.0	7.2	.	.	.	.	.	.
12	380750	01SEP92	0.5	17.0	7.2	220.5	112	137	0	0.001	0.99
13	380750	01SEP92	1.0	17.0	7.2	.	.	.	.	.	.
14	380750	01SEP92	2.0	17.0	7.0	.	.	.	.	.	.
15	380750	01SEP92	3.0	17.0	6.8	.	.	.	.	.	.
16	380750	01SEP92	4.0	17.0	6.5	220.5	112	137	0	0.002	1.16
17	380750	01SEP92	5.0	17.0	6.0	.	.	.	.	.	.
18	380750	01SEP92	6.0	17.0	4.8	.	.	.	.	.	.
19	380750	01SEP92	7.0	14.0	0.0	.	.	.	.	.	.
20	380750	01SEP92	8.0	13.0	0.0	249.8	125	153	0	0.604	2.19
21	380750	02MAR93	0.0	0.9	4.5	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.008	0.065	0.013	98	19.7	11.9	2.6	13.6	0.097	0.023	3.2	8	127
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.008	0.079	0.009	102	20.9	12.0	2.7	14.6	0.173	0.042	1.8	4	124
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.007	0.183	0.023	123	28.9	12.4	2.1	16.0	2.050	3.010	3.7	23	168
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.000	0.026	0.000	95	19.4	11.2	2.2	14.3	0.101	0.094	1.7	19	135
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.000	0.044	0.000	95	19.5	11.3	2.4	13.9	0.116	0.117	0.9	51	166
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.000	0.174	0.034	109	24.4	11.7	2.2	14.7	2.390	2.510	1.0	35	164
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380750	02MAR93	1.0	2.0	2.9	312.0	158	193	0	0.206	1.40
23	380750	02MAR93	2.0	3.5	2.8	.	.	.	.	.	.
24	380750	02MAR93	3.0	3.8	2.2	.	.	.	.	.	.
25	380750	02MAR93	4.0	4.0	1.0	306.9	153	187	0	0.229	1.32
26	380750	02MAR93	5.0	4.1	0.2	.	.	.	.	.	.
27	380750	02MAR93	6.0	4.4	0.2	.	.	.	.	.	.
28	380750	02MAR93	7.0	4.9	0.2	.	.	.	.	.	.
29	380750	02MAR93	8.0	5.2	0.1	328.2	168	205	0	0.660	1.95

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.000	0.020	0.030	121	27.8	12.5	2.4	15.5	0.176	0.492	0.0	0	153
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	.000	0.000	0.043	127	29.1	13.1	2.6	15.8	0.218	0.528	0.0	3	156
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.000	0.152	0.117	135	31.8	13.5	2.3	15.2	4.590	2.360	0.3	14	178

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381370	16JUL92	0.0	18.0	8.6	.	.	.	.	.	.
2	381370	16JUL92	0.5	18.0	8.6	934.9	358	366	35	0.036	0.99
3	381370	16JUL92	1.0	18.0	8.4	.	.	.	.	.	.
4	381370	16JUL92	2.0	18.0	8.3	931.9	360	366	36	0.047	1.66
5	381370	16JUL92	3.0	18.0	8.3	.	.	.	.	.	.
6	381370	16JUL92	4.0	18.0	8.2	936.9	359	367	35	0.044	1.64
7	381370	10AUG92	0.0	20.0	8.3	.	.	.	.	.	.
8	381370	10AUG92	0.5	20.0	8.3	956.0	367	356	45	0.015	1.45
9	381370	10AUG92	1.0	20.0	8.4	.	.	.	.	.	.
10	381370	10AUG92	2.0	20.0	8.4	955.0	366	359	43	0.021	1.32
11	381370	10AUG92	3.0	20.0	8.4	.	.	.	.	.	.
12	381370	10AUG92	4.0	20.0	8.3	952.3	369	359	45	0.022	1.44
13	381370	18FEB93	0.0	0.6	7.9	.	.	.	.	.	.
14	381370	18FEB93	1.0	1.0	7.6	1164.0	464	518	24	0.759	1.40
15	381370	18FEB93	2.0	2.0	7.1	.	.	.	.	.	.
16	381370	18FEB93	3.0	3.2	5.0	.	.	.	.	.	.
17	381370	18FEB93	3.5	.	.	1157.0	467	521	24	0.654	2.09
18	381370	18FEB93	4.0	4.0	0.5	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.012	0.055	0.041	452	34.0	89.3	51.9	14.1	0.059	0.023	11.5	169	585
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.013	0.075	0.044	455	33.9	89.9	52.2	15.1	0.074	0.024	11.5	170	589
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.011	0.056	0.038	467	34.5	92.5	54.3	14.9	0.086	0.025	10.0	175	597
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.000	0.024	0.048	464	37.1	90.2	51.7	16.1	0.064	0.025	13.4	185	614
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.002	0.018	0.040	460	35.4	90.2	53.0	14.7	0.061	0.021	14.0	175	602
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.000	0.018	0.049	450	34.6	88.3	52.3	13.7	0.080	0.021	12.7	180	603
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.000	0.119	0.075	492	39.8	95.5	56.0	16.1	0.001	0.045	16.5	242	745
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	0.000	0.195	0.000	548	46.2	105.0	61.7	16.3	0.000	0.067	15.9	234	760
18	.	.	.	.	.	.	.	.	.	.	.	.	.

Kota-Ray Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380785	13JUL92	0.0	20.0	8.8	.	.	.	.	.	.
2	380785	13JUL92	0.5	20.0	8.8	1109.0	423	470	23	0.003	0.65
3	380785	13JUL92	1.0	20.0	8.8	.	.	.	.	.	.
4	380785	13JUL92	2.0	20.0	8.6	.	.	.	.	.	.
5	380785	13JUL92	3.0	19.0	8.4	.	.	.	.	.	.
6	380785	13JUL92	4.0	18.0	6.6	1099.0	424	473	22	0.000	0.75
7	380785	13JUL92	5.0	17.0	4.4	.	.	.	.	.	.
8	380785	13JUL92	6.0	16.0	1.5	.	.	.	.	.	.
9	380785	13JUL92	7.0	15.0	1.1	1129.0	440	537	0	0.186	0.64
10	380785	11AUG92	0.0	19.5	7.8	.	.	.	.	.	.
11	380785	11AUG92	0.5	19.5	7.8	1111.0	422	470	22	0.001	0.67
12	380785	11AUG92	1.0	19.5	7.8	.	.	.	.	.	.
13	380785	11AUG92	2.0	19.5	7.6	.	.	.	.	.	.
14	380785	11AUG92	3.0	19.5	7.5	.	.	.	.	.	.
15	380785	11AUG92	4.0	19.5	7.4	1107.0	422	470	22	0.004	0.67
16	380785	11AUG92	5.0	19.0	5.9	.	.	.	.	.	.
17	380785	11AUG92	6.0	19.0	3.8	.	.	.	.	.	.
18	380785	11AUG92	7.0	18.0	1.0	1114.0	424	499	9	0.027	0.98
19	380785	18FEB93	0.0	0.4	7.1	.	.	.	.	.	.
20	380785	18FEB93	1.0	2.0	6.6	1363.0	547	654	7	0.328	0.72
21	380785	18FEB93	2.0	2.2	6.5	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.006	0.021	0.016	432	50.3	74.5	97.3	7.1	0.050	0.007	4.1	213	701
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.005	0.041	0.023	427	51.0	72.9	95.6	7.3	0.071	0.007	3.9	201	687
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.140	0.061	0.015	436	62.8	67.7	115.0	8.7	0.000	0.000	4.1	197	720
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.000	0.000	0.040	415	43.8	74.3	96.6	7.1	0.064	0.015	3.6	204	683
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.005	0.023	0.037	454	48.7	80.8	105.0	8.1	0.130	0.019	2.9	209	708
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.000	0.035	0.034	448	49.8	78.5	106.0	8.1	0.234	0.125	2.5	209	709
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.000	0.082	0.023	521	57.8	91.6	123.0	9.2	0.022	0.019	4.8	325	941
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380785	18FEB93	3.0	2.2	6.4	.	.	.	.	.	.
23	380785	18FEB93	4.0	2.5	5.5	1321.0	533	622	14	0.325	0.96
24	380785	18FEB93	5.0	2.7	4.1	.	.	.	.	.	.
25	380785	18FEB93	6.0	3.0	3.3	1331.0	538	657	0	0.293	1.05
26	380785	18FEB93	6.5	3.2	1.6	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.000	0.117	0.026	626	69.5	110.0	145.0	9.6	0.012	0.018	4.9	325	984
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.000	0.128	0.016	496	55.3	87.0	116.0	0.0	0.037	0.034	4.9	310	905
26	.	.	.	.	.	.	.	.	.	.	.	.	.

Lake Elsie

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380710	29JUL92	0.0	22.0	7.9	.	.	.	.	.	.
2	380710	29JUL92	0.5	22.0	7.9	1188.0	203	248	0	0.648	1.64
3	380710	29JUL92	1.0	22.0	7.9	.	.	.	.	.	.
4	380710	29JUL92	2.0	22.0	7.9	.	.	.	.	.	.
5	380710	29JUL92	3.0	21.5	6.9	1191.0	203	240	4	0.867	1.57
6	380710	29JUL92	4.0	21.5	4.5	.	.	.	.	.	.
7	380710	29JUL92	5.0	21.0	2.1	.	.	.	.	.	.
8	380710	29JUL92	6.0	21.0	0.8	1203.0	210	256	0	1.490	1.93
9	380710	02SEP92	0.0	18.0	10.2	.	.	.	.	.	.
10	380710	02SEP92	0.5	18.0	10.2	1200.0	195	218	10	0.116	1.59
11	380710	02SEP92	1.0	18.0	10.2	.	.	.	.	.	.
12	380710	02SEP92	2.0	18.0	10.2	.	.	.	.	.	.
13	380710	02SEP92	3.0	18.0	9.8	.	.	.	.	.	.
14	380710	02SEP92	4.0	17.5	9.5	1210.0	197	220	10	0.122	1.21
15	380710	02SEP92	5.0	17.5	9.3	.	.	.	.	.	.
16	380710	02SEP92	6.0	17.5	9.2	.	.	.	.	.	.
17	380710	02SEP92	7.0	17.5	4.8	1195.0	198	219	11	0.140	1.37
18	380710	02MAR93	0.0	0.4	5.0	.	.	.	.	.	.
19	380710	02MAR93	1.0	2.4	4.7	1410.0	236	288	0	0.339	1.78
20	380710	02MAR93	2.0	2.9	4.7	.	.	.	.	.	.
21	380710	02MAR93	3.0	3.0	4.5	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.060	0.051	0.017	628	94.1	95.4	38.5	14.7	0.061	0.017	10.3	435	810
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.060	0.053	0.000	540	98.2	98.4	40.1	15.2	0.059	0.018	10.4	440	825
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.027	0.084	0.022	653	99.3	98.3	39.6	15.1	0.178	0.128	10.7	445	834
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.017	0.047	0.000	616	89.7	95.2	37.9	15.0	0.042	0.018	10.6	484	850
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.014	0.057	0.026	650	97.8	98.6	40.9	14.7	0.114	0.022	11.9	475	857
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	0.017	0.050	0.037	629	97.3	93.7	39.0	14.3	0.111	0.028	11.3	477	851
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	0.099	0.053	0.053	660	99.7	99.7	42.1	14.5	0.053	0.106	14.2	506	918
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380710	02MAR93	4.0	3.9	3.6	1418.0	236	288	0	0.349	1.63
23	380710	02MAR93	5.0	4.3	2.4	1413.0	231	282	0	0.042	1.53

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.089	0.044	0.060	665	98.3	102.0	41.6	15.0	0.060	0.120	13.4	507	919
23	0.089	0.058	0.066	673	99.7	103.0	41.4	14.6	0.074	0.146	13.6	507	918

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381150	27JUL92	0.0	21.0	9.1	.	.	.	.	.	.
2	381150	27JUL92	0.5	21.0	9.1	2718.0	1070	822	238	0.001	2.81
3	381150	27JUL92	1.0	21.0	9.1	.	.	.	.	.	.
4	381150	27JUL92	2.0	21.0	9.1	.	.	.	.	.	.
5	381150	27JUL92	3.0	.	.	2708.0	1070	827	237	0.006	2.43
6	381150	31AUG92	0.0	17.0	10.0	.	.	.	.	.	.
7	381150	31AUG92	0.5	17.0	10.0	2842.0	1120	836	264	0.000	0.15
8	381150	31AUG92	1.0	16.0	10.5	.	.	.	.	.	.
9	381150	31AUG92	2.0	15.0	10.0	2832.0	1120	838	259	0.000	3.34
10	381150	01MAR93	0.0	0.8	4.2	.	.	.	.	.	.
11	381150	01MAR93	1.0	1.0	3.3	3872.0	1570	1290	309	0.168	4.24
12	381150	01MAR93	2.0	2.1	2.4	3882.0	1580	1290	312	0.169	3.88

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.011	0.089	0.017	674	4.5	161	451	57.8	0.031	0.046	45.0	513	1880
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.008	0.084	0.010	678	4.6	162	460	58.3	0.045	0.049	46.3	541	1920
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.000	0.109	0.000	673	4.1	161	442	58.7	0.027	0.037	47.9	668	2060
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.000	0.108	0.000	686	4.4	164	452	61.0	0.041	0.041	47.8	636	2040
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.107	0.099	0.042	873	7.0	208	585	77.6	0.016	0.042	67.9	835	2720
12	0.086	0.096	0.045	889	6.6	212	604	77.6	0.064	0.038	67.4	855	2770

Lake Metigoshe Center

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380612	18AUG92	0.0	21.0	10.0	.	.	.	.	.	.
2	380612	18AUG92	0.5	21.0	10.0	574.9	293	282	37	0.033	1.60
3	380612	18AUG92	1.0	21.0	10.0	.	.	.	.	.	.
4	380612	18AUG92	2.0	20.0	9.8	.	.	.	.	.	.
5	380612	18AUG92	3.0	20.0	9.8	571.9	294	272	43	0.319	1.55
6	380612	18AUG92	4.0	19.5	7.2	.	.	.	.	.	.
7	380612	18AUG92	5.0	19.5	3.2	573.9	294	282	38	0.149	1.48
8	380612	04MAR93	0.0	0.2	3.7	.	.	.	.	.	.
9	380612	04MAR93	1.0	1.3	3.0	703.2	354	393	19	0.105	2.12
10	380612	04MAR93	2.0	3.0	2.7	.	.	.	.	.	.
11	380612	04MAR93	3.0	3.6	1.9	705.2	357	395	20	0.103	1.99
12	380612	04MAR93	4.0	4.5	0.1	.	.	.	.	.	.
13	380612	04MAR93	4.5	4.8	0.3	721.5	362	407	17	0.224	2.30

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.000	0.000	0.000	305	23.4	59.8	9.2	14.2	0.018	0.029	5.8	36	324
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.000	0.027	0.025	301	23.5	58.8	9.3	13.9	0.030	0.029	6.3	45	334
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.000	0.029	0.028	330	25.4	64.7	9.6	14.1	0.090	0.038	6.3	38	335
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.077	0.023	0.019	348	26.0	68.8	10.6	15.4	0.031	0.021	8.7	54	396
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.080	0.000	0.037	345	25.6	68.3	10.4	14.7	0.053	0.033	8.9	54	396
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.030	0.000	0.031	365	25.7	73.0	10.6	15.7	0.052	0.556	8.9	55	406

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380610	21JUL92	0.0	19.5	8.6	.	.	.	.	.	.
2	380610	21JUL92	0.5	19.5	8.6	566.0	278	295	22	0.004	1.04
3	380610	21JUL92	1.0	18.5	8.9	.	.	.	.	.	.
4	380610	21JUL92	2.0	18.0	8.3	.	.	.	.	.	.
5	380610	21JUL92	3.0	18.0	8.2	568.0	278	299	20	0.006	1.69
6	380610	21JUL92	4.0	18.0	8.0	.	.	.	.	.	.
7	380610	21JUL92	5.0	17.5	7.8	572.0	279	300	20	0.004	1.31
8	380610	18AUG92	0.0	21.0	8.6	.	.	.	.	.	.
9	380610	18AUG92	0.5	21.0	8.6	570.8	287	271	39	0.003	1.30
10	380610	18AUG92	1.0	21.0	8.5	.	.	.	.	.	.
11	380610	18AUG92	2.0	21.0	8.6	.	.	.	.	.	.
12	380610	18AUG92	3.0	21.0	8.5	573.9	286	296	26	0.015	1.66
13	380610	18AUG92	4.0	21.0	8.4	.	.	.	.	.	.
14	380610	18AUG92	5.0	20.0	7.4	570.8	287	297	26	0.006	0.95
15	380610	04MAR93	0.0	0.8	3.9	.	.	.	.	.	.
16	380610	04MAR93	1.0	2.0	3.7	707.3	342	418	0	0.065	2.02
17	380610	04MAR93	2.0	2.9	3.7	.	.	.	.	.	.
18	380610	04MAR93	3.0	3.6	1.2	714.4	349	426	0	0.105	1.93
19	380610	04MAR93	4.0	3.9	0.5	.	.	.	.	.	.
20	380610	04MAR93	5.0	4.0	0.2	718.5	355	433	0	0.157	1.75

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.007	0.045	0.000	315	26.4	60.4	9.0	14.8	0.000	0.030	6.7	46	331
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.011	0.036	0.000	316	26.7	60.6	9.0	14.4	0.003	0.032	5.8	40	324
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.010	0.038	0.006	314	26.7	60.1	9.2	14.3	0.000	0.033	5.4	37	320
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.000	0.079	0.046	311	26.1	59.8	8.8	14.7	0.017	0.035	5.8	41	329
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.000	0.081	0.048	305	25.5	58.7	8.7	14.0	0.035	0.036	5.2	39	323
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.000	0.071	0.020	305	25.4	58.6	8.6	14.3	0.024	0.036	5.6	39	324
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.078	0.000	0.025	321	27.3	61.5	9.1	14.4	0.030	0.010	7.6	58	384
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.060	0.000	0.021	375	31.8	71.7	10.0	16.1	0.030	0.021	7.2	56	403
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.036	0.000	0.028	349	29.1	67.1	9.4	15.1	0.106	0.144	8.2	59	401

Lake Metigoshe South

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380611	21JUL92	0.0	18.0	8.6	.	.	.	.	.	.
2	380611	21JUL92	0.5	18.0	8.6	579.0	287	302	24	0.004	0.96
3	380611	21JUL92	1.0	18.0	8.4	.	.	.	.	.	.
4	380611	21JUL92	2.0	18.0	8.4	.	.	.	.	.	.
5	380611	21JUL92	3.0	17.5	8.1	577.0	288	289	31	0.000	1.16
6	380611	21JUL92	4.0	17.5	8.1	.	.	.	.	.	.
7	380611	21JUL92	5.0	17.5	7.5	577.0	288	293	29	0.000	1.47
8	380611	18AUG92	0.0	22.0	9.6	.	.	.	.	.	.
9	380611	18AUG92	0.5	22.0	9.6	545.6	284	237	54	0.184	1.76
10	380611	18AUG92	1.0	21.5	9.6	.	.	.	.	.	.
11	380611	18AUG92	2.0	21.0	9.4	543.6	283	234	55	0.073	1.73
12	380611	18AUG92	3.0	21.0	9.0	543.6	284	235	55	0.053	1.59
13	380611	04MAR93	0.0	0.5	0.5	.	.	.	.	.	.
14	380611	04MAR93	1.0	1.9	0.2	747.9	389	389	42	0.280	2.37
15	380611	04MAR93	2.0	3.9	0.1	.	.	.	.	.	.
16	380611	04MAR93	3.0	4.3	0.1	754.0	393	394	42	0.330	2.56

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.007	0.032	0.000	321	25.9	62.2	9.6	14.8	0.000	0.024	6.2	37	328
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.009	0.036	0.073	333	26.3	65.0	10.7	15.5	0.006	0.028	6.9	40	338
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.007	0.059	0.027	319	25.2	62.2	9.4	14.1	0.000	0.027	7.0	38	329
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.000	0.054	0.027	311	20.8	62.9	10.9	15.2	0.017	0.022	6.2	36	323
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.000	0.064	0.024	315	20.8	63.8	9.9	15.7	0.023	0.021	6.1	51	338
12	0.000	0.066	0.026	305	20.4	61.7	9.6	14.9	0.035	0.022	6.5	37	321
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.016	0.000	0.013	408	25.0	84.0	12.9	18.7	0.044	0.084	7.5	60	442
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.022	0.000	0.026	368	22.6	75.6	11.8	16.9	0.034	0.071	9.8	60	433

Lake Tschida

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380950	08JUL92	0.0	20.0	9.8	.	.	.	.	.	.
2	380950	08JUL92	1.0	20.0	9.5	1591.0	304	329	21	0.069	0.80
3	380950	08JUL92	2.0	19.5	10.0	.	.	.	.	.	.
4	380950	08JUL92	3.0	19.0	9.8	.	.	.	.	.	.
5	380950	08JUL92	4.0	18.5	9.2	.	.	.	.	.	.
6	380950	08JUL92	5.0	18.5	9.1	1594.0	305	307	32	0.104	0.66
7	380950	08JUL92	6.0	18.5	9.1	.	.	.	.	.	.
8	380950	08JUL92	7.0	18.5	8.9	.	.	.	.	.	.
9	380950	08JUL92	8.0	18.5	8.7	.	.	.	.	.	.
10	380950	08JUL92	9.0	18.5	8.6	.	.	.	.	.	.
11	380950	08JUL92	10.0	18.3	8.3	.	.	.	.	.	.
12	380950	08JUL92	11.0	18.0	8.2	1593.0	305	328	22	0.075	0.90
13	380950	05AUG92	0.0	19.5	6.5	.	.	.	.	.	.
14	380950	05AUG92	0.5	19.5	6.5	1541.0	295	314	23	0.182	1.00
15	380950	05AUG92	1.0	19.5	6.4	.	.	.	.	.	.
16	380950	05AUG92	2.0	19.5	6.4	.	.	.	.	.	.
17	380950	05AUG92	3.0	19.5	6.2	.	.	.	.	.	.
18	380950	05AUG92	4.0	19.5	6.2	.	.	.	.	.	.
19	380950	05AUG92	5.0	19.0	6.1	1631.0	297	324	19	0.186	0.84
20	380950	05AUG92	6.0	19.0	6.0	.	.	.	.	.	.
21	380950	05AUG92	7.0	19.0	5.7	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.028	0.047	0.024	317	50.2	46.6	250	12.6	0.151	0.028	15.5	452	1010
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.026	0.038	0.075	332	52.8	48.6	259	12.2	0.148	0.031	15.6	446	1020
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.031	0.058	0.018	320	50.4	47.1	250	12.0	0.370	0.046	15.9	448	1010
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.012	0.081	0.040	306	46.1	46.4	248	11.6	0.229	0.084	16.2	483	1030
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	0.016	0.062	0.041	314	47.1	47.7	250	11.5	0.242	0.088	15.0	512	1060
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.

Lake Tschida

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380950	05AUG92	8.0	19.0	5.0	.	.	.	.	.	.
23	380950	05AUG92	9.0	19.0	4.7	.	.	.	.	.	.
24	380950	05AUG92	10.0	18.5	2.9	.	.	.	.	.	.
25	380950	05AUG92	11.0	18.5	1.7	1541.0	304	351	10	0.076	1.14
26	380950	16FEB93	0.0	0.5	12.1	.	.	.	.	.	.
27	380950	16FEB93	1.0	1.0	12.0	1774.0	360	403	18	0.240	5.18
28	380950	16FEB93	2.0	2.0	12.0	.	.	.	.	.	.
29	380950	16FEB93	3.0	2.0	11.5	.	.	.	.	.	.
30	380950	16FEB93	4.0	2.2	11.0	.	.	.	.	.	.
31	380950	16FEB93	5.0	2.5	10.0	.	.	.	.	.	.
32	380950	16FEB93	6.0	2.9	8.9	1767.0	361	418	11	0.310	0.93
33	380950	16FEB93	7.0	3.0	7.4	.	.	.	.	.	.
34	380950	16FEB93	8.0	2.9	8.2	.	.	.	.	.	.
35	380950	16FEB93	9.0	2.8	7.8	.	.	.	.	.	.
36	380950	16FEB93	10.0	2.9	6.4	.	.	.	.	.	.
37	380950	16FEB93	11.0	3.0	5.5	.	.	.	.	.	.
38	380950	16FEB93	11.5	.	.	1949.0	406	496	0	0.301	0.78
39	380950	16FEB93	12.0	2.9	6.1	.	.	.	.	.	.
40	380950	16FEB93	12.5	2.9	6.1	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.047	0.155	0.100	298	46.3	44.2	236	10.2	1.350	0.414	14.7	518	1050
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	0.153	0.050	0.047	346	52.2	52.4	290	12.7	0.020	0.041	20.2	577	1220
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.
32	0.178	0.107	0.044	318	48.3	48.0	266	11.4	0.019	0.054	22.0	594	1210
33	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.
38	0.261	0.144	0.057	382	58.5	57.2	317	12.7	0.295	0.131	24.1	649	1360
39	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.

Lake Williams

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380970	23JUL92	0.0	19.5	8.7	.	.	.	.	.	.
2	380970	23JUL92	0.5	19.5	8.7	713.8	318	290	48	0.000	1.12
3	380970	23JUL92	1.0	19.5	8.8	.	.	.	.	.	.
4	380970	23JUL92	2.0	19.5	8.6	.	.	.	.	.	.
5	380970	23JUL92	3.0	19.5	8.7	.	.	.	.	.	.
6	380970	23JUL92	4.0	19.5	8.6	716.8	319	298	45	0.000	0.94
7	380970	23JUL92	5.0	19.5	8.6	.	.	.	.	.	.
8	380970	20AUG92	0.0	22.0	9.6	.	.	.	.	.	.
9	380970	20AUG92	0.5	22.0	9.6	724.1	327	293	52	0.004	1.02
10	380970	20AUG92	1.0	22.0	9.6	.	.	.	.	.	.
11	380970	20AUG92	2.0	22.0	9.6	.	.	.	.	.	.
12	380970	20AUG92	3.0	22.0	9.6	.	.	.	.	.	.
13	380970	20AUG92	4.0	22.0	9.6	.	.	.	.	.	.
14	380970	20AUG92	5.0	21.0	9.2	723.1	327	289	54	0.028	1.10
15	380970	20AUG92	6.0	21.0	8.1	.	.	.	.	.	.
16	380970	20AUG92	7.0	20.0	3.2	733.2	326	315	41	0.060	1.44
17	380970	01MAR93	0.0	0.7	9.2	.	.	.	.	.	.
18	380970	01MAR93	1.0	1.5	8.8	895.3	397	416	34	0.125	1.03
19	380970	01MAR93	2.0	2.8	9.3	.	.	.	.	.	.
20	380970	01MAR93	3.0	3.1	9.7	.	.	.	.	.	.
21	380970	01MAR93	4.0	3.9	8.2	897.3	405	429	32	0.063	1.00

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.007	0.019	0.009	375	13.2	83.1	30.6	13.6	0.017	0.045	9.6	94	435
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.007	0.033	0.007	374	13.4	82.8	30.8	14.5	0.015	0.047	9.4	89	432
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.000	0.065	0.045	405	14.5	89.5	32.1	14.8	0.020	0.054	9.3	96	453
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.002	0.041	0.041	388	13.9	85.8	30.9	13.1	0.052	0.053	9.7	97	447
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.000	0.051	0.045	413	15.1	91.2	32.0	14.5	0.127	0.175	9.6	97	456
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.060	0.043	0.034	414	22.3	87.1	31.3	14.7	1.140	0.076	12.3	120	527
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	0.050	0.113	0.041	382	18.9	81.4	31.2	14.2	0.028	0.028	12.1	120	521

Lake Williams

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380970	01MAR93	5.0	4.1	5.7	.	.	.	.	.	.
23	380970	01MAR93	6.0	4.8	0.9	935.9	420	470	21	0.183	1.34
24	380970	01MAR93	6.5	4.8	0.6	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.050	0.056	0.058	413	20.1	88.2	31.6	15.2	0.025	0.099	13.1	125	546
24	.	.	.	.	.	.	.	.	.	.	.	.	.

Larimore Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381250	22JUL92	0.0	22.0	13.3	.	.	.	.	.	.
2	381250	22JUL92	0.5	22.0	13.3	728.7	318	290	48	0.012	0.68
3	381250	22JUL92	1.0	21.0	13.7	.	.	.	.	.	.
4	381250	22JUL92	2.0	19.0	11.8	.	.	.	.	.	.
5	381250	22JUL92	3.0	19.0	8.4	.	.	.	.	.	.
6	381250	22JUL92	4.0	19.0	8.0	.	.	.	.	.	.
7	381250	22JUL92	5.0	18.0	4.0	836.5	242	295	0	0.109	0.55
8	381250	22JUL92	6.0	17.5	3.3	.	.	.	.	.	.
9	381250	22JUL92	7.0	17.0	4.7	.	.	.	.	.	.
10	381250	22JUL92	8.0	17.0	3.8	.	.	.	.	.	.
11	381250	22JUL92	9.0	16.0	1.2	904.4	253	309	0	0.244	0.17
12	381250	19AUG92	0.0	22.0	15.0	.	.	.	.	.	.
13	381250	19AUG92	0.5	22.0	15.0	625.3	151	180	2	0.099	1.32
14	381250	19AUG92	1.0	22.0	15.0	.	.	.	.	.	.
15	381250	19AUG92	2.0	21.0	15.0	.	.	.	.	.	.
16	381250	19AUG92	3.0	21.0	8.2	.	.	.	.	.	.
17	381250	19AUG92	4.0	20.0	5.8	.	.	.	.	.	.
18	381250	19AUG92	5.0	20.0	3.6	698.9	201	245	0	0.520	1.07
19	381250	19AUG92	6.0	19.0	1.8	.	.	.	.	.	.
20	381250	19AUG92	7.0	19.0	0.5	.	.	.	.	.	.
21	381250	19AUG92	8.0	19.0	0.5	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.006	0.064	0.009	338	83.7	31.2	34.7	4.7	0.035	0.138	28.3	139	512
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.016	0.110	0.048	376	97.4	32.3	42.1	5.0	0.062	0.343	32.5	169	524
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.020	0.181	0.103	407	105.0	35.2	50.5	4.6	0.257	0.655	33.5	189	507
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.000	0.046	0.000	263	58.1	28.7	33.1	4.4	0.040	0.082	28.4	130	373
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.002	0.067	0.080	285	69.4	27.2	30.6	4.0	0.065	0.382	27.4	150	429
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.

Larimore Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381250	19AUG92	9.0	18.0	0.0	719.1	223	272	0	0.966	1.71
23	381250	11MAR93	0.0	0.3	7.1	.	.	.	.	.	.
24	381250	11MAR93	1.0	2.0	7.8	648.2	239	292	0	0.295	0.65
25	381250	11MAR93	2.0	2.3	5.5	.	.	.	.	.	.
26	381250	11MAR93	3.0	2.8	4.6	.	.	.	.	.	.
27	381250	11MAR93	4.0	3.0	4.3	778.2	279	341	0	0.234	0.67
28	381250	11MAR93	5.0	3.2	4.0	.	.	.	.	.	.
29	381250	11MAR93	6.0	3.3	3.8	.	.	.	.	.	.
30	381250	11MAR93	7.0	3.9	2.6	.	.	.	.	.	.
31	381250	11MAR93	8.0	4.0	1.8	776.2	278	339	0	0.325	0.66

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.000	0.247	0.243	301	76.3	26.9	29.7	4.6	0.135	1.080	27.0	122	420
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	0.204	0.113	0.039	354	99.5	25.6	15.0	3.2	0.169	0.742	20.1	91	398
25	.	.	.	.	.	.	.	.	.	.	.	.	.
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	0.205	0.104	0.045	338	91.7	26.5	17.9	3.7	0.061	0.736	26.9	109	444
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.
31	0.184	0.072	0.041	415	109.0	34.6	23.1	5.6	0.116	0.826	27.7	111	478

McVille Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381075	22JUL92	0.0	20.5	13.6	.	.	.	.	.	.
2	381075	22JUL92	0.5	20.5	13.6	898.4	244	239	29	0.000	1.09
3	381075	22JUL92	1.0	20.5	13.6	.	.	.	.	.	.
4	381075	22JUL92	2.0	20.0	13.7	.	.	.	.	.	.
5	381075	22JUL92	3.0	18.5	1.2	912.4	238	248	21	0.000	1.05
6	381075	22JUL92	4.0	18.0	1.0	.	.	.	.	.	.
7	381075	22JUL92	5.0	17.0	0.9	.	.	.	.	.	.
8	381075	22JUL92	6.0	15.5	0.8	973.3	273	333	0	0.264	1.55
9	381075	19AUG92	0.0	20.5	3.2	.	.	.	.	.	.
10	381075	19AUG92	0.5	20.5	3.2	918.8	238	283	4	0.511	1.97
11	381075	19AUG92	1.0	20.0	2.6	.	.	.	.	.	.
12	381075	19AUG92	2.0	20.0	1.0	.	.	.	.	.	.
13	381075	19AUG92	3.0	20.0	0.5	919.8	240	277	8	0.042	1.68
14	381075	19AUG92	4.0	19.5	0.5	.	.	.	.	.	.
15	381075	19AUG92	5.0	19.0	0.4	.	.	.	.	.	.
16	381075	19AUG92	6.0	17.0	0.4	929.9	248	293	5	0.081	1.25
17	381075	10MAR93	0.0	0.0	4.0	.	.	.	.	.	.
18	381075	10MAR93	1.0	1.0	3.1	1166.0	320	391	0	0.392	1.58
19	381075	10MAR93	2.0	1.0	2.8	.	.	.	.	.	.
20	381075	10MAR93	3.0	1.0	2.0	.	.	.	.	.	.
21	381075	10MAR93	4.0	1.2	1.9	1170.0	314	384	0	0.706	1.60

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.006	0.181	0.042	362	53.1	55.6	76.2	8.2	0.016	0.135	15.0	257	612
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.008	0.166	0.068	352	52.7	53.6	73.7	8.0	0.018	0.344	15.6	261	608
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.010	0.296	0.248	387	62.6	56.1	75.6	7.4	0.000	0.500	15.7	256	637
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.000	0.291	0.242	387	57.3	59.3	77.8	7.0	0.029	1.910	14.7	235	595
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.000	0.231	0.155	380	54.4	59.4	77.1	7.4	0.027	0.860	15.0	224	582
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.000	0.188	0.192	390	55.8	60.9	79.1	7.0	0.024	0.693	15.1	232	599
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.101	0.125	0.082	410	69.4	57.4	80.3	7.7	0.050	0.727	20.4	307	735
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	0.084	0.133	0.081	423	71.3	59.4	84.2	7.7	0.060	0.750	20.4	306	738

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381075	10MAR93	5.0	1.2	0.9	.	.	.	.	.	.
23	381075	10MAR93	6.0	1.7	0.2	1173.0	325	397	0	0.412	1.49

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.078	0.135	0.075	419	69.8	59.3	81.4	7.7	0.069	0.931	20.0	301	735

Mirror Lake

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380630	08JUL92	0.0	18.8	8.6	.	.	.	.	.	.
2	380630	08JUL92	1.0	18.8	8.5	1048.0	230	250	15	0.001	1.06
3	380630	08JUL92	2.0	18.5	8.4	1036.0	231	247	17	0.000	1.00
4	380630	08JUL92	3.0	18.5	8.3	.	.	.	.	.	.
5	380630	08JUL92	4.0	18.5	6.0	1040.0	230	244	18	0.004	0.90
6	380630	05AUG92	0.0	18.5	7.3	.	.	.	.	.	.
7	380630	05AUG92	0.5	18.5	7.3	1031.0	222	232	19	0.007	1.05
8	380630	05AUG92	1.0	19.0	6.8	.	.	.	.	.	.
9	380630	05AUG92	2.0	19.0	6.6	1034.0	221	248	11	0.037	1.16
10	380630	05AUG92	3.0	18.5	6.4	.	.	.	.	.	.
11	380630	05AUG92	4.0	18.5	6.3	1037.0	222	242	14	0.024	1.14
12	380630	17FEB93	0.0	0.5	14.4	.	.	.	.	.	.
13	380630	17FEB93	1.0	2.5	14.4	1516.0	323	366	14	0.003	1.37
14	380630	17FEB93	2.0	3.1	14.2	.	.	.	.	.	.
15	380630	17FEB93	3.0	4.5	8.5	1497.0	321	366	13	0.011	1.48
16	380630	17FEB93	3.2	4.7	7.2	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.014	0.062	0.034	274	39.0	42.8	99	17.4	0.174	0.033	12.0	301	649
3	0.014	0.060	0.029	322	46.9	49.7	120	22.0	0.242	0.039	11.5	297	686
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.023	0.069	0.029	321	45.9	50.1	120	22.6	0.233	0.037	12.0	297	686
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.000	0.049	0.029	278	37.6	44.7	110	19.7	0.297	0.049	12.1	293	650
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.025	0.104	0.037	298	40.6	47.8	118	20.8	0.328	0.052	11.8	291	663
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.004	0.102	0.140	279	38.1	44.6	112	19.9	0.631	0.062	11.6	291	650
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.000	0.071	0.019	380	44.5	65.4	157	24.0	0.021	0.015	21.2	501	1010
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.000	0.720	0.000	420	49.0	72.2	173	26.2	0.027	0.015	21.0	505	1040
16	.	.	.	.	.	.	.	.	.	.	.	.	.

North Lemmon Lake

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380850	18AUG92	0.0	20.0	8.2	.	.	.	.	.	.
2	380850	18AUG92	0.5	20.0	8.2	502.5	295	199	79	0.028	1.46
3	380850	18AUG92	1.0	20.0	8.1	.	.	.	.	.	.
4	380850	18AUG92	2.0	20.0	8.1	500.4	294	200	78	0.035	1.26
5	380850	18AUG92	3.0	20.0	7.9	.	.	.	.	.	.
6	380850	18AUG92	4.0	20.0	7.6	504.5	294	206	75	0.032	1.22
7	380850	18AUG92	4.1	20.0	3.0	.	.	.	.	.	.
8	380850	16FEB93	0.0	0.5	12.8	.	.	.	.	.	.
9	380850	16FEB93	1.0	2.5	10.2	674.6	379	414	24	0.272	1.35
10	380850	16FEB93	2.0	3.9	8.4	.	.	.	.	.	.
11	380850	16FEB93	3.0	3.9	7.2	.	.	.	.	.	.
12	380850	16FEB93	4.0	4.0	2.1	672.6	377	420	20	0.244	1.52
13	380850	16FEB93	5.0	4.0	0.8	.	.	.	.	.	.
14	380850	16FEB93	6.0	4.5	0.1	.	.	.	.	.	.
15	380850	16FEB93	6.5	.	.	676.7	373	419	18	0.084	1.65
16	380850	16FEB93	7.0	5.0	0.1	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.000	0.014	0.033	256	14.0	53.8	40.4	12.5	0.019	0.007	7.2	15	320
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.002	0.025	0.000	256	14.6	53.3	40.5	12.1	0.093	0.011	7.3	17	321
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.001	0.020	0.044	253	14.0	52.9	38.8	11.7	0.046	0.009	7.0	16	317
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.000	0.104	0.000	304	20.9	61.2	48.0	14.2	0.034	0.003	9.0	12	393
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.040	0.162	0.016	271	19.1	54.3	43.5	12.5	0.037	0.004	9.1	12	377
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.024	0.138	0.019	310	22.0	61.9	48.4	13.6	0.000	0.006	8.8	11	390
16	.	.	.	.	.	.	.	.	.	.	.	.	.

Odland Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380860	07JUL92	0.0	20.0	8.9	.	.	.	.	.	.
2	380860	07JUL92	0.5	20.0	8.9	3905.0	415	470	18	0.105	1.98
3	380860	07JUL92	1.0	20.0	8.7	.	.	.	.	.	.
4	380860	07JUL92	2.0	19.5	7.4	3905.0	413	482	11	0.109	3.90
5	380860	07JUL92	3.0	19.0	6.6	.	.	.	.	.	.
6	380860	07JUL92	4.0	18.5	3.5	3905.0	416	486	11	0.178	1.82
7	380860	04AUG92	0.0	19.0	9.3	.	.	.	.	.	.
8	380860	04AUG92	0.5	19.0	9.3	3932.0	416	430	38	0.027	3.29
9	380860	04AUG92	1.0	19.0	9.1	.	.	.	.	.	.
10	380860	04AUG92	2.0	19.0	9.2	3952.0	414	424	40	0.021	1.54
11	380860	04AUG92	3.0	19.0	9.1	.	.	.	.	.	.
12	380860	04AUG92	4.0	19.0	8.5	3952.0	417	428	40	0.019	0.81
13	380860	17FEB93	0.0	1.0	9.2	.	.	.	.	.	.
14	380860	17FEB93	1.0	1.1	9.2	5873.0	628	747	10	0.047	3.81
15	380860	17FEB93	2.0	1.8	6.2	5883.0	624	741	10	0.022	3.84
16	380860	17FEB93	3.0	2.0	0.3	.	.	.	.	.	.
17	380860	17FEB93	4.0	2.9	0.1	5933.0	635	775	0	0.483	4.28

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.058	0.136	0.069	1160	115	211	536	21.4	0.093	0.076	43.8	1790	2970
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	0.088	0.248	0.094	1170	117	213	544	21.7	0.101	0.076	43.0	1850	3040
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.055	0.200	0.097	1140	114	207	550	22.9	0.235	0.106	44.5	1970	3160
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.000	0.174	0.092	1220	113	227	599	24.0	0.153	0.105	43.3	2050	3310
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.003	0.207	0.090	1230	117	227	610	24.9	0.158	0.106	43.3	2030	3300
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.000	0.181	0.099	1240	117	230	603	24.3	0.344	0.115	44.2	2020	3290
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.070	0.264	0.049	1800	156	342	919	34.3	0.283	0.199	74.5	3210	5110
15	0.070	0.293	0.047	1850	160	353	932	35.0	0.304	0.201	74.0	3060	4990
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	0.060	0.329	0.093	1890	165	359	945	36.0	0.391	0.380	73.3	3070	5030

Patterson Lake

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380865	07JUL92	0.0	19.0	11.5	.	.	.	.	.	.
2	380865	07JUL92	0.5	19.0	11.5	2185.0	375	378	39	0.000	2.91
3	380865	07JUL92	1.0	19.0	11.2	.	.	.	.	.	.
4	380865	07JUL92	2.0	19.0	11.2	.	.	.	.	.	.
5	380865	07JUL92	2.5	.	.	2206.0	376	384	37	0.016	2.74
6	380865	07JUL92	3.0	18.0	10.7	.	.	.	.	.	.
7	380865	07JUL92	4.0	18.0	9.0	.	.	.	.	.	.
8	380865	07JUL92	5.0	17.5	6.2	2195.0	380	409	27	0.017	2.24
9	380865	04AUG92	0.0	19.0	6.6	.	.	.	.	.	.
10	380865	04AUG92	0.5	19.0	6.6	2061.0	356	363	35	0.013	0.97
11	380865	04AUG92	1.0	19.0	6.2	.	.	.	.	.	.
12	380865	04AUG92	2.0	19.0	5.8	.	.	.	.	.	.
13	380865	04AUG92	2.5	.	.	2091.0	356	361	36	0.034	1.16
14	380865	04AUG92	3.0	19.0	5.6	.	.	.	.	.	.
15	380865	04AUG92	4.0	18.5	5.4	.	.	.	.	.	.
16	380865	04AUG92	5.0	18.5	4.5	2111.0	356	363	35	0.122	1.29
17	380865	17FEB93	0.0	1.0	8.1	.	.	.	.	.	.
18	380865	17FEB93	1.0	1.0	7.2	2835.0	536	646	4	0.355	3.34
19	380865	17FEB93	2.0	1.0	6.9	.	.	.	.	.	.
20	380865	17FEB93	3.0	2.0	0.3	2804.0	540	659	0	0.571	3.11
21	380865	17FEB93	4.0	2.4	0.1	2896.0	575	702	0	1.230	3.86

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.022	0.187	0.178	288	43.9	43.3	408	13.0	0.537	0.235	18.6	664	1420
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.009	0.466	0.059	309	48.1	45.8	418	13.9	0.544	0.245	19.3	670	1440
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.010	0.254	0.057	299	47.0	44.1	408	13.1	0.898	0.316	18.3	867	1630
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.001	0.364	0.067	268	39.6	41.0	427	14.0	1.050	0.241	17.9	777	1530
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.117	0.366	0.077	264	39.1	40.3	423	14.1	1.040	0.232	17.5	772	1520
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.010	0.417	0.085	266	39.7	40.5	417	13.5	1.580	0.299	17.2	783	1520
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.260	0.367	0.158	341	54.9	49.6	514	13.7	0.122	0.707	26.2	970	1950
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.180	0.423	0.196	316	50.5	46.1	476	11.8	0.122	0.866	27.7	989	1930
21	0.000	0.639	0.453	375	60.5	54.3	546	12.8	0.478	2.140	27.3	982	2030

Patterson Lake

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380865	17FEB93	4.2	2.7	0.0	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.

Red Willow Lake

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380500	22JUL92	0.0	20.0	10.4	.	.	.	.	.	.
2	380500	22JUL92	0.5	20.0	10.4	527.1	196	194	22	0.000	1.25
3	380500	22JUL92	1.0	20.0	10.2	.	.	.	.	.	.
4	380500	22JUL92	2.0	20.0	10.2	.	.	.	.	.	.
5	380500	22JUL92	3.0	20.0	10.2	524.1	195	191	23	0.000	1.23
6	380500	22JUL92	4.0	19.5	10.2	.	.	.	.	.	.
7	380500	22JUL92	5.0	19.0	7.9	.	.	.	.	.	.
8	380500	22JUL92	6.0	19.0	3.8	532.1	193	205	17	0.000	0.82
9	380500	19AUG92	0.0	20.5	8.5	.	.	.	.	.	.
10	380500	19AUG92	0.5	20.5	8.5	524.5	198	197	22	0.000	0.60
11	380500	19AUG92	1.0	20.5	8.6	.	.	.	.	.	.
12	380500	19AUG92	2.0	20.5	8.6	.	.	.	.	.	.
13	380500	19AUG92	3.0	20.5	8.6	.	.	.	.	.	.
14	380500	19AUG92	4.0	20.0	2.9	525.5	199	190	26	0.005	0.93
15	380500	19AUG92	5.0	20.0	2.0	.	.	.	.	.	.
16	380500	19AUG92	6.0	19.5	1.2	537.6	201	225	10	0.034	1.24
17	380500	10MAR93	0.0	0.9	4.9	.	.	.	.	.	.
18	380500	10MAR93	1.0	2.6	3.1	668.5	257	314	0	0.085	1.48
19	380500	10MAR93	2.0	3.8	2.2	.	.	.	.	.	.
20	380500	10MAR93	3.0	3.6	0.9	667.5	263	321	0	0.417	1.28
21	380500	10MAR93	4.0	3.5	0.4	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.011	0.041	0.012	255	26.7	45.8	16.2	14.0	0.025	0.026	6.2	87	313
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.007	0.037	0.009	256	26.5	46.1	16.4	14.4	0.037	0.029	6.3	85	312
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.010	0.035	0.016	255	27.0	45.5	16.2	13.9	0.027	0.035	5.0	84	310
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.000	0.095	0.013	249	24.8	45.4	16.4	14.3	0.032	0.051	6.0	84	310
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	0.000	0.086	0.028	251	25.0	45.7	16.5	14.1	0.053	0.054	0.0	94	321
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.001	0.098	0.000	251	25.8	45.3	16.5	14.2	0.055	0.161	5.8	86	314
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.095	0.081	0.020	324	39.4	54.8	18.4	16.0	0.023	0.030	7.1	107	397
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.094	0.066	0.027	336	38.9	57.9	18.5	16.2	0.067	0.053	7.2	105	402
21	.	.	.	.	.	.	.	.	.	.	.	.	.

Red Willow Lake

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380500	10MAR93	5.0	3.6	0.1	.	.	.	.	.	.
23	380500	10MAR93	6.0	3.8	0.7	669.5	269	328	0	0.118	1.35
24	380500	10MAR93	6.5	4.0	0.4	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.036	0.067	0.022	327	40.4	54.8	18.3	14.6	0.040	0.203	5.0	104	399
24	.	.	.	.	.	.	.	.	.	.	.	.	.

Riverdale Spillway Pond

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381315	20JUL92	0.0	21.0	9.0	.	.	.	.	.	.
2	381315	20JUL92	0.5	21.0	9.0	943.4	222	243	14	0.000	0.28
3	381315	20JUL92	1.0	21.0	8.9	.	.	.	.	.	.
4	381315	20JUL92	2.0	20.0	8.9	.	.	.	.	.	.
5	381315	20JUL92	3.0	20.0	9.0	.	.	.	.	.	.
6	381315	20JUL92	4.0	19.5	9.0	.	.	.	.	.	.
7	381315	20JUL92	5.0	19.5	9.0	.	.	.	.	.	.
8	381315	20JUL92	6.0	18.5	8.0	.	.	.	.	.	.
9	381315	20JUL92	7.0	15.0	8.0	.	.	.	.	.	.
10	381315	20JUL92	8.0	12.0	7.0	.	.	.	.	.	.
11	381315	20JUL92	9.0	9.0	7.9	.	.	.	.	.	.
12	381315	20JUL92	10.0	7.5	8.4	997.3	236	288	0	0.004	0.32
13	381315	20JUL92	11.0	7.0	8.4	.	.	.	.	.	.
14	381315	20JUL92	12.0	6.5	8.3	.	.	.	.	.	.
15	381315	20JUL92	13.0	6.0	8.2	.	.	.	.	.	.
16	381315	20JUL92	14.0	6.0	8.0	.	.	.	.	.	.
17	381315	20JUL92	15.0	6.0	7.2	.	.	.	.	.	.
18	381315	20JUL92	16.0	5.5	5.0	.	.	.	.	.	.
19	381315	20JUL92	17.0	5.5	4.4	.	.	.	.	.	.
20	381315	20JUL92	18.0	5.5	4.0	.	.	.	.	.	.
21	381315	20JUL92	19.0	5.0	3.0	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.007	0.057	0.000	209	44.4	23.7	136	3.7	0.083	0.003	13.7	247	602
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.075	0.016	0.000	205	43.2	23.6	149	3.4	0.127	0.006	15.0	255	631
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.

Riverdale Spillway Pond

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381315	20JUL92	20.0	5.0	2.0	1774.0	546	667	0	0.591	1.03
23	381315	10AUG92	0.0	21.0	8.2	.	.	.	.	.	.
24	381315	10AUG92	0.5	21.0	8.2	934.2	220	238	15	0.006	0.25
25	381315	10AUG92	1.0	21.0	8.2	.	.	.	.	.	.
26	381315	10AUG92	2.0	21.0	8.1	.	.	.	.	.	.
27	381315	10AUG92	3.0	21.0	8.1	.	.	.	.	.	.
28	381315	10AUG92	4.0	21.0	8.0	.	.	.	.	.	.
29	381315	10AUG92	5.0	20.5	8.0	.	.	.	.	.	.
30	381315	10AUG92	6.0	19.0	7.2	.	.	.	.	.	.
31	381315	10AUG92	7.0	14.0	7.1	.	.	.	.	.	.
32	381315	10AUG92	8.0	9.0	7.4	.	.	.	.	.	.
33	381315	10AUG92	9.0	7.0	7.4	.	.	.	.	.	.
34	381315	10AUG92	10.0	7.0	7.3	983.9	235	287	0	0.002	0.34
35	381315	10AUG92	11.0	6.0	7.3	.	.	.	.	.	.
36	381315	10AUG92	12.0	6.0	7.1	.	.	.	.	.	.
37	381315	10AUG92	13.0	6.0	6.0	.	.	.	.	.	.
38	381315	10AUG92	14.0	6.0	4.4	.	.	.	.	.	.
39	381315	10AUG92	15.0	6.0	4.4	.	.	.	.	.	.
40	381315	10AUG92	16.0	6.0	2.7	.	.	.	.	.	.
41	381315	10AUG92	17.0	5.5	2.2	.	.	.	.	.	.
42	381315	10AUG92	18.0	5.0	1.4	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.063	0.085	0.044	183	39.6	20.4	390	4.8	0.316	0.834	23.0	385	1190
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	0.000	0.000	0.026	202	43.1	22.9	142	3.1	0.045	0.001	15.6	233	592
25	.	.	.	.	.	.	.	.	.	.	.	.	.
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.
34	0.099	0.000	0.046	196	41.8	22.2	145	3.6	0.100	0.004	16.7	244	615
35	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.
41	.	.	.	.	.	.	.	.	.	.	.	.	.
42	.	.	.	.	.	.	.	.	.	.	.	.	.

Riverdale Spillway Pond

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
43	381315	10AUG92	19.0	5.0	1.0	.	.	.	.	.	.
44	381315	10AUG92	20.0	5.0	1.0	1922.0	634	774	0	1.060	1.56
45	381315	22FEB93	0.0	1.0	11.4	.	.	.	.	.	.
46	381315	22FEB93	1.0	1.9	11.4	988.8	240	281	6	0.228	0.83
47	381315	22FEB93	2.0	1.9	11.3	.	.	.	.	.	.
48	381315	22FEB93	3.0	2.1	11.3	.	.	.	.	.	.
49	381315	22FEB93	4.0	2.5	11.2	.	.	.	.	.	.
50	381315	22FEB93	5.0	2.8	11.2	.	.	.	.	.	.
51	381315	22FEB93	6.0	2.9	10.8	.	.	.	.	.	.
52	381315	22FEB93	7.0	2.9	10.6	.	.	.	.	.	.
53	381315	22FEB93	8.0	2.9	10.5	.	.	.	.	.	.
54	381315	22FEB93	9.0	2.9	10.4	.	.	.	.	.	.
55	381315	22FEB93	10.0	2.9	10.3	985.8	244	288	5	0.012	0.40
56	381315	22FEB93	11.0	2.9	10.2	.	.	.	.	.	.
57	381315	22FEB93	12.0	2.9	10.0	.	.	.	.	.	.
58	381315	22FEB93	13.0	2.9	10.0	.	.	.	.	.	.
59	381315	22FEB93	14.0	3.0	9.8	.	.	.	.	.	.
60	381315	22FEB93	15.0	3.0	9.4	.	.	.	.	.	.
61	381315	22FEB93	16.0	3.0	8.8	.	.	.	.	.	.
62	381315	22FEB93	17.0	3.2	7.7	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	NITRATE PHOSPHATE AS P (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	DISSOLVED IRON (mg/L)	TOTAL MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
43	.	.	.	.	.	.	.	.	.	.	.	.	.
44	0.150	0.165	0.179	172	38.2	18.6	363	4.9	0.355	0.827	25.6	381	1210
45	.	.	.	.	.	.	.	.	.	.	.	.	.
46	0.060	0.031	0.000	218	47.8	23.9	137	4.5	0.050	0.002	16.8	247	621
47	.	.	.	.	.	.	.	.	.	.	.	.	.
48	.	.	.	.	.	.	.	.	.	.	.	.	.
49	.	.	.	.	.	.	.	.	.	.	.	.	.
50	.	.	.	.	.	.	.	.	.	.	.	.	.
51	.	.	.	.	.	.	.	.	.	.	.	.	.
52	.	.	.	.	.	.	.	.	.	.	.	.	.
53	.	.	.	.	.	.	.	.	.	.	.	.	.
54	.	.	.	.	.	.	.	.	.	.	.	.	.
55	0.074	0.049	0.028	245	53.8	26.8	162	5.1	0.051	0.003	13.6	248	656
56	.	.	.	.	.	.	.	.	.	.	.	.	.
57	.	.	.	.	.	.	.	.	.	.	.	.	.
58	.	.	.	.	.	.	.	.	.	.	.	.	.
59	.	.	.	.	.	.	.	.	.	.	.	.	.
60	.	.	.	.	.	.	.	.	.	.	.	.	.
61	.	.	.	.	.	.	.	.	.	.	.	.	.
62	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
63	381315	22FEB93	18.0	4.0	0.2	.	.	.	.	.	.
64	381315	22FEB93	19.0	4.6	0.0	1530.0	457	558	0	0.072	0.58

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
63	.	.	.	.	.	.	.	.	.	.	.	.	.
64	0.427	0.064	0.041	213	47.6	22.8	335	5.0	0.212	0.282	22.3	370	1080

Sheep Creek Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380910	08JUL92	0.0	19.5	11.2	.	.	.	.	.	.
2	380910	08JUL92	0.5	19.5	11.2	1948.0	366	323	61	0.000	1.46
3	380910	08JUL92	1.0	19.5	11.4	.	.	.	.	.	.
4	380910	08JUL92	2.0	19.0	10.8	.	.	.	.	.	.
5	380910	08JUL92	3.0	19.0	10.6	.	.	.	.	.	.
6	380910	08JUL92	4.0	18.8	10.6	1938.0	366	319	63	0.001	2.20
7	380910	08JUL92	5.0	17.0	6.4	.	.	.	.	.	.
8	380910	08JUL92	6.0	17.0	5.7	.	.	.	.	.	.
9	380910	08JUL92	7.0	16.5	2.4	1968.0	374	361	47	0.284	1.82
10	380910	05AUG92	0.0	18.5	9.5	.	.	.	.	.	.
11	380910	05AUG92	0.5	18.5	9.5	1738.0	335	314	47	0.040	2.30
12	380910	05AUG92	1.0	19.0	9.6	.	.	.	.	.	.
13	380910	05AUG92	2.0	19.0	9.9	.	.	.	.	.	.
14	380910	05AUG92	3.0	19.0	9.9	.	.	.	.	.	.
15	380910	05AUG92	4.0	19.0	9.9	1732.0	337	316	47	0.043	2.37
16	380910	05AUG92	5.0	19.0	9.8	.	.	.	.	.	.
17	380910	05AUG92	6.0	19.0	2.0	.	.	.	.	.	.
18	380910	05AUG92	7.0	17.5	1.4	1747.0	343	341	38	0.514	1.90
19	380910	16FEB93	0.0	2.0	3.0	.	.	.	.	.	.
20	380910	16FEB93	1.0	1.9	2.4	2012.0	422	515	0	1.500	3.36
21	380910	16FEB93	2.0	2.0	2.3	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	NITRATE PHOSPHATE AS P (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	DISSOLVED IRON (mg/L)	TOTAL MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.790	0.179	0.103	390	43.0	68.7	327	15.4	0.065	0.030	9.4	680	1360
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.111	0.176	0.109	401	43.8	70.8	330	16.6	0.075	0.032	8.6	713	1400
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.014	0.199	0.151	398	44.1	70.0	328	16.4	0.093	0.093	8.6	557	1250
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.000	0.211	0.110	315	35.9	54.7	267	14.3	0.082	0.014	7.9	528	1110
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.001	0.211	0.097	338	39.0	58.4	298	15.8	0.130	0.018	8.3	528	1150
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.000	0.299	0.263	344	39.4	59.7	292	14.1	0.099	0.114	8.2	534	1150
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.170	0.219	0.130	382	43.3	66.5	322	15.5	0.064	0.425	9.6	656	1370
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380910	16FEB93	3.0	2.0	2.2	1998.0	414	505	0	1.460	3.47
23	380910	16FEB93	4.0	2.0	2.0	.	.	.	.	.	.
24	380910	16FEB93	5.0	3.0	1.8	.	.	.	.	.	.
25	380910	16FEB93	6.0	3.3	0.6	1993.0	423	517	0	1.560	3.36
26	380910	16FEB93	7.0	4.0	0.3	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.170	0.709	0.142	371	42.2	64.5	319	14.8	0.063	0.417	9.6	658	1360
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.100	0.182	0.135	384	44.1	66.6	332	14.8	0.117	0.518	9.8	643	1360
26	.	.	.	.	.	.	.	.	.	.	.	.	.

Silver Lake

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381100	29JUL92	0.0	21.5	8.2	.	.	.	.	.	.
2	381100	29JUL92	0.5	21.5	8.2	1886.0	287	350	0	0.255	1.32
3	381100	29JUL92	1.0	21.5	8.0	.	.	.	.	.	.
4	381100	29JUL92	2.0	21.5	7.8	.	.	.	.	.	.
5	381100	29JUL92	3.0	21.0	3.6	1882.0	286	349	0	0.263	1.31
6	381100	02SEP92	0.0	17.0	5.5	.	.	.	.	.	.
7	381100	02SEP92	0.5	17.0	5.5	2043.0	305	372	0	0.010	0.82
8	381100	02SEP92	1.0	17.0	5.4	.	.	.	.	.	.
9	381100	02SEP92	2.0	17.0	5.0	.	.	.	.	.	.
10	381100	02SEP92	3.0	17.0	4.5	2043.0	306	351	11	0.015	1.21
11	381100	02MAR93	0.0	0.5	10.6	.	.	.	.	.	.
12	381100	02MAR93	1.0	0.8	10.4	2876.0	423	516	0	0.206	1.95
13	381100	02MAR93	2.0	1.8	10.4	2876.0	421	514	0	0.199	1.82
14	381100	02MAR93	2.7	3.2	2.3	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.067	0.368	0.323	758	119	112	155	28.3	0.201	0.246	62.0	706	1350
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.069	0.374	0.311	768	123	112	162	28.0	0.400	0.297	62.4	726	1390
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	0.000	0.221	0.161	768	123	112	171	27.6	0.116	0.092	73.5	782	1470
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.000	0.227	0.159	788	131	112	174	27.5	0.173	0.101	70.7	782	1480
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.108	0.270	0.184	1090	169	161	242	34.5	0.038	0.296	113.0	1180	2150
13	0.100	0.222	0.189	1070	166	158	232	32.5	0.038	0.295	112.0	1150	2100
14	.	.	.	.	.	.	.	.	.	.	.	.	.

Skjermo Lake

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380915	14JUL92	0.0	20.0	8.6	.	.	.	.	.	.
2	380915	14JUL92	0.5	20.0	8.6	2497.0	126	154	0	0.000	1.35
3	380915	14JUL92	1.0	20.0	8.8	.	.	.	.	.	.
4	380915	14JUL92	2.0	20.0	8.8	.	.	.	.	.	.
5	380915	14JUL92	2.5	.	.	2497.0	127	155	0	0.000	1.29
6	380915	14JUL92	3.0	18.5	8.3	.	.	.	.	.	.
7	380915	14JUL92	4.0	17.5	4.2	.	.	.	.	.	.
8	380915	14JUL92	5.0	17.0	0.8	2497.0	135	165	0	0.000	1.10
9	380915	11AUG92	0.0	20.0	7.6	.	.	.	.	.	.
10	380915	11AUG92	0.5	20.0	7.6	2567.0	119	145	0	0.034	1.42
11	380915	11AUG92	1.0	20.0	7.5	.	.	.	.	.	.
12	380915	11AUG92	2.0	20.0	7.4	.	.	.	.	.	.
13	380915	11AUG92	3.0	20.0	7.2	2567.0	120	146	0	0.053	1.55
14	380915	11AUG92	4.0	20.0	5.2	.	.	.	.	.	.
15	380915	11AUG92	5.0	19.5	5.0	2567.0	119	145	0	0.047	1.29
16	380915	24FEB93	0.0	0.2	5.3	.	.	.	.	.	.
17	380915	24FEB93	1.0	0.8	5.0	3381.0	165	201	0	0.036	2.01
18	380915	24FEB93	2.0	1.0	4.8	.	.	.	.	.	.
19	380915	24FEB93	3.0	1.1	3.8	3381.0	164	200	0	0.044	1.85
20	380915	24FEB93	4.0	1.0	2.8	3381.0	169	206	0	0.041	1.81
21	380915	24FEB93	4.5	1.1	1.6	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.031	0.026	0.032	1560	244	232.0	94.2	26.1	0.051	0.135	72.6	1260	2000
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.756	0.035	0.011	1520	239	224.0	92.3	26.3	0.028	0.127	74.1	1200	1930
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.074	0.054	0.000	1470	229	218.0	90.6	25.4	0.059	1.020	74.7	1310	2030
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.000	0.022	0.041	1510	233	226.0	94.2	26.8	0.042	0.124	75.9	1510	2240
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.000	0.015	0.032	1500	229	225.0	93.0	25.9	0.066	0.121	75.3	1260	1980
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.002	0.021	0.041	1370	208	207.0	83.8	23.8	0.100	0.255	75.6	1280	1950
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	0.261	0.047	0.028	1920	282	295.0	114.0	31.5	0.047	0.200	101.0	1980	2900
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	0.267	0.038	0.019	1740	262	264.5	106.0	29.5	0.049	0.200	101.0	1870	2730
20	0.261	0.040	0.016	1850	279	280.0	114.0	31.4	0.039	0.233	101.0	1950	2860
21	.	.	.	.	.	.	.	.	.	.	.	.	.

Smishek Lake

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380920	15JUL92	0.0	18.0	8.1	.	.	.	.	.	.
2	380920	15JUL92	0.5	18.0	8.1	1685.0	377	420	20	0.015	0.80
3	380920	15JUL92	1.0	18.0	7.9	.	.	.	.	.	.
4	380920	15JUL92	2.0	18.0	7.9	.	.	.	.	.	.
5	380920	15JUL92	3.0	18.0	7.9	.	.	.	.	.	.
6	380920	15JUL92	4.0	18.0	7.8	1682.0	377	413	23	0.009	0.87
7	380920	15JUL92	5.0	17.0	4.3	.	.	.	.	.	.
8	380920	15JUL92	6.0	16.0	1.0	.	.	.	.	.	.
9	380920	15JUL92	7.0	16.0	0.5	1688.0	381	447	9	0.277	1.18
10	380920	11AUG92	0.0	20.0	9.1	.	.	.	.	.	.
11	380920	11AUG92	0.5	20.0	9.1	1704.0	382	411	27	0.036	0.78
12	380920	11AUG92	1.0	19.5	8.9	.	.	.	.	.	.
13	380920	11AUG92	2.0	19.5	8.6	.	.	.	.	.	.
14	380920	11AUG92	3.0	19.0	8.2	.	.	.	.	.	.
15	380920	11AUG92	4.0	19.0	8.0	1694.0	382	409	28	0.037	0.95
16	380920	11AUG92	5.0	19.0	7.9	.	.	.	.	.	.
17	380920	11AUG92	6.0	18.5	7.9	.	.	.	.	.	.
18	380920	11AUG92	7.0	18.5	5.2	1694.0	378	407	27	0.039	1.17
19	380920	23FEB93	0.0	0.0	4.4	.	.	.	.	.	.
20	380920	23FEB93	1.0	0.9	3.7	2193.0	501	612	0	0.196	1.14
21	380920	23FEB93	2.0	1.4	3.6	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.006	0.038	0.000	388	32.3	74.7	244	9.9	0.025	0.048	11.2	443	1040
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.006	0.025	0.014	393	32.7	75.7	238	9.5	0.029	0.047	12.6	450	1040
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.006	0.043	0.000	403	34.8	76.8	240	9.7	0.095	0.330	11.9	452	1050
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.000	0.025	0.032	422	32.8	82.7	261	10.2	0.042	0.049	12.2	546	1170
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.001	0.000	0.069	414	32.0	81.1	260	10.1	0.054	0.060	12.2	541	1170
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.001	0.030	0.044	427	33.7	83.3	268	10.4	0.055	0.063	11.8	538	1170
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.053	0.000	0.012	510	42.5	98.1	306	11.0	0.052	0.157	14.8	721	1490
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380920	23FEB93	3.0	1.8	3.4	.	.	.	.	.	.
23	380920	23FEB93	4.0	2.0	1.5	2173.0	508	620	0	0.226	1.06
24	380920	23FEB93	5.0	2.0	0.1	.	.	.	.	.	.
25	380920	23FEB93	6.0	2.4	0.0	2142.0	527	643	0	0.333	1.08
26	380920	23FEB93	6.7	2.1	0.0	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.047	0.033	0.030	492	42.4	93.9	295	10.7	0.050	0.216	17.1	712	1480
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.033	0.026	0.020	555	55.9	101.0	323	11.6	0.151	0.411	16.6	670	1490
26	.	.	.	.	.	.	.	.	.	.	.	.	.

Sweet Briar Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380620	06JUL92	0.0	18.0	8.0	.	.	.	.	.	.
2	380620	06JUL92	0.5	18.0	8.0	874.1	311	337	21	0.177	1.60
3	380620	06JUL92	1.0	17.5	7.9	.	.	.	.	.	.
4	380620	06JUL92	2.0	17.3	7.7	.	.	.	.	.	.
5	380620	06JUL92	3.0	17.2	7.6	.	.	.	.	.	.
6	380620	06JUL92	3.5	.	.	874.1	311	335	22	0.193	1.57
7	380620	06JUL92	4.0	17.1	7.2	.	.	.	.	.	.
8	380620	06JUL92	5.0	17.0	7.2	.	.	.	.	.	.
9	380620	06JUL92	6.0	17.0	7.0	.	.	.	.	.	.
10	380620	06JUL92	7.0	17.0	6.9	871.1	311	337	21	0.219	1.60
11	380620	04AUG92	0.0	19.0	4.6	.	.	.	.	.	.
12	380620	04AUG92	0.5	19.0	4.6	869.4	319	333	28	0.613	1.93
13	380620	04AUG92	1.0	19.0	4.5	.	.	.	.	.	.
14	380620	04AUG92	2.0	19.0	4.4	.	.	.	.	.	.
15	380620	04AUG92	3.0	19.0	4.3	.	.	.	.	.	.
16	380620	04AUG92	3.5	.	.	866.4	317	328	29	0.625	1.47
17	380620	04AUG92	4.0	19.0	4.3	.	.	.	.	.	.
18	380620	04AUG92	5.0	19.0	4.2	.	.	.	.	.	.
19	380620	04AUG92	6.0	19.0	4.2	.	.	.	.	.	.
20	380620	04AUG92	7.0	19.0	2.5	866.4	317	330	28	0.540	1.75
21	380620	16FEB93	0.0	0.9	8.0	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.018	0.275	0.275	134	24.7	17.6	169	10.5	0.174	0.086	4.8	149	563
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	.	.
6	0.019	0.283	0.287	130	24.2	17.0	164	9.7	0.164	0.090	5.4	144	551
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.018	0.287	0.246	121	21.8	16.2	147	8.4	0.154	0.088	4.8	145	530
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	0.006	0.371	0.346	132	23.5	17.7	166	9.0	0.122	0.076	4.9	148	561
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.006	0.373	0.344	134	24.3	17.9	168	9.2	0.138	0.079	4.4	146	560
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.007	0.366	0.341	130	23.1	17.6	160	9.0	0.136	0.074	4.2	148	552
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380620	16FEB93	1.0	2.5	7.2	1170.0	453	547	3	0.487	1.86
23	380620	16FEB93	2.0	3.0	7.0	.	.	.	.	.	.
24	380620	16FEB93	3.0	3.1	6.0	.	.	.	.	.	.
25	380620	16FEB93	4.0	3.5	4.2	1162.0	455	547	4	0.780	1.85
26	380620	16FEB93	5.0	3.9	2.2	.	.	.	.	.	.
27	380620	16FEB93	5.5	.	.	1223.0	475	580	0	0.595	1.80
28	380620	16FEB93	6.0	4.1	1.4	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	0.231	0.154	0.150	181	33.0	23.9	213	11.8	0.066	0.084	6.3	209	769
23	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.234	0.154	0.115	162	29.6	21.5	195	10.2	0.054	0.124	6.6	210	746
26	.	.	.	.	.	.	.	.	.	.	.	.	.
27	0.142	0.147	0.171	182	33.4	24.0	228	10.4	0.920	0.479	6.4	223	811
28	.	.	.	.	.	.	.	.	.	.	.	.	.

Tolna Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380945	22JUL92	0.0	19.5	9.8	.	.	.	.	.	.
2	380945	22JUL92	0.5	19.5	9.8	653.9	286	274	37	0.000	0.90
3	380945	22JUL92	1.0	19.5	10.2	.	.	.	.	.	.
4	380945	22JUL92	2.0	19.5	10.3	.	.	.	.	.	.
5	380945	22JUL92	3.0	19.5	10.4	653.9	285	271	38	0.001	0.40
6	380945	22JUL92	4.0	19.5	6.9	.	.	.	.	.	.
7	380945	22JUL92	5.0	19.0	5.6	.	.	.	.	.	.
8	380945	22JUL92	6.0	19.0	4.8	.	.	.	.	.	.
9	380945	22JUL92	7.0	.	.	664.8	288	290	30	0.058	0.82
10	380945	19AUG92	0.0	21.5	7.0	.	.	.	.	.	.
11	380945	19AUG92	0.5	21.5	7.0	616.2	265	254	34	0.230	1.17
12	380945	19AUG92	1.0	20.5	7.0	.	.	.	.	.	.
13	380945	19AUG92	2.0	20.5	7.0	.	.	.	.	.	.
14	380945	19AUG92	3.0	20.5	6.9	.	.	.	.	.	.
15	380945	19AUG92	4.0	20.0	6.2	616.2	263	254	33	0.152	1.28
16	380945	19AUG92	5.0	20.0	6.1	.	.	.	.	.	.
17	380945	19AUG92	6.0	20.0	2.5	.	.	.	.	.	.
18	380945	19AUG92	7.0	20.0	0.5	627.3	267	259	33	0.388	1.56
19	380945	03MAR93	0.0	0.9	5.3	.	.	.	.	.	.
20	380945	03MAR93	1.0	1.8	4.7	816.0	334	408	0	0.026	1.34
21	380945	03MAR93	2.0	3.0	4.2	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE PHOSPHATE AS P (mg/L)	HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.009	0.248	0.180	286	50.9	38.5	41.1	7.9	0.036	0.475	13.3	70	394
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.009	0.242	0.187	283	49.3	38.7	40.7	8.2	0.041	0.462	13.1	77	399
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	.	.	.	.	.
9	0.027	0.290	0.219	300	53.3	40.6	42.9	8.3	0.187	0.828	14.3	74	406
10	.	.	.	.	.	.	.	.	.	.	.	.	.
11	0.020	0.216	0.203	258	40.6	38.0	40.6	8.3	0.083	0.487	13.4	74	374
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	0.020	0.215	0.194	257	40.1	38.1	39.9	8.1	0.066	0.476	13.9	72	370
16	.	.	.	.	.	.	.	.	.	.	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.027	0.378	0.322	254	40.0	37.4	39.2	8.0	0.108	1.180	13.9	68	367
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.300	0.097	0.108	344	54.7	50.3	52.6	9.0	0.033	0.802	20.3	109	497
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380945	03MAR93	3.0	3.3	4.1	.	.	.	.	.	.
23	380945	03MAR93	4.0	4.0	1.6	819.1	333	406	0	0.033	3.09
24	380945	03MAR93	5.0	4.9	0.3	.	.	.	.	.	.
25	380945	03MAR93	6.0	5.0	0.3	855.6	346	423	0	0.348	1.47
26	380945	03MAR93	6.5	5.2	0.2	.	.	.	.	.	.

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.296	0.198	0.109	334	54.5	48.1	51.3	9.1	0.027	0.838	19.7	103	486
24	.	.	.	.	.	.	.	.	.	.	.	.	.
25	0.084	0.055	0.090	339	56.2	48.3	51.8	8.8	0.082	1.790	20.1	111	505
26	.	.	.	.	.	.	.	.	.	.	.	.	.

Warsing Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	381375	22JUL92	0.0	18.5	8.4	.	.	.	.	.	.
2	381375	22JUL92	0.5	18.5	8.4	861.5	273	290	21	0.014	1.00
3	381375	22JUL92	1.0	19.0	8.2	.	.	.	.	.	.
4	381375	22JUL92	2.0	19.0	8.2	.	.	.	.	.	.
5	381375	22JUL92	3.0	18.5	7.4	858.5	273	290	21	0.018	1.26
6	381375	22JUL92	4.0	18.0	7.0	.	.	.	.	.	.
7	381375	22JUL92	5.0	18.0	6.2	.	.	.	.	.	.
8	381375	22JUL92	6.0	17.5	1.6	860.5	273	295	19	0.086	1.37
9	381375	19AUG92	0.0	21.0	11.4	.	.	.	.	.	.
10	381375	19AUG92	0.5	21.0	11.4	842.1	280	266	37	0.021	2.12
11	381375	19AUG92	1.0	21.0	9.2	.	.	.	.	.	.
12	381375	19AUG92	2.0	20.5	7.2	.	.	.	.	.	.
13	381375	19AUG92	3.0	20.0	4.7	843.2	280	279	31	0.116	1.40
14	381375	19AUG92	4.0	19.5	1.3	.	.	.	.	.	.
15	381375	19AUG92	5.0	19.0	0.6	.	.	.	.	.	.
16	381375	19AUG92	6.0	19.0	0.6	860.3	283	307	19	0.736	1.86
17	381375	10MAR93	0.0	0.3	4.2	.	.	.	.	.	.
18	381375	10MAR93	1.0	1.4	4.2	1058.0	335	409	0	0.299	1.60
19	381375	10MAR93	2.0	3.0	4.1	.	.	.	.	.	.
20	381375	10MAR93	3.0	3.3	1.8	.	.	.	.	.	.
21	381375	10MAR93	4.0	3.9	0.8	1090.0	345	421	0	0.320	1.80

OBS	NITRITE AS N (mg/L)	NITRATE PHOSPHATE AS P (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.040	0.107	0.087	272	38.4	42.7	93.9	11.6	0.040	0.197	54.4	109	514
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.010	0.132	0.172	264	37.8	41.2	89.2	12.0	0.042	0.188	53.9	110	508
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.010	0.153	0.103	265	37.6	41.6	91.0	11.6	0.044	0.269	52.0	104	502
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.000	0.181	0.115	251	35.7	39.4	89.1	12.1	0.061	0.117	58.1	117	519
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.001	0.163	0.115	248	35.7	38.6	86.2	12.2	0.052	0.148	58.0	109	508
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.000	0.311	0.287	252	36.8	38.8	85.5	11.7	0.058	0.580	57.7	105	506
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.264	0.110	0.040	278	39.9	43.3	102.0	12.3	0.068	0.574	73.3	133	605
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	.	.	.	.	.	.	.	.	.	.	.	.	.
21	0.269	0.105	0.053	288	41.6	44.8	106.0	13.2	0.072	0.609	75.8	137	626

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	381375	10MAR93	5.0	3.9	0.7	.	.	.	.	.	.
23	381375	10MAR93	5.5	4.1	0.3	1112.0	351	429	0	0.505	0.25

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.269	0.147	0.112	287	40.9	44.9	106.0	12.9	0.126	0.738	75.2	134	625

White Earth Dam

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
1	380960	15JUL92	0.0	18.5	7.5	.	.	.	.	.	.
2	380960	15JUL92	0.5	18.5	7.5	2837.0	720	747	65	0.087	2.11
3	380960	15JUL92	1.0	18.5	7.4	.	.	.	.	.	.
4	380960	15JUL92	2.0	18.5	7.2	.	.	.	.	.	.
5	380960	15JUL92	3.0	18.5	7.1	2817.0	719	733	71	0.089	1.52
6	380960	15JUL92	4.0	18.5	7.0	.	.	.	.	.	.
7	380960	15JUL92	5.0	17.0	3.2	.	.	.	.	.	.
8	380960	15JUL92	6.0	17.0	2.3	2827.0	721	734	72	0.090	1.25
9	380960	13AUG92	0.0	18.5	7.5	.	.	.	.	.	.
10	380960	13AUG92	0.5	18.5	7.5	2860.0	739	774	63	0.145	1.75
11	380960	13AUG92	1.0	18.5	7.2	.	.	.	.	.	.
12	380960	13AUG92	2.0	18.5	7.2	.	.	.	.	.	.
13	380960	13AUG92	3.0	18.5	7.0	2850.0	735	757	69	0.134	2.51
14	380960	13AUG92	4.0	18.5	5.2	.	.	.	.	.	.
15	380960	13AUG92	5.0	18.5	4.9	.	.	.	.	.	.
16	380960	13AUG92	6.0	18.5	4.8	2905.0	736	758	69	0.258	2.48
17	380960	23FEB93	0.0	0.1	3.6	.	.	.	.	.	.
18	380960	23FEB93	1.0	0.5	3.5	3685.0	982	1040	78	0.090	2.22
19	380960	23FEB93	2.0	0.9	3.4	.	.	.	.	.	.
20	380960	23FEB93	3.0	1.4	2.8	3655.0	974	1030	78	0.095	2.23
21	380960	23FEB93	4.0	1.8	2.5	.	.	.	.	.	.

OBS	NITRITE AS N (mg/L)	PHOSPHATE AS P (mg/L)	PHOSPHATE AS P (mg/L)	NITRATE HARDNESS (mg/L)	CALCIUM (mg/L)	TOTAL MAGNESIUM (mg/L)	SODIUM (mg/L)	DISSOLVED POTASSIUM (mg/L)	TOTAL IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.015	0.227	0.184	547	50.8	102	547	15.5	0.127	0.059	18.5	828	1990
3	.	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	.	.	.	.	.	.
5	0.018	0.236	0.175	548	51.3	102	534	15.4	0.132	0.065	18.3	1030	2180
6	.	.	.	.	.	.	.	.	.	.	.	.	.
7	.	.	.	.	.	.	.	.	.	.	.	.	.
8	0.019	0.230	0.172	544	49.7	102	533	15.6	0.185	0.061	19.0	842	1990
9	.	.	.	.	.	.	.	.	.	.	.	.	.
10	0.021	0.216	0.231	536	48.2	101	542	16.1	0.150	0.051	19.3	1040	2210
11	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.
13	0.030	0.222	0.227	531	47.9	100	550	17.1	0.150	0.049	19.6	917	2090
14	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.
16	0.025	0.265	0.249	544	49.8	102	522	16.0	0.562	0.080	20.6	893	2050
17	.	.	.	.	.	.	.	.	.	.	.	.	.
18	0.173	0.289	0.246	587	50.3	112	653	16.8	0.086	0.034	24.9	1190	2640
19	.	.	.	.	.	.	.	.	.	.	.	.	.
20	0.156	0.273	0.236	612	52.2	117	669	17.7	0.104	0.043	26.1	1170	2640
21	.	.	.	.	.	.	.	.	.	.	.	.	.

OBS	STORET STATION	DATE COLLECTED	DEPTH (m)	TEMPERATURE (C)	DISSOLVED OXYGEN (mg/L)	LAB CONDUCTIVITY (umhos/cm)	TOTAL ALKALINITY (mg/L)	BICARBONATE ALKALINITY (mg/L)	CARBONATE ALKALINITY (mg/L)	TOTAL AMMONIA AS N (mg/L)	TOTAL KJELDAHL NITROGEN AS N (mg/L)
22	380960	23FEB93	5.0	1.9	1.4	.	.	.	.	.	.
23	380960	23FEB93	6.0	1.9	1.3	3706.0	996	1060	77	0.255	2.34

OBS	NITRATE NITRITE AS N (mg/L)	TOTAL PHOSPHATE AS P (mg/L)	DISSOLVED PHOSPHATE AS P (mg/L)	TOTAL HARDNESS (mg/L)	CALCIUM (mg/L)	MAGNESIUM (mg/L)	SODIUM (mg/L)	POTASSIUM (mg/L)	IRON (mg/L)	MANGANESE (mg/L)	CHLORIDE (mg/L)	SULFATE (mg/L)	TDS (mg/L)
22	.	.	.	.	.	.	.	.	.	.	.	.	.
23	0.148	0.301	0.274	568	49.3	108	650	16.1	0.215	0.065	27.2	1250	2700

Appendix B

1992-1993 Macrophyte Maps

(On Request)

Appendix C

1992-1993 Phytoplankton Data

(On Request)

Appendix D

1992-1993 Sediment Contaminant Data

(On Request)

Appendix E

1992-1993 Whole Fish Contaminants Data

(On Request)