PHASE I
WATERSHED ASSESSMENT AND TMDL
FINAL REPORT

CORSICA LAKE,
DOUGLAS 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

February, 2005

SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM ASSESSMENT/PLANNING PROJECT FINAL REPORT

CORSICA LAKE WATERSHED ASSESSMENT AND TMDL FINAL REPORT

By

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Sponsor

South Central Water Development District
Randall RC&D

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US Natural Resource Conservation Service
US Environmental Protection Agency
South Dakota Department of Environment and Natural Resources
South Dakota Department of Game, Fish and Parks

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ABBREVIATIONS

AFOs	Animal Feeding Operations
ANC	Acid Neutralizing Capacity
AnnAGNPS	Annualized Agricultural Non-Point Source
BMPs	Best Management Practices
CV	Coefficient of Variance
DC	District Conservationist
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
GPS	Global Positioning System
GLS	Great Little Sampler
IJC	International Joint Commission
NPS	Non-Point 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 and Parks
SU	Standard Units
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TSI	Trophic State Index
µmhos/cm	micrmohos/centimeter
USGS	United States Geologic Survey

EXECUTIVE SUMMARY

Project Title: South Central Lakes Watershed Assessment Project	
Project Sponsor: South Central Water Development District	
Project Start Date: April 1, 2000	**Project Completion Date:** December 31, 2001
Original Funding:	**Total Budget:** $ 189,438.00
Total EPA Budget:	$ 113,663.00
Total Expenditures of EPA Funds:	$ 126,857.14
Total Section 319 Match Accrued:	$ 77,510.11
Budget Revisions:	319 - $ 22,000.00 Reverted 319 - $ 8,805.86
Total Project Expenditures:	$ 204,367.25

SUMMARY ACCOMPLISHMENTS

The Corsica Lake Watershed Assessment was completed as a portion of a larger assessment in South Central South Dakota which covered several lakes and their associated drainages. The project was initiated as a result of these waterbodies inclusion on the 1998 and 2002 State 303(d) lists. These listings were based on an ecoregion based target through which mean trophic states index (TSI) based on phosphorus, chlorophyll *a*, and Secchi depth readings. Based on data collected during this study, it is recommended that the use of a nitrogen TSI be used as a surrogate for the phosphorus TSI. The resulting mean TSI was more representative of the lakes actual conditions during the assessment.

Work activities commenced in early 2000 when a coordinator was hired and data collection began. Collection of data continued through 2001. All milestones were accomplished in an acceptable and timely manner, with the exception of the final report, which was completed later than the initial proposal date.

The primary funding source for the project was provided through federal 319 funds. Additional funding and support was provided by local sources such as the lead sponsor, South Central Water Development District.

The major findings of this study include the following remediation plans:

- Implement managed grazing on 4,000 acres of range land in the critical regions listed in the AnnAGNPS section of this report.
- Implement 1,200 acres of grass seeding, waterways, and riparian buffers in the critical regions listed in the AnnAGNPS section of this report.
- Implement reduced runoff practices on the five animal feeding operations listed in the AnnAGNPS section of this report.

INTRODUCTION

PURPOSE

The long term goal of the Corsica Lake Assessment Project is to locate and document sources of nonpoint source pollution in the watershed. Feasible restoration recommendations will be produced in order to provide adequate background information needed to drive a watershed implementation project to reduce sedimentation and nutrient problems impacting the lake and its tributaries, and to produce a TMDL report for Corsica Lake.

GENERAL LAKE DESCRIPTION

Corsica Lake is a 110 acre man-made impoundment in northern Douglas County, South Dakota (see Figure 1). The reservoir receives runoff from agricultural operations. The creeks in the watershed and the lake have experienced declining water quality according to the state 303d report. The Corsica Lake watershed is approximately 56,038 acres in size. The land use in the watershed is predominately agricultural consisting of cropland and grazing.

LAKE IDENTIFICATION AND LOCATION

Lake Name: Corsica Lake	State: South Dakota
County: Douglas	Township: 99N
Range: 63W	Sections: 3,4,9
Nearest Municipality: Corsica	Latitude: 43.411063
Longitude: -98.295964	EPA Region: VIII
Primary Tributary: Choteau Creek	Receiving Body of Water: Choteau Creek
HUC Code: 10170101	HUC Name: Lewis and Clark Lake

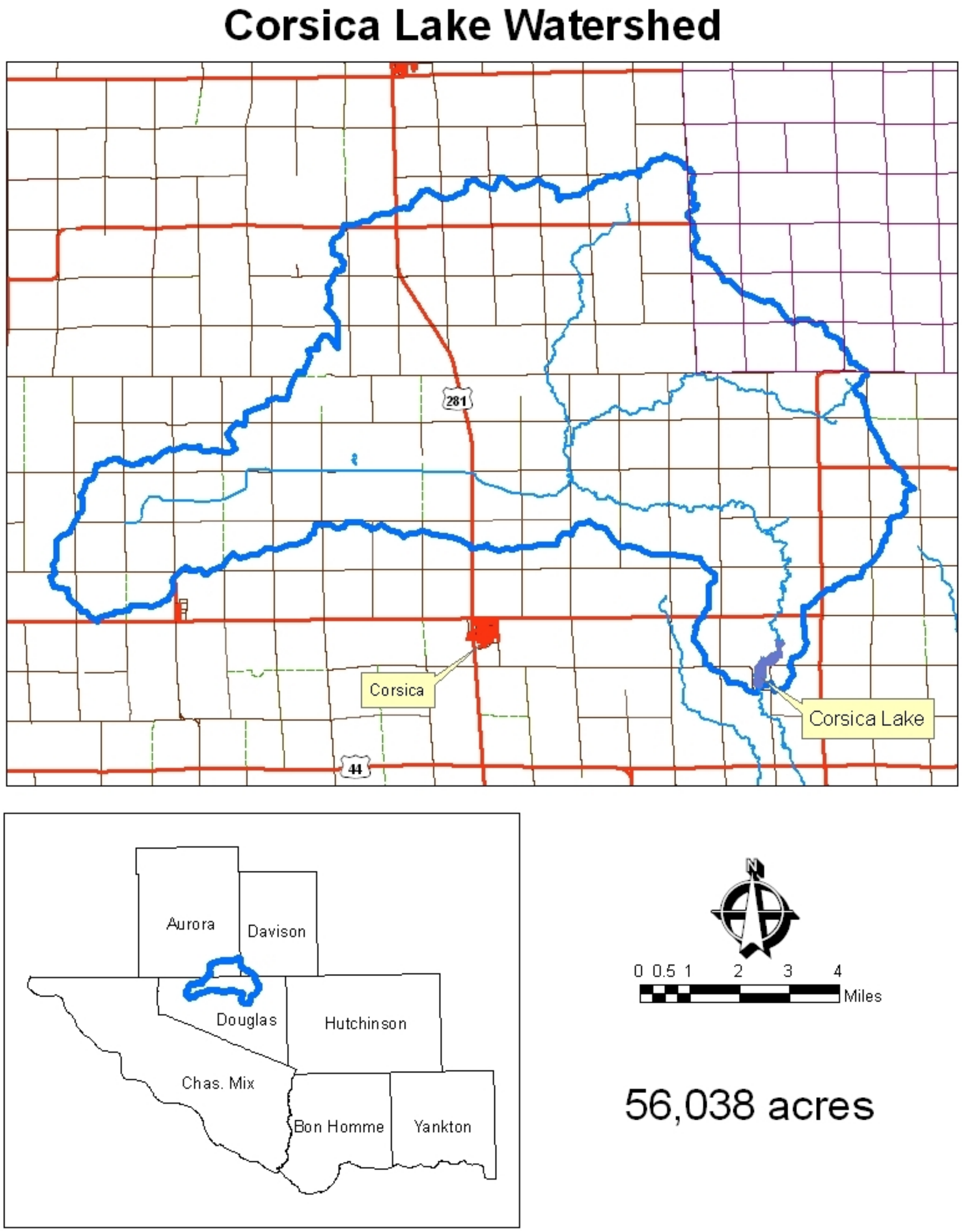


Figure 1. Corsica Lake Watershed

TROPHIC STATE COMPARISON

The trophic state of a lake is a numerical value that ranks its relative productivity. Developed by Carlson (1977), the Trophic State Index (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 Corsica Lake to other reservoirs in the Southern Missouri Coteau Ecoregion (Table 1) shows a wide range of productivity in the ecoregion. Corsica Lake has a higher than average 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, 1995). The TSI for Corsica Lake will vary slightly in this report due to the use of additional data gathered during this assessment.

Table 1. Comparison of Mean Trophic States for Lakes located in the Southern Missouri Coteau Ecoregion

Lake	County	TSI	Mean Trophic State
Andes	Charles Mix	93.98	Hyper-eutrophic
Geddes	Charles Mix	77.60	Hyper-eutrophic
Rosette	Edmunds	78.45	Hyper-eutrophic
Cottonwood	Sully	78.55	Hyper-eutrophic
Hiddenwood	Walworth	77.46	Hyper-eutrophic
Rose Hill	Hand	69.39	Hyper-eutrophic
Corsica	**Douglas**	**79.93**	**Hyper-eutrophic**
Loyalton	Edmunds	66.65	Hyper-eutrophic
Academy	Charles Mix	81.69	Hyper-eutrophic
Dante	Charles Mix	72.13	Hyper-eutrophic
Wilmarth	Aurora	72.09	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 Corsica 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. Corsica Lake is identified in *Ecoregion Targeting for Impaired Lakes in South Dakota* (Stueven et al, 2000) as not supporting its beneficial uses.

PROJECT OBJECTIVES, ACTIVITIES, AND MILESTONES

OBJECTIVE 1. Lake Sampling

Sampling of Corsica Lake was to begin in April 2000; however, the first samples were not collected until May 2000 when sampling equipment arrived. Sampling of nutrient and solids parameters continued at the two scheduled sites through October 2000 as planned. No samples were taken in the winter months due to ice cover. Spring samples were taken during April and May 2001.

OBJECTIVE 2. Tributary Sampling

The project coordinator began tributary monitoring and sampling at the start of the project in May 2000. A total of 37 tributary samples were collected during the project from the five monitoring stations on Choteau Creek. The sample set provided enough data to develop nutrient and sediment loadings for Corsica Lake.

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

Replicate 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 in July of 2000 and was completed in April 2001. It appears that the quality of the data was sufficient to complete a TMDL for this waterbody.

OBJECTIVE 4. Watershed Modeling

Collection of the data required to execute the AnnAGNPS model was conducted during the summer of 2003 and reached completion during the winter of 2004. Execution of the AnnAGNPS model was completed well after the expected date.

OBJECTIVE 5. Public Participation

The public was involved throughout the project. The coordinator attended various conservation district, water development district, and county commission meetings as well as having individual contact with landowners.

OBJECTIVES 6 and 7. Restoration Alternatives and Final Report

The restoration alternatives and the final report were completed during the Spring of 2005, well after the proposed completion date of December 2001.

EVALUATION OF GOAL ACHIEVEMENTS

With the exception of the watershed modeling, restoration alternatives and the final report, all the objectives were met in an acceptable time frame. These objectives were not completed during the original assessment as a result of the coordinator leaving the position, after which they were not replaced.

Table 2. Milestone Table

	2000									2001											
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Objective 1- Lake Sampling																					
Objective 2-Tributary Sampling																					
Objective 3- QA/QC																					
Objective 4- Watershed Modeling																			Later in 2004		
Objective 5- Public Participation																					
Objective 6- Restoration Alternatives																			Later in 2004		
Objective 7- Final Report																				4-Dec	

Proposed ■ Actual ■

MONITORING RESULTS

SURFACE WATER CHEMISTRY (CHOTEAU CREEK)

FLOW CALCULATIONS

A total of five (four tributary and one outlet) monitoring sites were selected on the tributaries to Corsica 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. All of the sites were equipped with ISCO 4230 flow meters connected to ISCO GLS auto samplers. Water stages were monitored and recorded to the nearest $1/100^{th}$ of a foot for each of the five sites. A Marsh-McBirney Model 210D velocity meter was used to determine flows at various stages. The stages and flows were then used to create a stage-to-discharge table for each site.

LOAD CALCULATIONS

Total nutrient and sediment loading were calculated with the use of the Army Corps of Engineers 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 was then used for each of the additional parameters. Sample data collected from the tributaries may be found in Appendix A.

TRIBUTARY SAMPLING SCHEDULE

Samples were collected at selected sites during the spring of 2000 through the spring of 2001. Most samples were collected using a suspended sediment sampler while some were collected with automatic samplers. Water samples were filtered, preserved, and packed in ice for shipping to the State Health Lab in Pierre, South Dakota. The laboratory then assessed the following parameters:

Fecal Coliform Counts
Total Solids
Total Suspended Solids
Nitrate
Total Phosphorus
Total Dissolved Phoshporus
Alkalinity
E. *coli* Bacteria Counts (2001)
Ammonia
Total Kjeldahl Nitrogen (TKN)
Volatile Total Suspended Solids

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

Precipitation
Odor
Dead Fish
Turbidity
Water Depth
Water Color

Wind
Septic Condtions
Film
Width
Ice Cover

Parameters measured in the field by sampling personnel were:

Water Temperature
Dissolved Oxygen
Conductivity

Air Temperature
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 the tributaries located within the Corsica Lake watershed must maintain the criteria that support these uses. In order for the creek to support 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 3.

Table 3. State Water Quality Standards for Choteau Creek

Parameters	Standard 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° C)	≤4,000 (mean) ≤7,000 (single sample)	Wildlife Propagation and Stock Watering
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 to ≤9.0	Warmwater Semi-permanent Fish Propagation
Solids, total dissolved	≤2,500 (mean) ≤4,375 (single sample)	Wildlife Propagation and Stock Watering
Total Petroleum Hydrocarbon	≤10	Wildlife Propagation and Stock Watering
Oil and Grease	≤10	
Sodium Adsorption Ratio	<10	Irrigation Waters

WATERSHED OVERVIEW

The drainage to Corsica Lake was divided into four subwatersheds. Gauging stations were placed at the outlets of each of the four subwatersheds (see Figure 2). Stage and discharge data were collected from each of the outlets along with water chemistry samples. This data was combined to calculate a load from each of the subwatersheds.

One of the subwatersheds, CLT5, is a man-made ditch. It is also known locally as Garden Valley Ditch.

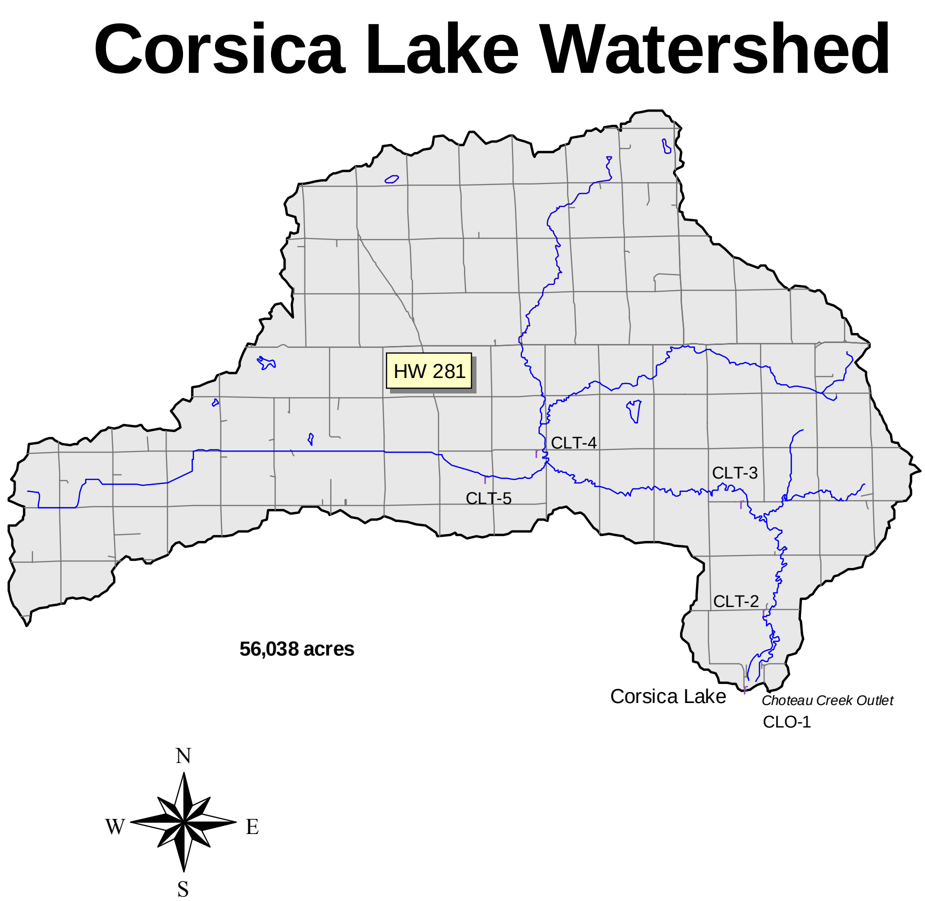


Figure 2. Corsica Subwatersheds

ANNUAL LOADINGS

BATHTUB models the current and future water quality in an impoundment. BATHTUB was developed by the Army Corps of Engineers. The model utilizes phosphorus and nitrogen loads entering the impoundment. These loads and their standard errors (CV) are calculated from the use of the FLUX model at the lake inlet. These models were used to calculate nutrient delivery to Corsica Lake.

FECAL COLIFORM BACTERIA

Fecal coliform bacteria 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). *E. coli* was not tested for until the spring of 2001. Most of the samples indicated the presence of *E. coli* at levels higher than the total fecal coliform count (Table 4). 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.

There are no fecal coliform standards for the tributaries entering Corsica Lake. As a reslt of this, there are no impairments of fecal contamination. Samples collected from the lake did not indicate any impairment; however, some of the larger tributary concentrations, such as those from CLT2 on June 1, 2000, likely result in higher counts then were measured in the lake.

Fecal contamination may also be an indicator of the type of nutrient enrichment that the streams and lake are experiencing. Fecal counts were high at some sites with multiple dates in excess of 1,000 colonies/100mL. This suggests that mitigation practices targeting livestock in these watersheds may result in the greatest immediate benefits to the lake through the reduction of fecal loads in addition to nutrient loads.

Table 4. Bacteria Concentration on Choteau Creek

	CLO1		CLT2		CLT3		CLT4		CLT5	
DATE	Fecal	E.coli	Fecal	E.coli	Fecal	E.coli	Fecal	E.coli	Fecal	E.coli
5/11/2000	1200		1100							
5/18/2000			2300		790		1400		2100	
6/1/2000			4200		230		170			
11/1/2000			12000							
4/4/2001	20	30.5	10	31.7	<10	10.9	20	41.3	20	30.5
4/4/2001									20	38.8
4/12/2001	2700	2420	300	276	520	435	4200	>2420	140	249
4/12/2001	670	1990			420	816				
4/17/2001	10	14.5			<10	5.1	20	23.1	<10	12
4/17/2001							<10	18.3		
4/25/2001					300	461	360	461	2100	1730
5/2/2001	40	36.9	20	37.3	100	122	40	35.4	<10	16.1
5/7/2001	210	101	640	866	290	1990	1800	>2420	730	488

ALKALINITY, WATER TEMPERATURE, AND DISSOLVED OXYGEN

These three parameters had no cause for concern. All three were well under the state standard or did not have a state standard to meet.

Alkalinity refers to the buffering capacity to neutralize strong acids such as HCl, H_2SO_4, and HNO_3. The highest value was 456 mg/L on May 18, 2000 at site CLT5. The lowest value was 80 mg/L on April 12, 2001 at site CLT5.

Water temperature is very important to the aquatic ecosystem. Many organisms are sensetivie to temperature. There is no state standard for the Corsica Lake portion of Choteau Creek. The highest temperature recorded was 18.74° C on May 11, 2000 at site CLO1.

Dissolved Oxygen (DO) is very important to aquatic communities. Oxygen depletion may lead to fish kills. The state standard for dissolved oxygen on Choteau Creek is >5.0 mg/L. The lowest DO measured was 5.08 on May 2, 2001 at site CLT4.

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 considered basic (more OH^- ions). pH values collected from the project streams had values that ranged from 7.46 su to 8.9 su, all within the state standards of 6.0 su to 9.5 su indicating no impairment as a result of high or low pH values

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 total solids loadings most closely depict the dissolved portion of the solids load. Ground water typically has higher concentrations of dissolved solids than surface water. The amount of ground water influence is evident when comparing the total solids loadings/ acre, see Table 5. Site CLT5, Garden Valley Ditch, has very little ground water flow. The sites on Choteau Creek are all influenced by groundwater flow.

Table 5. Solid Loadings for Corsica Lake

	Total Solids(kg/yr)	Suspended Solids(kg/yr)	Acres	Total Solids/Acre	Suspended Solids/Acre	Total Solids(tons/yr)	Suspended Solids(tons/yr)
CLO1	6,481,751	587,514.6	56,038	115.67	10.48	7,145	648
CLT2	8,165,218	282,444.9	55,687	146.63	5.07	9,001	311
CLT3	5,939,962	133,783.4	49,274	120.55	2.72	6,548	147
CLT4	5,765,263	118,065.6	28,957	199.10	4.08	6,355	130
CLT5	1,063,409	75,530.3	15,128	70.29	4.99	1,172	83

The suspended solids load at the inlet site recorded 311 tons of sediment entering the lake each year while the outlet site recorded 648 tons of sediment leaving the lake, which makes it appear that the lake discharged more than it acquired. The data may be somewhat misleading when you take into account when the samples were taken, all during high flow events. It also appears as if the initial flushing of nutrients was sampled closer to the outlet of the lake. It is likely that some sediment is deposited into the lake when the flow is lower and is allowed to settle. There are a limited number of discharge measurements, which may have also affected the loading calculations.

Due to the incompleteness of the sampling and stage to discharge data, a sediment budget for the lake can not be accurately calculated. Future investigations in this watershed should more accurately target critical flows during the initial flushing of material from the lake and develop more comprehensive stage to discharge relationships.

NITROGEN

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.

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 50 mg/L mean over any 30 day period of time and 88 mg/L for any single sample. Nitrate levels were low in the watershed throughout the project. The maximum concentration recorded was measured at site CLT2 on April 4, 2001 at 1.1 mg/L, indicating full support of all beneficial uses for this parameter.

Table 6. Nitrogen Loads in Choteau Creek

	Units	CLO1	CLT2	CLT3	CLT4	CLT5
Area	Acres	56,038	55,687	49,274	28,957	15,128
Total Nitrogen	KG	16,814	25,025	12,374	40,066	5,920
Total Inorganic Nitrogen	KG	2,328	6,123	1,969	20,322	523
Total Organic Nitrogen	KG	14,486	18,902	10,405	19,744	5,397
Total Nitrogen	Kg/Acre	0.30	0.45	0.25	1.38	0.39
Total Inorganic Nitrogen	Kg/Acre	0.04	0.11	0.04	0.70	0.03
Total Organic Nitrogen	Kg/Acre	0.26	0.34	0.21	0.68	0.36

The total nitrogen budget calculated for the tributaries indicates that site CLT4 accounts for 39% of the nitrogen load entering Corsica Lake. When calculating inorganic nitrogen (Figure 3), CLT4 accounts for 65% of the load entering Corsica Lake. Mitigation practices targeted at reducing the amount of inorganic nitrogen in this specific subwatershed would likely reduce the loads entering Corsica Lake.

PHOSPHORUS

Phosphorus is one of the macronutirents 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. Total phosphorus is the sum of all attached and dissolved phosphorus in the lake.

The phosphorus loads and discharge coeffieceients for each subwatershed are listed in Table 7. The highest coeffieceients were calculated for the upper parts of the watershed indicating these contribute the highest amounts of nutrients to Corsica Lake. Mitigation practices should target these areas to reduce phosphorus transport to the lake.

Table 7. Phosphorus Loads in Choteau Creek

	Units	CLO1	CLT2	CLT3	CLT4	CLT5
Area	Acres	56,038	55,687	49,274	28,957	15,128
Total Phosphorus	KG	6,408	6,639	6,092	4,145	2,960
Total Dissolved Phosphorus	KG	4,852	5,780	5,442	3,668	2,587
Total Phosphorus	Kg/Acre	0.114	0.119	0.124	0.143	0.196
Total Dissolved Phosphorus	Kg/Acre	0.087	0.104	0.110	0.127	0.171

Tributary Site Summary

Fecal Coliform bacteria levels were higher in the lower part of the watershed. Although there is no standard that needs to be met, it would be advisable to lower the amount of fecal coliform bacteria in the watershed. This would be accomplished by grazing management, managing animal feeding operations and keeping the livestock out of the riparian areas.

Solids in the lower part of the watershed were higher than they were in the upper part of the watershed. This could be contributed to the landscape itself. The upper part of the watershed is much flatter than the lower part. There are more failing banks downstream of CLT-3 than above it. Slowing down the water flow would improve the failing banks. This could be accomplished by grassed waterways and grazing management.

Nitrogen was high at site CLT-4. Fertilizer and livestock operations would probably be the main sources of the nitrogen load.

Phosphorus loads were also high in the upper part of the watershed, mainly CLT-4 and CLT-5. This is also due to the fertilizer and livestock operations.

SURFACE WATER CHEMISTY (CORSICA LAKE)

INLAKE SAMPLING SCHEDULE

Sampling began in May 2000 and was conducted on a monthly basis until project completion in June of 2001. Samples were not collected during the winter months of 2000, because of ice cover. Two sites were selected for sample collection. Water samples were filtered, preserved, and packed in ice for shipping to the State Health Lab in Pierre, South Dakota. Sample data collected at Corsica Lake may be found in Appendix B. The laboratory 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	Chlorophyll *a*
E. coli Bacteria Counts (2001)	

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

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

Parameters measured in the field by sampling personnel were:

Water Temperature	Air Temperature
Secchi Depth	Dissolved Oxygen
Field pH	Turbidity

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. Corsica 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 parameters and their associated values listed in Table 8 are those 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 8. State Water Quality Standards for Corsica Lake

Parameters	Standard 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° C)	≤4,000 (mean) ≤7,000 (single sample)	Wildlife Propagation and Stock Watering
Nitrogen, unionized ammonia as N	≤0.04 (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	Warmwater Semi-permanent Fish Propagation
pH (standard units)	≥6.5 to ≤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	≤32.22° C	Warmwater Semi-permanent Fish Propagation
Total Petroleum Hydrocarbon	≤10	Wildlife Propagation and Stock Watering
Oil and Grease	≤10	

INLAKE WATER QUALITY PARAMETERS

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.

Alkalinity concentrations in Corsica Lake ranged from a low of 125 mg/L recorded during April of 2001 to a maximum concentration of 288 mg/L during May of 2000. These values are well within state standards (<750 mg/L for a mean) indicating that Corsica Lake is not impaired as a result of excessive concentrations of alkalinity.

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 Corsica Lake require temperatures to be maintained below 32° C. the maximum recorded temperature for the surface water of Corsica Lake was recorded on July 31, 2000 at CL2 with a value of 26.85° C, which is well within the standards for this body of water. Site CL1 also experienced its highest temperature on this date at 26.82° C.

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. Die-offs of large algae blooms and shading as a result of snow cover in the winter can result in depressed oxygen levels that may result in fish kills. Dissolved oxygen concentrations for the surface and bottom of the lake are listed in Table 9.

Table 9. Corsica Lake DO Concentrations

DATE	DEPTH	DO CL1	DO CL2	DATE	DEPTH	DO CL1	DO CL2
5/17/2000	Surface	8.47	7.91	9/7/2000	Surface	4.21	4.29
5/17/2000	Bottom	7.25	7.68	9/7/2000	Bottom	4.04	4.05
6/6/2000	Surface	9.03	9.62	9/27/2000	Surface	6.78	6.52
6/6/2000	Bottom	8.67	8.74	9/27/2000	Bottom	6.6	6.4
6/20/2000	Surface	8.16	8.01	10/11/2000	Surface	9.67	10.3
6/20/2000	Bottom	7.91	7.96	10/11/2000	Bottom	9.57	
7/6/2000	Surface	5.76	6.45	10/25/2000	Surface	9.06	9.58
7/6/2000	Bottom	2.5	6.14	10/25/2000	Bottom	8.32	9.51
7/18/2000	Surface	4.67	4.95	4/17/2001	Surface	11.08	11
7/18/2000	Bottom	4.48	4.78	4/17/2001	Bottom	11.35	10.52
7/31/2000	Surface	9.45	13.5	5/2/2001	Surface	6.93	7.26
7/31/2000	Bottom	3.95	12.4	5/2/2001	Bottom	6.82	7.29
8/15/2000	Surface	7.58	6.67				
8/15/2000	Bottom	6.57	6.27				

The beneficial use of warm-water, semi-permanent fish propagation requires a minimum DO of 5.0 mg/L. Samples collected on July 18, 2000 and September 7, 2000 had recorded values less than 5.0 mg/L. The samples collected in September coincide with what appears to be the end of a large algae bloom that was recorded in August suggesting the DO readings were depressed as a result of decaying Algae. It is unclear what caused the low DO levels during July, but likely causes could be a smaller (because the levels were not as low as the September samples) algae or macrophyte die-off. There were two additional sample dates (7/6/2000 and 7/31/2000) with one of the four levels recorded below this level. Considering that the other 3 samples on these dates were significantly higher, it is likely that these were inaccurate readings as a result of the instrument contacting the bottom sediments prior or during the reading.

There were no recorded instances of a fish kill on the lake indicating that the periods of low DO were short in duration or that areas of the lake maintained adequate levels to provide sufficient refuge for fish to survive. Mitigation activities reducing the nutrient load will reduce the frequency and intensity of algae blooms also reducing the occurrence of DO values below the state standards.

pH

pH is a measure of free hydrogen ions (H^+) or potential hydrogen. Table 9 lists the pH values taken throughout the project. 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 considered 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.

Recorded pH values for Corsica Lake ranged from a low of 7.79 su to a maximum of 9.14 su. The values recorded on October 11, 2000 were both greater than state standards. This is likely due to the large algae blooms which occur throughout the summer and fall. It is likely that this occurs during or immediately following large algae blooms in the lake. The effects of these blooms are often short in duration and do not result in long term impairments of the lake. Mitigation activities reducing the nutrient load will reduce the frequency and intensity of algae blooms also reducing the occurrence of pH values above the state standards.

Table 10. Corsica Lake pH Values

DATE	DEPTH	pH CL1	pH CL2	DATE	DEPTH	pH CL1	pH CL2
5/17/2000	Surface	8.53	8.55	9/7/2000	Surface	8.89	8.81
5/17/2000	Bottom	8.23	8.55	9/7/2000	Bottom	8.92	8.85
6/6/2000	Surface	8.36	8.37	9/27/2000	Surface	8.92	9.07
6/6/2000	Bottom	8.36	8.37	9/27/2000	Bottom	8.9	8.98
6/20/2000	Surface	8.39	8.39	10/11/2000	Surface	9.09	9.14
6/20/2000	Bottom	8.38	8.38	10/11/2000	Bottom	9.08	
7/6/2000	Surface	8.47	8.5	10/25/2000	Surface	8.68	8.61
7/6/2000	Bottom	8.28	8.51	10/25/2000	Bottom	8.68	8.67
7/18/2000	Surface	8.42	8.4	4/17/2001	Surface	8.14	8.13
7/18/2000	Bottom	8.44	8.42	4/17/2001	Bottom	8.14	8.07
7/31/2000	Surface	8.38	8.59	5/2/2001	Surface	7.91	7.79
7/31/2000	Bottom	8.15	8.52	5/2/2001	Bottom	7.82	7.82
8/15/2000	Surface	8.84	8.8				
8/15/2000	Bottom	8.76	8.76				

SECCHI DEPTH

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. Table 11 lists the Secchi depths and TSI values for each site and sample taken during the project.

Table 11. Corsica Lake Secchi Depth Readings

SITE	DATE	SECCHI (m)	TSI	SITE	DATE	SECCHI (m)	TSI
CL-1	5/17/2000	0.7	65.15	CL-2	5/17/2000	0.7	65.15
CL-1	6/6/2000	1.25	56.78	CL-2	6/6/2000	0.9	61.52
CL-1	6/20/2000	1	60.00	CL-2	6/20/2000	0.9	61.52
CL-1	7/6/2000	1.1	58.62	CL-2	7/6/2000	1.1	58.62
CL-1	7/18/2000	1.2	57.37	CL-2	7/18/2000	1.1	58.62
CL-1	7/31/2000	1.85	51.12	CL-2	7/31/2000	1.2	57.37
CL-1	8/15/2000	0.9	61.52	CL-2	8/15/2000	0.9	61.52
CL-1	9/7/2000	1	60.00	CL-2	9/7/2000	1	60.00
CL-1	9/27/2000	2.1	49.30	CL-2	9/27/2000	2	50.00
CL-1	10/11/2000	1.2	57.37	CL-2	10/11/2000	1.1	58.62
CL-1	10/25/2000	1	60.00	CL-2	10/25/2000	1	60.00
CL-1	4/17/2001	1	60.00	CL-2	4/17/2001	1	60.00
CL-1	5/2/2001	0.9	61.52	CL-2	5/2/2001	0.9	61.52
	Max	2.1	65.15		Max	2.0	65.15
	Min	0.7	49.30		Min	0.7	50.00
	Average	1.2	58.37		Average	1.1	59.57

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/m^3 (ppb) and is used in Carlson's Trophic State Index to rank a lake's state of eutrophication.

A lake is considered hyper-eutrophic if the TSI values are greater than 65. The average chlorophyll a concentration in Corsica Lake during the growing season over the past 10 years was 67.7ppb (Table 12), however limiting the data used to that which was collected during the project (for comparability with other parameters), the mean concentration is 56.5 ppb which indicates that the lake is hyper-eutrophic. The mean Chl a TSI for the project period was 67.2. Mitigation practices to reduce the amount of nutrient and sediment loading to the lake would benefit the lakes productivity.

Table 12. Corsica Lake Chlorophyll *a*

Project	Sample Date	Site	Total Chl	Project	Sample Date	Site	Total Chl
SWLAZZZ1	31-Jul-02	SWLAZZZ2502	112.12	SCENTRL1	18-Jul-00	SCENTRLCL02	40.46
SWLAZZZ1	10-Jul-02	SWLAZZZ2502	40.96	SCENTRL1	18-Jul-00	SCENTRLCL01	31.61
SWLAZZZ1	10-Jul-02	SWLAZZZ2502	41.08	SCENTRL1	06-Jul-00	SCENTRLCL02	25.08
SCENTRL1	02-May-01	SCENTRLCL01	27.85	SCENTRL1	06-Jul-00	SCENTRLCL01	20.59
SCENTRL1	02-May-01	SCENTRLCL01	31.15	SCENTRL1	06-Jul-00	SCENTRLCL01	
SCENTRL1	02-May-01	SCENTRLCL02	27.32	SCENTRL1	20-Jun-00	SCENTRLCL01	26.86
SCENTRL1	17-Apr-01	SCENTRLCL02	21.45	SCENTRL1	20-Jun-00	SCENTRLCL02	32.74
SCENTRL1	17-Apr-01	SCENTRLCL01	27.72	SCENTRL1	20-Jun-00	SCENTRLCL02	28.51
SCENTRL1	25-Oct-00	SCENTRLCL01	109.56	SCENTRL1	06-Jun-00	SCENTRLCL02	30.32
SCENTRL1	27-Sep-00	SCENTRLCL01	32.27	SCENTRL1	06-Jun-00	SCENTRLCL01	25.91
SCENTRL1	27-Sep-00	SCENTRLCL02	31.68	SCENTRL1	06-Jun-00	SCENTRLCL02	30.85
SCENTRL1	07-Sep-00	SCENTRLCL02	121.11	SCENTRL1	17-May-00	SCENTRLCL02	47.59
SCENTRL1	07-Sep-00	SCENTRLCL01	71.02	SCENTRL1	17-May-00	SCENTRLCL01	51.41
SCENTRL1	15-Aug-00	SCENTRLCL02	180.77	SWLAZZZ1	27-Jul-98	SWLAZZZ2502	83.08
SCENTRL1	15-Aug-00	SCENTRLCL01	281.09	SWLAZZZ1	27-Jul-98	SWLAZZZ2502	79.06
SCENTRL1	31-Jul-00	SCENTRLCL01	57.49				

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.

Solids data collected during the project is presented in Table 13. State standards for suspended solids limit the daily maximum to be less than 158 mg/L. Samples collected at Corsica Lake were all within the state standards with a maximum recorded concentration of 90 mg/L recorded on May 17, 2000 at site CL1.

Dissolved solids concentrations also remained well within the state standard of 4,375 mg/L with a maximum concentration of 1,853 mg/L collected on October 25, 2000.

Table 13. Corsica Lake Solids Concentrations

SITE	DATE	Total	Suspended	Volatile Suspended	Dissolved
CL-1	5/17/2000	1572	90	16	1482
CL-1	6/20/2000	1678	45	14	1633
CL-1	7/18/2000	1773	39	8	1734
CL-1	8/15/2000	1793	80	46	1713
CL-1	9/27/2000	1827	23	14	1804
CL-1	10/25/2000	1899	46	12	1853
CL-1	4/17/2001	670	30	4	640
CL-1	5/2/2001	764	50	12	714
CL-2	5/17/2000	1544	78	16	1466
CL-2	6/20/2000	1706	62	15	1644
CL-2	7/18/2000	1792	54	10	1738
CL-2	8/15/2000	1791	72	34	1719
CL-2	9/27/2000	1840	24	12	1816
CL-2	10/25/2000	1898	48	14	1850
CL-2	4/17/2001	681	20	3	661
CL-2	5/2/2001	768	56	12	712
	Max	1899	90	46	1853
	Min	670	20	3	640
	Average	1500	51	15	1449

NITROGEN

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. In addition, there are bacterial species capable of fixing atmospheric nitrogen for use by algae resulting in a virtually limitless supply of nitrogen.

Nitrogen concentrations (Table 14) are important for several reasons, the first of which is in the determining the limiting nutrients. If nitrogen is the limiting nutrient, reductions in the phosphorus load to the lake may not result in improvements in water quality. This will be discussed in greater detail in later sections of this report.

Ammonia can be toxic to fish life, particularly in its unionized form which is dependant on water temperature and pH. The highest ammonia concentration recorded during the project was 0.33 mg/L recorded on April 17, 2001 which for the pH and temperature for that day was within the allowable limits. Ammonia is typically more toxic during the summer as a result of warm water temperatures. Since summer fish kills are not a frequent problem on this lake, it is unlikely that ammonia levels impair this waterbody.

Maximum allowable limits for nitrogen in the form of nitrates are 50 mg/L for a mean or a single sample of 88 mg/L. The maximum concentration observed on Corsica Lake during the project was 0.5 mg/L recorded on April 17, 2001. This is well within state standards indicating no impairment as a result of nitrogen in the form of nitrates.

Table 14. Nitrogen Concentrations for Corsica Lake

SITE	DATE	Ammonia	Nitrate	TKN	Total	Organic	Inorganic
CL-1	5/17/2000	0.01	0.05	2.61	2.66	2.6	0.06
CL-1	6/20/2000	0.08	0.1	1.74	1.84	1.66	0.18
CL-1	7/18/2000	0.02	0.1	2	2.1	1.98	0.12
CL-1	8/15/2000	0.02	0.1	4.92	5.02	4.9	0.12
CL-1	9/27/2000	0.02	0.1	1.88	1.98	1.86	0.12
CL-1	10/25/2000	0.02	0.1	2.87	2.97	2.85	0.12
CL-1	4/17/2001	0.33	0.5	1.6	2.1	1.27	0.83
CL-1	5/2/2001	0.12	0.2	1.4	1.6	1.28	0.32
CL-2	5/17/2000	0.01	0.05	2.31	2.36	2.3	0.06
CL-2	6/20/2000	0.09	0.1	1.89	1.99	1.8	0.19
CL-2	7/18/2000	0.02	0.1	1.95	2.05	1.93	0.12
CL-2	8/15/2000	0.02	0.1	4.2	4.3	4.18	0.12
CL-2	9/27/2000	0.02	0.1	1.87	1.97	1.85	0.12
CL-2	10/25/2000	0.02	0.1	2.74	2.84	2.72	0.12
CL-2	4/17/2001	0.27	0.5	1.34	1.84	1.07	0.77
CL-2	5/2/2001	0.14	0.2	1.4	1.6	1.26	0.34
	Max	0.33	0.5	4.92	5.02	4.9	0.83
	Min	0.01	0.05	1.34	1.6	1.07	0.06
	Average	0.08	0.16	2.30	2.45	2.22	0.23

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.

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.

There are no state standards relating to the concentration of phosphorus in water bodies. Phosphorus is an important measurement of a lakes productivity and is directly linked to its trophic state. Concentrations (Table 15) ranged from a low of 0.235 mg/L recorded on June 20, 2000 at site CL1 to a high of 0.705 mg/L recorded on August 15, 2000 at site CL1. Reducing watershed loads may reduce long term concentrations, but would likely show little influence for many years.

Table 15. Corsica Lake Phosphorus Concentrations

SITE	DATE	Total P	Total Dissolved P	TSI
CL-1	5/17/2000	0.338	0.062	88.16
CL-1	6/20/2000	0.235	0.106	82.92
CL-1	7/18/2000	0.310	0.151	86.91
CL-1	8/15/2000	0.705	0.221	98.77
CL-1	9/27/2000	0.491	0.331	93.55
CL-1	10/25/2000	0.605	0.324	96.56
CL-1	4/17/2001	0.647	0.491	97.53
CL-1	5/2/2001	0.574	0.384	95.80
CL-2	5/17/2000	0.276	0.063	85.24
CL-2	6/20/2000	0.274	0.100	85.13
CL-2	7/18/2000	0.322	0.136	87.46
CL-2	8/15/2000	0.598	0.236	96.39
CL-2	9/27/2000	0.481	0.330	93.25
CL-2	10/25/2000	0.606	0.356	96.58
CL-2	4/17/2001	0.635	0.519	97.26
CL-2	5/2/2001	0.526	0.347	94.54
	Max	0.705	0.519	98.77
	Min	0.235	0.062	82.92
	Average	0.476	0.260	92.25

FECAL COLIFORM BACTERIA

Fecal coliform bacteria 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). Testing for *E. coli* did not begin until the spring of 2001.

The state standard for fecal coliform bacteria between May 1 and September 30 is less than 400 colonies/100 ml in any one sample. The geometric mean must remain less than 200 colonies/100 ml 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.

Samples collected from Corsica Lake (Table 16) were well within the state standard with a maximum recorded fecal coliform count of 180 collected on May 17, 2000 from site CL2. Current data does not indicate impairment to Corsica Lake as a result of bacterial concentrations.

Table 16. Bacteria Concentrations on Corsica Lake

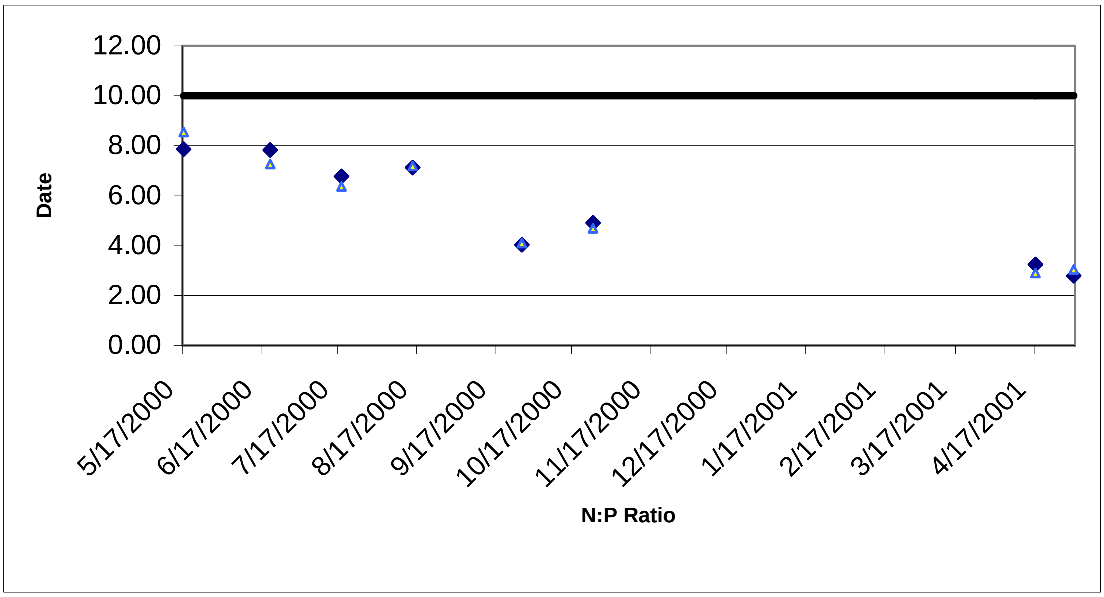
SITE	DATE	Fecal Coli.	*E. coli*	SITE	DATE	Fecal Coli.	*E. coli*
CL-1	5/17/2000	<5		CL-2	5/17/2000	180	
CL-1	6/20/2000	20		CL-2	6/20/2000	10	
CL-1	7/18/2000	<10		CL-2	7/18/2000	<10	
CL-1	8/15/2000	<10		CL-2	8/15/2000	20	
CL-1	9/27/2000	<10		CL-2	9/27/2000	<10	
CL-1	10/25/2000	<10		CL-2	10/25/2000	<10	
CL-1	4/17/2001	<10	24.9	CL-2	4/17/2001	<10	8.5
CL-1	5/2/2001	30	52.1	CL-2	5/2/2001	20	28.1
	Max	30	52.1				
	Min	<5	24.9				
	Average	25	38.5				

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 10:1 indicate a phosphorus-limited system. Those that are less than 10:1 represent nitrogen-limited systems.

Corsica Lake (Table 17) was a nitrogen-limited system, with a mean ratio of 5.54 throughout the project. This is further reinforced when nitrate/nitrite samples (the most readily available plant form of nitrogen) are taken into consideration. Concentrations were consistently below the detection limit indicating all available nitrate is being used by the aquatic life.

Table 17. N:P Ratio for Corsica Lake



TROPHIC STATE

Trophic state relates to the degree of nutrient enrichment of 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 (Table 18).

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 bloom and have large amounts of primary production. Hyper-eutrophic lakes receive scores greater than 65 and are subject to frequent and massive algal blooms that severely impair their beneficial uses and aesthetic beauty.

Table 18. Carlson's Trophic State Index

Trophic State	Combined TSI Numeric Range
Oligotrophic	0-35
Mesotrophic	36-50
Eutrophic	51-64
Hyper-eutrophic	65-100

Individual measured TSI values are represented in Figure 4. TSI values ranged from a low of 49.3 (Secchi) at site CL1 on September 27, 2000 to a high of 98.8 (phosphorus) at site CL1 on August 15, 2000.

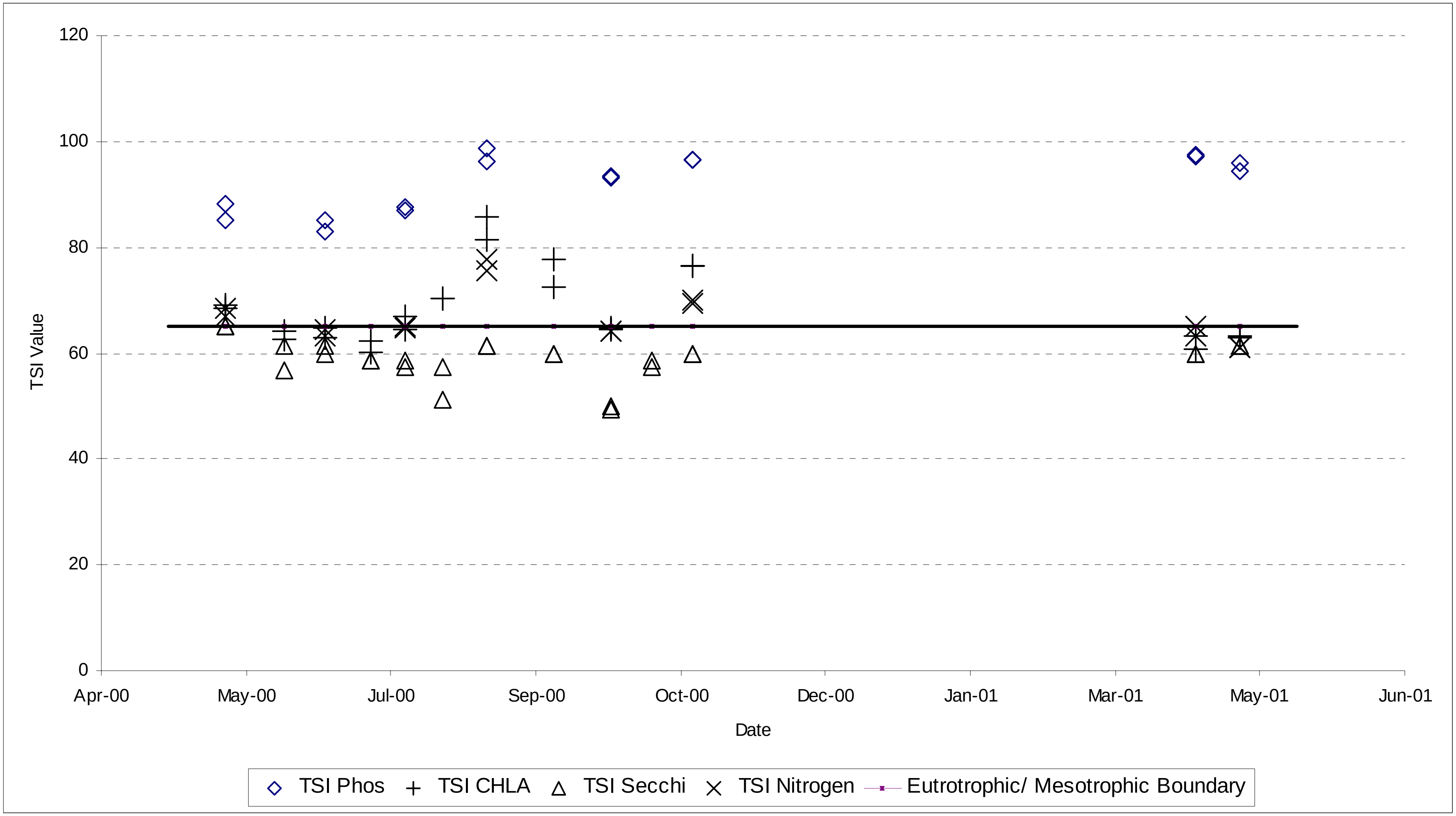
Mean TSI values are typically only calculated on dates where data for Secchi, phosphorus and chlorophyll are all available. The mean TSI for Corsica Lake was calculated by taking the average of all the TSI values. The mean TSI for phosphorus was 92.3, while Secchi and chlorophyll a values were 59.0 and 67.2, respectively. If these values are averaged a mean TSI of 73 is developed, requiring unrealistic reductions in phosphorus in excess of 75% to reach a mean TSI of 65.

Corsica Lake is nitrogen limited during the entire growing season (see previous section "Limiting Nutrients"). Limiting phosphorus concentrations will have little effect on the TSI of the lake until it is reduced to a level in which it becomes the limiting nutrient. A nitrogen TSI was proposed by Kratzer and Brezonik (1981) to be used in systems where the phosphorus TSI deviates from the Secchi and chlorophyll *a* indices. The index is calculated using the following formula where TN is total nitrogen measured in mg/L.

$$TSI(TN) = 54.45 + 14.43 \ln(TN)$$

Corsica Lake fit the description of a system in which the phosphorus index deviates from the chlorophyll a and Secchi indices therefore a nitrogen TSI will be used as a substitute for the phosphorus TSI. The nitrogen TSI results in an index value of 67.4(assuming a mean total nitrogen concentration of 2.45 from Table 14). Combining the nitrogen, Secchi, and Chl a TSI values results in an overall mean TSI of 65 (rounded from 64.5). A TSI of 65 places Corsica Lake on the threshold between full and partial support and within a realistic management goal that may be obtained through mitigation practices.

Figure 3. TSI Values by Date for Corsica 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 the creeks. Loading data for the creeks was taken directly from the results obtained from the FLUX modeling data calculated for the inlets to the lake. Atmospheric loads were provided by SD DENR. A summary of the data is listed in Table 20.

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. Due to differences in calculation methods, the TSI values in the BATHTUB model outputs will be slightly different from those calculated in the report.

BATHTUB not only predicts the inlake concentrations of nutrients; it also produces a number of diagnostic variables that help to explain the lake responses. Table 19 shows the response to reductions in the phosphorus load. The observed and predicted mean.

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 models prediction suggests that the lake is nitrogen limited. Phosphorus limitation is not possible with a 50% reduction, however it is possible between 50% and 75%.

The variables FREQ (CHL-a)% represent the predicted algal nuisance frequencies or bloom frequencies. Blooms are often associated with concentrations of 30 to 40 ppb 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.

Taking into consideration that the TSI value for Corsica Lake is on the threshold between full and partial support, any reductions in nutrient loading (both phosphorus and nitrogen) will provide increased protection for the lakes beneficial uses. Initial implementation activities should target 10% to 20% reductions prior to reassessment of lake conditions to determine if full support is continuing.

Table 19. BATHTUB Calculations for Corsica Lake

Variable	Values calculated using Bathtub Observed	Condition of lake based on current loadings Estimated	Equal Reductions assumed in all subwatersheds, percentages are for total lake load						
			10% est	20% est	30% est	40% est	50% est	75% est	99% est
TOTAL P	464.0	439.9	401.7	361.2	322.8	281.9	239.9	128.5	6.4
TOTAL N	2790.0	2401.5	2401.5	2401.5	2401.5	2401.5	2401.5	2401.5	2401.5
CHL-A	74.1	74.1	73.4	72.5	71.4	69.9	67.8	56.4	3.0
SECCHI	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.3	12.8
ORGANIC N	2670.0	1852.0	1836.2	1815.4	1790.7	1756.5	1709.1	1448.7	232.2
ANTILOG PC-1	3880.6	3205.8	3138.0	3048.9	2943.0	2798.6	2603.1	1679.3	11.5
ANTILOG PC-2	23.9	23.4	23.4	23.5	23.5	23.6	23.8	24.5	19.9
(N-150) / P	5.7	5.1	5.6	6.2	7.0	8.0	9.4	17.5	352.2
INORGANIC N / P	0.5	1.8	2.1	2.5	3.1	4.0	5.7	31.4	678.0
FREQ (CHL-a>10)%	99.8	99.8	99.8	99.8	99.8	99.8	99.7	99.3	1.3
FREQ (CHL-a>20)%	96.0	96.4	96.3	96.1	95.9	95.6	95.1	91.3	0.0
FREQ (CHL-a>30)%	86.5	87.5	87.1	86.7	86.2	85.4	84.3	76.1	0.0
FREQ (CHL-a>40)%	73.8	75.3	74.8	74.2	73.4	72.2	70.6	59.6	0.0
FREQ (CHL-a>50)%	60.9	62.7	62.1	61.4	60.4	59.1	57.2	45.4	0.0
FREQ (CHL-a>60)%	49.3	51.2	50.6	49.8	48.8	47.4	45.5	34.1	0.0
TSI-P	92.7	91.9	90.6	89.1	87.5	85.5	83.2	74.2	30.9
TSI-CHLA	72.6	72.8	72.7	72.6	72.5	72.3	72.0	70.2	41.5
TSI-SEC	59.3	59.5	59.4	59.2	59.0	58.7	58.3	55.8	23.2
Mean TSI	74.9	74.7	74.2	73.6	73.0	72.2	71.2	66.7	31.9
TSI Shift	0.0	0.0	0.5	1.1	1.7	2.6	3.6	8.0	42.9

Table 20 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 variables. 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 variable. 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, and 60 ppb. Related to risk or frequency of use impairment.
TSI	Trophic State Indices (Carlson 1977)

BIOLOGICAL MONITIORING

PHYTOPLANKTON

Composited surface algae samples were collected approximately twice a month at two inlake water quality monitoring sites, from May 17 to October 11, 2000, and April 17 and May 2, 2001. A total of 92 algal taxa (genera or species) including two ‘unidentified’ categories were collected from this small 110-acre impoundment during this survey (Appendix C). Algae species richness (the number of taxa observed) was rated as ‘high’ compared to other recently monitored small (< 200 ac.) eutrophic state lakes (mean: 72 taxa). However, the relative abundance of individual taxa was very uneven, with 65% of taxa each contributing less than 0.1% to total algal abundance, and only three species comprising 73 % of total density for the survey (Appendix C). A similar distribution was observed in Corsica Lake during a summer survey in 1998.

Five phyla of motile(flagellated) algae represented the most diverse algal group in Corsica Lake with 34 taxa (37% of all species) collected, including an ‘unidentified flagellates’ category. Euglenoid flagellates (e.g. *Euglena* sp., *Trachelomonas* sp. and *Phacus* sp.) and yellow-brown (or, golden-brown) flagellates (Chrysophyta) were the most diverse phyla of the motile algae with 9 and 8 taxa, respectively, followed by green flagellates (Chlorophyta) and dinoflagellates (Pyrrhophyta) with 6 taxa each. Cryptomonads accounted for the remaining 4 identified motile taxa.

Non-motile green algae (Chlorophyta) were the second most diverse group of algae collected with 26 taxa, followed by diatoms (Bacillariophyta) containing 22 taxa. As frequently occurred in monitored small lakes, blue-green algae were the least diverse but often the most abundant algal group collected. Corsica Lake had 9 taxa identified during the present survey. *Aphanizomenon flos-aquae* and *Oscillatoria agardhii* together comprised 52% of total algal abundance during this study.

Algae biovolume in Corsica Lake ranged from 1,562,202 um^3/ml in early July to 93,295,725 um3 / ml in mid-August, 2000 (Appendix C). Corresponding algal abundance (population density) for those dates amounted to 10,311 cells/ml and 139,062 cells/ml, respectively. However, maximum algae density occurred on October 11 at 273,733 cells/ml which had a biovolume of 62,376,735 um3/ml. Average monthly density and biovolume for the study period amounted to 58,357 cells/ml and 20,172,511 um3/ml.

The plankton algae (phytoplankton) population during this survey consisted of 58% blue-green algae which made up only slightly more than 18% of the total algal volume, in contrast to the large-sized dinoflagellates which, while comprising less than 2% of algal numbers made up more than half (52%) of total algal biomass for the project period. Diatoms were next in importance, contributing 26% and 25% to total algae numbers and volume, respectively. Non-motile green algae were less common, providing 11% of biovolume but only 2.4% of total algal density. Flagellated algae represented the least common algae group in Corsica Lake during this study, accounting for only 3% of total algae and less than 2% of annual biovolume (dinoflagellates excluded). They were most prevalent in spring and fall (Appendix C).

The seasonal pattern of algal abundance in Corsica Lake consisted of two large population peaks, one in summer and the other in fall (Appendix C). The August 15 population pulse consisted of a bloom of blue-green algae, primarily *Aphanizomenon*, and a large-sized dinoflagellate, *Glenodinium gymnodinium*. The latter, although much less abundant, provided 83% of the algal biovolume of the bloom on that date. The algae pulse on October 11 consisted mostly of a very large bloom of small and medium-sized centric diatoms (139,059 cells/ml), primarily *Stephanodiscus* and an autumn blue-green bloom of *Oscillatoria agardhii* (previously identified as *Aphanizomenon*). The large spring diatom blooms frequently reported in eutrophic lakes were not observed in Corsica Lake, although diatoms did attain a moderately high density on May 17, 2000 (7,087 cells/ml).

Blue-green algae, primarily the nuisance species *Aphanizomenon flos-aquae*, did not become prominent in Corsica Lake until late July when they made up 79% of the algal volume (Appendix C). By the end of the first week of September, the summer population had declined to 11,841 cells/ml. The blue-green population doubled later in September and by about mid-October experienced a sharp increase to 112,750 cells/ml with a biovolume of 13,191,750 um3/ml. An examination of algae reference slides for October indicated that the major component of this blue-green bloom was *Oscillatoria agardhii*. Apparently, what occurred was a seasonal succession in September from *Aphanizomenon* to *Oscillatoria*. Whereas *Aphanizomenon flos-aquae* is normally a warmwater species, *Oscillatoria agardhii* can also be abundant over the fall season, as observed in some eutrophic Indiana lakes where it frequently developed autumn blooms (Frey 1964).

The dominance of the dinoflagellate species *Glenodinium gymnodinium* (by volume) in the mid-summer plankton is a fairly common occurrence in some highly eutrophic state lakes other than Corsica, for example, this large-sized organism was also found to be prominent during July and August in Lakes Alvin, Faulkton, Jones, and Lake Campbell (Brookings Co.). It is believed some dinoflagellates and a number of other motile algae species respond favorably to the presence of abundant nitrogenous organic compounds such as those supplied by runoff from feedlots and other sources(Wetzel 2001, Prescott 1962).

THREATENED AND ENDANGERED SPECIES

There has only been one federally threatened or endangered species documented in the Choteau Creek/Corsica Lake 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 watershed.

Bald eagles (*Haliaeetus leucocephalus*) typically prefer large trees for perching and roosting. As there are no confirmed documentation of bald eagles within the Corsica Lake 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 (*Grus americana*) have been documented once in the Choteau Creek watershed. The sighting was documented in 1888. 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, artifical 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 mititgation 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 (*Platanthera praeclara*) 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).

OTHER MONITIORING

ANNUALIZED AGRICULTURAL NON-POINT SOURCE MODEL (ANNAGNPS)

AnnAGNPS 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 cells of varying sizes based on topography. Each cell is then assigned a primary land use and soil type. Best Management Practices (BMPs) are then simulated by altering the land use in the individual cells and reductions are calculated at the outlet to the watershed.

The input data set for AnnAGNPS Pollutant Loading Model consists of 33 sections of data, which can be supplied by the user in a number of ways. This model execution utilized; digital elevation maps (DEMs) to determine cell and reach geometry, SSURGO soil layers to determine primary soil types and the associated NASIS data tables for each soils properties, and primary land use based on the Digital Ortho Quads (DOQs). The DOQ was digitized and many land uses were determined directly from it. Additional detail on cropping rotations and grass conditions were added through utilizing Farm Service Agency (FSA) records, using some data from the Oak Lake Field Station, and through some ground truthing. Impoundment data was generated using a synthetic weather generator based on climate information from the two closest stations, Huron and Sioux Falls. Mean annual precipitation for this watershed is about 21 inches.

It is important to note that these model results are based on 25 years of simulated weather data with precipitation ranging from 15 to 27 inches per year. The model run does not represent the project period, it instead represents what may typically occur on any given year, and when analyzed as a group provides a risk analysis for practices in the watershed.

The water quality data collected from Choteau Creek above Corsica Lake depicted annual loads of phosphorus and nitrogen at 7 and 27 tons respectively. Sediment loads were modeled to be approximately 648 tons annually. The modeled loads for this watershed were calculated to be roughly double what the measured loads were. There are a number of potential reasons why the loads do not agree. Soil nutrient estimates may be assumed higher than are actually present, fertilizer applications may be less than what was modeled, or the measured loads may be underestimated as a result of precipitation. Typical modeling runs with AnnAGNPS model commonly underestimate the sediment load in the watershed. This is frequently attributed to in channel processes that are not adequately captured by the model. Assuming that this may have been the case for Corsica as well, it is likely that the measured loads are an underestimate of actual loading to the lake. Taking this into account, it will be important to verify the effectiveness of BMPs in the field prior to their implementation and consider the recommendations from this section as guidelines and not site specific targets for implementing.

Part of the modeling process includes the assessment of animal feeding operations (AFOs) located in the watershed. This assessment was completed through a survey of the feeding areas to gather information on the number and types of animal units and size of lots. Model data indicated that nutrient production in the assessed feeding operations does have some impact on the lake.

There are 31 notable animal feeding operations located in the Corsica Lake watershed. (See Figure 4) According to model analysis, they account for approximately 10% of the total phosphorus load to Corsica Lake. To break down the individual impact of the various operations, they were analyzed for their impact on the receiving waterbody during the largest storm event simulated, a 3.76 inch rainfall event that occurred over 24 hours which is approximately equivalent to a 10 year runoff event. Table 21 lists the individual lot ratings; cell where they are primarily located, and nitrogen and phosphorus loads from each lot. The rating numbers are based on the chemical oxygen demand of the lot runoff which varies depending on animal type and various dilution factors. The simulated phosphorus and nitrogen (which are the parameters of concern) make better ranking tools for identifying lots that will provide the greatest reductions in loading to the lake.

The animal feeding operation located in cell 1493 has been identified as a potential CAFO, possibly exceeding the maximum number of animal units fundable through the voluntary EPA section 319 program. It has also been identified as contributing nearly 25% of the feeding operation load or 2.5% of the total load to the lake. South Dakota DENR began the process of contacting the operation owners to determine the need for permitting. Should this operation be found to fall within the qualifying criteria for 319 money, it should be placed at the top of the priority list. The first five lots listed in Table 21 account for 50% of the feeding operation load or 5% of the watershed load. The first phase of any implementation project should target these operations to establish initial reductions in the watershed.

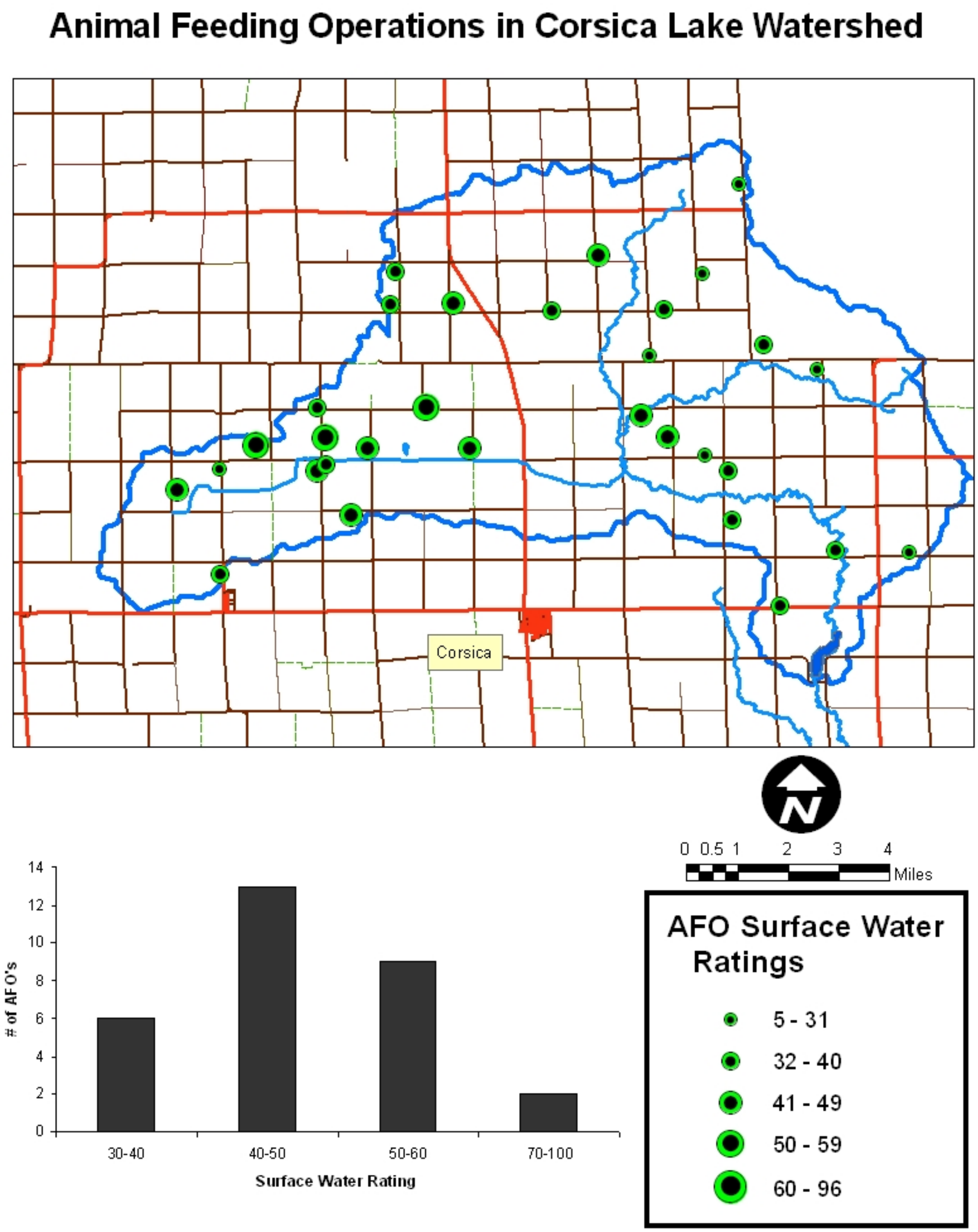


Figure 4. Animal Feeding Operation Locations

Table 21. Animal Feeding Operation Loading Data for 10 Year 24 Hour Rain Event

Simulation date 4/11/0011 3.76 inch rainfall event						
	Phosphorus			Nitrogen		
Cell	Pounds	% of Load	Rating	Pounds	% of Load	Accumulative Reduction
1493	**536.7**	**24.9%**	**92**	**1241.9**	**24.9%**	**24.9%**
1441	**240.1**	**11.1%**	**68**	**557.7**	**11.2%**	**36.1%**
3603	**132.1**	**6.1%**	**63**	**301.9**	**6.1%**	**42.1%**
1632	**98.8**	**4.6%**	**71**	**222.0**	**4.5%**	**46.6%**
1661	**92.5**	**4.3%**	**57**	**212.7**	**4.3%**	**50.9%**
921	82.2	3.8%	61	197.3	4.0%	54.8%
2551	84.0	3.9%	55	196.7	3.9%	58.8%
963	68.5	3.2%	57	162.0	3.2%	62.0%
2361	70.0	3.3%	54	161.1	3.2%	65.2%
3062	54.6	2.5%	45	130.9	2.6%	67.9%
1361	53.0	2.5%	53	123.1	2.5%	70.3%
1131	51.8	2.4%	45	122.5	2.5%	72.8%
1461	50.3	2.3%	50	118.6	2.4%	75.2%
2142	49.0	2.3%	43	109.0	2.2%	77.4%
362	46.5	2.2%	50	107.9	2.2%	79.5%
2152	40.1	1.9%	45	90.9	1.8%	81.3%
3272	41.6	1.9%	44	87.4	1.8%	83.1%
992	37.7	1.8%	53	86.0	1.7%	84.8%
103	33.9	1.6%	45	77.8	1.6%	86.4%
3732	31.6	1.5%	46	72.9	1.5%	87.8%
3412	29.1	1.4%	39	69.4	1.4%	89.2%
2463	28.4	1.3%	50	64.7	1.3%	90.5%
3112	30.7	1.4%	42	64.6	1.3%	91.8%
3002	24.0	1.1%	41	58.1	1.2%	93.0%
3701	22.8	1.1%	41	57.7	1.2%	94.2%
2881	25.4	1.2%	38	57.6	1.2%	95.3%
972	24.1	1.1%	44	56.1	1.1%	96.4%
252	22.5	1.0%	51	54.0	1.1%	97.5%
3153	22.9	1.1%	50	53.8	1.1%	98.6%
4112	16.3	0.8%	35	37.2	0.7%	99.3%
1431	13.2	0.6%	33	32.8	0.7%	100.0%
	2154.5	Total P		4986.3	Total N	

AnnAGNPS Management Scenarios

Several management scenarios were completed for the Corsica Lake watershed. A comparison of the nutrient and sediment loads at the outlet to the watershed is available in Table 22. These comparisons were completed to obtain an estimate of the nutrient load reductions possible for this watershed. The loads in Table 22 are the accumulated load at the watershed outlet for the entire 25 year simulation period.

Table 22. AnnAGNPS Management Scenario Loads and Reduction Percentages

	Sediment	TN	AN	DN	TP	AP	DP
Water Qaulity	16200	689			182		
Current Condition	35444	1332.21	116.37	1215.84	318.76	60.78	257.98
All Grass Watershed	1811	75.11	3.68	71.43	56.28	8.65	47.63
No Impoundments	38308	1343.9	128.06	1215.84	332.8	64.3	268.5
Pasture Poor	45935	1428.54	131.22	1297.32	370.11	69.98	300.13
No Till	19305	1222.86	65.86	1157	306	53	253
	Percent Change for Management Scenario						
All Grass Watershed	-95%	-94%	-97%	-94%	-82%	-86%	-82%
No Impoundments	8%	1%	10%	0%	4%	6%	4%
Pasture Poor	30%	7%	13%	7%	16%	15%	16%
No Till	-46%	-8%	-43%	-5%	-4%	-13%	-2%

The first simulation completed was the watershed in its "Current State" which is a best estimation of the current land use practices applied to the soils and slopes of the watershed to obtain nutrient and sediment losses from the individual cells as well as the watershed as a whole. Some default values were incorporated in this step, such as rangeland condition which was simulated in a good condition. Actual range conditions in the watershed did vary from this condition and would require analysis on a tract by tract basis during the implementation of any activities targeted at its improvement. Cropland acres were defaulted to minimum tillage practices consisting primarily of spring tillage prior to planting with a conventional planter. Actual tillage practices vary considerably between producers and would require a detailed analysis to determine the benefits of the BMP prior to its implementation on any individual tract within the watershed. The estimated sediment load was calculated to be approximately 35,000 tons. Nitrogen and phosphorus loads were 1300 tons and 320 tons respectively. As was mentioned earlier in this report, these loads are roughly double what was measured during the assessment. Regardless of the reason, percent reductions from these loads will be applied to the actual loads coming from the watershed.

The second simulation completed involved simulating the watershed as it may have been prior to settlement. Grass conditions similar to tall grass prairie or CRP were applied to all of the non water cells in the watershed. As is typical in most watersheds, the simulated load reductions were between 80% and 90% for soil loss and nutrients. Comparing the values from the first two simulations it can be assumed that approximately 94% of the current nitrogen load, 82% of the phosphorus load, and 95% of the sediment load are a result of human activity. These percentages are **NOT** to be used as a TMDL goal, but are only a reference point from where the TMDL may begin development. These goals are unachievable based on socioeconomic issues and are cost prohibitive.

The third simulation completed involved the removal of the impoundments (including small dams and wetland areas) throughout the watershed. There are approximately 880 acres of impoundments of 10 acres or larger in size throughout the watershed. Removal of these impoundments increased sediment loading by 8% and nitrogen and phosphorus loading by 1% and 4% respectively. While these reductions are fairly insignificant, it is important to note that the majority of these wetlands and impoundments were located upstream of the most critical areas in the watershed and that wetland restoration or small dam repair and maintenance downstream of critical areas may result in greater reductions than were represented in this simulation.

The fourth simulation consisted of current crops with pastures in poor condition. This simulation was intended to represent the watershed with its current cropping practices as determined by the LANDSAT derived dataset with pasturelands in poor condition. Sediment loadings increased by 30% while nitrogen and phosphorus increased by 7% and 16% respectively indicating the importance of well managed rangeland in this watershed. There are approximately 17,000 acres of pasture and rangeland in the watershed and are frequently located close to stream corridors or on steep slopes unsuitable for row crop agriculture.

The fifth simulation completed changed the cropping practices from minimum tillage in the initial or current state model to no-till for the corn and soybean acres which comprise the majority of the cropland within this watershed. Sediment reductions at the outlet were 46% reinforcing the importance of conservation tillage to reducing sediment concentrations in runoff. Nitrogen and phosphorus concentrations dropped by 8% and 4% respectively. These modest reductions can be linked to the fertilizer application rates for the tillage practices. Fertilizer application rates for the model were applied uniformly to the entire watershed due to a lack of detailed data on individual tracts. Actual fertilizer application rates will likely make significant differences in the nutrient loading from individual cells.

AnnAGNPS Targeting

The priority areas and acres depicted in Figure 5 were developed from a combination of areas targeted by the model as producing excessive sediment loads in addition to areas that have a high risk of producing excessive sediment loads. Cells scoring parameters are located in Table 23. Each of the four categories was broken into two groups. All of the cell values for each category were averaged and those cells with values greater than two standard deviation over the mean were given the higher of the two listed values while those cells only one standard deviation over the mean were given the lower of the two values. The remainder of the cells received 0 points in that category. A sum of the scores was then prioritized; all areas receiving a composite score of 7 or greater were selected as priority areas. Some of the priority areas may currently be under conservation friendly management, but should be protected to prevent increased loading from them.

The scores for the proximity to higher stream orders were calculated by dividing the AnnAGNPS assigned stream order for each reach by 2. For the Corsica watershed, the highest stream order was a 5, resulting in a maximum score of 2.5 for this category. This was done to give cells closer to the lake greater priority over those along the fringes of the watershed and is also based on the assumption that the transport capacity of higher order streams is greater than lower order streams resulting in greater delivery ratios for nutrients and sediments.

Values for the scores were selected to give equal weight to both the model targeted cells and those cells that met all of the criteria for critical targeting, steep slopes, erosive soils, and close proximity to the lake/ higher order streams. The majority of the critical areas were located very close to Corsica Lake, this may be interpreted as excessive emphasis given to the proximity portion of the equation. For this particular watershed, the areas closest to the lake are also comprised of the steepest slopes and most erosive soils.

Table 23. Cell Scoring Values and Justifications

	1 std Dev	2 std Dev	Justification
Modeled Erosion	3.5	7.5	Based on current conditions, Landuse is the primary influencing factor
Cell Slope	1.5	2.5	Steeper slopes with a higher erosive potential
Soil Erosive Potential	1.5	2.5	Soils prone to erosion but not necessarily on steep slopes
Proximity to high stream order	0.5 to 2.5		Higher stream orders are closer to the receiving water body and have an increased transport capacity for sediment and nutrients

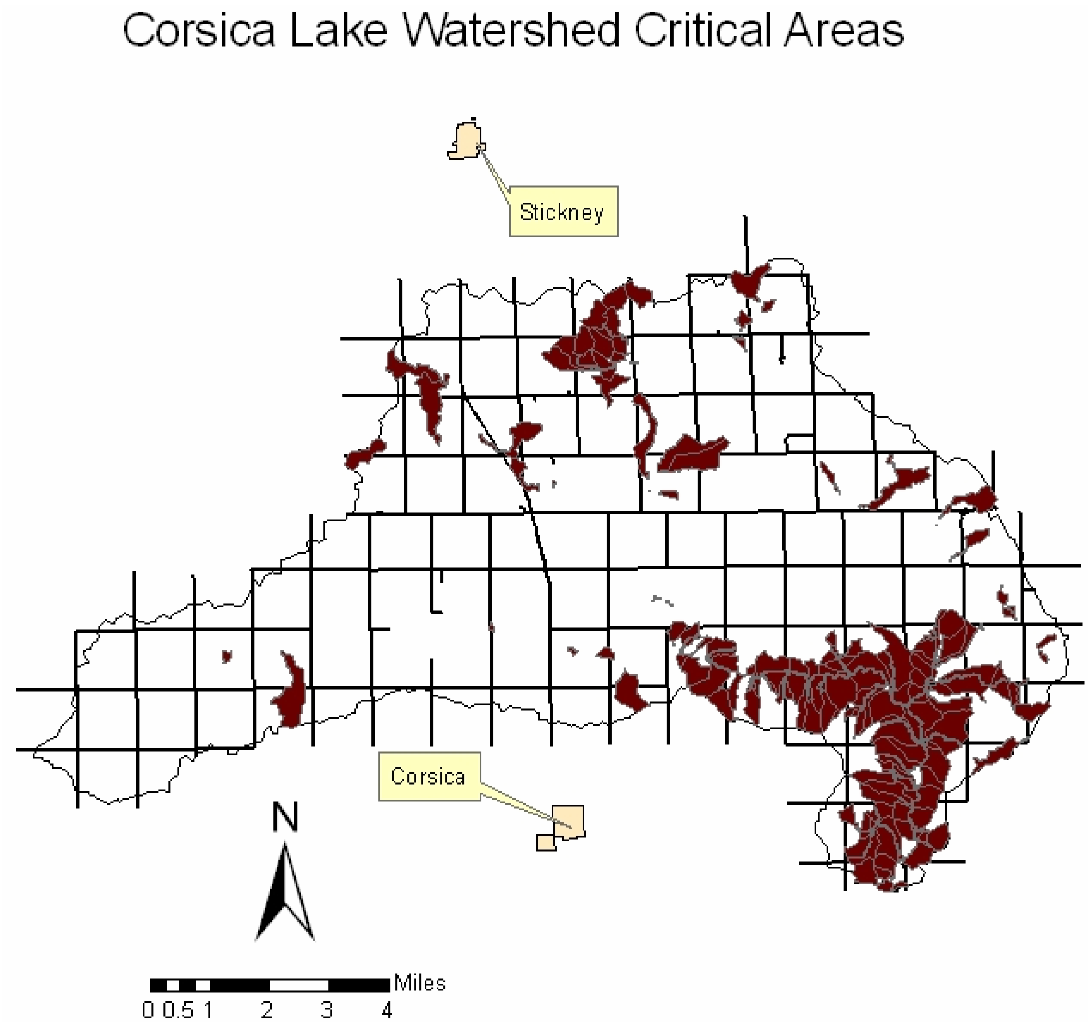


Figure 5. Corsica Lake Watershed Priority Areas

The priority areas accounts for approximately 12,800 acres of the watershed were selected for BMP implementation. A breakdown of this acreage shows that approximately 30% or 3,840 acres are composed rangeland while the remaining 70% or 8,960 acres was cropped. Phosphorus reductions from rangeland were calculated to be 16% for the watershed as a whole, assuming the critical acres would yield greater reductions, an implicit margin of safety can be included and targeting the 3,840 critical acres will result in a phosphorus reduction of approximately 4%.

Phosphorus reductions from reduced tillage practices on the cropland were not as significant as those from the rangeland, however conversion of critical cropland to grass buffers will result in measurable reductions. As with the rangeland, reductions were calculated basin wide, but if targeted areas are converted, a margin of safety is generated. Converting cropland to grassland through critical area seeding, CRP, and riparian buffers will result in 1% reductions in phosphorus, nitrogen, and sediment for every 200 acres. An estimate of 3% participation by operators in critical areas will result in a 6 % reduction from 1200 acres.

SEDIMENT SURVEY

Elutriate samples were collected with a Petite Ponar and shipped to the State Health Lab in Pierre, South Dakota, for analysis. In addition to sediment, a volume of 3 gallons of water were collected at each of the testing sites and were analyzed for the same chemicals as the sediment. Table 24 indicates the various parameters that were tested for in the elutriate sample.

Table 24. Elutriate and Receiving Water Results for Corsica Lake

Parameter	Elutriate	Receiving Water	Units
COD	48.9	34.6	mg/L
Total Phosphorus	3.51	0.308	mg/L
TKN	4.67	1.46	mg/L
Ammonia	3.47	0.2	mg/L
Hardness	600	580	mg/L
Nitrate	0.1	0.1	mg/L
Aluminum	<0.3	<0.3	µg/L
Zinc	<2.0	<2.0	µg/L
Silver	<0.2	<0.2	µg/L
Selenium	1.8	2.1	µg/L
Nickel	1.6	2.1	µg/L
Total Mercury	<0.1	<0.1	µg/L
Lead	<0.1	<0.1	µg/L
Copper	0.3	0.3	µg/L
Cadmium	<0.2	<0.2	µg/L
Arsenic	0.01	0.002	mg/L
Nitrite	<0.02	<0.02	mg/L
Endosulfan II	<0.500	<0.500	µg/L
Atrazine	**1.05**	**1.99**	**µg/L**

Parameter		Elutriate	Receiving Water	Units
Alachlor		<0.100	<0.100	µg/L
Chlordane		<0.500	<0.500	µg/L
Endrin		<0.500	<0.500	µg/L
Heptachlor		<0.400	<0.400	µg/L
Heptachlor Epoxide		<0.500	<0.500	µg/L
Methoxychlor		<0.500	<0.500	µg/L
Toxaphene		NonDetect	NonDetect	µg/L
Aldrin		<0.500	<0.500	µg/L
Dieldrin		<0.500	<0.500	µg/L
PCB Screen	Aroclor 1016	<0.100	<0.100	µg/L
	Aroclor 1221	<0.100	<0.100	µg/L
	Aroclor 1232	<0.100	<0.100	µg/L
	Aroclor 1242	<0.100	<0.100	µg/L
	Aroclor 1248	<0.100	<0.100	µg/L
	Aroclor 1254	<0.100	<0.100	µg/L
	Aroclor 1260	<0.100	<0.100	µg/L
Diazinon		<0.500	<0.500	µg/L
DDD		<0.500	<0.500	µg/L
DDT		<0.500	<0.500	µg/L
DDE		<0.800	<0.800	µg/L
Beta BHC		<0.500	<0.500	µg/L
Gamma BHC		<0.500	<0.500	µg/L
Alpha BHC		<0.500	<0.500	µg/L

Results from the elutriate and receiving water tests yielded many concentrations below the detection limit. Those metals and chemicals were detected were not at concentrations high enough to generate any concern, except for Atrazine.

The atrazine level for the water sample was slightly below EPA's maximum contaminant level of 3 ppb. There are no aquatic life standards established in the United States, however Canadian water quality guidelines lists a maximum level of 1.8 ppb. Maximum limits for agricultural uses are 10 ppb for irrigation waters and 5 ppb for livestock water. The water sample had higher levels at 1.99 ppb, while the elutriate had a concentration of 1.05 ppb.

It is difficult to determine whether this was a one-time contamination or a recurring problem in this watershed. Remediation steps should include information and educational materials dealing with safe pesticide use and disposal. Additional testing (preferably on a monthly bases for a two year period of time) for this compound is also advisable.

A sediment survey was completed during the winter of 2000. Water and sediment depths were recorded throughout the lake to determine the total amount of deposited material in the lake. A mean sediment depth of 3 feet and a mean water depth of 5.7 feet were recorded during the assessment. The total sediment volume in the lake was 476,000 cubic yards. There was a maximum sediment depth of 11 feet. Figure 6 shows the sediment depths in the lake.

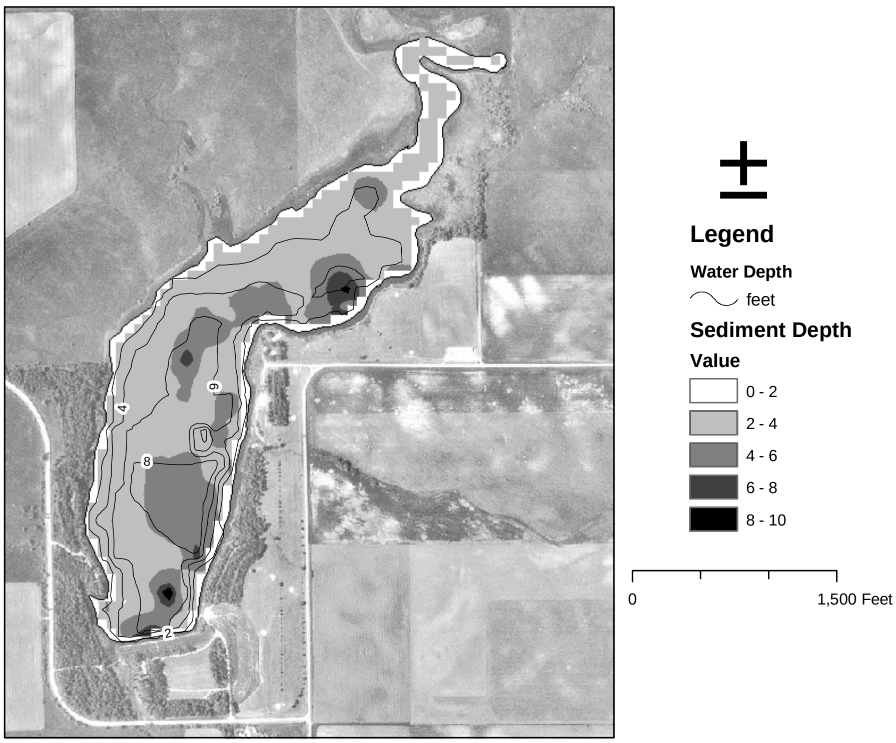


Figure 6. Corsica Lake Sediment Map

QUALITY ASSURANCE REPORTING (QA/QC)

Quality assurance and quality control or QA/QC samples were supposed to be collected for 10% of the inlake and tributary samples taken. There were 37 tributary samples and 16 inlake samples taken for a overall total of 53 samples. There were five replicate samples taken and five blank samples taken. All QA/QC samples may be found in Table 25.

Table 25. QA/QC Results for Corsica Lake

SITE	DATE	Alk. M	T. Solids	Sus. Solids	VTSS	Ammonia	Nitrate	TKN	T. Phos.	TDP	Fecal Coli.	E-COLI
CL-2	6/20/2000	283	1706	62	15	0.09	<0.1	1.89	0.274	0.1	10	
CL-2A	6/20/2000	281	1701	60	16	0.09	<0.1	1.72	0.27	0.292	10	
% difference		**1%**	**0%**	**3%**	**6%**	**0%**	**NA**	**9%**	**1%**	**98%**	**0%**	
CLO-1	4/12/2001	119	695	84	10	0.59	0.6	1.88	0.754	0.59	2700	2420
CLO-1A	4/12/2001	120	691	92	24	0.6	0.6	1.71	0.831	0.572	670	1990
% difference		**1%**	**1%**	**9%**	**82%**	**2%**	**0%**	**9%**	**10%**	**3%**	**120%**	**20%**
CLT-3	4/12/2001	109	557	30	5	0.66	0.4	1.99	0.706	0.562	520	435
CLT-3A	4/12/2001	109	546	27	3	0.65	0.4	2.25	0.715	0.598	420	816
% difference		**0%**	**2%**	**11%**	**50%**	**2%**	**0%**	**12%**	**1%**	**6%**	**21%**	**61%**
CLT-4	4/17/2001	187	1001	1	1	<0.02	0.1	0.92	0.344	0.3	20	23.1
CLT-4A	4/17/2001	185	995	1	1	<0.02	0.1	0.76	0.354	0.316	<10	18.3
% difference		**1%**	**1%**	**0%**	**0%**	**NA**	**0%**	**19%**	**3%**	**5%**	**NA**	**23%**
CLT-5	4/4/2001	83	275	30	10	4.52	0.2	7.65	1.54	1.21	20	30.5
CLT-5A	4/4/2001	82	269	32	11	4.52	0.2	7.22	1.4	0.997	20	38.8
% difference		**1%**	**2%**	**6%**	**10%**	**0%**	**0%**	**6%**	**10%**	**19%**	**0%**	**24%**
BLANK SAMPLES												
CL-2B	6/20/2000	<6	<7	<1	<1	<0.02	0.1	<0.21	<0.002	<0.002	<10	
CLT-5B	4/4/2001	<6	13	<1	<1	<0.02	0.1	<0.36	<0.002	<0.002	<10	<1
CLO-1B	4/12/2001	<6	14	<1	<1	<0.02	0.1	<0.36	<0.002	<0.002	<10	<1
CLT-3B	4/12/2001	<6	14	<1	<1	<0.02	0.1	<0.36	0.002	0.024	<10	<1
CLT-4B	4/17/2001	<6	11	<1	<1	<0.02	0.1	<0.36	<0.002	<0.002	<10	<1

Replicate samples were within the ranges expected for the different parameters. Typically suspended solids have a greater amount of variation than other parameters. Considering the low amount of variation in most of the parameters, the samples are likely representative of the water quality in the lake and the tributaries.

Fecal coliform bacteria and E. *coli* have a large amount of variation due to the nature of the bacteria.

Due to very low concentrations, total volatile suspended solids (VTSS) and total dissolved phosphorus had large variations of concentrations. Although the difference is large, acceptable accuracy can still be expected in the loadings and concentrations for these parameters.

The blank samples were relatively clean with the exception of total solids, which were slightly above the detection limit. If this level of contamination was consistent throughout the project, it would still minimally affect the results.

PUBLIC INVOLVEMENT AND COORDINATION

STATE AGENCIES

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

South Dakota Game Fish and Parks Department (SDGF&P) provided information on threatened and endangered species within the watershed.

FEDERAL AGENCIES

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

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

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

LOCAL GOVERNMENT; INDUSTRY, ENVIRONMENTAL, AND OTHER GROUPS; AND PUBLIC AT LARGE

The South Central Water Development District provided work space and financial assistance.

The Charles Mix Conservation District provided storage space and transportation for the project.

Randall Resource, Conservation, and Development (RC&D) provided work space, financial assistance, and aided in the completion of the AnnAGNPS portion of the report. Randall RC&D also provided personnel for the collection of field data and watershed modeling.

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 AnnAGNPS model.

ASPECTS OF THE PROJECT THAT DID NOT WORK WELL

The personnel that collected the water quality data left the project before the AnnAGNPS data and the final report were written. Consequently, the new personnel spent time reviewing and familiarizing themselves with the watershed prior to completion of these activities.

While sufficient amounts of data were collected during the project to develop a TMDL, additional data in the following areas would have been beneficial during the analysis phase of the final report.

Additional stage/discharge measurements would have resulted in more reliable stage/discharge tables for loading calculations.

Increased sample distribution made it difficult to calculate loads. There were only approximately 3 months of water quality data for the project.

FUTURE ACTIVITY RECOMMENDATIONS

Through the use of a nitrogen TSI Corsica Lake was determined to have a mean trophic state of 65. The listing criteria for this ecoregion state that lakes with a TSI in excess of 65 did not fully support their beneficial uses. Corsica Lake will benefit from watershed improvements that reduce both nutrients and bacteria. Reductions of phosphorus by 15% will result in a minimal shift in the TSI, but will provide increased assurance that the lake will continue to maintain full support of its beneficial uses.

While no bacterial concentrations were recorded above state standards within the lake, reduced runoff from animal feeding operations will reduce nutrient loading as well as providing additional protection from bacterial loading to the lake immediately following storm events. Range management and seeding critical areas that were under tillage practices would also result in reduced nutrient and sediment loading to the lake. The following management practices should be considered for implementation in the Corsica Lake watershed.

- Implement managed grazing on 4,000 acres of range land in the critical regions listed in the AnnAGNPS section of this report.
- Implement 1,200 acres of grass seeding, waterways, and riparian buffers in the critical regions listed in the AnnAGNPS section of this report.
- Implement reduced runoff practices on the five animal feeding operations listed in the AnnAGNPS section of this report.

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Appendix A. Tributary Data

SITE	DATE	TIME	Air Temp	Cond.	DO	pH	TYPE	W. Temp	TURB.	Fecal Coli.	Alk. M	T. Solids
CLO-1	5/11/2000	19:30	15	1793	8.97	8.46	GRAB	18.74	60.6	1200	297	1552
CLO-1	4/4/2001	12:00	1	417	14.55	8.3	GRAB	4.05	23.3	20	98	519
CLO-1	4/12/2001	7:35	3	538	10.5	8.2	GRAB	5	73.3	2700	119	695
CLO-1A	4/12/2001	7:40	3	538	10.5	8.2	GRAB	5	73.3	670	120	691
CLO-1B	4/12/2001	7:45	3	538	10.5	8.2	GRAB	5	73.3	<10	<6	14
CLO-1	4/17/2001	14:30	11	612	11.34	8.16	GRAB	9.94	32.7	10	124	674
CLO-1	5/2/2001	9:48	12	792	7.53	7.87	GRAB	17.69	47.2	40	150	761
CLO-1	5/7/2001	11:40	16	789	10.61	7.93	INT	14.83	107.1	210	160	772
CLT-2	5/11/2000	18:18	15	2450	9.37	8.06	COMP	18.68	48.5	1100	287	2232
CLT-2	5/18/2000	13:50	11.38	2367	8.66	7.65	COMP	14.84	160.4	2300	283	2292
CLT-2	6/1/2000	10:18	15.5	2045	9.37	8.03	COMP	15.56	78.8	4200	344	2277
CLT-2	11/1/2000	7:35	10				GRAB			12000	148	1717
CLT-2	4/4/2001	12:50	12.4	545	15.34	7.58	GRAB	4.54	14	10	119	683
CLT-2	4/12/2001	8:30	3	461	9.2	8.9	GRAB	3.9	43.7	300	106	600
CLT-2	5/2/2001	10:44	12	782	7.41	7.56	GRAB	16.6	12.6	20	165	745
CLT-2	5/7/2001	11:08	16	819	9.8	7.82	INT	13.34	26	640	180	900
CLT-3	5/18/2000	14:45	12.57	2169	10.01	8.28	GRAB		41.2	790	257	1943
CLT-3	6/1/2000	11:00	17.8	2252	5.61	7.83	GRAB	16.8	17.5	230	342	2479
CLT-3	4/4/2001	13:25	12.4	518	15.54	8.21	GRAB	4.58	10.9	<10	118	638
CLT-3	4/12/2001	8:45	3	439	9.3	8.06	GRAB	3.98	34.6	520	109	557
CLT-3A	4/12/2001	8:50	3	439	9.3	8.06	GRAB	3.98	34.6	420	109	546
CLT-3B	4/12/2001	8:55	3	439	9.3	8.06	GRAB	3.98	34.6	<10	<6	14
CLT-3	4/17/2001	13:00	11	545	11.2	8.05	GRAB	6.34	16.5	<10	131	643
CLT-3	4/25/2001	10:02	18	573	6.96	7.52	INT	12.27	12.5	300	117	576
CLT-3	5/2/2001	11:05	13	702	7.15	7.59	GRAB	16.59	8	100	155	659
CLT-3	5/7/2001	10:37	15	925	7.32	7.61	INT	12.51	14.2	290	190	962
CLT-4	5/18/2000	15:15	13.7	1932	9.61	8.19	GRAB	14.3	2.6	1400	325	1620
CLT-4	6/1/2000	11:35	17.8	1579	9.61	7.94	GRAB	16.62	9.1	170	367	1628
CLT-4	4/4/2001	13:54	11	608	14.52	8.22	GRAB	4.27	6.7	20	136	764
CLT-4	4/12/2001	9:36	8	428	9.03	8.02	GRAB	3.72	44.3	4200	111	548
CLT-4	4/17/2001	12:20	10	778	10.5	7.99	GRAB	4.75	2.8	20	187	1001
CLT-4A	4/17/2001	12:25	10	778	10.5	7.99	GRAB	4.75	2.8	<10	185	995
CLT-4B	4/17/2001	12:30	10	778	10.5	7.99	GRAB	4.75	2.8	<10	<6	11
CLT-4	4/25/2001	9:35	17	686	5.89	7.75	INT	11.17	8.4	360	141	721
CLT-4	5/2/2001	11:30	13	1054	5.08	7.46	GRAB	15.86	3.3	40	225	1054
CLT-4	5/7/2001	10:09	15	1055	7.3	7.51	INT	11.41	5.4	1800	207	1181
CLT-5	5/18/2000	15:45	15	4714	13.67	8.52	GRAB	14.48	44	2100	456	5162
CLT-5	4/4/2001	14:10	11	221	13.8	8.27	GRAB	4.27	6.7	20	83	275
CLT-5A	4/4/2001	14:20	11	221	13.8	8.27	GRAB	4.27	6.7	20	82	269
CLT-5B	4/4/2001	14:25	11	221	13.8	8.27	GRAB	4.27	6.7	<10	<6	13
CLT-5	4/12/2001	9:54	8.5	214	9.3	8.17	GRAB	4.3	153	140	80	352
CLT-5	4/17/2001	11:40	10	271	11.48	8.24	GRAB	5.26	35.6	<10	81	341
CLT-5	4/25/2001	9:05	17	333	9.8	8.12	INT	11.02	32.3	2100	86	361
CLT-5	5/2/2001	11:51	13	437		7.5	GRAB	17.2	7.8	<10	105	396
CLT-5	5/7/2001	9:40	15	429	6.5	7.58	GRAB	12.58	16.9	730	115	425

SITE	DATE	TIME	Sus. Solids	Ammonia	Nitrate	TKN	T. Phos.	T DIS P	VTSS	E-COLI
CLO-1	5/11/2000	19:30	100	0.01	0.05	2.17	0.323	0.081	24	
CLO-1	4/4/2001	12:00	19	0.91	0.9	2.01	0.672	0.624	3	30.5
CLO-1	4/12/2001	7:35	84	0.59	0.6	1.88	0.754	0.59	10	2420
CLO-1A	4/12/2001	7:40	92	0.6	0.6	1.71	0.831	0.572	24	1990
CLO-1B	4/12/2001	7:45	<1	<0.02	0.1	<0.36	<0.002	<0.002	<1	<1
CLO-1	4/17/2001	14:30	31	0.32	0.5	1.66	0.674	0.502	8	14.5
CLO-1	5/2/2001	9:48	52	0.13	0.2	1.23	0.522	0.375	12	36.9
CLO-1	5/7/2001	11:40	39	0.06	0.1	1.46	0.504	0.369	12	101
CLT-2	5/11/2000	18:18	47	0.01	0.05	1.72	0.276	0.138	4	
CLT-2	5/18/2000	13:50	41	0.03	0.1	1.49	0.229	0.124	10	
CLT-2	6/1/2000	10:18	80	0.03	0.1	1.28	0.374	0.195	10	
CLT-2	11/1/2000	7:35	52	0.17	0.4	2.06	0.35	0.132	8	
CLT-2	4/4/2001	12:50	14	1.07	1.1	2.24	0.739	0.645	2	31.7
CLT-2	4/12/2001	8:30	44	0.41	0.5	1.25	0.579	0.511	9	276
CLT-2	5/2/2001	10:44	17	<0.02	0.1	0.96	0.716	0.637	2	37.3
CLT-2	5/7/2001	11:08	13	<0.02	0.1	1.48	0.648	0.561	3	866
CLT-3	5/18/2000	14:45	14	0.01	0.1	1.34	0.776	0.248	7	
CLT-3	6/1/2000	11:00	21	0.3	0.05	2.78	1.3	1.02	4	
CLT-3	4/4/2001	13:25	7	1.25	1	2.19	0.776	0.695	<1	10.9
CLT-3	4/12/2001	8:45	30	0.66	0.4	1.99	0.706	0.562	5	435
CLT-3A	4/12/2001	8:50	27	0.65	0.4	2.25	0.715	0.598	3	816
CLT-3B	4/12/2001	8:55	<1	<0.02	0.1	<0.36	0.002	0.024	<1	<1
CLT-3	4/17/2001	13:00	9	0.38	0.2	1.81	0.74	0.638	2	5.1
CLT-3	4/25/2001	10:02	8	0.05	0.3	1.3	0.591	0.581	<1	461
CLT-3	5/2/2001	11:05	7	<0.02	0.1	1.41	0.72	0.679	1	122
CLT-3	5/7/2001	10:37	9	<0.02	0.1	1.4	0.664	0.596	5	1990
CLT-4	5/18/2000	15:15	6	0.01	0.05	0.75	0.267	0.22	3	
CLT-4	6/1/2000	11:35	17	0.01	0.05	0.89	0.332	0.284	2	
CLT-4	4/4/2001	13:54	6	0.49	1	1.31	0.571	0.554	<1	41.3
CLT-4	4/12/2001	9:36	35	0.3	0.5	1.66	0.691	0.533	7	>2420
CLT-4	4/17/2001	12:20	1	<0.02	0.1	0.92	0.344	0.3	<1	23.1
CLT-4A	4/17/2001	12:25	1	<0.02	0.1	0.76	0.354	0.316	<1	18.3
CLT-4B	4/17/2001	12:30	<1	<0.02	0.1	<0.36	<0.002	<0.002	<1	<1
CLT-4	4/25/2001	9:35	8	<0.02	0.2	1.12	0.462	0.444	1	461
CLT-4	5/2/2001	11:30	1	<0.02	0.1	0.98	0.416	0.374	<1	35.4
CLT-4	5/7/2001	10:09	5	<0.02	0.1	1.41	0.498	0.486	3	>2420
CLT-5	5/18/2000	15:45	35	0.01	0.05	5.7	2.48	1.48	22	
CLT-5	4/4/2001	14:10	30	4.52	0.2	7.65	1.54	1.21	10	30.5
CLT-5A	4/4/2001	14:20	32	4.52	0.2	7.22	1.4	0.997	11	38.8
CLT-5B	4/4/2001	14:25	<1	<0.02	0.1	<0.36	<0.002	<0.002	<1	<1
CLT-5	4/12/2001	9:54	42	2.22	0.3	4.27	1.19	0.969	12	249
CLT-5	4/17/2001	11:40	28	0.9	0.2	3.28	0.993	0.926	8	12
CLT-5	4/25/2001	9:05	36	0.14	0.2	2.54	0.947	0.865	4	1730
CLT-5	5/2/2001	11:51	10	0.02	0.1	1.6	1.01	0.986	4	16.1
CLT-5	5/7/2001	9:40	21	<0.02	0.1	1.85	1	0.944	7	488

Appendix B. Lake Data

SITE	DATE	TIME	Air Temp	Cond.	DO	pH	Sample type	TEMP	DEPTH	TURB.	SECCHI	T Depth	Fecal Coli.	Alk. M
CL-1	5/17/2000	12:30	15.54		8.47	8.53	GRAB	17.05	S		0.7	8.5	<10	288
CL-1	5/17/2000	12:30	15.54		7.76	8.53	GRAB	17.1	3					
CL-1	5/17/2000	12:30	15.54		7.71	8.53	GRAB	17.11	6					
CL-1	5/17/2000	12:30	15.54		7.25	8.23	GRAB	17.09	B					
CL-1	6/6/2000	12:00	26.5	1755	9.03	8.36	GRAB(A,C)	17.87	S	40.2	1.25	8.5		
CL-1	6/6/2000	12:00	26.5	1754	9.09	8.37	GRAB(A,C)	17.89	3	40.5				
CL-1	6/6/2000	12:00	26.5	1748	8.79	8.36	GRAB(A,C)	17.75	6	38.5				
CL-1	6/6/2000	12:00	26.5	1744	8.67	8.36	GRAB(A,C)	17.66	B	40.7				
CL-1	6/20/2000	11:55	23	1973	8.16	8.39	GRAB	20.96	S	38	1	7.8	20	280
CL-1	6/20/2000	11:55	23	1971	8.02	8.39	GRAB	20.92	3	39.9				
CL-1	6/20/2000	11:55	23	1968	7.91	8.38	GRAB	20.88	B	44.1				
CL-1	7/6/2000	12:21	27.75	2165	5.76	8.47	GRAB(A,C)	26.61	S	24.8	1.1	7.6		
CL-1	7/6/2000	12:21	27.75	2118	2.5	8.28	GRAB(A,C)	25.26	B	28.8				
CL-1	7/18/2000	11:30	17	2223	4.67	8.42	GRAB	24.61	S	31.3	1.2	7.2	<10	246
CL-1	7/18/2000	11:30	17	2223	4.48	8.44	GRAB	24.62	B	38.2				
CL-1	7/31/2000	10:50	22	2254	9.45	8.38	GRAB(A,C)	26.82	S	26	1.85	6.6		
CL-1	7/31/2000	10:50	22	2218	3.95	8.15	GRAB(A,C)	25.68	B	32.6				
CL-1	8/15/2000	12:11	21	1914	7.58	8.84	GRAB	26.34	S	73.7	0.9	6.5	<10	182
CL-1	8/15/2000	12:11	21	1910	6.57	8.76	GRAB	26.16	B	65.9				
CL-1	9/7/2000	10:05	21	1956	4.21	8.89	GRAB(A,C)	21.34	S	46	1	6.6		
CL-1	9/7/2000	10:05	21	1950	4.04	8.92	GRAB(A,C)	21.19	B	54.1				
CL-1	9/27/2000	11:34	18	1937	6.78	8.92	GRAB	12.1	S	20.6	2.1	6.3	<10	221
CL-1	9/27/2000	11:34	18	1916	6.6	8.9	GRAB	11.6	B	19.3				
CL-1	10/11/2000	11:10	15		9.67	9.09	GRAB(A,C)	7.98	S	37.3	1.2	5.6		
CL-1	10/11/2000	11:10	15		9.57	9.08	GRAB(A,C)	7.96	B	34.2				
CL-1	10/25/2000	13:25	13.5	1849	9.06	8.68	GRAB	14.85	S	50.7	1	5.7	<10	248
CL-1	10/25/2000	13:25	13.5	1841	8.32	8.68	GRAB	14.64	B	75.4				
CL-1	4/17/2001	14:00	11	626	11.08	8.14	GRAB	9.6	S	25.4	1	4.9	<10	125
CL-1	4/17/2001	14:00	11	579	11.35	8.14	GRAB	6.05	B	20.3				
CL-1	5/2/2001	9:04	12	798	6.93	7.91	GRAB	17.81	S	47.6	0.9	5.8	30	154
CL-1	5/2/2001	9:04	12	801	6.82	7.82	GRAB	17.69	B	74.6				
CL-2	5/17/2000	12:15	15.54		7.91	8.55	GRAB	16.91	S		0.7	6	180	286
CL-2	5/17/2000	12:15	15.54		7.73	8.55	GRAB	17.03	3					
CL-2	5/17/2000	12:15	15.54		7.68	8.55	GRAB	16.81	B					
CL-2	6/6/2000	12:10	26.5	1786	9.62	8.37	GRAB(A,C)	18.53	S	49	0.9	5.1		
CL-2	6/6/2000	12:10	26.5	1786	8.98	8.37	GRAB(A,C)	18.53	3	48.2				
CL-2	6/6/2000	12:10	26.5	1786	8.74	8.37	GRAB(A,C)	18.53	B	50.4				
CL-2	6/20/2000	11:45	23	1867	8.01	8.39	GRAB	21	S	46.9	0.9	5	10	283
CL-2	6/20/2000	11:45	23	1868	7.99	8.38	GRAB	20.99	3	48.9				
CL-2	6/20/2000	11:45	23	1943	7.96	8.38	GRAB	20.99	B	56.2				
CL-2	7/6/2000	12:15	27.75	2174	6.45	8.5	GRAB(A,C)	26.73	S	107.5	1.1	3.6		
CL-2	7/6/2000	12:15	27.75	2170	6.14	8.51	GRAB(A,C)	26.67	B	103.9				
CL-2	7/18/2000	11:20	17	2160	4.95	8.4	GRAB	23.28	S	36.1	1.1	3.5	<10	249
CL-2	7/18/2000	11:20	17	2159	4.78	8.42	GRAB	23.21	B	39				
CL-2	7/31/2000	10:35	22	2239	13.5	8.59	GRAB(A,C)	26.85	S	36.3	1.2	3.8		
CL-2	7/31/2000	10:35	22	2224	12.4	8.52	GRAB(A,C)	26.3	B	58.4				
CL-2	8/15/2000	12:20	21	1904	6.67	8.8	GRAB	26.02	S	55.4	0.9	5.6	20	183
CL-2	8/15/2000	12:20	21	1903	6.27	8.76	GRAB	25.95	B	56.9				

CL-2	9/7/2000	9:57	21	1934	4.29	8.81	GRAB(A,C)	20.86	S	53.6	1	4.5		
CL-2	9/7/2000	9:57	21	1933	4.05	8.85	GRAB(A,C)	20.81	B	55.2				
CL-2	9/27/2000	11:24	18	1937	6.52	9.07	GRAB	12.02	S	22.6	2	2.9	<10	224
CL-2	9/27/2000	11:24	18	1937	6.4	8.98	GRAB	11.99	B	22.8				
CL-2	10/11/2000	11:00	15		10.3	9.14	GRAB(A,C)	7.96	S	31.9	1.1	2.2		
CL-2	10/25/2000	13:15	13.5	1848	9.58	8.61	GRAB	14.86	S	49.7	1	3.5	<10	245
CL-2	10/25/2000	13:15	13.5	1848	9.51	8.67	GRAB	14.88	B	57.1				
CL-2	4/17/2001	13:45	11	595	11	8.13	GRAB	8.89	S	33.4	1	8.2	<10	129
CL-2	4/17/2001	13:45	11		11.15		GRAB	8.14	3					
CL-2	4/17/2001	13:45	11		10.91		GRAB	7.18	6					
CL-2	4/17/2001	13:45	11	565	10.52	8.07	GRAB	6.71	B	31.4				
CL-2	5/2/2001	9:20	12	796	7.26	7.79	GRAB	17.86	S	50.5	0.9	7.8	20	152
CL-2	5/2/2001	9:20	12		7.33		GRAB	17.88	3					
CL-2	5/2/2001	9:20	12	794	7.29	7.82	GRAB	17.77	B	61.6				
CL-2A	6/20/2000	11:47	23	1867	8.01	8.39	GRAB	21	S				10	281
CL-2B	6/20/2000	11:50	23	1867	8.01	8.39	GRAB	21					<10	<6

SITE	DATE	TIME	T. Solids	Sus. Solids	Ammonia	Nitrate	TKN	T. Phos.	TDP	VTSS	TDS	E-COLI
CL-1	5/17/2000	12:30	1572	90	<0.02	<0.1	2.61	0.338	0.062	16	1414	
CL-1	5/17/2000	12:30										
CL-1	5/17/2000	12:30										
CL-1	5/17/2000	12:30										
CL-1	6/6/2000	12:00										
CL-1	6/6/2000	12:00										
CL-1	6/6/2000	12:00										
CL-1	6/6/2000	12:00										
CL-1	6/20/2000	11:55	1678	45	0.08	<0.1	1.74	0.235	0.106	14	1575	
CL-1	6/20/2000	11:55										
CL-1	6/20/2000	11:55										
CL-1	7/6/2000	12:21										
CL-1	7/6/2000	12:21										
CL-1	7/18/2000	11:30	1773	39	<0.02	<0.1	2	0.31	0.151	8		
CL-1	7/18/2000	11:30										
CL-1	7/31/2000	10:50										
CL-1	7/31/2000	10:50										
CL-1	8/15/2000	12:11	1793	80	<0.02	<0.1	4.92	0.705	0.221	46		
CL-1	8/15/2000	12:11										
CL-1	9/7/2000	10:05										
CL-1	9/7/2000	10:05										
CL-1	9/27/2000	11:34	1827	23	<0.02	<0.1	1.88	0.491	0.331	14		
CL-1	9/27/2000	11:34										
CL-1	10/11/2000	11:10										
CL-1	10/11/2000	11:10										
CL-1	10/25/2000	13:25	1899	46	<0.02	<0.1	2.87	0.605	0.324	12		
CL-1	10/25/2000	13:25										
CL-1	4/17/2001	14:00	670	30	0.33	0.5	1.6	0.647	0.491	4		24.9
CL-1	4/17/2001	14:00										
CL-1	5/2/2001	9:04	764	50	0.12	0.2	1.4	0.574	0.384	12		52.1
CL-1	5/2/2001	9:04										
CL-2	5/17/2000	12:15	1544	78	<0.02	<0.1	2.31	0.276	0.063	16	1409	
CL-2	5/17/2000	12:15										
CL-2	5/17/2000	12:15										

CL-2	6/6/2000	12:10										
CL-2	6/6/2000	12:10										
CL-2	6/6/2000	12:10										
CL-2	6/20/2000	11:45	1706	62	0.09	<0.1	1.89	0.274	0.1	15	1572	
CL-2	6/20/2000	11:45										
CL-2	6/20/2000	11:45										
CL-2	7/6/2000	12:15										
CL-2	7/6/2000	12:15										
CL-2	7/18/2000	11:20	1792	54	<0.02	<0.1	1.95	0.322	0.136	10		
CL-2	7/18/2000	11:20										
CL-2	7/31/2000	10:35										
CL-2	7/31/2000	10:35										
CL-2	8/15/2000	12:20	1791	72	<0.02	<0.1	4.2	0.598	0.236	34		
CL-2	8/15/2000	12:20										
CL-2	9/7/2000	9:57										
CL-2	9/7/2000	9:57										
CL-2	9/27/2000	11:24	1840	24	<0.02	<0.1	1.87	0.481	0.33	12		
CL-2	9/27/2000	11:24										
CL-2	10/11/2000	11:00										
CL-2	10/25/2000	13:15	1898	48	<0.02	<0.1	2.74	0.606	0.356	14		
CL-2	10/25/2000	13:15										
CL-2	4/17/2001	13:45	681	20	0.27	0.5	1.34	0.635	0.519	3		8.5
CL-2	4/17/2001	13:45										
CL-2	4/17/2001	13:45										
CL-2	4/17/2001	13:45										
CL-2	5/2/2001	9:20	768	56	0.14	0.2	1.4	0.526	0.347	12		28.1
CL-2	5/2/2001	9:20										
CL-2	5/2/2001	9:20										
CL-2A	6/20/2000	11:47	1701	60	0.09	<0.1	1.72	0.27	0.292	16	1560	
CL-2B	6/20/2000	11:50	<7	<1	<0.02	<0.1	<0.21	<0.002	<0.002	<1	<7	

Appendix C. Corsica Lake Algae Tables

Project Algae Species List

Corsica Lake : 2000 - 2001 — 17 samples total

#	Algae Species	Avg % Density	# samples	Algae Type
1	Aphanizomenon flos-aquae	36.0	6	Blue-Green Algae (filament)
2	Stephanodiscus astraea minutula	21.5	12	Diatom (centric)
3	Oscillatoria agardhii	16.0	6	Blue-Green Algae (filament)
4	Crucigenia quadrata	5.3	9	Green Algae (colonial)
5	Cyclotella meneghiniana	3.0	17	Diatom (centric)
6	Anabaena flos-aquae	2.9	2	Blue-Green Algae (filament)
7	Microcystis aeruginosa	2.6	2	Blue-Green Algae (filament)
8	Oocystis pusilla	2.4	10	Green Algae (colonial)
9	Rhodomonas minuta	1.7	17	Flagellated Algae (Cryptophyte)
10	Glenodinium gymnodinium	1.4	6	Flagellated Algae (Dinoflagellate)
11	Selenastrum minutum	0.9	12	Green Algae
12	Scenedesmus quadricauda	0.7	12	Green Algae (colonial)
13	Nitzschia acicularis	0.6	10	Diatom (pennate)
14	Ankistrodesmus falcatus	0.4	10	Green Algae
15	Unidentified algae	0.4	4	Algae
16	Scenedesmus acuminatus	0.4	6	Green Algae (colonial)
17	Chlamydomonas sp.	0.4	10	Flagellated Algae (Green Algae)
18	Micractinium sp.	0.3	4	Green Algae (colonial)
19	Stephanodiscus hantzschii	0.3	5	Diatom (centric)
20	Melosira granulata	0.3	11	Diatom (centric, filament)
21	Unidentified flagellates	0.3	4	Flagellated Algae
22	Cryptomonas erosa	0.2	11	Flagellated Algae (Cryptophyte)
23	Chrysococcus rufescens	0.2	5	Flagellated Algae (Yellow-Brown Algae)
24	Ankistrodesmus sp.	0.1	4	Green Algae
25	Aphanocapsa sp.	0.1	4	Blue-Green Algae (colonial)
26	Chaetoceros elmorei	0.1	4	Diatom (centric, filament)
27	Nitzschia paleacea	0.1	5	Diatom (pennate)
28	Oscillatoria limnetica	0.1	3	Blue-Green Algae (filament)
29	Sphaerocystis schroeteri	0.1	1	Green Algae (colonial)
30	Trachelomonas hispida	0.1	5	Flagellated Algae (Euglenoid)
31	Kirchneriella sp.	0.1	4	Green Algae (colonial)
32	Oocystis lacustris	0.1	1	Green Algae (colonial)
33	Nitzschia sp.	0.0	4	Diatom (pennate)
34	Dactylococcopsis sp.	0.0	2	Blue-Green Algae
35	Chroomonas sp.	0.0	1	Flagellated Algae(Cryptophyte)
36	Closteriopsis longissima	0.0	1	Green Algae
37	Crucigenia tetrapedia	0.0	3	Green Algae (colonial)
38	Eudorina sp.	0.0	2	Flagellated Algae (Green Algae)
39	Synura uvella	0.0	2	Flagellated Algae (Yellow-Brown Algae)
40	Microcystis sp.	0.0	1	Blue-Green Algae (colonial)
41	Chromulina sp.	0.0	3	Flagellated Algae (Yellow-Brown Algae)
42	Trachelomonas volvocina	0.0	4	Flagellated Algae (Euglenoid)
43	Pascheriella tetras	0.0	4	Flagellated Algae (Green Algae)
44	Pteromonas angulosa	0.0	4	Flagellated Algae (Green Algae)

45 Scenedesmus sp.	0.0	4	Green Algae (colonial)
46 Gymnodinium sp.	0.0	4	Flagellated Algae (Dinoflagellate)
47 Dinobryon sertularia	0.0	1	Fagellated Algae (Yellow-Brown Algae)
48 Cocconeis placentula	0.0	1	Diatom (pennate)
49 Fragilaria vaucheria	0.0	1	Diatom (pennate, filament)
50 Spermatozoopsis sp.	0.0	4	Flagellated Algae (Green Algae)
51 Synura sp.	0.0	2	Flagellated Algae (Yellow-Brown Algae)
52 Trachelomonas rugosa	0.0	1	Flagellated Algae (Euglenoid)
53 Nitzschia reversa	0.0	4	Diatom (pennate)
54 Merismopedia minima	0.0	2	Blue-Green Algae (colonial)
55 Trachelomonas sp.	0.0	5	Flagellated Algae (Euglenoid)
56 Scenedesmus bijuga	0.0	1	Green Algae (colonial)
57 Melosira granulata v. angustissima	0.0	1	Diatom (centric, filament)
58 Tetrastrum elegans	0.0	1	Green Algae (colonial)
59 Tetrastrum sp.	0.0	3	Green Algae (colonial)
60 Golenkinia radiata	0.0	1	Green Algae
61 Chrysochromulina parva	0.0	3	Flagellated Algae (Yellow-Brown Algae)
62 Dictyosphaerium pulchellum	0.0	2	Green Algae (colonial)
63 Amphora ovalis	0.0	1	Diatom (pennate)
64 Euglena sp.	0.0	5	Flagellated Algae (Euglenoid)
65 Navicula sp	0.0	4	Diatom (pennate)
66 Nitzschia palea	0.0	1	Diatom (pennate)
67 Ceratium hirundinella	0.0	1	Flagellated Algae (Dinoflagellate)
68 Navicula capitata	0.0	1	Diatom (pennate)
69 Navicula menisculus v. upsaliensis	0.0	1	Diatom (pennate)
70 Pediastrum duplex	0.0	2	Green Algae (colonial)
71 Gomphonema angustatum	0.0	1	Diatom (pennate)
72 Oocystis sp.	0.0	1	Green Algae (colonial)
73 Gomphonema olivaceum	0.0	1	Diatom (pennate)
74 Rhoicosphenia curvata	0.0	1	Diatom (pennate)
75 Trachelomonas pulchella	0.0	1	Flagellated Algae (Euglenoid)
76 Golenkinia sp.	0.0	1	Green Algae
77 Mallomonas tonsurata	0.0	2	Flagellated Algae (Yellow-Brown Algae)
78 Nephroselmis sp.	0.0	2	Flagellated Algae (Cryptophyte)
79 Coelastrum sp.	0.0	2	Green Algae (colonial)
80 Gymnodinium palustre	0.0	2	Flagellated Algae (Dinoflagellate)
81 Chlorogonium sp.	0.0	3	Flagellated Algae (Green Algae)
82 Actinastrum hantzschii	0.0	2	Green Algae (colonial)
83 Surirella ovalis	0.0	3	Diatom (pennate)
84 Phacus pseudonordstedtii	0.0	3	Flagellated Algae (Euglenoid)
85 Closterium sp.	0.0	3	Green Algae
86 Mallomonas akrokomos	0.0	3	Flagellated Algae (Yellow-Brown Algae)
87 Peridinium sp.	0.0	2	Flagellated Algae (Dinoflagellate)
88 Glenodinium sp.	0.0	1	Flagellated Algae (Dinoflagellate)
89 Lepocinclis sp.	0.0	1	Flagellated Algae (Euglenoid)
90 Navicula cuspidata	0.0	1	Diatom (pennate)
91 Phacus pleuronectes	0.0	1	Flagellated Algae (Euglenoid)
92 Staurastrum sp.	0.0	1	Green Algae

Corsica Lake Algae Abundance
(cells / ml) and Biovolume (um3 / ml)

Date	Algae Group	cells / ml	%	um3 / ml	%
17-May-00	Flagellated Algae	1,104	8.8	682,364	20.3
	Dinoflagellates	92	0.7	248,400	7.4
	Blue-Green Algae	0		0	
	Diatoms	7,087	56.6	2,062,938	61.5
	Non-Motile Green Algae	4,233	33.8	361,706	10.8
	Unidentified Algae	0		0	
Total		**12,516**		**3,355,408**	
6-Jun-00	Flagellated Algae	1,178	4.4	492,585	19.5
	Dinoflagellates	0		0	
	Blue-Green Algae	17,687	65.5	583,671	23.1
	Diatoms	4,238	15.7	1,221,520	48.3
	Non-Motile Green Algae	3,911	14.5	231,032	9.1
	Unidentified Algae	0		0	
Total		**27,014**		**2,528,808**	
20-Jun-00	Flagellated Algae	538	3.8	42,786	16.8
	Dinoflagellates	0		0	
	Blue-Green Algae	868	6.1	28,644	1.7
	Diatoms	2,371	16.6	865,018	52.8
	Non-Motile Green Algae	10,488	73.5	700,595	42.8
	Unidentified Algae	0		0	
Total		**14,265**		**1,637,043**	
6-Jul-00	Flagellated Algae	879	8.5	421,474	27.0
	Dinoflagellates	23	0.2	301,047	19.3
	Blue-Green Algae	451	4.4	52,767	3.4
	Diatoms	356	3.5	103,850	6.6
	Non-Motile Green Algae	8,602	83.4	683,067	43.7
	Unidentified Algae	0		0	
Total		**10,311**		**1,562,202**	
18-Jul-00	Flagellated Algae	73	0.3	1,460	0.0
	Dinoflagellates	73	0.3	955,497	25.3
	Blue-Green Algae	2,196	8.1	256,932	6.8
	Diatoms	2,050	7.6	678,664	17.9
	Non-Motile Green Algae	22,623	83.7	1,890,447	50.0
	Unidentified Algae	0		0	
Total		**27,015**		**3,783,000**	
31-Jul-00	Flagellated Algae	310	0.3	36,084	0.3
	Dinoflagellates	248	0.2	2,601,954	18.3
	Blue-Green Algae	101,289	96.8	11,197,541	78.9
	Diatoms	496		130,200	0.9
	Non-Motile Green Algae	2,293	2.2	226,587	1.6
	Unidentified Algae	0		0	
Total		**104,636**		**14,192,366**	

Date	Algae Group	cells / ml	%	um3 / ml	%

15-Aug-00	Flagellated Algae	435	0.3	97,440	0.1
	Dinoflagellates	5,927	4.3	77,578,503	83.2
	Blue-Green Algae	131,542	94.6	15,283,447	16.4
	Diatoms	1,013	0.7	332,710	0.4
	Non-Motile Green Algae	145	0.1	3,625	0.0
	Unidentified Algae	0		0	
Total		**139,062**		**93,295,725**	
7-Sep-00	Flagellated Algae	307	1.8	132,467	0.3
	Dinoflagellates	3,140	18.8	40,931,721	95.9
	Diatoms	668	4.0	163,685	0.4
	Blue-Green Algae	11,841	71.0	1,385,397	3.2
	Non-Motile Green Algae	720	4.3	69,245	0.2
	Unidentified Algae	0		0	
Total		**16,676**		**42,682,515**	
27-Sep-00	Flagellated Algae	1,716	3.4	163,435	1.3
	Dinoflagellates	245	0.5	3,206,805	25.1
	Diatoms	20,100	39.8	6,266,655	49.0
	Blue-Green Algae	24,511	48.5	2,867,787	22.4
	Non-Motile Green Algae	3,921	7.8	292,345	2.3
	Unidentified Algae	0		0	
Total		**50,493**		**12,797,027**	
11-Oct-00	Flagellated Algae	6,890	2.5	137,800	0.2
	Dinoflagellates	0		0	
	Diatoms	139,059	50.8	47,975,320	76.9
	Blue-Green Algae	112,750	41.2	13,191,750	21.1
	Non-Motile Green Algae	15,034	5.5	1,071,865	1.7
	Unidentified Algae	0		0	
Total		**273,733**		**62,376,735**	
17-Apr-01	Flagellated Algae	5,781	50.3	1,563,875	78.6
	Dinoflagellates	22	0.2	57,400	2.9
	Diatoms	769	6.7	203,170	10.2
	Blue-Green Algae	1,011	8.8	18,348	0.9
	Non-Motile Green Algae	2,548	22.2	105,130	5.3
	Unidentified Algae	1,360	11.8	40,800	2.1
Total		**11,491**		**1,988,723**	
2-May-01	Flagellated Algae	2,953	22.6	415,218	22.2
	Dinoflagellates	3	0.0	8,100	0.4
	Diatoms	4,725	36.1	1,214,040	64.9
	Blue-Green Algae	1,383	10.6	24,839	1.3
	Non-Motile Green Algae	2,334	17.9	158,129	8.5
	Unidentified Algae	1,675	12.8	50,250	2.7
		13,073		**1,870,576**	

TOTAL MAXIMUM DAILY LOAD EVALUATION

For

CORSICA LAKE

(HUC 7020003)

DOUGLAS COUNTY, SOUTH DAKOTA

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

FEBRUARY, 2005

Corsica Lake Total Maximum Daily Load

Waterbody Type:	Manmade Impoundment
303(d) Listing Parameter:	TSI
Designated Uses:	Recreation, Warmwater semi-permanent aquatic life
Size of Waterbody:	110 acres
Size of Watershed :	56,038 acres
Water Quality Standards:	Narrative and Numeric
Indicators:	Trophic State Index (TSI)
Analytical Approach:	AnnAGNPS, BATHTUB, FLUX
Location:	HUC Code: 10170101
Goal:	Complete restoration activities to reduce nutrient loads by 15%
Target:	Mean TSI (nitrogen/cholorphyll a/ Secchi) ≤ 64.5

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

Corsica Lake is a 110 acre man-made impoundment in northern Douglas County, South Dakota. The reservoir receives runoff from agricultural operations. The creeks in the watershed and the lake have experienced declining water quality according to the state 303d report. The Corsica Lake watershed is approximately 56,038 acres in size. The land use in the watershed is predominately agricultural consisting of cropland and grazing.

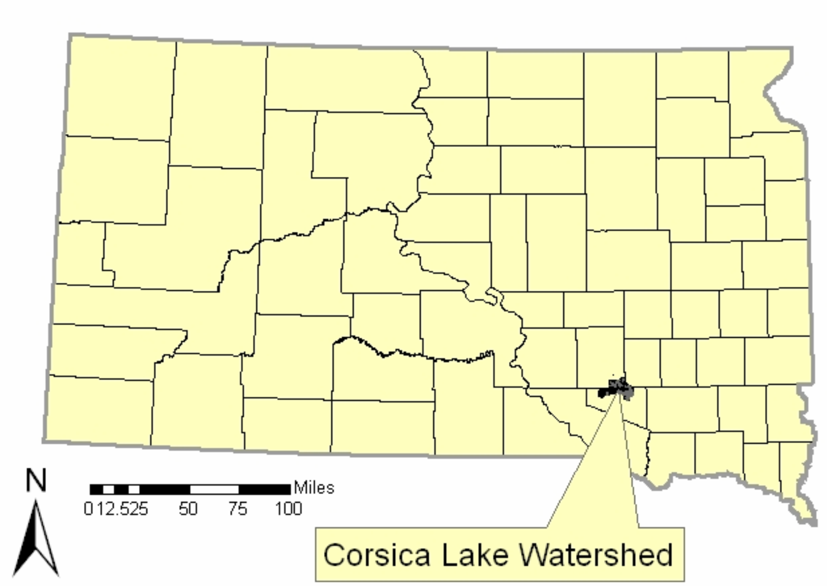

Figure 7. Corsica Lake Watershed Location

Problem Identification

The tributary to Corsica Lake drains a mixture of grazing and cropland acres. 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.

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

Corsica 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 Semi-permanent fish life propagation
Immersion recreation
Limited contact recreation
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.

Corsica Lake is identified in the 1998, 2002, and 2004 South Dakota Intergrated Report and "Ecoregion Targeting for Impaired Lakes in South Dakota" (2000) as partially supporting its aquatic life beneficial use. This support was determined through comparison of its trophic state to other lakes in its ecoregion.

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 state 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 Corsica Lake.

Typically phosphorus, chlorophyll a, and Secchi depth are used to calculate mean TSI as in the "Ecoregion Targeting for Impaired Lakes in South Dakota" (2000). Since Corsica Lake is nitrogen limited, the phosphorus TSI is artificially elevated. The actual trophic state is more closely represented by the nitrogen TSI (67.3) not the phosphorus TSI (92.3). To more accurately reflect the mean TSI value for Corsica Lake the nitrogen TSI value will be used in the mean equations, resulting in a mean TSI value of 65 for the lake.

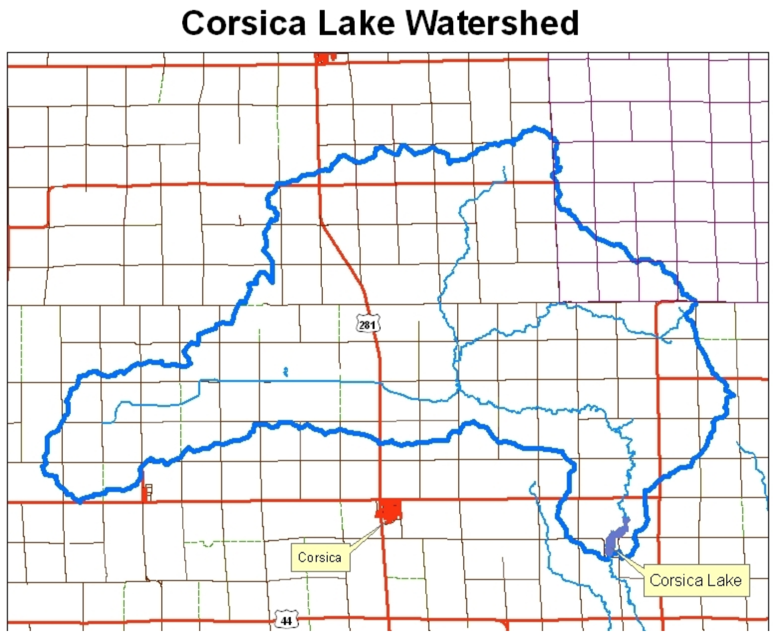

Figure 8. Corsica Lake Watershed

Corsica Lake currently has a mean TSI of 65, which is indicative of high levels of primary productivity. Assessment monitoring indicates that the primary cause of the high productivity is loads of nutrients from the watershed.

The numeric target, established to maintain the trophic state of Corsica Lake, is a growing season average TSI of less than 64.5. Currently the lake maintains a TSI of 65, but continued loads from the watershed place it in jeopardy of degradation beyond this point.

<u>**Pollutant Assessment**</u>

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

Nonpoint Sources/ Background Sources
Corsica Lake receives a load of 6,604 kg of phosphorus on an annual basis. Establishing a TSI of less than 65 for the TMDL target, with an increased margin of safety, will result in Corsica Lake maintaining full support of its beneficial uses. This is based on expected participation rates in an implementation program resulting in a 15% reduction in phosphorus loadings.

Linkage Analysis

Despite the use of a nitrogen TSI to establish the lakes mean TSI value, improvements to the lake will be based on phosphorus load reductions. The use of phosphorus reductions can be justified in a number of ways. The primary reasons include the fact that BMPs resulting in reductions of phosphorus can be accurately assumed to also reduce nitrogen, sediment, and other micronutrients that all result in increased TSI values for Corsica Lake. Additionally, reductions in phosphorus will result in small but significant reductions in algal concentrations, and ultimately the lakes mean TSI.

Water quality data was collected from five monitoring sites within the Corsica Lake 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. The data is considered to be of sufficient quality through analysis of the samples collected to adequately develop this TMDL. Details concerning water sampling techniques, analysis, and quality control are addressed on pages 9-49 of the assessment final report.

In addition to water quality monitoring, data was collected to complete a watershed landuse model. The Annualized Agriculture Nonpoint Pollution Source (AnnAGNPS) model was used to provide comparative values for each of the land uses and animal feeding operations located in the watershed. See the AnnAGNPS section of the final report, pages 39-46.

The impacts of phosphorus reductions on the condition of Corsica Lake were calculated using BATHTUB, an Army Corps of Engineers model. The model predicted that to achieve a TSI value equal to or less than 64.5 (ecoregion target), a 15% reduction in watershed phosphorus loads would be required. Participation rates in the watershed restoration programs are expected to be sufficient to achieve this goal. The lake currently has a mean growing season TSI of 65 and is maintaining full support of its beneficial uses.

TMDL and Allocations

TMDL for Phosphorus

	0 kg/yr	(WLA)
+	6,604 kg/yr	(LA)
+	,0 kg/yr	(Background)
+	Implicit	(MOS)
-	990 kg/yr	(Reduction)
	5,613 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 15% reduction in phosphorus is possible assuming participation in both crop and range land BMPs in the watershed. Containment of five of the animal feeding operations will result in a 5% reduction. Improved grass and range conditions on 3,840 acres of pasture lands may result in an additional 4% reduction. The final 6% may be attained from critical area seeding, grassed waterways, and buffer areas impacting 1,200 acres of cropland. These BMPs are expected to result in a load reduction of 990 kg/year and result in a positive TSI shift of 0.5 points.

Seasonal Variation
Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. The growing season (late spring through late summer) is the most important time to maintain support of beneficial uses. Not only is this the period of peak recreational use, but it is also the period during which most impairments occur to this lake. The TMDL targets for the lake during the growing season which will result in year round support of all beneficial uses.

Margin of Safety
Loading reductions from BMPs were calculated as an average reduction for the entire watershed. Targeting critical areas (as defined in the AnnAGNPS section of the report) well result in greater reductions per BMP for both cropland and rangeland management then was listed as the predicted improvement. As a result, implementation of BMPs on critical areas in the Corsica Lake watershed will result in an implicit margin of safety for the loading reductions.

Critical Conditions
The impairments to Corsica 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 may be necessary to assure that the TMDL has been reached and maintenance of the beneficial uses occurs. Corsica Lake will also be monitored continually as a part of the South Dakota Statewide Lakes Assessment program to ensure that the lake continues to support its beneficial uses in its improved state.

Public Participation
Efforts taken to gain public education, review, and comment during development of the TMDL involved local public meetings with the sponsor as well as with other groups that helped support the completion of the TMDL.

South Central Water Development District
Charles Mix County Conservation District
Douglas County Conservation District
Charles Mix County Commission
Douglas County Commission

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

Implementation Plan
A local sponsor is expected to approach the state for assistance in developing an implementation plan in conjunction with other watersheds located nearby.

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

NOTICE OF
TOTAL MAXIMUM DAILY LOADS

The South Dakota Department of Environment and Natural Resources (DENR) announces the availability of the following Total Maximum Daily Load (TMDL) for review and comment.

Corsica Lake, Douglas County

The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act. This TMDL was developed on a watershed basis that included public involvement.

TMDLs are an important tool for the management of water quality. The goal of a TMDL is to ensure that waters of the state attain water quality standards and provide designated beneficial uses. A TMDL is defined as "the sum of the individual waste load allocations for point sources and load allocations for both nonpoint source and natural background sources established at a level necessary to achieve compliance with applicable surface water quality standards." In other words, a TMDL identifies the total pollution load of any given water body can receive and still remain healthy. TMDLs are required on waters that do not attain water quality standards or assigned beneficial uses.

Any person interested in reviewing any TMDL document may request a copy by telephone or by mail. Also, each document has been uploaded to DENR's website under "NEW" at the Internet address

http://www.state.sd.us/denr/

Copies of the draft may also be obtained from Gene Stueven by writing to the address below, Gene Stueven at **denrinternet@state.sd.us** or by calling 1-800-438-3367.

Any person desiring to comment on the Corsica Lake TMDLs may submit comments to the address below. Persons are encouraged to comment electronically by sending the comments to Gene Stueven at the email address in the above paragraph. The department must receive the comments by September 23rd, 2005.

Department of Environment and Natural Resources
Water Resources Assistance Program
523 East Capitol Avenue – Joe Foss Building
Pierre, South Dakota 57501-3181

Steven M. Pirner
Secretary
Department of Environment and Natural Resources

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 8
999 18TH STREET- SUITE 300
DENVER, CO 80202-2466
Phone 800-227-8917
http://www.epa.gov/region08

August 30, 2006

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
Corsica Lake
Medicine Creek
Sheridan Lake
White Lake

Dear Mr. Pirner:

We have completed our review, and have received Endangered Species Act Section 7 concurrence from the U.S. 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 elements of the TMDLs listed in the enclosed table adequately address the pollutants of concern as given in the table, taking into consideration seasonal variation and a margin of safety. In the enclosed table, we have distinguished between TMDLs developed under Section 303(d)(1) *vs.* Section 303(d)(3) of the Clean Water Act. Section 303(d)(1) TMDLs are those for waterbodies that are water quality limited for the pollutant(s) of concern. The determination of whether a particular TMDL is (d)(1) or (d)(3) is made on a waterbody-by-waterbody and pollutant-by-pollutant basis.

Some of the TMDLs designated on the enclosed table as Section 303(d)(1) TMDLs, as distinguished from Section 303(d)(3) TMDLs, may be for waters not found on the current state 303(d) waterbody list. EPA understands that such waters would have been included on the list had the state been aware, at the time the list was compiled, of the information developed in the context of calculating these TMDLs. This information demonstrates that the non-listed water is

ENCLOSURE 1

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)
Corsica Lake*	Phosphorous	Maintain a mean annual TSI (N/Chl-*a*/SD) at or below 64.5	5,613 kg/yr total phosphorous (15% reduction in average annual total phosphorous loads)	Section 303(d)(1)	■ Phase I Watershed Assessment and TMDL Final Report, Corsica Lake, Douglas County, South Dakota (SD DENR, February 2005)
Medicine Creek*	Total Suspended Solids	TSS ≤ 263 mg/L daily maximum	20,172,490 kg/yr TSS (20.1% reduction in average annual TSS loads)	Section 303(d)(1)	■ Phase I Watershed Assessment Final Report and TMDL, Medicine Creek, Lyman and Jones Counties, South Dakota (SD DENR, August 2005)
	Fecal Coliform	Fecal coliform ≤ 2000 cfu/100mL	3.89×10^{13} cfu/fecal season (18.3% reduction in average annual fecal coliform loads)	Section 303(d)(1)	
Sheridan Lake*	Phosphorous	Maintain a mean annual Total Phosphorous TSI at or below 45.0	251 kg/yr total phosphorous (43% reduction in average annual total phosphorous loads)	Section 303(d)(1)	■ Total Maximum Daily Load Evaluation for Sheridan Lake, Pennington County, South Dakota (SD DENR, May 2006)
White Lake*	Phosphorous	Maintain a mean annual Total Phosphorous TSI at or below 70.0	2,355 kg/yr total phosphorous (30% reduction in average annual total phosphorous loads)	Section 303(d)(1)	■ Watershed Assessment/TMDL Final Report, White Lake, Marshall County, South Dakota (SD DENR, June 2005)
	Dissolved Oxygen	Dissolved oxygen ≥ 5.0 mg/L		Section 303(d)(1)	

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

Enclosure 2

EPA REGION VIII TMDL REVIEW FORM

Document Name:	**Corsica Lake**
Submitted by:	**Gene Stueven, SD DENR**
Date Received:	**April 4, 2006**
Review Date:	**May 10, 2006**
Reviewer:	**Vern Berry, EPA**
Formal or Informal Review?	**Formal – Final Approval**

This document provides a standard format for EPA Region 8 to provide comments to the South Dakota Department of Environment and Natural Resources on TMDL documents provided to the EPA for either official formal or informal review. All TMDL documents are measured against the following 12 review criteria:

1. Water Quality Impairment Status
2. Water Quality Standards
3. Water Quality Targets
4. Significant Sources
5. Technical Analysis
6. Margin of Safety and Seasonality
7. Total Maximum Daily Load
8. Allocation
9. Public Participation
10. Monitoring Strategy
11. Restoration Strategy
12. Endangered Species Act Compliance

Each of the 12 review criteria are described below to provide the rational for the review, followed by EPA's comments. This review is intended to ensure compliance with the Clean Water Act and also to ensure that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Water Quality Impairment Status

> ***Criterion Description – Water Quality Impairment Status***
>
> *TMDL documents must include a description of the listed water quality impairments. While the 303(d) list identifies probable causes and sources of water quality impairments, the information contained in the 303(d) list is generally not sufficiently detailed to provide the reader with an adequate understanding of the impairments. TMDL documents should include a thorough description/summary of all available water quality data such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and/or appropriate water quality standards.*

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Corsica Lake is a 110 acre man-make impoundment located in the Missouri River basin, Lewis and Clark Lake sub-basin, Douglas County, South Dakota. It is listed on SD's 2004 303(d) list as impaired for trophic state index (TSI) due to nonpoint sources and is ranked as priority 1 (i.e., high priority) for TMDL development. The watershed is approximately 56,038 acres and drains predominantly agricultural land consisting of cropland and grazing land. The mean TSI during the period of the project assessment was 73, and is not currently meeting its designated beneficial use for warmwater semi-permanent fish life propagation.

2. Water Quality Standards

> ***Criterion Description – Water Quality Standards***
>
> *The TMDL document must include a description of all applicable water quality standards for all affected jurisdictions. TMDLs result in maintaining and attaining water quality standards. Water quality standards are the basis from which TMDLs are established and the TMDL targets are derived, including the numeric, narrative, use classification, and antidegradation components of the standards.*

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Corsica Lake is impaired for TSI which is a surrogate measure used to determine whether the narrative standards are being met. South Dakota has applicable narrative standards that may be applied to the undesirable eutrophication of lakes. Data from Corsica Lake indicates problems with nutrient enrichment and nuisance algal blooms, which are typical signs of the eutrophication process. 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)

Other applicable water quality standards are included in the Surface Water Chemistry section of the assessment report.

3. Water Quality Targets

Criterion Description – Water Quality Targets
Quantified targets or endpoints must be provided to address each listed pollutant/water body combination. Target values must represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the TMDL target. For pollutants with narrative standards, the narrative standard must be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include targets representing water column sediment such as TSS, embeddeness, stream morphology, up-slope conditions and a measure of biota).

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – 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 Corsica Lake during the period of the assessment was 73. Nutrient reduction response modeling was conducted with BATHTUB, an Army Corps of Engineers eutrophication response model. The results of the modeling show that 75% or more reduction in the total phosphorous loading from the watershed would is necessary to meet the ecoregion-based beneficial use TSI target of 65 or less.

Based on calculated nitrogen to phosphorous ratios for the period of assessment, the lake may be nitrogen limited. Therefore the nitrogen TSI, rather than the phosphorous TSI, was used to derive the mean TSI for the lake. Using this approach the mean TSI for the lake is 64.5 (rounded to 65).

The proposed water quality target for this TMDL is: **maintain a mean annual TSI (N/Chl-*a*/SD) at or below 64.5.**

4. Significant Sources

Criterion Description – Significant Sources

TMDLs must consider all significant sources of the stressor of concern. All sources or causes of the stressor must be identified or accounted for in some manner. The detail provided in the source assessment step drives the rigor of the allocation step. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each significant source when the relative load contribution from each source has been estimated. Ideally, therefore, the pollutant load from each significant source should be quantified. This can be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach can be employed so long as the approach is clearly defined in the document.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The TMDL identifies the major sources of phosphorous as coming from nonpoint sources within the watershed. In particular, a loading analysis was done for nutrients and sediment considering various land use and land management factors. Approximately 30% of the land area in the watershed is rangeland and the remaining 70% is cropland. The results from modeling indicate that those two sources, as well as animal feeding areas are the primary sources of phosphorous loading to the lake.

5. Technical Analysis

Criterion Description – Technical Analysis

*TMDLs must be supported by an appropriate level of technical analysis. It applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader. Of particular importance, the cause and effect relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and allocations needs to be supported by an appropriate level of technical analysis.*

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The technical analysis addresses the needed phosphorous reduction to achieve the desired water quality. The TMDL recommends a 15% reduction in average annual total phosphorous loads to

Corsica Lake. Despite the use of a nitrogen TSI to derive the lake's mean TSI, improvements to the lake are based on phosphorous load reductions. Using the loads measured during the period of the assessment the total phosphorous load should be 5,613 kg/yr to achieve the desired TSI target. This reduction is based in large part on the BATHTUB mathematical modeling of the lake and its predicted response to nutrient load reductions.

The FLUX model was used to develop nutrient and sediment loadings for the Corsica Lake inlet and outlet sites. This information was used to derive export coefficients for nutrients and sediment to target areas within the watershed with excessive loads of these pollutants.

The Annualized Agricultural Non-Point Source Model (AnnAGNPS) model was used to simulate alterations in land use practices and the resulting nutrient reduction response. The nutrient loading source analysis, that was used to identify necessary controls in the watershed, was based on the identification of targeted or "critical" cells. Cell priority was assigned based on the mean phosphorous loads produced that ultimately reach the outlet of the watershed. Cells that produce phosphorous loads greater than two standard deviations over the mean for the watershed were assigned a higher priority than cells producing loads greater than one standard deviation over the mean. Other criteria for cell priority include steep slopes, erosive soils and close proximity to the lake / higher order streams. The initial load reductions under this TMDL will be achieved through controls on the critical cells, and the identified priority animal feeding areas, within the watershed.

6. Margin of Safety and Seasonality

Criterion Description – Margin of Safety and Seasonality

A margin of safety (MOS) is a required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (303(d)(1)(c)). The MOS can be implicitly expressed by incorporating a margin of safety into conservative assumptions used to develop the TMDL. In other cases, the MOS can be built in as a separate component of the TMDL (in this case, quantitatively, a TMDL = WLA + LA + MOS). In all cases, specific documentation describing the rational for the MOS is required.

Seasonal considerations, such as critical flow periods (high flow, low flow), also need to be considered when establishing TMDLs, targets, and allocations.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – 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 BMPs that can be tailored to seasonal needs.

7. **TMDL**

Criterion Description – Total Maximum Daily Load
TMDLs include a quantified pollutant reduction target. According to EPA regulations (see 40 CFR 130.2(i)). TMDLs can be expressed as mass per unit of time, toxicity, % load reduction, or other measure. TMDLs must address, either singly or in combination, each listed pollutant/water body combination.

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The TMDL established for Corsica Lake is a 5,613 kg/yr total phosphorus load to the lake (15% reduction in annual total phosphorus load). This is the "measured load" which is based on the flow and concentration data collected during the period of the assessment. Since the annual loading varies from year-to-year, this TMDL is considered a long term average percent reduction in phosphorous loading.

8. **Allocation**

Criterion Description – Allocation
TMDLs apportion responsibility for taking actions or allocate the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or dividing of responsibility. A performance based allocation approach, where a detailed strategy is articulated for the application of BMPs, may also be appropriate for nonpoint sources. Every effort should be made to be as detailed as possible and also, to base all conclusions on the best available scientific principles. *In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).*

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – This TMDL addresses the need to achieve further reductions in nutrients to attain water quality goals in Corsica Lake. The allocation for the TMDL is a "load allocation" attributed to nonpoint sources. There are no significant point source contributions in this watershed. The source allocations for phosphorous are assigned to nonpoint source runoff from cropland and rangeland in the watershed, as well as from animal feeding areas.

9. Public Participation

Criterion Description – Public Participation
The fundamental requirement for public participation is that all stakeholders have an opportunity to be part of the process. Notifications or solicitations for comments regarding the TMDL should clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for review, a copy of the comments received by the state should be also submitted to EPA..

☒ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☐ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – 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, individual contact with residents in the watershed, and widespread solicitation of comments on the draft TMDL. Also, the draft TMDL has been posted on the State's internet site to solicit comments during the public notice period. The level of public participation is found to be adequate.

10. Monitoring Strategy

Criterion Description – Monitoring Strategy
TMDLs may have significant uncertainty associated with selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL documents to articulate the means by which the TMDL will be evaluated in the field, and to provide supplemental data in the future to address any uncertainties that may exist when the document is prepared.

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – Corsica Lake will continue to be monitored through the statewide lake assessment project. Post-implementation monitoring will be necessary to assure the TMDL has been reached and maintenance of the beneficial use occurs.

11. Restoration Strategy

Criterion Description – Restoration Strategy
At a minimum, sufficient information should be provided in the TMDL document to demonstrate that if the TMDL were implemented, water quality standards would be attained or maintained. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document.

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – The South Dakota DENR will work with the local interested parties in the watershed to develop a plan for an implementation project for Corsica Lake.

12. Endangered Species Act Compliance

Criterion Description – Endangered Species Act Compliance
EPA's approval of a TMDL may constitute an action subject to the provisions of Section 7 of the Endangered Species Act (ESA). EPA will consult, as appropriate, with the US Fish and Wildlife Service (USFWS) to determine if there is an effect on listed endangered and threatened species pertaining to EPA's approval of the TMDL. The responsibility to consult with the USFWS lies with EPA and is not a requirement under the Clean Water Act for approving TMDLs. States are encouraged, however, to participate with USFWS and EPA in the consultation process and, most importantly, to document in its TMDLs the potential effects (adverse or beneficial) the TMDL may have on listed as well as candidate and proposed species under the ESA.

☐ Satisfies Criterion
☐ Satisfies Criterion. Questions or comments provided below should be considered.
☐ Partially satisfies criterion. Questions or comments provided below need to be addressed.
☐ Criterion not satisfied. Questions or comments provided below need to be addressed.
☒ Not a required element in this case. Comments or questions provided for informational purposes.

SUMMARY – EPA has received ESA Section 7 concurrence from the FWS for this TMDL.

13. Miscellaneous Comments/Questions