PHASE I
WATERSHED ASSESSMENT
AND TMDL
FINAL REPORT

JONES LAKE/ TURTLE CREEK, HAND COUNTY, SOUTH DAKOTA

South Dakota Watershed Protection Program
Division of Financial and Technical Assistance
South Dakota Department of Environment and Natural Resources
Steven M. Pirner, Secretary

MAY, 2002

SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM

ASSESSMENT/PLANNING PROJECT FINAL REPORT

JONES LAKE AND TURTLE CREEK WATERSHED ASSESSMENT AND TMDL FINAL REPORT

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Natural Resource Conservation Service

SD DENR – Watershed Resource Assistance Program

SD Department of Game, Fish and Parks

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Abbreviations

AFOs	Animal Feeding Operations
AGNPS	Agricultural Non-Point Source
BMPs	Best Management Practices
CPUE	Catch per Unit Effort
CV	Coefficient of Variance
DC	District Conservationist
DO	Dissolved Oxygen
GPS	Global Positioning System
GLS	Great Little Sampler
IJC	International Joint Commission
NPS	Nonpoint Source
NRCS	Natural Resource Conservation Service
NTU	Nephelometric Turbidity Units
Q WTD C	Flow Weighted Concentration
SD DENR	South Dakota Department of Environment and Natural Resources
SD GF&P	South Dakota Department of Game, Fish & Parks
SU	Standard Units
TKN	Total Kjeldahl Nitrogen
TSI	Trophic State Index
µmhos/cm	micromhos/centimeter
USGS	United States Geologic Survey

Executive Summary

PROJECT TITLE: Jones Lake/ Turtle Creek Watershed Assessment

PROJECT START DATE: 6/1/00 PROJECT COMPLETION DATE: 6/1/01

FUNDING: TOTAL BUDGET: $124,916

TOTAL EPA GRANT:	$74,370
TOTAL EXPENDITURES OF EPA FUNDS:	$58,075.50
TOTAL SECTION 319 MATCH ACCRUED:	$47,913.52
BUDGET REVISIONS:	None
TOTAL EXPENDITURES:	$105,989.02

SUMMARY ACCOMPLISHMENTS

The Jones Lake and Turtle Creek assessment project began in June of 2000 and lasted through October of 2001 when data analysis and compilation into a final report was completed. The project met all of its milestones in a timely manner.

An EPA section 319 grant provided a majority of the funding for this project. The South Dakota State Fee Funds, Central Plains Water Development District, and Hand County Conservation District provided local matching funds for the project.

Water quality monitoring and watershed modeling resulted in the identification of several sources of impairment. These sources may be addressed through Best Management Practices and the implementation of several nutrient management plans. Aquatic plant, algae, and sediment surveys were also completed for the lake.

The primary goal for the project was to determine sources of impairment to Jones Lake and provide sufficient background data to drive a section 319 implementation project. Through identification of sources of impairment in the watershed, this goal was accomplished.

Through the implementation of two animal nutrient management systems and buffer strips in targeted areas, reductions in nutrient loads of 2-3% will be achieved. Additional reductions will result through the exclusion of livestock from the lake shore.

Introduction

Purpose

The purpose of this pre-implementation assessment is to determine the sources of impairment to Jones Lake in Hand County, South Dakota, and the tributaries in its watershed resulting in a Total Maximum Daily Load (TMDL). The creeks and small tributaries are streams with loadings of sediment and nutrients related to snowmelt and spring rain events. The discharge from this watershed ultimately reaches the James River.

Turtle Creek is the primary tributary to Jones Lake and drains a mix of grazing lands with some cropland acres. Winter feeding areas for livestock are present in the watershed. The stream carries sediment and nutrient loads that degrade water quality in the lake and cause increased eutrophication.

General Lake Description

Jones Lake is a 100.5 acre (40.7 ha) man-made impoundment located in central Hand County, South Dakota. Damming Turtle Creek 3 miles south of the town of St. Lawrence created a lake, with an average depth of 7.5 feet (2.3 meters) and 2.1 miles (3.4 km) of shoreline. The lake has a maximum depth of 16 feet (4.9 m) and holds 752 acre-feet of water. Jones Lake is subject to periods of stratification during the summer. The outlet for the lake empties into Turtle Creek, which eventually reaches the James River south of the town of Redfield in Spink County, South Dakota. The Jones Lake watershed comprises a small portion of the Turtle Creek hydrologic unit, which has a priority rank of 18 in the South Dakota Unified Watershed Assessment. Figure 1 shows the location of Jones Lake in South Dakota and identifies the public lands located around the lake.

Lake Identification and Location

Lake Name: Jones Lake	State: South Dakota
County: Hand	Township: 112N
Range: 68W	Sections: 25 and 36
Nearest Municipality: Miller	Latitude: 44.470240
Longitude: -98.946847	EPA Region: VIII
Primary Tributary: Turtle Creek	Receiving Body of Water: Turtle Creek
HUC Code: 10160009	HUC Name: Turtle

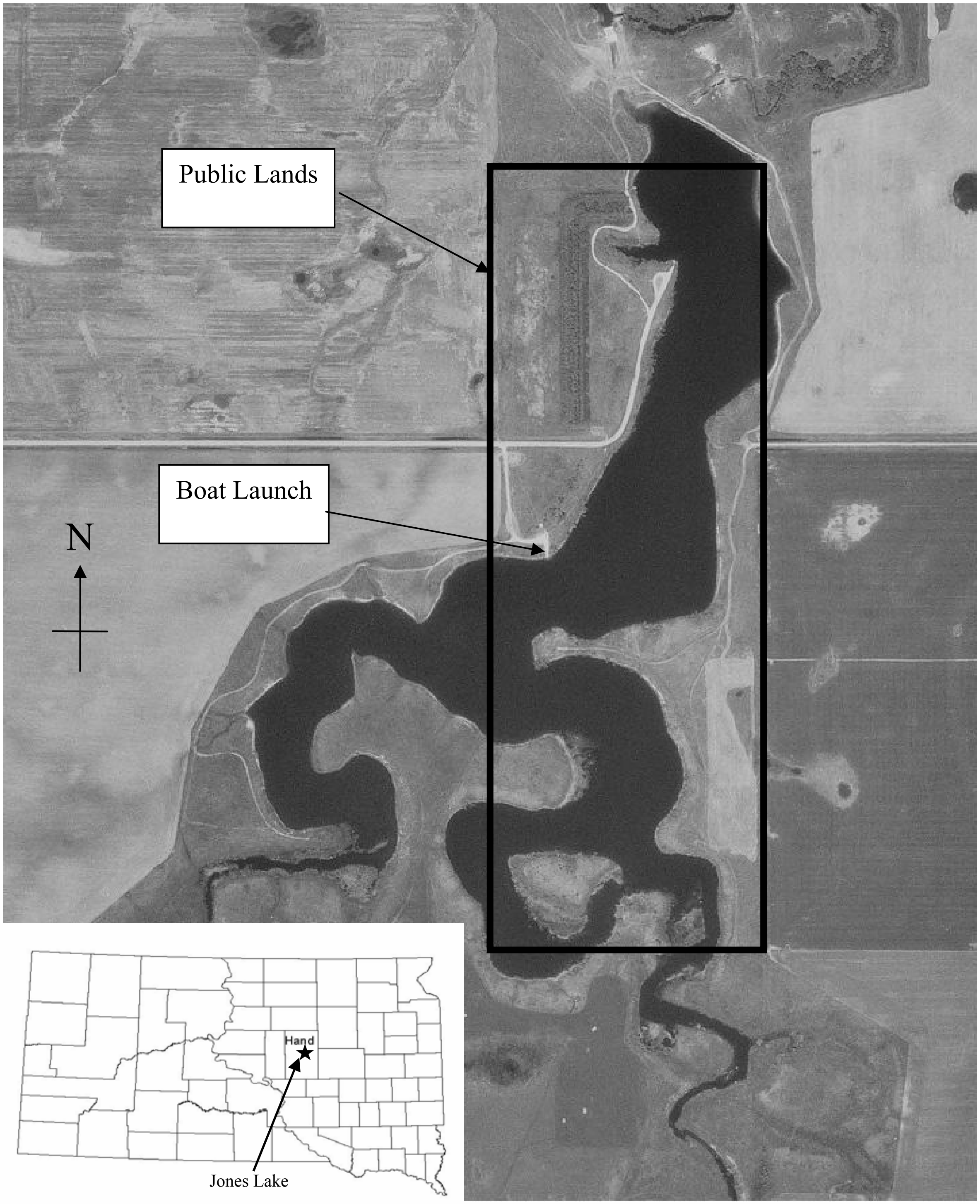


Figure 1. Jones Lake, Hand County South Dakota

Trophic Status Comparison

The trophic state of a lake is a numerical value that ranks its relative productivity. Developed by Carlson (1977), the Trophic State Index, or TSI, allows a lake's productivity to be easily quantified and compared to other lakes. Higher TSI values correlate with higher levels of primary productivity. A comparison of Jones Lake to other reservoirs in the Northern Glaciated Plains Ecoregion (Table 1) shows a wide range of productivity's in the ecoregion. Jones Lake has a typical mean TSI value for its ecoregion. The values provided in Table 1 were generated from the most recent statewide lake assessment final report (Stueven and Stewart, 1996). The TSI for Jones Lake will vary slightly in this report due to the use of additional new data gathered during this assessment.

Table 1. TSI Comparison to other Lakes in the Northen Plains Glaciated Ecoregion

Lake	County	TSI	Mean Trophic State
Mitchell (Davison)	Davison	61.34	Eutrophic
Hanson	Hanson	63.92	Eutrophic
Elm	Brown	69.84	Hyper-eutrophic
Richmond	Mcpherson	66.86	Hyper-eutrophic
Amsden		66.24	Hyper-eutrophic
Jones	**Hand**	**64.45**	**Eutrophic**
Faulkton	Faulk	70.63	Hyper-eutrophic
Mina	Edmunds	71.91	Hyper-eutrophic
Cresbard	Edmunds	70.06	Hyper-eutrophic
Louise	Hand	70.57	Hyper-eutrophic
Redfield	Spink	77.02	Hyper-eutrophic

Beneficial Uses

The State of South Dakota has assigned all of the water bodies that lie within its borders a set of beneficial uses. Along with these assigned uses are sets of standards for the chemical properties of the lake. These standards must be maintained for the lake to fully support its assigned beneficial uses. All bodies of water in the state receive the beneficial uses of fish and wildlife propagation, recreation, and stock watering. The following list of beneficial uses are assigned to Jones Lake.

(5) Warmwater semipermanent fish life propagation
(7) Immersion recreation
(8) Limited contact recreation
(9) Fish and wildlife propagation, recreation, and stock watering

Individual parameters as well as the lake's TSI value determine the support of these beneficial uses. Jones Lake is identified in *Ecoregion Targeting for Impaired Lakes in South Dakota* (Stueven et al, 2000) as not supporting its beneficial uses.

Recreational Use

The South Dakota Department of Game, Fish, and Parks provides a list of existing public facilities that are maintained at area lakes (Table 2). Jones Lake Recreation Area is located on the north side of the lake and has a number of facilities, primitive toilet facilities, a boat ramp, and access to shore fishing.

Table 2. Comparison of Recreational Uses and Facilities for Area Lakes

Lake	Parks	Ramps	Boating	Camping	Fishing	Picnicking	Swimming	County
Bierman Gravel Pit					X			Spink
Rosette		1	X		X			Edmunds
Cottonwood		2	X		X		X	Spink
Lake Louise	1	1	X	X	X	X	X	Hand
Jones Lake		**1**	**X**		**X**	**X**	**X**	**Hand**
Rose Hill		1	X	X	X	X	X	Hand
Faulkton	1	1	X	X	X	X	X	Faulk

Geology and Soils

Jones Lake and its primary tributary, Turtle Creek, are located on the edge of the Coteau du Missouri division of the Great Plains Physiographic Province. The outlet to the lake discharges into the James Basin division of the Central Lowland Physiographic Province (Fenneman, 1931). Located east of the Missouri River, the Jones Lake watershed was subject to several periods of glaciation, which formed the parent material of the present day soils. The Mankato Period of glaciation was the last to affect the area and had the greatest impact on the current soils. The landscape of the watershed is level to slightly rolling. This is due in part to the past activity of the glaciers as well as ongoing water erosion.

The climate in Hand County is continental with dry winters and wet springs. The weather is subject to frequent and extreme changes with fronts dropping temperatures by as much as 40 to 50 degrees in 24 hours. Annual precipitation can be expected to yield 18 inches of which 75 percent can be expected to fall in the months of April through September.

Four primary soil associations best characterize the watershed. The dominant association is the Raber-Eakin association. It is most commonly characterized by undulating and nearly level clay loam soils from loess and clayey till. The second most common association is the Houdek-Bonilla association. It is most commonly characterized by nearly level to gently undulating loamy soils from glacial till. The final two associations are comprised of the Williams-Cavour-Miranda association and the Williams-Bonilla association. They are characterized by nearly level to gently undulating loamy soils from clayey till (with some soils containing claypans) and nearly level to gently undulating soils from loam or coarse clay loam till, respectively.

History

The area around Jones Lake and Turtle Creek has a diverse history. A few of the more outstanding events in the history of the area are covered here.

Hand County was founded in 1873 and named for politician George H. Hand. The boundaries were established in 1879 and it was opened for settlement in 1881. The town of Miller is the county seat and largest municipality located at the junction of highways 45 and 14.

The Jones Dam and spillway was constructed in the 1930s as a result of President Roosevelt's Emergency Re-Employment Campaign during the depression era. This got the Civilian Conservation Corps (CCC) and Works Program Administration (WPA) operating in Hand County undertaking projects like the construction of Jones Dam and Spillway. The lake was named for Evan Allen Jones, who resided near the location of the lake.

Project Goals, Objectives, and Activities

Planned and Actual Milestones, Products, and Completion Dates

Objective 1. Lake Sampling

Sampling of Jones Lake was to begin in May 2000, however, the first samples were not collected until June 2000, when a boat became available. Sampling of nutrient and solids parameters continued at the three scheduled sites through November 2000 as planned. Sufficient ice cover for foot travel lasted from late November 2000 through late March 2001, during which samples were collected through the ice. Spring samples were collected from March through May of 2000.

Objective 2. Tributary Sampling

At the onset of the project, the local coordinator and DENR staff installed Stevens Type F Stage Recorders as well as ISCO Flowmeters at pre-selected monitoring sites along the tributaries of Turtle Creek. This equipment was used to obtain a detailed picture of the daily discharge of nutrients and sediments from the watershed into Jones Lake. Sampling Turtle Creek was limited primarily to the months of April through May of 2001. Very mild and dry conditions during the winter of 1999/2000 resulted in little or no runoff in the watershed until the spring of 2001.

Objective 3. Quality Assurance/ Quality Control (QA/QC)

Duplicate and blank samples were collected during the course of the project to provide defendable proof that sample data were collected in a scientific and reproducible manner. QA/QC data collection began, and was completed, on schedule with the proposed timeline.

Objective 4. Watershed Modeling

Collection of the data required for completion of the Agricultural Non-Point Source (AGNPS) model was finished on schedule during the project. The local coordinator utilized public records as well as personal contact with landowners and operators in the watershed to gather the required data.

Objective 5. Public Participation

All of the landowners were contacted individually to assess the condition of animal feeding operations and land management practices located within the watershed. Responses to letters, phone calls, and personal contact were excellent with all of the landowners cooperating to provide needed information. Further information was provided to the community and stakeholders in the project at the Hand County

Conservation District and Central Plains Water Development District public board meetings.

Objective 6. Sediment Survey

The sediment survey of Jones Lake was completed during March of 2001. The most notable find during the sediment survey was the discovery that the lake was experiencing a major winterkill as a result of the heavy snow conditions.

Objectives 7 and 8. Restoration Alternatives and Final Report

Completion of the restoration alternatives and final report for Jones Lake and Turtle Creek in Hand County were completed during December 2001 through March of 2002. This delay was due to the completion of the Rose Hill Lake TMDL that was funded through the same grant.

Evaluation of Goal Achievements

The goal of the watershed assessment completed on Jones Lake was to determine and document sources of impairment to the lake and to develop feasible alternatives for restoration. This was accomplished through the collection of tributary and lake data and aided by the completion of the AGNPS watershed modeling tool. Through data analysis and modeling, identification of impairment sources was possible. The identification of these impairment sources will aid the state's nonpoint source (NPS) program by allowing strategic targeting of resources to portions of the watershed that will provide the greatest benefit per expenditure.

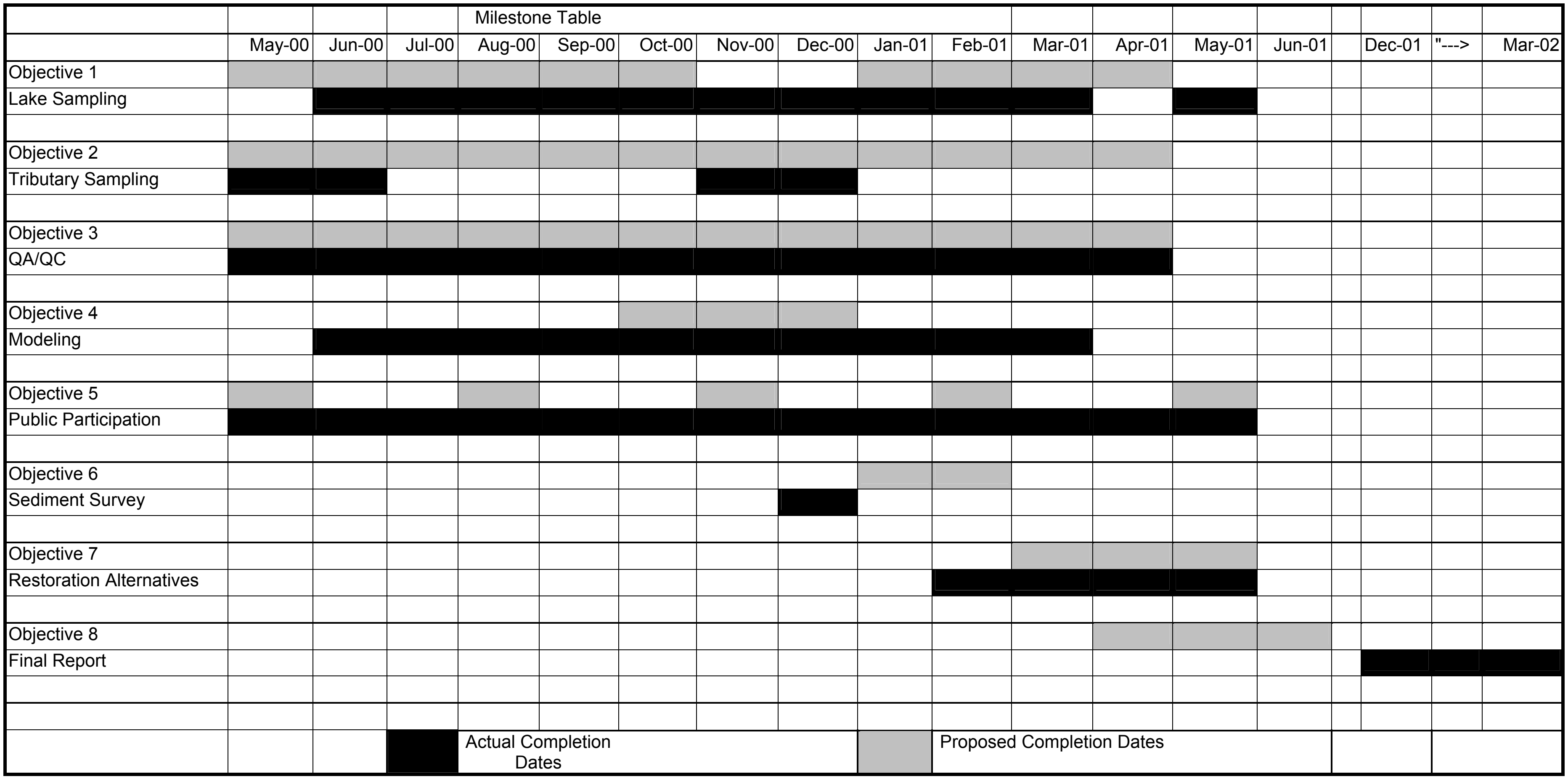


Table 3. Proposed and Actual Objective Completion Dates

Monitoring Results

Surface Water Chemistry (Turtle Creek)

Flow Calculations

A total of six (five tributary and one outlet) monitoring sites were selected along Turtle Creek, which is the primary tributary to Jones Lake. The sites were selected to determine which portions of the watershed were contributing the greatest amount of nutrient and sediment load to the lake. Three of the sites were equipped with Stevens Type F stage recorders. The remaining three sites were equipped with ISCO model 4230 Flow meters attached to a GLS auto-sampling unit. Water stages were monitored and recorded to the nearest $1/100^{th}$ of a foot for each of the six sites. A March-McBirney Model 210D flow meter was used to determine flows at various stages. The stages and flows were then used to create a stage/discharge table for each site. Stage-to-discharge tables may be found in Appendix A.

Load Calculations

Total nutrient and sediment loads were calculated with the use of the Army Corps of Engineers eutrophication model known as FLUX. FLUX uses individual sample data in correlation with daily average discharges to develop six loading calculations for each parameter. As recommended in the application sequence, a stratification scheme and method of calculation was determined using the total phosphorus load. This stratification scheme is then used for each of the additional parameters. Sample data collected on Turtle Creek may be found in Appendix B.

Tributary Sampling Schedule

Samples were collected at the sites during the spring of 2000 through the spring of 2001. Most samples were collected using a suspended sediment sampler. The sites that were equipped with GLS auto-sampling units sampled on their own and were usually collected within a few hours of the sample time. Water samples were then filtered, preserved, and packed in ice for shipping to the State Health Lab in Pierre, SD. The laboratory then assessed the following parameters:

Fecal Coliform Counts
Total Solids
Total Suspended Solids
Nitrate
Total Phosphorus
Total Dissolved Phosphorus
E. coli Bacteria Counts
Alkalinity
Total Dissolved Solids
Ammonia
Total Kjeldahl Nitrogen (TKN)
Volatile Total Suspended Solids
Un-ionized Ammonia

Personnel conducting the sampling at each of the sites recorded visual observations of weather and stream characteristics.

Precipitation	Wind
Odor	Septic Conditions
Dead Fish	Film
Turbidity	Width
Water Depth	Ice Cover
Water Color	

Parameters measured in the field by sampling personnel were:

Water Temperature	Air Temperature
Conductivity	Dissolved Oxygen
Field pH	

South Dakota Water Quality Standards

The State of South Dakota assigns at least two of the eleven beneficial uses to all bodies of water in the state. Fish and wildlife propagation, recreation and stock watering as well as irrigation are assigned to all streams and rivers. All portions of Turtle Creek located within the Jones Lake watershed must maintain the criteria that support these uses. In order for the creek to maintain these uses, there are seven standards that must be maintained, these standards, as well as the water quality values that must be met, are listed in Table 4.

Table 4. State Water Quality Standards

Nitrate	≤50 (mean) ≤88 (single sample)
Alkalinity	≤750 (mean) ≤1,313 (single sample)
pH	≥ 6.0 and ≤9.5 su
Total Dissolved Solids	≤2,500 mg/L for a 30-day geometric mean ≤ 4,375 mg/L daily maximum for a drab sample
Conductivity	≤2,500µmhos (mean) ≤4,375µmhos (single sample)
Total Petroleum Hydrocarbon Oil and Grease	≤10 mg/L ≤10 mg/L
Sodium Adsorption Ratio	≤10

Watershed Overview

Discharge from Turtle Creek as well as rainfall are the primary sources of water entering Jones Lake. The amount of ground water entering the lake is unknown. Very little change was observed in the lake chemistry over the course of the year 2000 sampling season. The 2000 sampling season was extremely dry with no discharges from Turtle Creek and very little rainfall entering the lake during sampling periods, which would indicate that any ground water entering the lake is having a minimal impact on the water quality.

Subwatersheds

Turtle Creek drainage was divided into six individual subwatersheds with a gauging station located at the outlet to each one. Stage and discharge data were collected from each subwatershed as well as water chemistry samples, which were combined to calculate a load from each of these subwatersheds. Site JLT-3 was removed part way through the project due to road construction activities. One sample was collected in the spring of 2001, further sampling activities were terminated at site JLT-3 due to the lack of gauging equipment which would result in the inability to calculate accurate loadings.

Figure 2 depicts the drainage pattern for the gauging stations. Discharge from site JLT-3 drains through site JLT-5. Discharge from sites JLT-2 and JLT-6 both drain through site JLT-4. The locations of the gauging stations within the watershed may be found in Figure 3.

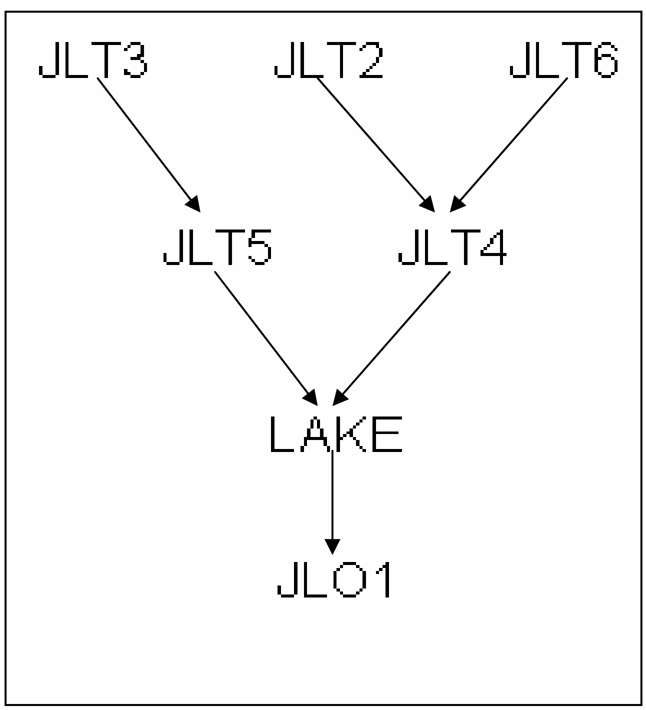


Figure 2. Turtle Creek Drainage Pattern

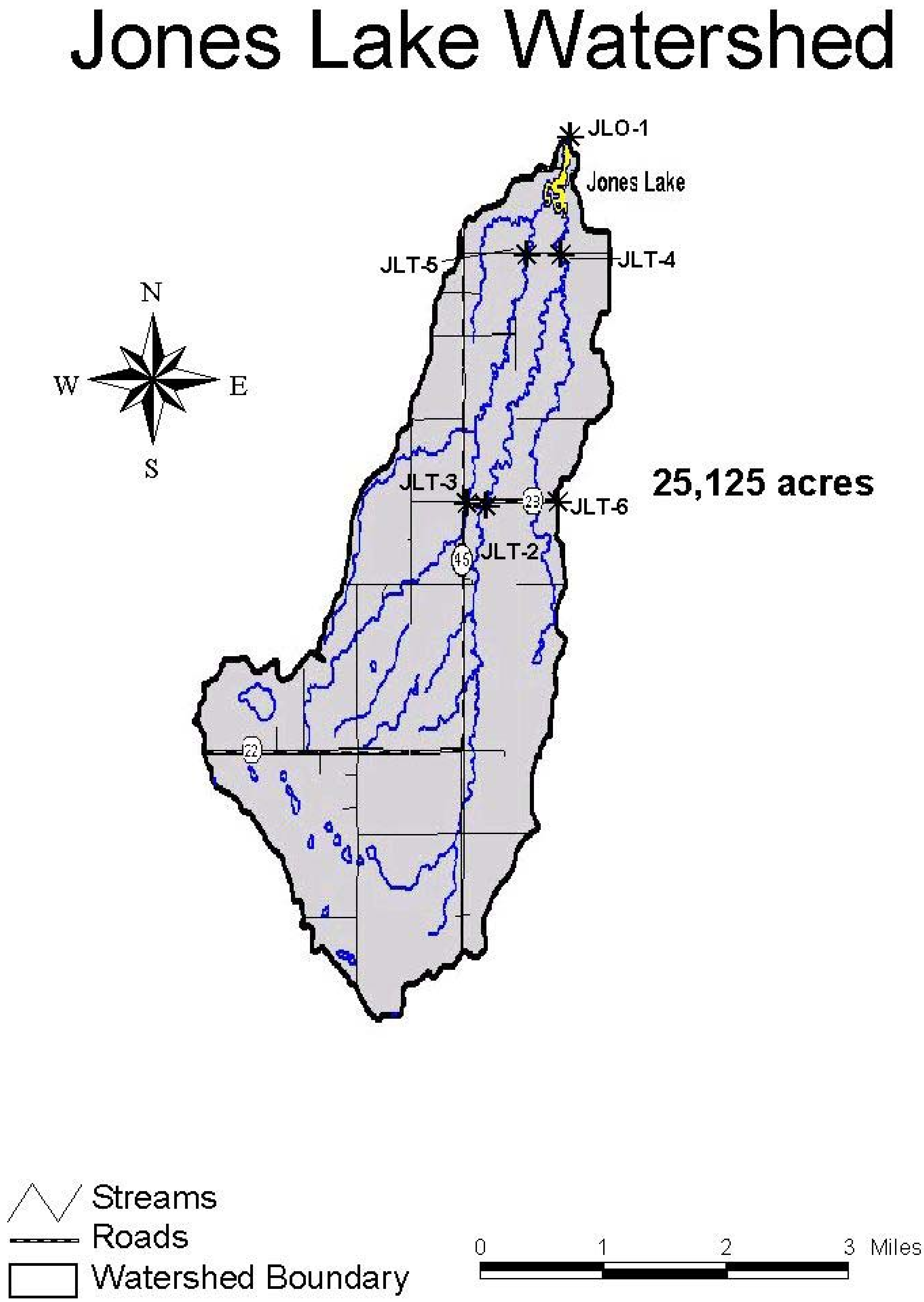


Figure 3. Turtle Creek Monitoring Stations

Water and Nutrient Budgets

As rivers and streams pass through impoundments they often lose some nutrient and sediment load. Table 5 indicates that Jones Lake traps a large volume of nutrients and sediment.

Part of the reason for the large decrease in the amount of nutrients and sediment between the two inlets and the outlet may be attributed to the low water conditions experienced by the lake prior to any of the measured inflows. The lake level was recorded at .91 m below the spillway on September 18, 2000. The level continued to fall to .97m on September, 26, 2000, the last recorded lake level for the year. The level most likely continued to drop throughout the fall prior to the winter freeze.

At the start of spring discharge in 2001, water began flowing in the tributaries above the lake, but the lake did not discharge until the water level had risen above the spillway. Termination of tributary and lake monitoring occurred shortly after spring runoff had come to an end and the tributaries to the lake had stopped flowing, but while some discharge from the lake was still occurring.

The combination of these two events accounts for some, but not all, of the load reductions which occurred in Turtle Creek as it passed through Jones Lake. The remaining reductions occurred as a result of the lake acting as a nutrient sink, collecting sediment and attached nutrients from the water that enters into it.

Table 5. Water and Nutrient Budgets for Jones Lake

		JLT 4	JLT5	JLO1	
	Units	Inlet	Inlet	Outlet	Difference
Total Phosphorus	Kg	2197	6272	4586	-3883
Total Dissolved Phosphorus	Kg	1558	5405	3566	-3397
Total Alkalinity	Tons	531	1508	965	-1074
Total Suspended Solids	Tons	159	2333	202	-2290
Total Nitrogen	Kg	8732	27471	23142	-13061
Water	HM3/yr	5.364	11.735	11.206	-6

Seasonal Loading

Seasonal loadings to Jones Lake are heavily influenced by snowmelt and spring rainstorm events. Table 6 depicts the percentage of discharge occurring in the watershed that entered the lake. The spring months of March, April, and May accounted for over 99% of the loading that occurred to the lake during the project. Runoff events that occur during the remainder of the year have a minimal impact on the water quality of Jones Lake. All BMPs implemented within the watershed should be designed with maximum protection to the lake provided during the spring.

Table 6. Monthly and Seasonal Loading for Jones Lake

Date	Days	Monthly Percent of Total Discharge	Seasonal Percent of Total Discharge
June	30	0.00%	0.05%
July	31	0.02%	
August	31	0.03%	
September	30	0.03%	0.08%
October	31	0.03%	
November	30	0.02%	
December	31	0.00%	0.00%
January	31	0.00%	
February	28	0.00%	
March	31	0.00%	99.87%
April	30	72.55%	
May	30	27.32%	

Annual Loading

To calculate the current and future water quality in an impoundment, BATHTUB (Army Corps of Engineers eutrophication model) utilizes phosphorus and nitrogen loads entering the impoundment. Located in Table 7, these loads and their standard errors (CV) are calculated through the use of FLUX (Army Corps of Engineers loading model) for the two primary inlets to the lake.

Table 7. Annual Loading to Jones Lake from its Two Primary Tributaries

	JLT 4			JLT5		
	Concentration (mg/L)	FLUX Load (kg/yr)	CV	Concentration (mg/L)	FLUX Load (kg/yr)	CV
Total Phosphorus	0.409	2197	0.049	0.534	6272	0.059
Total Dissolved Phosphorus	0.29	1558	0.064	0.46	5405	0.074
Total Alkalinity	89.76	481505	0.065	116.56	1367969	0.16
Total Suspended Solids	26.9	144579	0.578	180.32	2116116	0.949
Total Nitrogen	1.627	8732	0.13	2.34	27471	0.112
Area Drained (km^2)	58.4			24.4		
Annual Discharge (hm^3)	5.463			4.906		
Discharge Coeff.	0.0935			0.2011		

Fecal Coliform Bacteria

Fecal coliform bacteria are found in the waste of warm-blooded animals. Some common types of bacteria are *E. coli*, S*almonella,* and *Streptococcus,* which are associated with livestock, wildlife, and human waste (Novotny, 1994). Most of our samples indicated the presence of *E. coli* at levels higher than the total fecal coliform count (Table 8). This is the result of standard lab testing procedures. Fecal coliform tests are conducted with an incubation temperature of 45°C while *E. coli* tests are conducted with an incubation temperature of 35°C. The higher incubation temperatures for the fecal test inhibit the growth of some *E. coli,* resulting in the lower counts for total fecal coliform.

Fecal coliform standards are not a concern for the listed beneficial uses of those portions of Turtle Creek located upstream of Jones Lake. While no impairment for fecal coliforms or *E. coli* may be documented for the tributarties in the watershed, it is important to note that there were elevated counts throughout the watershed.

Table 8. Bacterial Counts for Turtle Creek

DATE	Data	SITE					
		JLO-1	JLT-2	JLT-3	JLT-4	JLT-5	JLT-6
4/2/01	Fecal Coliform		5				
	E COLI		33				
4/3/01	Fecal Coliform			5			50
	E COLI			15			36
4/5/01	Fecal Coliform				5		
	E COLI				11		
4/10/01	Fecal Coliform	100	90		5	700	5
	E COLI	236	126		26	1120	7
4/16/01	Fecal Coliform	30			5		5
	E COLI	73			29		1
4/19/01	Fecal Coliform	20	10		10	5	
	E COLI	23	36		13	25	
4/24/01	Fecal Coliform				220	350	
	E COLI				147	365	
4/25/01	Fecal Coliform	5			200		
	E COLI	1			308		
4/30/01	Fecal Coliform		440				30
	E COLI		866				25
5/8/01	Fecal Coliform		2100		900		5
	E COLI		1990		1120		15
5/15/01	Fecal Coliform	5	315				
	E COLI	33	269				
5/17/01	Fecal Coliform				95	40	
	E COLI				129	37	
Total Average of Fecal Coliform		28	468	5	171	227	19
Total Average of *E COLI*		67	513	15	212	317	17

Alkalinity

Historically, the term alkalinity referred to the buffering capacity of the carbonate system in water. Today, alkalinity is used interchangeably with acid neutralizing capacity (ANC), which refers to the capacity to neutralize strong acids such as HCL, H_2SO_4 and HNO_3. Alkalinity in water is due to any dissolved species (usually weak acid anions) with the ability to accept and neutralize protons (Wetzel, 2000). Due to the abundance of carbon dioxide (CO_2) and carbonates, most freshwater contains bicarbonates as its primary source of alkalinity. Alkalinity is commonly found in concentrations as high as 200 mg/L.

Alkalinity standards for all of Turtle Creek located upstream from Jones Lake are a maximum of 1,313 mg/L for any single sample and 750 mg/L for a mean. The highest recorded value during the project occurred at site JLT-5 on May 17, 2001 at a concentration of 211 mg/L, well within the standards for the tributary.

Table 9 lists all of the samples collected in Turtle Creek during the project. The site mean values are the average concentration for each site over the project period. It appears that as the stream gets closer to Jones Lake, the alkalinity concentration increases. The outlet site (JLO-1) has a lower mean concentration than the inlets (JLT-4 and JLT-5). This would suggest that the lake is acting as a sink, collecting carbonates in its sediments and plant life. The loading estimates discussed earlier reinforce this theory.

Table 9. Turtle Creek Alkalinity Concentrations in mg/L

Alkalinity (mg/L) DATE	SITE JLO-1	JLT-2	JLT-3	JLT-4	JLT-5	JLT-6
04/02/01		36				
04/03/01			45			62
04/05/01				65		
04/10/01	42	39		53	66	28
04/11/01					103	32
04/16/01	92			88		47
04/19/01	90	88		115	110	
04/21/01		88				
04/24/01				105	125	
04/25/01	89			87		
04/30/01		82				68
05/08/01		89		96		56
05/15/01	103	167				
05/17/01				198	211	
Site Mean	83	84	45	101	123	49

Nitrate/Nitrite

As a standard testing procedure, nitrates and nitrites are measured and recorded together. This form of nitrogen is inorganic and readily available for plant use. The water quality standards for wildlife propagation, recreation, and stock watering require that nitrate concentrations remain below 50mg/L mean over any 30 day period of time and 88 mg/L for any single sample.

Table 10 depicts all of the nitrate samples collected from Turtle Creek during the project as well as the mean concentrations measured at each site. The highest level was recorded at site JLT-4 on May 17, 2001 with a concentration of 1.8 mg/L, well within the state standards. Nitrate concentrations did not exceed the state standards during the project. Site JLT-5 would appear to be producing slightly larger concentrations than the other sites indicating some possible impairments in this portion of the watershed.

Table 10. Nitrate Sample Concentrations Collected from Turtle Creek

	Nitrate Concentrations in mg/L for Turtle Creek Tributary Samples					
DATE	JLO-1	JLT-2	JLT-3	JLT-4	JLT-5	JLT-6
4/2/01		0.60				
4/3/01			0.60			0.20
4/5/01				0.80		
4/10/01	0.90	0.90		0.90	1.30	1.10
4/11/01						
4/16/01	0.70			0.90		0.10
4/19/01	0.70	0.70		0.90	0.90	
4/21/01						
4/24/01				0.30	1.20	
4/25/01	0.60			0.30		
4/30/01		0.20				0.05
5/8/01		0.20		0.10		0.05
5/15/01	0.05	0.30				
5/17/01				1.80	0.10	
Site Mean	0.59	0.48	0.60	0.75	0.88	0.30

pH

pH is a measure of free hydrogen ions (H^+) or potential hydrogen. More simply it indicates the balance between acids and bases in water. It is measured on a logarithmic scale between 0 and 14 and is recorded as standard units (su). At neutral (pH of 7) acid ions (H^+) equal the base ions (OH^-). Values less than 7 are considered acidic (more H^+ ions) and greater than 7 are basic (more OH^- ions).

The state water quality standards for pH in Turtle Creek require that pH values remain in a range from 6.0 su to 9.5 su. Samples collected during the project indicate that the pH levels remained well within the standards for all of the sites in the watershed. The data shown in Table 11 represents all of the samples collected in Turtle Creek during the project. The site mean values are the average pH for each site. The maximum recorded value was 8.74 su found at the outlet site, JLO-1 on May 15, 2001. The lowest value was recorded on April 30, 2001 at site JLT-6 with a value of 6.85 su.

Table 11. pH Levels Collected in Turtle Creek

	pH Values Measured on Turtle Creek					
DATE	JLO-1	JLT-2	JLT-3	JLT-4	JLT-5	JLT-6
4/2/01						
4/3/01			8.15			8.26
4/5/01						
4/10/01		7.84		8.23	8.7	7.56
4/11/01						
4/16/01	8.63			8.25		8.01
4/19/01		8.73				
4/21/01						
4/24/01						
4/25/01	8.57			8.21		
4/30/01		7.16				6.85
5/8/01		7.48		7.87		7
5/15/01	8.74	7.89				
5/17/01				8.14	7.4	
Site Mean	8.65	7.82	8.15	8.14	8.05	7.54

Solids

Total solids are the sum of all dissolved and suspended as well as all organic and inorganic materials. Dissolved solids are typically found at higher concentrations in ground water, and typically constitute the majority of the total solids concentration.

The state standard for dissolved solids is a mean of 2,500 mg/L or a single-sample maximum of 4,375 mg/L. The state standards for suspended solids do not apply to the monitored portions of Turtle Creek as they are not listed as a warm or cold water fishery. Table 12 lists each of the samples collected from Turtle Creek as well as the mean concentration for each site. The state standards for dissolved solids were not exceeded during the course of the project.

Table 12. Mean Solids Concentrations for Turtle Creek Watershed Sites

DATE	Data	JLO-1	JLT-2	JLT-3	JLT-4	JLT-5	JLT-6
2-Apr-01	Total Dissolved		163				
	Total Suspended		79				
3-Apr-01	Total Dissolved			188			129
	Total Suspended			3			12
5-Apr-01	Total Dissolved				270		
	Total Suspended				12		
10-Apr-01	Total Dissolved	158	161		215	261	130
	Total Suspended	24	7		14	16	2
11-Apr-01	Total Dissolved					91	163
	Total Suspended					520	15
16-Apr-01	Total Dissolved	304			359		224
	Total Suspended	13			6		2
19-Apr-01	Total Dissolved	305	401		472	454	
	Total Suspended	26	2		3	6	
21-Apr-01	Total Dissolved		364				
	Total Suspended		9				
24-Apr-01	Total Dissolved				449	534	
	Total Suspended				9	10	
25-Apr-01	Total Dissolved	308			350		
	Total Suspended	14			43		
30-Apr-01	Total Dissolved		295				236.5
	Total Suspended		2				0.5
8-May-01	Total Dissolved		237		311		322
	Total Suspended		5		4		2
15-May-01	Total Dissolved	328	647				
	Total Suspended	12	2				
17-May-01	Total Dissolved				649	728	
	Total Suspended				5	6	
Total Average of TDS		280.6	324.0	188.0	384.4	413.6	200.8
Total Average of TSS		17.8	15.1	3.0	12.0	111.6	5.6

The suspended solids load to Jones Lake (calculated in FLUX) is 2,492 tons of sediment on an annual basis. Of this, only 202 tons were measured discharging from the lake. This difference indicates that there is an annual accumulation of 2,290 tons in the lake. Site JLT-5 had the highest suspended solids concentrations and accounts for the majority of the load to the lake, as shown in the annual loading data section. Using an estimate of 1 ton per cubic yard of soil, this would account for accumulations of .17 inches on an annual basis or 1 foot every 70 years.

Conductivity

The conductivity in Turtle Creek is closely related to the total dissolved solids concentrations. Figure 4 depicts the correlation between the two. Conductivity's in the stream ranged from a low of 55 µmhos / cm on April 3, 2001 at site JLT-6 to a high of 892 µmhos/ cm on May 17, 2001 at site JLT-5. The mean concentration for all of the sites was approximately 430 µmhos / cm. These values reflect complete compliance with state standards for the beneficial use of irrigation waters.

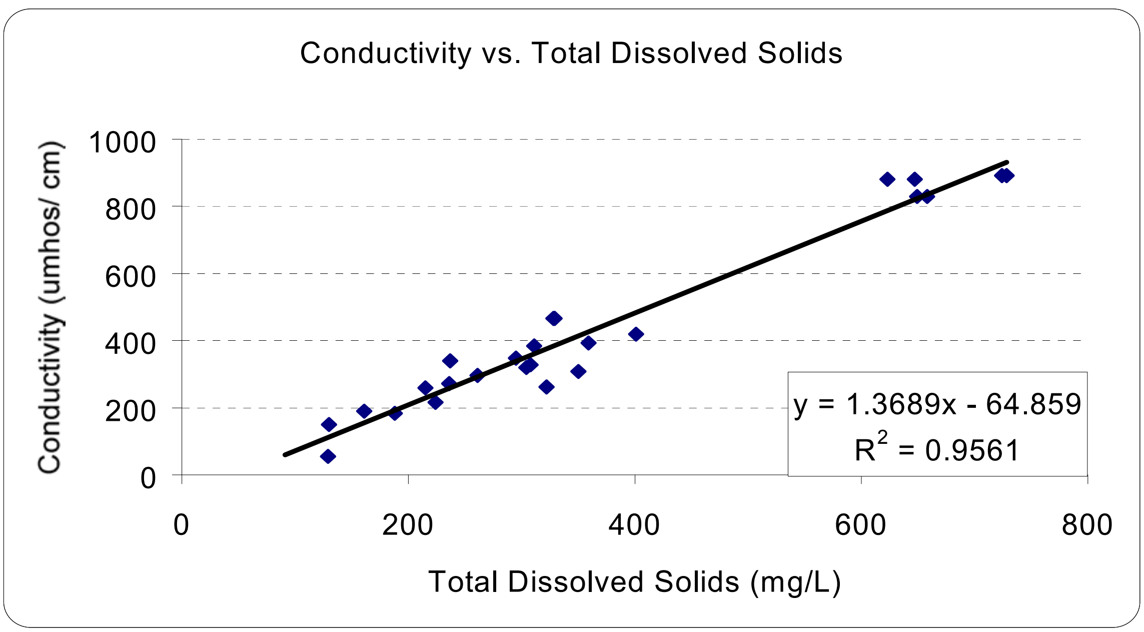


Figure 4. Conductivity to Total Dissolved Solids Relationship in Turtle Creek.

Nitrogen and Phosphorus

Nitrogen is assessed in four forms: nitrate/ nitrite, ammonia, and Total Kjeldahl Nitrogen (TKN). From these four forms, total, organic, and inorganic nitrogen may be calculated. Nitrogen compounds are major cellular components of organisms. Because its availability may be less than the biological demand, environmental sources may limit productivity in freshwater ecosystems. Nitrogen is difficult to manage because it is highly soluble and very mobile in water.

Phosphorus is one of the macronutrients required for primary production. In comparison to carbon, nitrogen, and oxygen, it is often the least abundant in natural systems (Wetzel, 2000). Phosphorus loading to lakes can be of an internal or external nature. External loading refers to surface runoff, dust, and precipitation. Internal loading refers to the transfer of phosphorus from the bottom sediments to the water column of the lake. Total phosphorus is the sum of all attached and dissolved phosphorus in the lake.

The total nitrogen, phosphorus, and inorganic nitrogen loads measured at each of the subwatershed outlets, as well as the acres drained, may be found in Table 13. The discharge coefficients are calculated by dividing the total load, in kg, by the number of acres drained through that site. It quickly becomes apparent that subwatersheds JLT-2 and JLT-5 are the most impaired portions of the watershed. The discharge coefficients from these two subwatersheds are three to four times that of any of the other subwatersheds. With this in mind, any mitigation activities should be targeted towards portions of the watershed located upstream from these two sites. JLT-2 does drain through site JLT-4 (see Figure 2), and this site yielded significantly smaller loads, indicating that a loss of nutrients occurs between these two sites. This is possibly the result of the stream passing through small stock dams that act as nutrient sinks.

Table 13. Nitrogen and Phosphorus Discharge for Subwatersheds

Total Discharge for Subwatersheds							
	Total load in Kg				Discharge Coefficient Kg/ ac		
	Acres	Total N	Total P	Inorganic N	Total N	Total P	Inorganic N
JLO1	23,920	23,142	4,586	9,830	0.97	0.19	0.41
JLT2	8,920	29,047	7,693	13,508	3.26	0.86	1.51
JLT3	2,644						
JLT4	14,431	8,732	2,197	2,649	0.61	0.15	0.18
JLT5	6,029	27,471	6,272	5,879	4.56	1.04	0.98
JLT6	3,039	977	262	243	0.32	0.09	0.08

Tributary Site Summary

Over 99% of the nutrient loading to Jones Lake occurs during spring snowmelt and rainstorm events. With this in mind, mitigation processes should target reductions in loadings that occur during this time of the year. There were no violations of any of the state water quality standards recorded during the project.

Sediment loading from the watershed does not appear to be a significant problem. Most of the crop acres in the watershed currently have some sort of conservation tillage practices used on them, likely resulting in the low amount of suspended sediments in the creek. Nutrient loads to the lake appear to be coming primarily from subwatersheds JLT-2 and JLT-5. Since loads from JLT-2 appear to be reduced significantly as the stream passes through the portion of the watershed located between sites JLT-2 and JLT-4, the most critical area impacting the lake is most likely the 6,029 acres located upstream of JLT-5. This subwatershed represents approximately 25% of the total acres draining into the lake, but it accounts for over 75% of the gauged load entering the lake.

Surface Water Chemistry (Jones Lake)

Inlake Sampling Schedule

Sampling began in June 2000 and was conducted on a monthly basis until project completion in June 2001 at the three pre-selected sites (See Figure 5). Water samples were filtered, preserved, and packed in ice for shipping to the State Health Lab in Pierre, SD. Sample data collected at Jones Lake may be found in Appendix C. The laboratory then assessed the following parameters:

Fecal Coliform Counts	Alkalinity
Total Solids	Total Dissolved Solids
Total Suspended Solids	Ammonia
Nitrate	Total Kjeldahl Nitrogen (TKN)
Total Phosphorus	Volatile Total Suspended Solids
Total Dissolved Phosphorus	Un-ionized Ammonia
Chlorophyll *a*	

Personnel conducting the sampling at each of the sites recorded visual observations of weather and lake characteristics.

Precipitation	Wind
Odor	Septic
Dead Fish	Film
Water Depth	Ice Cover
Water Color	

Parameters measured in the field by sampling personnel were:

Water Temperature	Air Temperature
Conductivity	Dissolved Oxygen
Field pH	Turbidity
Secchi Depth	

South Dakota Water Quality Standards

All public waters within the State of South Dakota have been assigned beneficial uses. All designated waters are assigned the use of fish and wildlife propagation, recreation, and stock watering. Along with each of these uses are sets of water quality standards that must not be exceeded in order to support these uses. Jones Lake has been assigned the beneficial uses of:

- (5) Warmwater semi-permanent fish life propagation
- (7) Immersion recreation
- (8) Limited contact recreation
- (9) Fish and wildlife propagation, recreation and stock watering

The following table lists the parameters that must be considered when maintaining beneficial uses as well as the concentrations for each. When multiple standards for a parameter exist, the most restrictive standard is used.

Table 14. State Beneficial Use Standards for Jones Lake

Parameters	mg/L (except where noted)	Beneficial Use Requiring this Standard
Alkalinity *($CaCO_3$)*	≤750 *(mean)* ≤1,313 *(single sample)*	Wildlife Propagation and Stock Watering
Coliform, fecal *(per 100 mL)* May 1 to Sept 30	≤200 *(mean)* ≤400 *(single sample)*	Immersion Recreation
Conductivity (µmhos / cm @ 25^{o} *C)*	≤4,000 *(mean)* ≤7,000 *(single sample)*	Wildlife Propagation and Stock Watering
Nitrogen, unionized ammonia as N	≤.04 *(mean)* ≤1.75 times the applicable limit *(single sample)*	Warmwater Semi-permanent Fish Propagation
Nitrogen, nitrate as N	≤50 *(mean)* ≤88 *(single sample)*	Wildlife Propagation and Stock Watering
Oxygen, dissolved	≥5.0	Immersion and Limited Contact Recreation
pH *(standard units)*	6.5 - 9.0	Warmwater Semi-permanent Fish Propagation
Solids, suspended	≤90 *(mean)* ≤158 *(single sample)*	Warmwater Semi-permanent Fish Propagation
Solids, total dissolved	≤2,500 *(mean)* ≤4,375 *(single sample)*	Wildlife Propagation and Stock Watering
Temperature	≤32 C	Warmwater Semi-permanent Fish Propagation
Total Petroleum Hydrocarbon Oil and Grease	≤10 mg/L ≤10 mg/L	Wildlife Propagation and Stock Watering

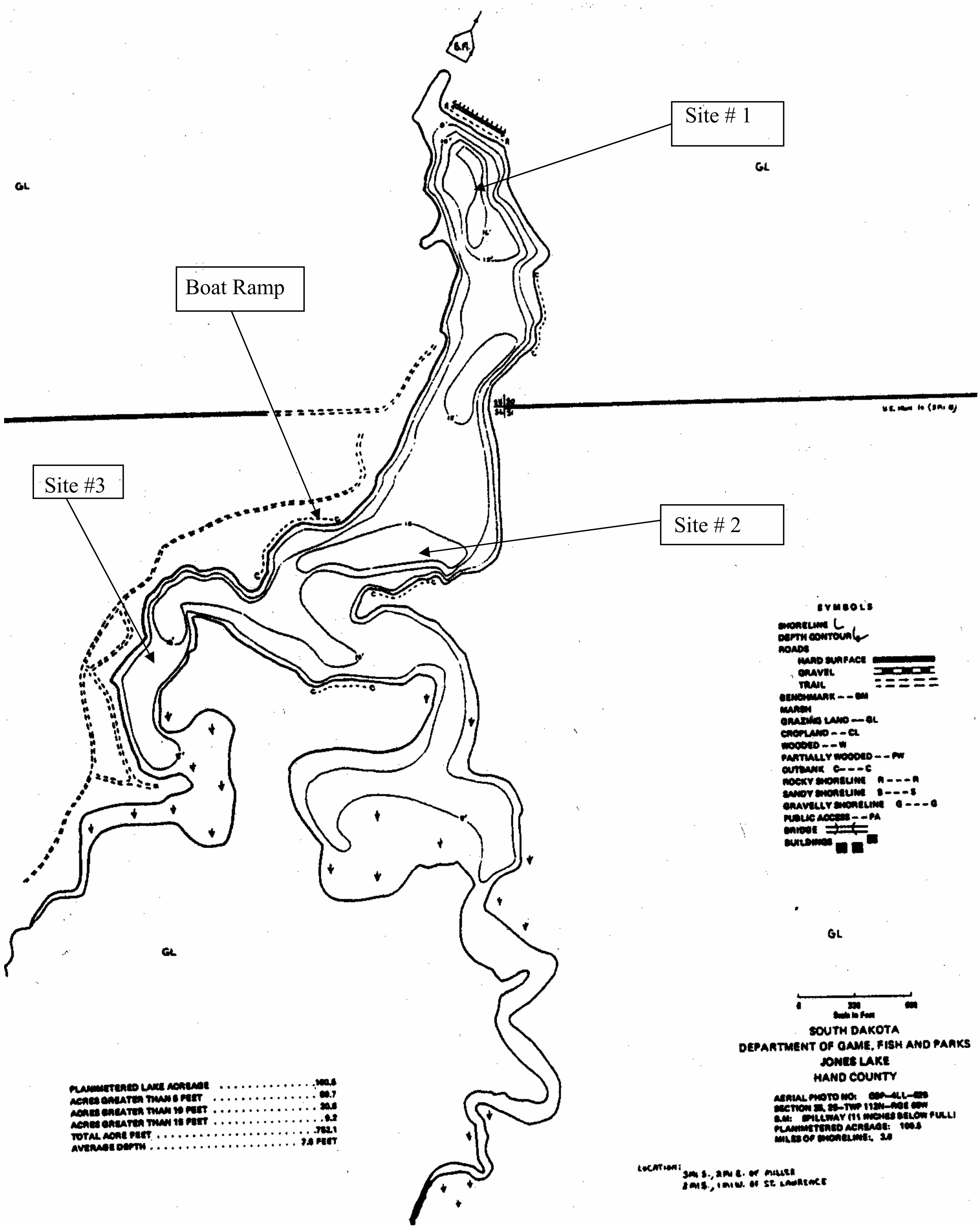


Figure 5. Jones Lake Sampling Locations

Inlake Water Quality Parameters

Water Temperature

Water temperature is of great importance to any aquatic ecosystem. Many organisms and biological processes are temperature sensitive. Blue-green algae tend to dominate warmer waters while green algae and diatoms generally do better under cooler conditions. Water temperature also plays an important role in physical conditions. Oxygen dissolves in higher concentrations in cooler water. Higher toxicity of un-ionized ammonia is also related directly to warmer temperatures.

The beneficial uses of Jones Lake require temperatures to be maintained below 32^{o}C. The maximum recorded temperature for the surface water of Jones Lake was recorded on July 10, 2000 at site 3 with a value of 27.7^{o}C, which is well within the standards for this body of water. This site is likely the most prone to excessive temperatures because it is located in a narrow and shallow portion of the lake that allows sediments to absorb heat and ultimately raise the temperature of the water. The other sites also experienced their highest temperature on this date at 26.9^{o}C and 27.4^{o}C for sites 1 and 2, respectively. Considering the low water conditions of the lake and the high air temperatures experienced during the summer of 2000, it is unlikely that the temperature of Jones Lake frequently, if ever, exceeds the maximum acceptable temperature of 32^{o}C required to maintain the beneficial uses of the lake.

Conductivity

Conductivity is a measure of water's ability to conduct electricity, which is a function of the total number of ions present. Conductivity increases reflect an increase in the concentration of dissolved ions in the waterbody. This may also be used to indicate hardness. It is measured in µmhos/cm, and is sensitive to changes in temperature.

The mean conductivity reading observed in Jones Lake was 974 µmhos/ cm. A maximum value of 1,150 µmhos/ cm was reached at site JL-1 on July 10, 2000. The minimum recorded value of 362 µmhos/ cm was recorded on May 9, 2001. The large decrease observed from the end of the 2000 water year to the beginning of the 2001 water year was most likely caused by surface runoff from spring rains and snowmelt that had lower conductivity. The state standard required to meet the lake's beneficial uses is a mean conductivity of <4,000 µmhos/ cm or a single sample of <7,000 µmhos/ cm. It is unlikely that Jones Lake ever exceeds the conductivity standard.

Alkalinity

A lake's total alkalinity affects its ability to buffer against changes in pH. Total alkalinity consists of all dissolved electrolytes (ions) with the ability to accept and neutralize protons (Wetzel, 2000). Due to the abundance of carbon dioxide (CO_2) and carbonates, most freshwater contains bicarbonates as their primary source of alkalinity. It is commonly found in concentrations as high as 200 mg/L or greater.

The maximum alkalinity measured in Jones Lake during the project was 250 mg/L recorded on October 4, 2000. This value falls well within the state standards of <750 mg/L mean and <1,313 mg/L for a single sample.

Dissolved Oxygen

There are many factors that influence the concentration of dissolved oxygen (DO) in a waterbody. Temperature is one of the most important of these factors. As the temperature of water increases, its ability to hold DO decreases. Daily and seasonal fluctuations in DO may occur in response to algal and bacterial action (Bowler, 1998). As algae photosynthesize during the day, they produce oxygen, which raises the concentration in the epilimnion. As photosynthesis ceases at night, respiration utilizes available oxygen causing a decrease in concentration. During winters with heavy snowfall, light penetration may be reduced to the point where algae and aquatic macrophytes in the lake cannot produce enough oxygen to keep up with consumption (respiration) rates. This results in oxygen depletion and may ultimately lead to a fish kill.

Minimum and maximum dissolved oxygen concentrations for the surface and bottom of the lake are listed in Table 15 along with the standard deviations for all samples collected at each depth. The beneficial use of warm-water, semi-permanent fish propagation requires a minimum DO of 5.0 mg/L. All of the samples collected during the project indicated that there was no impairment to the lake as a result of low DO concentrations.

The bottom sample collected on August 23, 2000, indicated that some anoxic conditions did exist in the lake. These low DO concentrations were restricted to samples collected within 0.5 meters of the bottom at site 1, the deepest site located in front of the dam. During years when the water level in the lake is higher, it is possible that these conditions would exist in other parts of the lake with water depths in excess of 3 meters. It is unlikely that these isolated areas of low DO would have a significant impact on the fishery in the lake.

The lake did experience a fish kill during the winter of 2000-2001 as a result of near record snowfalls in the area. The snow cover created a blanket on the ice likely resulting in a die-off of plant life which would have created anoxic conditions resulting in the fish kill. The snowfall also resulted in travel complications that prevented sampling of the lake water to verify this, however it is the most likely cause as many other lakes throughout the region experienced the same conditions and results that winter.

Table 15. Dissolved Oxygen Statistics for Jones Lake

Depth	Average	Max (mg/L)	Min (mg/L)	Standard Deviation
Surface	9.05	15.13	5.75	2.37
Date		10-Jul-00	26-Jul-00	
Bottom	5.87	9.73	0.98	2.26
Date		7-Sep-00	23-Aug-00	

pH

pH is a measure of free hydrogen ions (H^+) or potential hydrogen. More simply, it indicates the balance between acids and bases in water. It is measured on a logarithmic scale between 0 and 14 and is recorded as standard units (su). At neutral (pH of 7) acid ions (H^+) equal the base ions (OH^-). Values less than 7 are considered acidic (more H^+ ions) and greater than 7 are basic (more OH^- ions). Algal and macrophyte photosynthesis act to increase a lake's pH. Respiration and the decomposition of organic matter will reduce the pH. The extent to which this occurs is affected by the lake's ability to buffer against changes in pH. The presence of a high alkalinity (>200 mg/L) represents considerable buffering capacity and will reduce the effects of both photosynthesis and decay in producing large fluctuations in pH.

The beneficial uses for Jones Lake require that the pH values in the lake remain between the values of 6.5 su and 9.0 su. The data in Table 16 depicts the mean pH values recorded for the surface and bottom samples collected on each date as well as the overall mean pH value for the surface of the lake and the bottom of the lake. The mean surface pH for Jones Lake did not exceeded the water quality standard of ≤9.0 su during the summer of 2000. The only exceedence of pH recorded at the bottom of the lake occurred on June 14, 2000, with a pH of 9.11.

Table 16. Mean pH Values by Depth and Date for Jones Lake

Date	5/31/00	6/14/00	6/26/00	7/10/00	7/26/00	8/9/00	8/23/00	9/7/00	9/21/00	10/4/00	5/9/01	Mean
Surface	8.9	9.0	9.0	8.9	8.9	9.0	9.0	9.0	8.9	8.6	8.0	8.9
Bottom	8.7	9.1	8.9	8.9	8.9	8.9	9.0	8.9	8.9	8.8	7.8	8.8

The data in Table 17 depicts the individual measurements that were recorded at or above the state standard for pH. A total of 15 samples were recorded at or above 9.0 su with eleven on the surface and four on the bottom. Elevated pH levels are often associated with high concentrations of chlorophyll *a* in the water. This does not appear to be the case for Jones Lake. Chlorophyll *a* concentrations of less than 20 ppb were collected on over 50% of the days that pH exceeded the standard.

Table 17. Samples pH exceeded the State Standard by Site, Date, and Depth for Jones Lake

Site	Date	Depth	pH
JL-2	31-May-00	Surface	9.1
JL-1	14-Jun-00	Surface	9.1
JL-2	14-Jun-00	Surface	9.0
JL-3	14-Jun-00	Surface	9.0
JL-2	26-Jun-00	Surface	9.1
JL-3	26-Jun-00	Surface	9.1
JL-3	10-Jul-00	Surface	9.0
JL-2	09-Aug-00	Surface	9.0
JL-2	23-Aug-00	Surface	9.0
JL-2	7-Sep-00	Surface	9.0
JL-3	7-Sep-00	Surface	9.1
JL-1	14-Jun-00	Bottom	9.1
JL-2	14-Jun-00	Bottom	9.1
JL-1	23-Aug-00	Bottom	9.0
JL-2	7-Sep-00	Bottom	9.0

Figure 6 indicates that there is little to no relationship between the concentrations of chlorophyll *a* and the measured pH. High pH levels might be attributed to a number of causes, including soils and landuse in the watershed, and plant growth in the lake. When looking at each of these factors for Jones Lake, soils appear to be the most likely source of the impairment.

The soil that underlies the lake has a number of subsurface horizons with some of the highest pH levels in the county. It is likely that the high pH levels are the result of several factors. Any dredging activities planned for this lake should closely examine the soils present. The high pH in the subsoil may result in even greater pH levels if it is disturbed.

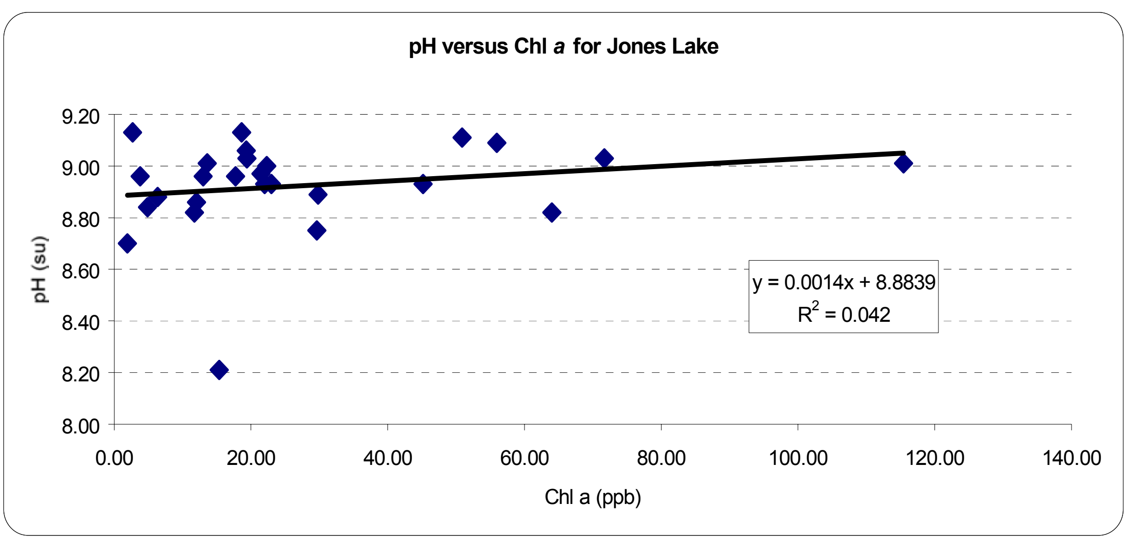


Figure 6. pH versus Chlorophyll *a* for Jones Lake

Turbidity / Secchi Depth

Turbidity is a measure of water transparency and indicates the presence of fine suspended particulate matter. Turbidity is measured in Nephelometric Turbidity Units or NTU, which measure reflection and absorption of light when it passes through a water sample. Due to the wide variety of sizes, shapes, and densities of particles, there is often little or no direct relationship between the turbidity of a sample and the concentration and/or weight of the particulate matter present. This is addressed as total suspended solids later in the report.

There are no state standards for turbidity in waterbodies. It is important to note that high turbidity levels limit photosynthetic activity (Bowler, 1998). Aquatic plants are negatively impacted at values >30 NTU. Fish experience a reduction in feeding energy intake at values >50 NTU, in addition, the structure and dynamics of fish and zooplankton populations could be affected (Claffy, 1955).

Secchi depth visibility is the most commonly used measurement to determine water clarity. No regulatory standards for this parameter exist, however the Secchi reading is an important tool used for determining the trophic state of a lake. The two primary causes for low Secchi readings are suspended solids and algae. Deeper Secchi readings are found in lakes that have clearer water, which is often associated with lower nutrient levels and "cleaner" water.

The mean turbidity for the surface of Jones Lake was 46 NTU with a maximum recorded value of 109.6 and a minimum of 7.6. Secchi readings ranged from 0.5 meters to 2.5 meters with a mean of 0.88. The data in Table 18 depict the strength of the relationships for the various factors that typically affect a lake's turbidity and Secchi visibility.

Table 18. R^2 Relationships between Turbidity, Secchi, Solids and Chlorophyll *a* for Jones Lake

	Turbidity	Secchi	TSSOL	VTSS	Chl *a*
Turbidity	1				
Secchi	0.0316	1			
TSSOL	0.5971	0.2712	1		
VTSS	0.3500	0.1344	0.6179	1	
Chl *a*	0.4938	0.2159	0.7268	0.8169	1

The relationship between the turbidity in Jones Lake and its Secchi depth is nearly nonexistent. It is likely that the Secchi readings in Jones Lake are affected by staining of the water by humic substances. This affect has been observed in other small reservoirs in the area that have large watersheds with significant amounts of grassland. It is believed that runoff occurring on this type of landscape gives the water a tea-colored appearance that reduces transparency but does not have the fine suspended particles that are present in turbid waters. These substances have also been identified as inhibiting algal growth.

Chlorophyll *a*

Chlorophyll *a* is the primary photosynthetic pigment found in oxygen producing organisms (Wetzel, 1982). Chlorophyll *a* is a good indicator of a lake's productivity as well as its state of eutrophication. The total concentration of chlorophyll *a* is measured in mg/m3 (ppb) and is used in Carlson's Trophic State Index to rank a lake's state of eutrophication.

There are no state standards that regulate the concentration of chlorophyll *a* in a waterbody. Large concentrations indicate large numbers of algae and are often representative of degraded water quality. Chlorophyll *a* concentrations in Jones Lake (Figure 7) ranged from a maximum value of 115.4 ppb recorded on September 11, 2000 to a minimum value of 1.7 ppb recorded on June 3, 2000. The mean Chlorophyll *a* value for the project was 27.4 ppb. Chlorophyll *a* represents the majority of the volatile solids found in Jones Lake, as represented by the strong relationship found in Table 18.

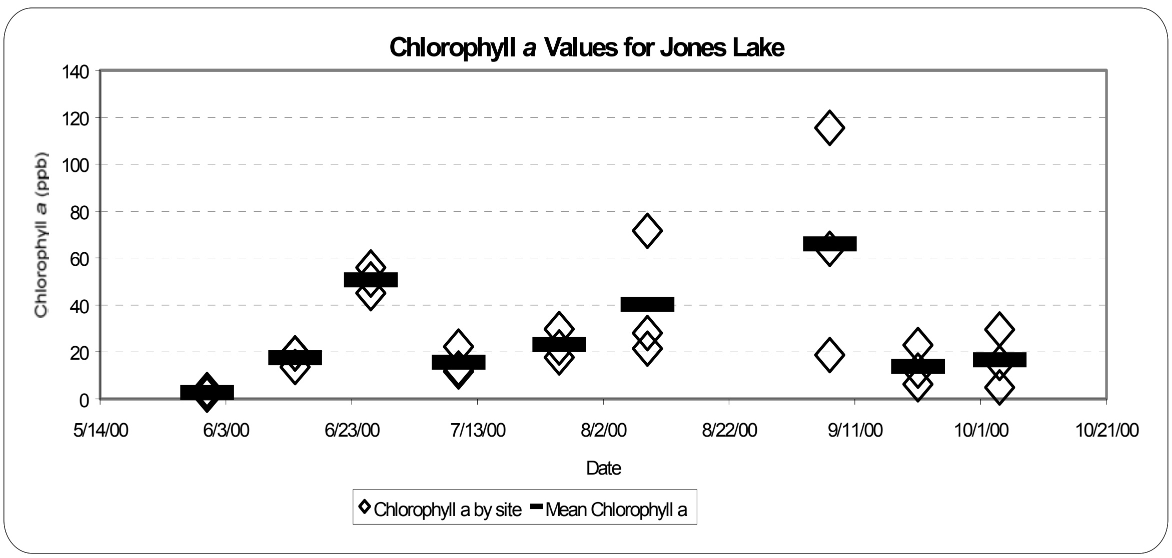


Figure 7. Chlorophyll *a* Values for Jones Lake

Chlorophyll *a* concentrations are typically expected to be found in relation to the nutrients available in the waterbody, particularly phosphorus. The relationships developed from the data collected during the project represent a weak relationship for both total phosphorus and total nitrogen to the chlorophyll *a* concentration. Figures 8 and 9 outline these relationships.

Since both relationships are weak, it is difficult to predict that nutrient reductions will result in reduced chlorophyll *a* concentrations. The abundance of phosphorus results in a nitrogen-limited system, limiting the effectiveness of phosphorus reductions. Limiting nutrients will be addressed later in this report in greater detail.

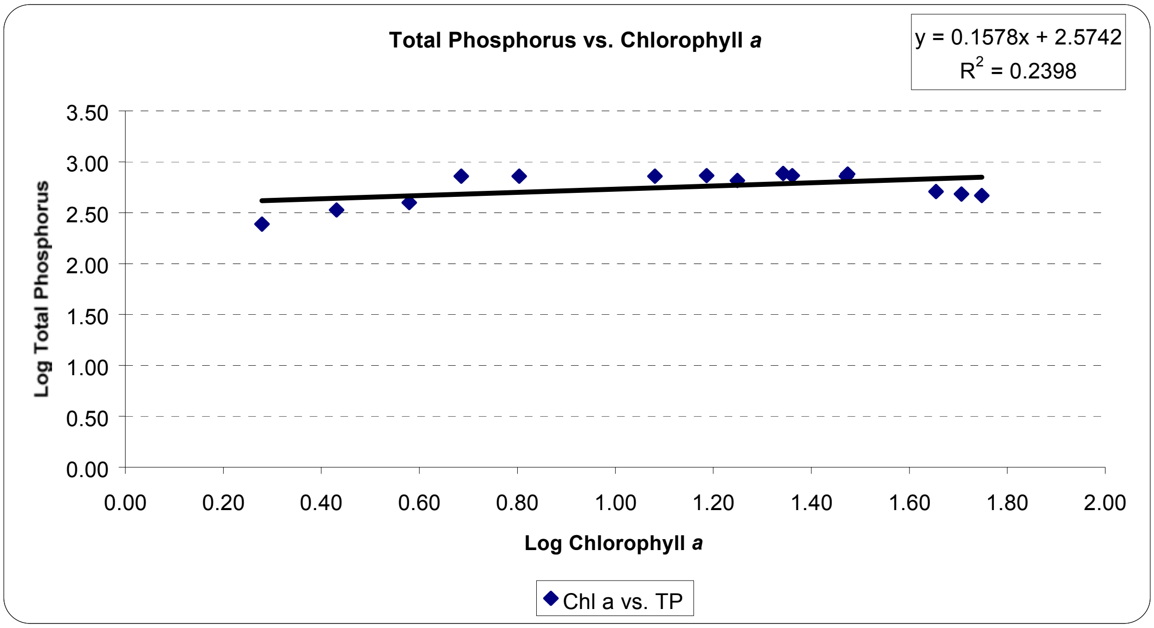


Figure 8. Total Phosphorus to Chlorophyll *a*

Nitrogen is a poor limiting nutrient for chlorophyll *a* growth as there are many bacteria that fix atmospheric nitrogen creating a readily available supply of nitrogen for plant growth. The production of chlorophyll *a* in Jones Lake is likely controlled by factors such as available light and micro nutrient supplies instead of the availability macronutrients such as phosphorus and nitrogen.

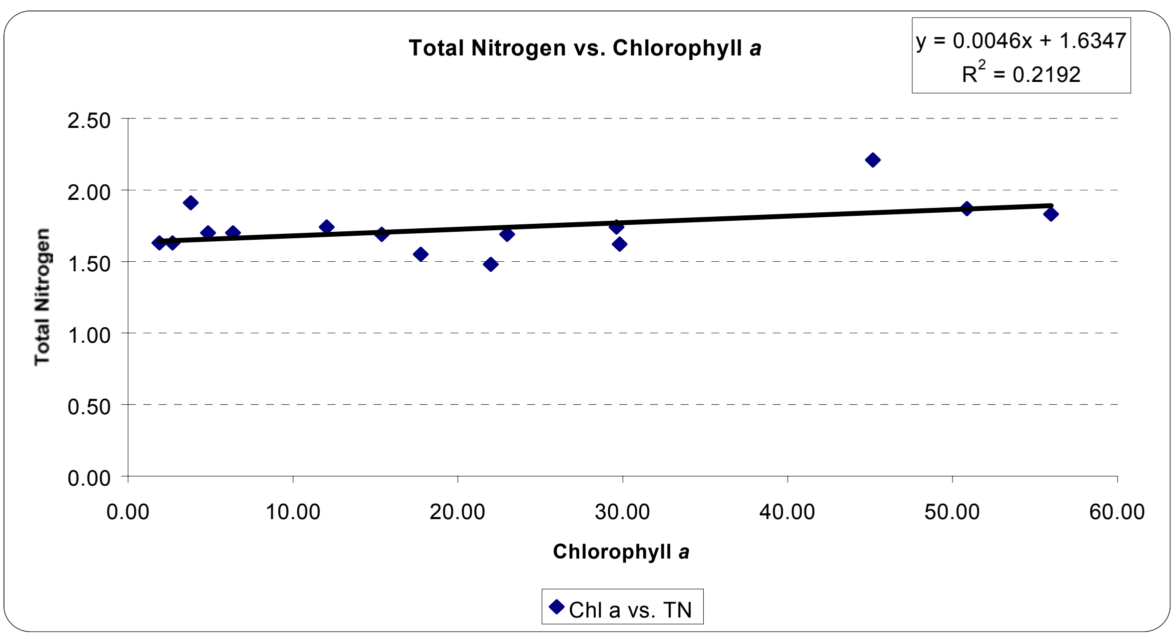


Figure 9. Total Nitrogen to Chlorophyll *a*

Solids

Solids are addressed as four separate parts in the assessment; total solids, dissolved solids, suspended solids, and volatile suspended solids. Total solids are the sum of all forms of material including suspended and dissolved as well as organic and inorganic materials that are found in a given volume of water.

Suspended solids consist of particles of soil and organic matter that may be eventually deposited in stream channels and lakes in the form of silt. Silt deposition into a stream bottom buries and destroys the complex bottom habitat. This habitat destruction reduces the diversity of aquatic insect, snail, and crustacean species. In addition to reducing stream habitat, large amounts of silt may also fill-in lake basins. As silt deposition reduces the water depth in a lake, several things occur. Wind-induced wave action increases turbidity levels by suspending solids from the bottom that had previously settled out. Shallow water increases and maintains higher temperatures. Shallow water also allows for the establishment of beds of aquatic macrophytes.

Suspended solids concentrations in Jones Lake ranged from a low of less than 5 mg/L to a maximum of 25 mg/L, of which the organic or volatile portion consisted of between 20% and 80%, (Figure 10). State standards for the fishery require maximum sample concentrations of less than 158 mg/L for a single sample and a mean of less than 90 mg/L. The concentrations measured in Jones Lake fully support these standards.

Total dissolved solids composed an average of 94% of the total solids measured during the project. State standards for total dissolved solids are a maximum of 4,375 mg/L for a single sample and a 30 day mean of less than 2,500 mg/L. The maximum recorded value at Jones Lake during the project was 671 mg/L, indicating that the beneficial uses are not impaired as a result of dissolved solids concentrations.

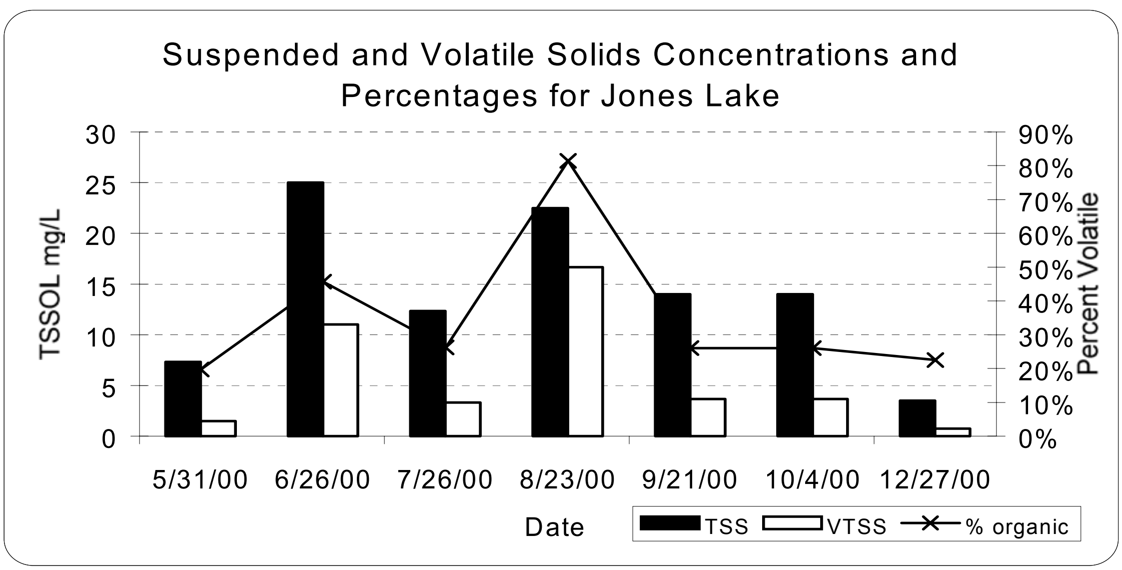
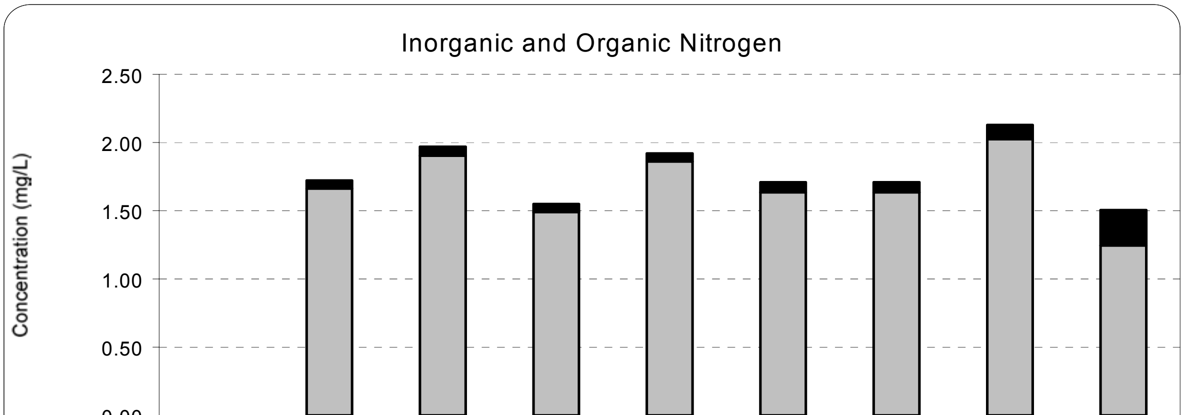


Figure 10. Suspended and Volatile Suspended Solids Concentrations and Percentages in Jones Lake

Nitrogen

Nitrogen is analyzed in four forms: nitrate/nitrite, ammonia, and Total Kjeldahl Nitrogen (TKN). From these four forms, total, organic, and inorganic nitrogen may be calculated. Nitrogen compounds are major cellular components of organisms. Because its availability may be less than the biological demand, environmental sources may limit productivity in freshwater ecosystems. Nitrogen is difficult to manage because it is highly soluble and very mobile. In addition, there are bacterial species capable of fixing atmospheric nitrogen for use by algae resulting in a virtually limitless supply of nitrogen.

The majority of the nitrogen found in Jones Lake is in an organic form (Figure 11). Inorganic nitrogen is the sum of the nitrate/ nitrite and ammonia measurements. Most of the samples collected during the project were at or less than the detection limit for one or both of the measurements used to determine inorganic nitrogen. Since inorganic nitrogen is a more plant-available form, this would indicate that plant life in Jones Lake was consuming nearly all of the available nitrogen for growth, indicating that it is the limiting nutrient. The exception to this occurred during spring discharge (5/9/01 sample). This most likely represents nitrogen loading from the watershed as well as an algae community that had not yet developed to the point that it could use all of the available nitrogen.



	Date	5/31/00	6/26/00	7/26/00	8/23/00	9/21/00	10/4/00	12/27/00	5/9/01
Inorganic N	0.00	0.060	0.067	0.060	0.060	0.077	0.077	0.105	0.260
Organic N	0.00	1.66	1.90	1.49	1.86	1.63	1.63	2.03	1.25

Date and Concentration averaged for all sites

Organic N Inorganic N

Figure 11. Organic Nitrogen in Jones Lake

Ammonia may be found in two forms, ionized and unionized. The latter form can be extremely toxic to fish. The unionized fraction of ammonia is dependent on pH and temperature. As these two parameters increase, so does the unionized fraction of ammonia. Ammonia tends to remain in its ionic form (NH^{4+}) except under higher alkaline conditions (pH > 9.0) (Wetzel 2000). Unionized levels in excess of 5% are lethal to fish and other aquatic life. Samples collected from Jones Lake all remained below 1% unionized, resulting in no impairment of beneficial uses.

Total Phosphorus

Phosphorus is one of the macronutrients required for primary production. When compared with carbon, nitrogen, and oxygen, it is often the least abundant (Wetzel, 2000). Phosphorus loading to lakes can be of an internal or external nature. External loading refers to surface runoff, dust, and precipitation. Internal loading refers to the release of phosphorus from the bottom sediments to the water column of the lake. Total phosphorus is the sum of all attached and dissolved phosphorus in the lake. The attached phosphorus is directly related to the amount of total suspended solids present. An increase in the amount of suspended solids increases the fraction of attached phosphorus.

Phosphorus concentrations in Jones Lake increased steadily during the growing season (see Figure 12) of 2000, May through August samples. There were no runoff events to add phosphorus to the lake. The most likely sources of these increases would be livestock on the shoreline or nutrient releases from the sediments. The winter samples collected in December showed a sharp decline that resulted in concentrations similar to those measured at the start of the previous spring. This indicates that the sediments reabsorb the phosphorus in the lake and they will remain there until anoxic conditions the following year release them. The sample collected on May 9, 2001 appears to be the start of the summer increase. This curve is probably typical of phosphorus concentrations during an average year for Jones Lake.

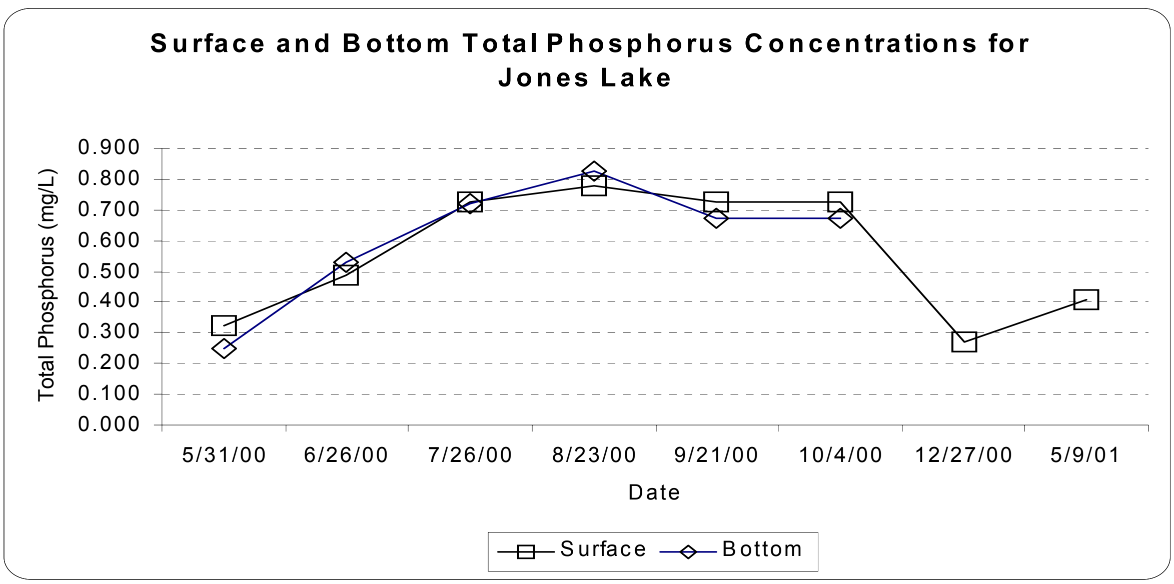


Figure 12. Total Phosphorus Concentrations in Jones Lake

Complete elimination of this internal loading would result in summertime phosphorus concentrations of .25 to .3 mg/L. This is similar to what would be attained through a 60% reduction in phosphorus loadings from the stream. Internal load reductions may be possible through aeration of the water column to the sediment interface.

Other inlake treatments would include an alum treatment. Alum treatments use an aluminum sulfate slurry that, when applied to water, creates a aluminum hydroxide precipitate (floc). The aluminum hydroxide (Al_3O_2) floc removes phosphorus and suspended solids, both organic and inorganic, from the water column by reacting with the assimilated phosphorus to create aluminum phosphate that settles to the bottom. By collecting and settling out suspended particles including algae, alum leaves the lake noticeably clearer.

Treatments may last up to ten years and are dependent upon the amount of alum applied, total suspended solids sedimentation rate and external phosphorus loading.

Welch and Cooke (1995) studied lakes treated with alum and found that phosphorus concentrations were reduced from 30 percent to 90 percent after application. If long-term disturbance and tributary loadings are significantly reduced, a significant reduction in in-lake phosphorus is estimated based upon in-lake concentrations prior to application. A conservative estimate for in-lake phosphorus reductions may be 30%.

Dissolved Phosphorus

Total dissolved phosphorus is the unattached portion of the total phosphorus load. It is found in solution, but readily binds to soil particles when they are present. Total dissolved phosphorus, including soluble reactive phosphorus, is more readily available to plant life than attached phosphorus.

Typically, there is a relationship between the percentage of dissolved phosphorus and the total suspended solids concentrations. This relationship does not seem to exist in Jones Lake (Figure 13). One possible explanation for this is that the concentration of phosphorus is so high that most, if not all of the suspended sediment particles are fully saturated with phosphorus molecules. As is addressed later in this report, the abundance of phosphorus in the lake results in nitrogen limited growing conditions.

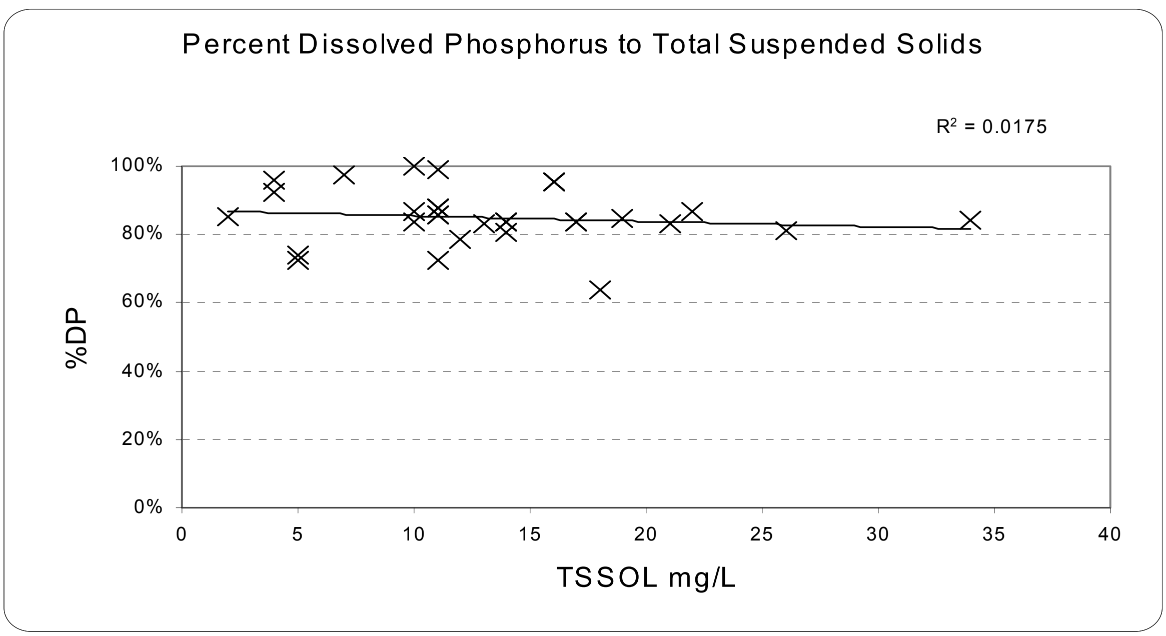


Figure 13. Total Suspended Solids vs. Total Dissolved Phosphorus

Fecal Coliform Bacteria

Fecal coliform are bacteria that are found in the waste of warm-blooded animals. Some common types of bacteria are *E. coli*, Salmonella, and Streptococcus, which are associated with livestock, wildlife, and human waste. (Novotny, 1994).

The state standard for fecal coliform between May 1 and September 30 is less than 400 colonies/ 100mL in any one sample. The geometric mean must remain less than 200 colonies/ 100mL based on samples collected during a minimum of five separate 24-hour periods for any 30-day period, and they may not exceed this value in more than 20 % of the samples examined in this same 30-day period. All of the fecal coliform samples that were above the detection limit of 10 coliforms/ 100mL and collected from Jones Lake during the project are represented in Table 19. An additional 13 samples were collected that were below the detection limit.

The dry conditions during the first portion of the project (represented by samples collected during 2000) resulted in no runoff from the creek entering the lake. Samples collected during this period, all of which were at or below the detection limit, indicate that there is little or no fecal contamination occurring around the lake itself.

Samples collected from Jones Lake remained within the state standards during the project period. The values collected on May 9, 2001 were the highest recorded during the project. This is likely due to runoff events occurring at this time. These values, although high, were within the state standards. It is likely that these levels are typical during periods of spring discharge, resulting in short periods of impairment.

Table 19. Fecal Coliform Counts in Jones Lake

SITE	DATE	DEPTH	Fecal (colonies/100mL)
JL-3	31-May-00	Surface	10
JL-1	26-Jun-00	Surface	30
JL-1	9-May-01	Surface	260
JL-2	9-May-01	Surface	370

Limiting Nutrients

Two primary nutrients are required for cellular growth in organisms, phosphorus and nitrogen. Nitrogen is difficult to limit in aquatic environments due to its highly soluble nature. Phosphorus is easier to control, making it the primary nutrient targeted for reduction when attempting to control lake eutrophication. The ideal ratio of nitrogen to phosphorus for aquatic plant growth is 10:1 (EPA, 1990). Ratios higher than 10 indicate a phosphorus-limited system. Those that are less than 10:1 represent nitrogen-limited systems.

Figure 14 indicates the N to P ratios that were recorded during the project. While the mean was 3.6:1, the majority of the latter part of the growing season had ratios near 2:1. Jones Lake maintained an N to P ratio of considerable less than 10 for the entire project, meaning the lake is clearly nitrogen limited.

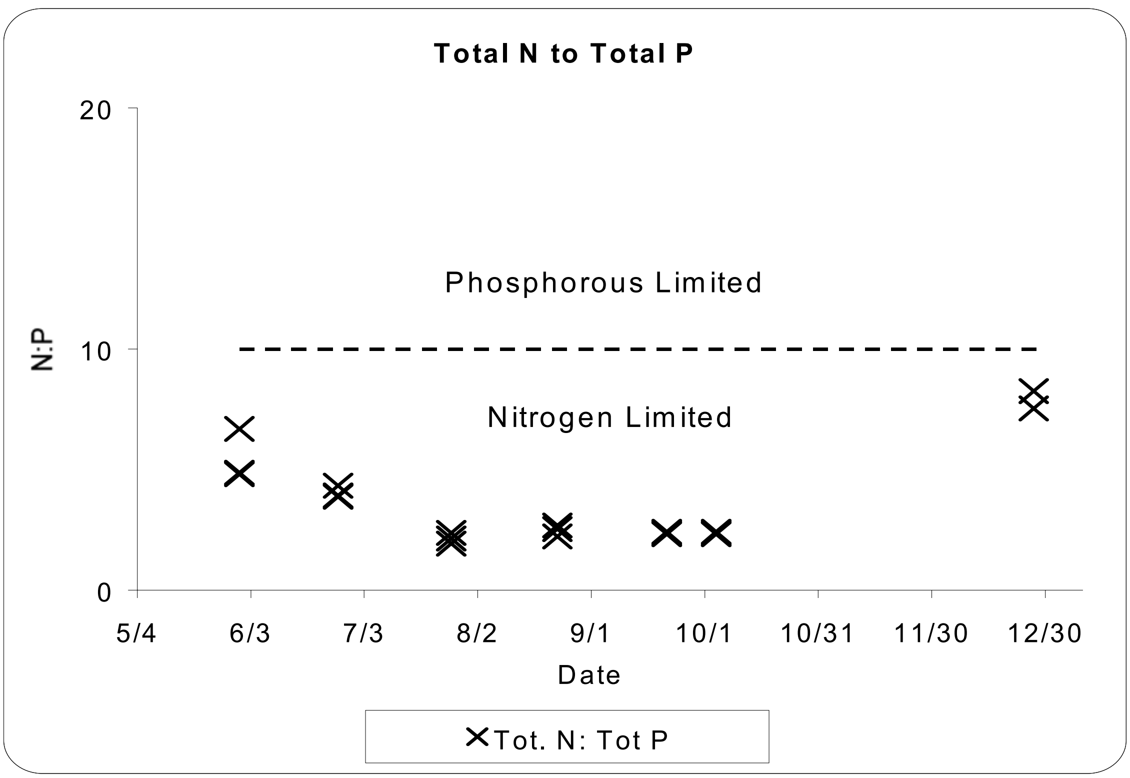


Figure 14. Total Nitrogen to Total Phosphorus Ratio

While no samples were collected during the latter part of the winter, it appears that adsorption of nutrients by sediments during the winter resulted in a shift of limiting nutrients to a less nitrogen-limited system.

It is likely that immediately prior to and following ice-off in the spring that the lake is phosphorus-limited. This indicates that the primary nutrient problem in Jones Lake is internal loading. Figure 15 shows that as nitrogen levels remained relatively constant through the summer, the phosphorus concentration steadily increased. To improve the trophic state of Jones Lake, a reduction in the internal loading to the lake is required.

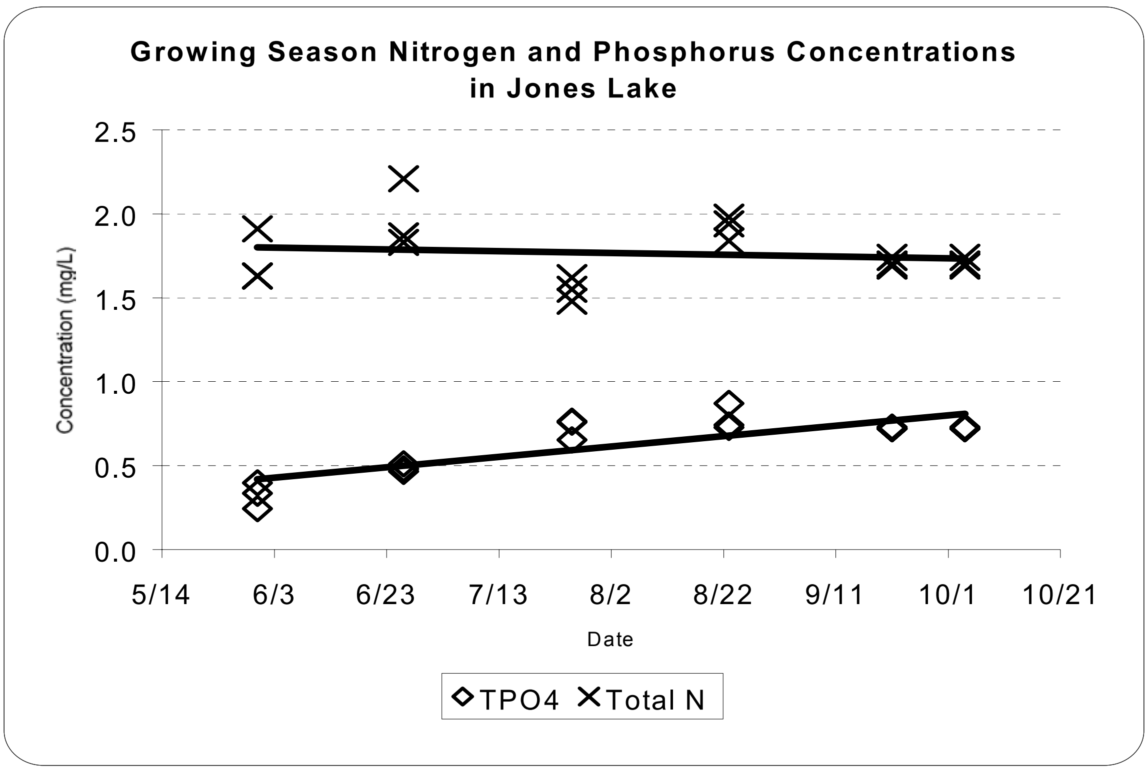


Figure 15. Growing Season Nitrogen and Phosphorus Concentrations in Jones Lake

Trophic State

Trophic state relates to the degree of nutrient enrichment of a lake and its ability to produce aquatic macrophytes and algae. The most widely used and commonly accepted method for determining the trophic state of a lake is the Trophic State Index (TSI) (Carlson, 1977). It is based on Secchi depth, total phosphorus, and chlorophyll *a* in surface waters. The values in a combined TSI number of the aforementioned parameters are averaged to give the lake's trophic state.

Lakes with TSI values less than 35 are generally considered to be oligotrophic and contain very small amounts of nutrients, little plant life, and are generally very clear. Lakes that obtain a score of 35 to 50 are considered to be mesotrophic and have more nutrients and primary production than oligotrophic lakes. Eutrophic lakes have a score between 50 and 65 and are subject to algal blooms and have large amounts of primary production. Hyper-eutrophic lakes receive scores greater than 65 and are subject to frequent and massive blooms of algae that severely impair their beneficial uses and aesthetic beauty.

Table 20. Carlson's Trophic State Index

TROPHIC STATE	COMBINED TSI NUMERIC RANGE
OLIGOTROPHIC	0-35
MESOTROPHIC	36-50
EUTROPHIC	51-64
HYPER-EUTROPHIC	65-100

The mean phosphorus TSI values for Jones Lake were 94.85, which is considerably higher than the Secchi or the Chlorophyll *a* values recorded at 62.93 and 59.07, respectively. The highest phosphorus TSI values were collected in August while the lowest were recorded in May and December of 2000. The May 2000 samples also produced the lowest TSI values for Secchi and Chlorophyll *a*. Chlorophyll *a* and Secchi TSI values began to drop in the fall (early September) prior to the decline of the phosphorus TSI (October to November).

Figure 16 shows that the mean TSI value for Jones Lake is within the hyper-eutrophic category and that as the growing season progressed, the TSI values in the lake steadily rose. The TSI value for the samples collected at the end of May in 2000 were 60.5, which is fully supporting its beneficial uses. The overall mean of 71.07 places Jones within the partially supporting category for lakes located in the Northern Glaciated Plains Ecoregion. To reach full support, as assigned in "Ecoregion Targeting for Impaired Lakes in South Dakota", a shift of 6 TSI units would be required to drop the mean TSI value for the lake below 65.

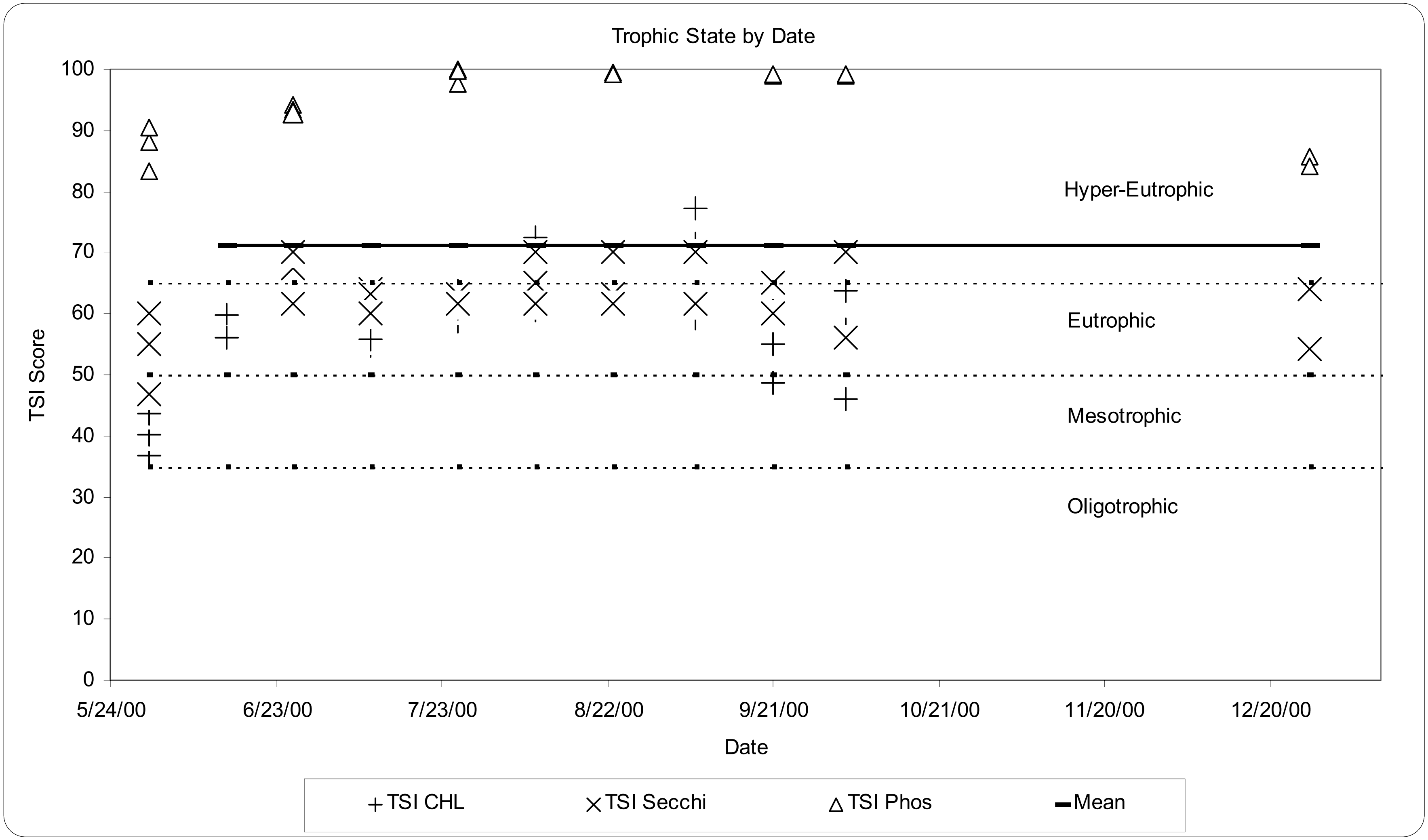


Figure 16. Trophic State by Date for Jones Lake

Reduction Response Modeling

Inlake reduction response modeling was conducted with BATHTUB, an Army Corps of Engineers eutrophication response model (Walker, 1999). System responses were calculated using reductions in the loading of phosphorus to the lake from Turtle Creek. Loading data for Turtle Creek was taken directly from the results obtained from the FLUX modeling data calculated for the inlet to the lake. Atmospheric loads were provided by SDDENR.

BATHTUB provides numerous models for the calculation of inlake concentrations of phosphorus, nitrogen, chlorophyll *a*, and Secchi depth. Models are selected that most closely predict current inlake conditions from the loading data provided. As reductions in the phosphorus load are predicted in the loading data, the selected models will closely mimic the response of the lake to these reductions.

BATHTUB not only predicts the inlake concentrations of nutrients; it also produces a number of diagnostic variables that help to explain the lake responses. Figure 17 shows the response to reductions in the phosphorus load. The observed and predicted water quality is listed in the first two columns. The observed and predicted trophic states are 74.3 and 76.8 respectively, approximately 3% difference between them.

The variables (N-150)/P and INORGANIC N/P are both indicators of phosphorus and nitrogen limitation. The first, (N-150)/P, is a ratio of total nitrogen to total phosphorus. Values less than 10 are indicators of a nitrogen-limited system. The second variable, INORGANIC N/P, is an inorganic nitrogen to ortho-phosphorus ratio. Values less than 7 are nitrogen-limited. The current state of Jones Lake is nitrogen-limited. Phosphorus limitation would only be possible through greater than 70% reductions in the total phosphorus load from the watershed, or elimination of nutrient release by sediment in the lake.

The variables FREQ (CHL-a)% represent the predicted algal nuisance frequencies or bloom frequencies. Blooms are often associated with concentrations of 30 to 40ppb of total phosphorus. These frequencies are the percentage of days during the growing season that algal concentrations may be expected to exceed the respective values. Reductions in phosphorus of 50% to 70% predict less frequent algal blooms.

TSI responses to the reductions in phosphorus load to the lake exhibited substantial variation. The TSI phosphorus value showed consistent positive responses to the reductions. The chlorophyll *a* and Secchi responses were much less significant. Each showed very little response to the reductions until they reached 70% or greater. The limited responses are a result of the limited nitrogen supply and excessive phosphorus concentrations. The model predicted a mean TSI value reduction of 6 points with phosphorus reductions of 70% or greater.

Figure 17. BATHTUB Calculations for Jones Lake

VARIABLE	OBSERVED	Est.	Est.	Est.	Est.	Est.	Est.	Est.	Est.	Est.
Percent Reduction	0%	0%	10%	20%	30%	40%	50%	70%	90%	99%
TOTAL P MG/M3	606	672	605	537	471	403	336	202	68	7
TOTAL N MG/M3	1740	1740	1740	1740	1740	1740	1740	1740	1740	1740
CHL-A MG/M3	32.43	43.72	43.63	43.51	43.34	43.08	42.66	40.47	27.25	2.08
SECCHI M	0.89	0.71	0.71	0.71	0.72	0.72	0.72	0.75	1.01	2.74
ORGANIC N MG/M3	1710	1177.29	1175.35	1172.61	1168.71	1162.74	1153.26	1103.35	801.79	228.05
ANTILOG PC-1	1790.77	2060.14	2050.01	2035.86	2015.89	1985.64	1938.61	1708.14	747.77	20.61
ANTILOG PC-2	12.52	12.43	12.44	12.44	12.45	12.46	12.48	12.55	12.49	5.28
(N - 150) / P	2.62	2.37	2.63	2.96	3.38	3.95	4.73	7.87	23.56	221.69
INORGANIC N / P	0.06	0.95	1.08	1.24	1.46	1.79	2.28	5.03	59.81	1511.95
FREQ(CHL-a>10) %	94.38	98.07	98.06	98.04	98.01	97.96	97.88	97.41	90.44	0.23
FREQ(CHL-a>20) %	68.07	82.93	82.85	82.74	82.57	82.32	81.91	79.59	57.49	0
FREQ(CHL-a>30) %	42.68	61.69	61.57	61.4	61.16	60.79	60.18	56.87	32.08	0
FREQ(CHL-a>40) %	25.83	43.37	43.25	43.07	42.82	42.44	41.83	38.55	17.64	0
FREQ(CHL-a>50) %	15.66	29.92	29.81	29.66	29.44	29.1	28.57	25.75	9.86	0
FREQ(CHL-a>60) %	9.64	20.59	20.5	20.37	20.19	19.92	19.49	17.23	5.67	0
CARLSON TSI-P	96.54	98.03	96.52	94.81	92.89	90.65	88.05	80.69	64.89	32.56
CARLSON TSI-CHLA	64.73	67.66	67.64	67.61	67.57	67.52	67.42	66.9	63.02	37.8
CARLSON TSI-SEC	61.68	64.91	64.89	64.85	64.81	64.74	64.64	64.05	59.91	45.47
Mean TSI	74.32	76.87	76.35	75.76	75.09	74.30	73.37	70.55	62.61	38.61

Figure 18. BATHTUB Calculations Legend

TOTAL P MG/M3	Pool Mean Phosphorus Concentration
TOTAL N MG/M3	Pool Mean Nitrogen Concentration
CHL-A MG/M3	Pool Mean Chlorophyll *a* Concentration
SECCHI M	Pool Mean Secchi depth
ORGANIC N MG/M3	Pool Mean Organic Nitrogen Concentration
ANTILOG PC-1	First principal component of reservoir response. Measure of nutrient supply. < 50 = Low Nutrient Supply and Low Eutrophication potential // >500 = High nutrient supply and high Eutrophication potential
ANTILOG PC-2	Second principal component of reservoir response variables. Nutrient association with organic vs. inorganic forms; related to light-limited areal productivity. Low: PC-2 < 4 = turbidity-dominated, light-limited, low nutrient response. High: PC-2 >10 = algae-dominated, light unimportant, high nutrient response.
(N - 150) / P	(Total N - 150)/ Total P ratio. Indicator of limiting nutrient. Low: (n-150)/P < 10-12 + nitrogen-limited High: (n-150)/P > 12-15 phosphorus-limited
INORGANIC N / P	Inorganic Nitrogen/ ortho-phosphorus ratio. Indicator of limiting nutrient Low: N/P < 7-10 Nitrogen- limited High: N/P > 7-10 phosphorus limited
FREQ(CHL-a>10) %	Algal nuisance frequencies or bloom frequencies. Estimated from mean chlorophyll *a*. Percent of time during growing season that Chl *a* exceeds 10, 20, 30, 40, 50, 60 ppb. Related to risk or frequency of use impairment.
TSI	Trophic State Indices (Carlson 1977)

Long-Term Trends

Jones Lake is listed on the state's 303(d) list as an impaired waterbody with a declining trend in water quality as a result of nutrients, sediment, and algal growth. This is supported in the 1995 South Dakota Lakes Assessment Final Report. Evaluation of the trend data indicates that Jones Lake has stabilized at a high trophic level.

There is little doubt that the water quality of the lake has degraded since the first samples were collected in 1979, but this trend appears to be stabilizing. TSI values during the 1979 study were 54, 61, and 77 for Secchi, chlorophyll *a*, and phosphorus, respectively. The lowest recorded phosphorus TSI during the study was an 83, indicating a very conservative increase in phosphorus concentrations of .1 mg/L. The mean TSI in 1979 was 64, which would have placed it within the fully supporting category for lakes within its ecoregion.

This may be the result of improved land management practices in the watershed, eliminating further degradation. It may also be the result of the lake reaching equilibrium with its nutrient sources, meaning that the nutrient load into the lake is adequate to maintain it in its present, degraded state.

The pH measurements recorded during the 1979 study indicates an average of 8.8 su. The average pH recorded on the surface during the assessment was 8.87 su. This suggests that the lake has always had high pH values and that the problem is not related to nutrient loading, and is actually an impact of the soils or some other natural factor located under and around the lake.

Biological Monitoring

Fishery

The data in Table 21 represent the species present in Jones Lake, as well as an indication of their relative abundance during the survey conducted in 1998. These numbers have little or no relevance to the fishery in the lake after the winter of 2000-2001. Heavy snowfall in combination with an extended ice period, and low water conditions resulted in severe oxygen depletion in the lake that killed all fish present.

The data is representative of the fish communities that the lake is capable of supporting. The Department of Game, Fish and Parks had begun stocking yellow perch and largemouth bass by the completion of this project. It is likely that all of the species present prior to the fish kill will eventually return to Jones Lake either through the efforts of SDGF&P or through angler transport and stocking.

Table 21. Fishery Data for Jones Lake

Species	Method	*Stock CPUE	*PSD	*RSD-P
Largemouth Bass	Electrofish	20.3	4	2
Black Bullhead	Trap Net	316.5	2	0
Yellow Perch	Trap Net	13.9	99	0
Black Crappie	Trap Net	9.4	41	12
Bluegill	Trap Net	2	100	6
Bluegill	Electrofish	5.7	100	0
Northern Pike	Trap Net	2	50	13
Walleye/Saugeye	Trap Net	0.13	0	0
Walleye	Electrofish	0	0	0
Saugeye	Electrofish	0	0	0

*(CPUE = Catch per Unit Effort, PSD= Proportional Stock Density, and RSD-P= Relative Stock Density of Preferred)

The 1998 angler survey estimated approximately 701 angler days per year on the lake, most of which were contributed or spent by local anglers. The local economic benefit translates into $52,575 based on the average South Dakota angler spending $75 per fishing day. (U.S. Department of Interior, Fish and Wildlife Service, and U.S. Department of Commerce, Bureau of Census 1997).

Phytoplankton

Composite surface algae samples were collected twice monthly from three in-lake water quality monitoring sites in Jones Lake from May 31 to October 4, 2000. A total of 59 taxa including one unidentified algae category were identified for the period of this survey found in Table B, (all tables for the phytoplankton section of this report are located in Appendix D). Algae species richness (the number of algal taxa observed) in Jones Lake during this study was rated as 'average' compared to other recently monitored small (< 200 ac.) state lakes.

Diatoms (Bacillariophyceae) represented the most diverse algae group in Jones Lake with 24 taxa, followed by non-motile green algae (Chlorophyta) with 17 taxa, including three filamentous species. The other algae groups in this lake were less varied. Blue-green algae (Cyanophyta) and flagellated (motile) algae belonging to five phyla contributed 8 and 9 taxa, respectively.

Of the motile algae, cryptomonads (Cryptophyta), and dinoflagellates (Pyrrhophyta) each accounted for 3 taxa, while green flagellates (Chlorophyta), euglenoids (Euglenophyta) and yellow-brown flagellates (Chrysophyta) contributed only a single taxon apiece. Motile algae were not as diverse in Jones Lake during this survey as encountered in other small state lakes of similar trophic status. The reasons are not clear at this time.

Jones Lake algal biovolume for the study period varied by more than a magnitude from 1,989,592 um^3 / ml on May 31 to 20,135,694 um^3 / ml on August 23, 2000 (Table D and Figure 19). Algal density (abundance of algae cells of all sizes) ranged from a minimum of 5,547 cells/ml in early September to a peak density of 39,148 cells/ml in late June, 2000 (Table C). Average density and biovolume for the study period amounted to 18,357 cells/ml and 7,021,515 um^3/ml, respectively.

The phytoplankton population during this survey consisted of 38% non-motile green algae which made up 24% of the total algal biovolume (approx. biomass). Blue-green algae comprised 42% of total algal abundance but only 22% of the biovolume, in contrast to flagellated algae which contributed only 14% to total abundance but made up 44% of algal volume due to the presence of relatively moderate numbers of several species of large-sized dinoflagellates, mainly *Glenodinium gymnodinium* (Table D). Diatoms represented the least common algae group in Jones Lake during this assessment accounting for 6% of density and 10% of annual biovolume.

The seasonal distribution of algae populations in Jones Lake consisted of a early summer maximum in abundance on June 26 and a smaller, poorly-defined peak in mid-summer on August 9, 2000 (Figure 19). Blue-green algae, mainly *Aphanizomenon flos-aquae*, were responsible for the late June maximum while several species of green algae, primarily *Oocystis pusilla* and *Pediastrum duplex*, were major components of the August peak.

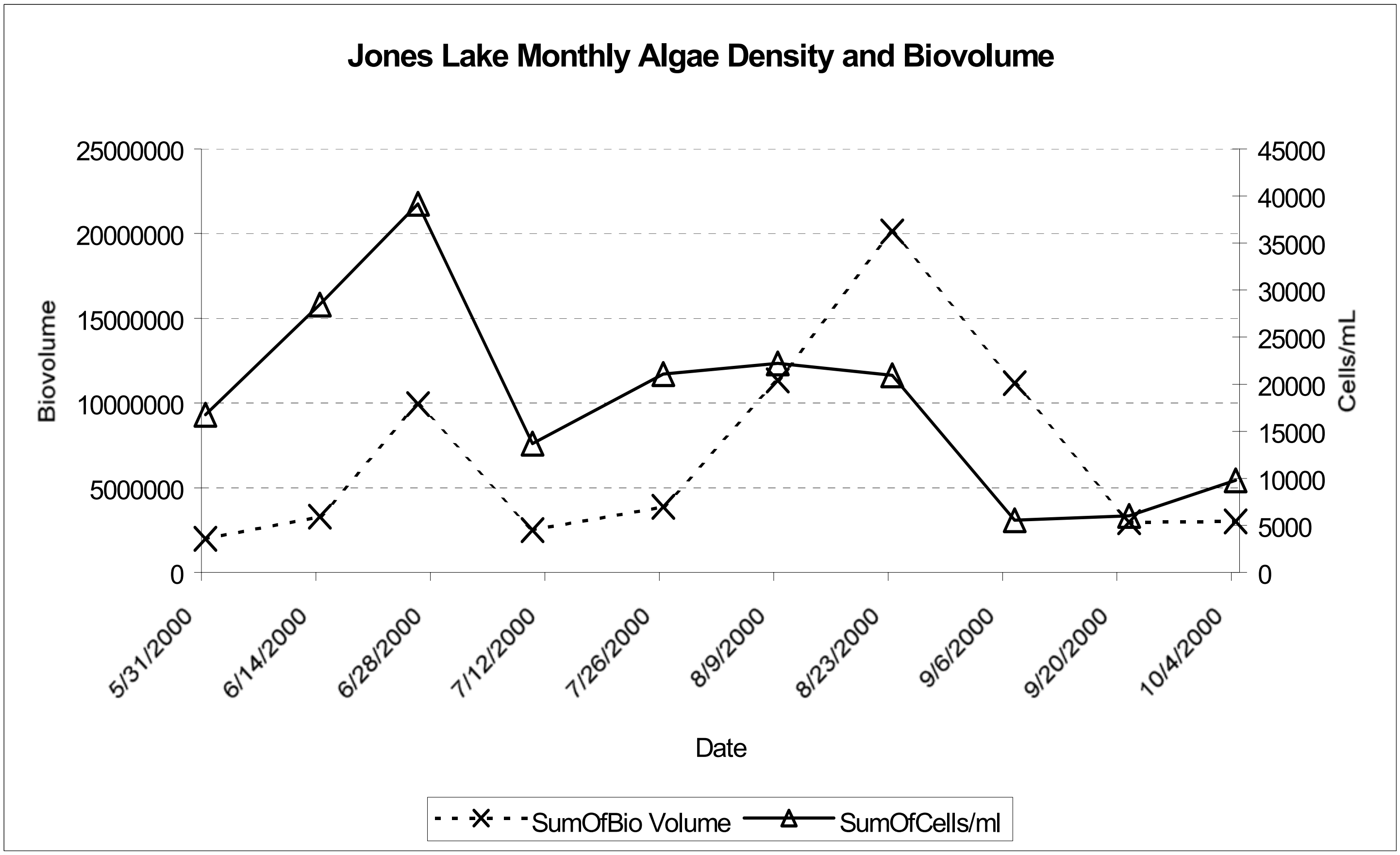
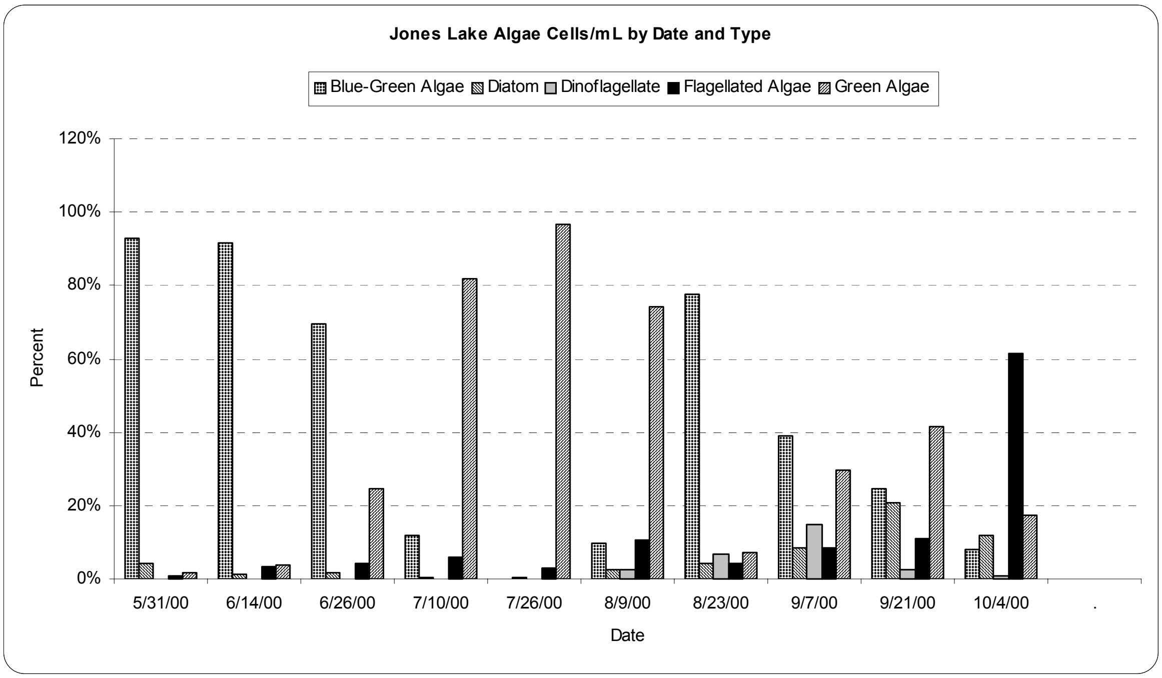


Figure 19. Jones Lake Monthly Algae Density and Biovolume

Blue-green algae numerically dominated the Jones Lake algae community from late May through June, due mainly to an early bloom of *Aphanizomenon* (Figure 20). In July and early August, *Aphanizomenon* was replaced by several species of planktonic green algae (Chlorococcales) primarily *Oocysis pusilla* and *O. lacustris* (Figure 20). Blue-greens then reappeared as numerical dominants in late August through September. These were mostly very small species, *Aphanothece and Anacystis*, that were insignificant in terms of biovolume. Similarly, green algae reappeared as major plankton components in late September and early October, mainly as *Oocystis pusilla.* However, in October flagellated algae, *Rhodomonas* and *Cryptomonas*, clearly became the dominant group in the autumn algae community of Jones Lake.

Figure 20. Jones Lake Algae Cells/ mL by Date and Type



Two seasonal peaks in algal biovolume were identified during this survey (Figure 19). The smaller peak in late June was partly the result of relatively large numbers of blue-green algae (*Aphanizomenon*) present at that time, but nearly half of the algal biovolume was provided by moderate numbers of a single large-sized diatom species, *Stephanodiscus niagarae* (Table D).

The larger peak on August 23 was produced almost entirely (93%) by a similarly large-sized dinoflagellate species, *Glenodinium gymnodinium* (Table D).

Blue-green algae were dominant both in terms of volume and numerically (cells/ml) during late May and early June (Figure 21). Of the 8 taxa of blue-greens collected in Jones Lake, *Aphanizomenon* was the only species to make up a significant portion of total density and algal biomass during this assessment (Tables A and C). In late June and July, blue-greens were replaced by green algae as the principal algae group by volume. In August, green algae were in their turn supplanted by dinoflagellates, mainly *Glenodinium gymnodinium*, which comprised from 34% to 95% of algal biovolume from August to October 2000 (Table D).

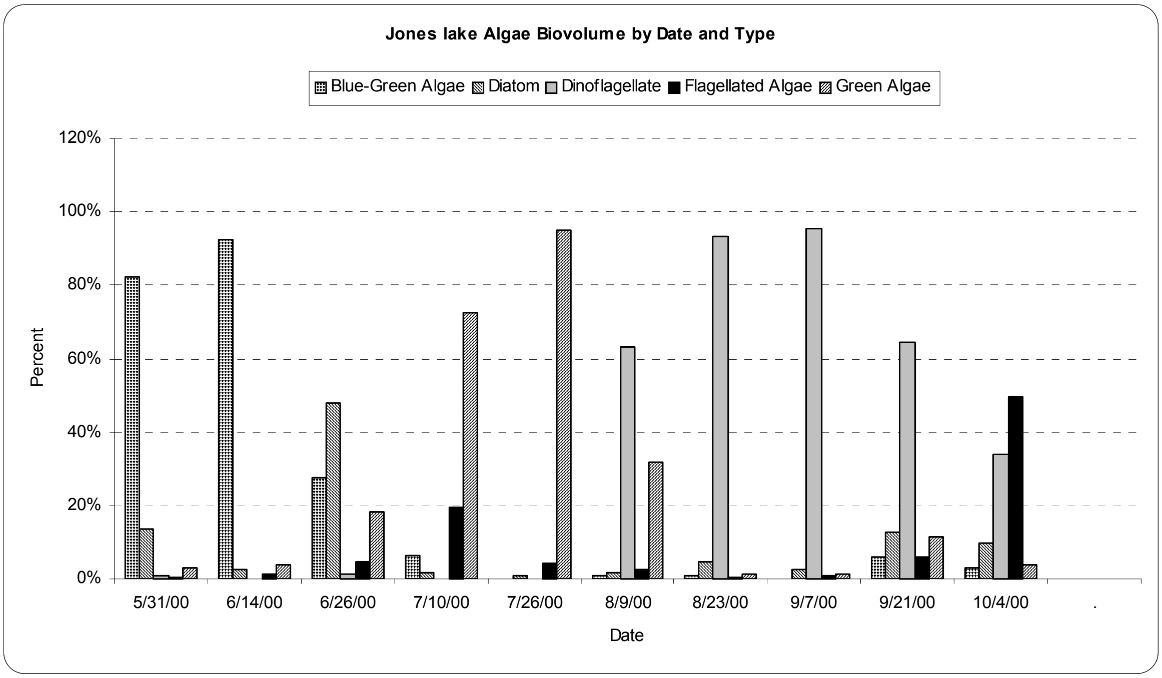


Figure 21. Jones Lake Algae Biovolume by Date and Type

The algae communities of typical Midwestern hardwater lakes are frequently dominated by blue-green algae and diatoms with green algae usually making up only a relatively small percentage of the total population (Prescott, 1962). In Jones Lake, green algae (Chlorophyta : Chlorococcales) replaced diatoms as one of the major algae groups during this survey. In ponds and smaller lakes, planktonic green algae may be abundant (Round 1965) especially if there is an ample supply of dissolved free carbon dioxide (Shapiro 1973). Whereas free CO^2 should typically be in low supply in alkaline waters such as Jones Lake (Reid 1961), CO^2 may be supplied in sufficient quantities through the decay of large amounts local vegetation and other organic matter derived from the immediate watershed. The presence of ample nitrogenous organic compounds in Jones Lake is suggested by the dominance (by volume) of the dinoflagellate *Glenodinium gymnodinium* in the summer plankton of Jones Lake. Some dinoflagellates and a number of other motile algae species respond favorably to the presence of organic compounds such as those supplied by runoff from feedlots and other sources (Prescott 1962).

Blue-green algae in Jones Lake were able to develop only moderate populations during the present survey compared to those reported from other recently monitored eutrophic state lakes. The principal blue-green species, *Aphanizomenon flos-aquae*, ranged from 783 cells/ml to 26,094 cells/ml (June 14) with a mean density of 11,177 cells/ml for when it was present in algae samples.

Aquatic Macrophyte Survey

The project coordinator and technician conducted an aquatic macrophyte survey on August 1, 2000. Submerged and emergent aquatic vegetation was located, sampled, identified, and recorded at fourteen predetermined sampling transects. In addition to vegetation sampling at each transect, the accessibility of the site to domestic livestock was also documented. Transects were located at 300-meter intervals (Figure 22) with the exception of transects 9 and 12 located near the two inlets of the lake. Shallow water limited access to a portion of the area near the inlets, this transect was made from shoreline to shoreline.

Emergent species in the riparian zone were identified and recorded as present or absent within 3 meters of the transect flag which was locate at the waters edge. Species recorded were limited to those identified as aquatic or wetland species in "Aquatic and Wetlands Plants of South Dakota", written by Gary E Larson. The plant species, both common and scientific names, identified in this survey and their habitat can be found in Table 22.

Table 22. Aquatic Plant Species Encountered at Jones Lake During the Year 2000

Common Name	Genus	Species	Habitat
Arrowhead	*Sagittaria*	*latifolia*	Emergent
Cattail (narrow leafed)	*Typha*	*angustifolia*	Emergent
Coontail	*Ceratophyllum*	*demersum*	Submergent
Common Smartweed	*Polygonum*	*pennsylvanicum*	Emergent
Dull-leaf Indigo	*Amorpha*	*fruiticosa*	Emergent
Dock	*Rumex*	sp.	Emergent
Moss	*Unidentified*	*species*	Submergent
Northern Water Milfoil	*Myriophyllum*	*sibiricum*	Submergent
Panic Grass	*Panicum*	sp.	Emergent
Pondweed Family	*Potamogeton*	*filiformis*	Submergent
Reed Canarygrass	*Phalaris*	*arundinacea*	Emergent
River Bulrush	*Scirpus*	*fluviatilis*	Emergent
Sago Pondweed	*Potamogeton*	*pectinatus*	Submergent
Sedge	*Carex*	sp.	Emergent
Strawcolored Nutsedge	*Cyperus*	*strigosus*	Emergent
Swamp Smartweed	*Polygonum*	*coccineum*	Emergent
Water Hemp	*Amaranthus*	*rudis*	Emergent
Waterweed	*Elodea*	sp.	Submergent
Wild Millet	*Echinochloa*	sp.	Emergent
Willows	*Salix*	sp.	Emergent

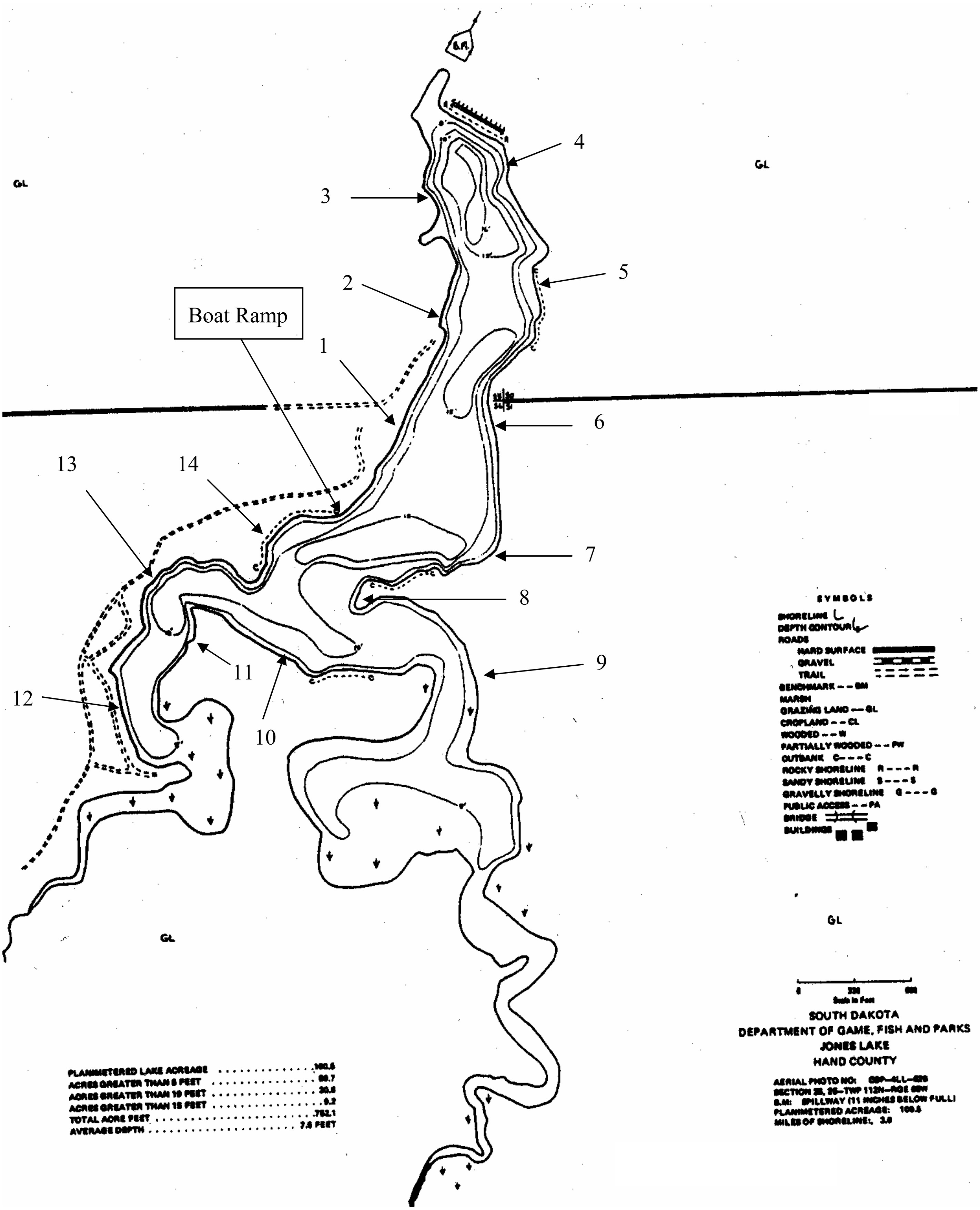


Figure 22. Aquatic Macrophyte Sampling Locations in Jones Lake

The submergent and emergent species were sampled using different methods which restricts the comparability of the data between them. Submerged species were sampled according to the Standard Operating Procedures for Field Samplers in which a plant grapple is thrown from a boat in four directions at each of the positions on a transect. The plants that are retrieved are then identified and given a numeric density rating. Emergent plants located along the shoreline were recorded as either present or absent within three meters of the flag placed at the waters edge which is used to begin the transect.

Table 23 lists the submerged species as well as the locations and densities at which they were measured. Livestock access to each transect line is also indicated in this table. Livestock have access to nine of the fourteen transects for at least a portion of the year. The transects that indicate no livestock access were located along portions of the shoreline that are publicly owned. The remaining transects are located along privately owned pastures that utilize the lake as a water source.

The most frequently encountered species was an *Elodea* sp. found at 89% of the transects with an average density of 3.6. The least abundant species was an unidentified species of moss growing on the bottom of the lake at transect 7.

There were some differences noted in the number and density of species found between transects with and without livestock access. The average number of species found at sites without access was 4.0 while the sites with access had an average of 3.7. The largest difference seen between the two groups of sites was the total plant density. Sites without livestock access had a density of 12.3 while the sites with access had a density of 8.8.

Table 23. Submergent Aquatic Macrophyte Abundance in Jones Lake

Species	1	2	3	4	5	6	7	8	9a	9b	9c	9d	10	11	12a	12b	12c	13	14	Mean Density	Frequency of Occurrence
Coontail	.	1	1	1	.	2	.	1	.	.	.	.	3	1	.	.	.	1	.	0.58	42%
Northern Water Milfoil	.	2	1	.	.	.	.	1	4	1	3	3	3	4	2	4	1	2	4	1.84	74%
Waterweed (Elodea)	.		3	3	2	3	5	4	5	5	5	3	5	4	3	2	1	2	5	3.16	89%
Sago pondweed	.	.	1	3	1	.	3	2	1	5	3	3	1	1	4	3	5	.	1	1.95	79%
Flatstem Pondweed	.	1	3	3	.	.	.	5	5	.	2	2	2	.	3	5	2	2	.	1.84	63%
Moss	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	0.05	5%
Livestock access	N	N	Y	Y	Y	Y	N	N	N				Y	Y	Y			Y	Y		
Livestock access			5	4	2	2							5	4	4			4	3	3.67	Average # of Species
No Livestock	0	3					3	5	4											4.0	
Livestock access			9	10	3	5							14	10	12			7	10	8.8	Total Density
No Livestock	0	4					9	13	15											12.3	

A total of 14 emergent species were identified along the shores of Jones Lake. All fourteen of the species were recorded at sites with livestock access, while only nine were documented at sites without livestock. While five species were recorded only in areas with livestock access, the average number of species located at a transect was higher for transects without livestock. It is likely that the portions of the lake with livestock excluded have higher plant densities. The most frequently encountered species found at Jones Lake was the common smartweed, *Polygonum pennsylvanicum,* documented at 79% of the transects (Table 24).

Table 24. Emergent Aquatic Macrophyte abundance in Jones Lake

Species	1	2	3	4	5	6	7	8	9a	9b	9c	9d	10	11	12a	12b	12c	13	14	Frequency of Occurrence	
River Bulrush	1	.	.	1	.	1	1	1	1				1	.	1			1	1	71%	
Carex sp.	1	.	.	.	.	.	.	1	.				1	1	1			1	1	50%	
Swamp Smartweed	1	.	.	.	.	.	.	1	.				.	.	1			.	.	21%	
Common Smartweed	1	1	.	1	.	1	1	1	1				1	1	.			1	1	79%	
Dull leaf indigo	.	1	.	.	1	1	1	1	1				.	.	.			.	.	43%	
Salex sp.	.	1	.	.	.	1	1	.	.				.	.	.			.	.	21%	
Wild Millet	.	1	.	1	1	1	.	.	.				.	.	.			.	.	29%	
Cattail	.	.	.	.	1	.	1	.	1				.	.	.			.	.	21%	
Rumex sp.	.	.	.	.	.	.	.	1	.				1	1	.			1	1	36%	
Reed Canary	.	.	.	.	.	.	.	.	.				1	1	.			1	.	21%	
Straw Colored Nutsedge	.	.	.	.	.	.	.	.	.				1	1	1			1	1	36%	
Arrowhead	.	.	.	.	.	.	.	.	.				.	1	.			.	.	7%	
Panic Grass	.	.	.	.	.	.	.	.	.				.	1	.			.	.	7%	
Water Hemp	.	.	.	.	.	.	.	.	.				.	1	.			.	.	7%	
Livestock access			0	3	3	5							6	8	4			6	5	Average # of Species	4.4
No Livestock	4	4					5	6	4												5.0

It appears that plant density (submergent and emergent) is adversely affected by the presence of livestock at Jones Lake. The number of species does not appear to be negatively impacted by livestock presence. Increasing plant densities along the shoreline of the lake may result in several changes. More plants would decrease shoreline erosion and may also use some of the available nutrients reducing the amount available for use by algae, ultimately improving the water quality of the lake.

Threatened and Endangered Species

There are no threatened or endangered species documented in the Turtle Creek watershed. The US Fish and Wildlife Service lists the whooping crane, bald eagle, and western prairie fringed orchid as species that could potentially be found in the area. None of these species were encountered during this study; however, care should be taken when conducting mitigation projects in the Turtle Creek watershed.

Bald eagles typically prefer large trees for perching and roosting. As there are no confirmed documentation of bald eagles within the Turtle Creek watershed, little impact to the species should occur. Any mitigation processes that take place should avoid the destruction of large trees that may be used as eagle perches, particularly if an eagle is observed using the tree as a perch or roost.

Whooping cranes have never been documented in the Turtle Creek watershed. Sightings in this area are likely only during fall and spring migration. When roosting, cranes prefer wide, shallow, open water areas such as flooded fields, marshes, artificial ponds, reservoirs, and rivers. Their preference for isolation and avoidance of areas that are surrounded by tall trees or other visual obstructions makes it unlikely that they will be present in the project area to be negatively impacted as a result of the implementation of BMPs. If whooping cranes are sighted during the implementation of mitigation practices, all disruptive activities should cease until the bird(s) leave of their own volition.

Although there have never been any confirmed documentations of the western prairie fringed orchid in this watershed, habitat suitable for its survival does exist. Western prairie fringed orchid grows in tall grass prairies and meadows. Wetland draining and the conversion of rich soil prairies to agricultural cropland threaten the orchid's survival. Overgrazing, improper use of pesticides, and collecting also threaten its survival (Missouri, 2001). Proposed BMPs for the Turtle Creek watershed should reduce the occurrence of overgrazing, ultimately enhancing the condition of local wetlands and increasing the survivability of this species, if it were ever to grow here.

Other Monitoring
Agricultural Non-Point Source Model (AGNPS)

AGNPS is a data intensive watershed model that routes sediment and nutrients through a watershed by utilizing land uses and topography. The watershed is broken up into equally sized portions, or cells of 40 acres. Each of these cells requires 26 parameters to be collected and entered into the program. Best Management Practices (BMPs) are then simulated by altering the land use in the individual cells.

The targeted or "critical" cells are identified by the amount of nutrients that they produce that ultimately reaches the outlet of the watershed. The cells in the Turtle Creek watershed were broken into four levels of priority. Cell priority was assigned based on average nutrient loads produced by cells within the watershed. Cells that produce nitrogen **and** phosphorus loads greater than two standard deviations over the mean for the watershed were given a priority ranking of 1. Cells that produce nitrogen **or** phosphorus loads greater than two standard deviations over the mean were given a priority ranking of 2. Cells that produce nitrogen **and** phosphorus loads greater than one standard deviation over the mean were given a priority ranking of 3. Cells that produce nitrogen **or** phosphorus loads greater than one standard deviation over the mean were given a priority ranking of 4. Figures 23 through 26 represent the approximate locations of the critical cells in the Jones Lake watershed.

Table 25. Expected Nutrient Reductions in the Turtle Creek Watershed after BMP Implementation

Expected Nutrient Reductions in the Turtle Creek Watershed after BMP Implementation				
	Lbs/acre at outlet	Total N	Lbs/acre at outlet	Total P
Current	1.53	36597.6	0.38	9089.6
Priority 1 (2.7% of the Watershed)	1.51	36119.2	0.38	9089.6
% Reduction		1.3%		0.0%
Current	1.53	36597.6	0.38	9089.6
Priority 2 (4.2% of the Watershed)	1.50	35880	0.37	8850.4
% Reduction		2.0%		2.6%
Current	1.53	36597.6	0.38	9089.6
Priority 3 (7.8% of the Watershed)	1.50	35880	0.37	8850.4
% Reduction		2.0%		2.6%
Current	1.53	36597.6	0.38	9089.6
Priority 4 (11.2% of the Watershed)	1.50	35880	0.37	8850.4
% Reduction		2.0%		2.6%

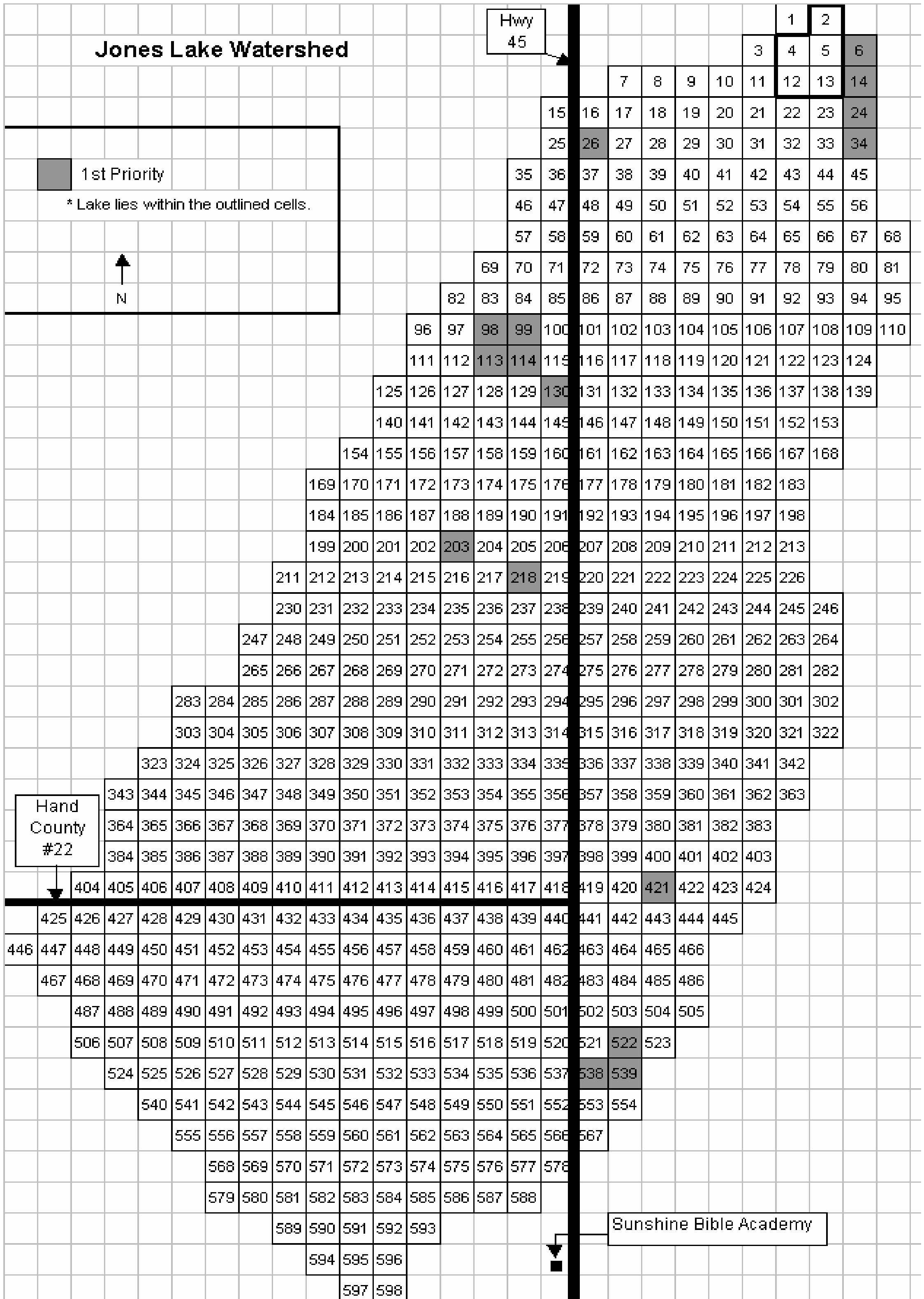


Figure 23. Priority 1 Cells, Jones Lake Watershed

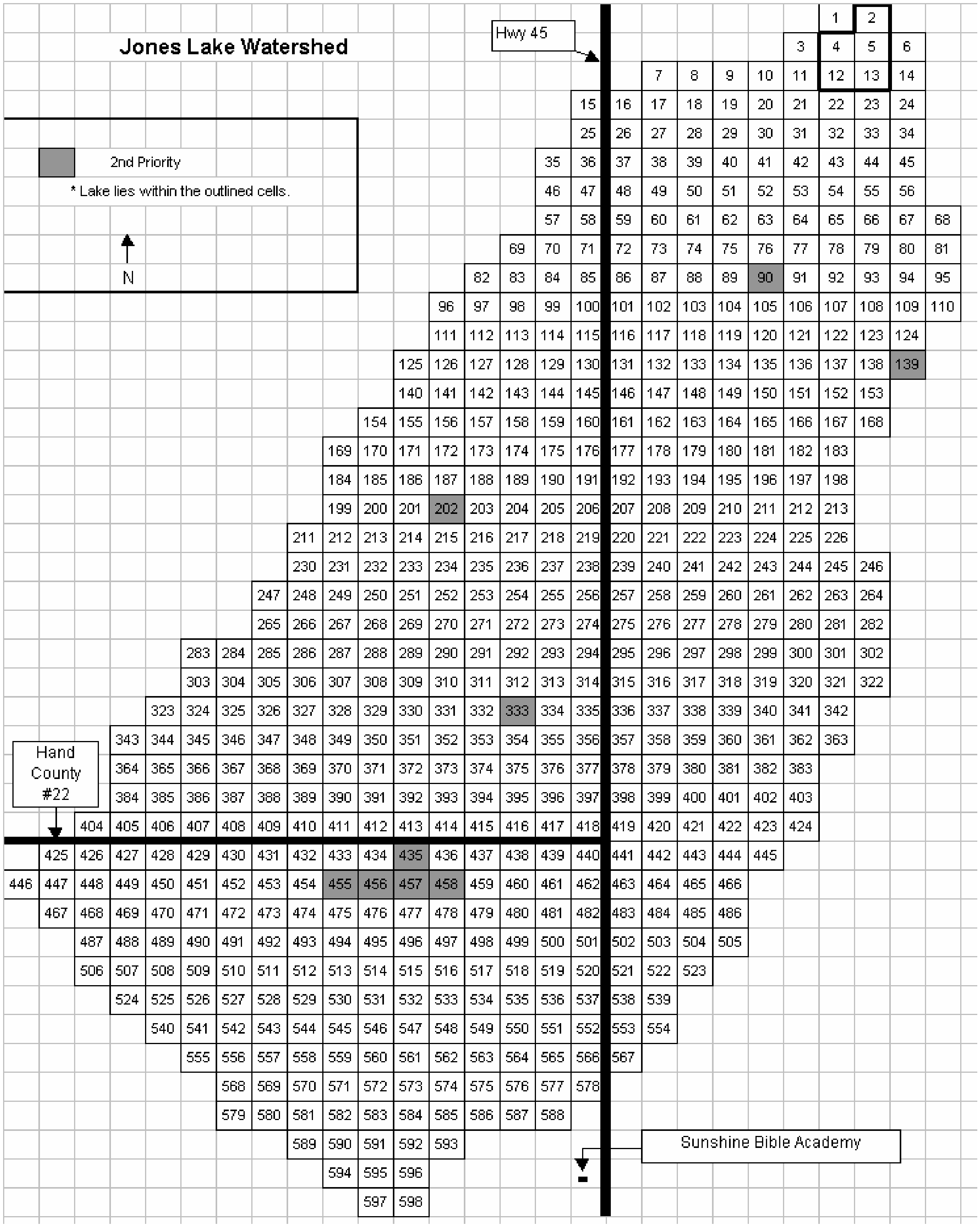


Figure 24. Priority 2 Cells, Jones Lake Watershed

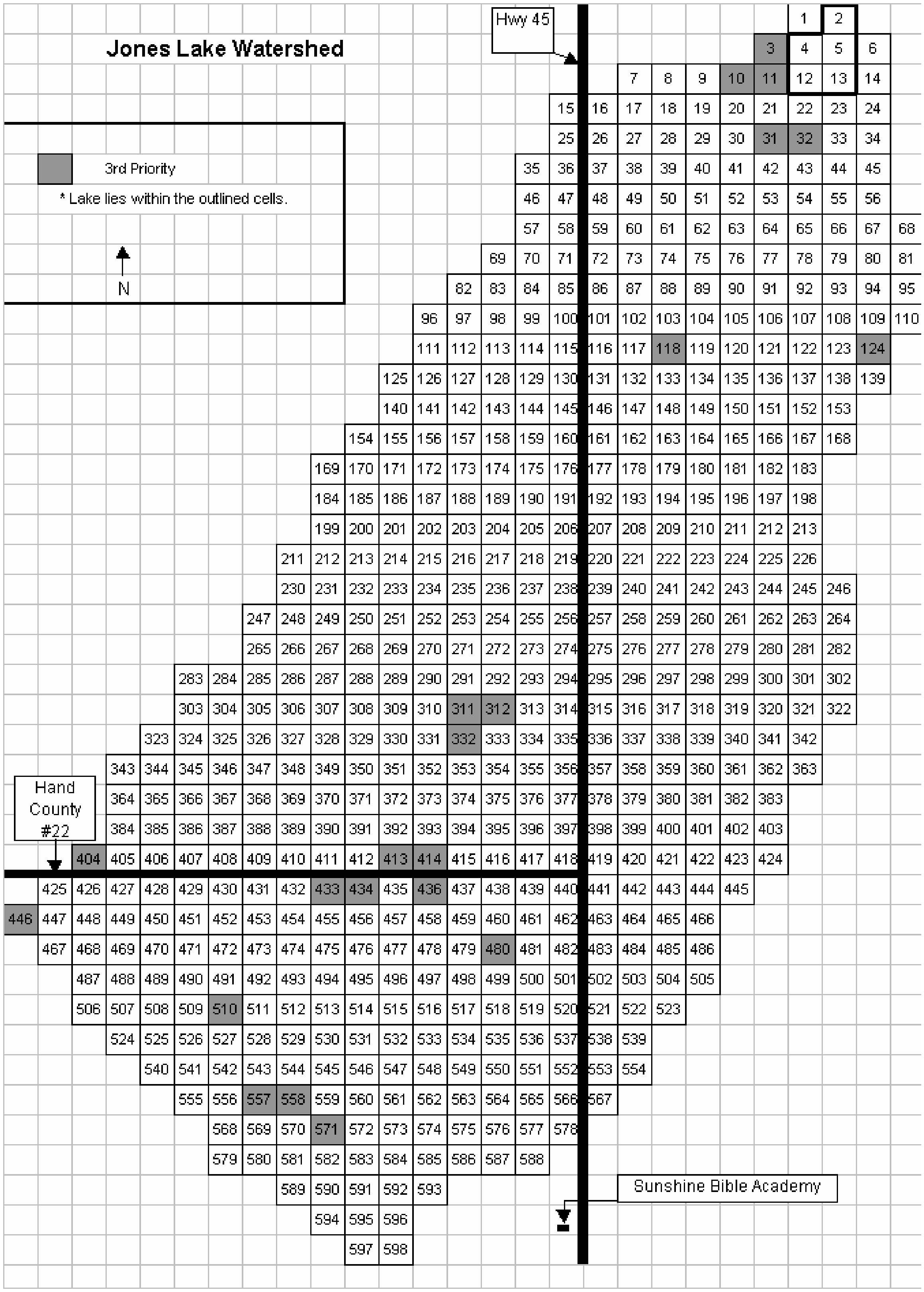


Figure 25. Priority 3 Cells, Jones Lake Watershed

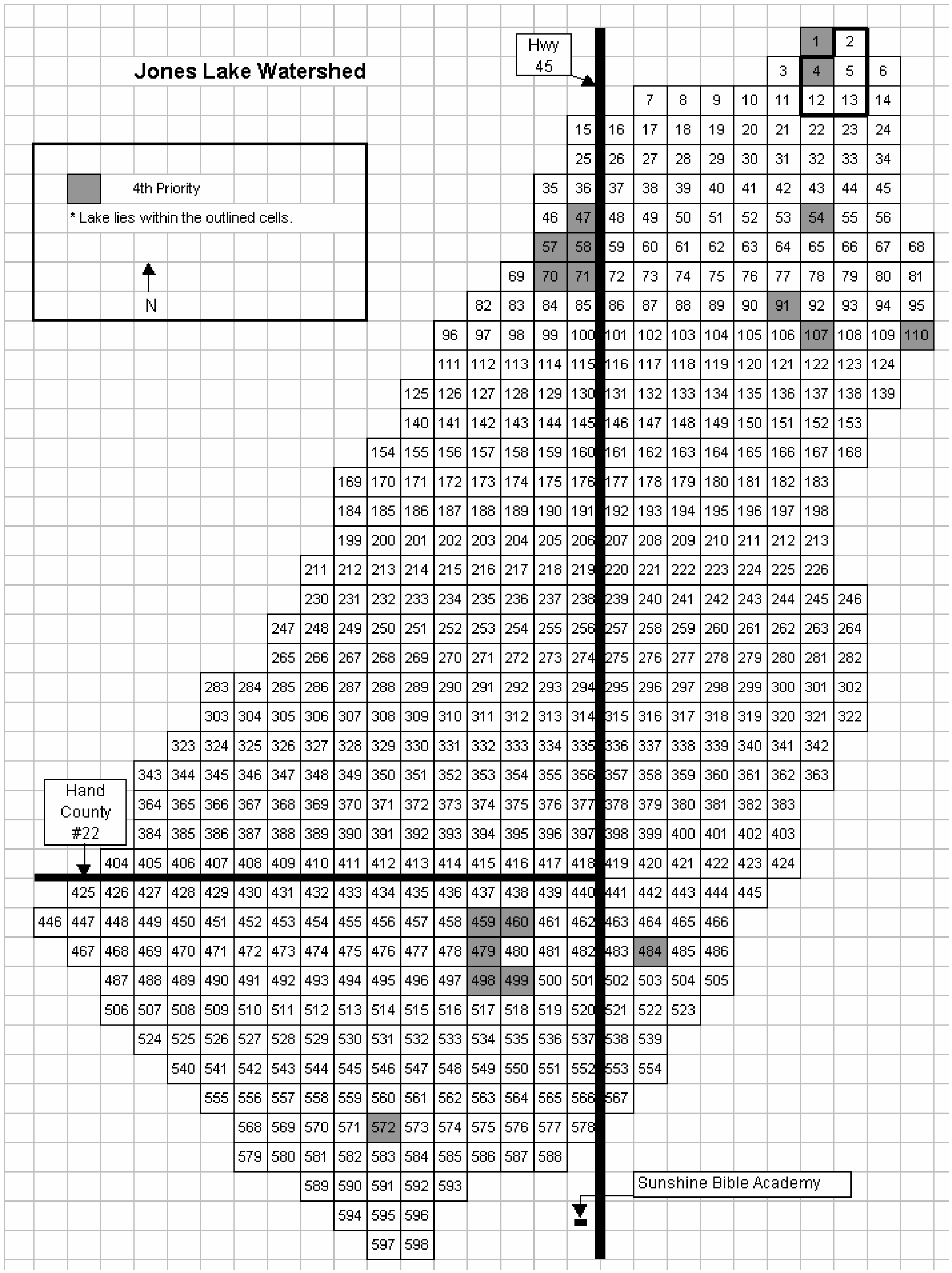


Figure 26. Priority 4 Cells, Jones Lake Watershed

The Turtle Creek watershed was composed of 598 cells resulting in a total of 23,920 acres. Of this, 640 acres (16 cells) or about 2.7% of the watershed falls within the priority 1 category. Best Management Practices for these cells include 1 animal nutrient management system, a buffer area and shoreline stabilization.

There are 360 acres (9 cells) that fall within the priority 2 category, which brought the total amount of acres to treat to 1000 or 4.2% of the watershed. All of these acres were cropland that had existing conservation tillage practices and were not located within close proximity to an identified channel. Best Management Practices would include an animal nutrient management system.

Table 26. Targeted Cells for BMP in the Jones Lake Watershed

Priority	Animal Feeding Operations	Buffer Strips
1	218	
2	90	
3		
4		47, 57, 58, 70, 71

In the priority 3 category there were a total of 880 acres (22 cells). This makes a total of 1,880 acres to treat or 7.8% of the watershed. All of the acres of cropland and grassland have existing conservation practices. The use of grassed waterways or buffer strips may reduce nutrient loadings in the cropland acres, however each one should be examined in the field.

Priority 4 cells totaled 800 acres (20 cells). This brings the final total to 2,680 acres or 11.2% of the watershed. A majority of these cells have existing conservation practices. Best Management Practices would include a cover crop to 40 acres of fallow ground near the lake and the use of grassed waterways or buffer strips, but these cells should be examined in the field first.

The priority areas consist of 88% conservation tillage, 7.5% conventional tillage and 4.5% grassland. Implementation efforts should be limited to those areas identified as first and second priority. The exclusion of third and fourth priority cells from implementation is due to the fact that little or no change was calculated with the model when changes were made to these cells. Due to the already extensive use of conservation tillage practices in the priority areas and the rest of the watershed, the treatment of cropland with BMPs will likely result in conservative nutrient loading reductions of 2-3% to the lake.

To better estimate what might be considered natural background levels of phosphorus, the watershed model was adjusted to simulate removal of all cropping and grazing practices. All of the cells were adjusted to numbers similar to what the best CRP acres in the watershed. Reductions in the phosphorus load of 68% were achieved through this process. This still falls 2% short of the 70% needed to alter the lakes trophic state to less than 65. Elimination of the internal loading is the only way to achieve this goal.

The AGNPS program was not designed to adequately assess range conditions. The Turtle Creek watershed was composed of 53.8% rangeland and 46.2% cropland. Rotational grazing and exclusion of livestock from critical areas (steep slopes adjacent to the lake and stream) will provide benefits that are difficult to simulate in this model. These additional practices will likely result in conservative reductions of 5% to 10% in addition to what the model had already simulated.

Sediment Survey

A sediment survey was conducted during February of 2001. The survey covered the northern half of the reservoir, snow and ice depths made the south end of the lake inaccessible. Sediment depths were greatest along areas of the lake that had problems with bank erosion indicating that this is a primary source of sediments in the lake. These areas may be identified in Figure 27 along the eastern shore of the lake. The measured sediment volume for the northern portion of the lake was 170,000 cubic yards. The remaining 45 acres of the lake is likely to have similar volumes of sediment bringing the total volume to an estimated 300,000 cubic yards (185 acre feet) of sediment.

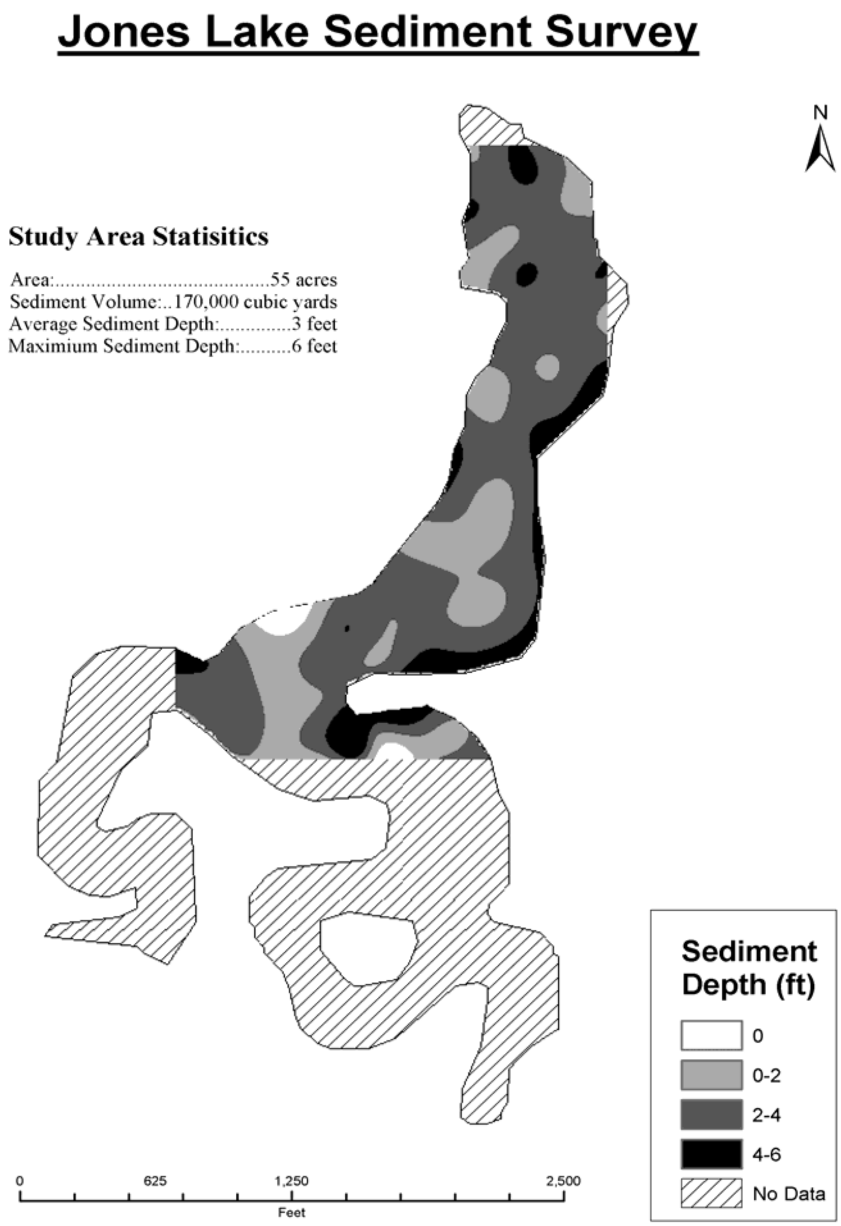


Figure 27. Sediment Depths in Jones Lake

Quality Assurance Reporting (QA/QC)

Quality assurance and quality control or QA/QC samples were collected for 10% of the inlake and tributary samples taken. A total of 32 tributary samples and 30 lake samples were collected along with seven sets of replicates and blanks. All QA/QC samples may be found in Table 27, with blank samples that were above the detection limit highlighted.

Blank samples were very 'clean' with the exception of total dissolved phosphorus concentrations. Four of the seven blank samples collected had detectable concentrations of dissolved phosphorus, while two of the samples had detectable levels of total phosphorus. It is unclear why these samples were contaminated, some possible causes could be improperly cleaned bottles, contamination in the field, or a contaminated distilled water supply. Regardless of the reason for the contamination, it is unlikely that contamination occurring at the concentrations detected in the blanks would greatly alter the results. The highest level measured in a blank was .013 mg/L, (from the lake sample collected on July 26, 2000) and is only enough to affect the sample +/- 2%. The only other parameter with a detectable contamination level was that of ammonia collected from the outlet of Jones Lake on September 21, 2000.

Replicate samples for alkalinity, total solids, total dissolved solids, ammonia, nitrates, total phosphorus and dissolved phosphorus were all within 5% of the actual samples. Fecal coliform and *E. coli* were 13% and 21% different, respectively, of actual samples. They would have fallen within the 10% range, however, each had a sample with a difference of greater than 40%. Samples that had the greatest differences were total suspended solids and volatile suspended solids.

Volatile solids may be considered to have the least reliable of the data with an average percent difference of 46%. Suspended solids had a mean percent difference of 28%.

The low concentrations and high variability in total suspended and volatile suspended solids makes this data somewhat questionable. The remainder of the data appears to be accurate and representative of the waters that were sampled. The phosphorus contamination likely poses little risk to the integrity of the data, as the detected concentrations were very minimal and would affect the overall concentrations by less than 2% in all cases.

Table 27. Quality Assurance and Quality Control Samples for Jones Lake and Turtle Creek

TYPE	SITE	DATE	Depth	TALK	Tot Sol	TDS	TSS	Amm	Nit	TKN	TP	TDP	Fecal	VTSS	*E COLI*
Blank	JL-9	5/31/00	Surface	<6	<7	<7	<1	<.02	<.1	<.21	0.004	0.006	<10	<1	
Grab	JL-2	5/31/00	Surface	224	649	618	7	0.01	0.05	1.58	0.335	0.327	5	2.0	
Rep	JL-12	5/31/00	Surface	224	660	614	11	0.01	0.05	1.63	0.348	0.302	5	2.0	
				0%	2%	1%	44%	0%	0%	3%	4%	8%	0%	0%	
Blank	JL-9	7/26/00	Surface	<6	<7	<7	<1	<.02	<.1	<.21	0.013	0.003	<10	<1	
Grab	JL-3	7/26/00	Surface	228	668	649	13	0.01	0.05	1.57	0.759	0.631		3.0	
Rep	JL-13	7/26/00	Surface	230	666	628	13	0.01	0.05	1.58	0.804	0.639		5.0	
				1%	0%	3%	0%	0%	0%	1%	6%	1%		50%	
Blank	Jl-9	9/21/00	Surface	<6	<7	<7	<1	0.05	<0.1	<0.21	<0.002	0.002	<10	<1	
Grab	JL-1	9/21/00	Surface	248	710	671	11	0.01	0.10	1.59	0.730	0.624	5	3.0	
Rep	JL-11	9/21/00	Surface	248	707	672	13	0.01	0.10	1.65	0.793	0.658	5	4.0	
				0%	0%	0%	17%	0%	0%	4%	8%	5%	0%	29%	
Blank	JLO-91	5/15/01	Surface	<6	<7	<7	<1	<0.02	<0.1	<0.36	<0.002	<0.002	<10	<1	<1
Grab	JLO-1	5/15/01	Surface	103	340	328	12	0.01	0.05	1.89	0.486	0.35	5	4	35
Rep	JLO-11	5/15/01	Surface	103	341	329	12	0.01	0.05	1.49	0.475	0.32	5	5	31.3
				0%	0%	0%	0%	0%	0%	24%	2%	9%	0%	22%	11%
Blank	JLT-92	5/15/01	Surface	<6	<7	<7	<1	<0.02	<0.1	<0.36	<0.002	<0.002	<10	<1	<1
Grab	JLT-2	5/15/01	Surface	167	649	647	2	0.01	0.3	1.06	0.474	0.441	310	0.5	326
Rep	JLT-12	5/15/01	Surface	167	624	623	1	0.01	0.3	1.34	0.481	0.438	320	0.5	211
				0%	4%	4%	67%	0%	0%	23%	1%	1%	3%	0%	43%
Blank	JLT-94	5/17/01	Surface	<6	<7	<7	<1	<0.02	<0.1	<0.36	<0.002	<0.002	<10	<1	<1
Grab	JLT-4	5/17/01	Surface	198	654	649	5	0.01	1.8	1.24	0.255	0.221	60	2	122
Rep	JLT-14	5/17/01	Surface	197	661	658	3	0.01	1.8	1.64	0.264	0.216	130	0.5	135
				1%	1%	1%	50%	0%	0%	28%	3%	2%	74%	120%	10%
Blank	JLT-95	5/17/01	Surface	<6	<7	<7	<1	<0.02	<0.1	<0.36	<0.002	0.003	<10	<1	<1
Grab	JLT-5	5/17/01	Surface	211	734	728	6	0.01	0.1	1.36	0.425	0.365	40	3	33.6
Rep	JLT-15	5/17/01	Surface	209	731	724	7	0.01	0.1	1.08	0.418	0.373	40	1	41.3
				1%	0%	1%	15%	0%	0%	23%	2%	2%	0%	100%	21%

Public involvement and coordination

State Agencies

The South Dakota Department of Environment and Natural Resources (SDDENR) was the primary state agency involved in the completion of this assessment. SDDENR provided equipment as well as technical assistance throughout the course of the project.

The South Dakota Department of Game, Fish and Parks also aided in the completion of the assessment by providing historical information on use of the recreation area and a complete report on the condition of the fishery in Jones Lake.

Federal Agencies

The Environmental Protection Agency (EPA) provided the primary source of funds for the completion of the assessment on Jones Lake.

The Natural Resource Conservation Service (NRCS) provided technical assistance, particularly in the collection of soils data for the AGNPS portion of the report.

The Farm Service Agency provided a great deal of information that was utilized in the completion of the AGNPS modeling portion of the assessment.

Local Governments; Industry, Environmental, and other Groups; and Public at Large

The Central Plains Water Development District (CPWDD) provided the local sponsorship that made this project possible. In addition to providing administrative sponsorship, CPWDD also provided local matching funds and personnel to complete the assessment.

The Hand County Conservation District provided work space, financial assistance, and aided in the completion of the AGNPS report.

Public involvement consisted of some individual meetings with landowners that provided a great deal of historic perspective on the watershed. Additionally, landowners were contacted through mailings to which most responded with information needed to complete the AGNPS model.

Aspects of the Project That Did Not Work Well

All of the objectives proposed for the project were met in an acceptable fashion and in a reasonable time frame (see the milestone table on page 8). The number of tributary samples collected during the project was less than proposed, but adequate for the completion of the report. The exception to this was the collection of data from site JLT-3, which was discontinued due to construction activities in the area.

Quality Assurance and Quality Control samples indicated that the data was accurate with the exception of volatile suspended solids, which had the highest percent differences between the samples and their replicates. It is unclear what steps need to be taken to reduce the error in this measurement to an acceptable level.

Future Activities Recommendations

There are a number of concerns that need to be addressed in the Turtle Creek and Jones Lake watershed. Mitigation processes in this watershed should take into consideration the following items:

1. Target spring runoff events. Most of the tributary nutrient loading to Jones Lake occurs during spring runoff events, lake improvement projects should take this into consideration and target this period of runoff if possible.

2. There may be some fecal coliform contamination during spring runoff events. Limiting livestock access to the tributary system during the spring may help to alleviate this problem.

3. Subwatershed JLT-5 is the most impaired and is the source of approximately 75% of the nutrient load to the lake. Restoration activities in this area may result in the greatest improvements to the water quality of the lake.

4. Subwatershed JLT-2 is releasing large amounts of nutrients, however it does not appear that they are reaching the lake.

5. There is a significant problem with internal loading of nutrients in the lake, particularly phosphorus. Reduction or elimination of this load during the summer may dramatically improve the trophic state of the lake and would likely result in full support of its beneficial uses.

6. Jones Lake currently needs a TSI shift of 6 points (requiring 70% load reductions) to reach 65, which was identified as an ideal state for lakes within its ecoregion. A shift to a TSI of less than 70 would require a loading reduction of 10% to 20%.

7. Additional reductions may be possible through inlake treatments such as the application of alum. Phosphorus concentrations may be expected to drop a conservative 30% making a TSI of 70 attainable.

8. pH values exceeding the state standard are common in Jones Lake. It is unclear what is causing the high pH levels, however the most likely cause may be the soils located under the lake. Proposed dredging or other activities that may disturb the subsoils in and near the lake should be examined closely to insure that further increases in the pH of the lake do not occur.

9. Exclusion of livestock from the shorelines of Jones Lake may result in greater plant diversity, a more stable shoreline, and a reduction in available nutrients. Future sampling activities should attempt to quantify the density of the emergent plant species.

10. The installation of two animal feeding operations and buffer strips will yield a 2-3% reduction in nutrient loading.

Taking into consideration the amount of conservation tillage already in use in the Jones Lake watershed, a 70% reduction in the phosphorus load to the lake is not possible. Elimination of the internal loading would likely result in a sufficient change in the lakes TSI to reach full support, however this lakes location and size would make it difficult to find the local support required for costly inlake restoration activities. These factors in addition to the semi-permanent fishery classification (occasional fish kills expected) and the absence of a swimming beach (limited immersion recreational use) indicate that a numeric target greater than 65 may be more appropriate for this lake. The first steps to improvement of this lake should be limited to the reduction in loads as identified in the AGNPS section of this report.

In addition to "on the ground" management practices, the use of informational meetings and materials will also aid in local understanding and involvement in a project. Continued monitoring as well as a post-implementation assessment should be completed if any or all of the discussed mitigation procedures are completed.

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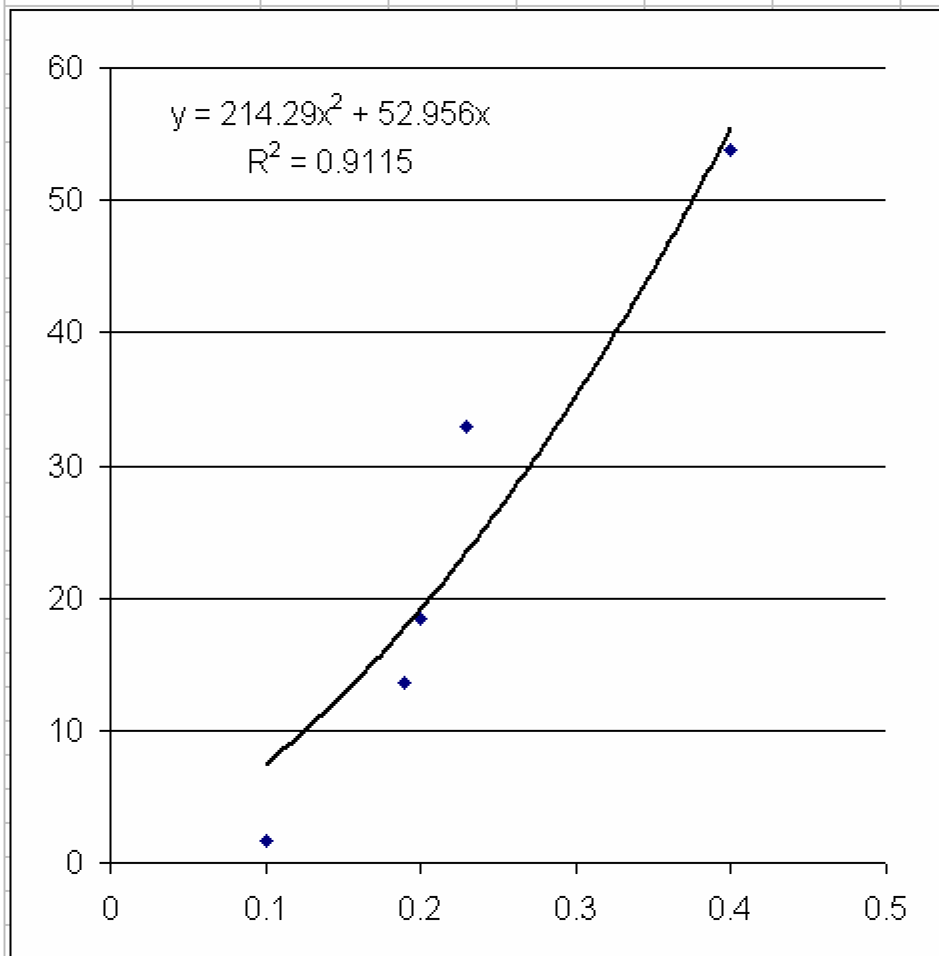
Appendix A. Stage to Discharge Tables

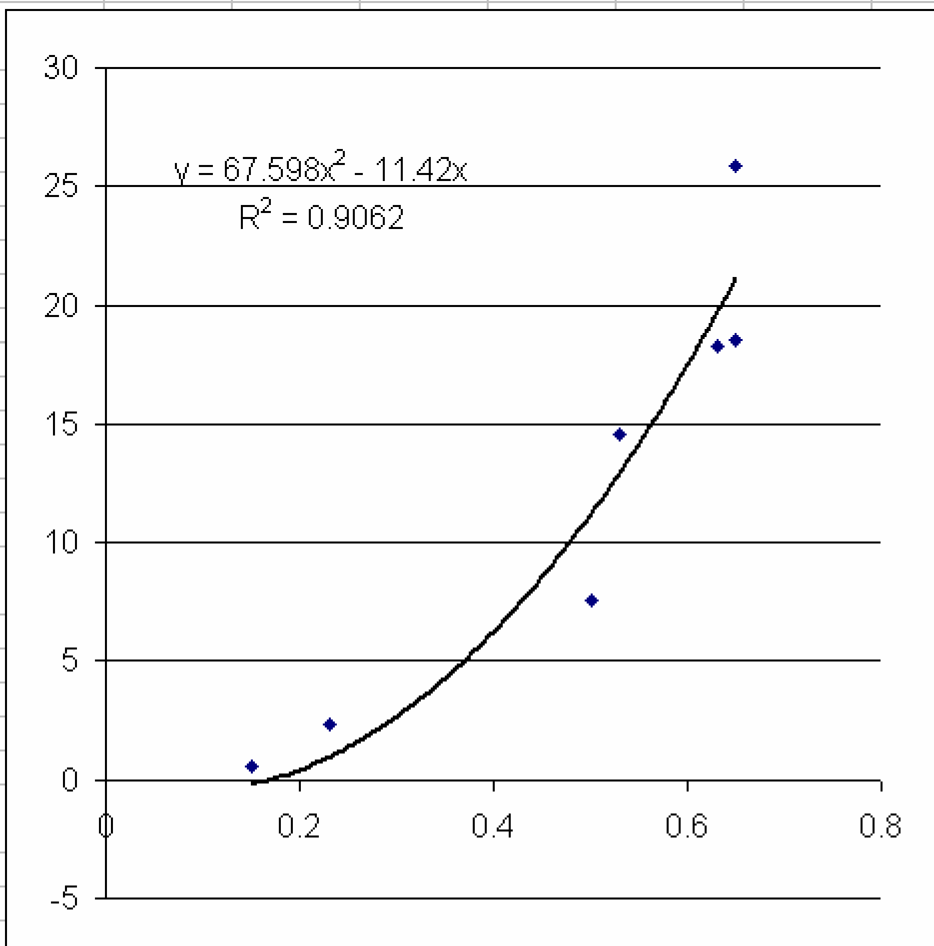
JLO-1

Stage	Discharge
0.4	53.84
0.2	18.5
0.19	13.57
0.23	32.91
0.1	1.7



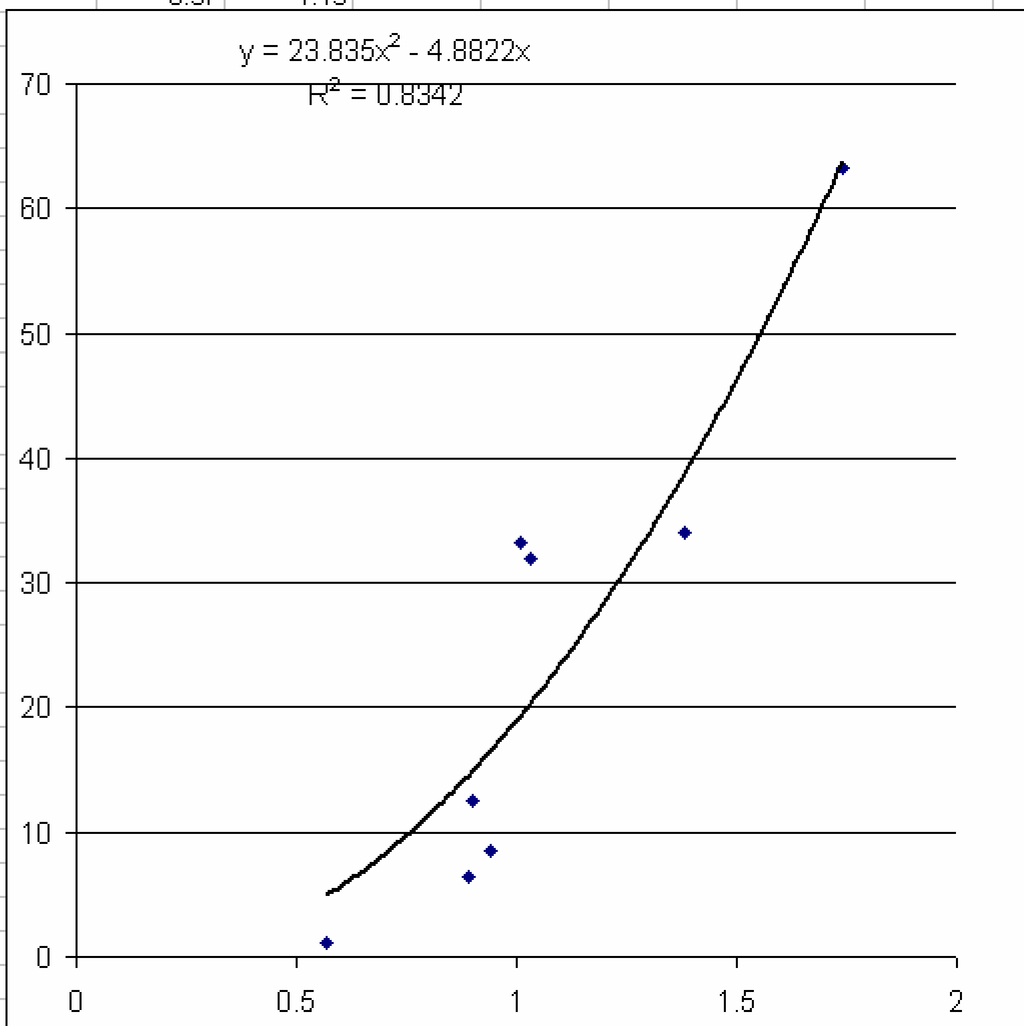
JLT-2

Stage	Discharge
0.65	18.5
0.63	18.3
0.65	25.89
0.23	2.3
0.5	7.59
0.53	14.53
0.15	0.54



JLT-4

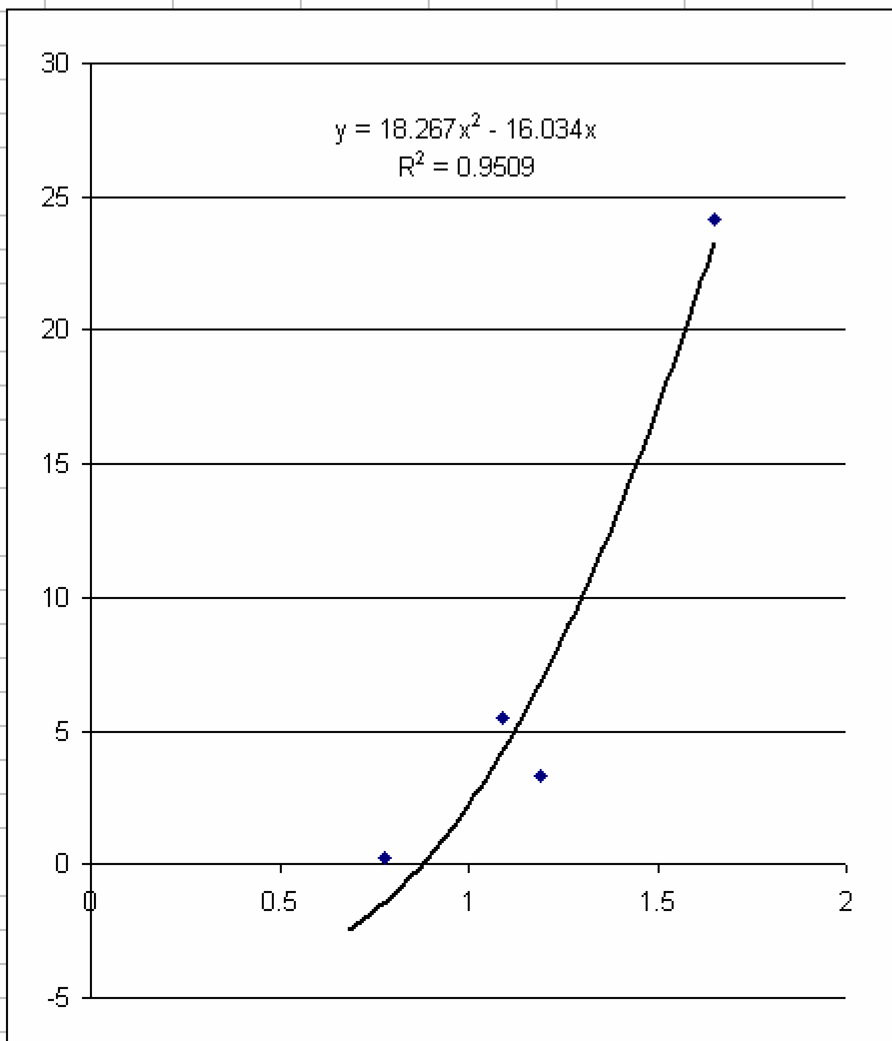
Stage	Discharge	
2.56	38.73	Throw out this point
1.01	33.18	
1.38	34.05	
0.94	8.51	
0.89	6.46	
0.9	12.58	
1.74	63.3	
1.03	31.92	
0.57	1.13	



JLT-5

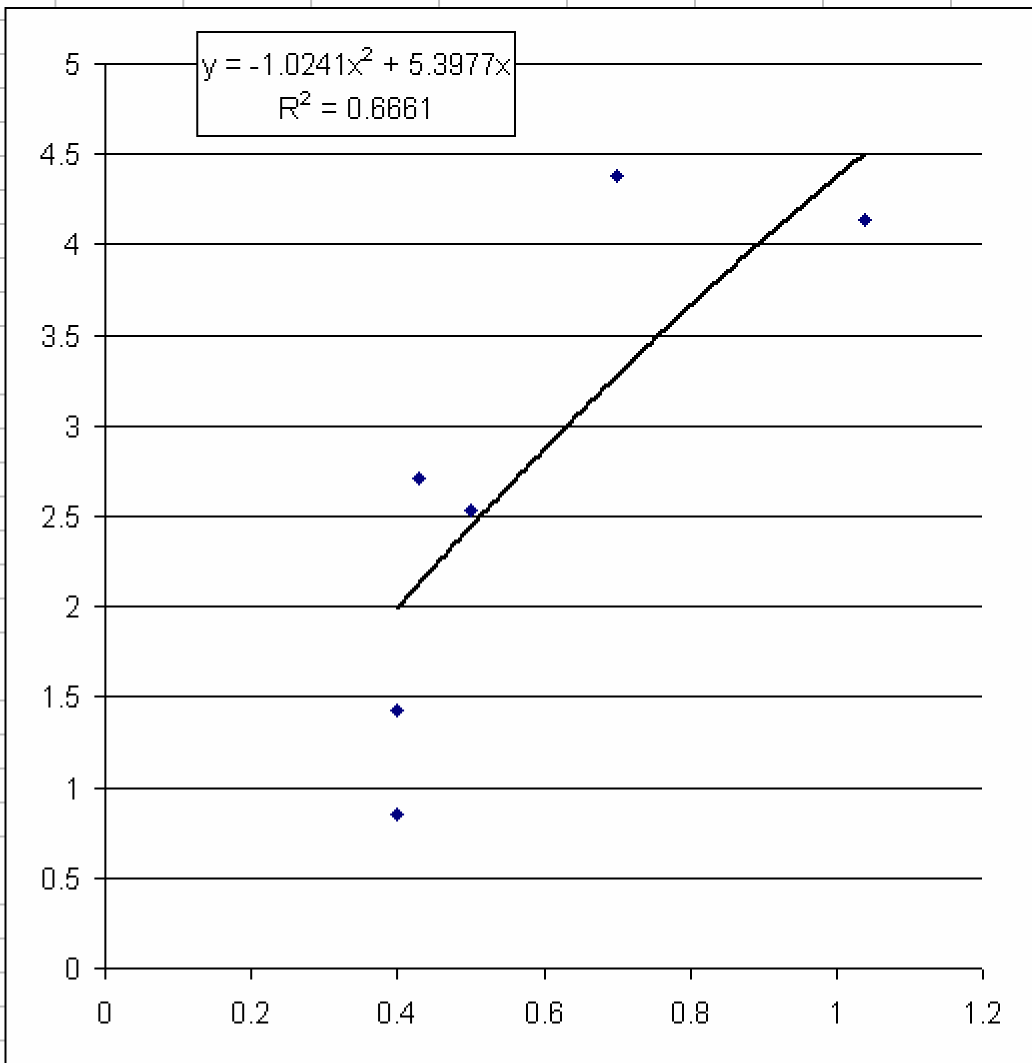
Stage	Discharge
1.09	5.52
1.19	3.32
1.65	24.15
0.78	0.24

True 0 = .71



JLT-6

Stage	Discharge	
1.04	4.14	
0.5	2.53	
0.43	2.71	
0.4	1.43	
0.4	0.85	
0.7	4.38	
1.35	0.24	Throw out point



Appendix B. Tributary Sample Data

TYPE	SITE	DATE	Depth	Wtemp	Depth	Width	Flow	DO	Cond
Grab	JLT-2	2-Apr-01	Surface						
Grab	JLT-3	3-Apr-01	Surface	0.52	1.2	5.6	2.44	12.01	183
Grab	JLT-6	3-Apr-01	Surface	0.2	1.5	9	0.54	10.81	55
Grab	JLT-4	5-Apr-01	Surface		2.8	10	0.78		
Grab	JLO-1	10-Apr-01	Surface						
Grab	JLT-2	10-Apr-01	Surface	6.56	0.65	16	27.04 cfs	10.58	190
Grab	JLT-4	10-Apr-01	Surface	3.08	1.5	10	29.85 cfs	12.22	259
Grab	JLT-5	10-Apr-01	Surface	4.57	1.2		0.36 ft/sec	10.7	296
Grab	JLT-6	10-Apr-01	Surface	9.21	0.5	4	3.42cfs	7.51	150
Integrated	JLT-5	11-Apr-01	Surface						
Integrated	JLT-6	11-Apr-01	Surface						
Grab	JLO-1	16-Apr-01	Surface	4.22	0.2		1.93 ft/sec	13.39	320
Grab	JLT-4	16-Apr-01	Surface	4.13	1.1	23	16.9	17.1	393
Grab	JLT-6	16-Apr-01	Surface	7.67	2	6	0.36	14.34	216
Grab	JLO-1	19-Apr-01	Surface		0.2		1.86 ft/sec		
Grab	JLT-2	19-Apr-01	Surface	9.24	0.2	6	2.7	8.95	419
Grab	JLT-4	19-Apr-01	Surface		1	23	10.35		
Grab	JLT-5	19-Apr-01	Surface		1.1	16.6	1.6		
Integrated	JLT-2	21-Apr-01	Surface						
Grab	JLT-4	24-Apr-01	Surface		1	23.5	18.8		
Grab	JLT-5	24-Apr-01	Surface		1.1	16	3.52		
Grab	JLO-1	25-Apr-01	Surface	6.88	0.2		2.82 ft/sec	14.32	328
Grab	JLT-4	25-Apr-01	Surface	3.17	1.45	33	56	11.8	308
Grab	JLT-2	30-Apr-01	Surface	15.66	0.5	9	9.45	7.92	348
Grab	JLT-6	30-Apr-01	Surface	16.68	0.4	2.5	0.85	6.38	272
Grab	JLT-2	8-May-01	Surface	12.28	0.5	12	14.46	10.2	340
Grab	JLT-4	8-May-01	Surface	15.92	1.1	20	29.48	11.25	384
Grab	JLT-6	8-May-01	Surface	17.38	0.8	4	5.09	9.83	262
Grab	JLO-1	15-May-01	Surface	21.32	0.1	50	2	12.7	466
Grab	JLO-11	15-May-01	Surface	21.32	0.1	50	2	12.7	466
Grab	JLO-91	15-May-01	Surface	21.32	0.1	50	2	12.7	466
Grab	JLT-2	15-May-01	Surface	22.87	0.2	5	0.77	10.53	881
Grab	JLT-12	15-May-01	Surface	22.87	0.2	5	0.77	10.53	881
Grab	JLT-92	15-May-01	Surface	22.87	0.2	5	0.77	10.53	881
Grab	JLT-4	17-May-01	Surface	17.28	0.6	8	1.2	13.28	829
Grab	JLT-14	17-May-01	Surface	17.28	0.6	8	1.2	13.28	829
Grab	JLT-94	17-May-01	Surface	17.28	0.6	8	1.2	13.28	829
Grab	JLT-5	17-May-01	Surface	15.24	0.8	15	0.24	5.86	892
Grab	JLT-15	17-May-01	Surface	15.24	0.8	15	0.24	5.86	892
Grab	JLT-95	17-May-01	Surface	15.24	0.8	15	0.24	5.86	892

TYPE	SITE	DATE	Depth	Turb	pH	Alkal	Alkalinity-P	Tot Sol	TDS
Grab	JLT-2	2-Apr-01	Surface			36	0	242	
Grab	JLT-3	3-Apr-01	Surface	4.8	8.15	45	0	191	
Grab	JLT-6	3-Apr-01	Surface	77.5	8.26	62	0	141	
Grab	JLT-4	5-Apr-01	Surface			65	0	282	
Grab	JLO-1	10-Apr-01	Surface			42	0	182	
Grab	JLT-2	10-Apr-01	Surface	23.2	7.84	39	0	168	
Grab	JLT-4	10-Apr-01	Surface	35	8.23	53	0	229	
Grab	JLT-5	10-Apr-01	Surface	49	8.7	66	0	277	
Grab	JLT-6	10-Apr-01	Surface	11.7	7.56	28	0	132	
Integrated	JLT-5	11-Apr-01	Surface			103	0	611	
Integrated	JLT-6	11-Apr-01	Surface			32	0	178	
Grab	JLO-1	16-Apr-01	Surface	37.9	8.63	92	0	317	
Grab	JLT-4	16-Apr-01	Surface	16	8.25	88	0	365	
Grab	JLT-6	16-Apr-01	Surface	5.3	8.01	47	0	226	
Grab	JLO-1	19-Apr-01	Surface			90	0	331	
Grab	JLT-2	19-Apr-01	Surface	9.2	8.73	88	0	403	
Grab	JLT-4	19-Apr-01	Surface			115	0	475	
Grab	JLT-5	19-Apr-01	Surface			110	0	460	
Integrated	JLT-2	21-Apr-01	Surface			88	0	373	
Grab	JLT-4	24-Apr-01	Surface			105	0	458	
Grab	JLT-5	24-Apr-01	Surface			125	0	544	
Grab	JLO-1	25-Apr-01	Surface	23	8.57	89	0	322	
Grab	JLT-4	25-Apr-01	Surface	63.5	8.21	87	0	393	
Grab	JLT-2	30-Apr-01	Surface	17.6	7.16	82	0	297	
Grab	JLT-6	30-Apr-01	Surface	3	6.85	68	0	237	
Grab	JLT-2	8-May-01	Surface	15.9	7.48	89	0	242	
Grab	JLT-4	8-May-01	Surface	18.4	7.87	96	0	315	
Grab	JLT-6	8-May-01	Surface	8.5	7	56	0	324	
Grab	JLO-1	15-May-01	Surface	16.3	8.74	103	16	340	
Grab	JLO-11	15-May-01	Surface	16.3	8.74	103	14	341	
Grab	JLO-91	15-May-01	Surface	16.3	8.74	<6	0	<7	
Grab	JLT-2	15-May-01	Surface	3.3	7.89	167	0	649	
Grab	JLT-12	15-May-01	Surface	3.3	7.89	167	0	624	
Grab	JLT-92	15-May-01	Surface	3.3	7.89	<6	0	<7	
Grab	JLT-4	17-May-01	Surface	2.5	8.14	198	0	654	
Grab	JLT-14	17-May-01	Surface	2.5	8.14	197	0	661	
Grab	JLT-94	17-May-01	Surface	2.5	8.14	<6	0	<7	
Grab	JLT-5	17-May-01	Surface	6.1	7.4	211	0	734	
Grab	JLT-15	17-May-01	Surface	6.1	7.4	209	0	731	
Grab	JLT-95	17-May-01	Surface	6.1	7.4	<6	0	<7	

TYPE	SITE	DATE	Depth	TSS	Amm	Nit	TKN	TP	TDP
Grab	JLT-2	2-Apr-01	Surface	79	0.61	0.6	1.51	0.564	0.461
Grab	JLT-3	3-Apr-01	Surface	3	0.36	0.6	0.92	0.562	0.534
Grab	JLT-6	3-Apr-01	Surface	12	0.06	0.2	0.38	0.324	0.279
Grab	JLT-4	5-Apr-01	Surface	12	0.39	0.8	1.11	0.463	0.408
Grab	JLO-1	10-Apr-01	Surface	24	0.35	0.9	1.05	0.469	0.349
Grab	JLT-2	10-Apr-01	Surface	7	0.28	0.9	0.91	0.39	0.373
Grab	JLT-4	10-Apr-01	Surface	14	0.23	0.9	0.73	0.359	0.303
Grab	JLT-5	10-Apr-01	Surface	16	0.39	1.3	1.24	0.549	0.455
Grab	JLT-6	10-Apr-01	Surface	2	0.05	1.1	0.85	0.41	0.365
Integrated	JLT-5	11-Apr-01	Surface	520					
Integrated	JLT-6	11-Apr-01	Surface	15					
Grab	JLO-1	16-Apr-01	Surface	13	0.41	0.7	1.42	0.496	0.409
Grab	JLT-4	16-Apr-01	Surface	6	0.07	0.9	0.8	0.327	0.294
Grab	JLT-6	16-Apr-01	Surface	2	<0.02	0.1	1.15	0.283	0.257
Grab	JLO-1	19-Apr-01	Surface	26	0.36	0.7	1.2	0.469	0.369
Grab	JLT-2	19-Apr-01	Surface	2	<1	0.7	0.7	0.346	0.32
Grab	JLT-4	19-Apr-01	Surface	3	<0.02	0.9	0.63	0.268	0.25
Grab	JLT-5	19-Apr-01	Surface	6	0.23	0.9	0.95	0.386	0.342
Integrated	JLT-2	21-Apr-01	Surface	9					
Grab	JLT-4	24-Apr-01	Surface	9	<0.02	0.3	0.62	0.228	0.185
Grab	JLT-5	24-Apr-01	Surface	10	0.33	1.2	1.43	0.572	0.504
Grab	JLO-1	25-Apr-01	Surface	14	0.15	0.6	1.5	0.387	0.311
Grab	JLT-4	25-Apr-01	Surface	43	<0.02	0.3	1.45	0.436	0.302
Grab	JLT-2	30-Apr-01	Surface	2	<0.02	0.2	0.94	0.423	0.377
Grab	JLT-6	30-Apr-01	Surface	<1	<0.02	<0.1	1.45	0.406	0.355
Grab	JLT-2	8-May-01	Surface	5	<0.02	0.2	1.59	0.518	0.467
Grab	JLT-4	8-May-01	Surface	4	<0.02	0.1	1.38	0.457	0.387
Grab	JLT-6	8-May-01	Surface	2	<0.02	<0.1	1.68	0.446	0.391
Grab	JLO-1	15-May-01	Surface	12	<0.02	<0.1	1.89	0.486	0.35
Grab	JLO-11	15-May-01	Surface	12	<0.02	<0.1	1.49	0.475	0.32
Grab	JLO-91	15-May-01	Surface	<1	<0.02	<0.1	<0.36	<0.002	<0.002
Grab	JLT-2	15-May-01	Surface	2	<0.02	0.3	1.06	0.474	0.441
Grab	JLT-12	15-May-01	Surface	1	<0.02	0.3	1.34	0.481	0.438
Grab	JLT-92	15-May-01	Surface	<1	<0.02	<0.1	<0.36	<0.002	<0.002
Grab	JLT-4	17-May-01	Surface	5	<0.02	1.8	1.24	0.255	0.221
Grab	JLT-14	17-May-01	Surface	3	<0.02	1.8	1.64	0.264	0.216
Grab	JLT-94	17-May-01	Surface	<1	<0.02	<0.1	<0.36	<0.002	<0.002
Grab	JLT-5	17-May-01	Surface	6	<0.02	0.1	1.36	0.425	0.365
Grab	JLT-15	17-May-01	Surface	7	<0.02	0.1	1.08	0.418	0.373
Grab	JLT-95	17-May-01	Surface	<1	<0.02	<0.1	<0.36	<0.002	0.003

TYPE	SITE	DATE	Depth	VTSS	Fecal	E COLI
Grab	JLT-2	2-Apr-01	Surface	4	<10	33.1
Grab	JLT-3	3-Apr-01	Surface	<1	<10	14.5
Grab	JLT-6	3-Apr-01	Surface	2	50	35.9
Grab	JLT-4	5-Apr-01	Surface	7	<10	11
Grab	JLO-1	10-Apr-01	Surface	5	100	236
Grab	JLT-2	10-Apr-01	Surface	3	90	126
Grab	JLT-4	10-Apr-01	Surface	3	<10	25.6
Grab	JLT-5	10-Apr-01	Surface	4	700	1120
Grab	JLT-6	10-Apr-01	Surface	<1	<10	7.4
Integrated	JLT-5	11-Apr-01	Surface	30		
Integrated	JLT-6	11-Apr-01	Surface	1		
Grab	JLO-1	16-Apr-01	Surface	1	30	73.3
Grab	JLT-4	16-Apr-01	Surface	<1	<10	29.2
Grab	JLT-6	16-Apr-01	Surface	<1	<10	1
Grab	JLO-1	19-Apr-01	Surface	3	20	23.1
Grab	JLT-2	19-Apr-01	Surface	<1	10	35.9
Grab	JLT-4	19-Apr-01	Surface	<1	10	13.2
Grab	JLT-5	19-Apr-01	Surface	1	<10	24.9
Integrated	JLT-2	21-Apr-01	Surface	2		
Grab	JLT-4	24-Apr-01	Surface	5	220	147
Grab	JLT-5	24-Apr-01	Surface	6	350	365
Grab	JLO-1	25-Apr-01	Surface	3	<10	1
Grab	JLT-4	25-Apr-01	Surface	7	200	308
Grab	JLT-2	30-Apr-01	Surface	<1	440	866
Grab	JLT-6	30-Apr-01	Surface	<1	30	24.6
Grab	JLT-2	8-May-01	Surface	<1	2100	1990
Grab	JLT-4	8-May-01	Surface	<1	900	1120
Grab	JLT-6	8-May-01	Surface	1	<10	14.6
Grab	JLO-1	15-May-01	Surface	4	<10	35
Grab	JLO-11	15-May-01	Surface	5	<10	31.3
Grab	JLO-91	15-May-01	Surface	<1	<10	<1
Grab	JLT-2	15-May-01	Surface	<1	310	326
Grab	JLT-12	15-May-01	Surface	<1	320	211
Grab	JLT-92	15-May-01	Surface	<1	<10	<1
Grab	JLT-4	17-May-01	Surface	2	60	122
Grab	JLT-14	17-May-01	Surface	<1	130	135
Grab	JLT-94	17-May-01	Surface	<1	<10	<1
Grab	JLT-5	17-May-01	Surface	3	40	33.6
Grab	JLT-15	17-May-01	Surface	1	40	41.3
Grab	JLT-95	17-May-01	Surface	<1	<10	<1

Appendix C. Lake Sample Data

SAMPLER	TYPE	SITE	DATE	SAMPLE DEPTH	Chl-A	Water Temp	SECCHI	DO	Cond	Turb
Kruger/Nielsen	Grab	RL-1	6-Jun-00	Surface	14.42	16.61		9.92	1496	44.9
Kruger/Nielsen	Grab	RL-2	6-Jun-00	Surface	9.21	17.93		9.73	1570	82.5
Kruger/Nielsen	Grab	RL-1	6-Jun-00	Bottom		14.57		0.38	1433	301.1
Kruger/Nielsen	Grab	RL-2	6-Jun-00	Bottom		16.80		5.81	1529	344.7
Kruger/Nielsen	Grab	RL-1	20-Jun-00	Surface	16.52	20.67	0.9	9.50	1706	36.4
Kruger/Nielsen	Grab	RL-2	20-Jun-00	Surface	15.02	20.59	0.4	7.46	1728	142.2
Kruger/Nielsen	Grab	RL-1	20-Jun-00	Bottom		13.29		0.37	1446	179.3
Kruger/Nielsen	Grab	RL-2	20-Jun-00	Bottom		19.92		6.30	1697	195.6
Kruger/Nielsen	Grab	RL-1	5-Jul-00	Surface	6.31	26.85	1.0	10.26	1839	40.8
Kruger/Nielsen	Grab	RL-2	5-Jul-00	Surface	11.21	27.14	1.3	13.01	1900	55.3
Kruger/Nielsen	Grab	RL-1	5-Jul-00	Bottom		16.32		0.84	1553	85.9
Kruger/Nielsen	Grab	RL-2	5-Jul-00	Bottom		25.43		6.75	1828	75.3
Kruger/Nielsen	Grab	RL-1	19-Jul-00	Surface	28.74	21.97	1.0	4.07	1688	43.0
Kruger/Nielsen	Grab	RL-2	19-Jul-00	Surface	41.44	21.91	0.8	7.51	1665	57.7
Kruger/Nielsen	Grab	RL-1	19-Jul-00	Bottom		15.91		0.65	1568	58.4
Kruger/Nielsen	Grab	RL-2	19-Jul-00	Bottom		21.05		5.69	1631	66.8
Kruger/Nielsen	Grab	RL-1	3-Aug-00	Surface	28.55	24.88	0.8	7.93	1788	55.4
Kruger/Nielsen	Grab	RL-2	3-Aug-00	Surface	34.33	25.41	0.6	8.89	1806	65.3
Kruger/Nielsen	Grab	RL-1	3-Aug-00	Bottom		15.28		3.90	1561	47.8
Kruger/Nielsen	Grab	RL-2	3-Aug-00	Bottom		24.91		7.15	1795	67.8
Kruger/Nielsen	Grab	RL-1	15-Aug-00	Surface	28.50	25.90	1.3	7.62	1786	29.6
Kruger/Nielsen	Grab	RL-2	15-Aug-00	Surface	35.85	25.57	1.0	7.32	1782	35.8
Kruger/Nielsen	Grab	RL-1	15-Aug-00	Bottom		16.54		1.23	1576	42.1
Kruger/Nielsen	Grab	RL-2	15-Aug-00	Bottom		25.05		6.34	1768	99.8
Kruger/Nielsen	Grab	RL-1	31-Aug-00	Surface	8.51	24.87	1.5	8.28	1788	53.2
Kruger/Nielsen	Grab	RL-2	31-Aug-00	Surface	20.33	25.16	1.0	8.12	1800	51.2
Kruger/Nielsen	Grab	RL-1	31-Aug-00	Bottom		15.28		3.90	1561	47.8
Kruger/Nielsen	Grab	RL-2	31-Aug-00	Bottom		24.91		7.15	1795	67.8
Kruger/Nielsen	Grab	RL-1	14-Sep-00	Surface	26.98	19.65	1.3	10.34	1627	27.1
Kruger/Nielsen	Grab	RL-2	14-Sep-00	Surface	34.43	19.70	1.0	12.10	1616	37.5
Kruger/Nielsen	Grab	RL-1	14-Sep-00	Bottom		18.82		3.09	1608	27.7
Kruger/Nielsen	Grab	RL-2	14-Sep-00	Bottom		19.55		10.68	1618	37.7
Kruger/Nielsen	Grab	RL-1	28-Sep-00	Surface	26.68	13.84	1.2	10.78	1435	31.2
Kruger/Nielsen	Grab	RL-2	28-Sep-00	Surface	6.36	13.83	1.0	10.84	1439	36.7
Kruger/Nielsen	Grab	RL-1	28-Sep-00	Bottom		12.32		2.49	1387	22.9
Kruger/Nielsen	Grab	RL-2	28-Sep-00	Bottom		13.31		9.09	1418	25.7
Kruger/Nielsen	Grab	RL-1	11-Oct-00	Surface	30.66	9.52	1.1	9.44	1284	28.3
Kruger/Nielsen	Grab	RL-2	11-Oct-00	Surface	31.09	9.67	0.8	11.01	1304	41.1
Kruger/Nielsen	Grab	RL-1	11-Oct-00	Bottom		9.06		6.71	1269	35.0
Kruger/Nielsen	Grab	RL-2	11-Oct-00	Bottom		9.64		8.96	1309	64.3
Kruger/Nielsen	Grab	RL-1	2-Nov-00	Surface	2.20	10.80	0.7	9.85	1343	75.3
Kruger/Nielsen	Grab	RL-2	2-Nov-00	Surface	59.97	9.17	0.5	10.23	1252	74.7
Kruger/Nielsen	Grab	RL-1	2-Nov-00	Bottom		10.84		7.71	1316	71.1
Kruger/Nielsen	Grab	RL-2	2-Nov-00	Bottom		9.16		10.13	1252	91.2
Kruger/Nielsen	Grab	RL-1	9-May-01	Surface		14.35		8.46	586	52.1
Kruger/Nielsen	Grab	RL-2	9-May-01	Surface		14.48		8.50	551	53.5

Kruger/Nielsen	Grab	RL-1	9-May-01	Bottom		4.74		0.83	1112	13.1
Kruger/Nielsen	Grab	RL-2	9-May-01	Bottom		12.15		7.07	590	60.7

SAMPLER	TYPE	SITE	DATE	SAMPLE DEPTH	pH	TALK	Tot Sol	TDS	TSS	Amm
Kruger/Nielsen	Grab	RL-1	6-Jun-00	Surface	8.57	213	1178	1083	16	0.01
Kruger/Nielsen	Grab	RL-2	6-Jun-00	Surface	8.53	211	1190	1104	21	0.01
Kruger/Nielsen	Grab	RL-1	6-Jun-00	Bottom	7.96	217	1196	1085	35	0.12
Kruger/Nielsen	Grab	RL-2	6-Jun-00	Bottom	8.39	210	1208	1091	40	0.01
Kruger/Nielsen	Grab	RL-1	20-Jun-00	Surface	8.36					
Kruger/Nielsen	Grab	RL-2	20-Jun-00	Surface	8.37					
Kruger/Nielsen	Grab	RL-1	20-Jun-00	Bottom	7.72					
Kruger/Nielsen	Grab	RL-2	20-Jun-00	Bottom	8.29					
Kruger/Nielsen	Grab	RL-1	5-Jul-00	Surface	8.79	141	1151	1123	11	0.01
Kruger/Nielsen	Grab	RL-2	5-Jul-00	Surface	8.76	148	1155	1136	8	0.01
Kruger/Nielsen	Grab	RL-1	5-Jul-00	Bottom	7.62	227	1194	1148	22	0.61
Kruger/Nielsen	Grab	RL-2	5-Jul-00	Bottom	8.67	158	1172	1125	26	0.01
Kruger/Nielsen	Grab	RL-1	19-Jul-00	Surface	7.88					
Kruger/Nielsen	Grab	RL-2	19-Jul-00	Surface	8.18					
Kruger/Nielsen	Grab	RL-1	19-Jul-00	Bottom	7.16					
Kruger/Nielsen	Grab	RL-2	19-Jul-00	Bottom	8.12					
Kruger/Nielsen	Grab	RL-1	3-Aug-00	Surface	8.54	134	1150	1075	19	0.01
Kruger/Nielsen	Grab	RL-2	3-Aug-00	Surface	8.60	132	1156	1076	13	0.01
Kruger/Nielsen	Grab	RL-1	3-Aug-00	Bottom	6.99	239	1171	1102	13	1.01
Kruger/Nielsen	Grab	RL-2	3-Aug-00	Bottom	8.58	134	1166	1092	18	0.01
Kruger/Nielsen	Grab	RL-1	15-Aug-00	Surface	8.56					
Kruger/Nielsen	Grab	RL-2	15-Aug-00	Surface	8.56					
Kruger/Nielsen	Grab	RL-1	15-Aug-00	Bottom	7.09					
Kruger/Nielsen	Grab	RL-2	15-Aug-00	Bottom	8.55					
Kruger/Nielsen	Grab	RL-1	31-Aug-00	Surface	8.53	152	1084	986	7	0.01
Kruger/Nielsen	Grab	RL-2	31-Aug-00	Surface	8.60	153	1086	991	11	0.04
Kruger/Nielsen	Grab	RL-1	31-Aug-00	Bottom	6.99	158	1073	985	7	0.09
Kruger/Nielsen	Grab	RL-2	31-Aug-00	Bottom	8.58	154	1115	1106	14	0.01
Kruger/Nielsen	Grab	RL-1	14-Sep-00	Surface	8.43					
Kruger/Nielsen	Grab	RL-2	14-Sep-00	Surface	8.55					
Kruger/Nielsen	Grab	RL-1	14-Sep-00	Bottom	8.10					
Kruger/Nielsen	Grab	RL-2	14-Sep-00	Bottom	8.51					
Kruger/Nielsen	Grab	RL-1	28-Sep-00	Surface	8.44	174	1125	1069	10	0.01
Kruger/Nielsen	Grab	RL-2	28-Sep-00	Surface	8.59	174	1136	1073	15	0.01
Kruger/Nielsen	Grab	RL-1	28-Sep-00	Bottom	7.98	175	1120	1057	4	0.12
Kruger/Nielsen	Grab	RL-2	28-Sep-00	Bottom	8.41	175	1135	1062	15	0.06
Kruger/Nielsen	Grab	RL-1	11-Oct-00	Surface	8.25					
Kruger/Nielsen	Grab	RL-2	11-Oct-00	Surface	8.52					
Kruger/Nielsen	Grab	RL-1	11-Oct-00	Bottom	8.12					
Kruger/Nielsen	Grab	RL-2	11-Oct-00	Bottom	8.32					
Kruger/Nielsen	Grab	RL-1	2-Nov-00	Surface	8.05	185	1149	1130	19	0.07
Kruger/Nielsen	Grab	RL-2	2-Nov-00	Surface	8.29	184	1175	1155	20	0.01
Kruger/Nielsen	Grab	RL-1	2-Nov-00	Bottom	8.14	185	1165	1148	17	0.07
Kruger/Nielsen	Grab	RL-2	2-Nov-00	Bottom	8.25	185	1170	1147	23	0.01
Kruger/Nielsen	Grab	RL-1	27-Dec-00	Surface		204	1307	1300	7	0.19
Kruger/Nielsen	Grab	RL-2	27-Dec-00	Surface		210	1312	1307	5	0.13

Kruger/Nielsen	Grab	RL-1	27-Dec-00	Bottom		212	1346	1342	4	0.29
Kruger/Nielsen	Grab	RL-2	27-Dec-00	Bottom		210	1330	1326	4	0.07
Kruger/Nielsen	Grab	RL-1	9-May-01	Surface	7.46	109	501		22	0.03
Kruger/Nielsen	Grab	RL-2	9-May-01	Surface	7.44	106	467		21	0.03
Kruger/Nielsen	Grab	RL-1	9-May-01	Bottom	7.10	173	810		16	0.87
Kruger/Nielsen	Grab	RL-2	9-May-01	Bottom	7.28	111	520		25	0.09

SAMPLER	TYPE	SITE	DATE	SAMPLE DEPTH	Nit	TKN	TP	TDP	Fecal	VTSS
Kruger/Nielsen	Grab	RL-1	6-Jun-00	Surface	0.05	1.29	0.095	0.031	5	5.0
Kruger/Nielsen	Grab	RL-2	6-Jun-00	Surface	0.05	0.92	0.101	0.041	10	5.0
Kruger/Nielsen	Grab	RL-1	6-Jun-00	Bottom	0.05	1.09	0.166	0.050		7.0
Kruger/Nielsen	Grab	RL-2	6-Jun-00	Bottom	0.05	0.78	0.199	0.051		8.0
Kruger/Nielsen	Grab	RL-1	5-Jul-00	Surface	0.05	1.18	0.066	0.024	5	3.0
Kruger/Nielsen	Grab	RL-2	5-Jul-00	Surface	0.05	1.05	0.073	0.025	20	2.0
Kruger/Nielsen	Grab	RL-1	5-Jul-00	Bottom	0.05	2.04	0.565	0.342		2.0
Kruger/Nielsen	Grab	RL-2	5-Jul-00	Bottom	0.05	0.98	0.113	0.044		6.0
Kruger/Nielsen	Grab	RL-1	3-Aug-00	Surface	0.05	1.37	0.314	0.076	5	13.0
Kruger/Nielsen	Grab	RL-2	3-Aug-00	Surface	0.05	0.98	0.237	0.079	10	7.0
Kruger/Nielsen	Grab	RL-1	3-Aug-00	Bottom	0.05	1.73	0.951	0.912		3.0
Kruger/Nielsen	Grab	RL-2	3-Aug-00	Bottom	0.05	1.00	0.174	0.092		4.0
Kruger/Nielsen	Grab	RL-1	31-Aug-00	Surface	0.05	1.04	0.377	0.302	5	4.0
Kruger/Nielsen	Grab	RL-2	31-Aug-00	Surface	0.05	1.06	0.344	0.251	30	8.0
Kruger/Nielsen	Grab	RL-1	31-Aug-00	Bottom	1.09	1.09	0.481	0.380		5.0
Kruger/Nielsen	Grab	RL-2	31-Aug-00	Bottom	0.05	0.98	0.363	0.264		8.0
Kruger/Nielsen	Grab	RL-1	28-Sep-00	Surface	0.05	1.36	0.346	0.252	5	6.0
Kruger/Nielsen	Grab	RL-2	28-Sep-00	Surface	0.05	1.38	0.353	0.236	10	8.0
Kruger/Nielsen	Grab	RL-1	28-Sep-00	Bottom	0.05	0.84	0.326	0.266		0.5
Kruger/Nielsen	Grab	RL-2	28-Sep-00	Bottom	0.05	1.37	0.347	0.221		11.0
Kruger/Nielsen	Grab	RL-1	2-Nov-00	Surface	0.10	1.96	0.288	0.188	5	7.0
Kruger/Nielsen	Grab	RL-2	2-Nov-00	Surface	0.05	1.52	0.304	0.156	280	8.0
Kruger/Nielsen	Grab	RL-1	2-Nov-00	Bottom	0.10	1.43	0.278	0.182		4.0
Kruger/Nielsen	Grab	RL-2	2-Nov-00	Bottom	0.50	1.77	0.305	0.157		8.0
Kruger/Nielsen	Grab	RL-1	27-Dec-00	Surface	0.10	1.80	0.202	0.134		5.0
Kruger/Nielsen	Grab	RL-2	27-Dec-00	Surface	0.10	2.03	0.216	0.144		1.0
Kruger/Nielsen	Grab	RL-1	27-Dec-00	Bottom	0.10	1.79	0.192	0.155		1.0
Kruger/Nielsen	Grab	RL-2	27-Dec-00	Bottom	0.10	1.86	0.187	0.134		1.0
Kruger/Nielsen	Grab	RL-1	9-May-01	Surface	0.40	1.14	0.570	0.436	1100	7.0
Kruger/Nielsen	Grab	RL-2	9-May-01	Surface	0.30	1.25	0.593	0.459	570	4.0
Kruger/Nielsen	Grab	RL-1	9-May-01	Bottom	0.20	1.82	0.583	0.478		5.0
Kruger/Nielsen	Grab	RL-2	9-May-01	Bottom	0.40	1.31	0.586	0.475		5.0

SAMPLER	TYPE	SITE	DATE	SAMPLE DEPTH	Total N	inorg	org
Kruger/Nielsen	Grab	RL-1	6-Jun-00	Surface	1.34	0.060	1.28
Kruger/Nielsen	Grab	RL-2	6-Jun-00	Surface	0.97	0.060	0.91
Kruger/Nielsen	Grab	RL-1	6-Jun-00	Bottom	1.14	0.170	0.97
Kruger/Nielsen	Grab	RL-2	6-Jun-00	Bottom	0.83	0.060	0.77
Kruger/Nielsen	Grab	RL-1	5-Jul-00	Surface	1.23	0.060	1.17
Kruger/Nielsen	Grab	RL-2	5-Jul-00	Surface	1.10	0.060	1.04
Kruger/Nielsen	Grab	RL-1	5-Jul-00	Bottom	2.09	0.660	1.43
Kruger/Nielsen	Grab	RL-2	5-Jul-00	Bottom	1.03	0.060	0.97
Kruger/Nielsen	Grab	RL-1	3-Aug-00	Surface	1.42	0.060	1.36

Kruger/Nielsen	Grab	RL-2	3-Aug-00	Surface	1.03	0.060	0.97
Kruger/Nielsen	Grab	RL-1	3-Aug-00	Bottom	1.78	1.060	0.72
Kruger/Nielsen	Grab	RL-2	3-Aug-00	Bottom	1.05	0.060	0.99
Kruger/Nielsen	Grab	RL-1	31-Aug-00	Surface	1.09	0.060	1.03
Kruger/Nielsen	Grab	RL-2	31-Aug-00	Surface	1.11	0.090	1.02
Kruger/Nielsen	Grab	RL-1	31-Aug-00	Bottom	2.18	1.180	1.00
Kruger/Nielsen	Grab	RL-2	31-Aug-00	Bottom	1.03	0.060	0.97
Kruger/Nielsen	Grab	RL-1	28-Sep-00	Surface	1.41	0.060	1.35
Kruger/Nielsen	Grab	RL-2	28-Sep-00	Surface	1.43	0.060	1.37
Kruger/Nielsen	Grab	RL-1	28-Sep-00	Bottom	0.89	0.170	0.72
Kruger/Nielsen	Grab	RL-2	28-Sep-00	Bottom	1.42	0.110	1.31
Kruger/Nielsen	Grab	RL-1	2-Nov-00	Surface	2.06	0.170	1.89
Kruger/Nielsen	Grab	RL-2	2-Nov-00	Surface	1.57	0.060	1.51
Kruger/Nielsen	Grab	RL-1	2-Nov-00	Bottom	1.53	0.170	1.36
Kruger/Nielsen	Grab	RL-2	2-Nov-00	Bottom	2.27	0.510	1.76
Kruger/Nielsen	Grab	RL-1	27-Dec-00	Surface	1.90	0.290	1.61
Kruger/Nielsen	Grab	RL-2	27-Dec-00	Surface	2.13	0.230	1.90
Kruger/Nielsen	Grab	RL-1	27-Dec-00	Bottom	1.89	0.390	1.50
Kruger/Nielsen	Grab	RL-2	27-Dec-00	Bottom	1.96	0.170	1.79

Appendix D. Phytoplankton Tables

Table A Percent Density and Frequency of Occurrence of Algae Species in Jones Lake

Taxa	% Den	# of Samples	Algal Group
Aphanizomenon flos-aquae	34.31%	6	Blue-Green Algae (filamentous)
Oocystis pusilla	20.19%	10	Non-Motile Green Algae (colonial)
Aphanothece sp.	7.19%	1	Blue Green Algae (colonial)
Microcystis aeruginosa	6.28%	4	Blue-Green Algae (colonial)
Pediastrum duplex	5.13%	6	Non-Motile Green Algae (colonial)
Oocystis lacustris	4.76%	7	Non-Motile Green Algae (colonial)
Rhodomonas minuta	4.31%	10	Flagellated Algae
Cryptomonas erosa	3.01%	9	Flagellated Algae
Crucigenia quadrata	1.79%	3	Non-Motile Green Algae (colonial)
Glenodinium gymnodinium	1.58%	6	Flagellated Algae (dino)
Sphaerocystis schroeteri	1.43%	2	Non-Motile Green Algae (colonial)
Cyclotella meneghiniana	1.26%	5	Diatom (centric)
Anabaena flos-aquae	1.11%	1	Blue-Green Algae (filamentous)
Anacystis marina	1.10%	1	Blue Green (colonial)
Melosira granulata	0.87%	8	Diatom (centric)-filamentous
Ankistrodesmus falcatus	0.81%	9	Non-Motile Green Algae (single)
Scenedesmus quadricauda	0.52%	5	Non-Motile Green Algae (colonial)
Chlamydomonas sp.	0.46%	8	Flagellated Algae (green)
Selenastrum minutum	0.39%	5	Non-Motile GreenAlgae
Mougeotia sp.	0.30%	1	Green Algae (filamentous)
Stephanodiscus niagarae	0.29%	2	Diatom (centric)
Melosira granulata v. angustissima	0.27%	3	Diatom (centric)-filamentous
Chroococcus minimus	0.25%	2	Blue Green (colonial)
Closteriopsis longissima	0.20%	5	Non-Motile Green Algae (single)
Stephanodiscus astraea minutula	0.16%	4	Diatom (centric)
Anabaena circinalis	0.15%	1	Blue-Green Algae (filamentous)
Pediastrum boryanum	0.13%	1	Non-Motile Green Algae (colonial)
Cocconeis placentula	0.12%	6	Diatom (pennate)
Fragilaria capucina v. mesolepta	0.11%	1	Diatom (filamentous, pennate)
Crucigenia crucifera	0.11%	1	Non-Motile Green Algae (colonial)
Chlorella sp.	0.07%	3	Non-Motile GreenAlgae
Nephrocytium sp.	0.06%	1	Non-Motile Green Algae (colonial)
Ceratium hirundinella	0.06%	3	Flagellated Algae (dino)
Cryptomonas ovata	0.06%	1	Flagellated Algae
Gymnodinium sp.	0.06%	2	Flagellated Algae (dino)
Cyclotella stelligera	0.04%	2	Diatom (centric)
Asterionella formosa	0.03%	1	Diatom (colonial, pennate)
Navicula rhynchocephala	0.03%	1	Diatom (pennate)
Nitzschia recta	0.03%	1	Diatom (pennate)
Spirogyra sp.	0.03%	1	Non-Motile Green Algae (filamentous)
Oscillatoria sp.	0.02%	1	Blue Green Algae (filamentous)
Chromulina sp.	0.02%	2	Flagellated Algae (single, yellow-brown)
Staurastrum sp.	0.02%	1	Non-Motile Green Algae (single, desmid)
Rhoicosphenia curvata	0.02%	2	Diatom (pennate)
Cyclotella sp.	0.01%	1	Diatom (centric)
Stephanodiscus astraea	0.01%	1	Diatom (centric)

Euglena sp.	0.01%	1	Flagellated Algae (green)
Ulothrix sp.	0.01%	1	Non-Motile Green Algae (filamentous)
Nitzschia dissipata	0.01%	1	Diatom (pennate)
Unidentified algae	0.01%	1	Algae
Nitzschia fonticola	0.01%	1	Diatom (pennate)
Stephanodiscus hantzschii	0.00%	1	Diatom (centric)
Nitzschia frustulum	0.00%	1	Diatom (pennate)
Navicula sp.	0.00%	1	Diatom (pennate)
Navicula capitata	0.00%	1	Diatom (pennate)
Navicula minuscula	0.00%	1	Diatom (pennate)
Amphora ovalis	0.00%	1	Diatom (pennate)
Nitzschia palea	0.00%	1	Diatom (pennate)
Synedra rumpens	0.00%	1	Diatoms (pennate)
Nitzschia capitellata	0.00%	1	Diatom (pennate)

Table B. Percent Biovolume and Frequency of Occurrence of Algae Species in Jones Lake

Taxa	% Biovolume	# of Samples	Algal Group
Glenodinium gymnodinium	54.45%	6	Flagellated Algae (dino)
Aphanizomenon flos-aquae	10.58%	6	Blue-Green Algae (filamentous)
Stephanodiscus niagarae	7.53%	2	Diatom (centric)
Pediastrum duplex	6.75%	6	Non-Motile Green Algae (colonial)
Cryptomonas erosa	3.98%	9	Flagellated Algae
Oocystis lacustris	3.86%	7	Non-Motile Green Algae (colonial)
Oocystis pusilla	2.87%	10	Non-Motile Green Algae (colonial)
Ceratium hirundinella	1.62%	3	Flagellated Algae (dino)
Mougeotia sp.	1.26%	1	Green Algae (filamentous)
Melosira granulata	1.26%	8	Diatom (centric)-filamentous
Sphaerocystis schroeteri	1.01%	2	Non-Motile Green Algae (colonial)
Cyclotella meneghiniana	0.83%	5	Diatom (centric)
Microcystis aeruginosa	0.55%	4	Blue-Green Algae (colonial)
Gymnodinium sp.	0.41%	2	Flagellated Algae (dino)
Crucigenia quadrata	0.40%	3	Non-Motile Green Algae (colonial)
Cryptomonas ovata	0.28%	1	Flagellated Algae
Anabaena flos-aquae	0.23%	1	Blue-Green Algae (filamentous)
Rhodomonas minuta	0.23%	10	Flagellated Algae
Scenedesmus quadricauda	0.21%	5	Non-Motile Green Algae (colonial)
Closteriopsis longissima	0.19%	5	Non-Motile Green Algae (single)
Chlamydomonas sp.	0.18%	8	Flagellated Algae (green)
Melosira granulata v. angustissima	0.18%	3	Diatom (centric)-filamentous
Pediastrum boryanum	0.17%	1	Non-Motile Green Algae (colonial)
Stephanodiscus astraea minutula	0.15%	4	Diatom (centric)
Cocconeis placentula	0.15%	6	Diatom (pennate)
Stephanodiscus astraea	0.10%	1	Diatom (centric)
Aphanothece sp.	0.08%	1	Blue Green Algae (colonial)
Fragilaria capucina v. mesolepta	0.07%	1	Diatom (filamentous, pennate)
Spirogyra sp.	0.07%	1	Non-Motile Green Algae (filamentous)
Anabaena circinalis	0.06%	1	Blue-Green Algae (filamentous)
Ankistrodesmus falcatus	0.05%	9	Non-Motile Green Algae (single)
Nitzschia recta	0.02%	1	Diatom (pennate)
Crucigenia crucifera	0.02%	1	Non-Motile Green Algae (colonial)
Navicula rhynchocephala	0.02%	1	Diatom (pennate)

Selenastrum minutum	0.02%	5	Non-Motile GreenAlgae
Asterionella formosa	0.02%	1	Diatom (colonial, pennate)
Cyclotella stelligera	0.02%	2	Diatom (centric)
Euglena sp.	0.02%	1	Flagellated Algae (green)
Nephrocytium sp.	0.02%	1	Non-Motile Green Algae (colonial)
Anacystis marina	0.01%	1	Blue Green (colonial)
Chlorella sp.	0.01%	3	Non-Motile GreenAlgae
Staurastrum sp.	0.01%	1	Non-Motile Green Algae (single, desmid)
Cyclotella sp.	0.01%	1	Diatom (centric)
Rhoicosphenia curvata	0.00%	2	Diatom (pennate)
Nitzschia dissipata	0.00%	1	Diatom (pennate)
Amphora ovalis	0.00%	1	Diatom (pennate)
Nitzschia palea	0.00%	1	Diatom (pennate)
Chromulina sp.	0.00%	2	Flagellated Algae (single, yellow-brown)
Chroococcus minimus	0.00%	2	Blue Green (colonial)
Navicula sp.	0.00%	1	Diatom (pennate)
Stephanodiscus hantzschii	0.00%	1	Diatom (centric)
Ulothrix sp.	0.00%	1	Non-Motile Green Algae (filamentous)
Navicula capitata	0.00%	1	Diatom (pennate)
Oscillatoria sp.	0.00%	1	Blue Green Algae (filamentous)
Nitzschia capitellata	0.00%	1	Diatom (pennate)
Nitzschia frustulum	0.00%	1	Diatom (pennate)
Synedra rumpens	0.00%	1	Diatoms (pennate)
Nitzschia fonticola	0.00%	1	Diatom (pennate)
Unidentified algae	0.00%	1	Algae
Navicula minuscula	0.00%	1	Diatom (pennate)

Table C. Jones Lake Algae Biovolumes by Species

Taxa	% Den Biovolume	# of Samples	Algal Group
Glenodinium gymnodinium	54.45%	6	Flagellated Algae (dino)
Aphanizomenon flos-aquae	10.58%	6	Blue-Green Algae (filamentous)
Stephanodiscus niagarae	7.53%	2	Diatom (centric)
Pediastrum duplex	6.75%	6	Non-Motile Green Algae (colonial)
Cryptomonas erosa	3.98%	9	Flagellated Algae
Oocystis lacustris	3.86%	7	Non-Motile Green Algae (colonial)
Oocystis pusilla	2.87%	10	Non-Motile Green Algae (colonial)
Ceratium hirundinella	1.62%	3	Flagellated Algae (dino)
Mougeotia sp.	1.26%	1	Green Algae (filamentous)
Melosira granulata	1.26%	8	Diatom (centric)-filamentous
Sphaerocystis schroeteri	1.01%	2	Non-Motile Green Algae (colonial)
Cyclotella meneghiniana	0.83%	5	Diatom (centric)
Microcystis aeruginosa	0.55%	4	Blue-Green Algae (colonial)
Gymnodinium sp.	0.41%	2	Flagellated Algae (dino)
Crucigenia quadrata	0.40%	3	Non-Motile Green Algae (colonial)
Cryptomonas ovata	0.28%	1	Flagellated Algae
Anabaena flos-aquae	0.23%	1	Blue-Green Algae (filamentous)
Rhodomonas minuta	0.23%	10	Flagellated Algae

Scenedesmus quadricauda	0.21%	5	Non-Motile Green Algae (colonial)
Closteriopsis longissima	0.19%	5	Non-Motile Green Algae (single)
Chlamydomonas sp.	0.18%	8	Flagellated Algae (green)
Melosira granulata v. angustissima	0.18%	3	Diatom (centric)-filamentous
Pediastrum boryanum	0.17%	1	Non-Motile Green Algae (colonial)
Stephanodiscus astraea minutula	0.15%	4	Diatom (centric)
Cocconeis placentula	0.15%	6	Diatom (pennate)
Aphanothece sp.	0.08%	1	Blue Green Algae (colonial)
Fragilaria capucina v. mesolepta	0.07%	1	Diatom (filamentous, pennate)
Spirogyra sp.	0.07%	1	Non-Motile Green Algae (filamentous)
Anabaena circinalis	0.06%	1	Blue-Green Algae (filamentous)
Ankistrodesmus falcatus	0.05%	9	Non-Motile Green Algae (single)
Nitzschia recta	0.02%	1	Diatom (pennate)
Crucigenia crucifera	0.02%	1	Non-Motile Green Algae (colonial)
Navicula rhynchocephala	0.02%	1	Diatom (pennate)
Selenastrum minutum	0.02%	5	Non-Motile GreenAlgae
Asterionella formosa	0.02%	1	Diatom (colonial, pennate)
Cyclotella stelligera	0.02%	2	Diatom (centric)
Euglena sp.	0.02%	1	Flagellated Algae (green)
Nephrocytium sp.	0.02%	1	Non-Motile Green Algae (colonial)
Anacystis marina	0.01%	1	Blue Green (colonial)
Chlorella sp.	0.01%	3	Non-Motile GreenAlgae
Staurastrum sp.	0.01%	1	Non-Motile Green Algae (single, desmid)
Cyclotella sp.	0.01%	1	Diatom (centric)

Table D. Jones Lake Cells/ mL and Biovolumes by Date and Algae Group

Date	Groups	Cells/mL		Biovolume	
31-May-00	Blue-Green Algae	15569	93%	1636439	82%
	Diatom	679	4%	267879	13%
	Dinoflagellate	2	0%	19600	1%
	Flagellated Algae	160	1%	5958	0%
	Green Algae	310	2%	59416	3%
	Unidentified algae	10	0%	300	0%
Total		16730		1989592	
14-Jun-00	Blue-Green Algae	26094	92%	3052998	93%
	Diatom	322	1%	89171	3%
	Flagellated Algae	966	3%	37260	1%
	Green Algae	1058	4%	120198	4%
Total		28440		3299627	
26-Jun-00	Blue-Green Algae	27144	69%	2737368	28%
	Diatom	626	2%	4774620	48%
	Dinoflagellate	52	0%	140400	1%
	Flagellated Algae	1617	4%	473394	5%
	Green Algae	9709	25%	1813728	18%
Total		39148		9939510	
10-Jul-00	Blue-Green Algae	1607	12%	157439	6%
	Diatom	84	1%	43680	2%
	Flagellated Algae	818	6%	481099	19%
	Green Algae	11163	82%	1809710	73%
Total		13672		2491928	
26-Jul-00	Diatom	70	0%	32200	1%
	Flagellated Algae	634	3%	166934	4%

	Green Algae	20365	97%	3677566	95%
Total		21069		3876700	
09-Aug-00	Blue-Green Algae	2200	10%	72600	1%
	Diatom	550	2%	201025	2%
	Dinoflagellate	605	3%	7166555	63%
	Flagellated Algae	2365	11%	307340	3%
	Green Algae	16500	74%	3582370	32%
Total		22220		11329890	
23-Aug-00	Blue-Green Algae	16254	78%	150711	1%
	Diatom	858	4%	943850	5%
	Dinoflagellate	1448	7%	18758821	93%
	Flagellated Algae	857	4%	46928	0%
	Green Algae	1537	7%	235384	1%
Total		20954		20135694	
07-Sep-00	Blue-Green Algae	2154	39%	8616	0%
	Diatom	467	8%	269470	2%
	Dinoflagellate	813	15%	10641357	95%
	Flagellated Algae	467	8%	109636	1%
	Green Algae	1646	30%	141010	1%
Total		5547		11170089	
21-Sep-00	Blue-Green Algae	1464	24%	171288	6%
	Diatom	1244	21%	373300	13%
	Dinoflagellate	146	2%	1910994	64%
	Flagellated Algae	659	11%	173386	6%
	Green Algae	2488	41%	343335	12%
Total		6001		2972303	
04-Oct-00	Blue-Green Algae	783	8%	91611	3%
	Diatom	1174	12%	293890	10%
	Dinoflagellate	78	1%	1020942	34%
	Flagellated Algae	6029	62%	1489478	49%
	Green Algae	1722	18%	113892	4%
Total		9786		3009813	

Appendix E. Total Maximum Daily Load Summary (TMDL)

TOTAL MAXIMUM DAILY LOAD EVALUATION

For

JONES LAKE

TURTLE CREEK WATERSHED

(HUC 10160009)

HAND COUNTY, SOUTH DAKOTA

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

MARCH, 2002

Jones Lake Total Maximum Daily Load

Waterbody Type:	Lake (Impounded)
303(d) Listing Parameter:	TSI Trend,
Designated Uses:	Recreation, Warmwater permanent aquatic life
Size of Waterbody:	100.5 acres
Size of Watershed :	23,920 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Average TSI,
Analytical Approach:	AGNPS, BATHTUB, FLUX
Location:	HUC Code: 10160009
Goal:	10 % reduction in phosphorus from the watershed and a 35% reduction in sediment released phosphorus
Target:	TSI of less than 70

Objective:

The intent of this summary is to clearly identify the components of the TMDL submittal to support adequate public participation and facilitate the US Environmental Protection Agency (EPA) review and approval. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

Jones Lake is a 100.5 acre (40.7 ha) man-made impoundment located in central Hand County, South Dakota. Damming Turtle Creek 3 miles south of the town of St Lawrence created a lake, with an average depth of 7.5 feet (2.3 meters) and 2.1 miles (3.4 km) of shoreline. The lake has a maximum depth of 16 feet (4.9 m) and a pool elevation capacity of 752 acre-feet of water. Jones Lake is subject to periods of stratification during the summer. The outlet for the lake empties into Turtle Creek, which eventually reaches the James River south of the town of Redfield in Spink County, South Dakota. The Jones Lake watershed comprises a small portion of the Turtle Creek hydrologic unit, which has a priority rank of 18 in the South Dakota Unified Watershed Assessment.

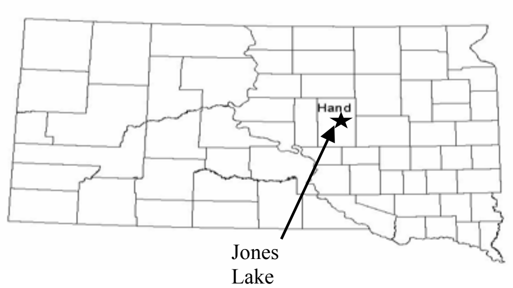


Figure 28. Watershed Location in South Dakota

Problem Identification

Turtle Creek is the primary tributary to Jones Lake and drains a mixture of grazing lands with some cropland acres. Winter feeding areas for livestock are present in the watershed. The stream carries nutrient loads, which degrade water quality in the lake and cause increased eutrophication.

Data indicate that a 70% reduction in phosphorus is needed in this watershed to meet designated beneficial uses (fully supporting) based on reference lake criteria for ecoregion 46 (mean TSI <65). However, Jones Lake appears not to fit ecoregion-based beneficial use criteria based on the large reduction in total phosphorus needed to meet current targets. Both economical and technical limitations preclude the realization of a 70% reduction in total phosphorus. Current data indicate that a 10% reduction in phosphorus can be achieved in this watershed.

Jones Lake is heavily impacted by internal phosphorus loading from its sediments. Elimination of the internal load would result in lake conditions similar to what would be achieved through a 60% reduction in the tributary load. Similarly, treatment of the lake with alum (pages 35-36 of the Assessment Report) will realize ambient phosphorus reductions of 30% to 90%.

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

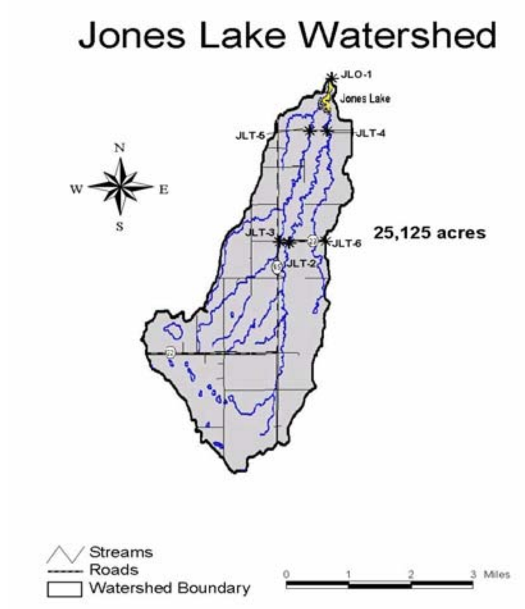


Figure 29. Jones Lake and Turtle Creek Watershed

Jones Lake has been assigned beneficial uses by the state of South Dakota Surface Water Quality Standards regulations. Along with these assigned uses are narrative and numeric criteria that define the desired water quality of the lake. These criteria must be maintained for the lake to satisfy its assigned beneficial uses, which are listed below:

Warmwater semipermanent fish life propagation; Immersion recreation; Limited contact recreation; and Fish and wildlife propagation, recreation and stock watering.
Individual parameters, including the lake's Trophic State Index (TSI) (Carlson, 1977) value, determine the support of beneficial uses and compliance with standards. A gradual increase in fertility of the water due to nutrients washing into the lake from external sources is a sign of the eutrophication process. Jones Lake is identified in both the 1998 South Dakota Waterbody List and "Ecoregion Targeting for Impaired Lakes in South Dakota" as partially supporting its aquatic life beneficial use.

South Dakota has several applicable narrative standards that may be applied to the undesired eutrophication of lakes and streams. Administrative Rules of South Dakota Article 74:51 contains language that prohibits the existence of materials causing pollutants to form, visible pollutants, taste and odor producing materials, and nuisance aquatic life.

If adequate numeric criteria are not available, the South Dakota Department of Environment and Natural Resources (SD DENR) uses surrogate measures. To assess the trophic status of a lake, SD DENR uses the mean TSI which incorporates Secchi depth, chlorophyll *a* concentrations and phosphorus concentrations. SD DENR has developed a protocol that establishes desired TSI levels for lakes based on an ecoregion approach. This protocol was used to assess impairment and determine a numeric target for Jones Lake.

Jones Lake currently has a mean TSI of 71.07, which is indicative of high levels of primary productivity. Assessment monitoring indicates that the primary cause of the high productivity is phosphorus loads from the watershed and the bottom sediments in the lake. Growing season releases of phosphorus from bottom sediments in Jones Lake resulted in an increase in the phosphorus concentration from .3 mg/L to .75 mg/L (page 35).

The numeric target, established to improve the trophic state of Jones Lake, is a growing season average TSI of 70 or less. This target may be achieved in part by a 10% reduction in phosphorus loading from Turtle Creek. Reducing the release of phosphorus from the bottom sediments by 35% in addition to the 10% watershed load reduction will result in a TSI of less than 70.

Pollutant Assessment

Point Sources

There are no point sources of pollutants of concern in this watershed.

Nonpoint Sources/ Background Sources

Of the 8,469 kg of phosphorus that enter the lake on an average annual basis, approximately 5,758 kg or 68% may be attributed to the cultural influences of man. The remaining 2,710 kg can be attributed to natural background sources. Of the anthropogenic load, treatment of 4.2% of the most critical acres will result in phosphorus reductions of 239 kg or 3%. Additional reductions may be possible through livestock exclusion from the lake itself as well as improved grazing management, buffer strips, and grassed waterways resulting in the elimination of an additional 5% to 10% of the phosphorus load or 423kg to 847 kg. Total load reductions as a result of BMPs will be a conservative 10% or 847kg. Internal loading to the lake may account for as much as 60% to 70% of the phosphorus in the lake.

Linkage Analysis

Water quality data was collected from five monitoring sites within the Turtle Creek watershed. Samples collected at each site were taken according to South Dakota's EPA approved Standard Operating Procedures for Field Samplers. Water samples were sent to the State Health Laboratory in Pierre for analysis. Quality Assurance/Quality Control samples were collected on 10% of the samples according to South Dakota's EPA approved Clean Lakes Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed on pages 9-44 and 65 of the assessment final report.

In addition to water quality monitoring, data was collected to complete a watershed landuse model. The Agriculture Nonpoint Pollution Source (AGNPS) model was used to provide comparative values for each of the land uses and animal feeding operations located in the watershed. See the AGNPS section of the final report, pages 55-60.

The impacts of phosphorus reductions on the condition of Jones Lake were calculated using BATHTUB, an Army Corps of Engineers model. The model predicted that by reducing phosphorus from Turtle Creek by 70% a TSI shift of 6 points would occur resulting in a trophic state of 65 or less, (page 42).

A 70% reduction was achieved by unrealistically modeling the entire watershed as grass. Economical and social factors would make grassing the entire watershed impossible. A TSI of 65 can not be reached. Similarly, attaining the financial resources to reduce inlake nutrient loading make this an unlikely practice.

The model predicted a TSI of 70 could be obtained with a 10% reduction in watershed phosphorus loads combined with a 35% reduction in the amount of phosphorus released from the sediment.

TMDL and Allocations

TMDL

	0 kg/yr	(WLA)
+	4,912 kg/yr	(LA)
+	2,710 kg/yr	(Background)
	Implicit (MOS)	
	7,622 kg/yr	(TMDL)

Wasteload Allocations (WLAs)

There are no point sources of pollutants of concern in this watershed. Therefore, the "wasteload allocation" component of these TMDLs is considered a zero value. The TMDLs are considered wholly included within the "load allocation" component.

Load Allocations (LAs)

A 10% reduction in the phosphorus load to Jones Lake may be obtained through the improvement of the critical cells identified in the AGNPS section of the final report reducing the annual load from 8,469 kg/yr to 7,622 kg/yr.

In lake reductions in total phosphorus were also estimated for Jones Lake. A 35% reduction in phosphorus concentrations resulting in a 5% reduction in the phosphorus TSI values were calculated with the application of alum.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. To determine seasonal differences, Jones Lake samples were separated into spring (March-May), summer (June-August), fall (September-November), and winter (December-February) collection periods. Seasonalized data may be found on page 14.

Margin of Safety

Conservative estimates were used throughout the modeling process. These estimates produced an implicit margin of safety.

Critical Conditions

The impairments to Jones Lake are most severe during the late summer. This is the result of warm water temperatures and peak algal growth as well as peak recreational use of the lake.

Follow-Up Monitoring

Once the implementation project is completed, post-implementation monitoring will be necessary following a recovery period to assure that the TMDL has been reached and improvement to the beneficial uses occurs.

Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. Central Plains Water Development District Board Meetings
2. Hand County Conservation District Board Meetings
3. Articles in the local newspapers
4. Individual contact with over 95% of the residents in the watershed.

The findings from these public meetings and comments have been taken into consideration in development of the Jones Lake TMDL.

Implementation Plan

The South Dakota DENR is working with the Hand County Conservation District and the Central Plains Water Development District to initiate an implementation project beginning in the spring of 2003. It is expected that a local sponsor will request project assistance during the spring 2002 EPA Section 319 funding round.

Forty copies of this document were printed by the Department of Environment and Natural Resources at a cost of $3.25 per copy.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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DENVER, CO 80202-2466
http://www.epa.gov/region08

APR - 2 2003

Ref: 8EPR-EP

Steven M. Pirner, Secretary
Department of Environment & Natural Resources
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3181

Re: TMDL Approvals
Jones Lake
Loyalton Dam
Mina Lake
Rose Hill Lake

Dear Mr. Pirner:

We have completed our review, and have received ESA Section 7 concurrence from the US Fish and Wildlife Service, on the total maximum daily loads (TMDLs) as submitted by your office for the waterbodies listed in the enclosure to this letter. In accordance with the Clean Water Act (33 U.S.C. 1251 *et. seq.*), we approve all aspects of the TMDLs as developed for the water quality limited waterbodies as described in Section 303(d)(1).

Based on our review, we feel the separate TMDL elements listed in the enclosed review table adequately address the pollutants of concern, taking into consideration seasonal variation and a margin of safety. Please find enclosed a detailed review of these TMDLs.

For years, the State has sponsored an extensive clean lakes program. Through the lakes assessment and monitoring efforts associated with this program, priority waterbodies have been identified for cleanup. It is reasonable that these same priority waters have been a focus of the Section 319 nonpoint source projects as well as one of the priorities under the State's Section 303(d) TMDL efforts.

In the course of developing TMDLs for impaired waters, EPA has recognized that not all impairments are linked to water chemistry alone. Rather, EPA recognizes that *"Section 303(d) requires the States to identify all impaired waters regardless of whether the impairment is due to toxic pollutants, other chemical, heat, habitat, or other problems."* (see 57 Fed. Reg. 33040 for July 24, 1992). Further, EPA states that "*...in some situations water quality standards – particulary designated uses and biocriteria – can only be attained if nonchemical factors such as hydrology, channel morphology, and habitat are also addressed. EPA recognizes that it is* *chemical parameters that are preventing the attainment of water quality standards.*" (see Guidance for Water Quality-based Decisions: The TMDL Process; USEPA; EPA 440/4-91-001, April 1991; pg. 4). We feel the State has developed TMDLs that are consistent with this guidance, taking a comprehensive view of the sources and causes of water quality impairment within each of the watersheds. For example, in several of the TMDLs, the State considered nonchemical factors such as trophic state index (TSI) and its relationship to the impaired uses. Further, we feel it is reasonable to use factors such as TSI as surrogates to express the final endpoint of the TMDL.

Thank you for your submittal. If you have any questions concerning this approval, feel free to contact Vernon Berry of my staff at 303-312-6234.

Sincerely,

Max H. Dodson
Assistant Regional Administrator
Office of Ecosystems Protection and
Remediation

Enclosure

Enclosure

APPROVED TMDLS

Waterbody Name*	TMDL Parameter/ Pollutant	Water Quality Goal/Endpoint	TMDL	Section 303(d)1 or 303(d)3 TMDL	Supporting Documentation (not an exhaustive list of supporting documents)
Jones Lake*	phosphorus	TSI mean ≤ 70.0	10% reduction in tributary phosphorus loads and 35% reduction of inlake phosphorous	Section 303(d)(1)	■ Phase I Watershed Assessment and TMDL Final Report, Jones Lake/Turtle Creek, Hand County, South Dakota (SD DENR, May 2002)
Loyalton Dam*	phosphorus	TSI mean ≤ 65	10% reduction in tributary phosphorus loads and 50% reduction of inlake phosphorous	Section 303(d)(1)	■ Phase I Watershed Assessment Final Report and TMDL, Loyalton Dam Watershed, Edmunds County, South Dakota (SD DENR, October 2002)
Mina Lake*	phosphorus	TSI mean < 79.18	38.8% reduction of total phosphorus load	Section 303(d)(1)	■ Phase I Watershed Assessment Final Report and TMDL, Mina Lake/Snake Creek, Brown, Edmunds and McPherson Counties, South Dakota (SD DENR, March 2002)
Rose Hill Lake*	phosphorus	TSI mean < 65	20% reduction in tributary phosphorus loads and 30% reduction of inlake phosphorous	Section 303(d)(1)	■ Phase I Watershed Assessment and TMDL Final Report, Rose Hill Lake/Sand Creek, Hand County, South Dakota (SD DENR, January 2002)

* An asterisk indicates the waterbody has been included on the State's Section 303(d) list of waterbodies in need of TMDLs.

■ TMDL Checklist ■

EPA Region VIII

State/Tribe: South Dakota
Waterbody Name: Loyalton Dam, Edmunds County
Point Source-control TMDL: Nonpoint Source-control TMDL: X (check one or both)
Date Received: December 24, 2002 Date Review completed: January 24, 2003 VEB

Review Criteria (All criteria must be met for approval)	Approved (check if yes)	Comments
■ **TMDLs result in maintaining and attaining water quality standards**	X	The waterbody classification uses which are addressed by this TMDL are warmwater semipermanent fish life propagation, immersion recreation, limited contact recreation, and criteria for fish and wildlife propagation, recreation and stock watering.
■ **Water Quality Standards Target**	X	Water quality targets were established based on trophic status. This is a reasonable approach because the trophic status of the waterbody relates to the uses of concern.
■ **TMDL**	X	The TMDL is expressed in terms of annual phosphorus load reduction. This is a reasonable way to express the TMDL for this lake because it provides an effective surrogate that reflects both aquatic life and recreational needs, and reflects the long response time of lakes of this type to pollutant controls within the watershed.
■ **Significant Sources Identified**	X	Significant sources were adequately identified in a categorical and/or individual source-by-source basis. All sources that need to be addressed through controls were identified.
■ **Technical Analysis**	X	Monitoring, empirical relationships, AGNPS and BATHTUB modeling, and best professional judgement were used in identifying pollutant sources, and in identifying acceptable levels of pollutant control. This level of technical analysis is reasonable and appropriate because of the character of the pollutants, the type of land use practices, and the waterbody type.
■ **Margin of Safety and Seasonality**	X	An appropriate margin of safety is included through conservative assumptions in the derivation of the target and in the modeling. Additionally, ongoing monitoring has been proposed to assure water quality goals are achieved. Seasonality was adequately considered by evaluating the cumulative impacts of the various seasons on water quality and by proposing that BMPs be tailored to seasonal needs.
■ **Allocation**	X	The allocation for the TMDL was a "load allocation" attributed to nonpoint sources. Allocation was attributed to range and cropland management practices, and internal loading.
■ **Public Review**	X	Public review and participation was conducted through meetings, electronic media, and mailings. The extent of public review is acceptable. Further, the review process sponsored by the State was adequate for purposes of developing a TMDL that will be implemented because of public acceptance.
■ **EPA approved Water Quality Standards**	X	Standards upon which this TMDL was based have been formally approved by the EPA. No tribal waters were involved in this TMDL.

■ TMDL Checklist ■

EPA Region VIII

State/Tribe: South Dakota
Waterbody Name: Rose Hill Lake, Hand County
Point Source-control TMDL: Nonpoint Source-control TMDL: X (check one or both)
Date Received: December 24, 2002 Date Review completed: January 24, 2003 VEB

Review Criteria (All criteria must be met for approval)	Approved (check if yes)	Comments
■ TMDLs result in maintaining and attaining water quality standards	X	The waterbody classification uses which are addressed by this TMDL are warmwater permanent fish life propagation, immersion recreation, limited contact recreation and fish and wildlife propagation, recreation and stock watering.
■ Water Quality Standards Target	X	Water quality targets were established based on trophic status. This is a reasonable approach because the trophic status of the waterbody relates to the uses of concern.
■ TMDL	X	The TMDL is expressed in terms of inlake phosphorus load reduction. This is a reasonable way to express the TMDL for this lake because it provides an effective surrogate that reflects both aquatic life and recreational needs.
■ Significant Sources Identified	X	Significant sources were adequately identified in a categorical and/or individual source-by-source basis. All sources that need to be addressed through controls were identified.
■ Technical Analysis	X	Monitoring, empirical relationships, AGNPS and BATHTUB modeling , and best professional judgement were used in identifying pollutant sources, and in identifying acceptable levels of pollutant control. This level of technical analysis is reasonable and appropriate because of the character of the pollutants, the type of land use practices, and the waterbody type.
■ Margin of Safety and Seasonality	X	An appropriate margin of safety is included through conservative assumptions in the derivation of the target and in the modeling. Additionally, ongoing monitoring has been proposed to assure water quality goals are achieved. Seasonality was adequately considered by evaluating the cumulative impacts of the various seasons on water quality and by proposing that BMPs be tailored to seasonal needs.
■ Allocation	X	The allocation for the TMDL was a "load allocation" attributed to nonpoint sources. Allocation was attributed to range and cropland management practices, and internal loading.
■ Public Review	X	Public review and participation was conducted through meetings, electronic media, and mailings. The extent of public review is acceptable. Further, the review process sponsored by the State was adequate for purposes of developing a TMDL that will be implemented because of public acceptance.
■ EPA approved Water Quality Standards	X	Standards upon which this TMDL was based have been formally approved by the EPA. No tribal waters were involved in this TMDL.

■ TMDL Checklist ■

EPA Region VIII

State/Tribe: South Dakota Waterbody Name: Jones Lake, Hand County Point Source-control TMDL: Nonpoint Source-control TMDL: X (check one or both) Date Received: December 24, 2002 Date Review completed: January 24, 2003 VEB	
A. Water Quality Standards - **Approved**	The State's submittal provides a good description of the geographic scope of the TMDL as well as information on the watershed and land use characteristics of Jones Lake. The South Dakota Department of Environment and Natural Resources (SD DENR) has identified Jones Lake as a water that is intended to support a range of designated uses including: warmwater semipermanent fish life propagation, immersion recreation, limited contact recreation, fish and wildlife propagation, recreation and stock watering. The narrative standards being implemented in this TMDL are: "*Materials which produce nuisance aquatic life may not be discharged or caused to be discharged into surface waters of the state in concentrations that impair a beneficial use or create a human health problem.*" (See ARSD §74:51:01:09) "*All waters of the state must be free from substances, whether attributable to human-induced point source discharges or nonpoint source activities, in concentration or combinations which will adversely impact the structure and function of indigenous or intentionally introduced aquatic communities.*" (See ARSD §74:51:01:12)
B. Water Quality Standards Targets - **Approved**	Water quality targets for this TMDL are based on interpretation of narrative provisions found in State water quality standards. In May 2000, SD DENR published *Ecoregion Targeting for Impaired Lakes in South Dakota*. This document proposed ecoregion-specific targeted Trophic State Index (TSI) values based on beneficial uses. EPA approved the use of these ecoregion-specific targets to evaluate lakes using beneficial use categories. In South Dakota algal blooms can limit contact and immersion recreation beneficial uses. Also algal blooms can deplete oxygen levels which can affect aquatic life uses. SD DENR considers several algal species to be nuisance aquatic species. TSI measurements can be used to estimate how much algal production may occur in lakes. Therefore, TSI is used as a measure of the narrative standard in order to determine whether beneficial uses are being met. The overall mean TSI for Jones Lake during the period of the assessment (June 2000 through spring 2001) was 71.1. Nutrient reduction response modeling was conducted with BATHTUB, an Army Corps of Engineers eutrophication response model. The results of the modeling show that 70% or more reduction in the total phosphorous loading from the watershed would be necessary to meet the ecoregion-based beneficial use TSI target of 65 or less. However, Jones Lake does not appear to fit the ecoregion-based beneficial use criteria due to legacy phosphorous loading to the lake and the technical and financial inability to fully treat new loading to the lake. Therefore, a higher TSI target has been established for Jones Lake. The target used in this TMDL is: ▪ TSI mean less than 70 (growing season average)

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C. Significant Sources - **Approved**	The TMDL identifies the major sources of phosphorous as coming from nonpoint source agricultural landuses within the watershed and internal loading from bottom sediments within the lake. In particular, a loading analysis was done for nutrients and sediment considering various agricultural land use and land management factors.
D. Technical Analysis - **Approved**	The technical analysis addresses the needed phosphorous reduction to achieve the desired water quality. The TMDL recommends a 10% reduction in phosphorous loading from the watershed to Jones Lake, and a 35% reduction in sediment released phosphorous to achieve the desired results. This reduction is based in large part on the BATHTUB mathematical modeling of the Lake and its predicted response to nutrient load reductions. The Agricultural Non-Point Source Model (AGNPS) model was used to simulate alterations in land use practices and the resulting nutrient reduction response. The analysis of which nutrient loading sources were in need of control was based on a identification of targeted or "critical" cells. Cell priority was assigned based on average nutrient loads produced that ultimately reach the outlet of the watershed. Cells that produce nitrogen *and* phosphorous loads greater than two standard deviations over the mean for the watershed were given a priority ranking of 1. Cells that produce nitrogen *or* phosphorous loads greater than two standard deviations over the mean were given a priority ranking of 2. The initial load reductions under this TMDL will be achieved through controls on the priority 1 and 2 cells within the watershed combined with modification of grazing practices. The reduction in sediment released phosphorous will be possible through inlake treatments such as the application of alum.
E. Margin of Safety & Seasonality - **Approved**	An appropriate margin of safety is included through conservative assumptions in the derivation of the target and in the modeling. Additionally, ongoing monitoring has been proposed to assure water quality goals are achieved. Seasonality was adequately considered by evaluating the cumulative impacts of the various seasons on water quality and by proposing that BMPs be tailored to seasonal needs.
F. TMDL - **Approved**	The TMDL established for Jones Lake is a 10% reduction in annual tributary loading phosphorus and a 35% reduction in sediment released phosphorous. Since the annual loading varies from year-to-year, this TMDL is considered a long term average reduction in phosphorous loading.
G. Allocation - **Approved**	This TMDL addresses the need to achieve further reductions in nutrients to attain water quality goals in Jones Lake. The allocation for the TMDL was a "load allocation" attributed to nonpoint sources. The allocation for phosphorous was attributed to such sources as animal feeding areas, internal loading and cropland tillage. There is a desire to move forward with controls in the areas of the basin where there is confidence that phosphorous reductions can be achieved through modifications to priority 1 and 2 cells within the watershed combined with modification of grazing practices and modest reductions in sediment released phosphorous. Additional phosphorous load reductions are possible if all of the cropping and grazing uses were converted to conservation reserve program (CRP) use (i.e., 68% reduction in phosphorus), or through extensive inlake restoration activities. However, much of the cropland within the watershed is already following conservation tillage practices and complete conversion to CRP is unrealistic. The size and location of this lake would make it difficult to obtain local support and funding for extensive inlake restoration activities necessary to achieve significantly higher phosphorous load reductions.

H. Public Participation - **Approved**	The State's submittal includes a summary of the public participation process that has occurred which describes the ways the public has been given an opportunity to be involved in the TMDL development process. In particular, the State has encouraged participation through public meetings in the watershed, articles in local newspapers, individual contact with over 95% of the residents in the watershed, and widespread solicitation of comments on the draft TMDL. The State also employed the Internet to post the draft TMDL and to solicit comments. The level of public participation is found to be adequate.

State/Tribe: South Dakota Waterbody Name: Mina Lake, Brown, Edmunds and McPherson Counties Point Source-control TMDL: Nonpoint Source-control TMDL: X (check one or both) Date Received: December 24, 2002 Date Review completed: January 24, 2003 VEB	
A. Water Quality Standards - **Approved**	The State's submittal provides a good description of the geographic scope of the TMDL as well as information on the watershed and land use characteristics of Mina Lake. The South Dakota Department of Environment and Natural Resources (SD DENR) has identified Mina Lake as a water that is intended to support a range of designated uses including: domestic water supply, warmwater permanent fish life propagation, immersion recreation, limited contact recreation, fish and wildlife propagation, recreation and stock watering. The narrative standards being implemented in this TMDL are: "*Materials which produce nuisance aquatic life may not be discharged or caused to be discharged into surface waters of the state in concentrations that impair a beneficial use or create a human health problem.*" (See ARSD §74:51:01:09) "*All waters of the state must be free from substances, whether attributable to human-induced point source discharges or nonpoint source activities, in concentration or combinations which will adversely impact the structure and function of indigenous or intentionally introduced aquatic communities.*" (See ARSD §74:51:01:12)
B. Water Quality Standards Targets - **Approved**	Water quality targets for this TMDL are based on interpretation of narrative provisions found in State water quality standards. In May 2000, SD DENR published *Ecoregion Targeting for Impaired Lakes in South Dakota*. This document proposed ecoregion-specific targeted Trophic State Index (TSI) values based on beneficial uses. EPA approved the use of these ecoregion-specific targets to evaluate lakes using beneficial use categories. In South Dakota algal blooms can limit contact and immersion recreation beneficial uses. Also algal blooms can deplete oxygen levels which can affect aquatic life uses. SD DENR considers several algal species to be nuisance aquatic species. TSI measurements can be used to estimate how much algal production may occur in lakes. Therefore, TSI is used as a measure of the narrative standard in order to determine whether beneficial uses are being met. The overall mean TSI for Mina Lake during the period of the assessment (June 1999 through spring 2000) was 79.4. Nutrient reduction response modeling was conducted with BATHTUB, an Army Corps of Engineers eutrophication response model. The results of the modeling show that 94% or more reduction in the total phosphorous loading from the watershed would be necessary to meet the ecoregion-based beneficial use TSI target of 65 or less. However, Mina Lake does not appear to fit the ecoregion-based beneficial use criteria due to legacy phosphorous loading to the lake and the technical and financial inability to fully treat new loading to the lake. Therefore, a higher TSI target has been established for Mina Lake. The target used in this TMDL is: ▪ TSI mean less than 79.2 (growing season average) ▪ Phosphorous TSI less than 98.4

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C. Significant Sources - **Approved**	The TMDL identifies the major sources of phosphorous as coming from nonpoint source agricultural landuses within the watershed and internal loading from bottom sediments within the lake. In particular, a loading analysis was done by sub-watershed for nutrients and sediment considering various agricultural land use and land management factors.
D. Technical Analysis - **Approved**	The technical analysis addresses the needed phosphorous reduction to achieve the desired water quality. The TMDL recommends a 38.8% reduction in total phosphorous loading from watershed and sediment released phosphorous sources to Mina Lake. This reduction is based in large part on the BATHTUB mathematical modeling of the Lake and its predicted response to nutrient load reductions. The Agricultural Non-Point Source Model (AGNPS) model was used to simulate alterations in land use practices and the resulting nutrient reduction response. The analysis of which nutrient loading sources were in need of control was based on a identification of targeted or "critical" cells. Cell priority was assigned based on average nutrient loads produced that ultimately reach the outlet of the watershed. Cells that produce phosphorous loads greater than 1, 2, and 3 standard deviations over the mean for each sub-watershed were given a priority ranking of 1, 2 and 3 respectively. The initial load reductions under this TMDL will be achieved through controls on the priority 1 and 2 cropland cells within the watershed such as reducing fertilizer application rates and conversion to conservation tillage (i.e., minimum or no-till) practices. Controls at critical livestock feeding area combined with modification of grazing practices will also be necessary to achieve the desired results. The reduction in sediment released phosphorous will be possible through inlake treatments such as the application of alum.
E. Margin of Safety & Seasonality - **Approved**	An appropriate margin of safety is included through conservative assumptions in the derivation of the target and in the modeling. Additionally, ongoing monitoring has been proposed to assure water quality goals are achieved. Seasonality was adequately considered by evaluating the cumulative impacts of the various seasons on water quality and by proposing that BMPs be tailored to seasonal needs.
F. TMDL - **Approved**	The TMDL established for Mina Lake is a 38.8% reduction in total annual phosphorus loading from the watershed and sediment released sources. Since the annual loading varies from year-to-year, this TMDL is considered a long term average reduction in total phosphorous loading.
G. Allocation - **Approved**	This TMDL addresses the need to achieve further reductions in nutrients to attain water quality goals in Mina Lake. The allocation for the TMDL was a "load allocation" attributed to nonpoint sources. The allocation for phosphorous was attributed to such sources as cropland tillage, fertilizer application, animal feeding areas, and internal loading. There is a desire to move forward with controls in the areas of the basin where there is confidence that phosphorous reductions can be achieved through modifications to priority 1 and 2 cropland cells within the watershed combined with animal feeding area controls, modification of grazing practices and modest reductions in sediment released phosphorous. Additional phosphorous load reductions are possible if all of the cropping and grazing uses were converted to conservation reserve program (CRP) use and other drastic changes in land use and management. However, historic data indicate that Mina Lake has been hyper-eutrophic for the entire period of data collection (beginning in 1979). Therefore, the goal is to reverse the TSI trend. It would be technically and economically very difficult to implement enough BMPs within the watershed to achieve long term TSI values in eutrophic range.

H. Public Participation - **Approved**	The State's submittal includes a summary of the public participation process that has occurred which describes the ways the public has been given an opportunity to be involved in the TMDL development process. In particular, the State has encouraged participation through public meetings in the watershed, articles in local newspapers, individual contact with landowners in the watershed, and widespread solicitation of comments on the draft TMDL. The State also employed the Internet to post the draft TMDL and to solicit comments. The level of public participation is found to be adequate.