MARSHALL COUNTY LAKES ASSESSMENT PROJECT

FINAL REPORT
FOR
SOUTH BUFFALO LAKE
MARSHALL 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

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

MARSHALL COUNTY LAKES ASSESSMENT PROJECT

FINAL REPORT FOR SOUTH BUFFALO LAKE

Prepared By

Richard A. Hanson

Sponsor

Marshall Conservation District

3/15/07

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The cooperation of the following organizations is gratefully appreciated. The assessment of North and South Buffalo Lakes and their watersheds could not have been completed without their assistance.

Marshall Conservation District

South Dakota Department of Environment and Natural Resources

South Dakota Department of Game, Fish & Parks

USDA Natural Resource Conservation Service

Prairie Agricultural Research, Inc.

Sol Brich created the water and sediment depth map.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

EXECUTIVE SUMMARY

PROJECT TITLE: Marshall County Lakes Assessment Project

PROJECT START DATE: 4/1/02	PROJECT COMPLETION DATE: 3/15/07
FUNDING:	TOTAL BUDGET: $192,000.00
TOTAL EPA GRANT:	$165,000.00 amended to $120,000.00
TOTAL EXPENDITURE OF EPA FUNDS:	$79,981.22
NONFEDERAL MATCH	
State Natural Resources Fee Funds	$25,000.00
Marshall Con. District	1,003.50
BUDGET REVISIONS:	Decrease $165,000 EPA funds to $120,000
TOTAL EXPENDITURES:	$105,984.72

SUMMARY ACCOMPLISHMENTS

The Marshall County Lakes Assessment Project was conducted because a number of lakes in the County were placed on the 1996-2006 303(d) lists for an increasing TSI trend, siltation, nutrients and aquatic nuisances (algae). The primary goal for the project was to determine sources of impairment to South Buffalo Lake, South Red Iron Lake, and North Buffalo Lake, and provide sufficient background data to drive a Section 319 Implementation Project. This report is about South Buffalo Lake.

An EPA section 319 grant provided a majority of the funding for this project. The State of South Dakota provided non-federal matching funds/in-kind services for the project.

Water quality monitoring indicated a trophic state relatively similar to other lakes in the region. The lake did not exhibit thermal stratification and dissolved oxygen concentrations were sometimes below the water quality standard. The standards criteria for nitrate, unionized ammonia, conductivity, total suspended solids, and fecal coliform bacteria were not exceeded. Seasonality was indicated by typical temperature changes throughout the year and by seasonal changes in some parameter concentrations. An aquatic macrophyte survey was completed for the lake. Aquatic macrophytes were not considered a major problem in the lake.

Seasonality was indicated by peaks in phosphorus loading that occurred during the spring runoff period. Results from the BATHTUB model were used to establish a total maximum annual load of 357.9 kg/year (0.98 kg/day) for total phosphorus, which will maintain the lake under the Secchi-chlorophyll *a* TSI target of 63.4

The Annualized Agricultural Non-point Source computer model (AnnAGNPS) was not used because the lake was already meeting its TSI target. In-lake restoration techniques such as aeration/circulation were recommended to alleviate the low dissolved oxygen concentrations. Best Management Practices were also recommended for maintaining the TMDL and for improving dissolved oxygen concentrations.

INTRODUCTION

Purpose

The purpose of this assessment is to determine the sources of impairment to South Buffalo Lake and its tributaries, determine total maximum daily loads (TMDLs) that will maintain full support of the lake's beneficial uses.

General Lake Description

South Buffalo Lake is a 1,780-acre natural lake located in Marshall County, South Dakota (Figure 1). The lake is primarily used for fishing. The average depth of the lake is 1.8 meters (6 feet) and it has a maximum depth of 3.7 meters (12 feet). A few homes are located adjacent to the lake. All use septic systems.

No large streams enter the lake but five small unnamed tributaries that receive drainage from primarily grazing lands and some cropland acres drain into South Buffalo Lake.

Lake Identification and Location

Lake Name: South Buffalo Lake	State: South Dakota
County: Marshall	Township: 125N
Range: 53W	Sections: 2, 10-11, 14-17
Nearest Municipality: Eden	Latitude: 45.616667
Longitude: -97.280000	EPA Region: VIII
Primary Tributary: Unnamed	Receiving Body of Water: North Buffalo Lake
HUC Code: 101600100	HUC Name: North Big Sioux Coteau

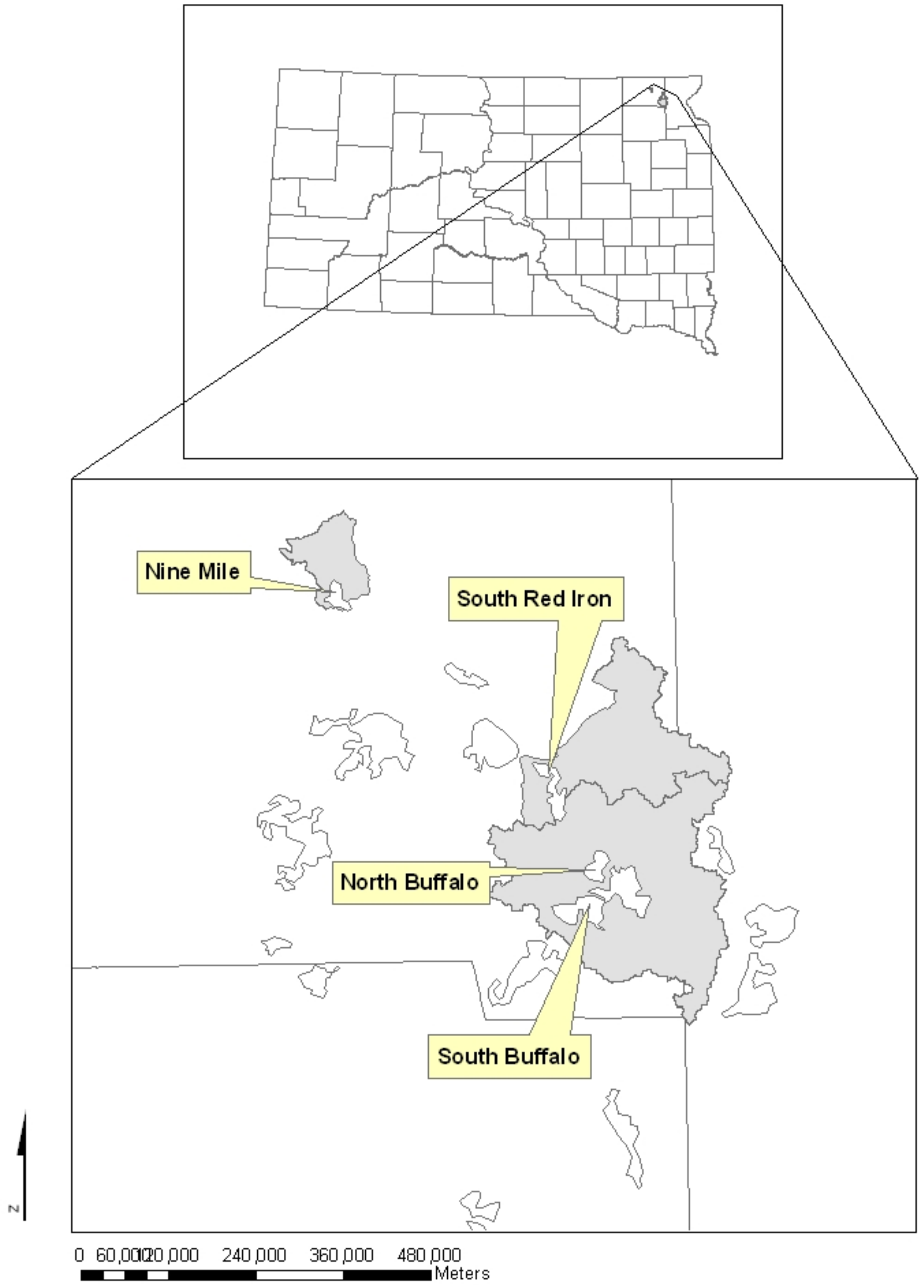


Figure 1. Lakes and their watersheds in the Marshall County Lakes Assessment Project.

Trophic State Comparison

Developed by Carlson (1977), the Trophic State Index (TSI), is a numerical value from 0 to 100 that 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 the growing-season TSI for South Buffalo Lake to other lakes in the area (Table 1) shows that South Buffalo Lake had slightly higher average TSI values than most other lakes in the area and that a moderate to high rate of productivity is common for the region

Table 1. TSI comparison of South Buffalo Lake and other area lakes*.

Lake	1989 Avg. TSI	1991 Avg. TSI	1993 Avg. TSI	Mean Trophic State
White Lake	69.05	71.74	69.59	Eutrophic
Roy	62.95	65.01	60.88	Eutrophic
S. Red Iron	51.28	62.02	59.07	Eutrophic
Nine Mile	60.08	66.11	63.87	Eutrophic
Average	**60.84**	**66.22**	**63.35**	Eutrophic
S. Buffalo	**54.17**	**70.09**	**64.24**	**Eutrophic**

* TSI values taken from Stueven and Stewart, 1996.

Beneficial Uses and Water Quality Standards

The State of South Dakota has assigned all of the water bodies that are within its borders a set of beneficial uses. With these assigned uses are sets of standards for various physical and chemical properties. These standards must be maintained for the water body to satisfy its assigned beneficial uses. All bodies of water in the state receive the beneficial uses of fish and wildlife propagation, recreation, and stock watering. Following is the list of beneficial uses assigned to South Buffalo Lake.

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

With each of these uses are sets of water quality standards that must not be exceeded in order to maintain these uses. The following tables list those parameters measured during this study that must be considered when maintaining the beneficial uses as well as the concentrations for each parameter. When multiple standards for a parameter exist, the most restrictive standard is used. Additional "narrative" standards that may apply can be found in the "Administrative Rules of South Dakota: Articles 74:51:01:05; 06; 08; and 09". These contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, and nuisance aquatic life. Carlson's (1977) trophic state indices are used during this study as a measure of beneficial use support. The indices are based on total phosphorus, Secchi disc transparency and chlorophyll *a*. The critical values for beneficial use status were derived from a SDDENR study of South Dakota lakes and from regionality of various lake attributes (Lorenzen, 2005).

Individual parameters as well as the lake's TSI value determine the support of these beneficial uses. South Buffalo Lake is listed in the state's 2006 303(d) list and was identified as not supporting its fish life propagation use due to an elevated TSI and pH.

Table 2. State beneficial use standards for South Buffalo Lake, Marshall County, South Dakota.

Parameters	mg/l (except where noted)	Beneficial Use Requiring this Standard
Alkalinity *($CaCO_3$)*	≤ 750 *(mean),* ≤ 1,313 *(single sample)*	Wildlife Propagation and Stock Watering
Coliform, fecal *(per 100 ml)* May 1 to Sept 30	≤ 200 *(Geo.mean),* ≤ 400 *(single sample)*	Immersion Recreation
Conductivity *(μmhos/cm @ 25 °C)*	≤ 4,000 *(mean,)* ≤ 7,000 *(single sample)*	Wildlife Propagation and Stock Watering
Nitrogen, Total ammonia as N	$(0.411/(1+10^{7.204-pH}))+(58.4/(1+10^{pH-7.204}))$ *(single sample)*	Warmwater Semi-permanent Fish Propagation
Nitrogen, nitrates as N	≤ 50 *(mean),* ≤ *88 (single sample)*	Wildlife Propagation and Stock Watering
Oxygen, dissolved	≥ 5.0	Immersion and Limited Contact Recreation
pH (standard units)	≥ 6.5 - ≤ 9.0	Warmwater Semi-permanent Fish Propagation
Solids, suspended	≤ 90 *(mean),* ≤ 158 *(single sample)*	Warmwater Semi-permanent Fish Propagation
Temperature	≤ 32.22 C	Warmwater Semi-permanent Fish Propagation

The tributaries of South Buffalo Lake have the beneficial uses of:

(9) Fish and wildlife propagation, recreation, and stock watering, and
(10) Irrigation

In order for the tributaries to maintain these uses, there are four standards that must be maintained. These standards, along with their numeric criteria, are listed in Table 3.

Table 3. State water quality standards for the unnamed tributaries of South Buffalo Lake.

Parameters	Criterion, mg/l (except where noted)
Nitrate	≤ 50 (mean), ≤ 88 (single sample)
Alkalinity	≤ 750 (mean), ≤ 1,313 (single sample)
pH	≥ 6.5 and ≤ 9.5
Conductivity	≤ 4,000 (mean), ≤ 7,000 (single sample)

Recreational Uses

The South Dakota Department of Game, Fish, and Parks provides a list of public facilities that are maintained at area lakes (Table 4). Most of the larger and more frequently used lakes in the area have adequate facilities. This includes South Buffalo Lake.

Table 4. Comparison of recreational uses on lakes near South Buffalo Lake.

Lake	State Parks	Ramps	Boating	Campground	Fishing	Picnic Tables	Swimming	Nearest Municipality
White Lake		X	X		X		X	Britton
Nine Mile		X	X		X		X	Lake City
South Red Iron		X	X		X		X	Lake City
Roy Lake	X	X	X	X	X	X	X	Lake City
North Buffalo		X	X		X		X	Lake City
South Buffalo		**X**	**X**		**X**		**X**	**Lake City**

Watershed

South Buffalo Lake has a 16,781-acre watershed that is characterized by rolling short-grass prairie, pastureland with a small portion in cultivation. The two major soil associations found in the watershed are of the Renshaw-Fordville-Sioux and the Forman-Aastad-Buse associations (USDA, 1975). The Renshaw-Fordville-Sioux association is characterized by nearly level to steep, well-drained to excessively drained, loamy soils underlain by sand and gravel. The Forman-Aastad-Buse association is characterized by nearly level to sloping, well drained and moderately well drained, loamy soils formed in glacial till.

Land use in the watershed is primarily agricultural grazing with some cropland. Small grains and hay are the main crops on cultivated lands. The average annual precipitation in Britton is 20.68 inches, of which most usually falls in April through September. Tornadoes and severe thunderstorms strike occasionally. These storms are local and of short duration and occasionally produce heavy rainfall events

History

South Buffalo Lake is a natural lake so named because it is located in Buffalo Township. The lake is approximately 9.4 miles southeast of Lake City and 5 miles east of Eden, the nearest municipality.

Previous water quality data and anecdotal information indicated South Buffalo Lake experienced algae and aquatic vegetation problems in the past. The 1996, 1998, 2000, and 2002 South Dakota Reports to Congress documents listed the lake as not meeting its beneficial uses because of nutrients, siltation, and aquatic plants. The 2006 South Dakota Integrated Report described the water quality of South Buffalo Lake as not meeting its fish life propagation use because of pH and TSI. The cause of the problems has been thought to be from non-point source pollution. The Marshall Conservation District was concerned enough about the quality of the lakes in the area that they agreed to sponsor a four-lake assessment in Marshall County.

Threatened and Endangered Species

The only species on the federal list of threatened and endangered species likely to occur in the South Buffalo Lake watershed is the bald eagle (*Haliaeetus leucocephalis*), which is listed as threatened. No bald eagles were encountered during this study; however, care should be taken when conducting mitigation projects in the watershed.

Nesting bald eagles have not been documented in the project area but there could be eagles migrating through the area, especially during the fall waterfowl migration. 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.

PROJECT GOALS, OBJECTIVES, AND ACTIVITIES

<u>Planned and Actual Milestones, Products, and Completion Dates</u>

Objective 1. Lake Sampling and Sediment Survey

The lake water sampling commenced June, 2002 and continued through May 2003. Spring samples were collected during March, April and May of 2003. Bimonthly samples were collected during June and August. A cursory sediment survey was conducted at South Buffalo Lake during March of 2003.

Objective 2. Tributary Sampling

The local coordinator began sampling the tributaries during June, 2002. Detailed cross-sectional and water velocity data were collected along with daily stage readings from Isco or OTT Thalimedes stage recorders. These data were to be used to develop stage/discharge relationships so water flows could be calculated.

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

Duplicate and blank samples were collected during the course of the project to provide defendable proof that sample data were collected in a scientific and reproducible manner. QA/QC data collection began in June of 2002 and was completed as planned.

Objective 4. AnnAGNPS Modeling

Prairie Agricultural Research, Inc. toured the watershed and made initial determinations for the AnnAGNPS model. The NRCS office located in Britton made available information concerning land use information. The AnnAGNPS modeling was not completed because the lake was already meeting its target TSI.

Objective 5. Public Participation

The public was kept informed of the project through monthly meetings of the Marshall Conservation District.

Objectives 6 and 7. Restoration Alternatives and Final Report

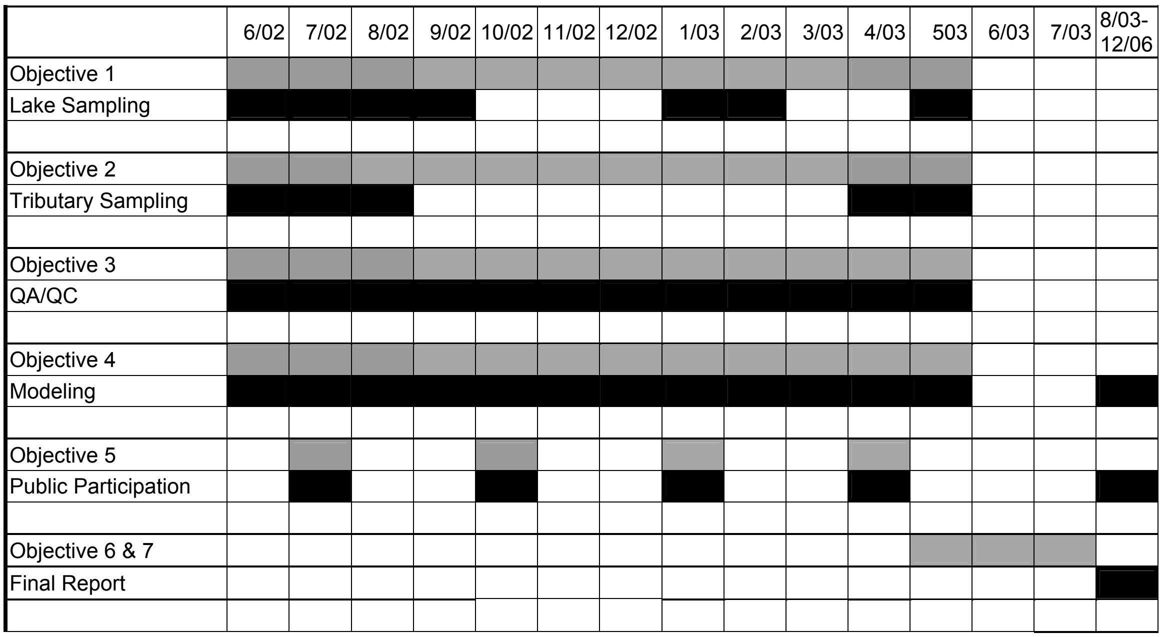
The completion of the restoration alternatives and final report for South Buffalo Lake was delayed due to DENR personnel having other commitments.

<u>Evaluation of Goal Achievements</u>

The goal of the watershed assessment project for South Buffalo Lake was to determine and document sources of impairment to the lake and to develop feasible restoration strategies. This was accomplished through the collection of tributary and lake data.

Through data analysis and modeling, identification of impairment sources was made and restoration strategies were developed. A comparison of the planned and actual objective completion dates is given in Table 5.

Table 5. Proposed and actual objective completion dates for the Marshall County Lakes Assessment Project.



Monitoring Methods and Results

OBJECTIVE 1 – Lake Sampling and Sediment Survey

In-lake Sampling Schedule, Methods, and Materials

Three sampling sites were chosen to monitor South Buffalo Lake (Figure 2). Sampling began in June, 2002, and was conducted on a bimonthly basis at the three in-lake sites during June, July, and August, and monthly during other months. Water samples were collected at both sites with a Van Dorn sampler from the lake surface and near the bottom of the lake. The samples were filtered, preserved, and packed in ice for shipping to the State Health Lab in Pierre, SD according to the "Standard Operating Procedures for Field Samplers" (Stueven, et al., 2000). The laboratory analyzed the samples for the following parameters:

Fecal coliform bacteria	Alkalinity
Total solids	Total suspended solids
Total volatile suspended solids	Ammonia
Nitrate	Total Kjeldahl Nitrogen (TKN)
Total phosphorus	Total dissolved phosphorus
E. coli	Chlorophyll *a*

Personnel conducting the sampling at each of the sites recorded the following observations.

Precipitation	Wind
Odor	Septic conditions
Dead fish	Film
Width	Water depth
Ice cover	Water color

Parameters measured in the field by sampling personnel were:

Water temperature	Air temperature
Specific conductance	Dissolved oxygen
Field pH	Secchi depth

Original data may be found in Appendix A.

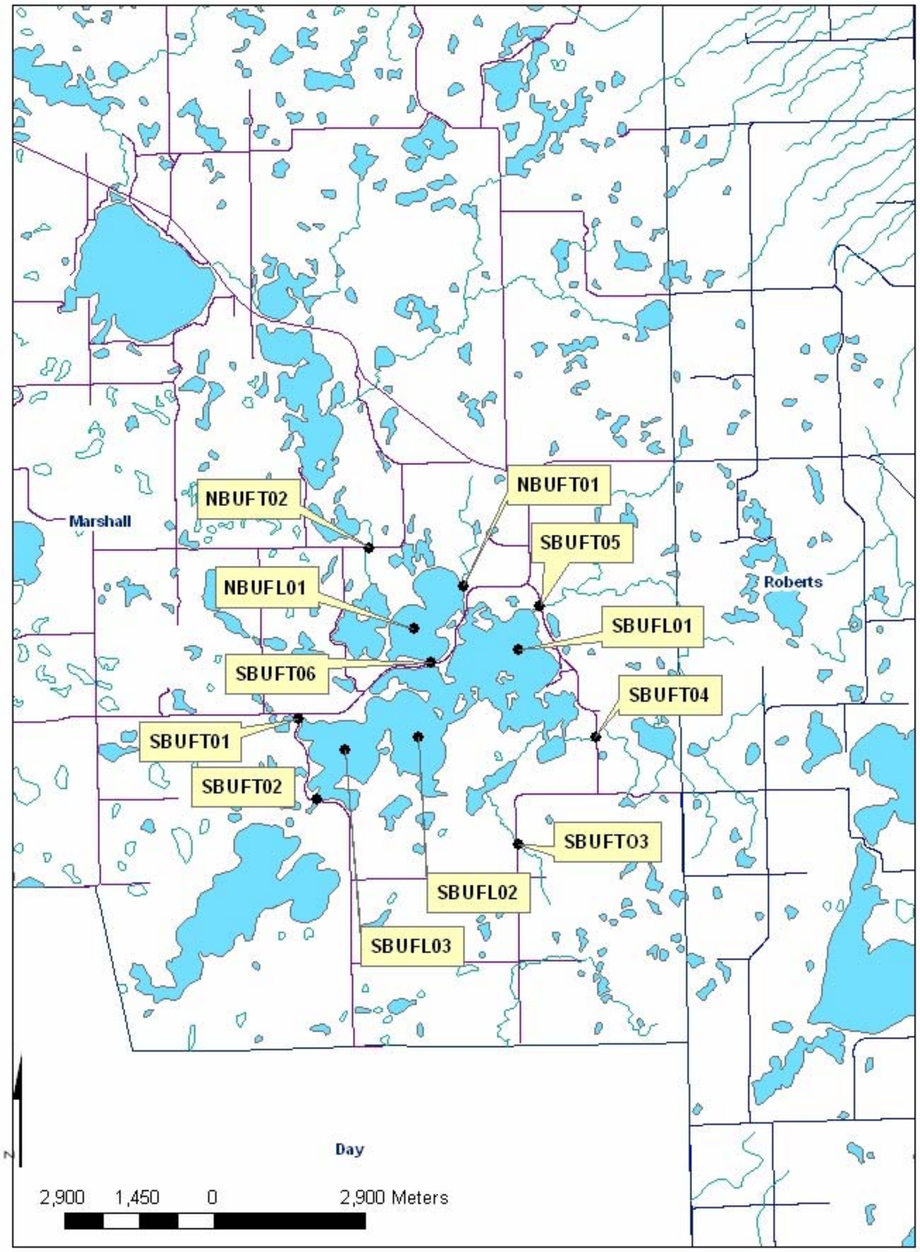


Figure 2. Sampling sites for North and South Buffalo Lakes and their watersheds.

In-lake Water Quality Results

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 do better under cooler conditions. Water temperature also plays a role in physical conditions. Oxygen dissolves in higher concentrations in cooler water. The toxicity of un-ionized ammonia is also related to warmer temperatures.

The surface water temperature in South Buffalo Lake exhibited little variation between the three sites. Temperatures showed seasonal variations that are consistent with the lake's geographic location, steadily increasing in the spring and summer and consistently decreasing in the fall and winter (Figure 3). It can be reasonably expected that during most years lake temperatures would be within a few degrees of the project data at their respective dates.

South Buffalo Lake showed no significant thermal stratification during the study and most temperature readings near the lake surface and bottom differed by two degrees or less (Figure 3). The water quality standard criterion for temperature was not exceeded.

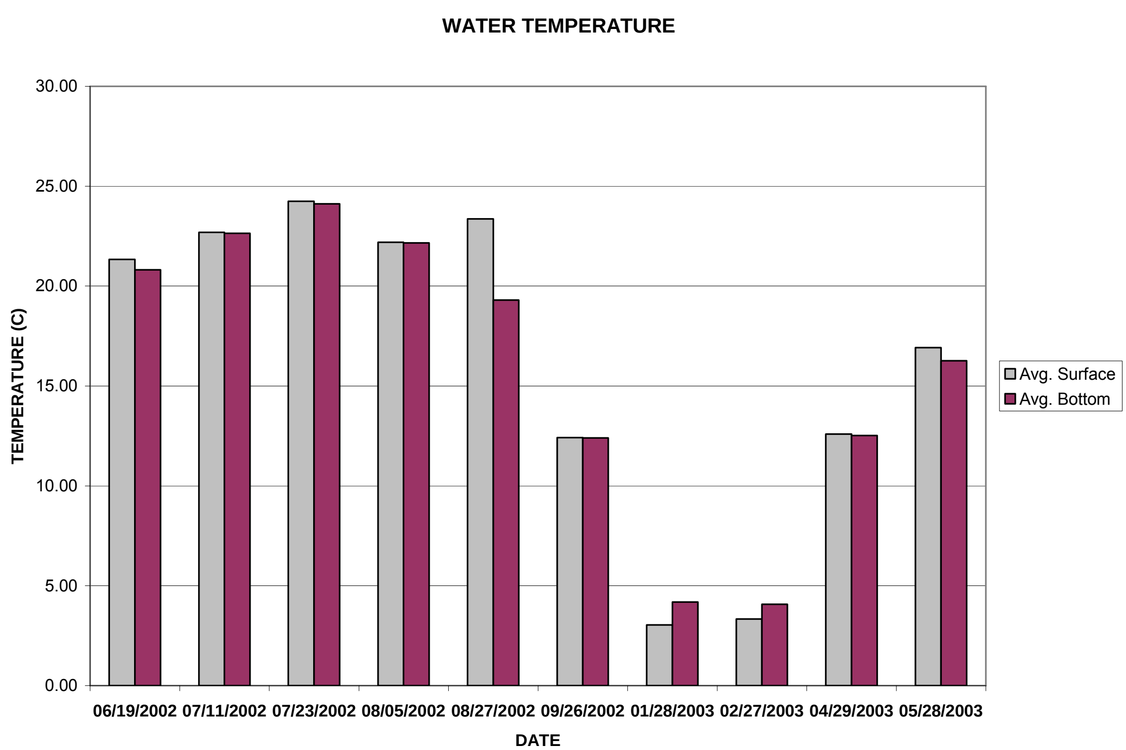


Figure 3. Average in-lake surface and bottom water temperatures for South Buffalo Lake, Marshall County, South Dakota, 2002/2003.

Dissolved Oxygen

Dissolved oxygen (DO) levels at the surface of South Buffalo Lake were sufficient to maintain the minimum requirement for the local managed fishery but oxygen depletion did occur during the project (see Figure 4 and Appendix A). DO depletion was not limited to the lake bottom but occurred throughout the water column. Twenty-six out of ninety-six readings (27.0%) had DO levels below 5.0 mg/l, the DO criterion for maintaining warmwater semi-permanent fish life propagation. This was most likely due to bacteria using oxygen during the decomposition of organic matter in the lake. Dead fish were not noticed during the time of oxygen depletion and fish kills have not been reported to SDDENR during the past ten years.

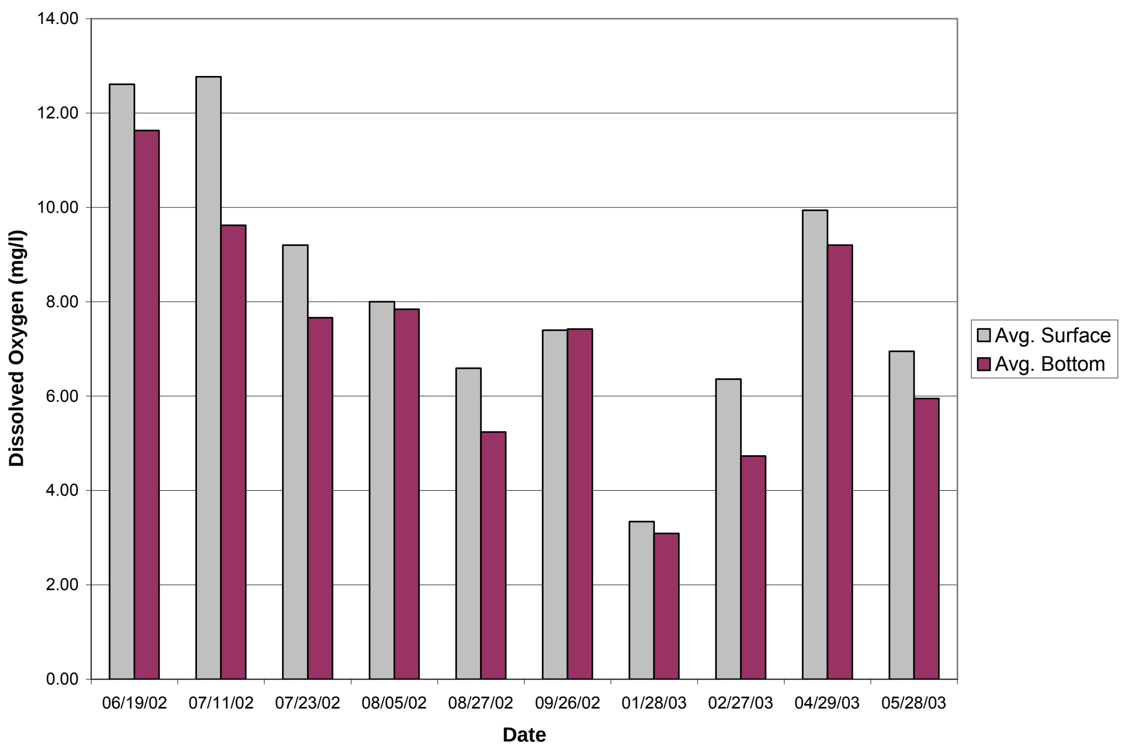


Figure 4. Average in-lake surface and bottom dissolved oxygen concentrations for South Buffalo Lake, Marshall County, South Dakota, 2002/2003.

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. At neutral (pH of 7) acid ions (H+) equal the base ions (OH-). Values less than 7 are considered acidic (more H+ ions) and greater than 7 are basic (more OH- ions). Algal and macrophyte photosynthesis act to increase a lake's pH. The decomposition of organic matter will reduce pH. The extent to which this occurs is affected by the lake's ability to buffer against changes in pH. The presence of 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.

pH values in South Buffalo Lake ranged from 8.07 to 10.21 (Table 6). However, the project coordinator indicated during the project that the YSI meter used to measure pH was operating abnormally. The YSI pH probe was eventually replaced but it was felt that much of the pH data were suspect. All four lakes monitored under the Marshall County Lakes Assessment Project exhibited a number of pH values greater than 9.0 and some as high as 10. This is not considered normal for lakes in this area of South Dakota. Algae are often implicated in causing higher pH values but none of these lakes had excessively high chlorophyll *a* concentrations. In addition, historical data show pH values in these lakes averaged 8.5-8.7 with only a couple of occurrences above 9.0 (Table 24 in Appendix A). Because of this, it was decided not to use the pH data obtained during the project. Given the historical data, pH was not considered problematic in these lakes.

Table 6. In-lake pH values for South Buffalo Lake, Marshall County, South Dakota, 2002/2003.

Site	Date	Depth (m)	pH	Site	Date	Depth (m)	pH	Site	Date	Depth (m)	pH
SBUFL01	06/19/2002	0.918	8.53	SBUFL02	06/19/2002	0.935	8.31	SBUFL03	06/19/2002	0.997	8.3
SBUFL01	06/19/2002	1.922	8.27	SBUFL02	06/19/2002	1.933	8.26	SBUFL03	06/19/2002	1.934	8.19
SBUFL01	06/19/2002	2.935	8.26	SBUFL02	06/19/2002	2.319	8.07	SBUFL03	06/19/2002	2.966	8.14
SBUFL01	06/19/2002	3.232	8.13	SBUFL02	07/11/2002	1.109	8.43	SBUFL03	06/19/2002	3.572	8.02
SBUFL01	07/11/2002	1.107	8.41	SBUFL02	07/11/2002	2.086	8.34	SBUFL03	07/11/2002	1.099	8.45
SBUFL01	07/11/2002	2.134	8.26	SBUFL02	07/11/2002	3.113	8.32	SBUFL03	07/11/2002	2.104	8.42
SBUFL01	07/11/2002	3.102	8.23	SBUFL02	07/11/2002	3.576	8.16	SBUFL03	07/11/2002	3.11	7.95
SBUFL01	07/11/2002	3.646	8.16	SBUFL02	08/05/2002	0.998	8.92	SBUFL03	07/11/2002	3.57	7.88
SBUFL01	08/05/2002	1.004	9.45	SBUFL02	08/05/2002	1.986	9.34	SBUFL03	08/05/2002	0.990	9.53
SBUFL01	08/05/2002	2.002	9.31	SBUFL02	08/05/2002	2.964	9.48	SBUFL03	08/05/2002	1.988	9.29
SBUFL01	08/05/2002	2.985	9.47	SBUFL02	08/05/2002	3.537	9.42	SBUFL03	08/05/2002	2.973	9.32
SBUFL01	08/05/2002	3.501	9.22	SBUFL02	08/27/2002	1.025	10.14	SBUFL03	08/05/2002	3.660	9.28
SBUFL01	08/27/2002	1.018	10.21	SBUFL02	08/27/2002	2.012	10.02	SBUFL03	08/27/2002	1.019	10.07
SBUFL01	08/27/2002	2.007	10.06	SBUFL02	08/27/2002	2.998	9.84	SBUFL03	08/27/2002	1.998	10.11
SBUFL01	08/27/2002	3.001	9.85	SBUFL02	08/27/2002	3.33	9.75	SBUFL03	08/27/2002	2.985	9.97
SBUFL01	08/27/2002	3.313	9.81	SBUFL02	09/26/2002	1.01	9.49	SBUFL03	08/27/2002	3.522	9.74
SBUFL01	09/26/2002	1.002	9.56	SBUFL02	09/26/2002	2.013	9.5	SBUFL03	09/26/2002	0.999	9.57
SBUFL01	09/26/2002	2.025	9.61	SBUFL02	09/26/2002	3.009	9.53	SBUFL03	09/26/2002	2.002	9.57
SBUFL01	09/26/2002	3.021	9.59	SBUFL02	09/26/2002	3.181	9.53	SBUFL03	09/26/2002	3.017	9.56
SBUFL01	09/26/2002	3.253	9.61	SBUFL02	01/28/2003	1.556	10.03	SBUFL03	09/26/2002	3.286	9.53
SBUFL01	01/28/2003	1.058	9.88	SBUFL02	01/28/2003	2.05	10.05	SBUFL03	01/28/2003	1.192	9.92
SBUFL01	01/28/2003	1.97	9.87	SBUFL02	01/28/2003	2.984	10.06	SBUFL03	01/28/2003	2.041	9.9
SBUFL01	01/28/2003	3.057	9.95	SBUFL02	01/28/2003	3.958	10.04	SBUFL03	01/28/2003	2.922	9.91
SBUFL01	01/28/2003	3.99	9.87	SBUFL02	01/28/2003	3.971	10.02	SBUFL03	01/28/2003	3.961	9.88
SBUFL01	02/27/2003	0.853	9.37	SBUFL02	02/27/2003	0.847	9.43	SBUFL03	02/27/2003	0.837	9.23
SBUFL01	02/27/2003	1.896	9.35	SBUFL02	02/27/2003	1.828	9.42	SBUFL03	02/27/2003	1.833	9.26
SBUFL01	02/27/2003	2.842	9.32	SBUFL02	02/27/2003	2.857	9.4	SBUFL03	02/27/2003	2.851	9.26
SBUFL01	02/27/2003	3.203	9.23	SBUFL02	02/27/2003	3.126	9.36	SBUFL03	02/27/2003	3.316	9.26
SBUFL01	05/28/2003	1.098	9.08	SBUFL02	05/28/2003	1.08	9.05	SBUFL03	05/28/2003	1.055	9.04
SBUFL01	05/28/2003	2.074	9.08	SBUFL02	05/28/2003	2.108	9.05	SBUFL03	05/28/2003	2.093	9.04
SBUFL01	05/28/2003	3.092	9.05	SBUFL02	05/28/2003	3.073	9.04	SBUFL03	05/28/2003	3.131	9
SBUFL01	05/28/2003	3.604	8.78	SBUFL02	05/28/2003	3.565	9.01	SBUFL03	05/28/2003	3.617	8.99

Specific Conductance

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

Specific conductance ranged from 348 to 650 µS/cm and usually did not differ between the surface and bottom measurements (Figure 5). State standards for fish and wildlife propagation and stock watering require that conductivity should not equal or exceed 7,000 µS/cm on any single day. All conductivity readings at South Buffalo Lake were less than the state standard criterion.

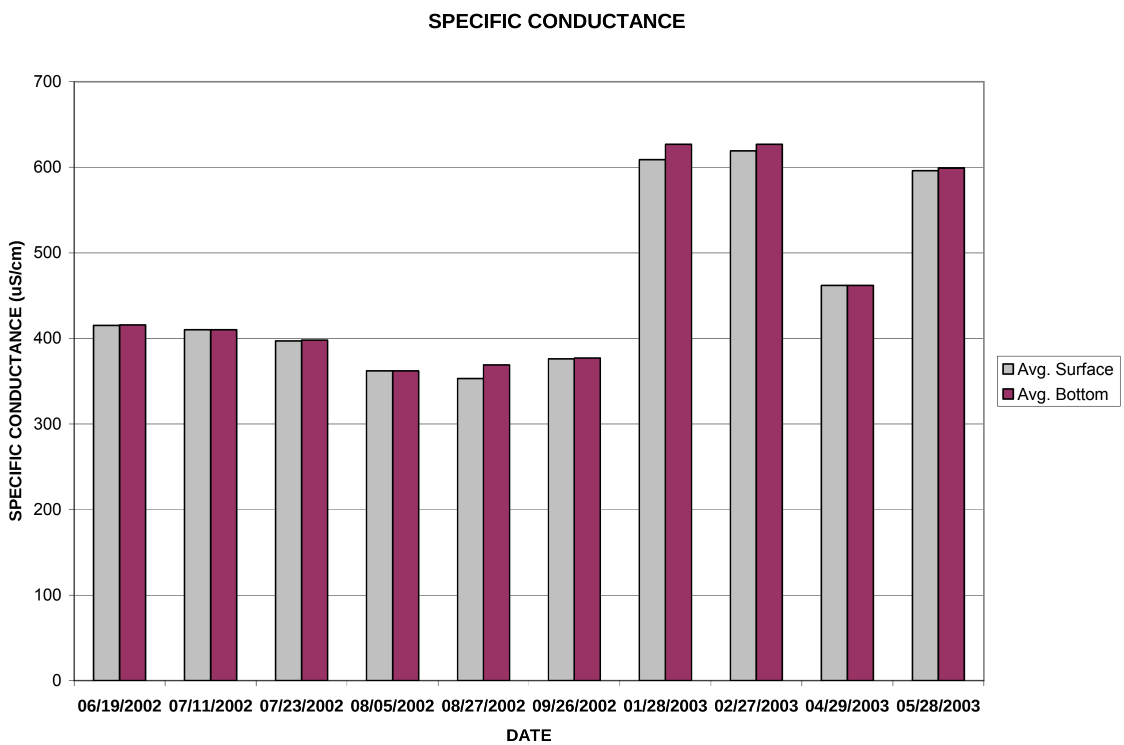


Figure 5. Average in-lake surface and bottom specific conductance for South Buffalo Lake, Marshall County, South Dakota, 2002/2003.

Secchi Depth

Secchi depth is the most commonly used method to determine water clarity. The two primary causes for low Secchi readings are suspended solids and algae. Higher Secchi readings are found in lakes that have clearer water, which is often associated with lower nutrient levels and "cleaner" water.

Secchi transparency readings in South Buffalo Lake averaged 1.09 meters with the greatest readings found during February, 2003 (Figure 6). This was probably due to an algae die-off during the winter and a settling of algae and other suspended matter to the bottom during ice cover. The mean Secchi transparency reading during the primary growing season (May 15 through September 15) was 0.89 meter, equivalent to a TSI value of 61.7. This indicates eutrophic conditions but the TSI was not considered indicative of a problem. The target growing-season median Secchi-chlorophyll a TSI is 63.4 (Lorenzen, 2005) and the Secchi TSI was below this.

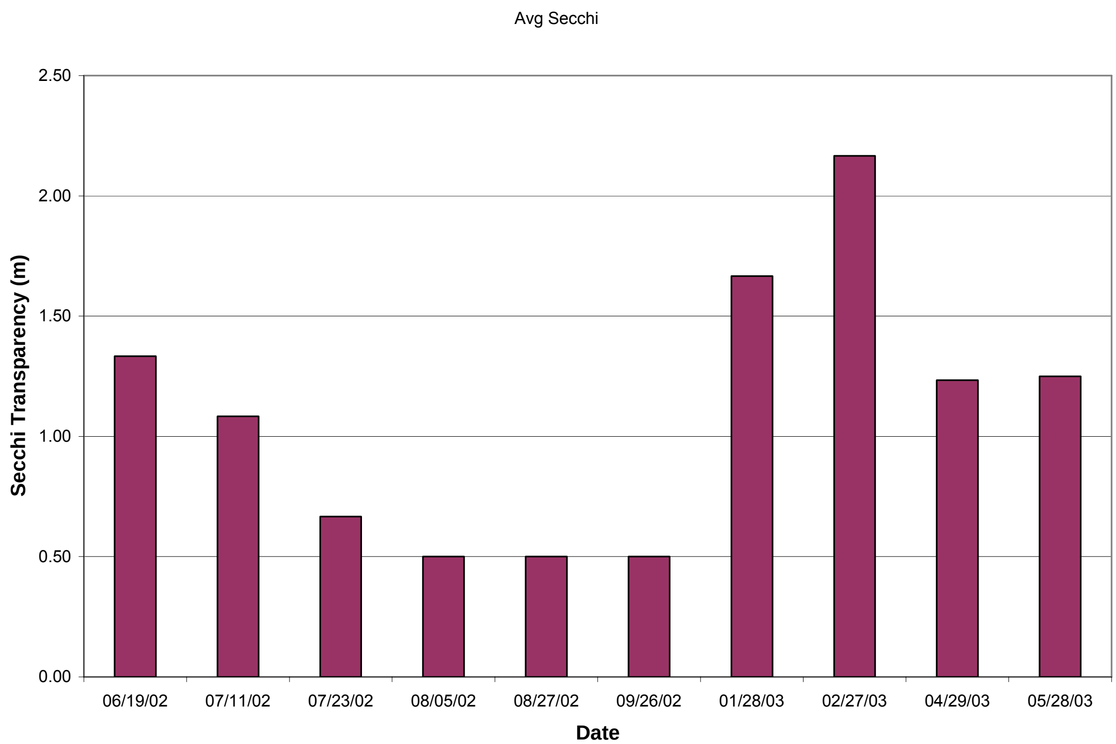


Figure 6. Average Secchi transparency for South Buffalo Lake, Marshall County, South Dakota, 2002/2003.

Alkalinity

A lake's total alkalinity affects the ability of its water 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. Total alkalinty is also used in the estimation procedure for calculating the amount of alum necessary for phosphorus precipitation.

The total alkalinity in South Buffalo Lake averaged 212 mg/l and varied from a low of 180 mg/l during August, 2002 to a peak value of 260 mg/l during February, 2003. There was little difference in total alkalinity in samples collected from the surface or the bottom (Figure 7). The total alkalinity concentrations are typical for lakes in South Dakota. The alkalinity standard criterion was never exceeded.

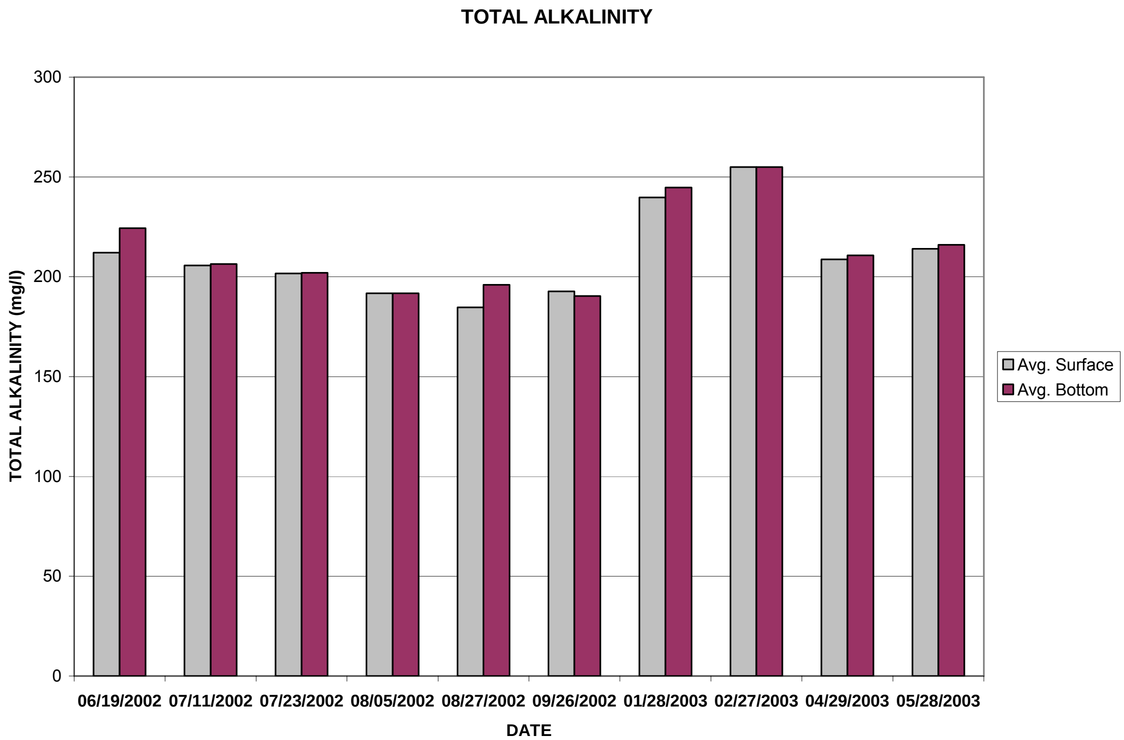


Figure 7. Average in-lake surface and bottom total alkalinity concentrations for South Buffalo Lake, Marshall County, South Dakota, 2002/2003.

<u>Solids</u>

Solids can be separated into four separate fractions; total solids, total dissolved solids (TDS), total suspended solids (TSS), and total volatile suspended solids (TVSS). 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.

South Buffalo Lake exhibited some seasonality in total solids concentrations with slightly higher values during the winter (Figure 8). This was likely due to an increase in dissolved solids rather than suspended solids because the algae had decreased substantially during this time of the year. Total solids ranged from 331 mg/l to 513 mg/l and averaged 373.2 mg/l. TSS concentrations in South Buffalo Lake exhibited similar seasonality with lower concentrations during the winter, probably a result of algae die-off (Figure 8). TSS concentrations ranged from 2 mg/l to 174 mg/l and averaged 20.44 mg/l. The maximum value may have been due to the sampling device hitting the bottom. The next highest concentration was 70 mg/l. TVSS comprised about 61% of the total suspended solids. Algae likely comprised the bulk of the organic matter in the lake.

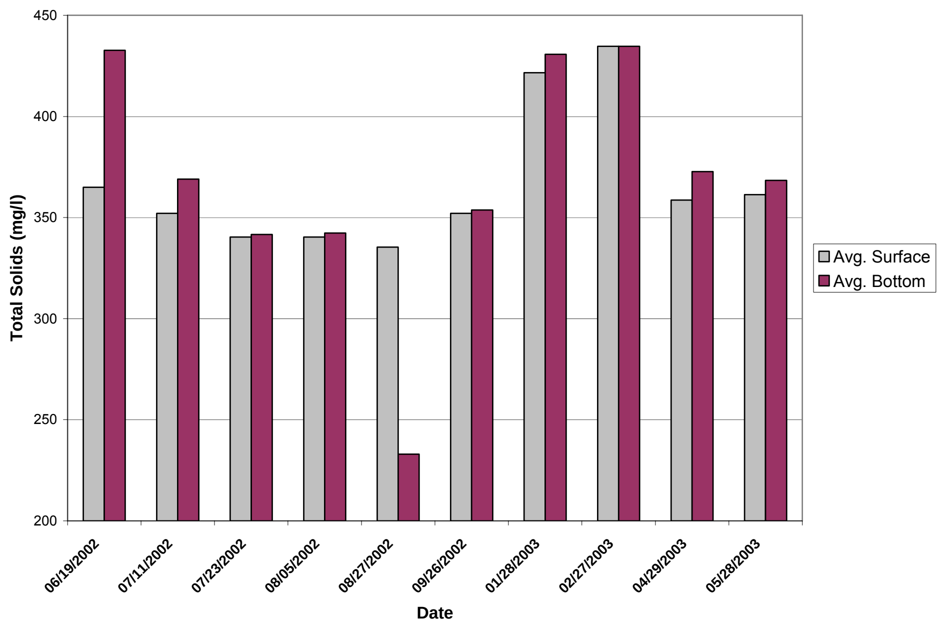


Figure 8. Average in-lake surface and bottom total solids concentrations for South Buffalo Lake, Marshall County, South Dakota, 2002/2003.

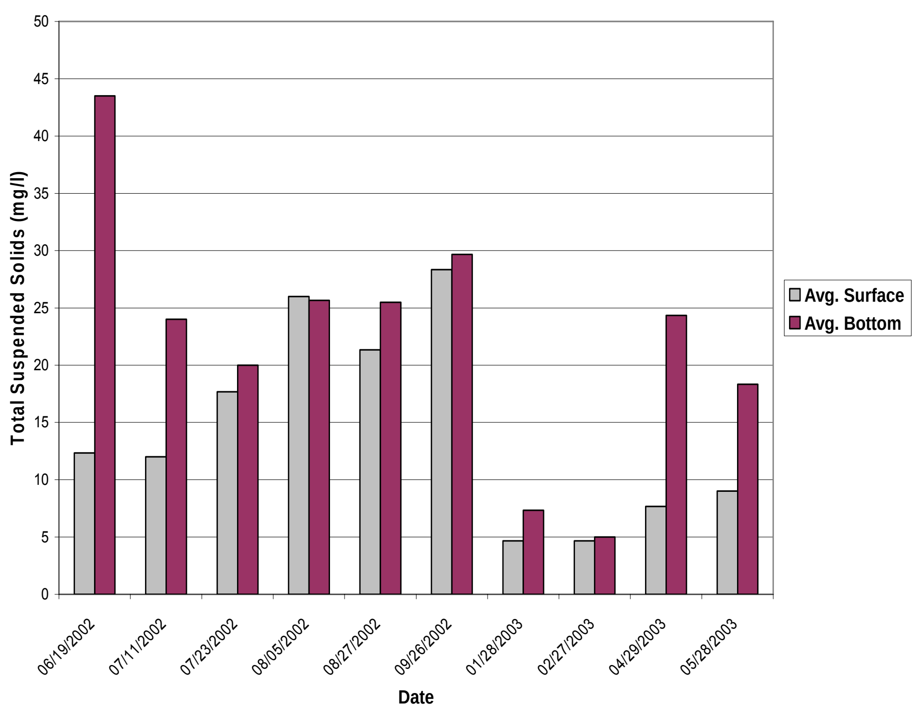


Figure 9. Average in-lake surface and bottom total suspended solids concentrations for South Buffalo Lake, Marshall County, South Dakota, 2002/2003 (one outlier removed).

Nitrogen

Nitrogen is assessed in three forms: nitrate, ammonia, and Total Kjeldahl Nitrogen (TKN). Nitrogen compounds are major cellular components of organisms. Because its availability may be less than the biological demand, environmental sources may limit productivity in freshwater ecosystems. Nitrogen is difficult to manage because it is highly soluble and very mobile. In addition, some forms of algae fix atmospheric nitrogen, adding it to the nutrient supply in the lake. Ammonia and nitrate/nitrite are the most readily available forms of nitrogen for plant growth.

All fifty-nine of the samples collected from South Buffalo Lake and analyzed for nitrates had concentrations at or below the 0.1 mg/l detection limit (see Appendix A). Ammonia concentrations were at or below the 0.02 mg/l detection limit forty-four out of fifty-nine samples (74.6% of the samples). Ammonia concentrations averaged 0.060 mg/l and ranged from below the 0.02 mg/l detection limit to 0.37 mg/l (Table 7). The median concentration was 0.02 mg/l. The water quality standard criterion for total ammonia was not exceeded in any of the samples

Total nitrogen in South Buffalo Lake averaged 1.36 mg/l and ranged from 0.83 mg/l to 1.88 mg/l. Organic nitrogen comprised about 88% of the total nitrogen. This was likely due to macrophyte debris, algae and other organic matter in the lake.

Table 7. Total ammonia concentrations (mg/l) for South Buffalo Lake, Marshall County, South Dakota during 2002/2003.

	SBUFL01 Surface	SBUFL01 Bottom	SBUFL02 Surface	SBUFL02 Bottom	SBUFL03 Surface	SBUFL03 Bottom
6/19/02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
7/11/02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02
7/23/02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
8/05/02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
8/27/02	<0.02	<0.02	<0.02	<0.02	0.07	<0.02
9/26/02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1/28/03	0.22	0.16	0.14	0.14	0.23	0.14
2/27/03	0.33	0.37	0.18	0.23	0.23	0.23
4/29/03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
5/28/03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Phosphorus

Phosphorus is one of the macronutrients required for primary production. In comparison to carbon, nitrogen, and oxygen, it is the least abundant in natural systems (Wetzel, 2000). Total phosphorus is the sum of all attached and dissolved phosphorus in the lake.

Total dissolved phosphorus is found in solution, but readily adsorbs to soil particles when they are present. Total dissolved phosphorus is more readily available to plant life.

The average in-lake total phosphorus concentration during the assessment was 0.050 mg/l. Total phosphorus concentrations greater than 0.02 mg/l are generally regarded as indicative of eutrophic conditions (USEPA, 1974) and so South Buffalo Lake could be considered eutrophic. Total phosphorus concentrations were generally highest during the latter half of the growing season (Table 8).

Table 8. Total phosphorus concentrations (mg/l) for South Buffalo Lake, Marshall County, South Dakota during 2002/2003.

Date	SBUFL01 Surface	SBUFL01 Bottom	SBUFL02 Surface	SBUFL02 Bottom	SBUFL03 Surface	SBUFL03 Bottom
6/19/02	.022	.048	.036	.038	.029	.081
7/11/02	.061	.071	.036	.037	.034	.030
7/23/02	.082	.075	.054	.044	.047	.043
8/05/02	.074	.076	.056	.056	.060	.059
8/27/02	.051		.043	.087	.040	.058
9/26/02	.067	.065	.071	.063	.057	.058
1/28/03	.032	.032	.032	.029	.031	.029
2/27/03	.033	.036	.028	.029	.028	.029
4/29/03	.054	.064	.037	.044	.034	.038
5/28/03	.042	.048	.036	.035	.030	.053

Total dissolved phosphorus (TDP) in South Buffalo Lake averaged .010 mg/l and ranged from .002 to .042 mg/l (Table 9). TDP comprised about 29% of the total phosphorus and did not exhibit much seasonality.

Table 9. Total dissolved phosphorus concentrations (mg/l) for South Buffalo Lake, Marshall County, South Dakota during 2002/2003.

Date	SBUFL01 Surface	SBUFL01 Bottom	SBUFL02 Surface	SBUFL02 Bottom	SBUFL03 Surface	SBUFL03 Bottom
6/19/02	.012	.010	.011	.011	.011	.011
7/11/02	.011	.010	.010	.009	.010	.010
7/23/02	.014	.012	.009	.010	.008	.008
8/05/02	.008	.008	.010	.008	.008	.008
8/27/02	.009		.008	.008	.007	.009
9/26/02	.011	.011	<.002	.011	.009	.010
1/28/03	.019	.015	.011	.010	.016	.012
2/27/03	.026	.026	.011	.011	.016	.015
4/29/03	.015	.009	.007	.009	.009	.008
5/28/03	.013	.014	.042	.011	.016	.010

Fecal Coliform Bacteria

South Buffalo Lake is listed for the beneficial use of immersion recreation which requires that no single sample exceed 400 colonies/100ml or the 30-day geometric mean (consisting of at least 5 samples) not exceed 200 colonies/100ml. No exceedences of the state standard criterion were observed during the project. Samples collected and analyzed by the State Health Lab for fecal coliform were consistently at or below the detection limit of 10 colonies per 100 ml (see Appendix A).

Limiting Nutrients

Two primary nutrients are required for cellular growth in organisms, phosphorus and nitrogen. 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.

The average total nitrogen (TN) to total phosphorus (TP) ratio for the water samples collected from South Buffalo Lake was 31.94 with a range of 12.35 to 84.91 (Appendix A). All of the TN:TP ratios calculated for the lake were greater than 10 and indicated phosphorus limitation. There was little seasonality to the TN:TP ratios.

Chlorophyll *a*

The data indicated relatively low concentrations throughout the project. (Table 10). Chlorophyll *a* concentrations in South Dakota lakes are often as high as 100 µg/l, but in South Buffalo Lake, the growing-season chlorophyll *a* concentration only averaged 10.34 µg/l. This level indicates moderately eutrophic conditions (USEPA, 1974). Chlorophyll *a* concentrations were greatest during the summer months. The growing season chlorophyll *a* concentrations correlated fairly well with in-lake total phosphorus concentrations (Figure 10).

Table 10. Chlorophyll *a* concentrations (µg/l) for South Buffalo Lake, Marshall County, South Dakota during 2002/2003.

Date	SBUFL01 (µg/l)	SBUFL02 (µg/l)	SBUFL03 (µg/l)
6/19/02		8.01	5.21
7/11/02	7.91	8.11	6.61
7/23/02	18.72	14.12	11.51
8/05/02	20.13	13.12	10.31
8/27/02		13.42	14.82
9/26/02	17.82	12.82	16.62
1/28/03			
2/27/03	1.80	4.11	2.10
4/29/03	4.71	1.80	3.70
5/28/03	5.21	4.41	3.80

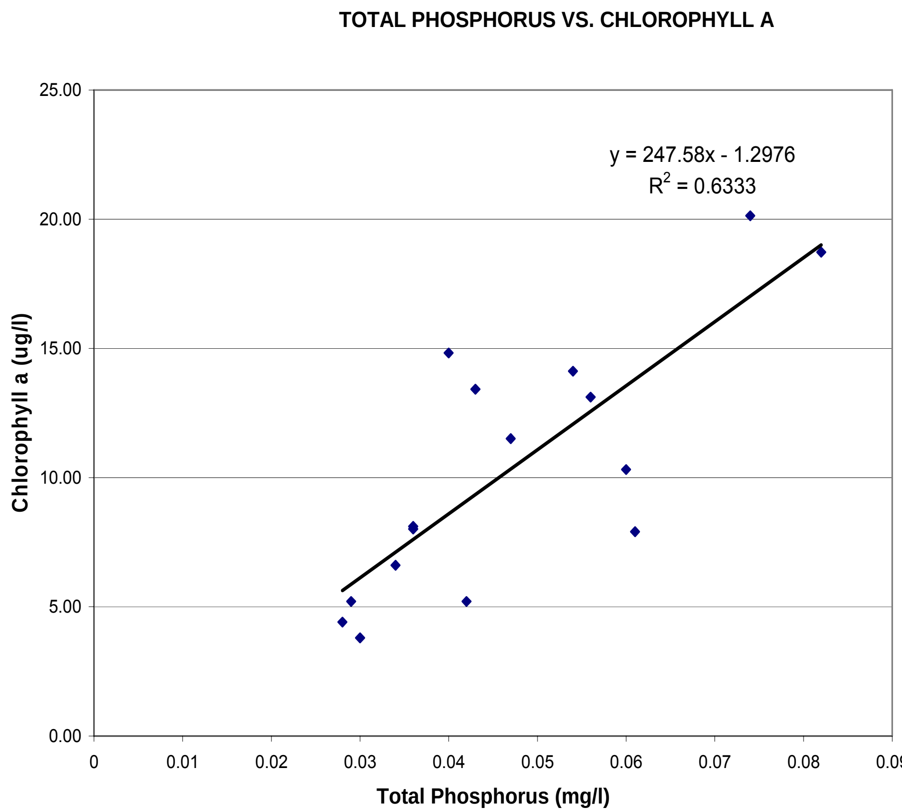


Figure 10. Regression between growing-season total phosphorus and chlorophyll *a* in South Buffalo Lake, 2002/2003.

Trophic State

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

Lakes with TSI values less than 35 are generally considered to be oligotrophic and contain very small amounts of nutrients, little plant life, and are generally very clear. Lakes that have a score of 35 to 50 are considered mesotrophic and have more nutrients and primary production than oligotrophic lakes (Table 11). Eutrophic lakes have a score between 50 and 65 and are subject to algal blooms and have large amounts of primary production. Hyper-eutrophic lakes receive scores greater than 65 and are subject to frequent and massive blooms of algae that severely impair their beneficial use and aesthetic beauty.

During the study the average growing season trophic state numerical value for South Buffalo Lake was 58.22, placing the lake in the eutrophic category. This TSI was based on total phosphorus, Secchi transparency, and chlorophyll *a*.

Table 11. Trophic state and TSI values.

TROPHIC STATE	TSI NUMERIC RANGE
OLIGOTROPHIC	0-35
MESOTROPHIC	36-50
EUTROPHIC	51-65
HYPER-EUTROPHIC	66-100

Lorenzen (2005) recognized the problems with using total phosphorus in TSIs and developed narrative standard targets based on the fish life classification of a lake. For a lake with a semi-permanent fish life propagation use, full support of the use is obtained at a median growing-season Secchi-chlorophyll *a* TSI of $\leq$63.4. The median growing-season Secchi-chlorophyll *a* TSI for South Buffalo Lake was 56.78. This indicated the lake was meeting its target TSI value.

Sediment Survey

Because it was felt that the local financial base was insufficient to support dredging in the lake, only a cursory sediment survey was conducted. During March 2003 a total of nine holes were drilled through the ice. At each hole, the water depth was recorded and a piece of rebar was pushed into the sediment as far as possible and the length of rebar from the end back to the surface ice was noted. The difference between that measurement and the water depth equals the sediment depth.

Figure 11 shows the test holes and the corresponding water and sediment depths. Water depth averaged 10.8 feet (3.29 meters) with a maximum depth of 15.0 feet (4.57 meters). The sediment depths ranged from 0 to 8.5 feet (2.59 meters) with an average sediment depth of 3.4 feet (1.04 meters). The average sediment depth is not considered unusually high but lake volume could be increased, possibly up to 24%, if this sediment was removed. Dredging might remove sediment that could otherwise release nutrients into the water column, and thereby extend the life of the lake.

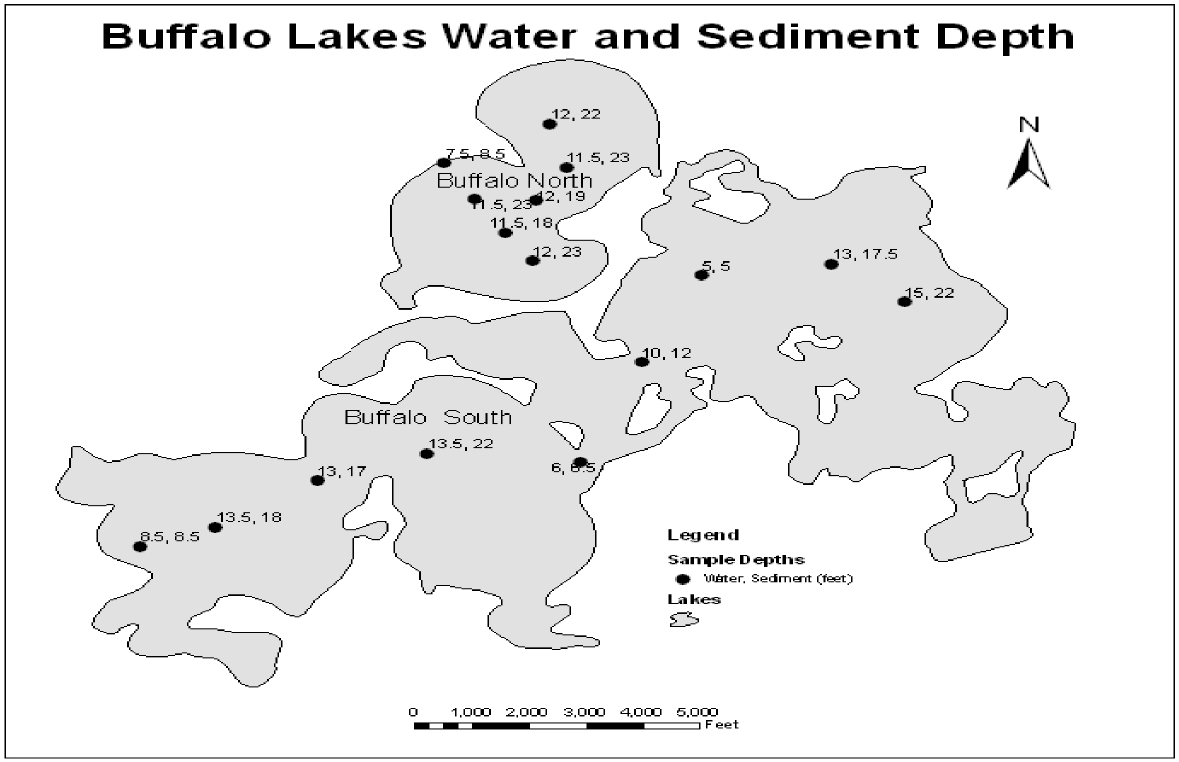


Figure 11. Water and sediment depths at test holes in South Buffalo Lake, Marshall County, South Dakota, 2003.

Macrophyte Survey

A macrophyte/shoreline condition survey was conducted during September 2003. Twenty-four locations were established approximately equidistant from each other around the perimeter of the lake. At each location, the bank stability, vegetative cover, and vegetative zone width were rated from 0 to 10 (10 being the optimal condition). Three macrophyte survey points were also established at each location with the nearest point being approximately ten feet from the shoreline and the farthest point 30-40 feet away from the shoreline. At each point, a weighted garden rake (tined portion with one foot of handle) was thrown in four directions. The relative percent recovery of plant species on the rake was noted and the relative plant density at each point was judged from the four rake pulls.

The shoreline of South Buffalo Lake was rated as being in marginal to optimal condition. The rating scores for bank stability, vegetative cover, and vegetative zone width averaged scores of 9.17, 3.50, and 2.54 respectively (with scores of 9-10 being optimal, 6-8 as suboptimal, 3-5 as marginal, and 0-2 as poor). Bank stability was optimal but some cut banks and a relatively large amount of natural rock or old rip-rap contributed to the lower score for vegetative cover and vegetative zone width.

The macrophyte survey indicated light density of emergent vegetation, cattails (*Typha* spp.) and bulrush (*Scirpus* spp.) along the lake's shoreline. The emergent vegetation was not considered a problem for the lake users. Submergent vegetation consisted of a scattered to moderate mix of coontail (*Ceratophyllum demersum*), sago pondweed (*Potamogeton pectinatus* L.), *Chara* spp., and curly leaf pondweed (*Potamogeton crispus*). Decay of this vegetation may contribute to low oxygen concentrations periodically occurring in the lake.

Long-Term Trends

Data from this report are included in Figure 12 as well as TSI values calculated during previous sampling efforts. South Buffalo Lake is listed on the state's 2006 303(d) list as an impaired water body due to TSI but the trend in median Secchi-chlorophyll a TSI shows a decreasing trend in TSI (Figure 12).

Lorenzen's (2005) TSI target for full support was a median growing season Secchi-chlorophyll *a* TSI of $\leq$ 63.4. It is clear that the recent data show a median growing-season Secchi-chlorophyll *a* TSI that meets the 63.4 target value and will improve even more if the trend continues.

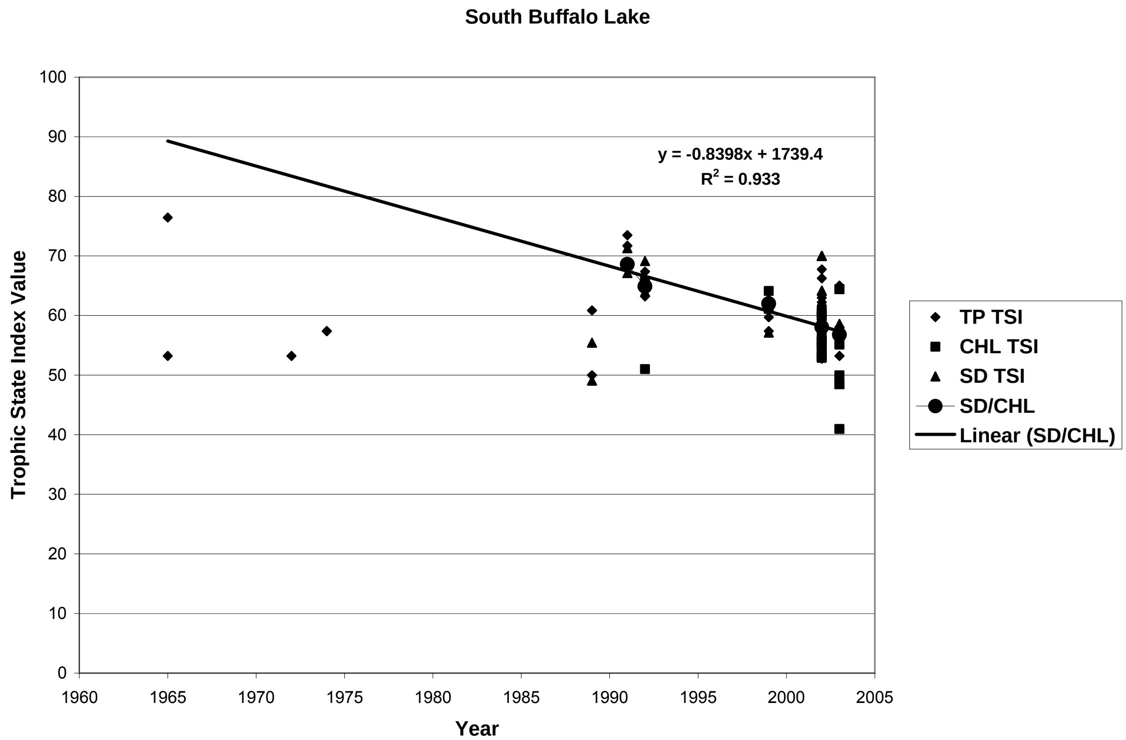


Figure 12. Growing-season total phosphorus, Secchi transparency and chlorophyll *a* trophic state indices in South Buffalo Lake, South Dakota; with trend line for median Secchi-chlorophyll TSI.

<u>OBJECTIVE 2 – Tributary Sampling</u>

Tributary Sampling Schedule, Methods, and Materials

Six tributary monitoring sites were selected for South Buffalo Lake (five tributaries and one outlet) (Figure 2). Sites SBUFT01, SBUFT03, and SBUFT06 were equipped with OTT Thalimedes type stage recorders. Sites SBUFT04 and SBUFT05 were equipped with ISCO Model 4230 stage recorders. Site SBUFT02 proved to have no connection with the lake and was discontinued. Site SBUFT01 had no flow during the study.

Water stages were monitored and recorded at each of the sites. A Marsh-McBirney Model 210D velocity meter was used to determine water velocities and cross-sectional measurements of the stream were done with a tape and measuring rod. The velocity and cross-sectional data were used to calculate stream flow. The stream stages and the calculated flows were then used to create a stage/discharge relationship for each site.

Sampling at the tributary sites began June, 2002 and continued until flows stopped. Samples were collected with the "grab" method by holding the sample bottle under the water until filled. The water samples were then prepared (filtered and/or preserved, if necessary) and packed in ice for shipping to the State Health Lab in Pierre, SD according to the "Standard Operating Procedures for Field Samplers" (Stueven, et al., 2000).

The laboratory analyzed the samples for the following parameters:

Fecal coliform bacteria
Total solids
Total suspended solids
Nitrate
Total phosphorus
E. coli
Alkalinity
Total volatile suspended solids
Ammonia
Total Kjeldahl Nitrogen (TKN)
Total dissolved phosphorus

Parameters measured in the field by sampling personnel were; water temperature, air temperature, specific conductance, dissolved oxygen, and field pH. Additional observations were noted for; precipitation, odor, presence of dead fish, wind speed, septic conditions, surface film, ice cover, and water color and depth.

Tributary Sampling Results

Fecal Coliform Bacteria

Approximately 54% of the samples had fecal coliform bacteria concentrations at or below 10 colonies/100 ml (Appendix A). Although no fecal coliform standard exists for the tributaries, five of the forty-one samples had a concentration above the 400 colonies/100 ml criterion for immersion recreation. These higher concentrations are thought to be due to livestock. The lake outlet site had fecal coliform bacteria concentrations at or close to the detection limit and indicated no bacterial contamination of the lake.

Alkalinity

Alkalinity concentrations in South Buffalo Lake tributaries ranged from 173 mg/l to 375 mg/l (Appendix A). The state standard for alkalinity is a maximum of 750 mg/l as a geometric mean or 1,313 mg/l in a single sample, which the tributary sites did not exceed in any of their samples. The mean concentrations for the sampling sites ranged from 199 to 324 mg/l. These concentrations are generally typical of water bodies in South Dakota.

Solids

Total solids ranged from 312 to 669 mg/l (Appendix A). The lake outlet site had consistently lower total solids concentrations than the tributary sites. There was no clear seasonal pattern to the concentrations. The mean total solids concentrations for the tributaries ranged from 353 to 573 mg/l. The obtained data are not unusual for streams in South Dakota.

Total suspended solids concentrations ranged from <1 to 104 mg/l and usually comprised 1% or less of the total solids. The outlet site generally had greater TSS concentrations. There is no state standard for total suspended solids that applies to the tributaries.

Nitrogen

Nitrate nitrogen and ammonia nitrogen concentrations were usually at their respective detection limits for sites SBUFT03 and SBUFT06. Sites SBUFT04 and SBUFT05 had periods of elevated concentrations of these parameters during early spring run-off and the summer but the nitrate standard criterion was not exceeded.

The total inorganic nitrogen concentrations were highest during the summer when flows had decreased and during the initial spring flush during April (Table 12). Inorganic nitrogen levels at the lake outlet were consistently at 0.12 mg/l. These low values are probably a reflection of nitrogen being used by algae in the lake. Total organic nitrogen concentrations (Table 13) averaged 82% of the total nitrogen concentration.

Table 12. Total inorganic nitrogen concentrations (mg/l) for South Buffalo Lake tributaries, Marshall County, South Dakota during 2002/2003.

	Total Inorganic Nitrogen (mg/l)			
Date	**SBUFT03**	**SBUFT04**	**SBUFT05**	**SBUFT06**
6/17/02	0.12		0.42	0.12
7/15/02		0.12	0.92	0.12
8/13/02			0.42	0.12
10/01/02			0.52	0.12
4/03/03	0.12	0.65	0.32	0.12
4/16/03	0.12	0.28	0.32	0.12
4/24/03	0.12	0.12	0.12	0.12
4/30/03	0.12	0.12	0.12	0.12
5/07/03	0.12	0.12	0.12	0.12
5/13/03	0.12	0.12	0.12	0.12
5/21/03	0.12	0.12	0.12	0.40
5/29/03	0.12	0.12	0.12	0.12
Mean	0.12	0.20	0.30	0.14

Table 13. Total organic nitrogen concentrations (mg/l) for South Buffalo Lake tributaries, Marshall County, South Dakota during 2002/2003.

	Total Organic Nitrogen (mg/l)			
Date	**SBUFT03**	**SBUFT04**	**SBUFT05**	**SBUFT06**
6/17/02	0.96		0.57	1.04
7/15/02		1.05	0.34	1.26
8/13/02			0.47	0.8
10/01/02			0.43	1.07
4/03/03	0.42	1.6	0.94	0.93
4/16/03	0.81	1.39	1.09	1.27
4/24/03	0.52	0.99	0.51	1.14
4/30/03	0.55	1.36	0.45	1.11
5/07/03	0.88	0.97	0.95	1.12
5/13/03	0.56	0.94	0.8	1.32
5/21/03	0.58	0.89	0.69	0.84
5/29/03	0.96	1.3	0.59	1.26
Mean	0.66	1.17	0.65	1.10

<u>Phosphorus</u>

The total phosphorus concentrations in the tributaries ranged from 0.029 to 0.20 mg/l and averaged 0.047 to 0.106 mg/l (Table 14). Total dissolved phosphorus (Appendix A) averaged 29% of the total phosphorus in the incoming tributaries.

Table 14. Total phosphorus concentrations (mg/l) for South Buffalo Lake tributaries, Marshall County, South Dakota during 2002/2003.

	Total Phosphorus (mg/l)			
Date	**SBUFT03**	**SBUFT04**	**SBUFT05**	**SBUFT06**
6/17/02	0.054		0.2	0.037
7/15/02		0.104	0.084	0.056
8/13/02			0.062	0.045
10/01/02			0.092	0.04
4/03/03	0.069	0.174	0.061	0.062
4/16/03	0.099	0.23	0.155	0.079
4/24/03	0.041	0.1	0.049	0.043
4/30/03	0.044	0.098	0.048	0.041
5/07/03	0.038	0.067	0.073	0.038
5/13/03	0.036	0.043	0.037	0.053
5/21/03	0.036	0.051	0.051	0.029
5/29/03	0.069	0.09	0.054	0.046
Mean	0.052	0.106	0.081	0.047

Tributary flows and phosphorus loading using the BATHTUB model

Tributary flows were calculated from regression equations established between the stages and the measured flows at each tributary. The r^2 value of the regression equation for Site SBUFT03 was only .09 so clearly the stage recorder was either located in a bad spot or the instrument was not working properly. Rather than use the regression to calculate the flows for Site SBUFT03, the measured flows (based on velocity readings and cross-sectional measurements) were used to represent the daily flows for each time interval during the study and an annual flow was estimated (Scheider, et al., 1979).

Table 15 exhibits the total inflows and outflow calculated for South Buffalo Lake during 2002/2003. Atmospheric data came from a South Dakota State University database (http://climate.sdstate.edu/climate_site/climate.htn) where the precipitation data were collected from Britton, South Dakota. The precipitation total for the study period compared favorably with the long term average precipitation (20.13" vs. 20.68") so these data are considered representative of annual precipitation. The Britton evaporation data were not available and so evaporation was based on the Brookings evaporation:precipitation ratio. Detailed information on the calculation of flow data can be obtained from DENR upon request.

The spring months of April through June comprised most of the total measured inflow. This is typical of South Dakota where water inflows (and nutrient and sediment loadings) peak during the spring and early summer.

Table 15. Monthly total water inflows/outflows (acre-feet) for South Buffalo Lake, Marshall County, South Dakota, 2002/2003.

Month/Year	SBUFT 03 inflow	SBUFT04 inflow	SBUFT05 inflow	Avg. Ann. Ppt.	SBUFT06 outflow	Avg. Ann. Evap.
½June, 2002	3.50	73.33	21.84	5.758	290.05	
July 2002	0.13	0	4.39	82.485	257.986	
August 2002	0	0	4.76	72.615	61.29	
September 2002	0	0	0.92	13.865	0	
October 2002	0	0	0	41.830	0	
November 2002	0	0	0	1.645	0	
December 2002	0	0	0	8.225	0	
January 2003	0	0	0	3.995	0	
February 2003	0	0	0	3.760	0	
March 2003	0	0	0	4.230	0	
April 2003	28.70	64.65	79.20	71.440	0	
May 2003	18.58	224.08	126.28	91.650	0.45	
½June , 2003	0	117.12	60.54	71.558	0	
Total (Ac-ft)	**50.91**	**479.18**	**371.26**	**473.06**	**609.77**	**433.04**

The Army Corps of Engineers BATHTUB program (Walker, 1999) was used to predict Secchi depth, and concentrations of phosphorus, nitrogen, chlorophyll *a,* and the corresponding trophic state indices in South Buffalo Lake. A model was selected that most closely predicted current in-lake conditions and TSIs. These estimates are used in determining a total phosphorus TMDL for the lake.

The BATHTUB model produced good agreement between the observed and predicted total phosphorus concentration and TP TSI (Table 16). The predicted average Secchi/chlorophyll *a* TSIs were also similar (57.95 predicted vs. 57.60 observed).

The total phosphorus mass balance for South Buffalo Lake was as follows:

Precipitation	204.3 kg/yr	Advective outflow	24.9 kg/yr
Tributary inflows	102.4 kg/yr	Outflow	28.0 kg/yr
Total inflow	306.7 kg/yr	Total outflow	52.9 kg/yr
Retention	253.8 kg/yr		

Based on the BATHTUB model results, the total maximum daily load can be set at 357.9 kg/yr (0.98 kg/day). This will ensure meeting the target TSI of 63.4.

Table 16. Predicted & Observed Values Ranked Against CE Model Development Dataset.

Segment:	1 Segname 1					
	Predicted Values--->			Observed Values--->		
Variable	Mean	CV	Rank	Mean	CV	Rank
TOTAL P MG/M3	37.3	0.51	39.0%	46.3	0.34	48.5%
TOTAL N MG/M3	1224.0	0.19	62.3%	1224.0	0.19	62.3%
C.NUTRIENT MG/M3	34.4	0.44	48.2%	41.1	0.29	57.0%
CHL-A MG/M3	15.9	0.79	75.4%	10.3	0.49	55.0%
SECCHI M	1.1	0.40	52.8%	0.9	0.43	40.0%
ORGANIC N MG/M3	622.2	0.48	70.3%	1103.0	0.21	95.1%
TP-ORTHO-P MG/M3	56.3	0.49	74.6%	34.6	0.53	56.0%
ANTILOG PC-1	345.5	1.03	60.3%	416.2	0.38	65.7%
ANTILOG PC-2	10.1	0.32	80.5%	6.7	0.45	53.2%
(N - 150) / P	28.8	0.56	78.1%	23.2	0.39	67.6%
INORGANIC N / P	601.8	0.63	99.9%	10.3	3.43	14.4%
TURBIDITY 1/M	1.4	0.42	81.7%	1.4	0.42	81.7%
ZMIX * TURBIDITY	2.9	0.42	45.3%	2.9	0.42	45.3%
ZMIX / SECCHI	1.9	0.40	5.4%	2.4	0.42	11.8%
CHL-A * SECCHI	18.1	0.45	79.2%	9.2	0.65	44.2%
CHL-A / TOTAL P	0.4	0.35	89.0%	0.2	0.59	58.1%
FREQ(CHL-a>10) %	67.1	0.69	75.4%	39.9	0.76	55.0%
FREQ(CHL-a>20) %	25.0	1.62	75.4%	8.5	1.47	55.0%
FREQ(CHL-a>30) %	9.2	2.29	75.4%	2.1	1.96	55.0%
FREQ(CHL-a>40) %	3.6	2.79	75.4%	0.6	2.32	55.0%
FREQ(CHL-a>50) %	1.6	3.20	75.4%	0.2	2.62	55.0%
FREQ(CHL-a>60) %	0.7	3.53	75.4%	0.1	2.87	55.0%
CARLSON TSI-P	56.3	0.13	39.0%	59.5	0.08	48.5%
CARLSON TSI-CHLA	57.8	0.13	75.4%	53.5	0.09	55.0%
CARLSON TSI-SEC	58.1	0.10	47.2%	61.7	0.10	60.0%

OBJECTIVE 3 - Quality Assurance Reporting

Quality Assurance/ Quality Control (QA/QC) samples were collected for at least 10% of the total number of samples taken. One hundred one samples were taken from South Buffalo Lake and its tributaries. Ten sets of blanks and duplicate samples were collected during the project for QA/QC purposes (Table 17). The industrial statistic "%I" was used to assess the data precision; where precision (%I) = difference between duplicate analytical values divided by the sum of the values, multiplied by 100. Values greater than 10% were considered problematic and further investigation may be needed to correct the problem.

The field blanks were consistently at or below the detection limits of the parameters tested except for total and dissolved phosphorus. This may be due to laboratory error, contamination of the water used for the blank samples, or perhaps not rinsing the sample bottle well enough with distilled water. Because most of the blank samples were satisfactory, it is felt that no further action needed to be taken to investigate reasons for the errant data.

The duplicate samples were generally satisfactory except for total dissolved phosphorus, total suspended solids, and total volatile suspended solids; all of which had average %I values greater than 10% The total dissolved phosphorus issue may have been due to poor filtering of the sample and the high total suspended solids value may have been due to natural variation. Further investigation may be needed to resolve these issues. These data should not be used or at least used with caution.

Table 17. Field blanks and duplicates for the South Buffalo Lake assessment project.

StationID	SampleDate	Relative Depth	Type	Alka, mg/l	Fecal Col., #/100ml	E. Coli, #/100ml	NH3, mg/l	TKN, mg/l	NO3, mg/l	Diss P, mg/l	Total P, mg/l	TS, mg/l	TSS, mg/l	VSS, mg/l
MARSHALSBUFL01	04/29/2003	Surface	Blank	<6	<10	<1	0.11	<0.11	<0.1	0.007	0.006	<7	<1	<1
MARSHALSBUFL01	04/29/2003	Surface	Sample	209	<10	<1	<0.02	0.94	<0.1	0.015	0.054	353	10	7
MARSHALSBUFL01	04/29/2003	Surface	Replicate	207	<10	<1	<0.02	0.88	<0.1	0.009	0.057	369	10	6
%I				0.48	0.00	0.00	0.00	3.30	0.00	25.00	2.70	2.22	0.00	7.69
MARSHALSBUFL01	04/29/2003	Bottom	Blank	<6			<0.02	<0.11	<0.1	0.006	0.006	<7	<1	<1
MARSHALSBUFL01	04/29/2003	Bottom	Sample	210			<0.02	1.07	<0.1	0.009	0.064	379	34	14
MARSHALSBUFL01	04/29/2003	Bottom	Replicate	206			<0.02	1.05	<0.1	0.009	0.061	365	8	6
%I				0.96			0.00	0.94	0.00	0.00	2.40	1.88	61.90	40.00
MARSHALSBUFL02	09/26/2002	Bottom	Blank	<6			<0.02	<.32	<0.1	0.193	0.003	<7	<1	<1
MARSHALSBUFL02	09/26/2002	Bottom	Sample	192			<0.02	1.34	<0.1	0.011	0.063	362	23	12
MARSHALSBUFL02	09/26/2002	Bottom	Replicate	191			<0.02	1.53	<0.1	0.009	0.06	349	26	18
%I				0.26			0.00	6.62	0.00	10.00	2.44	1.83	6.12	20.00
MARSHALSBUFL02	09/26/2002	Surface	Blank	<6	<10	<1	<0.02	<.32	<0.1	<.002	0.002	<7	<1	<1
MARSHALSBUFL02	09/26/2002	Surface	Sample	192	<10	<1	<0.02	1.41	<0.1	<.002	0.071	355	27	16
MARSHALSBUFL02	09/26/2002	Surface	Replicate	192	<10	<1	<0.02	1.53	<0.1	0.009	0.063	348	30	18
%I				0.00	0.00	0.00	0.00	4.08	0.00	63.64	5.97	1.00	5.26	5.88
MARSHALSBUFL03	06/19/2002	Surface	Sample	213	<10	<1	<0.02	1.29	<0.1	0.011	0.029	364	12	8
MARSHALSBUFL03	06/19/2002	Surface	Replicate	213	<10	<1	<0.02	0.79	<0.1	0.01	0.03	360	11	6
%I				0.00	0.00	0.00	0.00	24.04	0.00	4.76	1.69	0.55	4.35	14.29
MARSHALSBUFL03	06/19/2002	Bottom	Blank	<6			<0.02	<.32	<0.1	<0.002	<0.002	<7	<1	<1
MARSHALSBUFL03	06/19/2002	Bottom	Sample	239			<0.02	0.9	<0.1	0.011	0.081	513	174	54
MARSHALSBUFL03	06/19/2002	Bottom	Replicate	216			<0.02	0.83	<0.1	0.011	0.031	359	13	10
%I				0.67			0.00	4.05	0.00	0.00	44.64	17.66	86.10	68.75
MARSHALSBUFT03	04/03/2003		Sample	301	<10	<1	<0.02	0.44	<0.1	0.06	0.069	406	1	<1
MARSHALSBUFT03	04/03/2003		Replicate	299	<2	<1	<0.02	0.44	<0.1	0.058	0.065	399	4	2
%I				0.33	0.00	0.00	0.00	0.00	0.00	1.69	2.99	0.87	60.00	33.33
MARSHALSBUFT04	05/21/2003		Blank	<6	<10	<1	0.08	<0.11	<0.1			<7	<1	<1
MARSHALSBUFT04	05/21/2003		Sample	191	60	39.9	<0.02	0.91	<0.1	0.04	0.051	498	4	<1
MARSHALSBUFT04	05/21/2003		Replicate	192	20	52.9	<0.02	1	<0.1	0.04	0.04	519	3	1
%I				0.26	50.00	14.01	0.00	4.71	0.00	0.00	12.09	2.06	14.29	0.00
MARSHALSBUFT05	05/29/2003		Blank	<6	<10	<1	<0.02	<0.11	<0.1	<0.002	<0.002	<7	<1	<1
MARSHALSBUFT05	05/29/2003		Sample	314	370	613	<0.02	0.61	<0.1	0.024	0.054	467	8	2
MARSHALSBUFT05	05/29/2003		Replicate	312	300	328	<0.02	0.82	<0.1	0.022	0.046	473	11	3
%I				0.32	10.45	30.29	0.00	14.69	0.00	4.35	8.00	0.64	15.79	20.00
MARSHALSBUFT06	07/15/2002		Blank	<6	<10	<1	<0.02	<.32	<0.1	<0.002	<0.002	<7	<1	<1
MARSHALSBUFT06	07/15/2002		Sample	189	<10	1	<0.02	1.28	<0.1	0.011	0.056	359	22	15
MARSHALSBUFT06	07/15/2002		Replicate	192	<10	<1	<0.02	1.34	<0.1	0.011	0.056	359	23	15
%I				0.79	0.00	0.00	0.00	2.29	0.00	0.00	0.00	0.00	2.22	0.00
Average %I				0.41	8.64	6.32	0.00	6.47	0.00	10.94	8.29	2.87	25.60	20.99

OBJECTIVE 4 - 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 in nutrient and sediment loads are calculated at the outlet to the watershed.

The AnnAGNPS model was not used because the lake was already meeting its target TSI of 63.4. However, to maintain the condition of the lake the current effort to implement Best Management Practices (BMPs) through the U.S. Department of Agriculture or other cost-share programs should continue. Potential nutrient and sediment reductions in this watershed will be largely dependent on the willingness of the small number of land owners to participate in these programs

OBJECTIVE 5 - Public Participation

State Agencies

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

The South Dakota Department of Game, Fish and Parks provided information about threatened and endangered species and a copy of the latest fishery report on South Buffalo Lake.

Federal Agencies

The Environmental Protection Agency (EPA) provided the primary source of funds for the completion of the assessment on South Buffalo Lake. The Natural Resource Conservation Service (NRCS) provided technical assistance. The Farm Service Agency allowed access to historical records to obtain data for this project report.

Local Governments; Industry, Environmental, and other Groups; and General Public

The Marshall Conservation District sponsored the project, provided project accounting, and hired a consulting firm, Prairie Agricultural Research, to do the field work. Public involvement primarily consisted of monthly meetings of the Marshall Conservation District.

Table 18 shows the funding sources, the budgeted amounts from each of these sources, total expenditures, and the percentages that were utilized. In-kind match came primarily from the Marshall Conservation District (CD) for utilizing their time to manage and direct the project. The project was completed using only about 72% of the proposed budget. This was probably due to fewer samples being collected than what was proposed and a general overestimation of project costs.

Table 18. Funding sources and funds utilization for the Marshall County Lakes Assessment Project.

Organization	Amount in Budget	Spent	In-Kind	% utilized
EPA 319	165,000.00 amended to 120,000.00	79,981.22	0	67%
SDDENR	25,000.00	25,000.000	0	100%
Marshall CD	2,000.00	0	1,003.50	50%

RECOMMENDATIONS

There are a limited number of lake restoration techniques available to lake managers and the bulk of these are summarized by Cooke, et al. (1986). A number of lake restoration strategies were reviewed for their applicability to the South Buffalo Lake situation and each one is discussed below.

Lake Restoration Techniques Rejected for South Buffalo Lake

Dilution/flushing

Dilution/flushing is a technique to reduce algal biomass by introducing water of lower nutrient concentration while concurrently increasing water exchange (flushing) in the lake. This category was not considered a viable option for South Buffalo Lake because there is no source of dilution water nearby and because algae are currently not a problem.

Lake Drawdown/Harvesting

Lake drawdown is sometimes used to control aquatic macrophytes. Because South Buffalo Lake is a natural lake with no controllable outlet, this technique is not recommended at this time.

Harvesting nuisance aquatic plants has been a common lake restoration technique. This technique is not recommended because macrophytes are not a problem in the lake.

Biological Controls

Use of biological controls to control algae or aquatic macrophytes is considered experimental and is in need of additional studies to refine the technique. As such, biological controls are not recommended. Also, macrophytes were not a problem.

Surface/Sediment Covers

Various materials have been used for rooted aquatic plant control. Because macrophytes were not considered a problem in the lake, this technique is not recommended.

Hypolimnetic Withdrawal

Water can be withdrawn from the hypolimnion to remove nutrient-laden water that might otherwise be available for algal growth. Withdrawals may also be used to improve dissolved oxygen conditions in the lake by replenishing the hypolimnion with well-oxygenated epilimnetic water. This would improve conditions for aquatic life at the bottom of the lake.

Hypolimnetic withdrawal for South Buffalo Lake is not recommended at this time because there is no dam or structure where hypolimnetic water can be released

Macrophyte/Algae Control by Application of Herbicides/Algicides

Use of herbicides or algicides has been shown to be an effective means to control nuisance aquatic macrophytes and algae. These techniques are not recommended because macrophytes and algae are not a problem in the lake.

Phosphorus Inactivation and Bottom Sealing with Aluminum Sulfate

This technique is not recommended because the lake is currently meeting its TSI target and does not need extensive nutrient controls.

Sediment Removal for Nutrient/Organics Control

Sediment removal is sometimes used to remove nutrient-rich sediments that might release nutrients during anaerobic conditions. The idea is to remove enough sediment until a "new" layer of sediment is exposed that contains lower concentrations of nutrients than what was removed or that has a lower nutrient release rate. In addition, organic matter in the overlying sediment might be removed, resulting in less bacterial decomposition of organic matter and less oxygen depletion in the hypolimnion.

The lake is currently meeting its target TSI value and is not in need of extensive nutrient controls such as dredging. In addition, it is unlikely the local financial base is adequate to support a dredging project. Sediment removal for nutrient control is not recommended at this time.

Organic matter is likely decomposing at the bottom of the lake and could create oxygen deficits from time to time. Only once during the study did the dissolved oxygen concentrations from both the surface and bottom samples drop below 5.0 mg/l so it is still unclear whether organics in the sediment are producing serious oxygen deficits in the lake. Given the expense of this kind of endeavor, sediment removal for organics control is not recommended. This technique should be reconsidered if dissolved oxygen depletions become problematic and cause repeated fish kills.

Sediment Removal for Lake Longevity

One process of lake aging is the gradual sedimentation and filling of a lake. This could eventually lead to shallower depths, increased fish kills due to oxygen depletion, and other negative impacts to the lake's beneficial uses. This study determined that nearly 24% of the lake volume is occupied by sediment. Therefore, it is clear that removing sediment from a lake is an option to extend the life of the lake and maintain lake conditions related to lake depth and volume. Secondary benefits of sediment removal might be the removal of phosphorus-rich sediment that may release nutrients to the lake, and improved dissolved oxygen through the removal of organics that decompose and create oxygen deficits.

Although there are obvious positive attributes to this activity, the expense of dredging is likely prohibitive given the lack of a local financial base to support the activity.

Techniques Recommended for Consideration

Watershed conservation practices/animal waste management

The lake is currently meeting its target TSI of 63.4 and does not need extensive watershed conservation practices or animal waste management facilities (AWMFs). However, in order to maintain beneficial use support status, it is recommended that the current effort to promote and implement existing and new BMPs and AWMFs through the USDA programs or other cost-share programs continue.

In addition, nutrients, especially phosphorus, have been shown to increase eutrophication in lakes and reservoirs throughout the country increasing oxygen depletion caused by decomposition of algae and aquatic plants (Carpenter et al., 1998). Carpenter et al. (1998) and Bertram (1993) also indicate that reductions in nutrients will eventually lead to the reversal of eutrophication and attainment designated beneficial uses. Nurnberg (1995, 1995a, 1996, 1997), developed a model that quantified duration (days) and extent of lake oxygen depletion, referred to as an anoxic factor (AF). This model showed that AF is positively correlated with average annual local phosphorous (TP) concentrations. The AF may also be used to quantify response to watershed restoration measures which makes it very useful for TMDL development. Nurnberg also developed several regression models that show nutrients (P and N) control all trophic state indicators related to oxygen and phytoplankton in lakes/reservoirs. South Buffalo Lake's morphological characteristics are well within those Nurnberg used to develop regression models Nurnberg's dataset ranges were: $\bar{z}$ mean depth (m), 1.8 – 200; A_o lake surface area (hectares), 1.0 – $8.2*10^6$ and $\bar{z} / A_o^{0.5}$ (m/km^2), 0.14 – 48.1. The dataset for South Buffalo Lake were: $\bar{z}$ (m), 2.0; A_o (hectares), 114.12; and $\bar{z} / A_o^{0.5}$ (m/km^2), 0.19. This supports SDDENR conclusions that nutrients can affect dissolved oxygen concentrations in South Buffalo Lake. Thus, reduction in nutrient (phosphorus) loads to the lake will improve dissolved oxygen concentrations and overall water quality in the lake. South Dakota's approach to treat the sources of nutrients and reduce/eliminate nutrient loads to impaired waters is consistent with accepted watershed strategies to treat sources rather than symptoms (low dissolved oxygen).

However, controlling nutrient loads to South Buffalo Lake will be difficult and in-lake treatments, such as aeration, should also be considered to alleviate low DO conditions. Adding oxygen (air) to the lake will break up stratification and increase conversion of organic matter improving dissolved oxygen concentrations throughout the lake profile. Two lakes in South Dakota, Stockade Lake in Custer County and Lake Waggoner in Haakon County, have or have had aeration systems installed to break up stratification to improve water quality. The Stockade Lake aeration system was put into service in 1999 and operates only during the summer months during thermal stratification. SD GF&P monitoring results indicate aeration during the summer did not allow the lake to stratify, improving the dissolved oxygen profile and increasing fish habitat during the summer. Improved water quality, especially dissolved oxygen concentrations, has been observed in Stockade Lake in recent years based on SD GF&P monitoring data and current SD DENR statewide lake assessment data (SD GF&P, 2004, SD GF&P, 2005, SD GF&P, 2005a and SD DENR, 1996).

Waggoner Lake installed a mechanical aeration system in the mid 1990s to break up thermal stratification and improve drinking water taste. This system successfully operated during the summer months through 2002 when the City of Philip switched its drinking water source from Waggoner Lake to West River/Lyman Jones rural water.

Aeration/Circulation

Aeration and circulation are well known techniques for preventing oxygen depletion in a lake. Numerous aeration/circulation units are available and the proper sizing and use of the unit(s) must be done by someone who is knowledgeable about the particular unit. Frequent monitoring (including the winter months) for dissolved oxygen must be undertaken in order to know when to aerate and when to cease operation. Otherwise, an aeration system should be set up to continuously operate. The target dissolved oxygen concentration is 5.0 mg/l.

ASPECTS OF THE PROJECT THAT DID NOT WORK WELL

All of the objectives proposed for the project were met in an acceptable fashion and in a reasonable time frame except for the preparation of the final report. This was due to DENR personnel having other commitments.

The decision not to use the pH data would have been made easier if all of the calibration information was documented. E-mails and/or written notes concerning telephone conversations between the project officer and the project coordinator that clearly describe the calibration information and any problems with the pH probe would have provided documentation and helped initiate corrective actions when the problems arose. Project coordinators may not know what readings might be considered abnormal so it is imperative that the project officer have access to the data (and calibration information) as soon as possible so corrective measures can be initiated.

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APPENDIX A

Water Quality Data for the South Buffalo Lake Assessment

Table 19. Water quality data for South Buffalo Lake, Marshall County, South Dakota.

StationID	SampleDate	Relative Depth	Air Temp. ºC	Water Temp. ºC	DO, mg/l	pH	Secchi, m	Spec. Cond.	Chloro .a ug/l	Alka, mg/l	Fecal Col., #/100ml	E. Coli, #/100 ml	NH3, mg/l	TKN, mg/l	NO3, mg/l	TN, mg/l	Diss P, mg/l	Total P, mg/l	TS, mg/l	TDS, mg/l	TSS, mg/l	VSS, mg/l	TN:TP	CHL TSI	SEC TSI	TP TSI
SBUFL01	06/19/2002	Surface	23.33	21.6	13.03	8.71	1.50	414		210	<10	<1	<0.02	1.34	<0.1	1.44	0.012	0.022	368	355	13	10	65.45		54.15	48.74
SBUFL01	06/19/2002	Bottom	23.33	20.87	12.79	8.12		413		221			<0.02	1.18	<0.1	1.28	0.01	0.048	420	350	70	27	26.67			60.00
SBUFL01	07/11/2002	Surface	18.33	22.63	11.1	8.41	0.75	405	7.91	203	<10	3.1	<0.02	0.92	<0.1	1.02	0.011	0.061	351	334	17	9	16.72	50.86	64.15	63.46
SBUFL01	07/11/2002	Bottom	18.33	22.46	4.42	8.16		406		205			<0.02	0.93	<0.1	1.03	0.01	0.071	403	350	53	22	14.51			65.65
SBUFL01	07/23/2002	Surface	17.77	24.24	8.9	9.41	0.50	391	18.72	195	<10	<1	<0.02	1.19	<0.1	1.29	0.014	0.082	344	322	22	13	15.73	59.31	70.00	67.73
SBUFL01	07/23/2002	Bottom	17.77	24.15	7.51	9.24		391		195			<0.02	1.09	<0.1	1.19	0.012	0.075	347	324	23	13	15.87			66.44
SBUFL01	08/05/2002	Surface	20	22.26	8.15	9.45	0.50	354	20.13	185	<10	<1	<0.02	1.78	<0.1	1.88	0.008	0.074	344	315	29	21	25.41	60.02	70.00	66.25
SBUFL01	08/05/2002	Bottom	20	22.18	7.65	9.34		355		185			<0.02	1.67	<0.1	1.77	0.008	0.076	333	304	29	20	23.29			66.63
SBUFL01	08/27/2002	Surface	24.44	23.67	4.94	10.19	0.50	348		180	<10	<1	<0.02	0.95	<0.1	1.05	0.009	0.051	331	311	20	15	20.59		70.00	60.87
SBUFL01	08/27/2002	Bottom		19.36	0.81	9.81		362																		
SBUFL01	09/26/2002	Surface	7.22	12.51	7.1	9.58	0.50	374	17.82	190	<10	14.3	<0.02	1.47	<0.1	1.57	0.011	0.067	354	326	28	20	23.43	58.83	70.00	64.81
SBUFL01	09/26/2002	Bottom	7.2	12.51	6.75	9.62		374		188			<0.02	1.36	<0.1	1.46	0.011	0.065	347	311	36	22	22.46			64.37
SBUFL01	01/28/2003	Surface	-6.11	2.94	3.42	9.9	2.25	613		242	<10	<1	0.22	1.52	<0.1	1.62	0.019	0.032	425	421	4	3	50.63		48.30	54.15
SBUFL01	01/28/2003	Bottom	-6.11	4.23	2.65	9.88		645		253			0.16	1.52	<0.1	1.62	0.015	0.032	444	440	4	3	50.63			54.15
SBUFL01	02/27/2003	Surface	-9.44	3.07	6.51	9.38	2.25	628	1.80	260	<10	3.1	0.33	1.64	0.1	1.74	0.026	0.033	443	438	5	2	52.73	36.33	48.30	54.59
SBUFL01	02/27/2003	Bottom	-9.44	4.29	3.69	9.23		650		260			0.37	1.6	0.1	1.7	0.026	0.036	447	442	5	1	47.22			55.85
SBUFL01	04/29/2003	Surface	9.44	12.72	10.29	8.94	1.20	460	4.71	209	<10	<1	<0.02	0.94	<0.1	1.04	0.015	0.054	353	343	10	7	19.26	45.77	57.37	61.70
SBUFL01	04/29/2003	Bottom	9.44	12.71	10.02	8.93		460		210			<0.02	1.07	<0.1	1.17	0.009	0.064	379	345	34	14	18.28			64.15
SBUFL01	05/28/2003	Surface	21.11	17.22	7.47	9.07	1.25	595	5.21	215	<10	2	<0.02	1.12	<0.1	1.22	0.013	0.042	360	350	10	8	29.05	46.76	56.78	58.07
SBUFL01	05/28/2003	Bottom	21.11	15.87	4.9	8.68		603		214			<0.02	1.14	<0.1	1.24	0.014	0.048	367	357	10	9	25.83			60.00
SBUFL02	06/19/2002	Surface	25	21.31	12.5	8.48	1.25	414	8.01	213	<10	<1	<0.02	1.06	<0.1	1.16	0.011	0.036	363	351	12	8	32.22	50.98	56.78	55.85
SBUFL02	06/19/2002	Bottom	25	21.04	10.47	8.07		413		213			<0.02	1.15	<0.1	1.25	0.011	0.038	365	348	17	10	32.89			56.63
SBUFL02	07/11/2002	Surface	18.33	22.68	11.97	8.43	1.25	412	8.11	207	<10	<1	0.03	0.77	<0.1	0.87	0.01	0.036	356	345	11	6	24.17	51.10	56.78	55.85
SBUFL02	07/11/2002	Bottom	18.33	22.67	11.52	8.16		413		207			<0.02	0.81	<0.1	0.91	0.009	0.037	345	335	10	5	24.59			56.24
SBUFL02	07/23/2002	Surface	17.77	24.12	9.47	9.45	0.75	400	14.12	205	<10	<1	<0.02	1.06	<0.1	1.16	0.009	0.054	342	325	17	10	21.48	56.54	64.15	61.70
SBUFL02	07/23/2002	Bottom	17.77	24.02	8.18	9.27		400		206			<0.02	0.91	<0.1	1.01	0.01	0.044	340	315	25	9	22.95			58.74
SBUFL02	08/05/2002	Surface	19.44	22.15	8.02	8.93	0.50	366	13.12	195	<10	<1	<0.02	1.38	<0.1	1.48	0.01	0.056	338	316	22	17	26.43	55.82	70.00	62.22
SBUFL02	08/05/2002	Bottom	19.44	22.11	7.72	9.22		366		194			<0.02	1.67	<0.1	1.77	0.008	0.056	346	323	23	18	31.61			62.22
SBUFL02	08/27/2002	Surface	24.44	23.09	6.37	10.12	0.50	355	13.42	186	<10	1	<0.02	1.13	<0.1	1.23	0.008	0.043	339	318	21	14	28.60	56.04	70.00	58.41
SBUFL02	08/27/2002	Bottom	24.44	19.29	1.71	9.77		374		198			0.22	1.39	<0.1	1.49	0.008	0.087	362	332	30	22	17.13			68.58
SBUFL02	09/26/2002	Surface	7.2	12.33	7.4	9.43	0.50	377	12.82	192	<10	<1	<0.02	1.41	<0.1	1.51	<.002	0.071	355	328	27	16	21.27	55.59	70.00	65.65
SBUFL02	09/26/2002	Bottom	7.2	12.29	7.86	9.53		378		192			<0.02	1.34	<0.1	1.44	0.011	0.063	362	339	23	12	22.86			63.92
SBUFL02	01/28/2003	Surface	8.88	3.01	2.71	10.03	1.25	608		240	<10	<1	0.14	1.38	<0.1	1.48	0.011	0.032	422	417	5	5	46.25		56.78	54.15
SBUFL02	01/28/2003	Bottom	8.88	3.87	2.92	10.02		618		238			0.14	1.1	<0.1	1.2	0.01	0.029	424	416	8	4	41.38			52.73
SBUFL02	02/27/2003	Surface	-10	3.24	5.83	9.43	2.00	616	4.11	253	<10	12.1	0.18	1.21	0.1	1.31	0.011	0.028	435	428	7	1	46.79	44.43	50.00	52.22
SBUFL02	02/27/2003	Bottom	-10	3.81	4.79	9.36		615		254			0.23	1.26	0.1	1.36	0.011	0.029	433	429	4	<1	46.90			52.73
SBUFL02	04/29/2003	Surface	8.88	12.39	10.33	8.96	1.25	460	1.80	209	<10	<1	<0.02	0.94	<0.1	1.04	0.007	0.037	362	354	8	4	28.11	36.33	56.78	56.24
SBUFL02	04/29/2003	Bottom	8.88	12.42	10.58	8.95		460		211			<0.02	0.78	<0.1	0.88	0.009	0.044	372	342	30	11	20.00			58.74
SBUFL02	05/28/2003	Surface	21.11	16.74	6.98	9.05	1.25	596	4.41	212	<10	<1	<0.02	1.03	<0.1	1.13	0.042	0.036	367	357	10	8	31.39	45.13	56.78	55.85
SBUFL02	05/28/2003	Bottom	21.18	16.4	6.78	9.02		597		214			<0.02	1.13	<0.1	1.23	0.011	0.035	357	347	10	9	35.14			55.44

Table 19. Continued.

StationID	SampleDate	Relative Depth	Air Temp. ºC	Water Temp. ºC	DO, mg/l	pH	Secchi, m	Spec. Cond.	Chloro .a ug/l	Alka, mg/l	Fecal Col., #/100ml	E. Coli, #/100 ml	NH3, mg/l	TKN, mg/l	NO3, mg/l	TN, mg/l	Diss P, mg/l	Total P, mg/l	TS, mg/l	TDS, mg/l	TSS, mg/l	VSS, mg/l	TN:TP	CHL TSI	SEC TSI	TP TSI
SBUFL03	06/19/2002	Surface	24.44	21.11	12.29	8.39	1.25	418	5.21	213	<10	<1	<0.02	1.29	<0.1	1.39	0.011	0.029	364	352	12	8	47.93	46.76	56.78	52.73
SBUFL03	06/19/2002	Bottom	24.44	20.53	11.62	8.01		421		239			<0.02	0.9	<0.1	1	0.011	0.081	513	339	174	54	12.35			67.55
SBUFL03	07/11/2002	Surface	18.33	22.76	11.63	8.45	1.25	412	6.61	207	<10	<1	<0.02	0.79	<0.1	0.89	0.01	0.034	349	341	8	4	26.18	49.10	56.78	55.02
SBUFL03	07/11/2002	Bottom	18.33	22.77	11.15	7.88		412		207			<0.02	0.73	<0.1	0.83	0.01	0.03	359	350	9	5	27.67			53.22
SBUFL03	07/23/2002	Surface	17.77	24.38	9.22	9.19	0.75	401	11.51	205	<10	<1	<0.02	1.2	<0.1	1.3	0.008	0.047	335	321	14	9	27.66	54.54	64.15	59.70
SBUFL03	07/23/2002	Bottom	17.77	24.16	7.3	9.29		402		205			<0.02	1.33	<0.1	1.43	0.008	0.043	338	326	12	8	33.26			58.41
SBUFL03	08/05/2002	Surface	19.44	22.15	8.13	9.21	0.50	367	10.31	195			<0.02	1.08	<0.1	1.18	0.008	0.06	339	312	27	19	19.67	53.46	70.00	63.22
SBUFL03	08/05/2002	Bottom	19.44	22.18	7.89	8.95		366		196	<10	<1	<0.02	1.24	<0.1	1.34	0.008	0.059	348	323	25	16	22.71			62.98
SBUFL03	08/27/2002	Surface	24.44	23.31	6.32	10.1	0.50	355	14.82	188	<10	3	<0.02	0.96	<0.1	1.06	0.007	0.04	336	313	23	18	26.50	57.02	70.00	57.37
SBUFL03	08/27/2002	Bottom	24.44	19.32	1.26	9.75		372		194			0.07	1.42	<0.1	1.52	0.009	0.058	337	316	21	17	26.21			62.73
SBUFL03	09/26/2002	Surface	7.2	12.4	7.64	9.53	0.50	378	16.62	196	<10	1	<0.02	1.48	<0.1	1.58	0.009	0.057	347	317	30	18	27.72	58.14	70.00	62.48
SBUFL03	09/26/2002	Bottom	7.2	12.39	7.73	9.62		378		191			<0.02	1.47	<0.1	1.57	0.01	0.058	352	322	30	18	27.07			62.73
SBUFL03	01/28/2003	Surface	-8.33	3.16	3.88	9.92	1.50	606		237	<10	<1	0.23	1.31	<0.1	1.41	0.016	0.031	418	413	5	3	45.48		54.15	53.69
SBUFL03	01/28/2003	Bottom	-8.33	4.48	3.69	9.88		618		243			0.14	1.24	<0.1	1.34	0.012	0.029	424	414	10	5	46.21			52.73
SBUFL03	02/27/2003	Surface	-11.66	3.71	6.67	9.19	2.25	613	2.10	252	<10	7.4	0.23	1.63	0.1	1.73	0.016	0.028	426	424	2	2	61.79	37.85	48.30	52.22
SBUFL03	02/27/2003	Bottom	-11.66	4.13	5.73	9.26		615		251			0.23	1.5	0.1	1.6	0.015	0.029	424	418	6	1	55.17			52.73
SBUFL03	04/29/2003	Surface	7.77	12.67	9.21	8.9	1.25	466	3.70	208	<10	<1	<0.02	0.95	<0.1	1.05	0.009	0.034	361	356	5	5	30.88	43.40	56.78	55.02
SBUFL03	04/29/2003	Bottom	7.77	12.44	7.01	8.91		467		211			<0.02	0.9	<0.1	1	0.008	0.038	367	358	9	5	26.32			56.63
SBUFL03	05/28/2003	Surface	21.11	16.81	6.44	9.04	1.25	598	3.80	215	<10	<1	<0.02	1.18	<0.1	1.28	0.016	0.03	357	350	7	6	42.67	43.66	56.78	53.22
SBUFL03	05/28/2003	Bottom	21.11	16.52	6.52	8.99		598		220			<0.02	4.4	<0.1	4.5	0.01	0.053	381	346	35	15	84.91			61.43

Table 20. Water quality data for South Buffalo Lake's tributaries, Marshall County, South Dakota.

StationID	SampleDate	Relative Depth	Air Temp. ºC	Water Temp. ºC	DO, mg/l	pH	Secchi, m	Spec. Cond.	Chloro .a ug/l	Alka, mg/l	Fecal Col., #/100ml	E. Coli, #/100	NH3, mg/l	TKN, mg/l	NO3, mg/l	TN, mg/l	Diss P, mg/l	Total P, mg/l	TS, mg/l	TDS, mg/l	TSS, mg/l	VSS, mg/l	TN:TP
SBUFT03	06/17/2002		25.55	25.97	14.94	8.1		573		198	<10	56.5	<0.02	0.98	<0.1	1.08	0.022	0.054	555	554	1	<1	20.00
SBUFT03	04/03/2003		-1.66	0.28	21.74	8		607		301	<10	<1	<0.02	0.44	<0.1	0.54	0.06	0.069	406	405	1	<1	7.83
SBUFT03	04/16/2003		2.22	3.17	15	8.03		708		333	10	5.2	<0.02	0.83	0.1	0.93	0.068	0.099	574	569	5	4	9.39
SBUFT03	04/24/2003		12.77	8.48	8.6	7.79		735		323	<10	1	<0.02	0.54	<0.1	0.64	0.036	0.041	588	585	3	<1	15.61
SBUFT03	04/30/2003		9.99	7.21	10.6	7.8		958		367	<10	<1	<0.02	0.57	<0.1	0.67	0.035	0.044	598	596	2	<1	15.23
SBUFT03	05/07/2003		12.77	6.96	0.78	7.83		1027		341	<10	3.1	<0.02	0.9	<0.1	1	0.037	0.038	669		<1	<1	26.32
SBUFT03	05/13/2003		15	9.5	8.56			974		351	<10	1	<0.02	0.58	<0.1	0.68	0.034	0.036	609	603	6	3	18.89
SBUFT03	05/21/2003		15	9.31	7.48	7.67		947		375	<10	<1	<0.02	0.6	<0.1	0.7	0.031	0.036	584	583	1	<1	19.44
SBUFT04	07/15/2002		27.22	22.74	5.91	7.85		566		202	140	74.4	<0.02	1.07	<0.1	1.17	0.081	0.104	584	468	16	6	11.25
SBUFT04	04/03/2003		-2.77	0.36	18.86	7.82		572		196	4	8.5	0.55	2.15	<0.1	2.25	0.112	0.174	605	600	5	4	12.93
SBUFT04	04/16/2003		1.11	4.06	14.53	7.88		622		226	60	78.9	0.18	1057	0.1	1.67	0.181	0.23	508	497	11	10	######
SBUFT04	04/24/2003		12.22	9.34	11.72	7.89		628		206	90	93.1	<0.02	1.01	<0.1	1.11	0.079	0.1	511	509	2	<1	11.10
SBUFT04	04/30/2003		9.99	8.69	11.73	7.71		819		212	530	770	<0.02	1.38	<0.1	1.48	0.083	0.098	540	534	6	1	15.10
SBUFT04	05/07/2003		12.77	8.57	10.41	7.64		800		200	70	45.7	<0.02	0.99	<0.1	1.09	0.058	0.067	508		<1	<1	16.27
SBUFT04	05/13/2003		15	11.27	10.24			770		189	30	17.8	<0.02	0.96	<0.1	1.06	0.037	0.043	495	489	6	4	24.65
SBUFT04	05/21/2003		15	12.38	7.1	7.58		785		191	60	39.9	<0.02	0.91	<0.1	1.01	0.04	0.051	498	494	4	<1	19.80
SBUFT04	05/29/2003		22.77	17.78	7.2	7.39		781		199	30	29.2	<0.02	1.32	<0.1	1.42	0.075	0.09	538	533	5	1	15.78
SBUFT05	06/17/2002		25.55	23.78	15.47	8.19		477		281		1733	<0.02	0.59	0.4	0.99	0.042	0.2	477	373	104	21	4.95
SBUFT05	07/15/2002		25.55	20.9	19.54	7.99		503		303	490	866	0.02	0.36	0.9	1.26	0.045	0.084	438	430	8	3	15.00
SBUFT05	08/13/2002		29.44	17.43	11.52	9.29		365		265	530	687	<0.02	0.49	0.4	0.89	0.043	0.062	395	393	2	1	14.35
SBUFT05	10/01/2002		13.88		4.18	8.81		387		299	510	488	<0.02	0.45	0.5	0.95	0.038	0.092	484	463	21	5	10.33
SBUFT05	04/03/2003		-2.77	0.55	25.54	8.25		615		270	4	3.1	<0.02	0.96	0.3	1.26	0.031	0.061	326	307	19	4	20.66
SBUFT05	04/16/2003		2.22	3.98	14.14	8.15		579		269	200	205	<0.02	1.11	0.3	1.41	0.119	0.155	471	456	15	5	9.10
SBUFT05	04/24/2003		12.22	9.57	12.91	8.44		582		267	10	12.2	<0.02	0.53	<0.1	0.63	0.033	0.049	456	453	3	<1	12.86
SBUFT05	04/30/2003		9.99	8.64	14.39	8.36		789		296	280	228	<0.02	0.47	0.1	0.57	0.034	0.048	492	487	5	1	11.88
SBUFT05	05/06/2003		9.44	8.32	12.58	8.27		771		288	570	649	<0.02	0.97	<0.1	1.07	0.044	0.073	488	473	15	5	14.66
SBUFT05	05/13/2003		15	10.75	11.29			746		281	50	111	<0.02	0.82	<0.1	0.92	0.028	0.037	450	445	5	2	24.86
SBUFT05	05/21/2003		14.44	12.07	12.08	8.52		754		302	150	133	<0.02	0.71	<0.1	0.81	0.024	0.051	460	454	6	2	15.88
SBUFT05	05/29/2003		22.77	16.16	14.81	8.45		741		314	370	613	<0.02	0.61	<0.1	0.71	0.024	0.054	467	459	8	2	13.15

Table 20. Continued.

StationID	SampleDate	Relative Depth	Air Temp. ºC	Water Temp. ºC	DO, mg/l	pH	Secchi, m	Spec. Cond.	Chloro .a ug/l	Alka, mg/l	Fecal Col., #/100ml	E. Coli, #/100	NH3, mg/l	TKN, mg/l	NO3, mg/l	TN, mg/l	Diss P, mg/l	Total P, mg/l	TS, mg/l	TDS, mg/l	TSS, mg/l	VSS, mg/l	TN:TP
SBUFT06	06/17/2002		25	22.58	13.43	8.25		388		208	<10	<1	<0.02	1.06	<0.1	1.16	0.019	0.037	355	350	5	4	31.35
SBUFT06	07/15/2002		25.55	25.21	16.18	8.59		384		189	<10	1	<0.02	1.28	<0.1	1.38	0.011	0.056	359	337	22	15	24.64
SBUFT06	08/13/2002		20.55	22.3	9.89	9.75		319		173	<10	1	<0.02	0.82	<0.1	0.92	0.009	0.045	336	326	10	9	20.44
SBUFT06	10/01/2002		12.77	13.75	6.04	9.57		293		190	<10	4.1	<0.02	1.09	<0.1	1.19	0.01	0.04	344	334	10	4	29.75
SBUFT06	04/03/2003		-2.22	4.13	8.75	8.75		462		181	<10	<1	<0.02	0.95	<0.1	1.05	0.01	0.062	312	310	2	1	16.94
SBUFT06	04/16/2003		1.11	9.79	12.6	8.63		437		201	20	4.1	<0.02	1.29	<0.1	1.39	0.012	0.079	355	332	23	12	17.59
SBUFT06	04/24/2003		11.66	10.52	11.92	8.86		452		203	<10	1	<0.02	1.16	<0.1	1.26	0.017	0.043	353	347	6	2	29.30
SBUFT06	04/30/2003		9.99	12.12	10.29	8.73		582		205	<10	1	<0.02	1.13	<0.1	1.23	0.015	0.041	356	349	7	2	30.00
SBUFT06	05/06/2003		9.44	11.02	11.53	8.66		588		208	<10	1	<0.02	1.14	<0.1	1.24	0.01	0.038	346	335	11	6	32.63
SBUFT06	05/13/2003		14.44	12.15	10.14			588		210	20	21.3	<0.02	1.34	<0.1	1.44	0.012	0.053	370	348	22	11	27.17
SBUFT06	05/21/2003		14.44	14.18	10.32	8.93		593		211	<10	15.5	0.3	1.14	<0.1	1.24	0.013	0.029	371	347	24	11	42.76
SBUFT06	05/29/2003		21.66	18.47	10.06	8.78		578		214	<10	8.5	<0.02	1.28	<0.1	1.38	0.013	0.046	375	359	16	7	30.00

Table 21. Profile data for site SBUFL01 in South Buffalo Lake, Marshall County, South Dakota.

Site	Date	Temp	SpCond	DO%	DO Conc	Depth	pH
SBUFL01	06/19/2002	21.1	0.414	146.6	13.03	0.918	8.53
SBUFL01	06/19/2002	21.05	0.414	146.2	13.01	1.922	8.27
SBUFL01	06/19/2002	20.93	0.413	145.3	12.96	2.935	8.26
SBUFL01	06/19/2002	20.89	0.413	143.3	12.79	3.232	8.13
SBUFL01	07/11/2002	22.63	0.405	128.6	11.1	1.107	8.41
SBUFL01	07/11/2002	22.62	0.406	126.4	10.91	2.134	8.26
SBUFL01	07/11/2002	22.52	0.406	125	10.81	3.102	8.23
SBUFL01	07/11/2002	22.46	0.406	51	4.42	3.646	8.16
SBUFL01	08/05/2002	22.29	0.354	93.9	8.15	1.004	9.45
SBUFL01	08/05/2002	22.23	0.355	92.3	8.02	2.002	9.31
SBUFL01	08/05/2002	22.21	0.355	91.0	7.92	2.985	9.47
SBUFL01	08/05/2002	22.19	0.355	87.9	7.65	3.501	9.22
SBUFL01	08/27/2002	23.71	0.348	58.4	4.94	1.018	10.21
SBUFL01	08/27/2002	20.2	0.355	37.9	3.43	2.007	10.06
SBUFL01	08/27/2002	19.4	0.362	10.1	0.93	3.001	9.85
SBUFL01	08/27/2002	19.36	0.362	8.8	0.81	3.313	9.81
SBUFL01	09/26/2002	12.51	0.374	66.7	7.1	1.002	9.56
SBUFL01	09/26/2002	12.5	0.374	67.4	7.18	2.025	9.61
SBUFL01	09/26/2002	12.5	0.374	66.2	7.04	3.021	9.59
SBUFL01	09/26/2002	12.51	0.374	63.4	6.75	3.253	9.61
SBUFL01	01/28/2003	2.98	0.613	25.5	3.42	1.058	9.88
SBUFL01	01/28/2003	3.42	0.618	22.6	3.01	1.97	9.87
SBUFL01	01/28/2003	3.69	0.616	21.5	2.83	3.057	9.95
SBUFL01	01/28/2003	4.24	0.645	20.4	2.65	3.99	9.87
SBUFL01	02/27/2003	3.07	0.628	48.5	6.51	0.853	9.37
SBUFL01	02/27/2003	3.4	0.628	39.9	5.3	1.896	9.35
SBUFL01	02/27/2003	3.87	0.627	36.1	4.74	2.842	9.32
SBUFL01	02/27/2003	4.22	0.65	28.4	3.69	3.203	9.23
SBUFL01	05/28/2003	17.22	0.595	77.8	7.47	1.098	9.08
SBUFL01	05/28/2003	17.15	0.594	77.5	7.46	2.074	9.08
SBUFL01	05/28/2003	16.97	0.595	65.5	6.32	3.092	9.05
SBUFL01	05/28/2003	16.14	0.603	49.9	4.9	3.604	8.78

Table 22. Profile data for site SBUFL02 in South Buffalo Lake, Marshall County, South Dakota.

Site	Date	Temp	SpCond	DO%	DO Conc	Depth	pH
SBUFL02	06/19/2002	21.28	0.414	138.8	12.29	0.935	8.31
SBUFL02	06/19/2002	21.07	0.414	135.6	12.06	1.933	8.26
SBUFL02	06/19/2002	21.05	0.413	130.6	11.62	2.319	8.07
SBUFL02	07/11/2002	22.68	0.412	134.9	11.63	1.109	8.43
SBUFL02	07/11/2002	22.68	0.412	131.8	11.36	2.086	8.34
SBUFL02	07/11/2002	22.68	0.412	131.1	11.3	3.113	8.32
SBUFL02	07/11/2002	22.67	0.413	129.3	11.15	3.576	8.16
SBUFL02	08/05/2002	22.15	0.366	93.3	8.13	0.998	8.92
SBUFL02	08/05/2002	22.13	0.366	92.9	8.10	1.986	9.34
SBUFL02	08/05/2002	22.12	0.366	92.1	8.02	2.964	9.48
SBUFL02	08/05/2002	22.12	0.366	90.5	7.89	3.537	9.42
SBUFL02	08/27/2002	23.04	0.355	73.8	6.32	1.025	10.14
SBUFL02	08/27/2002	19.98	0.364	51.6	4.69	2.012	10.02
SBUFL02	08/27/2002	19.38	0.371	25	2.3	2.998	9.84
SBUFL02	08/27/2002	19.29	0.374	13.7	1.26	3.33	9.75
SBUFL02	09/26/2002	12.34	0.377	71.5	7.64	1.01	9.49
SBUFL02	09/26/2002	12.3	0.378	73.5	7.86	2.013	9.5
SBUFL02	09/26/2002	12.29	0.378	75.2	8.04	3.009	9.53
SBUFL02	09/26/2002	12.29	0.378	72.3	7.73	3.181	9.53
SBUFL02	01/28/2003	3.03	0.608	28.9	3.88	1.556	10.03
SBUFL02	01/28/2003	3.11	0.612	29.3	3.92	2.05	10.05
SBUFL02	01/28/2003	3.14	0.611	29.6	3.97	2.984	10.06
SBUFL02	01/28/2003	3.77	0.614	29.6	3.89	3.958	10.04
SBUFL02	01/28/2003	3.83	0.618	28.1	3.69	3.971	10.02
SBUFL02	02/27/2003	3.23	0.616	50	6.67	0.847	9.43
SBUFL02	02/27/2003	3.31	0.615	47.4	6.31	1.828	9.42
SBUFL02	02/27/2003	3.72	0.612	46.1	6.07	2.857	9.4
SBUFL02	02/27/2003	3.8	0.615	43.6	5.73	3.126	9.36
SBUFL02	05/28/2003	16.74	0.596	66.4	6.44	1.08	9.05
SBUFL02	05/28/2003	16.68	0.596	70.2	6.81	2.108	9.05
SBUFL02	05/28/2003	16.61	0.596	68.7	6.68	3.073	9.04
SBUFL02	05/28/2003	16.4	0.597	66.7	6.52	3.565	9.01

Table 23. Profile data for site SBUFL03 in South Buffalo Lake, Marshall County, South Dakota.

Site	Date	Temp	SpCond	DO%	DO Conc	Depth	pH
SBUFL03	06/19/2002	21.12	0.418	140.7	12.5	0.997	8.3
SBUFL03	06/19/2002	21.06	0.418	139.3	12.39	1.934	8.19
SBUFL03	06/19/2002	20.99	0.418	138.8	12.36	2.966	8.14
SBUFL03	06/19/2002	20.51	0.421	116.4	10.47	3.572	8.02
SBUFL03	07/11/2002	22.76	0.412	139.1	11.97	1.099	8.45
SBUFL03	07/11/2002	22.78	0.412	136.6	11.75	2.104	8.42
SBUFL03	07/11/2002	22.78	0.411	137.1	11.8	3.11	7.95
SBUFL03	07/11/2002	22.77	0.412	133.9	11.52	3.57	7.88
SBUFL03	08/05/2002	22.20	0.367	92.2	8.02	0.990	9.53
SBUFL03	08/05/2002	22.16	0.366	91.3	7.95	1.988	9.29
SBUFL03	08/05/2002	22.15	0.367	90.0	7.84	2.973	9.32
SBUFL03	08/05/2002	22.14	0.366	88.7	7.72	3.660	9.28
SBUFL03	08/27/2002	23.24	0.355	74.7	6.37	1.019	10.07
SBUFL03	08/27/2002	22.92	0.356	76.4	6.56	1.998	10.11
SBUFL03	08/27/2002	19.96	0.364	57	5.18	2.985	9.97
SBUFL03	08/27/2002	19.36	0.372	18.5	1.71	3.522	9.74
SBUFL03	09/26/2002	12.41	0.378	69.4	7.4	0.999	9.57
SBUFL03	09/26/2002	12.4	0.378	72.8	7.76	2.002	9.57
SBUFL03	09/26/2002	12.39	0.378	75.6	8.06	3.017	9.56
SBUFL03	09/26/2002	12.39	0.378	73.7	7.86	3.286	9.53
SBUFL03	01/28/2003	3.14	0.606	20.2	2.71	1.192	9.92
SBUFL03	01/28/2003	3.54	0.605	20.4	2.7	2.041	9.9
SBUFL03	01/28/2003	3.91	0.606	21.2	2.78	2.922	9.91
SBUFL03	01/28/2003	4.48	0.618	22.6	2.92	3.961	9.88
SBUFL03	02/27/2003	3.73	0.613	44.2	5.83	0.837	9.23
SBUFL03	02/27/2003	3.44	0.612	40.5	5.37	1.833	9.26
SBUFL03	02/27/2003	3.68	0.609	38.4	5.07	2.851	9.26
SBUFL03	02/27/2003	3.98	0.615	36.6	4.79	3.316	9.26
SBUFL03	05/28/2003	16.77	0.598	72	6.98	1.055	9.04
SBUFL03	05/28/2003	16.77	0.598	71.8	6.96	2.093	9.04
SBUFL03	05/28/2003	16.67	0.598	70.8	6.87	3.131	9
SBUFL03	05/28/2003	16.54	0.598	69.6	6.78	3.617	8.99

Table 24. Historical pH data and averages for South Buffalo Lake, South Red Iron Lake, and North and South Buffalo Lakes, Marshall County, South Dakota.

Nine Mile			N. Buffalo			S. Buffalo			S. Red Iron		
Date	pH	Ref.	Date	pH	Ref.	Date	pH	Ref.	Date	pH	Ref.
8/25/69	8	2	7/30/65	8.5	2	10/21/64	8.3	1	10/21/64	8.6	1
6/25/70	8.3	2	7/30/65	8.6	2	2/12/65	7.4	1	2/12/65	8.2	1
1989	8.96	4	7/30/65	8.6	2	5/21/65	8.3	1	5/21/65	7.6	1
6/28/91	8.8	5	11/26/65	8.7	2	9/10/65	8.7	1	9/10/65	8.7	1
6/28/91	8.85	5	11/26/65	8.7	2	8/25/69	8.5	2	8/25/69	8.7	2
9/10/91	8.08	5	2/11/66	8.2	2	6/25/70	8.6	2	4/29/74	8.5	2
9/10/91	7.83	5	2/11/66	8	2	8/13/79	8.6	3	4/29/74	8.4	2
7/7/93	8.8	5	2/11/66	7.9	2	8/13/79	8.6	3	7/10/74	8.9	2
7/7/93	8.76	5	4/24/66	8.4	2	1989	8.89	4	7/10/74	8.8	2
8/17/93	8.3	5	4/24/66	8.4	2	6/26/91	9.2	5	9/18/74	8.9	2
8/17/93	8.23	5	4/24/66	8.4	2	6/26/91	9.25	5	9/18/74	8.9	2
6/27/00	8.65	5	8/25/69	8.5	2	9/11/91	8.7	5	4/29/74	8.5	2
6/27/00	8.65	5	6/30/98	8.6	5	9/11/91	6.5	5	4/29/74	8.4	2
6/27/00	8.63	5	6/30/98	8.67	5	8/4/92	8.74	5	7/10/74	8.8	2
6/27/00	8.66	5	6/30/98	8.68	5	8/4/92	8.74	5	7/10/74	8.7	2
6/27/00	8.63	5	6/30/98	8.64	5	9/2/92	9.02	5	9/18/74	8.9	2
6/27/00	8.64	5	6/30/98	8.59	5	9/2/92	9.01	5	9/18/74	8.9	2
6/27/00	8.64	5	6/30/98	8.63	5	6/23/99	8.77	5	8/10/79	8.6	3
6/27/00	8.63	5	6/30/98	8.65	5	6/23/99	8.78	5	8/10/79	8.6	3
6/27/00	8.63	5	6/30/98	8.68	5	6/23/99	8.78	5	1989	9.37	4
6/27/00	8.62	5	6/30/98	8.66	5	6/23/99	8.74	5	6/26/91	9.11	5
5/27/03	8.86	5	6/30/98	8.66	5	6/23/99	8.76	5	6/26/91	9.08	5
5/27/03	8.92	5	6/30/98	8.67	5	6/23/99	8.74	5	9/10/91	8.61	5
6/16/04	8.7	5	8/11/98	8.53	5	6/23/99	8.75	5	9/10/91	8.65	5
6/16/04	8.7	5	8/11/98	8.97	5	6/23/99	8.75	5	7/7/93	8.62	5
7/20/04	8.7	5	8/11/98	9.01	5	6/23/99	8.76	5	7/7/93	8.65	5
	8.58		8/11/98	8.99	5	6/23/99	8.76	5	8/17/93	8.14	5
			8/11/98	8.74	5	7/1/03	8.41	5	8/17/93	7.85	5
			8/11/98	8.33	5	7/1/03	8.41	5	6/23/99	8.75	5
			8/11/98	9	5	7/1/03	8.44	5	6/23/99	8.71	5
			8/11/98	9	5	7/1/03	8.45	5	6/23/99	8.76	5
			8/11/98	9	5	7/1/03	8.51	5	6/23/99	8.73	5
			8/11/98	8.37	5	7/1/03	8.51	5	6/23/99	8.64	5
			8/11/98	8.79	5	7/1/03	8.53	5	6/23/99	8.75	5
			8/11/98	8.98	5	7/1/03	8.54	5	6/23/99	8.79	5
			8/11/98	8.99	5	7/1/03	8.68	5	6/23/99	8.79	5
			7/2/02	8.65	5	7/1/03	8.68	5	6/23/99	8.78	5
			7/2/02	8.64	5	7/1/03	8.68	5	6/23/99	8.78	5
			7/2/02	8.63	5	7/1/03	8.63	5	6/23/99	8.78	5
			7/2/02	8.63	5	8/5/03	8.49	5	6/23/99	8.78	5
			7/2/02	8.63	5	8/5/03	8.5	5	6/23/99	8.78	5
			7/2/02	8.62	5	8/5/03	8.49	5	8/4/99	8.65	5
			7/2/02	8.62	5	8/5/03	8.47	5	8/4/99	8.64	5
			7/2/02	8.61	5	8/5/03	8.45	5	8/4/99	8.56	5
			7/2/02	8.63	5	8/5/03	8.47	5	8/4/99	8.66	5
			7/2/02	8.64	5	8/5/03	8.46	5	8/4/99	8.67	5
			7/2/02	8.63	5	8/5/03	8.44	5	8/4/99	8.66	5
			7/2/02	8.62	5	8/5/03	8.57	5	8/4/99	8.62	5
			7/2/02	8.63	5	8/5/03	8.56	5	8/4/99	8.6	5
			8/5/02	8.85	5	8/5/03	8.56	5	8/4/99	8.52	5
			8/5/02	8.86	5	8/5/03	8.53	5	8/4/99	8.61	5
			8/5/02	8.86	5	8/5/03	8.52	5	8/4/99	8.62	5
			8/5/02	8.82	5		**8.57**		8/4/99	8.63	5
			8/5/02	8.82	5				8/4/99	8.6	5
			8/5/02	8.86	5				8/4/99	8.58	5
			8/5/02	8.87	5				8/4/99	8.65	5
			8/5/02	8.86	5				8/4/99	8.65	5
			8/5/02	8.8	5				8/4/99	8.64	5
			8/5/02	8.86	5				8/4/99	8.65	5
			8/5/02	8.87	5				7/1/03	8.43	5
			8/5/02	8.87	5				7/1/03	8.41	5
			8/5/02	8.81	5				7/1/03	8.4	5
				8.68					7/1/03	8.35	5

Table 24. Continued.

Nine Mile			N. Buffalo			S. Buffalo			S. Red Iron		
Date	**pH**	**Ref.**	**Date**	**pH**	**Ref.**	**Date**	**pH**	**Ref.**	**Date**	**pH**	**Ref.**
									7/1/03	8.3	5
									7/1/03	8.24	5
									7/1/03	8.22	5
									7/1/03	8.19	5
									7/1/03	8.18	5
									7/1/03	8.16	5
									7/1/03	8.2	5
									7/1/03	8.41	5
									7/1/03	8.37	5
									7/1/03	8.34	5
									7/1/03	8.35	5
									8/5/03	8.46	5
									8/5/03	8.44	5
									8/5/03	8.44	5
									8/5/03	8.42	5
									8/5/03	8.41	5
									8/5/03	8.47	5
									8/5/03	8.47	5
									8/5/03	8.46	5
									8/5/03	8.44	5
									8/5/03	8.5	5
									8/5/03	8.51	5
									8/5/03	8.51	5
									8/5/03	8.49	5
										8.57	

References: 1 – Petri, L.R. and L. R. Larson, no date. 2 – State Lakes Preservation Committee, 1977. 3 – Koth, 1981. 4 – Stueven and Stewart, 1996. 5 – SDDENR, 1991-2003, unpublished data.

APPENDIX B

TMDL Summary for South Buffalo Lake, Marshall County, South Dakota

(HUC 10140101)

MARSHALL COUNTY, SOUTH DAKOTA

SOUTH DAKOTA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

March, 2007

South Buffalo Lake Total Maximum Daily Load

Waterbody Type:	**Lake (natural)**
State Waterbody ID:	**SD-BS-L-SOUTH_BUFFALO_01**
303(d) Listing Parameter:	**TSI trend**
Designated Uses:	**Warm water semi-permanent fish life propagation, Immersion recreation, Limited contact recreation, and Fish and Wildlife propagation, recreation and stock watering**
Size of Waterbody:	**1780 acres**
Size of Watershed :	**16,781 acres**
Water Quality Standards:	**Narrative and numeric**
Indicators:	**Median growing-season Secchi-chlorophyll *a* TSI, dissolved oxygen, pH,**
Analytical Approach:	**BATHTUB**
Location:	**HUC Code: 10140101**
Action:	**Increase dissolved oxygen to 5.0 mg/l and maintain TP loading at 357.9 kg/yr. (0.98 kg/day).**
Target:	**Median growing-season Secchi-chlorophyll *a* TSI $\leq$ 63.4 average during the growing season, pH of 9.0, dissolved oxygen of 5.0 mg/l, 357.9 kg/yr (0.98 kg/day) external TP load.**

Objective:

The purpose of this TMDL summary is to clearly document and quantify the causes of beneficial use non-support with South Buffalo Lake. In addition, it documents the concern and support by the public for studying and restoring South Buffalo Lake to full beneficial use status. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by EPA.

Introduction

South Buffalo Lake is a 1,780-acre natural lake located in Marshall County, South Dakota (Figure 1). The 1996 - 2002 South Dakota 303(d) Waterbody lists the lake for aquatic nuisance plants (algae), siltation, and nutrients. The 2006 South Dakota Integrated Report identified the lake for TMDL development because of an unsatisfactory trophic state index (TSI).

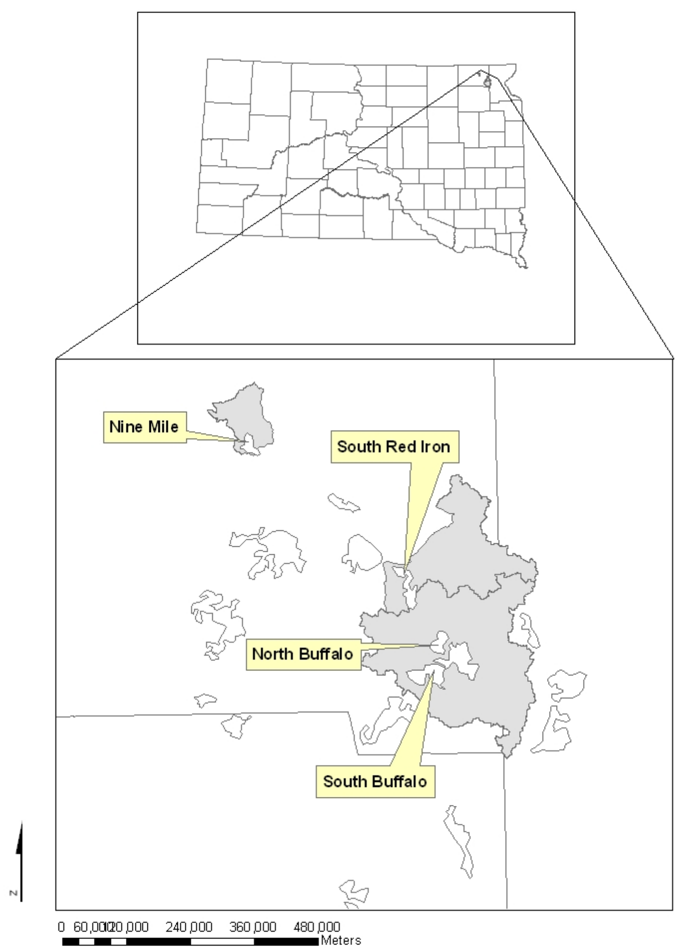


Figure 1. South Buffalo Lake watershed.

The lake has an average depth of 6 feet (1.8 meters), a maximum depth of 12 feet (3.7 meters). The lake outlet drains into North Buffalo Lake.

Problem Identification

Four tributaries flow into the lake and these drain predominantly grazing lands with some cropland acres. Bacteria decomposing organic matter on the bottom of the lake can cause occasional oxygen depletion, which may ultimately contribute to fish kills.

Description of Applicable Water Quality Standards & Numeric Water Quality Targets

South Buffalo Lake has been assigned the following beneficial uses by the state of South Dakota Surface Water Quality Standards regulations: warm water semi-permanent fish life propagation; immersion recreation; limited contact recreation; and fish and wildlife propagation, recreation and stock watering. 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.

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 entering the lake from external sources is a sign of eutrophication. South Buffalo Lake was identified as not supporting its beneficial uses in the 1996 - 2002 South Dakota 305(b) Water Quality Assessments and the 2004 and 2006 South Dakota Integrated Reports.

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.

The South Dakota Department of Environment and Natural Resources (SD DENR) also uses surrogate measures. SD DENR developed a protocol that established desired TSI levels for lakes based on a fish classification approach. To assess the trophic status of a lake, Lorenzen (2005) used the median growing season Secchi-Chlorophyll *a* TSI. This protocol was used to assess impairment and determine a numeric target for South Buffalo Lake. For South Buffalo Lake the targets are median growing season Sec-Chl *a* TSI values of $\leq$ 63.4 for full support and $\geq$ 63.5 for non-support.

During the assessment South Buffalo Lake had a median growing season (May 15 – September 15) Sec-Chl *a* TSI of 58.22, which indicated full support of its beneficial uses. To maintain the TSI target level of 63.4, an annual total phosphorus loading of 357.9 kg/yr (0.98 kg/day) is needed.

Pollutant Assessment

Point Sources

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

Nonpoint Sources/ Background Sources

The BATHTUB model predicted a total phosphorus loading rate of 357.9 kg/yr (0.98 kg/day) due to non-point and natural sources. The sediment survey of the lake did not reveal any unusual or extreme sediment accumulation in the lake, although deepening the reservoir will extend the life of the lake and remove legacy phosphorus.

Linkage Analysis

Water quality data were collected from three in-lake sites, three tributary sites and the outlet within the South Buffalo 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 at least 10% of the samples according to South Dakota's EPA approved Clean Lakes Quality Assurance/Quality Control Plan. Details concerning water sampling techniques, analysis, and quality control are addressed in the final report.

The impacts of phosphorus reductions on the condition of South Buffalo Lake were calculated using BATHTUB, an Army Corps of Engineers model. The model predicted a TP load of 357.9 kg/yr (0.98 kg/day) mg/l from the tributaries and natural sources and that this load will result in meeting the TSI target of 63.4.

The Annualized Agriculture Non-point Pollution Source (ANNAGNPS) model was not used to assess various land use scenarios and their effect of nutrient and sediment loading because the lake was already meeting its target TSI

TMDL and Allocations

Annual

0 kg/yr.	(WLA) point sources
357.9 kg/yr.	(LA) nonpoint sources + natural
Implicit	(MOS)
357.9 kg/yr.	(TMDL) target load

Daily

0 kg/day	(WLA) point sources
0.98 kg/day	(LA) nonpoint sources + natural
Implicit	(MOS)
0.98 kg/day	(TMDL) target load

Wasteload Allocations (WLAs)

There are no point sources of pollutants of concern in this watershed. Therefore, the "wasteload allocation" for this component is considered zero.

Load Allocations (LAs)

A total maximum annual phosphorus loading rate of 357.9 kg/yr (0.98 kg/day) is needed to meet the target TSI goal to maintain the lakes beneficial uses. No total phosphorus reductions are currently necessary to attain this target.

In-lake Targets

In-lake targets were established based on state water quality standards and the TSI targets developed by Lorenzen (2005).

Parameter	Target
Dissolved oxygen	5.0 mg/l
pH	9.0
Median growing-season Secchi-chlorophyll a TSI	63.4

Dissolved Oxygen

The proposed phosphorus TMDL should indirectly address the dissolved oxygen issue because nutrient loadings are likely the root cause of excess algae and the subsequent loss of dissolved oxygen through decomposition of dead algae and other organic matter. Addressing the phosphorus problem might also prevent or minimize dangerously low dissolved oxygen levels in the lake. Presumably phosphorus control will result in less algae and therefore less organic matter to decompose and less oxygen demand by bacteria. Aeration is recommended as a solution to the low DO levels.

Seasonal Variation

Different seasons of the year can yield differences in water quality due to changes in precipitation and agricultural practices. Seasonality was determined for the tributaries with the greatest flows (and nutrient and sediment loading) occurring during the spring run-off period. Seasonality in the lake was typical for a lake in south central South Dakota with summer peaks in algae. Thermal stratification did not occur but has been reported in the past. Oxygen depletion throughout the water column occurred once during the winter, probably due to decomposition of organic matter.

Margin of Safety

The margin of safety was implicit as conservative estimations were used in the development of the lake maintenance strategies. Best Management Practices are recommended to maintain the nutrient loads at levels that already result in meeting the TSI target and to improve dissolved oxygen concentrations in the lake. The recommended TMDL also provided a margin of safety by predicting in-lake Secchi and chlorophyll *a* TSIs well within the target TSI value.

Critical Conditions

The impairments to South Buffalo Lake are most severe during the summer. This is the result of warm water temperatures, peak macrophyte and algae growth, and resultant decomposition of organic matter on the bottom of the lake.

Follow-Up Monitoring

As part of the implementation effort, in-lake monitoring should be used to measure Secchi transparency, chlorophyll a levels (algae), pH, dissolved oxygen and total phosphorus concentrations. Once the implementation project is completed, the lake will be monitored as part of South Dakota's Statewide Lakes Assessment Project to see if the TMDL and full support of the beneficial uses was maintained.

Public Participation

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

1. Monthly meetings of the Marshall Conservation District.
2. Individual contact with landowners in the watershed.

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

Implementation Plan

The Day County Conservation District has initiated an implementation project for the northeast South Dakota glacial lakes. This project is intended to protect and improve the water quality of lakes in the project area by implementing best management practices. USEPA Section 319 funds are being used to assistance with the lake restoration efforts.

Lake maintenance strategies recommended for consideration include:
Best Management Practices, animal waste management systems, and aeration/circulation.

SDDENR RESPONSES TO COMMENTS RECEIVED AFTER THE PUBLIC WAS NOTIFIED OF THE FINAL ASSESSMENT REPORT

USEPA COMMENTS:

-----Original Message-----
From: Berry.Vern@epamail.epa.gov
Sent: Wednesday, July 25, 2007 5:06 PM
To: Stueven, Gene
Subject: EPA Comments on TMDLs for Geddes, Ninemile, N. Buffalo, S. Buffalo Lakes

Gene,

Thanks for the opportunity to review the Geddes Lake, Ninemile Lake, North Buffalo Lake and South Buffalo Lake Watershed Assessment Reports and TMDLs during the public notice period. The Geddes Lake TMDL, as well as all future TMDLs, need to include some daily expression of load. Please refer to the Anacostia documents attached below for guidance.

North Buffalo Lake
We reviewed the assessment report and "TMDL" for North Buffalo Lake. We do not consider this write up as an approvable TMDL for phosphorus because the waterbody is currently meeting the target TSI value, no reduction in phosphorus loading is needed, and it is currently meeting the applicable narrative WQS. The document also does not contain an approvable TMDL for dissolved oxygen because the linkage analysis (p 33-34) between TP reductions and improvement in DO concentrations is not valid because phosphorus reductions are not needed. If future data collection efforts in this lake conclude that it is impaired for TSI, DO or pH then it should be added to the 303(d) list and TMDLs can be developed at that time.

Nine Mile Lake
We reviewed the assessment report and "TMDL" for Nine Mile Lake. We do not consider this write up as an approvable TMDL for phosphorus because the waterbody is currently meeting the target TSI value, no reduction in phosphorus loading is needed, and it is currently meeting the applicable narrative WQS. The document also does not contain an approvable TMDL for dissolved oxygen because the linkage analysis (p 37-38) between TP reductions and improvement in DO concentrations is not valid because phosphorus reductions are not needed. If future data collection efforts in this lake conclude that it is impaired for TSI, DO or pH then TMDLs can be developed at that time. Alternately, if DENR is concerned that the current data is not representative of long term trends for the lake (i.e., that it will exceed the TSI target in subsequent sampling events), then historical data could be used to model what the necessary phosphorus load reductions would need to be if the TSI values were to return to that level in the future. Using this approach the a lower phosphorus load (which should be a reduction from the modeled higher

loads) could be written into the TMDL. Another alternative would be to delist Nine Mile Lake in the 2008 IR based on this new assessment data.

South Buffalo Lake
We reviewed the assessment report and "TMDL" for South Buffalo Lake. We do not consider this write up as an approvable TMDL for phosphorus because the waterbody is currently meeting the target TSI value, no reduction in phosphorus loading is needed, and it is currently meeting the applicable narrative WQS. The document also does not contain an approvable TMDL for dissolved oxygen because the linkage analysis (p 36-37) between TP reductions and improvement in DO concentrations is not valid because phosphorus reductions are not needed. If future data collection efforts in this lake conclude that it is impaired for TSI, DO or pH then TMDLs can be developed at that time. Alternately, if DENR is concerned that the current data is not representative of long term trends for the lake (i.e., that it will exceed the TSI target in subsequent sampling events), then historical data could be used to model what the necessary phosphorus load reductions would need to be if the TSI values were to return to that level in the future. Using this approach the a lower phosphorus load (which should be a reduction from the modeled higher loads) could be written into the TMDL. Another alternative would be to delist South Buffalo Lake in the 2008 IR based on this new assessment data.

(See attached file: Geddes Lake PN checklist comments.doc)

Please contact me with any questions.

Vern Berry
Environmental Engineer
US EPA Region 8
Denver, CO

SDDENR RESPONSE:

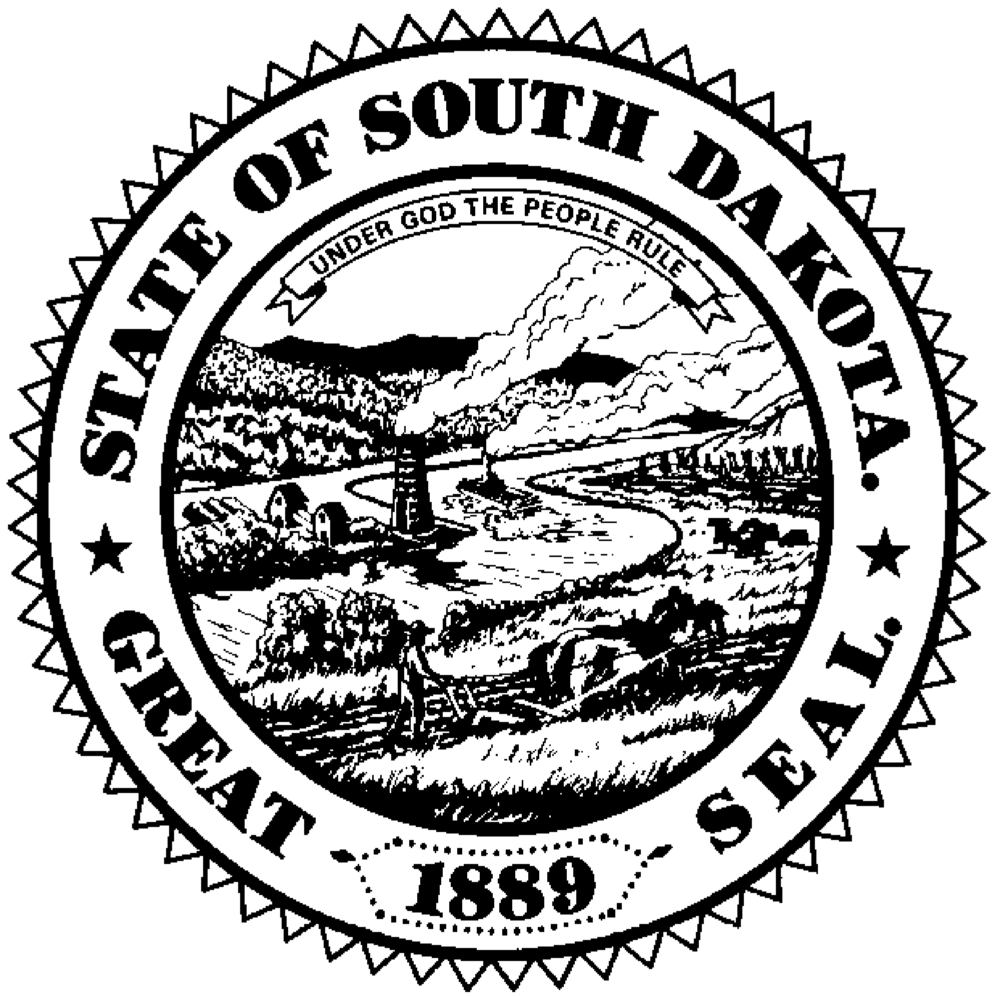
SDDENR believes that a TMDL can be established for a waterbody regardless of the waterbody's beneficial use status and a TMDL should not be limited to only those waters not fully supporting their beneficial uses. There are times when the median Secchi-chlorophyll *a* TSI target indicates full support of the waterbody's beneficial uses but is so close to the target TSI that prudence dictates establishment of a TMDL. This is especially true when previous and current data show a lake condition that wavers between full and non-support of the beneficial uses.

Such was the case with South Buffalo Lake. Previous data placed the lake on the 1996 - 2006 303(d) lists because of elevated pH and TSI but the current, detailed assessment (prompted by the listing) showed a lake meeting its pH and TSI targets. Establishment of a TMDL is critical in developing the proper level of lake/watershed <u>maintenance</u> or <u>restoration</u>.

It is also a more efficient use of funds (in this case, 319 Program funds) to establish a TMDL regardless of beneficial use status because there is no assurance that a detailed assessment will indicate beneficial use non-support. This means that there is a possibility that numerous detailed assessments may have to be done before non-support is shown and a TMDL established. SDDENR feels that doing numerous detailed assessments on a waterbody is not an efficient use of the state's resources. Indeed, this may be counter-productive because there could now be less incentive to run detailed assessments if it is known that the study will have to be re-done if non-support of the beneficial uses is not shown.

In addition, waterbodies such as those behind new or newly repaired dams could use an established TMDL (based on modeling) to direct development or land use in the watershed in a manner that would not exceed the pre-established TMDL. It is unreasonable to wait until these waterbodies are not supporting their beneficial uses before a TMDL can be established.

Finally, the USEPA has already set precedence for allowing TMDL establishment on waterbodies that were meeting their TSI targets and beneficial uses. A TMDL was approved for Lake Alice in Deuel County, South Dakota.



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