

Prepared in cooperation with the Grand Portage Band of Chippewa Indians and the Science Museum of Minnesota

# **Water Quality (2000–08) and Historical Phosphorus Concentrations from Paleolimnological Studies of Swamp and Speckled Trout Lakes, Grand Portage Reservation, Northeastern Minnesota**

Scientific Investigations Report 2010–5192

U.S. Department of the Interior  
U.S. Geological Survey

**Cover photo.** Swamp Lake, September 11, 2006. Photograph by Perry Jones, U.S. Geological Survey.

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By Victoria G. Christensen, Perry M. Jones, Mark B. Edlund, and Joy M. Ramstack

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KEN SALAZAR, Secretary

**U.S. Geological Survey**  
Marcia K. McNutt, Director

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## Conversion Factors

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
Area		
hectare (ha)	2.471	acre
square kilometer (km <sup>2</sup> )	0.3861	square mile (mi <sup>2</sup> )
square centimeter (cm <sup>2</sup> )	0.1550	square inch (in <sup>2</sup> )
Volume		
liter (L)	0.2642	gallon (gal)
Mass		
gram (g)	0.03527	ounce, avoirdupois (oz)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius ( $\mu\text{S}/\text{cm}$  at 25°C).

Concentrations of chemical constituents in water are given in milligrams per liter (mg/L) or micrograms per liter ( $\mu\text{g}/\text{L}$ ).





# Water Quality (2000–08) and Historical Phosphorus Concentrations from Paleolimnological Studies of Swamp and Speckled Trout Lakes, Grand Portage Reservation, Northeastern Minnesota

By Victoria G. Christensen<sup>1</sup>, Perry M. Jones<sup>1</sup>, Mark B. Edlund<sup>2</sup>, and Joy M. Ramstack<sup>2</sup>

## Abstract

A paleolimnological approach was taken to aid the Grand Portage Reservation, in northeastern Minnesota, in determining reference conditions for lakes on the reservation. The U.S. Geological Survey, in cooperation with the Grand Portage Band of Chippewa Indians and the Science Museum of Minnesota, conducted a study to describe water quality (2000–08) and historical total phosphorus concentrations (approximately 1781–2006) for Swamp and Speckled Trout Lakes. Results from this study may be used as a guide in establishing nutrient criteria in these and other lakes on the Grand Portage Reservation.

Historical phosphorus concentrations were inferred through paleolimnological reconstruction methods involving diatom analysis and lead-210 dating of lake-sediment cores. Historical diatom-inferred total phosphorus concentrations in Swamp Lake ranged from 0.017 to 0.025 milligrams per liter (mg/L) based on diatom assemblages in sediment samples dated 1781–2005. Historical diatom-inferred total phosphorus concentrations in Speckled Trout Lake ranged from 0.008 to 0.014 mg/L based on diatom assemblages in sediment samples dated 1825–2006. In both lakes, historical changes in diatom-inferred total phosphorus concentrations did not exceed model error estimates, indicating that there has been minimal change in total phosphorus concentrations in the two lakes over about two centuries.

Nutrient concentrations in monthly water samples collected May through October during 2000, 2002, 2004, 2006, and 2008 were compared to the diatom-inferred total phosphorus concentrations. Total phosphorus concentrations from water samples collected from Swamp Lake during 2000–08 ranged from less than 0.002 to 0.160 mg/L (median=0.023 mg/L) compared to diatom-inferred total phosphorus

concentrations of 0.018 to 0.020 mg/L for 2002 to 2005. Total phosphorus concentrations in water samples collected from Speckled Trout Lake during 2000–08 were similar to those of Swamp Lake, ranging from less than 0.002 to 0.147 mg/L (median=0.012 mg/L), whereas the diatom-inferred total phosphorus concentrations were smaller, ranging from 0.009 to 0.010 mg/L for 2003 to 2006. Differences in total phosphorus concentrations between the two lakes may be because of differences in watershed characteristics, particularly the number of wetlands in the two watersheds. Similarities between recent total phosphorus concentrations in water-quality samples and diatom-inferred total phosphorus indicate that diatom-inferred phosphorus reconstructions might be used to help establish reference conditions. Nutrient criteria for Grand Portage Reservation lakes may be established when a sampling program is designed to ensure representative phosphorus concentrations in water samples are comparable to diatom-inferred concentrations.

## Introduction

The Grand Portage Reservation, in northeastern Minnesota, established water-quality standards in 2005 and subsequently has the responsibility to derive nutrient criteria for the reservation. The U.S. Environmental Protection Agency (USEPA) has established ecoregion-specific guidance for developing and defining local nutrient criteria (U.S. Environmental Protection Agency, 2000). The development of these nutrient criteria may be based on historical information of reference conditions, local nutrient-enrichment trends, and theoretical modeling of historical and current data. In accordance with the ecoregion-specific guidance, three general approaches are available for establishing reference conditions: (1) direct observation (data collection) of sites and estimation or inference of reference conditions, (2) model-based estimation or extrapolation of reference conditions for datasets of related

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information, and (3) paleolimnological reconstruction of past conditions (U.S. Environmental Protection Agency, 2000).

Water-quality data collected by Grand Portage Reservation Environmental Department (GPR) and U.S. Geological Survey (USGS) during 1997–98 and 2003–04 indicated that nutrient concentrations in lakes on the reservation are quite low, commonly less than reporting levels (Winterstein, 2000; Jones, 2006). Most lakes on the reservation currently (2010) are not substantially affected by major sources of nutrients such as agricultural activities or wastewater discharge. Possible sources for nutrients in lakes are the bacterial and fungal decomposition of plant and animal protein (Christensen and Pope, 1997) and precipitation (Jones, 2006).

GPR personnel have chosen to undertake direct observation and the paleolimnological approach to aid in establishing reference conditions for lakes on the reservation. A paleolimnological approach establishes the historical nutrient productivity of a lake through the characterization of nutrients and the fossil remains of organisms (diatoms and chrysophytes) in lake-sediment cores. Lead-210 dating of sediments is well documented (Robbins and Edgington, 1975; Pennington and others, 1976; Oldfield and Appleby, 1984) as is paleolimnological research based on diatoms preserved in lake sediments (Round, 1964; Bradbury, 1975). Many species of diatoms are sensitive to specific water conditions and are useful bioindicators. Statistical methods are used to estimate quantitative environmental properties or constituent concentrations (for example, total phosphorus) from diatom assemblages. This approach has been used to infer historical chemical conditions in many lakes in Minnesota and other States (Dixit and others, 1992; Charles and Smol, 1994; Ramstack and others, 2003, 2004; Heiskary and others, 2004).

The paleolimnological approach was undertaken on two lake types that are common on the Grand Portage Reservation: a dystrophic (Swamp Lake) and an oligotrophic (Speckled Trout Lake, also called Trout Lake) lake. Dystrophic and oligotrophic are terms that refer to the trophic state of a lake, or the rate at which organic matter is produced or supplied to the lake. Dystrophic lakes receive large amounts of organic matter from sources in the lake's watershed, have large amounts of dissolved humic matter, have low planktonic productivity (Wetzel, 2001, p. 274), and commonly are heavily stained. Oligotrophic lakes receive few nutrients from the watershed, contain small amounts of organic matter dominantly produced in the lake, and may be stained. The amounts of organic material and dissolved organic carbon play major roles in nutrient concentrations in lakes. For example, humic material can bind nutrients, and nutrients may affect the production of dissolved organic carbon.

The U.S. Geological Survey, in cooperation with the Grand Portage Band of Chippewa Indians and the Science Museum of Minnesota, conducted a study to describe water quality (2000–08) and historical phosphorus concentrations (approximately 1781–2006) for Swamp and Speckled Trout Lakes. The purpose of the study was to aid the Grand Portage

Reservation in establishing nutrient criteria and determining reference conditions for lakes on the reservation.

### Purpose and Scope

The purpose of this report is to describe water quality and nutrient conditions in two lakes on the Grand Portage Reservation—Swamp and Speckled Trout Lakes. This report summarizes recent (2000–08) water-quality data and compares the results to historical total phosphorus concentrations (approximately 1781–2006) inferred through paleolimnological reconstruction methods based on diatom analysis of lead-210 dated lake-sediment cores.

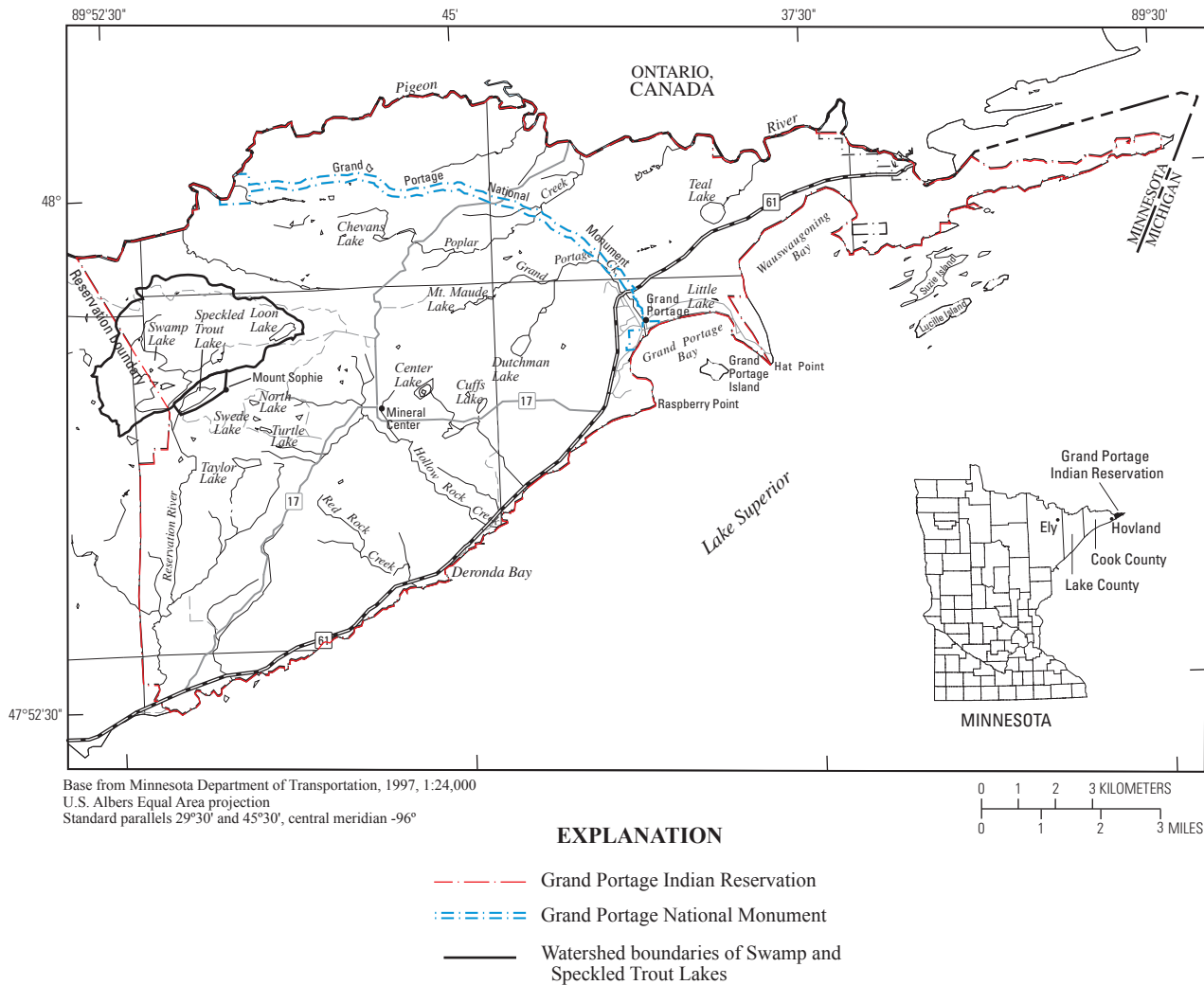
Nutrient concentrations were analyzed in water samples collected during the ice-free season in 2000–08, including nitrite plus nitrate, total Kjeldahl nitrogen, total nitrogen, and total phosphorus. Other properties and constituents analyzed in water samples included field properties (specific conductance, pH, water temperature, and dissolved-oxygen concentrations), major ions, chlorophyll *a*, pheophyton, and dissolved organic carbon. The sediment cores were collected in 2006 and dated back to 1781 for Swamp Lake and 1825 for Speckled Trout Lake. Diatom analysis on these cores was used to infer historical total phosphorus concentrations in lake water.

### Description of Study Area

The Grand Portage Reservation is located along the northwestern shore of Lake Superior in northern Cook County, Minnesota, at the boundary between Minnesota, United States, and Ontario, Canada (fig. 1). The Grand Portage Reservation covers 228 square kilometers (Goldstein, 2000) in the Northern Lakes and Forests Ecoregion (Omernik, 1987) and contains numerous hills, small valleys, streams, lakes, and wetlands within boreal and mixed hardwood forest communities (Jones, 2006). Most of the residential areas and tourist and historical attractions are located in the community of Grand Portage, along State Highway 61, and along State Highway 17 (Ruhl, 1995). Swamp and Speckled Trout Lakes are in the western part of the reservation, near the reservation boundary (fig. 1).

The reservation was almost entirely logged during the late 1800s and early 1900s (Winterstein, 2002). The northeast shore of Swamp Lake was logged in 1958 (Edlund and others, 2007). Some areas of the reservation continue to be logged (Goldstein, 2000); however, most of the forest on the reservation is undisturbed second growth (Winterstein, 2002).

Climate on the reservation is continental and locally affected by Lake Superior, with cold winters and warm summers (Jones, 2006). The mean temperature in August is about 16.7 degrees Celsius (°C), whereas the mean temperature in January is about -12°C (High Plains Regional Climate Center, 2009). Mean annual precipitation is about 72.5 centimeters (cm; High Plains Regional Climate Center, 2009).



**Figure 1.** Location of watershed boundaries of Swamp and Speckled Trout Lakes, Grand Portage Reservation, northeastern Minnesota.

The topography and hydrology of the Grand Portage Reservation are affected by bedrock geology, which is described in detail in Jones (2006). Poorly sorted glacial till and lake clay of Pleistocene age cover much of the bedrock of the reservation. These glacial deposits are thin, generally less than 19 meters (m) thick (Winterstein, 2002). The glacial till is part of ground and end moraines deposited during advances and subsequent wasting of ice sheets that moved southwesterly and westerly out of what is now Lake Superior (Wright, 1972). Post-glacial deposits (including alluvium, beach deposits, and peat) also overlie bedrock of the reservation (Jones, 2006).

The land surface of the reservation rises from Lake Superior in the southeast to highlands in the center of the reservation and then declines near the Pigeon River in the north (fig. 1). Land-surface altitudes range from about 183 m at the shore of Lake Superior to about 553 m at Mount Sophie (Jones, 2006). Large changes in altitude occur along diabase dikes and gabbro intrusions that cross the reservation (Jones, 2006).

In general, rivers and streams in the southeastern part of the reservation flow toward Lake Superior, whereas rivers and streams in the northeastern part flow toward the Pigeon River (fig. 1). The courses of rivers and streams are affected by the diabase dikes, with rivers and streams crossing the dikes along fault and fracture zones (Winterstein, 2002). Numerous lakes and wetlands are present, with the lakes lying mainly between the diabase dikes.

Surface water is used for most public water supplies, whereas groundwater is used for domestic water supplies (Jones, 2006). Much of the groundwater on the reservation is rich in calcium, sodium, and chloride and too saline to be used for water supplies (Olcott and others, 1978; Winterstein, 2002). Throughout the reservation, springs also are used by individuals whose wells are completed in (or sealed off in) deep fractured bedrock aquifers that contain unusable saline iron-rich water (Jones, 2006). Beaver activity is common, affecting the local hydrology. Swamp Lake has numerous

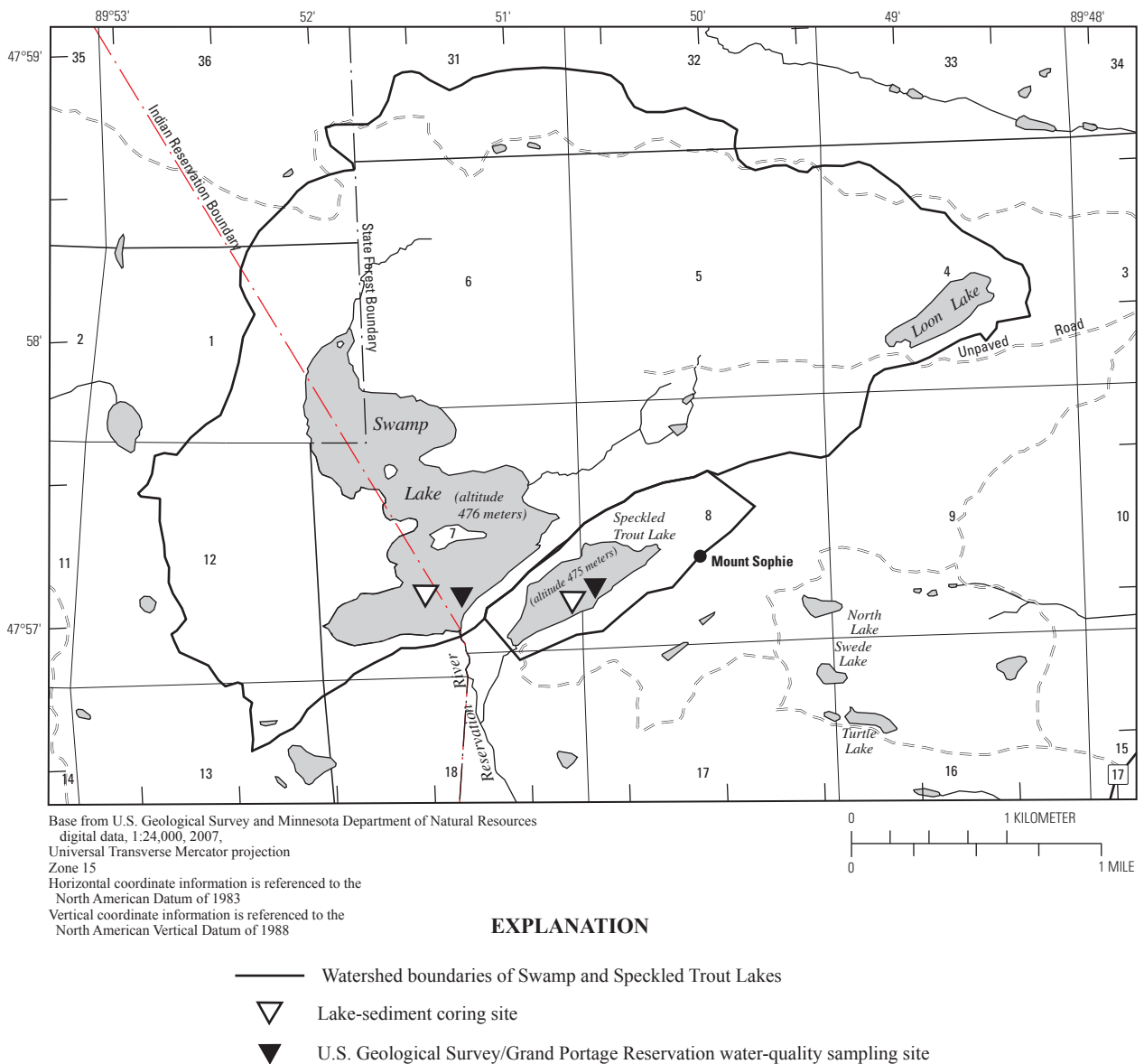
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beaver lodges in small bays and inlets. Speckled Trout Lake has no in-lake lodges, but has a few lodges in the surrounding wetlands and inlets (Margaret Watkins, Grand Portage Band of Chippewa, written commun., 2009).

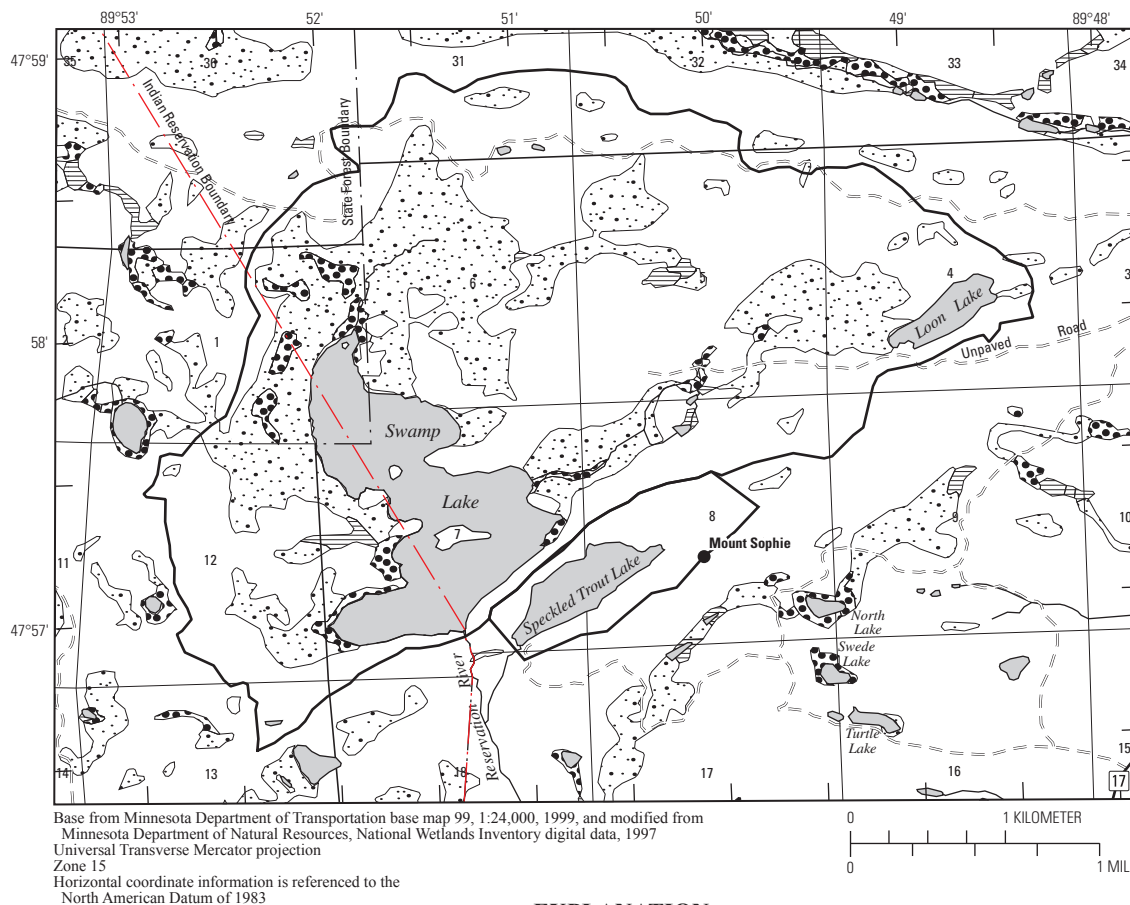
Swamp Lake is large relative to other Grand Portage lakes with an area of 144 hectares and a maximum depth of 5.8 m (Lafrancois and others, 2009). Speckled Trout Lake has an area of 26 hectares and a maximum depth of 6.4 m (Lafrancois and others, 2009). The altitudes of the two lakes are high relative to other Grand Portage lakes at 476 m and 475 m, respectively (fig. 2). The watershed area is larger for Swamp Lake than Speckled Trout Lake (1,458 and 114 hectares, respectively; LaFrancois and others, 2009), and Swamp Lake is surrounded by several bogs and swamps (fig. 3).

A shoreline development value is the ratio of the length of the shoreline to the circumference of a circle of area equal to that of the lake (Wetzel, 2001). The shoreline development value provides an indication of potential littoral community, and higher values indicate less circular lakes and, therefore, higher biological productivity (Wetzel and Likens, 2000). The shoreline development value was higher in Swamp Lake (1.89) than in Speckled Trout Lake (1.44), indicating higher potential for nutrient production in Swamp Lake.

Swamp and Speckled Trout Lakes are natural lakes that are stocked and fished (Goldstein, 2000). These lakes were monitored as part of the Grand Portage Reservation Monitoring Program for change in resource quality and to provide additional information about the fishery (Goldstein, 2000).



**Figure 2.** Watershed boundaries, lake-sediment coring sites, and water-quality sampling sites, Swamp and Speckled Trout Lakes, Grand Portage Reservation, northeastern Minnesota.



**EXPLANATION**

- Bogs
- Wooded swamp
- Shrub swamp
- Watershed boundaries of Swamp and Speckled Trout Lakes

**Figure 3.** Bogs and swamps in the Swamp and Speckled Trout Lakes areas, Grand Portage Reservation, northeastern Minnesota.

Stocking programs to maintain a successful sport fishery usually have minor effects on the quality of the water resource (Goldstein, 2000). However, game fish could alter food-web dynamics by preying on fish that forage on algae and zooplankton. Alternately, game fish could be affected by excessive nutrient loads that alter algal populations.

**Methods**

Site selection for water-quality and sediment-core sampling was based on the site’s applicability to USEPA’s definition of reference conditions (U.S. Environmental Protection Agency, 2000), the availability of recent (1997 or later) water-quality (nutrient) data for the lake, minimal development around the lake, knowledge of the lake’s watershed ecology, and accessibility to the lake. Swamp Lake and Speckled Trout Lake were selected as reference lakes for water-quality and

sediment-core sampling based on their different trophic states. The sampling locations (fig. 2) were identified by global positioning systems (GPS) to establish a common sampling location (at the deepest point) for each lake for all sampling trips.

**Water-Data Collection and Analysis by the Grand Portage Reservation Environmental Department**

Water sampling for field properties, major ions, and nutrients was conducted at Swamp and Speckled Trout Lakes by GPR personnel. Samples generally were collected on the same day in Swamp and Speckled Trout Lakes, with two exceptions, October 2000 and July 2008.

Depth profiles were recorded (appendixes 1 and 2) for field properties (specific conductance, pH, temperature, and dissolved oxygen). Field properties are important to

water-quality studies in lakes because they can be indicators of overall lake quality. Depth profiles of field properties were measured with a multiprobe sonde.

Water samples were collected and field properties were measured by GPR personnel monthly during the ice-free season (May through October) in 2000, 2002, 2004, 2006, and 2008 according to the GPR Quality Assurance Project Plan (Margaret Watkins, Grand Portage Band of Chippewa, written commun., September 10, 2009). Briefly, lake samples were collected using a 2-m long integrated sampler, which was rinsed with distilled water and then lake water prior to sampling. The water in the integrated sampler was poured into a 2-liter (L) brown polyethylene container. The 2-L container was capped and gently shaken to mix the contents. The water from the 2-L container was used to fill a 1-L *general chemistry* bottle and one 500-mL *nutrients* bottle. Pre-cleaned sample containers were provided by the laboratories performing the analyses. Each container was labeled, indicating location, date, and time of collection. All containers were transferred to an ice chest for temporary storage until they were shipped or delivered to the laboratories.

The samples were analyzed by Era Laboratories Inc., Duluth, Minn., or Northeast Technical Services, Virginia, Minn. The GPR alternated monthly samples between the two laboratories according to their Quality Assurance Project Plan (Margaret Watkins, Grand Portage Band of Chippewa, written commun., 2009). Samples were not filtered in the field and, therefore, samples were analyzed for total (unfiltered) concentrations of calcium, magnesium, chloride, sulfate, ammonia plus organic nitrogen, nitrite plus nitrate, nitrogen, phosphorus, chlorophyll *a*, and pheophyton. The laboratories filtered samples for dissolved organic carbon (Robert Magnuson, Era Laboratories, written commun., April 2, 2010, and Brandy Baker-Muhich, Northeast Technical Services, written commun., April 22, 2010). Analytes were determined with the following methods: major ions by EPA 200.7 (U.S. Environmental Protection Agency, 1994) and EPA 375.4 (U.S. Environmental Protection Agency, 1978); nutrients by EPA 351.1, EPA 353.2, EPA 365.2, and EPA 365.4 (U.S. Environmental Protection Agency, 1978) and Lachat 20–107–04–1B (Era Standard Operating Procedure Number 9503, Robert Magnuson, Era Laboratories, written commun., April 13, 2010); and chlorophyll *a* and pheophyton by SM10200H (American Public Health Association and others, 1999).

Era Laboratories and Northeast Technical Services were provided a copy of the GPR Quality Assurance Project Plan (Margaret Watkins, Grand Portage Reservation, written commun., 2009), which states that contract laboratories are required to adhere to the methodology, limits of detection, and quality-assurance objectives and criteria outlined in the plan. Era Laboratories and Northeast Technical Services were Minnesota Department of Health approved laboratories through the Minnesota Department of Health Laboratory Certification Program. The Minnesota Department of Health Certification Program rules and statutes may be found on the Minnesota Department of Health Web site at <http://www.health.state>.

[mn.us/accreditation](http://mn.us/accreditation) (accessed October, 2010). A laboratory receives certification for 2 years and certified laboratories are inspected every 3 years. A certified laboratory must successfully complete a proficiency test study demonstrating analytical proficiency for all its certified analyses annually. In addition, certified laboratories must use specific quality-control practices and maintain records according to the certification.

Era Laboratories and Northeast Technical Services provided information on their expected precision and expected accuracy for the constituents of interest (table 1). Expected precision indicates acceptance criteria for laboratory duplicates. Expected accuracy refers to the acceptance criteria for laboratory spikes. A review of the quality-assurance results for total phosphorus provided by the laboratories indicates expected precision of 10–15 percent and an expected accuracy of 80–120 percent (table 1).

## Sample Collection and Analysis by U.S. Geological Survey

The USGS collected water samples and measured field properties from Swamp Lake and Speckled Trout Lake on September 11, 2006. Water samples were collected concurrent with samples collected by GPR personnel, using the same sampling methods. Field properties were measured with a multi-probe sonde according to methods presented in Wagner and others (2006). Alkalinity was measured within 24 hours after sampling using the inflection point titration method (U.S. Geological Survey, variously dated). USGS water samples were processed according to methods described in the National Field Manual (U.S. Geological Survey, variously dated), which included the filtering of nutrient samples. Samples were sent to the National Water Quality Laboratory (NWQL) in Lakewood, Colo., and analyzed for dissolved concentrations of chloride, ammonia plus organic nitrogen, nitrite plus nitrate, total nitrogen, total phosphorus, and organic carbon using methods described by Fishman and Friedman (1989), Patton and Kryskalla (2003), Patton and Truitt (2000), Fishman (1993), and Brenton and Arnett (1993). Because USGS nutrient samples were filtered, analytical results are for dissolved concentrations and thus are not compared to diatom-inferred total phosphorus concentrations in this report. USGS analytical results for Swamp Lake (site 475702089511901) and Speckled Trout Lake (site 475704089504401) are available at <http://waterdata.usgs.gov/mn/nwis/qw> and in appendix 3.

## Sediment Core Collection and Analysis

Lake sediments were cored at the two selected sites (fig. 2) on September 11, 2006, by the USGS and Science Museum of Minnesota, St. Croix Watershed Research Station personnel. Sediment cores were collected in 6.5-cm diameter polycarbonate tubes with a hand-operated piston sampler pushed into the sediments with rigid coring rods. The

**Table 1.** Method reference and reporting levels of nutrients, chlorophyll *a*, and pheophyton analyzed by Era Laboratories and Northeast Technical Services in Swamp and Speckled Trout Lakes near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 2000–08. Site location shown in figure 2.

[mg/L, milligrams per liter; µg/L, micrograms per liter; N, nitrogen; P, phosphorus; expected precision, acceptance criteria for laboratory duplicate analyses; expected accuracy, the acceptance criteria for laboratory spikes; --, no data]

	Era Laboratories				Northeast Technical Services			
	Method reference	Reporting level	Expected precision (percent)	Expected accuracy (percent)	Method	Reporting level	Expected precision <sup>1</sup> (percent)	Expected accuracy <sup>2</sup> (percent)
Nitrite plus nitrate (mg/L as N)	--	--	--	--	EPA 353.2	0.1	15	85–115
Total nitrogen (mg/L as N)	Lachat 20-107-04-	0.1	10	80–120	EPA 351.2/ 353.2	.1	15	85–116
Total Kjeldahl nitrogen (mg/L as N)	--	--	--	--	EPA 351.2	.5	15	85–117
Total phosphorus (mg/L as P)	EPA 365.2	0.002	10	80–120	EPA 365.1 Rev. 2.0	.004	15	85–118
Chlorophyll <i>a</i> (µg/L)	SM10200H	1	25	--	SM10200H	1	15	85–119
Pheophyton (µg/L)	SM10200H	1	25	--	--	--	--	--

<sup>1</sup> Beginning in mid-2007, the expected precision for nutrients analyzed by Northeast Technical Services changed to 10 percent.

<sup>2</sup> Beginning in mid-2007, the expected accuracy for nutrients analyzed by Northeast Technical Services changed to 90–100 percent.

recovered cores were approximately 1 m in length. The cores were collected at water depths of 1.4 and 4.3 m for Swamp and Speckled Trout Lakes, respectively. The two lake-sediment cores were collected, labeled, described, logged, and sampled in the field by Science Museum of Minnesota, St. Croix Watershed Research Station personnel. Descriptions included color, texture, odor, and presence of biota and organic detritus or other visible characteristics.

At the St. Croix Watershed Research Station, samples were stored at 4°C and subsampled at intervals of 1.0 to 2.0 cm (Edlund and others, 2007, 2009). Selected subsamples were analyzed for lead-210 age dates, loss-on-ignition (LOI), and subfossil diatom community assemblage as described by Edlund and others (2007, 2009). Unused core portions were freeze dried and stored for future reference. Dates and sedimentation rates were determined according to the constant rate of supply model (Appleby and Oldfield, 1978).

Core subsamples were analyzed for diatom microfossils at 15 depths spanning the length of the cores from Swamp Lake (Edlund and others, 2007) and Speckled Trout Lake (Edlund and others, 2009); diatoms were identified to the lowest taxonomic level. Multivariate statistical analyses (Detrended Correspondence Analysis and Principal Components Analysis) were performed on the diatom data to interpret variations in the subfossil diatom assemblages (Edlund and others, 2007, 2009).

A transfer function, based on weighted-averaging regression and calibration on diatom assemblages and total phosphorus concentrations, was used to estimate historical diatom-inferred total-phosphorus concentrations. The transfer function used for Swamp and Speckled Trout Lakes was derived by comparing modern diatom species assemblages to total phosphorus concentrations in 89 reference lakes (Edlund and Ramstack, 2006; Edlund and others, 2007, 2009). These 89

reference lakes spanned major Minnesota ecoregions (Edlund and Ramstack, 2006) that differed in their history of settlement and land use, and in surficial geology, climate, and vegetation (Ramstack and others, 2003). A similar transfer function, using 55 reference lakes, is described in detail in Ramstack and others (2003). Relations between total phosphorus concentrations in the 89 reference lakes and diatom assemblages were evaluated using canonical correspondence analysis. In the canonical correspondence analysis total phosphorus concentrations had a statistically significant (*p*-value less than (<) 0.005) influence on diatom distribution (Ramstack and others, 2003).

## Water Quality of Swamp and Speckled Trout Lakes, 2000–08

Median values for field properties were smaller in Swamp Lake (table 2) than in Speckled Trout Lake (table 3). Median specific conductance values measured in Swamp and Speckled Trout Lakes were 36.9 and 48.0 microsiemens per centimeter at 25°C (µS/cm), respectively, indicating that dissolved ion concentrations in waters of both lakes are small. Median values for pH and alkalinity were lower in water samples from Swamp Lake than in water samples from Speckled Trout Lake. The pH at Swamp Lake likely is lower because bogs and other wetlands, which typically have lower pH (Mitsch and Gosselink, 1993), are attached to the shoreline (fig. 3). This also is supported by higher dissolved organic carbon in Swamp Lake (table 2) than in Speckled Trout Lake (table 3).

The pH and alkalinity values of waters in both lakes indicate that general water-quality conditions likely are not threatening fish or acid-intolerant forms of aquatic life. Alkalinity is

**Table 2.** Water-quality data collected by the Grand Portage Reservation Environmental Department for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 2000–08.

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; ERA, Era Laboratories; NTS, Northeast Technical Services; --, no data; <, less than]

Date and time	Analyzing laboratory	Specific conductance (µS/cm)	pH (standard units)	Alkalinity (mg/L)	Hardness (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Nitrite plus nitrate (mg/L)	Total nitrogen (mg/L)	Total Kjeldahl nitrogen (mg/L)	Total phosphorus (mg/L)	Chlorophyll <i>a</i> (µg/L)	Pheophyton (µg/L)	Dissolved organic carbon (mg/L)
5/1/00 11:00	ERA	37.0	7.20	8.0	14.0	3.0	1.49	0.80	3.0	--	0.50	--	0.032	4.0	<1	--
6/6/00 10:10	NTS	45.0	7.20	12.0	16.0	--	--	.70	<1	<0.1	.80	0.80	.020	1.0	--	--
7/10/00 10:30	ERA	37.0	7.10	12.0	22.0	--	--	.80	4.0	--	.80	--	.024	7.0	<1	--
8/14/00 12:00	NTS	36.7	7.88	8.0	20.0	--	--	<20	<1	<1	1.40	1.40	<.002	5.0	--	--
9/11/00 11:00	ERA	38.0	8.00	20.0	24.0	--	--	.80	3.0	--	.80	--	.026	8.0	<1	--
10/1/00 10:30	NTS	36.4	--	<1	38.0	--	--	.80	<1	<1	.95	.95	.020	20.0	--	--
5/13/02 10:00	ERA	28.0	7.00	9.0	14.0	3.8	1.18	.80	4.0	--	.60	--	.024	4.0	<1	--
6/17/02 10:30	NTS	36.0	6.81	10.0	20.0	5.4	--	.50	<1	<1	.30	.30	.002	<1	--	--
7/17/02 10:00	ERA	36.0	6.80	15.0	20.0	5.1	--	.50	5.0	--	.80	--	.031	8.0	<1	--
8/13/02 14:35	NTS	43.0	--	16.0	42.0	6.9	--	1.30	<1	.200	1.00	.80	.040	1.0	--	--
9/10/02 10:45	ERA	42.0	7.20	14.0	19.0	4.7	--	.50	3.0	--	.60	--	.029	10.0	<1	--
10/2/02 11:30	NTS	34.6	6.60	18.0	38.0	5.7	--	.80	<1	<1	.80	.80	.160	2.0	--	--
5/24/04 10:20	NTS	28.1	6.60	10.0	15.0	3.5	--	.90	6.3	<1	1.60	1.60	.020	2.0	--	--
6/7/04 10:20	ERA	31.0	6.30	8.0	15.0	4.0	--	.80	6.0	--	.50	--	.022	3.0	1	--
7/12/04 9:50	NTS	41.1	6.90	13.1	20.0	4.8	--	.25	.5	<1	1.60	1.60	.005	10.0	--	--
8/2/04 15:00	ERA	54.0	8.60	20.0	20.0	5.2	1.80	.40	4.0	--	.70	--	.010	5.0	2.0	--
9/7/04 10:10	NTS	49.7	6.90	15.5	22.0	5.5	--	.25	.5	<1	.75	.75	.070	8.0	--	--
10/6/04 14:15	ERA	38.0	7.20	11.0	18.0	4.4	--	.80	4.0	--	1.00	--	.038	1.0	<1	--
5/15/06 10:05	NTS	38.5	8.10	17.7	13.0	3.3	1.10	<.5	2.1	<1	.83	.83	<.01	1.0	--	21.1
6/7/06 10:00	ERA	29.0	6.80	8.0	15.0	3.8	--	.70	5.0	<.01	1.00	1.00	.020	6.0	<1	20.8
7/10/06 9:52	NTS	32.0	7.70	14.3	18.0	4.5	1.73	<1	2.9	<1	.77	.77	.030	<1	--	20.3
8/15/06 10:30	ERA	38.0	6.90	12.0	19.0	4.4	2.00	.80	3.0	<.01	1.10	1.10	.038	11.0	<1	19.2
9/11/06 10:40	NTS	36.2	7.00	14.6	21.0	5.0	2.25	<.5	2.6	<1	1.84	1.84	.040	7.0	--	20.4
10/3/06 10:10	ERA	41.0	7.00	13.0	20.0	4.5	--	.70	4.0	.690	2.00	1.30	.030	8.0	<1	20.4
5/12/08 10:40	NTS	16.0	6.40	<1	11.7	3.1	.96	<.5	2.3	<1	.96	.96	.010	1.0	--	12.7
6/2/08 9:15	ERA	28.0	6.40	8.0	13.0	3.3	--	1.10	3.4	<.01	.70	.70	.020	2.0	<1	13.3
7/15/08 10:10	NTS	21.3	7.00	<1	18.4	4.9	1.52	<.5	2.4	<1	.98	.98	.016	6.0	--	20.5
8/11/08 11:34	ERA	41.0	6.60	14.0	21.5	5.6	1.80	1.00	2.5	<.02	.90	.90	.021	7.0	<1	22.4
9/8/08 9:50	NTS	30.3	7.20	17.4	22.3	6.0	1.78	<.5	2.9	<1	4.24	4.24	.007	4.0	--	19.1
10/2/08 10:00	ERA	42.0	7.00	16.0	21.7	5.8	--	.30	2.4	<.02	1.00	1.00	.021	7.0	<1	22.0
Number of samples		30	28	30	30	25	11	30	30	21	30	21	30	30	15	12
Median concentration		36.9	7.00	12.5	20.0	4.7	1.73	.80	2.9	<.1	.87	.96	.023	5.5	<.1	20.4

<sup>1</sup>Differences in reporting levels and types of analyses occur because two laboratories, Era Laboratories in Duluth, Minn. and Northeast Technical Services in Virginia, Minn., were used for the analyses, generally alternating monthly (Margaret Watkins, Grand Portage Band of Chippewa, written commun., 2009).



**Table 3.** Water-quality data collected by the Grand Portage Reservation Environmental Department for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 2000–08.

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; ERA, Era Laboratories; NTS, Northeast Technical Services; --, no data, <, less than]

Date and time	Analyzing laboratory	Specific conductance (µS/cm)	pH (standard units)	Alkalinity (mg/L)	Hardness (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Nitrite plus nitrate (mg/L)	Total nitrogen (mg/L)	Total Kjeldahl nitrogen (mg/L)	Total phosphorus (mg/L)	Chlorophyll <i>a</i> (µg/L)	Pheophyton (µg/L)	Dissolved organic carbon (mg/L)
5/1/00 11:40	ERA	48.0	7.20	12.0	14.0	2.7	1.69	0.4	3.0	--	0.40	--	0.011	3.0	<1	--
6/6/00 11:20	NTS	51.0	7.66	18.0	22.0	--	--	<2	<1	<0.1	.50	0.53	.010	39.0	--	--
7/10/00 11:20	ERA	49.0	7.40	19.0	22.0	--	--	.4	4.0	--	.40	--	.012	3.0	<1	--
8/14/00 12:00	NTS	48.0	7.70	16.0	20.0	--	--	<2	<1	<.1	.88	.88	<.002	2.0	--	--
9/11/00 11:40	ERA	41.0	7.80	21.0	30.0	--	--	.4	2.0	--	.50	--	.012	6.0	<1	--
10/3/00 10:30	NTS	43.9	6.46	24.0	38.0	--	--	<2	3.0	<.1	.61	.61	.010	5.0	--	--
5/13/02 11:00	ERA	40.0	7.10	17.0	20.0	5.2	1.82	.4	2.0	--	2.90	--	.147	1.0	<1	--
6/17/02 11:30	NTS	45.0	6.84	18.0	22.0	5.9	--	.5	<1	<.1	.20	.20	<.002	<1	--	--
7/17/02 10:30	ERA	46.0	7.00	21.0	21.0	5.3	--	.4	2.0	--	.30	--	.011	4.0	<1	--
8/13/02 15:15	NTS	49.0	--	22.0	44.0	7.7	--	1.3	2.5	.50	1.20	.70	<.002	<1	--	--
9/10/02 11:25	ERA	52.0	7.30	21.0	22.0	5.6	--	.4	3.0	--	1.00	--	.014	8.0	<1	--
10/2/02 12:20	NTS	44.6	6.40	20.0	22.0	6.3	--	.5	<1	<.1	.60	.60	.090	2.0	--	--
5/24/04 11:40	NTS	50.4	7.10	20.0	22.0	5.2	--	.3	<1	<.1	1.60	1.60	.005	2.0	--	--
6/7/04 11:25	ERA	52.0	6.90	21.0	19.0	4.8	--	.4	5.0	--	1.20	--	.013	2.0	<1	--
7/12/04 10:40	NTS	58.0	7.90	20.8	21.0	5.0	--	.3	<1	<.1	1.70	1.70	.005	<1	--	--
8/2/04 16:05	ERA	38.0	6.90	12.0	19.0	4.5	1.80	.9	5.0	--	1.00	--	.030	3.0	<1	--
9/7/04 11:00	NTS	64.0	7.70	23.3	19.0	4.4	--	.3	<1	<.1	.94	.94	.090	7.0	--	--
10/6/04 15:10	ERA	51.0	7.60	21.0	21.0	5.5	--	.3	3.0	--	.70	--	.017	2.0	<1	--
5/15/06 10:45	NTS	52.7	8.40	27.1	22.0	5.6	2.00	<.6	3.2	<.1	1.00	1.00	.020	1.0	--	12.5
6/7/06 11:25	ERA	47.0	7.50	17.0	20.0	5.2	--	.3	3.0	.10	.30	.20	.010	2.0	<1	7.4
7/10/06 10:50	NTS	48.0	7.70	26.9	23.0	5.9	1.96	<.1	3.8	<.1	<.1	<.5	<.01	<.1	--	7.8
8/15/06 11:30	ERA	51.0	7.40	20.0	23.0	5.8	2.00	.4	4.0	<.02	.40	.40	.009	2.0	<1	7.3
9/11/06 11:50	NTS	45.2	7.40	32.0	23.0	5.8	2.08	<.6	3.1	<.1	1.14	1.14	.030	2.0	--	7.7
10/3/06 11:10	ERA	52.0	7.40	21.0	22.0	5.3	--	.4	4.0	.03	.70	.70	.009	1.0	<1	8.2
5/12/08 11:35	NTS	32.0	7.10	17.7	20.2	5.3	1.69	<.6	2.2	<.1	1.24	1.24	.006	3.0	--	6.2
6/2/08 11:48	ERA	46.0	7.20	18.0	19.0	4.9	--	.3	2.6	.04	.54	.50	.011	<.1	<.1	5.7
7/14/08 11:00	NTS	31.2	7.10	17.4	21.6	5.5	1.94	<.6	2.2	<.1	.80	.80	.007	2.0	--	6.6
8/11/08 0:58	ERA	75.0	6.40	28.0	24.4	6.6	1.95	.5	4.8	<.02	1.40	1.40	.021	5.0	<.1	8.9
9/8/08 11:00	NTS	29.8	7.30	18.2	19.8	5.1	1.73	<.6	2.3	<.1	.76	.76	.007	3.0	--	7.0
10/2/08 11:00	ERA	45.0	6.90	19.0	19.7	5.0	--	.3	2.2	<.02	.60	.60	.015	<.1	<.1	8.1
Number of samples		30	29	30	30	25	11	30	30	21	30	21	30	30	15	12
Median concentration		48.0	7.30	20.0	21.8	5.3	1.94	.4	2.6	<.1	.76	.73	.012	2	<.1	7.6

<sup>1</sup>Differences in reporting levels and types of analyses occur because two laboratories, Era Laboratories in Duluth, Minn. and Northeast Technical Services in Virginia, Minn., were used for the analyses, generally alternating monthly (Margaret Watkins, Grand Portage Band of Chippewa, written commun., 2009).

defined as the capacity of solutes in the water to react with and neutralize acid. Lakes with a low alkalinity have a low buffering capacity and, thus, could have low (acidic) pH values. Lethal effects for aquatic life begin to appear near a pH of 4.5 (Wetzel, 2001, p. 191). The pH levels in low-alkalinity lakes can decrease because of acid from rainfall. Although alkalinity concentrations are low in both lakes, the pH levels are close to neutral (7.0) indicating that recent (2000–08) conditions do not pose a substantial threat for fish or acid-intolerant forms of aquatic life.

Median total calcium and magnesium concentrations were smaller in Swamp Lake than in Speckled Trout Lake, whereas total chloride concentrations were larger in Swamp Lake (tables 2 and 3). Cations (calcium and magnesium) and anions (chloride and sulfate) occur naturally in all surface water at varying concentrations and may concentrate in water as a result of natural dissolution of minerals from bedrock, glacial deposits, and soils. The natural variability in concentration depends on chemical characteristics of drainage-basin soils and in some situations the minerals in deeper geologic strata (Christensen and Pope, 1997). Total chloride and sulfate concentrations are small in Swamp and Speckled Trout Lakes compared with concentrations in some saline groundwater on the reservation, which have exceeded the USEPA Secondary Maximum Contaminant Level of 250 mg/L (Winterstein, 2002).

Median total nitrogen concentrations were larger in Swamp Lake than in Speckled Trout Lake, perhaps indicating a larger source of organic matter in Swamp Lake or its watershed. However, the difference in total nitrogen concentrations between the lakes was not significant using a Wilcoxon signed-rank test (Helsel and Hirsch, 1992) with a significance value ( $\alpha$ ) of 0.05 (p-value=0.0597).

Total phosphorus concentrations also are small in both lakes with medians of 0.023 mg/L in Swamp Lake and 0.012 mg/L in Speckled Trout Lake (tables 2 and 3). The difference was statistically significant (p-value=0.0043). Nitrogen to phosphorus ratios based on median concentrations were 38:1 in Swamp Lake and 63:1 in Speckled Trout Lake. Nitrogen to phosphorus ratios greater than 23:1 indicate phosphorus limitation (Wetzel, 2001).

Chlorophyll-*a* concentrations were larger in Swamp Lake than in Speckled Trout Lake (tables 2 and 3). In other northern Minnesota lakes, chlorophyll *a* tends to vary seasonally with peak concentrations normally occurring in late summer (Christensen and others, 2004). However, seasonal patterns generally were not evident in the Swamp Lake or Speckled Trout Lake water samples. For both Swamp and Speckled Trout Lakes, the peak concentrations occurred in 2000 and were 20 and 39 micrograms per liter ( $\mu\text{g/L}$ ), respectively. This possibly indicates a larger algal biomass during 2000 than in later years. Lower-than-normal precipitation rates in September and October may have affected the peak chlorophyll-*a* concentrations. The peak concentration in Swamp Lake occurred in October, and total precipitation for September and October 2000 was about 7 cm below normal (Minnesota Climatology

Working Group, 2009). The peak concentration at Speckled Trout Lake occurred in June, and total precipitation for June was about 10 cm, near the average for the period of record (Minnesota Climatology Working Group, 2009). Although median pheophyton concentrations were the same in both lakes ( $< 1 \mu\text{g/L}$ ), one sample from Swamp Lake, had a pheophyton concentration of 2.0  $\mu\text{g/L}$ .

Dissolved organic carbon concentrations were larger in Swamp Lake than in Speckled Trout Lake (tables 3 and 4) with median concentrations of 20.4 and 7.6 mg/L, respectively. Dissolved organic carbon is an approximation of the total concentration of dissolved organic material (Hem, 1992).

Differences in concentrations of total phosphorus, chlorophyll *a*, and dissolved organic carbon between the two lakes may be because of differences in watershed characteristics, particularly the number of wetlands in the two watersheds (fig. 3). The attached bogs and upgradient swamps in the Swamp Lake watershed are a possible nutrient and organic carbon source, leading to enhanced algal growth and thus higher chlorophyll-*a* concentrations in Swamp Lake than Speckled Trout Lake. Water quality in Swamp and Speckled Trout Lakes were compared to concentrations in other reservation lakes (LaFrancois and others, 2009). The median total phosphorus concentration for 15 lakes on the Grand Portage Reservation, including Swamp and Speckled Trout Lakes (0.024 mg/L; LaFrancois and others, 2009) was similar to the median concentration for Swamp Lake (0.023 mg/L). Swamp Lake also had similar total nitrogen and larger dissolved organic carbon concentrations, whereas Speckled Trout Lake had smaller total nitrogen, total phosphorus, and dissolved organic carbon concentrations than most other reservation lakes.

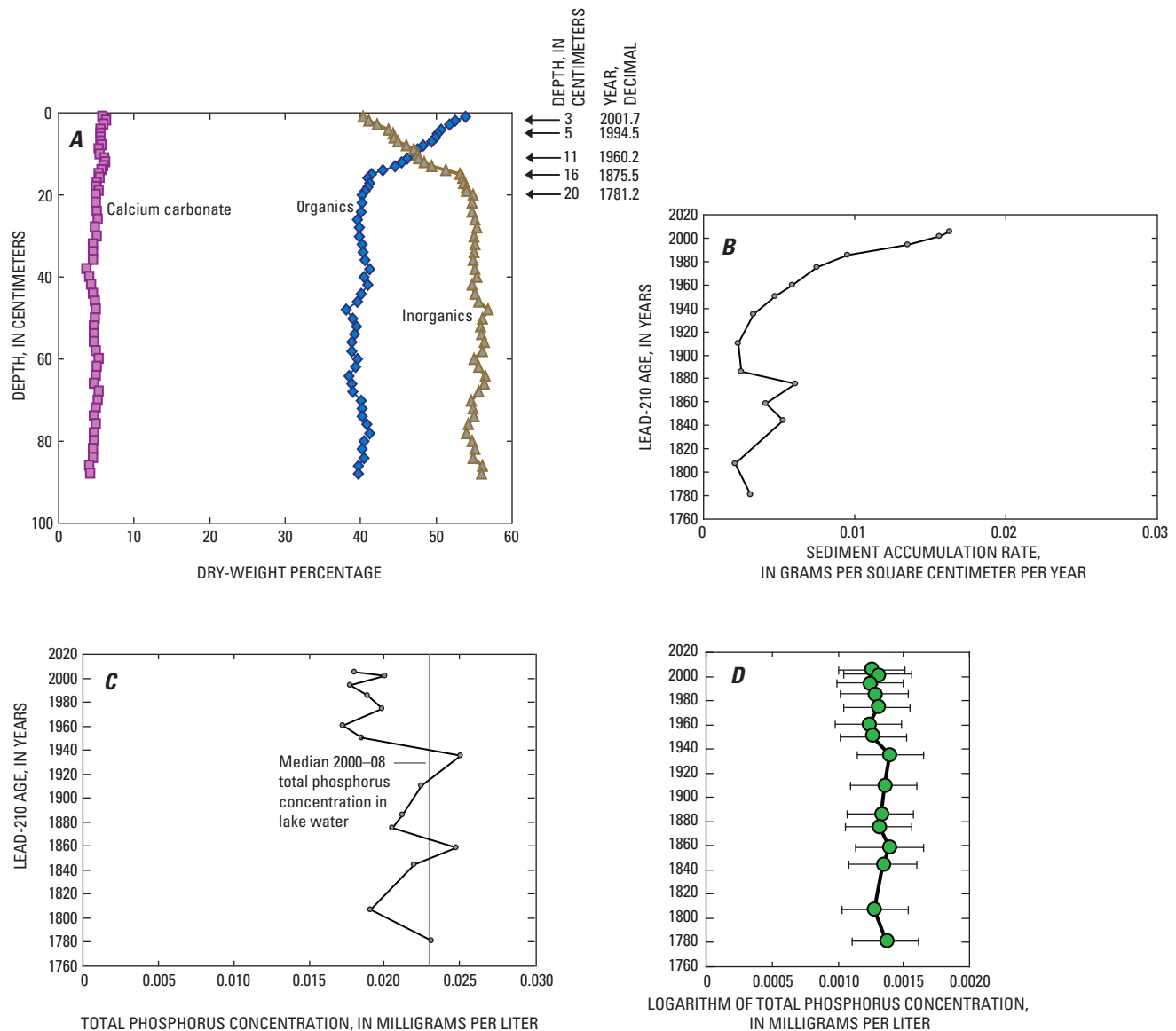
## Historical Phosphorus Concentrations from Paleolimnological Studies

Lake-sediment cores from Swamp and Speckled Trout Lakes were collected in 2006 and dated back to 1781 for Swamp Lake and 1825 for Speckled Trout Lake. Historical phosphorus concentrations were inferred through paleolimnological reconstruction methods involving diatom analysis and lead-210 dating of lake-sediment cores.

### Swamp Lake Sediments

Dry-weight percentages of organic matter, calcium carbonate, and inorganic matter were determined by LOI for Swamp Lake sediments (fig. 4.4). Results indicated that sediment from Swamp Lake historically has been dominated by the inorganic component with a shift to a higher organic component after about 1900.

Lead-210 dating decreased downward to a depth of 16 cm (Edlund and others, 2007). An age-depth model



**Figure 4.** Swamp Lake sediment core analyses, Grand Portage Reservation, Minnesota. *A*, dry-weight percentage of calcium carbonate, organic matter, and inorganic matter; *B*, sediment accumulation rates; *C*, diatom-inferred total phosphorus concentrations; and *D*, model error estimates (from Edlund and others, 2007).

indicated that sediments below 16 cm were deposited prior to 1875 (fig. 4*A*). The large shifts in the percentages of organic and inorganic components (fig. 4*A*) and in the sediment accumulation rate (fig. 4*B*) at core depths of 15 to 16 cm (1880s) likely were because of logging during early European settlement (1880–1920) of the area (Edlund and others, 2007). A large increase in sediment accumulation rate after 1960 likely was a result of logging along the northeastern shore of Swamp Lake in 1958 (Edlund and others, 2007).

The diatom flora of Swamp Lake is very diverse with more than 280 diatom taxa found in the core samples. These diatoms included many rare or uncommon species and several unknown taxa (Edlund and others, 2007). Detrended correspondence and principal components analyses were applied to the diatom data to visualize relations among diatom

communities with depth. Stratigraphic zones of the diatom assemblages were identified by the principal components analysis, but only minor changes were seen in the historical Swamp Lake diatom communities.

The diatom assemblages were used to reconstruct historical epilimnetic total phosphorus concentrations in Swamp Lake (fig. 4*C*). Diatom-inferred total phosphorus concentrations ranged from 17 to 25  $\mu\text{g/L}$  (0.017 to 0.025 mg/L) in sediments dated 1781–2005. The transfer function reconstructs logarithmic total phosphorus concentrations with model error estimates (fig. 4*D*). Results of the transfer function were back-transformed to total phosphorus concentrations in milligrams per liter (fig. 4*C*). Differences among these values were not greater than the root mean square error of prediction for the transfer functions. In other words, there were no statistically

significant changes given the uncertainties associated with the transfer functions, inferring that no major changes in total phosphorus concentrations occurred during the past 200 years. Comparison of the Swamp Lake diatom communities with diatom communities of the 89 Minnesota lakes indicated that any shift in the Swamp Lake communities could not be correlated to a specific environmental stressor (Edlund and others, 2007).

### Speckled Trout Lake Sediments

LOI analysis on the Speckled Trout Lake core indicated that sediment from Speckled Trout Lake historically has been dominated by the inorganic component with the organic component increasing between 1850 and 1900 (fig. 5A). This shift could represent the effects of the initial logging in the watershed around 1900–1910 (Edlund and others, 2009). Disturbance of soils during logging could lead to enhanced erosion and an increase in the rate of deposition. Slash (the unused logs and debris left after land has been logged) may contribute to increased organic content relative to inorganic material. Similar increases were present in dated cores from other lakes along Minnesota's North Shore region (Edlund and others, 2009). The percentage of inorganic sediments decreased to 39 percent at the top of the core (above a depth of 28 cm).

Minor increases in sediment accumulation rates in the Speckled Trout Lake core occurred between 1840 and 1880. These increases may have resulted from fires following droughts in northeastern Minnesota. Heinselman (1973) identified five periods of fire in the 1800s for the Boundary Waters Canoe Area, Minnesota: 1801, 1824, 1863–64, 1875, and 1894. Most of these fire periods followed prolonged droughts of subcontinental extent, including the 1864 drought (Heinselman, 1973). These minor increases are followed by an increase in sediment accumulation rate from about 0.01 gram per square centimeter per year ( $\text{g}/\text{cm}^2/\text{yr}$ ) in 1900 to about 0.03  $\text{g}/\text{cm}^2/\text{yr}$  in 2005 (fig. 5B). Overall, sedimentation rates were slightly larger for the Speckled Trout Lake core than for the Swamp Lake core, possibly because of the steeper slope in the land surface surrounding Speckled Trout Lake or basin morphometry that produces more focused sedimentation.

Sediments from the Speckled Trout Lake core were analyzed for diatom microfossils at 15 discrete depths in the core, spanning the time before European settlement (which occurred about 1870) to 2006, when the core was collected. Similar to the Swamp Lake core, the diatom flora of the Speckled Trout Lake core was very diverse and dominated by softwater diatoms. More than 215 diatom taxa were found in the core samples including many rare or uncommon species and several unknown taxa (Edlund and others, 2009). Similar to the Swamp Lake core, only minor changes in the diatom communities occurred through the length of the cores. As a reflection of these minor changes, historical diatom-inferred total phosphorus concentrations indicated that there were no major changes in total phosphorus concentrations since the early 1860s. Diatom-inferred total phosphorus concentrations

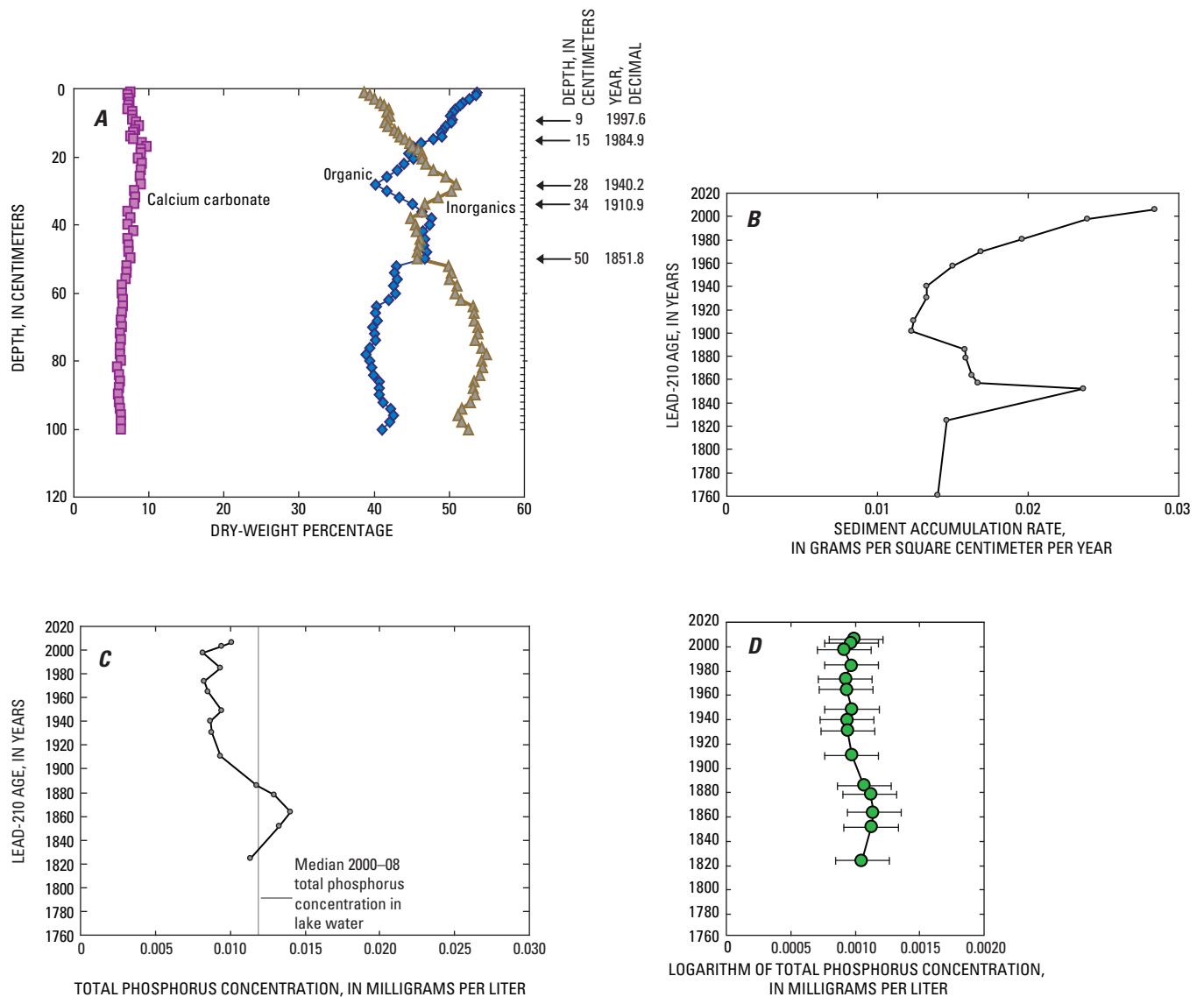
ranged from 8 to 14  $\mu\text{g}/\text{L}$  (0.008 to 0.014  $\text{mg}/\text{L}$ ) in sediments dated between 1825 and 2006 (fig. 5C). Differences among these values were not greater than the root mean square error of prediction for the transfer function and infer that no major changes in total phosphorus concentrations have occurred in the past 200 years.

### Comparison of 2000–08 Total Phosphorus Concentrations to Inferred Historical Concentrations

Total phosphorus concentrations from water samples collected from Swamp Lake during 2000–08 by GPR personnel ranged from less than 0.002 to 0.16  $\text{mg}/\text{L}$  (median = 0.023  $\text{mg}/\text{L}$ , table 2) compared to diatom-inferred total phosphorus concentrations of 0.017 to 0.025  $\text{mg}/\text{L}$  based on sediments dated 1781–2005. Sediments deposited concurrently with monitoring (sediments dated from 2002 to 2005) produced diatom-inferred total phosphorus concentrations of 0.018 to 0.020  $\text{mg}/\text{L}$ .

Total phosphorus concentrations from water samples collected from Speckled Trout Lake during 2000–08 were similar to those of Swamp Lake, ranging from less than 0.002 to 0.147  $\text{mg}/\text{L}$  (median = 0.012  $\text{mg}/\text{L}$ , table 3). Diatom-inferred total phosphorus concentrations in Speckled Trout Lake ranged from 0.008 to 0.014  $\text{mg}/\text{L}$  based on sediments dated 1825–2006, which are somewhat smaller than those inferred for Swamp Lake. Diatom-inferred total phosphorus concentrations based on sediments deposited during the monitoring period ranged from 0.009 to 0.010  $\text{mg}/\text{L}$  (sediments dated from 2003 to 2006). The diatom-inferred total phosphorus values for Swamp and Speckled Trout Lakes were similar to the diatom-inferred total phosphorus concentrations determined for other lakes in the Northern Lakes and Forest ecoregion in Cook and Lake Counties (range of 0.011 to 0.027  $\text{mg}/\text{L}$ ; Ramstack and others, 2003).

The narrow range of diatom-inferred values (from 2002 to 2005 for Swamp Lake and 2003 to 2006 for Speckled Trout Lake) represent temporally integrated samples (1 to 3 years). As expected with monthly ice-free seasonal sampling in Swamp and Speckled Trout Lakes, water-sample total phosphorus concentrations have a much greater range of values than diatom-inferred values. Although the median water-sample total phosphorus concentrations (0.023 and 0.012  $\text{mg}/\text{L}$ ) compare favorably with the diatom-inferred concentrations (figs. 4C and 5C), a limitation of this study was the absence of field replicate samples analyzed for total phosphorus concentrations. The small differences between 2000–08 total phosphorus concentrations and diatom-inferred total phosphorus concentrations for the Swamp and Speckled Trout Lakes may be because of several factors, including (1) the lack of year-round total phosphorus data for the lakes; (2) the transfer functions based on other Minnesota



**Figure 5.** Speckled Trout Lake sediment core analyses, Grand Portage Reservation, Minnesota. *A*, dry weight percentage of calcium carbonate, organic matter and inorganic matter; *B*, sediment accumulation rates; and *C*, diatom-inferred total phosphorus concentrations for the Speckled Trout Lake sediment core, Grand Portage Reservation, Minnesota; *D*, model error estimates (from Edlund and others, 2009).

lakes, possibly with different diatom-phosphorus relations; (3) historic nutrient production rates may be different than current rates; (4) differences in field and laboratory techniques used for samples collected from the Swamp and Speckled Trout Lakes and the 89 lakes used in the transfer function; and (5) the time period of the sample collection may have been too short to capture the inherent variability of the water-quality data.

This study showed similarities between median values of recent total phosphorus concentrations in water-quality samples and diatom-inferred phosphorus concentrations based on recent sedimentation, coupled with strong analogues for subfossil diatom communities for both lakes within the 89 Minnesota lakes diatom transfer function. This indicates that

recent and historical diatom-inferred phosphorus reconstructions might be used to help develop reference conditions and nutrient criteria for Grand Portage Reservation lakes, when a sampling program is designed to ensure representative phosphorus concentrations in water samples are comparable to diatom-inferred concentrations.

## Summary

The Grand Portage Reservation, in northeastern Minnesota, established water-quality standards in 2005 and subsequently has the responsibility to derive nutrient criteria for the reservation. Personnel from the Grand Portage Reservation.

Environmental Department (GPR) have chosen to undertake a paleolimnological approach and direct observation to establish reference conditions for lakes on the reservation. A paleolimnological approach establishes the historical nutrient productivity of a lake through the characterization of nutrients and the fossil remains of organisms (diatoms and chrysophytes) in lake-sediment cores. The U.S. Geological Survey (USGS), in cooperation with the Grand Portage Band of Chippewa Indians and the Science Museum of Minnesota, conducted a study to describe the water quality (2000–08) and historical phosphorus concentrations (1781–2006) for Swamp and Speckled Trout Lakes. Results from this study may be used as a guide in establishing reference conditions and nutrient criteria in these and other lakes on the Grand Portage Reservation.

This report summarizes recent (2000–08) water-quality data and their comparison to historical total phosphorus concentrations (1781–2006) in Swamp and Speckled Trout Lakes. The historical total phosphorus concentrations were inferred through paleolimnological reconstruction methods involving diatom analysis of lead-210 dated lake-sediment cores. Water samples were analyzed for field properties, major ions, nutrients, and dissolved organic carbon concentrations. Median specific conductance, pH, and alkalinity values were smaller in Swamp Lake than in Speckled Trout Lake. This is likely because of more bogs and swamps attached to the shoreline of Swamp Lake. Median total calcium and magnesium concentrations were smaller in Swamp Lake than in Speckled Trout Lake, whereas total chloride concentrations were larger in Swamp Lake.

Median nutrient concentrations for water samples collected by GPR personnel during 2000–08 in both lakes were small, as Swamp and Speckled Trout Lakes are not substantially affected by major sources of nutrients such as agricultural activities or wastewater discharge. Total phosphorus concentrations were small in both lakes with a median concentration of 0.023 mg/L in Swamp Lake and a median concentration of 0.012 mg/L in Speckled Trout Lake. Chlorophyll-*a* concentration, an indicator of algal biomass, and dissolved organic carbon concentrations were larger in Swamp Lake than in Speckled Trout Lake.

Results of loss-on-ignition analyses indicated that sediment from Swamp Lake historically has been dominated by the inorganic component with a shift to an organic component in modern sedimentation. Lead-210 dating and an age-depth model indicated that sediments below 16 centimeters (cm) in Swamp Lake were deposited prior to 1875. A large shift in the percentage of organic and inorganic components and in the sedimentation rate occurred at a core depth of 15 to 16 cm (1880s). This shift was likely because of logging during early European settlement (1880–1920) of the area. A large increase in sedimentation rate after 1960 likely was a result of logging along the northeastern shore of Swamp Lake in 1958.

Loss-on-ignition analysis on the Speckled Trout Lake core indicated that the sediment historically has been dominated by the inorganic component with the organic component increasing between 1850 and 1900. Above a depth of 28 cm, the percentage of inorganic components decreased to 39 percent. Overall, sedimentation rates were slightly larger for the Speckled Trout Lake core than in the Swamp Lake core, possibly because of the steeper slope in the land surface surrounding Speckled Trout Lake or greater sediment focusing because of basin morphometry.

The diatom flora of Swamp and Speckled Trout Lakes was diverse. These diatoms included many rare or uncommon species and several unknown taxa. Diatom-inferred total phosphorus concentrations ranged from 0.017 to 0.025 mg/L in Swamp Lake from sediment samples dated 1781–2005 and from 0.008 to 0.014 mg/L in the Speckled Trout Lake core based on sediments dated 1825–2006. Differences among the diatom-inferred total phosphorus concentrations were not greater than the model error estimates, inferring that no major changes in total phosphorus concentrations occurred during the past 200 years in either Swamp Lake or Speckled Trout Lake.

Total phosphorus concentrations from water samples collected from Swamp Lake during 2000–08 ranged from less than 0.002 to 0.160 mg/L (median=0.023 mg/L) compared to diatom-inferred total phosphorus concentrations of 0.018 to 0.020 mg/L from sediments dated from 2002 to 2005. Total phosphorus concentrations from water samples collected from Speckled Trout Lake during 2000–08 were similar to those from Swamp Lake, whereas the diatom-inferred total phosphorus concentrations were smaller in Speckled Trout Lake than in Swamp Lake. Total phosphorus concentrations in water samples collected from Speckled Trout Lake during 2000–08 ranged from less than 0.002 to 0.147 mg/L (median=0.012 mg/L). Historical diatom-inferred total phosphorus concentrations in Speckled Trout Lake ranged from 0.009 to 0.010 mg/L in sediments dated from 2003 to 2006. Differences in total phosphorus concentrations between the two lakes may be because of differences in watershed characteristics, particularly the number of wetlands in the two watersheds.

Median values of recent (2000–08) total phosphorus concentrations in water-quality samples and diatom-inferred phosphorus in recent sedimentation in Swamp and Speckled Trout Lakes were similar. These similarities, coupled with strong analogues for subfossil diatom communities for both lakes within the 89 Minnesota lakes diatom transfer function, indicate that recent and historical diatom-inferred phosphorus reconstructions might be used to help establish reference conditions and nutrient criteria for Grand Portage Reservation lakes when a sampling program is designed to ensure representative phosphorus concentrations in water samples are comparable to diatom-inferred concentrations.

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## **Appendixes 1–3**

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**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Pelouidy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ( $\mu\text{S}/\text{cm}$ )	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
7/16/1997	230	--	23.9	Clear	0.6	25.7	7.34	29	7.03	313	16.9
7/16/1997	230	--	23.9	Clear	1.2	25.6	7.20	26	6.90	309	28.3
6/26/1998	930	28.27	21.1	Pelouidy	.3	19.3	8.21	26	7.32	--	3.0
6/26/1998	930	28.27	21.1	Pelouidy	.9	18.7	8.27	25	7.21	--	3.3
6/26/1998	930	28.27	21.1	Pelouidy	1.5	18.6	8.14	26	7.19	--	3.8
6/26/1998	930	28.27	21.1	Pelouidy	2.1	18.4	7.81	26	7.16	--	3.9
6/26/1998	930	28.27	21.1	Pelouidy	2.7	18.4	7.70	26	7.14	--	4.0
6/26/1998	930	28.27	21.1	Pelouidy	3.4	18.3	7.66	26	7.05	--	3.7
6/26/1998	930	28.27	21.1	Pelouidy	4.0	18.3	7.45	26	7.07	--	5.8
6/26/1998	930	28.27	21.1	Pelouidy	4.6	18.2	7.40	26	7.06	--	4.7
7/16/1998	1000	28.47	21.1	Clear	.3	21.9	7.81	28	7.26	324	--
7/16/1998	1000	28.47	21.1	Clear	.9	21.9	7.29	28	7.28	319	--
7/16/1998	1000	28.47	21.1	Clear	1.5	21.9	7.41	28	7.41	313	3.8
7/16/1998	1000	28.47	21.1	Clear	2.1	21.9	7.40	29	7.40	315	3.0
7/16/1998	1000	28.47	21.1	Clear	2.7	21.4	7.33	28	7.38	316	5.5
7/16/1998	1000	28.47	21.1	Clear	3.4	20.9	7.01	28	7.22	325	3.2
7/16/1998	1000	28.47	21.1	Clear	4.0	20.7	6.93	28	7.22	325	4.1
7/16/1998	1000	28.47	21.1	Clear	4.6	20.6	6.88	28	7.20	321	6.9
9/25/1998	1000	27.99	15.6	Pelouidy	.3	12.8	9.75	30	7.35	333	3.0
9/25/1998	1000	27.99	15.6	Pelouidy	.9	12.7	9.25	30	7.32	343	5.7
9/25/1998	1000	27.99	15.6	Pelouidy	1.5	12.7	9.17	30	7.37	347	5.7
9/25/1998	1000	27.99	15.6	Pelouidy	2.1	12.7	9.14	31	7.37	351	5.5
9/25/1998	1000	27.99	15.6	Pelouidy	2.7	12.8	9.07	31	7.37	354	5.9
9/25/1998	1000	27.99	15.6	Pelouidy	3.4	12.8	9.05	31	7.37	357	5.8
9/25/1998	1000	27.99	15.6	Pelouidy	4.0	12.6	8.43	32	7.28	357	5.5
9/25/1998	1000	27.99	15.6	Pelouidy	4.6	12.6	2.77	43	6.38	283	8.1

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Pelouly, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
10/21/1998	1150	28.65	7.2	Pelouly	0.3	5.4	11.77	28	6.94	268	3.3
10/21/1998	1150	28.65	7.2	Pelouly	.6	5.4	11.71	28	6.88	264	3.5
10/21/1998	1150	28.65	7.2	Pelouly	.9	5.4	11.63	28	6.89	264	3.3
10/21/1998	1150	28.65	7.2	Pelouly	1.2	5.4	11.60	28	6.90	263	3.4
10/21/1998	1150	28.65	7.2	Pelouly	1.5	5.4	11.59	28	6.90	263	3.2
10/21/1998	1150	28.65	7.2	Pelouly	1.8	5.4	11.53	28	6.90	263	3.2
10/21/1998	1150	28.65	7.2	Pelouly	2.1	5.4	11.48	28	6.90	262	3.4
10/21/1998	1150	28.65	7.2	Pelouly	2.4	5.4	11.49	28	6.92	261	3.2
10/21/1998	1150	28.65	7.2	Pelouly	2.7	5.4	11.50	28	6.91	261	3.2
10/21/1998	1150	28.65	7.2	Pelouly	3.0	5.4	11.45	28	6.93	261	3.0
10/21/1998	1150	28.65	7.2	Pelouly	3.4	5.4	11.50	28	6.93	261	3.4
10/21/1998	1150	28.65	7.2	Pelouly	3.7	5.4	11.49	28	6.93	260	3.0
10/21/1998	1150	28.65	7.2	Pelouly	4.0	5.4	11.44	28	6.93	260	3.4
10/21/1998	1150	28.65	7.2	Pelouly	4.3	5.4	11.46	28	6.93	260	3.2
10/21/1998	1150	28.65	7.2	Pelouly	4.6	5.4	11.46	28	6.94	255	4.2
5/1/2000	1021	29.09	20.7	Pelouly	.3	11.3	10.24	32	7.08	357	--
5/1/2000	1021	29.09	20.7	Pelouly	.9	11.3	10.13	32	7.01	356	--
5/1/2000	1021	29.09	20.7	Pelouly	1.5	10.7	4.79	27	6.64	237	--
5/1/2000	1021	29.09	20.7	Pelouly	2.1	10.7	4.79	37	6.32	252	3.0
5/1/2000	1021	29.09	20.7	Pelouly	2.7	11.0	4.60	37	6.29	251	--
5/1/2000	1021	29.09	20.7	Pelouly	3.4	10.9	4.63	37	6.23	243	--
5/1/2000	1021	29.09	20.7	Pelouly	4.0	10.9	.10	37	6.23	240	--
6/6/2000	950	29.44	20.6	Pelouly	.3	15.8	9.16	30	7.15	368	--
6/6/2000	950	29.44	20.6	Pelouly	.6	15.8	9.25	30	7.16	363	--
6/6/2000	950	29.44	20.6	Pelouly	.9	15.8	9.11	30	7.12	365	--
6/6/2000	950	29.44	20.6	Pelouly	1.2	15.8	9.11	31	7.09	366	--
6/6/2000	950	29.44	20.6	Pelouly	1.5	15.8	9.12	31	7.06	366	--

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Peloudu, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ( $\mu\text{S}/\text{cm}$ )	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
6/6/2000	950	29.44	20.6	Peloudu	1.8	15.8	9.08	31	7.13	363	--
6/6/2000	950	29.44	20.6	Peloudu	2.1	15.8	9.03	31	7.12	363	--
6/6/2000	950	29.44	20.6	Peloudu	2.4	15.7	9.06	31	7.06	365	--
6/6/2000	950	29.44	20.6	Peloudu	2.7	15.8	9.03	31	7.05	364	--
6/6/2000	950	29.44	20.6	Peloudu	3.0	15.6	9.02	31	7.03	365	--
6/6/2000	950	29.44	20.6	Peloudu	3.4	15.6	9.02	31	7.04	364	--
6/6/2000	950	29.44	20.6	Peloudu	3.7	15.5	8.94	31	7.04	364	--
6/6/2000	950	29.44	20.6	Peloudu	4.0	15.5	8.88	31	7.02	364	--
6/6/2000	950	29.44	20.6	Peloudu	4.3	15.3	9.69	31	7.04	361	--
6/6/2000	950	29.44	20.6	Peloudu	4.6	15.2	8.91	31	6.99	362	--
6/6/2000	950	29.44	20.6	Peloudu	4.9	14.9	8.73	31	7.02	362	--
6/6/2000	950	29.44	20.6	Peloudu	5.2	14.5	.70	108	6.10	296	--
7/10/2000	1010	29.32	24.9	Peloudu	.3	21.8	8.91	31	7.25	311	1.6
7/10/2000	1010	29.32	24.9	Peloudu	.6	21.8	8.92	31	7.24	311	3.1
7/10/2000	1010	29.32	24.9	Peloudu	.9	21.9	9.02	31	7.23	311	2.6
7/10/2000	1010	29.32	24.9	Peloudu	1.2	21.8	8.77	31	7.23	310	3.2
7/10/2000	1010	29.32	24.9	Peloudu	1.5	21.9	8.36	31	7.24	310	2.2
7/10/2000	1010	29.32	24.9	Peloudu	1.8	21.9	8.47	31	7.25	310	2.3
7/10/2000	1010	29.32	24.9	Peloudu	2.1	21.8	8.45	31	7.25	310	2.3
7/10/2000	1010	29.32	24.9	Peloudu	2.4	21.8	8.46	31	7.23	311	2.4
7/10/2000	1010	29.32	24.9	Peloudu	2.7	21.8	7.49	31	6.90	209	2.4
7/10/2000	1010	29.32	24.9	Peloudu	3.0	21.3	7.97	31	7.05	218	2.7
7/10/2000	1010	29.32	24.9	Peloudu	3.4	21.0	6.73	33	6.08	183	2.6
7/10/2000	1010	29.32	24.9	Peloudu	3.7	18.6	6.41	33	6.52	218	2.4
7/10/2000	1010	29.32	24.9	Peloudu	4.0	18.3	4.02	34	6.41	189	2.3
7/10/2000	1010	29.32	24.9	Peloudu	4.3	18.3	5.64	34	6.41	207	2.4
7/10/2000	1010	29.32	24.9	Peloudu	4.6	18.0	1.74	86	6.07	1,434	27.1

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Peloudu, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
8/15/2000	950	29.59	23.6	Peloudu	0.3	19.8	8.35	36	6.92	291	3.1
8/15/2000	950	29.59	23.6	Peloudu	.6	19.8	8.35	36	6.92	291	4.4
8/15/2000	950	29.59	23.6	Peloudu	.9	19.8	8.34	35	6.92	291	4.7
8/15/2000	950	29.59	23.6	Peloudu	1.2	19.8	8.38	36	6.92	291	2.8
8/15/2000	950	29.59	23.6	Peloudu	1.5	19.7	8.24	36	6.90	291	3.3
8/15/2000	950	29.59	23.6	Peloudu	1.8	19.7	8.18	35	6.89	292	2.7
8/15/2000	950	29.59	23.6	Peloudu	2.1	19.7	8.15	36	6.91	291	3.0
8/15/2000	950	29.59	23.6	Peloudu	2.4	19.7	8.31	36	6.92	292	2.9
8/15/2000	950	29.59	23.6	Peloudu	2.7	19.7	8.32	36	6.92	292	3.0
8/15/2000	950	29.59	23.6	Peloudu	3.0	19.7	8.33	35	6.93	292	3.3
8/15/2000	950	29.59	23.6	Peloudu	3.4	19.7	8.28	35	6.93	293	3.1
8/15/2000	950	29.59	23.6	Peloudu	3.7	19.7	8.33	36	6.92	294	3.3
8/15/2000	950	29.59	23.6	Peloudu	4.0	19.7	8.30	36	6.92	294	3.1
8/15/2000	950	29.59	23.6	Peloudu	4.3	19.7	8.30	36	6.92	295	3.2
8/15/2000	950	29.59	23.6	Peloudu	4.6	19.7	8.23	36	6.91	295	3.1
8/15/2000	950	29.59	23.6	Peloudu	4.9	19.6	3.21	42	6.25	155	--
9/11/2000	1035	28.73	24.1	Peloudu	.3	16.7	9.13	33	7.27	344	--
9/11/2000	1035	28.73	24.1	Peloudu	.6	16.3	9.09	33	7.22	346	1.8
9/11/2000	1035	28.73	24.1	Peloudu	.9	16.2	9.05	33	7.17	348	2.2
9/11/2000	1035	28.73	24.1	Peloudu	1.2	16.1	9.01	33	7.12	349	2.7
9/11/2000	1035	28.73	24.1	Peloudu	1.5	16.1	8.90	33	7.10	349	2.1
9/11/2000	1035	28.73	24.1	Peloudu	1.8	16.0	8.83	33	7.07	351	2.3
9/11/2000	1035	28.73	24.1	Peloudu	2.1	15.9	8.82	33	7.08	350	2.3
9/11/2000	1035	28.73	24.1	Peloudu	2.4	15.9	8.85	33	7.07	350	2.4
9/11/2000	1035	28.73	24.1	Peloudu	2.7	15.9	8.63	33	6.89	234	2.3
9/11/2000	1035	28.73	24.1	Peloudu	3.0	15.9	8.84	33	7.00	223	2.8
9/11/2000	1035	28.73	24.1	Peloudu	3.4	15.9	8.75	33	6.99	224	2.3
9/11/2000	1035	28.73	24.1	Peloudu	3.7	15.8	8.44	34	6.89	206	2.3

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Pcloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ( $\mu\text{S}/\text{cm}$ )	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
9/11/2000	1035	28.73	24.1	Pcloudy	4.0	15.7	8.00	34	6.51	196	2.8
9/11/2000	1035	28.73	24.1	Pcloudy	4.3	14.7	7.36	37	6.36	191	--
10/3/2000	1005	28.85	20.9	Clear	.3	12.0	9.98	34	7.43	347	--
10/3/2000	1005	28.85	20.9	Clear	.6	12.0	9.90	34	7.43	347	0
10/3/2000	1005	28.85	20.9	Clear	.9	12.0	9.84	34	7.40	348	2.9
10/3/2000	1005	28.85	20.9	Clear	1.2	11.9	9.90	34	7.37	348	1.9
10/3/2000	1005	28.85	20.9	Clear	1.5	11.9	9.81	34	7.40	347	2.0
10/3/2000	1005	28.85	20.9	Clear	1.8	11.8	9.83	34	7.37	348	2.3
10/3/2000	1005	28.85	20.9	Clear	2.1	11.7	9.82	34	7.37	347	2.4
10/3/2000	1005	28.85	20.9	Clear	2.4	11.7	9.83	34	7.37	346	2.5
10/3/2000	1005	28.85	20.9	Clear	2.7	11.7	9.90	34	7.37	346	2.1
10/3/2000	1005	28.85	20.9	Clear	3.0	11.6	9.86	34	7.40	345	2.2
10/3/2000	1005	28.85	20.9	Clear	3.4	11.6	9.91	34	7.40	345	3.0
10/3/2000	1005	28.85	20.9	Clear	3.7	11.6	9.90	34	7.40	345	2.2
10/3/2000	1005	28.85	20.9	Clear	4.0	11.6	9.98	34	7.41	344	2.8
10/3/2000	1005	28.85	20.9	Clear	4.3	11.6	9.94	34	7.41	345	2.2
10/3/2000	1005	28.85	20.9	Clear	4.6	11.6	9.91	34	7.41	344	2.5
10/3/2000	1005	28.85	20.9	Clear	4.9	11.6	9.94	34	7.39	330	20.1
5/13/2002	939	29.12	17.5	Pcloudy	.3	8.1	12.31	20	6.99	435	6.7
5/13/2002	939	29.12	17.5	Pcloudy	.6	8.1	12.20	20	6.94	430	6.4
5/13/2002	939	29.12	17.5	Pcloudy	.9	8.0	12.14	20	6.89	428	6.4
5/13/2002	939	29.12	17.5	Pcloudy	1.2	8.0	12.11	20	6.88	426	6.5
5/13/2002	939	29.12	17.5	Pcloudy	1.5	7.8	12.11	20	6.87	424	6.3
5/13/2002	939	29.12	17.5	Pcloudy	1.8	7.8	12.02	21	6.86	422	6.3
5/13/2002	939	29.12	17.5	Pcloudy	2.1	7.8	11.97	20	6.84	421	6.3
5/13/2002	939	29.12	17.5	Pcloudy	2.4	7.8	11.96	21	6.83	420	6.0
5/13/2002	939	29.12	17.5	Pcloudy	2.7	7.6	--	126	6.40	132	--



**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Peloudu, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
6/17/2002	1010	29.06	24.9	Peloudu	0.3	18.1	9.00	29	7.21	369	9.8
6/17/2002	1010	29.06	24.9	Peloudu	.6	18.0	9.09	29	7.22	366	9.3
6/17/2002	1010	29.06	24.9	Peloudu	.9	17.8	9.13	29	7.21	365	10.2
6/17/2002	1010	29.06	24.9	Peloudu	1.2	17.7	9.06	29	7.19	364	9.8
6/17/2002	1010	29.06	24.9	Peloudu	1.5	17.7	9.01	29	7.15	356	12.9
6/17/2002	1010	29.06	24.9	Peloudu	1.8	17.4	8.94	29	7.10	356	9.5
6/17/2002	1010	29.06	24.9	Peloudu	2.1	17.3	8.84	29	7.05	354	15.2
6/17/2002	1010	29.06	24.9	Peloudu	2.4	17.2	8.81	29	7.03	352	11.8
6/17/2002	1010	29.06	24.9	Peloudu	2.7	17.1	8.72	29	7.00	351	9.6
6/17/2002	1010	29.06	24.9	Peloudu	3.0	17.0	8.59	29	6.70	350	10.3
6/17/2002	1010	29.06	24.9	Peloudu	3.4	17.0	8.51	29	6.89	352	9.6
6/17/2002	1010	29.06	24.9	Peloudu	3.7	17.0	8.60	29	7.09	350	9.2
7/17/2002	940	29.12	27.5	Peloudu	.3	25.4	7.16	37	7.18	376	9.6
7/17/2002	940	29.12	27.5	Peloudu	.6	25.3	7.17	37	7.15	376	9.7
7/17/2002	940	29.12	27.5	Peloudu	.9	25.3	7.19	37	7.16	376	9.6
7/17/2002	940	29.12	27.5	Peloudu	1.2	25.3	7.27	37	7.14	376	9.3
7/17/2002	940	29.12	27.5	Peloudu	1.5	25.3	7.12	37	7.11	376	9.2
7/17/2002	940	29.12	27.5	Peloudu	1.8	25.2	7.14	37	7.11	376	9.5
7/17/2002	940	29.12	27.5	Peloudu	2.1	25.2	6.98	37	7.06	377	9.7
7/17/2002	940	29.12	27.5	Peloudu	2.4	24.9	6.75	37	6.98	380	9.6
7/17/2002	940	29.12	27.5	Peloudu	2.7	24.7	6.35	37	6.86	380	9.5
7/17/2002	940	29.12	27.5	Peloudu	3.0	24.5	4.96	39	6.76	386	9.9
7/17/2002	940	29.12	27.5	Peloudu	3.4	20.4	3.52	40	6.73	219	10.0
7/17/2002	940	29.12	27.5	Peloudu	3.7	19.5	1.01	53	6.86	163	10.0
7/17/2002	940	29.12	27.5	Peloudu	4.0	18.6	.31	59	7.13	109	10.4
7/17/2002	940	29.12	27.5	Peloudu	4.3	18.1	.20	83	7.14	77	--

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Peloudu, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
8/13/2002	211	29	24.4	Peloudu	0.3	21.7	9.03	35	7.91	300	10.4
8/13/2002	211	29	24.4	Peloudu	.6	21.6	9.27	35	7.88	301	10.1
8/13/2002	211	29	24.4	Peloudu	.9	21.6	9.00	35	7.86	301	10.3
8/13/2002	211	29	24.4	Peloudu	1.2	21.5	8.91	35	7.72	305	10.2
8/13/2002	211	29	24.4	Peloudu	1.5	21.3	8.91	35	7.62	309	10.3
8/13/2002	211	29	24.4	Peloudu	1.8	20.8	8.33	36	7.46	314	10.3
8/13/2002	211	29	24.4	Peloudu	2.1	20.7	8.53	36	7.37	318	10.5
8/13/2002	211	29	24.4	Peloudu	2.4	20.6	8.10	36	7.27	321	10.2
8/13/2002	211	29	24.4	Peloudu	2.7	20.5	7.54	36	7.16	324	10.4
8/13/2002	211	29	24.4	Peloudu	3.0	20.5	7.04	36	7.07	328	10.5
8/13/2002	211	29	24.4	Peloudu	3.4	20.3	7.01	37	6.95	331	11.1
8/13/2002	211	29	24.4	Peloudu	3.7	20.3	4.42	41	6.88	280	--
9/10/2002	1018	29.18	16.7	Clear	.3	20.2	8.56	35	7.10	356	10.8
9/10/2002	1018	29.18	16.7	Clear	.6	20.1	8.27	35	7.05	356	10.6
9/10/2002	1018	29.18	16.7	Clear	.9	20.1	8.30	34	7.05	356	10.7
9/10/2002	1018	29.18	16.7	Clear	1.2	20.1	8.29	35	7.04	355	10.8
9/10/2002	1018	29.18	16.7	Clear	1.5	20.1	8.21	34	7.01	355	10.7
9/10/2002	1018	29.18	16.7	Clear	1.8	20.1	8.24	35	7.01	355	10.6
9/10/2002	1018	29.18	16.7	Clear	2.1	20.1	8.11	35	6.97	356	10.7
9/10/2002	1018	29.18	16.7	Clear	2.4	20.1	8.18	34	6.96	356	10.8
9/10/2002	1018	29.18	16.7	Clear	2.7	20.1	8.08	34	6.94	356	11.1
9/10/2002	1018	29.18	16.7	Clear	3.0	20.0	8.11	35	6.92	357	10.5
9/10/2002	1018	29.18	16.7	Clear	3.4	20.1	8.09	35	6.92	356	10.9
9/10/2002	1018	29.18	16.7	Clear	3.7	20.0	8.11	35	9.88	357	11.0
9/10/2002	1018	29.18	16.7	Clear	4.0	20.0	8.11	35	6.89	358	11.3
10/2/2002	1120	29.44	15.6	Peloudu	.3	11.2	11.07	30	7.71	369	11.3
10/2/2002	1120	29.44	15.6	Peloudu	.6	11.1	11.13	30	7.70	369	10.5

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Peloudu, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
10/2/2002	1120	29.44	15.6	Peloudu	0.9	11.2	10.95	30	7.72	367	11.2
10/2/2002	1120	29.44	15.6	Peloudu	1.2	11.2	10.95	30	7.72	367	10.7
10/2/2002	1120	29.44	15.6	Peloudu	1.5	11.2	10.87	30	7.72	367	10.8
10/2/2002	1120	29.44	15.6	Peloudu	1.8	11.2	10.89	30	7.64	367	10.9
10/2/2002	1120	29.44	15.6	Peloudu	2.1	11.2	10.98	30	7.67	368	10.8
10/2/2002	1120	29.44	15.6	Peloudu	2.4	11.2	10.84	30	7.66	368	10.8
10/2/2002	1120	29.44	15.6	Peloudu	2.7	11.2	10.94	30	7.66	364	10.6
10/2/2002	1120	29.44	15.6	Peloudu	3.0	11.1	10.86	30	7.63	369	10.7
10/2/2002	1120	29.44	15.6	Peloudu	3.4	11.1	10.85	30	7.61	369	10.8
10/2/2002	1120	29.44	15.6	Peloudu	3.7	11.0	--	30	7.59	369	--
5/24/2004	1005	29.97	16.6	Clear	.3	9.2	10.82	25	6.63	184	10.4
5/24/2004	1005	29.97	16.6	Clear	.6	9.2	10.83	25	6.63	213	10.0
5/24/2004	1005	29.97	16.6	Clear	.9	9.0	10.87	25	6.51	234	10.3
5/24/2004	1005	29.97	16.6	Clear	1.2	8.9	10.86	25	6.49	245	9.9
5/24/2004	1005	29.97	16.6	Clear	1.5	8.9	10.93	25	6.46	251	10.1
5/24/2004	1005	29.97	16.6	Clear	1.8	8.9	10.84	25	6.46	255	9.9
5/24/2004	1005	29.97	16.6	Clear	2.1	8.8	10.86	25	6.45	259	10.1
5/24/2004	1005	29.97	16.6	Clear	2.4	8.9	10.81	25	6.46	233	10.8
5/24/2004	1005	29.97	16.6	Clear	2.7	8.9	9.95	25	6.13	105	--
5/24/2004	1005	29.97	16.6	Clear	3.0	9.3	6.09	147	5.93	67	--
5/24/2004	1005	29.97	16.6	Clear	3.4	9.4	1.45	128	5.96	60	--
6/7/2004	1001	28.91	15.3	Cloudy	.3	16.4	9.69	25	6.52	393	10.5
6/7/2004	1001	28.91	15.3	Cloudy	.6	16.4	9.46	25	6.51	392	10.3
6/7/2004	1001	28.91	15.3	Cloudy	.9	16.2	9.34	26	6.47	392	10.6
6/7/2004	1001	28.91	15.3	Cloudy	1.2	16.2	9.42	25	6.45	392	10.7
6/7/2004	1001	28.91	15.3	Cloudy	1.5	16.2	9.29	25	6.45	392	10.8
6/7/2004	1001	28.91	15.3	Cloudy	1.8	16.2	9.32	25	6.44	392	9.8

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Pelouidy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ( $\mu\text{S}/\text{cm}$ )	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
6/7/2004	1001	28.91	15.3	Cloudy	2.1	16.2	9.38	26	6.42	310	10.1
6/7/2004	1001	28.91	15.3	Cloudy	2.4	16.0	9.36	25	6.41	324	9.7
6/7/2004	1001	28.91	15.3	Cloudy	2.7	16.2	9.09	25	6.39	319	10.7
6/7/2004	1001	28.91	15.3	Cloudy	3.0	15.5	8.75	26	6.28	294	10.1
6/7/2004	1001	28.91	15.3	Cloudy	3.4	14.9	7.92	46	5.94	112	10.7
6/7/2004	1001	28.91	15.3	Cloudy	3.7	14.7	5.15	47	6.02	145	--
6/7/2004	1001	28.91	15.3	Cloudy	4.0	15.1	2.12	202	6.06	97	--
7/12/2004	930	29.06	23.4	Clear	.3	21.8	8.21	29	6.95	342	11.6
7/12/2004	930	29.06	23.4	Clear	.6	21.5	8.20	29	6.92	341	12.6
7/12/2004	930	29.06	23.4	Clear	.9	21.1	8.11	29	6.93	338	11.7
7/12/2004	930	29.06	23.4	Clear	1.2	20.9	8.12	29	6.94	335	11.4
7/12/2004	930	29.06	23.4	Clear	1.5	19.3	7.03	30	6.62	343	11.7
7/12/2004	930	29.06	23.4	Clear	1.8	18.1	7.08	29	6.55	343	11.3
7/12/2004	930	29.06	23.4	Clear	2.1	17.5	6.94	30	6.48	344	11.0
7/12/2004	930	29.06	23.4	Clear	2.4	17.1	6.90	30	6.47	344	11.3
7/12/2004	930	29.06	23.4	Clear	2.7	16.8	6.90	30	6.46	343	11.3
7/12/2004	930	29.06	23.4	Clear	3.0	16.7	6.82	30	6.43	344	11.0
7/12/2004	930	29.06	23.4	Clear	3.4	16.5	6.15	31	6.39	345	11.1
7/12/2004	930	29.06	23.4	Clear	3.7	16.4	5.89	32	6.35	346	11.7
7/12/2004	930	29.06	23.4	Clear	4.0	16.3	3.47	108	6.08	137	--
8/2/2004	222	29.06	27.8	Pelouidy	.3	23.2	9.07	32	7.54	389	39.1
8/2/2004	222	29.06	27.8	Pelouidy	.6	22.5	9.09	31	7.47	389	29.7
8/2/2004	222	29.06	27.8	Pelouidy	.9	21.8	9.05	32	7.47	389	40.4
8/2/2004	222	29.06	27.8	Pelouidy	1.2	21.4	9.04	32	7.43	391	39.6
8/2/2004	222	29.06	27.8	Pelouidy	1.5	21.1	9.04	32	7.36	393	39.4
8/2/2004	222	29.06	27.8	Pelouidy	1.8	21.0	8.96	32	7.32	394	39.2
8/2/2004	222	29.06	27.8	Pelouidy	2.1	21.0	8.96	32	7.29	395	39.1

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Pcloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
8/2/2004	222	29.06	27.8	Pcloudy	2.4	20.3	8.61	32	7.23	397	39.4
8/2/2004	222	29.06	27.8	Pcloudy	2.7	19.8	8.22	32	7.15	398	39.1
8/2/2004	222	29.06	27.8	Pcloudy	3.0	19.4	7.93	32	7.07	397	17.1
8/2/2004	222	29.06	27.8	Pcloudy	3.4	18.9	3.19	220	6.19	277	--
8/2/2004	222	29.06	27.8	Pcloudy	3.7	18.7	1.53	200	6.10	247	--
9/7/2004	947	30.05	16.4	Cloudy	.3	16.4	10.24	33	7.01	333	5.2
9/7/2004	947	30.05	16.4	Cloudy	.6	16.4	9.95	33	6.95	327	5.3
9/7/2004	947	30.05	16.4	Cloudy	.9	16.4	9.81	33	6.89	323	5.4
9/7/2004	947	30.05	16.4	Cloudy	1.2	16.3	9.60	33	6.86	318	5.4
9/7/2004	947	30.05	16.4	Cloudy	1.5	16.3	9.60	33	6.83	315	5.3
9/7/2004	947	30.05	16.4	Cloudy	1.8	16.2	9.58	33	6.79	312	5.3
9/7/2004	947	30.05	16.4	Cloudy	2.1	16.3	9.56	33	6.81	309	5.3
9/7/2004	947	30.05	16.4	Cloudy	2.4	16.1	9.44	33	6.76	308	5.2
9/7/2004	947	30.05	16.4	Cloudy	2.7	15.9	9.31	33	6.74	307	5.1
9/7/2004	947	30.05	16.4	Cloudy	3.0	15.9	9.35	33	6.77	306	5.2
9/7/2004	947	30.05	16.4	Cloudy	3.4	15.9	9.38	33	6.69	304	5.1
9/7/2004	947	30.05	16.4	Cloudy	3.7	15.9	9.39	33	6.88	304	5.3
9/7/2004	947	30.05	16.4	Cloudy	4.0	15.9	8.93	33	6.55	240	--
9/7/2004	947	30.05	16.4	Cloudy	4.3	15.9	5.91	69	6.06	108	--
10/6/2004	120	28.37	19.9	Clear	.3	7.9	12.61	31	7.64	284	.7
10/6/2004	120	28.37	19.9	Clear	.6	7.8	12.51	31	7.60	283	.8
10/6/2004	120	28.37	19.9	Clear	.9	7.7	12.43	31	7.59	281	.7
10/6/2004	120	28.37	19.9	Clear	1.2	7.6	12.49	31	7.62	279	.8
10/6/2004	120	28.37	19.9	Clear	1.5	7.5	12.52	31	7.62	278	.8
10/6/2004	120	28.37	19.9	Clear	1.8	7.5	12.55	31	7.62	276	.9
10/6/2004	120	28.37	19.9	Clear	2.1	7.5	12.47	31	7.60	275	.8
10/6/2004	120	28.37	19.9	Clear	2.4	7.2	12.49	31	7.60	275	.8

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Pcloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ( $\mu\text{S}/\text{cm}$ )	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
10/6/2004	120	28.37	19.9	Clear	2.7	7.1	12.36	31	7.57	276	0.7
10/6/2004	120	28.37	19.9	Clear	3.0	7.0	12.33	31	7.55	275	.7
10/6/2004	120	28.37	19.9	Clear	3.4	7.0	11.67	33	7.24	226	2.6
10/6/2004	120	28.37	19.9	Clear	3.7	7.0	12.26	34	7.20	224	--
10/6/2004	120	28.37	19.9	Clear	4.0	7.2	5.15	222	6.31	140	--
10/6/2004	120	28.37	19.9	Clear	4.3	8.5	2.87	247	6.32	150	--
5/15/2006	930	29.26	13.3	Cloudy	.3	8.9	12.53	18	6.78	454	0
5/15/2006	930	29.26	13.3	Cloudy	.6	8.8	12.49	18	6.79	453	0
5/15/2006	930	29.26	13.3	Cloudy	.9	8.8	12.38	18	6.82	450	0
5/15/2006	930	29.26	13.3	Cloudy	1.2	8.8	12.36	17	6.84	450	0
5/15/2006	930	29.26	13.3	Cloudy	1.5	8.8	12.28	18	6.84	450	0
5/15/2006	930	29.26	13.3	Cloudy	1.8	8.7	12.30	18	6.85	450	0
5/15/2006	930	29.26	13.3	Cloudy	2.1	8.6	12.25	18	6.85	451	0
5/15/2006	930	29.26	13.3	Cloudy	2.4	8.5	12.31	18	6.86	452	0
5/15/2006	930	29.26	13.3	Cloudy	2.7	8.6	12.12	18	6.90	305	.5
5/15/2006	930	29.26	13.3	Cloudy	3.0	8.6	12.21	18	6.90	320	.2
5/15/2006	930	29.26	13.3	Cloudy	3.4	8.1	12.28	18	6.92	329	.7
5/15/2006	930	29.26	13.3	Cloudy	3.7	7.5	4.96	123	6.49	200	--
5/15/2006	930	29.26	13.3	Cloudy	4.0	7.8	.94	153	6.57	170	--
6/7/2006	930	29.06	24.3	Clear	.3	19.9	7.95	22	6.91	235	1.4
6/7/2006	930	29.06	24.3	Clear	.6	19.8	8.00	22	6.89	242	1.5
6/7/2006	930	29.06	24.3	Clear	.9	19.8	7.95	22	6.82	248	1.4
6/7/2006	930	29.06	24.3	Clear	1.2	19.7	7.94	22	6.85	253	1.4
6/7/2006	930	29.06	24.3	Clear	1.5	19.5	7.90	22	6.89	255	1.4
6/7/2006	930	29.06	24.3	Clear	1.8	19.5	7.81	22	6.87	259	1.4
6/7/2006	930	29.06	24.3	Clear	2.1	19.0	7.32	23	6.85	262	1.5
6/7/2006	930	29.06	24.3	Clear	2.4	19.0	7.38	22	6.85	263	1.4

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; μS/cm, microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Pcloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (μS/cm)	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
6/7/2006	930	29.06	24.3	Clear	2.7	19.0	7.34	22	6.84	265	1.4
6/7/2006	930	29.06	24.3	Clear	3.0	19.9	7.14	22	6.83	266	1.6
6/7/2006	930	29.06	24.3	Clear	3.4	18.9	7.03	23	6.77	265	--
6/7/2006	930	29.06	24.3	Clear	3.7	18.5	2.24	82	6.43	170	--
6/7/2006	930	29.06	24.3	Clear	4.0	16.7	1.75	196	6.47	135	--
6/7/2006	930	29.06	24.3	Clear	4.3	15.1	.85	153	6.54	117	--
7/10/2006	930	29.21	14.8	Clear	.3	20.6	8.50	26	6.79	249	7.5
7/11/2006	930	29.21	14.8	Clear	.6	20.2	8.53	26	6.79	270	7.6
7/12/2006	930	29.21	14.8	Clear	.9	20.0	8.52	26	6.79	277	7.1
7/13/2006	930	29.21	14.8	Clear	1.2	19.8	8.34	26	6.68	286	6.2
7/14/2006	930	29.21	14.8	Clear	1.5	19.7	8.37	26	6.85	289	5.7
7/15/2006	930	29.21	14.8	Clear	1.8	19.6	8.32	26	6.84	290	5.5
7/16/2006	930	29.21	14.8	Clear	2.1	19.6	8.26	26	6.85	292	5.3
7/17/2006	930	29.21	14.8	Clear	2.4	19.6	8.19	26	6.84	294	5.4
7/18/2006	930	29.21	14.8	Clear	2.7	19.5	8.17	26	6.83	296	5.5
7/19/2006	930	29.21	14.8	Clear	3.0	19.4	8.14	26	6.84	298	5.7
7/20/2006	930	29.21	14.8	Clear	3.4	19.4	8.00	26	6.81	294	--
7/21/2006	930	29.21	14.8	Clear	3.7	19.4	5.18	88	6.09	201	--
7/22/2006	930	29.21	14.8	Clear	4.0	19.3	4.75	125	6.13	190	--
7/23/2006	930	29.21	14.8	Clear	4.3	19.3	5.04	185	6.15	170	--
8/15/2006	1012	29.68	17.2	Clear	.3	17.8	10.09	29	7.09	374	5.4
8/15/2006	1012	29.68	17.2	Clear	.6	17.8	9.60	29	7.02	376	5.6
8/15/2006	1012	29.68	17.2	Clear	.9	17.8	9.44	29	7.01	377	5.7
8/15/2006	1012	29.68	17.2	Clear	1.2	17.8	9.48	29	7.03	377	5.7
8/15/2006	1012	29.68	17.2	Clear	1.5	17.6	9.33	29	7.06	375	5.5
8/15/2006	1012	29.68	17.2	Clear	1.8	17.4	9.16	29	7.06	374	5.6
8/15/2006	1012	29.68	17.2	Clear	2.1	17.3	9.25	29	7.05	375	5.7

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Pcloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ( $\mu\text{S}/\text{cm}$ )	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
8/15/2006	1012	29.68	17.2	Clear	2.4	17.2	9.13	29	7.03	376	5.5
8/15/2006	1012	29.68	17.2	Clear	2.7	17.2	9.08	29	7.06	377	5.4
8/15/2006	1012	29.68	17.2	Clear	3.0	17.1	8.87	29	7.06	378	5.5
8/15/2006	1012	29.68	17.2	Clear	3.4	17.0	8.54	29	6.74	383	5.1
8/15/2006	1012	29.68	17.2	Clear	3.7	17.4	1.03	184	6.15	299	--
9/11/2006	1005	29.41	14.3	Pcloudy	.3	14.7	9.73	32	7.42	384	3.3
9/11/2006	1005	29.41	14.3	Pcloudy	.6	14.5	9.65	32	7.33	388	3.5
9/11/2006	1005	29.41	14.3	Pcloudy	.9	14.3	9.47	32	7.24	392	3.6
9/11/2006	1005	29.41	14.3	Pcloudy	1.2	14.2	9.47	32	7.18	394	3.4
9/11/2006	1005	29.41	14.3	Pcloudy	1.5	14.2	9.52	32	7.16	395	3.5
9/11/2006	1005	29.41	14.3	Pcloudy	1.8	14.1	9.39	32	7.13	396	3.2
9/11/2006	1005	29.41	14.3	Pcloudy	2.1	14.1	9.38	32	7.11	397	3.4
9/11/2006	1005	29.41	14.3	Pcloudy	2.4	14.1	9.48	33	7.11	398	3.0
9/11/2006	1005	29.41	14.3	Pcloudy	2.7	14.0	9.24	33	7.10	399	3.6
9/11/2006	1005	29.41	14.3	Pcloudy	3.0	14.0	9.53	33	7.08	399	3.8
9/11/2006	1005	29.41	14.3	Pcloudy	3.4	13.9	9.20	32	7.06	401	4.8
9/11/2006	1005	29.41	14.3	Pcloudy	3.7	13.9	9.08	33	6.86	369	6.0
10/3/2006	955	29.21	12.3	Cloudy	.3	11.8	11.44	30	7.42	379	4.3
10/3/2006	955	29.21	12.3	Cloudy	.6	11.8	11.43	30	7.37	381	4.2
10/3/2006	955	29.21	12.3	Cloudy	.9	11.8	11.45	30	7.32	383	4.2
10/3/2006	955	29.21	12.3	Cloudy	1.2	11.7	11.31	30	7.29	384	4.3
10/3/2006	955	29.21	12.3	Cloudy	1.5	11.7	11.36	30	7.29	384	4.4
10/3/2006	955	29.21	12.3	Cloudy	1.8	11.6	11.40	30	7.27	385	4.4
10/3/2006	955	29.21	12.3	Cloudy	2.1	11.2	11.45	30	7.26	386	4.4
10/3/2006	955	29.21	12.3	Cloudy	2.4	10.5	11.08	30	7.18	391	4.6
10/3/2006	955	29.21	12.3	Cloudy	2.7	9.3	10.73	30	7.06	397	4.6
10/3/2006	955	29.21	12.3	Cloudy	3.0	8.8	10.46	30	7.00	400	5.0



**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; μS/cm, microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; Pc, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (μS/cm)	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
10/3/2006	955	29.21	12.3	Cloudy	3.4	8.7	10.20	30	6.94	403	5.1
10/3/2006	955	29.21	12.3	Cloudy	3.7	8.6	10.09	30	6.89	405	4.9
10/3/2006	955	29.21	12.3	Cloudy	4.0	8.6	9.95	30	6.87	406	5.7
10/3/2006	955	29.21	12.3	Cloudy	4.3	8.6	10.05	30	6.84	406	5.8
10/3/2006	955	29.21	12.3	Cloudy	4.6	8.6	10.06	30	6.82	407	6.0
5/12/2008	1010	29.09	13.9	Pc	.3	8.0	11.04	21	7.52	486	.6
5/12/2008	1010	29.09	13.9	Pc	.6	7.4	11.28	20	7.59	485	.5
5/12/2008	1010	29.09	13.9	Pc	.9	7.3	11.20	20	7.59	487	.4
5/12/2008	1010	29.09	13.9	Pc	1.2	7.2	11.15	20	7.60	488	.3
5/12/2008	1010	29.09	13.9	Pc	1.5	7.2	11.15	20	7.58	489	.3
5/12/2008	1010	29.09	13.9	Pc	1.8	7.1	11.09	20	7.57	490	.3
5/12/2008	1010	29.09	13.9	Pc	2.1	7.0	11.12	20	7.58	490	.3
5/12/2008	1010	29.09	13.9	Pc	2.4	7.0	11.12	20	7.58	491	.3
5/12/2008	1010	29.09	13.9	Pc	2.7	6.9	11.07	20	7.57	491	.2
5/12/2008	1010	29.09	13.9	Pc	3.0	6.9	11.07	20	7.54	493	.2
5/12/2008	1010	29.09	13.9	Pc	3.4	6.9	4.17	21	8.03	390	--
6/2/2008	1020	29.8	18.3	Clear	.3	16.3	9.51	27	6.54	539	.4
6/2/2008	1020	29.8	18.3	Clear	.6	16.3	9.54	25	6.62	537	.5
6/2/2008	1020	29.8	18.3	Clear	.9	16.1	9.57	25	6.65	537	.8
6/2/2008	1020	29.8	18.3	Clear	1.2	16.1	9.56	25	6.67	537	.4
6/2/2008	1020	29.8	18.3	Clear	1.5	15.9	9.56	25	6.48	544	.4
6/2/2008	1020	29.8	18.3	Clear	1.8	15.8	9.51	25	6.54	543	.5
6/2/2008	1020	29.8	18.3	Clear	2.1	15.8	9.45	25	6.61	541	.5
6/2/2008	1020	29.8	18.3	Clear	2.4	15.7	9.45	25	6.66	541	.4
6/2/2008	1020	29.8	18.3	Clear	2.7	15.5	9.35	25	6.60	542	.3
6/2/2008	1020	29.8	18.3	Clear	3.0	15.4	9.28	25	6.61	542	.4
6/2/2008	1020	29.8	18.3	Clear	3.4	15.4	8.82	25	6.56	469	.1

**Appendix 1.** Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; P, cloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ( $\mu\text{S}/\text{cm}$ )	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
6/2/2008	1020	29.8	18.3	Clear	3.7	15.1	8.76	26	6.47	431	--
6/2/2008	1020	29.8	18.3	Clear	4.0	14.3	7.17	26	6.34	397	--
7/15/2008	943	30.27	22.0	Clear	.3	18.6	8.82	31	6.76	412	0
7/15/2008	943	30.27	22.0	Clear	.6	18.5	8.86	31	6.80	410	0
7/15/2008	943	30.27	22.0	Clear	.9	18.4	8.84	31	6.85	405	0
7/15/2008	943	30.27	22.0	Clear	1.2	18.4	8.82	31	6.81	406	0
7/15/2008	943	30.27	22.0	Clear	1.5	18.4	8.79	31	6.78	407	0
7/15/2008	943	30.27	22.0	Clear	1.8	18.2	8.75	31	6.87	400	.2
7/15/2008	943	30.27	22.0	Clear	2.1	18.1	8.71	31	6.89	398	.1
7/15/2008	943	30.27	22.0	Clear	2.4	18.1	8.68	31	6.84	396	.1
7/15/2008	943	30.27	22.0	Clear	2.7	17.7	8.67	31	6.86	393	0
7/15/2008	943	30.27	22.0	Clear	3.0	16.8	8.55	31	6.72	396	0
7/15/2008	943	30.27	22.0	Clear	3.4	16.4	8.51	32	6.70	397	0
7/15/2008	943	30.27	22.0	Clear	3.7	15.9	8.14	31	6.62	394	0
7/15/2008	943	30.27	22.0	Clear	4.0	15.8	7.97	32	6.54	396	1.1
7/15/2008	943	30.27	22.0	Clear	4.3	15.8	7.65	33	6.54	300	--
7/15/2008	943	30.27	22.0	Clear	4.6	15.8	5.30	94	6.32	342	--
8/11/2008	1036	30.86	20.3	Clear	.3	21.2	8.63	36	6.87	487	2.5
8/11/2008	1036	30.86	20.3	Clear	.6	20.6	8.53	36	6.86	493	2.6
8/11/2008	1036	30.86	20.3	Clear	.9	20.3	8.30	36	6.80	498	2.5
8/11/2008	1036	30.86	20.3	Clear	1.2	20.3	8.21	37	6.76	501	2.6
8/11/2008	1036	30.86	20.3	Clear	1.5	20.2	8.10	37	6.68	509	2.4
8/11/2008	1036	30.86	20.3	Clear	1.8	20.1	8.06	36	6.69	509	2.8
8/11/2008	1036	30.86	20.3	Clear	2.1	20.1	7.96	37	6.71	507	2.9
8/11/2008	1036	30.86	20.3	Clear	2.4	20.1	7.76	37	6.63	506	3.1
8/11/2008	1036	30.86	20.3	Clear	2.7	20.0	7.30	37	6.56	503	3.0
8/11/2008	1036	30.86	20.3	Clear	3.0	20.0	7.30	37	6.53	503	3.1
8/11/2008	1036	30.86	20.3	Clear	3.4	19.9	7.18	37	6.48	505	--
8/11/2008	1036	30.86	20.3	Clear	3.7	19.6	1.16	233	5.90	271	--

## Appendix 1. Depth profiles of field properties for Swamp Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25°C; mV, millivolts, NTU, nephelometric turbidity units; --, no data; P, cloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky condition	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ( $\mu\text{S}/\text{cm}$ )	pH (standard units)	Oxidation reduction potential (mV)	Turbidity (NTU)
8/11/2008	1036	30.86	20.3	Clear	4.0	19.2	0.29	223	5.88	231	--
8/11/2008	1036	30.86	20.3	Clear	4.3	19.1	0.24	213	5.91	247	--
9/8/2008	940	30.22	10.4	Clear	.3	13.8	9.19	40	7.05	538	1.3
9/8/2008	940	30.22	10.4	Clear	.6	13.9	9.19	40	6.99	540	1.3
9/8/2008	940	30.22	10.4	Clear	.9	13.9	9.16	40	9.97	541	1.1
9/8/2008	940	30.22	10.4	Clear	1.2	13.9	9.17	40	6.95	542	1.1
9/8/2008	940	30.22	10.4	Clear	1.5	13.9	9.15	40	6.97	541	1.3
9/8/2008	940	30.22	10.4	Clear	1.8	13.9	9.14	40	6.96	541	1.3
9/8/2008	940	30.22	10.4	Clear	2.1	13.9	9.13	40	6.97	539	1.3
9/8/2008	940	30.22	10.4	Clear	2.4	13.9	9.13	40	7.01	535	1.5
9/8/2008	940	30.22	10.4	Clear	2.7	13.9	9.13	40	7.02	531	1.7
9/8/2008	940	30.22	10.4	Clear	3.0	13.8	9.11	40	6.98	531	2.8
9/8/2008	940	30.22	10.4	Clear	3.4	13.8	9.07	40	6.97	527	2.6
9/8/2008	940	30.22	10.4	Clear	3.7	13.8	8.75	40	6.94	471	3.7
9/8/2008	940	30.22	10.4	Clear	4.0	13.8	8.79	41	6.84	414	7.0
9/8/2008	940	30.22	10.4	Clear	4.3	13.9	5.28	119	6.53	345	--
10/2/2008	945	30.62	7.6	Cloudy	.3	10.4	10.18	38	7.24	446	1.3
10/2/2008	945	30.62	7.6	Cloudy	.6	10.3	10.16	38	7.20	448	1.2
10/2/2008	945	30.62	7.6	Cloudy	.9	10.3	10.13	38	7.20	448	1.8
10/2/2008	945	30.62	7.6	Cloudy	1.2	10.3	10.14	37	7.16	449	1.4
10/2/2008	945	30.62	7.6	Cloudy	1.5	10.4	10.14	38	7.13	450	1.4
10/2/2008	945	30.62	7.6	Cloudy	1.8	10.4	10.15	38	7.12	451	1.3
10/2/2008	945	30.62	7.6	Cloudy	2.1	10.4	10.13	38	7.10	452	1.3
10/2/2008	945	30.62	7.6	Cloudy	2.4	10.4	10.13	38	7.11	450	1.3
10/2/2008	945	30.62	7.6	Cloudy	2.7	10.4	10.12	38	7.11	450	1.3
10/2/2008	945	30.62	7.6	Cloudy	3.0	10.4	10.13	38	7.12	450	1.4
10/2/2008	945	30.62	7.6	Cloudy	3.4	10.4	10.15	38	7.13	449	1.8
10/2/2008	945	30.62	7.6	Cloudy	3.7	10.4	10.13	38	7.14	449	1.7
10/2/2008	945	30.62	7.6	Cloudy	4.0	10.4	10.12	38	7.16	447	1.9

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Pcloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
7/16/1997	315	--	--	Pcloudy	0.3	25.6	7.78	40	7.69	276	2.7
7/16/1997	315	--	--	Pcloudy	.9	25.5	7.71	40	7.68	274	12.9
7/16/1997	315	--	--	Pcloudy	1.5	25.2	7.87	40	7.70	265	11.4
7/16/1997	315	--	--	Pcloudy	2.1	25.1	7.70	40	7.61	186	11.2
10/10/1997	325	--	7.22	Clear	.3	11.8	9.65	37	7.34	--	0
10/10/1997	325	--	7.22	Clear	.9	11.7	9.48	37	7.32	--	2.6
10/10/1997	325	--	7.22	Clear	1.5	11.4	9.40	37	7.31	--	7.2
6/26/1998	1040	28.29	23.89	Pcloudy	.3	20.5	7.79	40	7.67	--	--
6/26/1998	1040	28.29	23.89	Pcloudy	.9	20.2	7.82	40	7.67	--	.2
6/26/1998	1040	28.29	23.89	Pcloudy	1.5	20.1	7.71	40	7.64	--	.9
6/26/1998	1040	28.29	23.89	Pcloudy	2.1	19.8	7.91	39	7.70	--	.7
6/26/1998	1040	28.29	23.89	Pcloudy	2.7	18.6	8.03	39	7.73	--	.7
6/26/1998	1040	28.29	23.89	Pcloudy	3.4	19.5	2.43	54	6.81	--	--
7/16/1998	1110	28.48	21.11	Clear	.3	23.7	7.32	45	7.63	340	--
7/16/1998	1110	28.48	21.11	Clear	.9	23.6	7.29	45	7.55	343	.2
7/16/1998	1110	28.48	21.11	Clear	1.5	23.5	7.15	45	7.56	343	.7
7/16/1998	1110	28.48	21.11	Clear	2.1	23.5	7.10	45	7.59	341	.2
7/16/1998	1110	28.48	21.11	Clear	2.7	23.3	7.15	45	7.68	338	1.3
7/16/1998	1110	28.48	21.11	Clear	3.4	23.0	3.69	57	6.68	71	--
9/25/1998	1110	28.48	21.11	Clear	.3	14.6	9.51	41	7.61	345	1.3
9/25/1998	1110	28.48	21.11	Clear	.9	14.5	8.68	41	7.61	346	0
9/25/1998	1110	28.48	21.11	Clear	1.5	14.4	8.49	41	7.63	346	1
9/25/1998	1110	28.48	21.11	Clear	2.1	14.4	8.45	41	7.62	348	1.4
9/25/1998	1110	28.48	21.11	Clear	2.7	14.3	8.63	41	7.62	300	1
9/25/1998	1110	28.48	21.11	Clear	3.4	14.5	5.60	61	6.54	246	--

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter;  $\mu$ S/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Pcloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ( $\mu$ S/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
10/21/1998	300	28.65	7.22	Pcloudy	0.3	7.6	10.87	36	7.50	293	0
10/21/1998	300	28.65	7.22	Pcloudy	.6	7.6	10.79	37	7.48	291	.4
10/21/1998	300	28.65	7.22	Pcloudy	.9	7.4	10.81	36	7.49	291	.6
10/21/1998	300	28.65	7.22	Pcloudy	1.2	7.3	10.91	36	7.48	291	.7
10/21/1998	300	28.65	7.22	Pcloudy	1.5	7.3	10.91	36	7.48	291	.5
10/21/1998	300	28.65	7.22	Pcloudy	1.8	7.2	10.89	36	7.51	290	.4
10/21/1998	300	28.65	7.22	Pcloudy	2.1	7.2	10.86	36	7.52	290	.7
10/21/1998	300	28.65	7.22	Pcloudy	2.4	7.2	10.85	36	7.52	290	.7
10/21/1998	300	28.65	7.22	Pcloudy	2.7	7.1	10.94	36	7.52	290	.5
10/21/1998	300	28.65	7.22	Pcloudy	3.0	6.9	10.86	36	7.52	289	1.1
10/21/1998	300	28.65	7.22	Pcloudy	3.4	7.0	10.04	38	7.37	253	--
5/1/2000	1140	29.15	12.78	Cloudy	.3	10.5	11.45	42	7.31	345	--
5/1/2000	1140	29.15	12.78	Cloudy	.9	10.5	11.01	43	7.20	339	--
5/1/2000	1140	29.15	12.78	Cloudy	1.5	10.5	11.06	43	7.18	337	.2
5/1/2000	1140	29.15	12.78	Cloudy	2.1	10.5	11.05	43	7.15	337	--
5/1/2000	1140	29.15	12.78	Cloudy	2.7	10.5	11.04	43	7.13	336	--
5/1/2000	1140	29.15	12.78	Cloudy	3.4	10.5	6.00	43	6.61	250	--
6/6/2000	1120	29.44	18.33	Clear	.3	16.7	9.34	41	7.58	333	--
6/6/2000	1120	29.44	18.33	Clear	.6	16.7	9.26	41	7.53	333	--
6/6/2000	1120	29.44	18.33	Clear	.9	16.7	9.20	41	7.50	334	--
6/6/2000	1120	29.44	18.33	Clear	1.2	16.6	9.14	41	7.50	334	--
6/6/2000	1120	29.44	18.33	Clear	1.5	16.5	9.09	41	7.49	334	--
6/6/2000	1120	29.44	18.33	Clear	1.8	16.5	9.08	41	7.48	334	--
6/6/2000	1120	29.44	18.33	Clear	2.1	16.2	9.02	41	7.46	335	--
6/6/2000	1120	29.44	18.33	Clear	2.4	16.1	9.01	41	7.45	335	--
6/6/2000	1120	29.44	18.33	Clear	2.7	16.1	9.00	41	7.40	336	--
6/6/2000	1120	29.44	18.33	Clear	3.0	15.9	8.87	41	7.30	338	--

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Peloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
6/6/2000	1120	29.44	18.33	Clear	3.4	15.8	8.48	41	7.25	337	--
6/6/2000	1120	29.44	18.33	Clear	3.7	15.7	8.71	41	7.28	337	--
6/6/2000	1120	29.44	18.33	Clear	4.0	15.7	8.80	41	7.33	335	--
6/6/2000	1120	29.44	18.33	Clear	4.3	15.6	7.31	42	6.91	277	--
6/6/2000	1120	29.44	18.33	Clear	4.6	15.1	6.52	56	6.61	233	--
7/10/2000	1130	29.35	24.22	Peloudy	.3	21.8	9.40	44	7.79	204	--
7/10/2000	1130	29.35	24.22	Peloudy	.6	21.7	9.12	44	7.78	207	1.2
7/10/2000	1130	29.35	24.22	Peloudy	.9	21.7	9.00	44	7.80	209	.6
7/10/2000	1130	29.35	24.22	Peloudy	1.2	21.7	8.95	44	7.80	210	.6
7/10/2000	1130	29.35	24.22	Peloudy	1.5	21.7	8.93	43	7.81	212	.5
7/10/2000	1130	29.35	24.22	Peloudy	1.8	21.6	8.96	44	7.80	214	.9
7/10/2000	1130	29.35	24.22	Peloudy	2.1	21.6	8.87	44	7.80	215	1
7/10/2000	1130	29.35	24.22	Peloudy	2.4	21.5	8.88	43	7.79	217	.8
7/10/2000	1130	29.35	24.22	Peloudy	2.7	21.5	8.89	44	7.76	220	.8
7/10/2000	1130	29.35	24.22	Peloudy	3.0	20.6	8.73	43	7.65	223	.9
7/10/2000	1130	29.35	24.22	Peloudy	3.4	20.1	8.26	43	7.50	237	1.4
7/10/2000	1130	29.35	24.22	Peloudy	3.7	19.4	7.06	44	7.11	248	1.9
7/10/2000	1130	29.35	24.22	Peloudy	4.0	18.3	5.93	45	6.76	255	2.2
7/10/2000	1130	29.35	24.22	Peloudy	4.3	17.1	2.27	48	6.54	262	3.6
7/10/2000	1130	29.35	24.22	Peloudy	4.6	17.0	.86	88	6.20	158	--
8/15/2000	1100	29.62	20.50	Peloudy	.3	21.2	8.15	48	7.13	246	--
8/15/2000	1100	29.62	20.50	Peloudy	.6	21.2	8.21	48	7.15	247	0
8/15/2000	1100	29.62	20.50	Peloudy	.9	21.1	8.19	48	7.16	248	0
8/15/2000	1100	29.62	20.50	Peloudy	1.2	21.1	8.18	48	7.16	249	.8
8/15/2000	1100	29.62	20.50	Peloudy	1.5	21.1	8.19	48	7.17	250	2.3
8/15/2000	1100	29.62	20.50	Peloudy	1.8	21.1	8.05	48	7.17	252	1.1
8/15/2000	1100	29.62	20.50	Peloudy	2.1	21.1	8.15	48	7.17	252	1.7

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Peloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
8/15/2000	1100	29.62	20.50	Peloudy	2.4	21.1	8.10	48	7.17	253	1.1
8/15/2000	1100	29.62	20.50	Peloudy	2.7	21.0	7.94	48	7.16	255	1.4
8/15/2000	1100	29.62	20.50	Peloudy	3.0	20.9	7.83	48	7.11	258	1.3
8/15/2000	1100	29.62	20.50	Peloudy	3.4	20.9	7.91	48	7.09	259	1.7
8/15/2000	1100	29.62	20.50	Peloudy	3.7	20.9	7.90	48	7.08	260	1.4
8/15/2000	1100	29.62	20.50	Peloudy	4.0	20.8	7.27	48	6.99	249	1.9
8/15/2000	1100	29.62	20.50	Peloudy	4.3	20.6	5.86	49	6.50	176	8.3
9/11/2000	1140	28.67	26.39	Peloudy	.3	16.7	9.30	43	7.56	270	--
9/11/2000	1140	28.67	26.39	Peloudy	.6	16.6	9.41	43	7.55	270	1.1
9/11/2000	1140	28.67	26.39	Peloudy	.9	16.5	9.48	43	7.53	269	1.8
9/11/2000	1140	28.67	26.39	Peloudy	1.2	16.5	9.41	43	7.53	269	1.4
9/11/2000	1140	28.67	26.39	Peloudy	1.5	16.4	9.48	43	7.54	268	1.5
9/11/2000	1140	28.67	26.39	Peloudy	1.8	16.4	9.44	43	7.55	267	1.2
9/11/2000	1140	28.67	26.39	Peloudy	2.1	16.3	9.43	43	7.52	269	1.3
9/11/2000	1140	28.67	26.39	Peloudy	2.4	16.2	9.32	43	7.48	269	1.5
9/11/2000	1140	28.67	26.39	Peloudy	2.7	16.2	9.26	42	7.46	270	1.4
9/11/2000	1140	28.67	26.39	Peloudy	3.0	16.1	9.20	42	7.45	269	1.6
9/11/2000	1140	28.67	26.39	Peloudy	3.4	16.1	9.13	43	7.43	270	1.5
9/11/2000	1140	28.67	26.39	Peloudy	3.7	16.1	9.11	43	7.37	272	1.7
9/11/2000	1140	28.67	26.39	Peloudy	4.0	16.0	8.29	44	7.09	203	--
10/3/2000	1115	28.88	12.50	Clear	.3	12.5	10.53	43	7.49	317	--
10/3/2000	1115	28.88	12.50	Clear	.6	12.5	10.44	43	7.51	316	0
10/3/2000	1115	28.88	12.50	Clear	.9	12.5	10.47	42	7.52	317	0
10/3/2000	1115	28.88	12.50	Clear	1.2	12.5	10.41	43	7.54	317	.3
10/3/2000	1115	28.88	12.50	Clear	1.5	12.5	10.39	43	7.54	318	2.3
10/3/2000	1115	28.88	12.50	Clear	1.8	12.5	10.34	42	7.58	317	.9
10/3/2000	1115	28.88	12.50	Clear	2.1	12.5	10.37	43	7.56	318	1.2

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Peloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
10/3/2000	1115	28.88	12.50	Clear	2.4	12.5	10.30	43	7.58	318	1.3
10/3/2000	1115	28.88	12.50	Clear	2.7	12.5	10.32	43	7.57	319	1.1
10/3/2000	1115	28.88	12.50	Clear	3.0	12.4	10.27	42	7.58	319	1.3
10/3/2000	1115	28.88	12.50	Clear	3.4	12.4	10.23	42	7.57	320	--
10/3/2000	1115	28.88	12.50	Clear	3.7	12.4	10.20	42	7.55	321	1.5
10/3/2000	1115	28.88	12.50	Clear	4.0	12.4	7.92	42	7.23	204	--
5/13/2002	1100	29.12	17.50	Peloudy	.3	8.4	12.00	36	7.67	267	3.6
5/13/2002	1100	29.12	17.50	Peloudy	.6	8.4	12.01	36	7.65	268	3.0
5/13/2002	1100	29.12	17.50	Peloudy	.9	8.1	12.06	36	7.64	268	3.1
5/13/2002	1100	29.12	17.50	Peloudy	1.2	7.9	12.13	36	7.63	269	3.0
5/13/2002	1100	29.12	17.50	Peloudy	1.5	7.9	12.08	36	7.61	270	3.0
5/13/2002	1100	29.12	17.50	Peloudy	1.8	7.8	12.06	36	7.59	271	2.7
5/13/2002	1100	29.12	17.50	Peloudy	2.1	7.8	12.02	36	7.57	272	2.9
5/13/2002	1100	29.12	17.50	Peloudy	2.4	7.8	12.05	36	7.58	271	6.4
5/13/2002	1100	29.12	17.50	Peloudy	2.7	7.8	11.19	39	7.35	150	--
5/13/2002	1100	29.12	17.50	Peloudy	3.0	7.4	9.13	43	7.32	120	--
5/13/2002	1100	29.12	17.50	Peloudy	3.4	7.8	11.19	38	7.34	271	6.4
5/13/2002	1100	29.12	17.50	Peloudy	3.7	7.7	11.18	39	7.36	271	6.3
5/13/2002	1100	29.12	17.50	Peloudy	4.0	7.7	11.19	38	7.35	271	6.3
5/13/2002	1100	29.12	17.50	Peloudy	4.3	7.7	11.20	39	7.36	271	6.3
6/17/2002	1122	29.06	24.89	Peloudy	.3	18.5	8.99	40	7.34	264	8.0
6/17/2002	1122	29.06	24.89	Peloudy	.6	18.4	8.93	40	7.34	265	8.2
6/17/2002	1122	29.06	24.89	Peloudy	.9	18.1	8.89	40	7.34	265	8.0
6/17/2002	1122	29.06	24.89	Peloudy	1.2	18.0	8.90	40	7.35	266	8.2
6/17/2002	1122	29.06	24.89	Peloudy	1.5	18.0	8.89	40	7.36	266	8.3
6/17/2002	1122	29.06	24.89	Peloudy	1.8	17.9	8.95	40	7.33	268	8.2
6/17/2002	1122	29.06	24.89	Peloudy	2.1	17.9	8.88	40	7.32	269	8.3



**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997-2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Peloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
6/17/2002	1122	29.06	24.89	Peloudy	2.4	17.8	8.90	40	7.35	269	8.1
6/17/2002	1122	29.06	24.89	Peloudy	2.7	17.7	8.95	39	7.39	267	10.4
6/17/2002	1122	29.06	24.89	Peloudy	3.0	17.5	8.70	40	7.32	162	--
7/17/2002	1024	29.15	27.72	Peloudy	.3	25.6	7.31	46	7.43	331	8.7
7/17/2002	1024	29.15	27.72	Peloudy	.6	25.6	7.38	46	7.39	329	8.5
7/17/2002	1024	29.15	27.72	Peloudy	.9	25.6	7.37	46	7.38	329	8.2
7/17/2002	1024	29.15	27.72	Peloudy	1.2	25.5	7.37	46	7.37	328	8.7
7/17/2002	1024	29.15	27.72	Peloudy	1.5	25.4	7.24	46	7.30	331	8.6
7/17/2002	1024	29.15	27.72	Peloudy	1.8	25.4	7.10	47	7.23	331	8.7
7/17/2002	1024	29.15	27.72	Peloudy	2.1	25.4	7.05	47	7.22	330	8.6
7/17/2002	1024	29.15	27.72	Peloudy	2.4	25.3	7.03	47	7.16	330	9.0
7/17/2002	1024	29.15	27.72	Peloudy	2.7	25.3	6.93	47	7.13	296	--
8/13/2002	315	28.63	22.22	Peloudy	.3	22.2	8.71	46	7.74	259	9.3
8/13/2002	315	28.63	22.22	Peloudy	.6	22.2	8.73	46	7.73	260	9.1
8/13/2002	315	28.63	22.22	Peloudy	.9	22.2	8.75	45	7.72	262	8.7
8/13/2002	315	28.63	22.22	Peloudy	1.2	22.1	8.71	46	7.72	262	8.9
8/13/2002	315	28.63	22.22	Peloudy	1.5	22.1	8.75	46	7.73	264	8.9
8/13/2002	315	28.63	22.22	Peloudy	1.8	22.1	8.71	46	7.76	264	9.4
8/13/2002	315	28.63	22.22	Peloudy	2.1	22.0	8.70	45	7.83	243	--
9/10/2002	1125	29.15	18.33	Peloudy	.3	21.1	7.68	45	7.14	364	9.8
9/10/2002	1125	29.15	18.33	Peloudy	.6	21.1	7.59	45	7.10	361	9.5
9/10/2002	1125	29.15	18.33	Peloudy	.9	21.1	7.66	45	7.07	361	9.6
9/10/2002	1125	29.15	18.33	Peloudy	1.2	21.1	7.60	45	7.10	358	9.5
9/10/2002	1125	29.15	18.33	Peloudy	1.5	21.1	7.63	45	7.08	359	9.4
9/10/2002	1125	29.15	18.33	Peloudy	1.8	21.1	7.69	45	7.06	360	9.5
9/10/2002	1125	29.15	18.33	Peloudy	2.1	21.1	7.77	45	7.06	359	9.7

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury, °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Pelouly, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
9/10/2002	1125	29.15	18.33	Pelouly	2.4	21.0	7.82	45	7.06	359	9.5
9/10/2002	1125	29.15	18.33	Pelouly	2.7	21.0	7.70	45	7.06	359	9.6
9/10/2002	1125	29.15	18.33	Pelouly	3.0	21.0	7.73	45	7.07	357	9.5
9/10/2002	1125	29.15	18.33	Pelouly	3.4	21.0	7.70	45	7.07	358	9.5
9/10/2002	1125	29.15	18.33	Pelouly	3.7	21.0	7.18	50	6.98	195	--
10/2/2002	1215	29.44	17.22	Pelouly	.3	12.2	9.13	41	7.97	277	9.9
10/2/2002	1215	29.44	17.22	Pelouly	.6	12.1	9.02	41	7.86	282	9.8
10/2/2002	1215	29.44	17.22	Pelouly	.9	12.1	8.98	41	7.85	283	10.0
10/2/2002	1215	29.44	17.22	Pelouly	1.2	12.1	8.94	41	7.74	288	9.7
10/2/2002	1215	29.44	17.22	Pelouly	1.5	12.1	8.95	41	7.72	291	9.9
10/2/2002	1215	29.44	17.22	Pelouly	1.8	12.1	9.01	41	7.67	294	9.9
10/2/2002	1215	29.44	17.22	Pelouly	2.1	12.1	8.99	41	7.66	295	9.7
10/2/2002	1215	29.44	17.22	Pelouly	2.4	120.5	8.98	41	7.64	297	9.6
10/2/2002	1215	29.44	17.22	Pelouly	2.7	120.5	8.94	41	7.62	298	9.6
10/2/2002	1215	29.44	17.22	Pelouly	3.0	12.0	8.94	41	7.61	299	9.8
10/2/2002	1215	29.44	17.22	Pelouly	3.4	12.1	8.97	41	7.58	302	9.8
10/2/2002	1215	29.44	17.22	Pelouly	3.7	12.0	8.96	41	7.57	302	9.7
10/2/2002	1215	29.44	17.22	Pelouly	4.0	11.9	8.95	41	7.57	303	9.7
5/24/2004	1127	29.97	13.78	Clear	.3	10.9	10.84	47	7.16	309	8.8
5/24/2004	1127	29.97	13.78	Clear	.6	10.8	10.76	47	7.12	309	9.0
5/24/2004	1127	29.97	13.78	Clear	.9	10.8	10.70	47	7.13	309	8.7
5/24/2004	1127	29.97	13.78	Clear	1.2	10.6	10.64	47	7.10	309	8.2
5/24/2004	1127	29.97	13.78	Clear	1.5	10.6	10.76	47	7.10	308	8.3
5/24/2004	1127	29.97	13.78	Clear	1.8	10.5	10.75	47	7.10	307	8.6
5/24/2004	1127	29.97	13.78	Clear	2.1	10.5	10.74	47	7.09	307	8.5
5/24/2004	1127	29.97	13.78	Clear	2.4	10.6	10.62	48	6.75	150	--
5/24/2004	1127	29.97	13.78	Clear	2.7	10.5	8.43	70	6.42	57	--
5/24/2004	1127	29.97	13.78	Clear	3.0	10.4	4.12	53	6.44	75	--

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Pelouly, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
6/7/2004	1111	28.88	14.89	Cloudy	0.3	15.9	10.58	44	7.34	282	8.4
6/7/2004	1111	28.88	14.89	Cloudy	.6	15.9	10.58	44	7.33	278	8.3
6/7/2004	1111	28.88	14.89	Cloudy	.9	15.9	10.61	44	7.32	279	8.5
6/7/2004	1111	28.88	14.89	Cloudy	1.2	15.9	10.55	44	7.31	279	8.2
6/7/2004	1111	28.88	14.89	Cloudy	1.5	15.8	10.58	44	7.30	278	8.5
6/7/2004	1111	28.88	14.89	Cloudy	1.8	15.7	10.57	44	7.31	278	8.7
6/7/2004	1111	28.88	14.89	Cloudy	2.1	15.5	10.54	44	7.30	278	9.0
6/7/2004	1111	28.88	14.89	Cloudy	2.4	15.4	10.68	44	7.29	278	8.6
6/7/2004	1111	28.88	14.89	Cloudy	2.7	15.7	9.58	44	7.16	130	--
6/7/2004	1111	28.88	14.89	Cloudy	3.0	15.6	8.86	56	6.95	90	--
7/12/2004	1027	29.09	28.78	Clear	.3	21.6	9.10	44	8.04	292	8.6
7/12/2004	1027	29.09	28.78	Clear	.6	21.3	9.18	44	8.00	293	8.1
7/12/2004	1027	29.09	28.78	Clear	.9	21.2	9.25	44	8.04	290	8.3
7/12/2004	1027	29.09	28.78	Clear	1.2	21.1	9.31	44	8.12	283	8.6
7/12/2004	1027	29.09	28.78	Clear	1.5	21.0	9.30	45	8.08	282	8.5
7/12/2004	1027	29.09	28.78	Clear	1.8	20.9	9.22	44	8.17	283	8.8
7/12/2004	1027	29.09	28.78	Clear	2.1	20.8	9.20	44	8.03	284	8.5
7/12/2004	1027	29.09	28.78	Clear	2.4	20.2	9.53	44	8.43	269	8.9
7/12/2004	1027	29.09	28.78	Clear	2.7	19.7	9.38	44	8.05	163	--
7/12/2004	1027	29.09	28.78	Clear	3.0	18.4	2.90	68	6.37	119	--
8/2/2004	340	29.06	26.78	Pelouly	.3	23.1	9.16	46	8.36	295	30.7
8/2/2004	340	29.06	26.78	Pelouly	.6	22.9	9.21	46	8.37	296	29.6
8/2/2004	340	29.06	26.78	Pelouly	.9	22.7	9.29	46	8.39	296	30.4
8/2/2004	340	29.06	26.78	Pelouly	1.2	22.4	9.27	46	8.41	297	30.3
8/2/2004	340	29.06	26.78	Pelouly	1.5	22.1	9.42	46	8.41	298	30.7
8/2/2004	340	29.06	26.78	Pelouly	1.8	21.9	9.46	46	8.44	299	30.6
8/2/2004	340	29.06	26.78	Pelouly	2.1	21.9	9.46	46	8.46	299	30.0

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Peloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
8/2/2004	340	29.06	26.78	Peloudy	2.4	21.9	9.51	46	8.46	299	33.0
8/2/2004	340	29.06	26.78	Peloudy	2.7	21.9	8.57	50	8.18	287	--
9/7/2004	1041	30.05	16.61	Peloudy	.3	18.1	10.43	46	7.67	264	.8
9/7/2004	1041	30.05	16.61	Peloudy	.6	18.1	10.13	46	7.64	262	.8
9/7/2004	1041	30.05	16.61	Peloudy	.9	18.0	9.88	46	7.64	257	.9
9/7/2004	1041	30.05	16.61	Peloudy	1.2	18.0	9.89	46	7.64	255	.9
9/7/2004	1041	30.05	16.61	Peloudy	1.5	18.0	9.99	46	7.65	253	1.0
9/7/2004	1041	30.05	16.61	Peloudy	1.8	18.0	9.84	46	7.66	252	1.0
9/7/2004	1041	30.05	16.61	Peloudy	2.1	18.0	9.95	46	7.74	249	1.0
9/7/2004	1041	30.05	16.61	Peloudy	2.4	18.0	9.93	46	7.78	247	1.4
9/7/2004	1041	30.05	16.61	Peloudy	2.7	18.0	9.85	46	7.73	220	25.5
9/7/2004	1041	30.05	16.61	Peloudy	3.0	18.0	9.74	57	6.99	59	--
10/6/2004	300	28.37	20.28	Clear	.3	10.5	11.30	44	7.73	266	0
10/6/2004	300	28.37	20.28	Clear	.6	10.5	11.34	44	7.74	264	0
10/6/2004	300	28.37	20.28	Clear	.9	10.4	11.19	44	7.74	262	0
10/6/2004	300	28.37	20.28	Clear	1.2	10.3	11.27	44	7.74	260	0
10/6/2004	300	28.37	20.28	Clear	1.5	10.3	11.29	44	7.76	259	0
10/6/2004	300	28.37	20.28	Clear	1.8	10.3	11.26	44	7.78	257	0
10/6/2004	300	28.37	20.28	Clear	2.1	10.2	11.27	44	7.79	256	0
10/6/2004	300	28.37	20.28	Clear	2.4	9.4	11.27	43	7.71	213	9.5
10/6/2004	300	28.37	20.28	Clear	2.7	9.5	11.26	43	7.78	200	23.3
10/6/2004	300	28.37	20.28	Clear	3.0	9.8	9.62	51	7.56	111	--
5/15/2006	1030	29.26	14.11	Rain	.3	9.3	11.96	38	7.48	338	0
5/15/2006	1030	29.26	14.11	Rain	.6	9.3	12.01	37	7.47	341	0
5/15/2006	1030	29.26	14.11	Rain	.9	9.3	11.92	38	7.50	341	0
5/15/2006	1030	29.26	14.11	Rain	1.2	9.3	11.94	38	7.52	341	0

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; P, cloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
5/15/2006	1030	29.26	14.11	Rain	1.5	9.2	11.96	38	7.54	341	0
5/15/2006	1030	29.26	14.11	Rain	1.8	9.1	12.01	38	7.55	341	0
5/15/2006	1030	29.26	14.11	Rain	2.1	9.1	11.96	38	7.54	342	0
5/15/2006	1030	29.26	14.11	Rain	2.4	8.9	11.97	37	7.56	343	0
5/15/2006	1030	29.26	14.11	Rain	2.7	8.9	11.90	38	7.56	343	0
5/15/2006	1030	29.26	14.11	Rain	3.0	8.8	11.85	38	7.56	344	0
5/15/2006	1030	29.26	14.11	Rain	3.4	8.8	11.85	38	7.55	345	0
5/15/2006	1030	29.26	14.11	Rain	3.7	8.7	11.88	38	7.56	346	0
5/15/2006	1030	29.26	14.11	Rain	4.0	8.6	11.89	38	7.57	346	0
5/15/2006	1030	29.26	14.11	Rain	4.3	8.6	11.84	38	7.58	350	0
5/15/2006	1030	29.26	14.11	Rain	4.6	8.5	11.87	38	7.57	348	0
5/15/2006	1030	29.26	14.11	Rain	4.9	8.5	11.89	38	7.57	351	0
5/15/2006	1030	29.26	14.11	Rain	5.2	8.4	11.75	38	7.56	351	0
5/15/2006	1030	29.26	14.11	Rain	5.5	8.4	11.68	38	7.56	352	0
5/15/2006	1030	29.26	14.11	Rain	5.8	8.4	11.64	38	7.56	348	--
6/7/2006	1100	29.09	23.94	Clear	.3	20.9	9.08	38	7.91	263	0
6/7/2006	1100	29.09	23.94	Clear	.6	20.9	9.17	38	7.90	263	0
6/7/2006	1100	29.09	23.94	Clear	.9	20.9	9.19	38	7.93	262	0
6/7/2006	1100	29.09	23.94	Clear	1.2	20.8	9.13	38	7.95	261	0
6/7/2006	1100	29.09	23.94	Clear	1.5	20.8	9.19	38	7.98	259	0
6/7/2006	1100	29.09	23.94	Clear	1.8	20.8	9.07	38	8.00	258	0
6/7/2006	1100	29.09	23.94	Clear	2.1	20.5	9.02	38	8.00	258	0
6/7/2006	1100	29.09	23.94	Clear	2.4	20.2	9.03	38	7.98	258	0
6/7/2006	1100	29.09	23.94	Clear	2.7	20.1	8.98	38	7.95	259	0
6/7/2006	1100	29.09	23.94	Clear	3.0	19.8	9.13	38	7.92	261	0
6/7/2006	1100	29.09	23.94	Clear	3.4	19.0	10.45	37	8.01	256	0
6/7/2006	1100	29.09	23.94	Clear	3.7	17.0	11.34	37	8.09	255	0
6/7/2006	1100	29.09	23.94	Clear	4.0	16.1	11.23	37	8.04	258	0

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; P, cloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
6/7/2006	1100	29.09	23.94	Clear	4.3	15.4	11.47	38	8.06	257	0
6/7/2006	1100	29.09	23.94	Clear	4.6	14.9	11.49	38	8.10	256	0
6/7/2006	1100	29.09	23.94	Clear	4.9	14.2	11.33	39	8.07	258	1.4
6/7/2006	1100	29.09	23.94	Clear	5.2	13.7	10.46	40	7.92	266	2.6
6/7/2006	1100	29.09	23.94	Clear	5.5	13.5	7.30	63	7.03	191	--
6/7/2006	1100	29.09	23.94	Clear	5.8	13.4	3.56	65	6.76	200	--
7/10/2006	1040	29.21	18.61	Clear	.3	22.1	8.67	41	7.37	248	2.0
7/10/2006	1040	29.21	18.61	Clear	.6	21.9	8.62	40	7.39	251	2.1
7/10/2006	1040	29.21	18.61	Clear	.9	21.8	8.68	41	7.41	252	2.0
7/10/2006	1040	29.21	18.61	Clear	1.2	21.7	8.70	41	7.47	251	2.1
7/10/2006	1040	29.21	18.61	Clear	1.5	21.6	8.57	41	7.48	251	1.9
7/10/2006	1040	29.21	18.61	Clear	1.8	21.6	8.57	41	7.48	251	1.8
7/10/2006	1040	29.21	18.61	Clear	2.1	21.6	8.47	41	7.49	252	1.9
7/10/2006	1040	29.21	18.61	Clear	2.4	21.5	8.57	41	7.49	253	2.0
7/10/2006	1040	29.21	18.61	Clear	2.7	21.5	8.58	41	7.49	253	2.0
7/10/2006	1040	29.21	18.61	Clear	3.0	21.4	8.61	41	7.53	253	1.9
7/10/2006	1040	29.21	18.61	Clear	3.4	21.3	8.68	41	7.51	254	2.0
7/10/2006	1040	29.21	18.61	Clear	3.7	21.3	8.50	41	7.50	255	1.9
7/10/2006	1040	29.21	18.61	Clear	4.0	21.3	8.52	41	7.49	256	1.9
7/10/2006	1040	29.21	18.61	Clear	4.3	21.3	8.48	41	7.48	257	1.8
7/10/2006	1040	29.21	18.61	Clear	4.6	21.3	8.48	41	7.47	258	1.9
7/10/2006	1040	29.21	18.61	Clear	4.9	21.3	8.45	41	7.46	259	1.8
7/10/2006	1040	29.21	18.61	Clear	5.2	21.2	2.75	67	6.59	184	--
7/10/2006	1040	29.21	18.61	Clear	5.5	20.9	1.54	78	6.28	188	--
8/15/2006	1118	29.68	18.44	Clear	.3	20.4	7.49	43	7.49	322	1.4
8/15/2006	1118	29.68	18.44	Clear	.6	20.4	7.51	43	7.51	322	1.3
8/15/2006	1118	29.68	18.44	Clear	.9	20.4	7.52	42	7.52	322	1.3

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Peloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ( $\mu\text{S}/\text{cm}$ )	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
8/15/2006	1118	29.68	18.44	Clear	1.2	20.4	7.55	43	7.55	321	1.4
8/15/2006	1118	29.68	18.44	Clear	1.5	20.4	7.58	42	7.58	320	1.5
8/15/2006	1118	29.68	18.44	Clear	1.8	20.3	7.61	42	7.61	319	1.5
8/15/2006	1118	29.68	18.44	Clear	2.1	20.3	7.63	43	7.63	319	1.4
8/15/2006	1118	29.68	18.44	Clear	2.4	20.3	7.63	42	7.63	319	1.6
8/15/2006	1118	29.68	18.44	Clear	2.7	20.2	7.64	42	7.64	318	1.5
8/15/2006	1118	29.68	18.44	Clear	3.0	20.2	7.63	43	7.63	319	1.4
8/15/2006	1118	29.68	18.44	Clear	3.4	20.1	7.63	43	7.63	319	1.5
8/15/2006	1118	29.68	18.44	Clear	3.7	20.1	7.62	43	7.62	320	1.4
8/15/2006	1118	29.68	18.44	Clear	4.0	20.1	7.61	42	7.61	321	1.3
8/15/2006	1118	29.68	18.44	Clear	4.3	20.1	8.98	42	7.62	321	1.6
8/15/2006	1118	29.68	18.44	Clear	4.6	20.1	7.42	43	7.28	307	5.4
8/15/2006	1118	29.68	18.44	Clear	4.9	20.1	6.52	62	6.78	299	--
9/11/2006	1132	29.41	16.22	Peloudy	.3	17.0	9.58	42	7.66	282	0
9/11/2006	1132	29.41	16.22	Peloudy	.6	17.0	9.34	42	7.67	283	.3
9/11/2006	1132	29.41	16.22	Peloudy	.9	17.0	9.36	42	7.66	285	.2
9/11/2006	1132	29.41	16.22	Peloudy	1.2	17.0	9.46	42	7.66	287	.3
9/11/2006	1132	29.41	16.22	Peloudy	1.5	16.9	9.43	42	7.66	287	.4
9/11/2006	1132	29.41	16.22	Peloudy	1.8	16.8	9.35	42	7.64	289	0
9/11/2006	1132	29.41	16.22	Peloudy	2.1	16.7	9.23	42	7.64	289	.2
9/11/2006	1132	29.41	16.22	Peloudy	2.4	16.6	9.29	42	7.63	290	0
9/11/2006	1132	29.41	16.22	Peloudy	2.7	16.6	9.26	42	7.63	292	.2
9/11/2006	1132	29.41	16.22	Peloudy	3.0	16.6	9.23	42	7.62	292	0
9/11/2006	1132	29.41	16.22	Peloudy	3.4	16.5	9.14	42	7.59	295	0
9/11/2006	1132	29.41	16.22	Peloudy	3.7	16.5	9.18	42	7.58	295	0
9/11/2006	1132	29.41	16.22	Peloudy	4.0	16.4	9.26	42	7.58	296	.1
9/11/2006	1132	29.41	16.22	Peloudy	4.3	16.4	9.23	42	7.58	296	0
9/11/2006	1132	29.41	16.22	Peloudy	4.6	16.5	4.24	51	7.04	236	--

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; P, cloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
10/3/2006	1100	29.18	13.00	Cloudy	0.3	11.4	11.05	40	7.51	347	1.3
10/3/2006	1100	29.18	13.00	Cloudy	.6	11.4	10.98	40	7.50	347	1.0
10/3/2006	1100	29.18	13.00	Cloudy	.9	11.4	10.99	40	7.49	348	2.0
10/3/2006	1100	29.18	13.00	Cloudy	1.2	11.4	10.95	40	7.48	349	1.6
10/3/2006	1100	29.18	13.00	Cloudy	1.5	11.4	10.98	40	7.46	350	1.1
10/3/2006	1100	29.18	13.00	Cloudy	1.8	11.4	10.90	40	7.45	351	1.3
10/3/2006	1100	29.18	13.00	Cloudy	2.1	11.4	10.88	40	7.43	351	1.7
10/3/2006	1100	29.18	13.00	Cloudy	2.4	11.3	10.85	40	7.42	353	1.6
10/3/2006	1100	29.18	13.00	Cloudy	2.7	10.9	10.84	40	7.42	354	1.2
10/3/2006	1100	29.18	13.00	Cloudy	3.0	10.8	10.88	40	7.39	355	1.2
10/3/2006	1100	29.18	13.00	Cloudy	3.4	10.8	10.83	40	7.39	355	1.2
10/3/2006	1100	29.18	13.00	Cloudy	3.7	10.7	10.85	40	7.39	356	1.2
10/3/2006	1100	29.18	13.00	Cloudy	4.0	10.7	10.85	40	7.37	357	1.4
10/3/2006	1100	29.18	13.00	Cloudy	4.3	10.7	10.91	40	7.36	357	1.2
10/3/2006	1100	29.18	13.00	Cloudy	4.6	10.7	10.84	40	7.35	358	1.0
10/3/2006	1100	29.18	13.00	Cloudy	4.9	10.6	10.86	40	7.35	358	.9
10/3/2006	1100	29.18	13.00	Cloudy	5.2	10.6	10.48	40	7.30	361	1.5
10/3/2006	1100	29.18	13.00	Cloudy	5.5	10.8	4.18	51	6.62	365	--
5/12/2008	1120	29.09	11.11	Cloudy	.3	7.8	9.61	42	8.10	420	0
5/12/2008	1120	29.09	11.11	Cloudy	.6	7.8	9.51	42	8.04	421	0
5/12/2008	1120	29.09	11.11	Cloudy	.9	7.8	9.40	42	7.91	425	0
5/12/2008	1120	29.09	11.11	Cloudy	1.2	7.8	9.38	42	7.91	425	.1
5/12/2008	1120	29.09	11.11	Cloudy	1.5	7.8	9.38	42	7.89	426	0
5/12/2008	1120	29.09	11.11	Cloudy	1.8	7.7	9.39	42	7.83	428	0
5/12/2008	1120	29.09	11.11	Cloudy	2.1	7.5	9.36	42	7.90	427	.1
5/12/2008	1120	29.09	11.11	Cloudy	2.4	7.4	9.36	42	7.88	428	.1
5/12/2008	1120	29.09	11.11	Cloudy	2.7	7.3	9.35	42	7.87	428	.1



**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; P, cloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
5/12/2008	1120	29.09	11.11	Cloudy	3.0	7.3	9.34	42	7.85	428	0.2
5/12/2008	1120	29.09	11.11	Cloudy	3.4	7.2	9.23	42	7.86	430	.2
5/12/2008	1120	29.09	11.11	Cloudy	3.7	7.1	9.23	42	7.82	431	.1
5/12/2008	1120	29.09	11.11	Cloudy	4.0	7.1	9.20	42	7.83	431	.2
5/12/2008	1120	29.09	11.11	Cloudy	4.3	7.1	9.15	42	7.82	430	.3
5/12/2008	1120	29.09	11.11	Cloudy	4.6	7.0	9.19	42	7.83	430	.4
5/12/2008	1120	29.09	11.11	Cloudy	4.9	7.0	9.23	42	7.80	431	.4
5/12/2008	1120	29.09	11.11	Cloudy	5.2	6.6	5.15	53	7.54	422	--
6/2/2008	1130	29.8	20.56	Clear	.3	16.2	10.49	41	7.41	486	0
6/2/2008	1130	29.8	20.56	Clear	.6	16.2	10.49	41	7.50	486	0
6/2/2008	1130	29.8	20.56	Clear	.9	16.1	10.48	41	7.57	484	0
6/2/2008	1130	29.8	20.56	Clear	1.2	16.1	10.45	41	7.55	485	0
6/2/2008	1130	29.8	20.56	Clear	1.5	16.1	10.44	41	7.54	486	0
6/2/2008	1130	29.8	20.56	Clear	1.8	15.6	10.52	41	7.55	488	0
6/2/2008	1130	29.8	20.56	Clear	2.1	15.4	10.59	41	7.60	486	0
6/2/2008	1130	29.8	20.56	Clear	2.4	15.2	10.63	41	7.59	487	0
6/2/2008	1130	29.8	20.56	Clear	2.7	15.0	10.65	41	7.57	487	0
6/2/2008	1130	29.8	20.56	Clear	3.0	15.0	10.69	41	7.62	485	0
6/2/2008	1130	29.8	20.56	Clear	3.4	14.8	10.77	41	7.62	484	0
6/2/2008	1130	29.8	20.56	Clear	3.7	14.7	10.84	41	7.64	483	0
6/2/2008	1130	29.8	20.56	Clear	4.0	14.4	10.71	41	7.53	484	0
6/2/2008	1130	29.8	20.56	Clear	4.3	14.0	10.36	42	7.36	489	0
6/2/2008	1130	29.8	20.56	Clear	4.6	13.7	10.21	41	7.26	491	0
6/2/2008	1130	29.8	20.56	Clear	4.9	13.5	9.85	41	7.12	490	0
6/2/2008	1130	29.8	20.56	Clear	5.2	12.7	9.11	41	6.99	421	.2
6/2/2008	1130	29.8	20.56	Clear	5.5	12.5	6.42	44	6.50	366	--

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Peloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
7/14/2008	954	29.53	19.50	Peloudy	0.3	18.7	8.26	42	7.50	407	0
7/14/2008	954	29.53	19.50	Peloudy	.6	18.7	8.38	42	7.52	412	0
7/14/2008	954	29.53	19.50	Peloudy	.9	18.7	8.41	42	7.48	416	0
7/14/2008	954	29.53	19.50	Peloudy	1.2	18.7	8.40	42	7.40	422	0
7/14/2008	954	29.53	19.50	Peloudy	1.5	18.7	8.40	43	7.42	422	0
7/14/2008	954	29.53	19.50	Peloudy	1.8	18.6	8.41	42	7.46	421	0
7/14/2008	954	29.53	19.50	Peloudy	2.1	18.4	8.34	42	7.37	426	0
7/14/2008	954	29.53	19.50	Peloudy	2.4	18.4	8.33	42	7.38	428	0
7/14/2008	954	29.53	19.50	Peloudy	2.7	18.3	8.32	43	7.37	427	0
7/14/2008	954	29.53	19.50	Peloudy	3.0	18.3	8.31	43	7.40	427	0
7/14/2008	954	29.53	19.50	Peloudy	3.4	18.3	8.31	42	7.37	428	0
7/14/2008	954	29.53	19.50	Peloudy	3.7	18.3	8.32	43	7.36	429	0
7/14/2008	954	29.53	19.50	Peloudy	4.0	18.2	8.31	42	7.39	428	0
7/14/2008	954	29.53	19.50	Peloudy	4.3	18.1	8.38	43	7.32	437	0
7/14/2008	954	29.53	19.50	Peloudy	4.6	18.0	8.40	42	7.37	435	0
7/14/2008	954	29.53	19.50	Peloudy	4.9	17.9	8.43	42	7.41	434	0
7/14/2008	954	29.53	19.50	Peloudy	5.2	17.8	8.47	43	7.37	435	0
7/14/2008	954	29.53	19.50	Peloudy	5.5	17.8	8.44	42	7.36	412	--
7/14/2008	954	29.53	19.50	Peloudy	5.8	17.6	3.34	95	6.39	299	--
8/11/2008	1218	30.3	20.11	Clear	.3	23.3	8.50	42	7.22	252	1.4
8/11/2008	1218	30.3	20.11	Clear	.6	22.3	8.58	42	7.32	265	1.5
8/11/2008	1218	30.3	20.11	Clear	.9	22.1	8.57	42	7.37	275	1.4
8/11/2008	1218	30.3	20.11	Clear	1.2	22.0	6.59	42	7.39	281	1.6
8/11/2008	1218	30.3	20.11	Clear	1.5	22.0	8.72	42	7.46	285	1.7
8/11/2008	1218	30.3	20.11	Clear	1.8	22.0	8.76	42	7.45	292	1.7
8/11/2008	1218	30.3	20.11	Clear	2.1	21.9	8.60	42	7.42	293	1.8
8/11/2008	1218	30.3	20.11	Clear	2.4	21.9	8.59	42	7.39	298	1.7
8/11/2008	1218	30.3	20.11	Clear	2.7	21.8	8.61	42	7.37	300	1.7

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; Pelouidy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance (µS/cm)	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
8/11/2008	1218	30.3	20.11	Clear	3.0	21.8	8.60	42	7.35	302	1.8
8/11/2008	1218	30.3	20.11	Clear	3.4	21.8	8.57	42	7.29	604	1.9
8/11/2008	1218	30.3	20.11	Clear	3.7	21.8	8.56	42	7.30	605	1.9
8/11/2008	1218	30.3	20.11	Clear	4.0	21.7	8.54	42	7.24	609	1.9
8/11/2008	1218	30.3	20.11	Clear	4.3	21.6	8.16	42	7.13	313	2.1
8/11/2008	1218	30.3	20.11	Clear	4.6	21.2	6.94	43	6.79	327	3.3
8/11/2008	1218	30.3	20.11	Clear	4.9	20.2	2.02	49	6.34	393	4.4
8/11/2008	1218	30.3	20.11	Clear	5.2	19.2	.59	51	6.22	347	5
8/11/2008	1218	30.3	20.11	Clear	5.5	18.5	.29	56	6.13	309	4.6
8/11/2008	1218	30.3	20.11	Clear	5.8	18.1	.24	67	6.19	235	--
8/11/2008	1218	30.3	20.11	Clear	6.1	17.3	.23	114	6.09	197	--
8/11/2008	1218	30.3	20.11	Clear	6.4	17.3	.22	124	6.03	188	--
9/8/2008	1042	30.21	14.28	Clear	.3	17.1	8.66	44	7.27	423	0
9/8/2008	1042	30.21	14.28	Clear	.6	17.1	8.64	43	7.25	425	0
9/8/2008	1042	30.21	14.28	Clear	.9	17.1	8.60	44	7.26	425	0
9/8/2008	1042	30.21	14.28	Clear	1.2	17.1	8.57	44	7.20	428	0
9/8/2008	1042	30.21	14.28	Clear	1.5	17.1	8.57	43	7.16	430	0
9/8/2008	1042	30.21	14.28	Clear	1.8	17.1	8.58	43	7.12	430	0
9/8/2008	1042	30.21	14.28	Clear	2.1	17.0	8.55	43	7.16	431	0
9/8/2008	1042	30.21	14.28	Clear	2.4	17.0	8.55	44	7.16	431	0
9/8/2008	1042	30.21	14.28	Clear	2.7	17.0	8.53	44	7.12	433	0
9/8/2008	1042	30.21	14.28	Clear	3.0	17.0	8.51	43	7.13	433	0
9/8/2008	1042	30.21	14.28	Clear	3.4	17.0	8.51	44	7.12	433	0
9/8/2008	1042	30.21	14.28	Clear	3.7	17.0	8.50	43	7.11	434	0
9/8/2008	1042	30.21	14.28	Clear	4.0	17.0	8.48	44	7.12	434	0
9/8/2008	1042	30.21	14.28	Clear	4.3	16.9	8.47	44	7.09	436	0
9/8/2008	1042	30.21	14.28	Clear	4.6	16.8	8.36	44	7.08	436	.1
9/8/2008	1042	30.21	14.28	Clear	4.9	16.9	8.36	44	7.08	435	1.9

**Appendix 2.** Depth profiles of field properties for Speckled Trout Lake near Grand Portage, Grand Portage Reservation, northeastern Minnesota, 1997–2008.—Continued

[BP, barometric pressure in millimeters mercury; °C, degrees Celsius; m, meters; mg/L, milligrams per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25°C; mV, millivolts; NTU, nephelometric turbidity units; --, no data; P, cloudy, partly cloudy]

Date	Time	BP	Air temperature (°C)	Sky conditions	Depth (m)	Water temperature (°C)	Dissolved oxygen (mg/L)	Specific conductance ( $\mu\text{S}/\text{cm}$ )	pH	Oxidation reduction potential (mV)	Turbidity (NTU)
9/8/2008	1042	30.21	14.28	Clear	5.2	16.8	8.28	44	7.10	429	0.4
9/8/2008	1042	30.21	14.28	Clear	5.5	16.9	3.00	49	6.27	353	--
10/2/2008	1057	30.65	9.17	Cloudy	.3	12.9	9.34	41	7.45	421	0
10/2/2008	1057	30.65	9.17	Cloudy	.6	13.0	9.31	41	7.46	421	0
10/2/2008	1057	30.65	9.17	Cloudy	.9	13.0	9.29	41	7.43	422	0
10/2/2008	1057	30.65	9.17	Cloudy	1.2	13.0	9.28	41	7.45	420	0
10/2/2008	1057	30.65	9.17	Cloudy	1.5	12.9	9.28	40	7.44	420	0
10/2/2008	1057	30.65	9.17	Cloudy	1.8	13.0	9.26	41	7.43	421	0
10/2/2008	1057	30.65	9.17	Cloudy	2.1	13.0	9.25	40	7.36	424	0
10/2/2008	1057	30.65	9.17	Cloudy	2.4	13.0	9.24	41	7.36	424	0
10/2/2008	1057	30.65	9.17	Cloudy	2.7	13.0	9.23	41	7.35	424	0
10/2/2008	1057	30.65	9.17	Cloudy	3.0	13.0	9.24	41	7.33	424	0
10/2/2008	1057	30.65	9.17	Cloudy	3.4	13.0	9.24	41	7.30	426	0
10/2/2008	1057	30.65	9.17	Cloudy	3.7	13.0	9.23	40	7.35	423	0
10/2/2008	1057	30.65	9.17	Cloudy	4.0	13.0	9.23	40	7.36	422	0
10/2/2008	1057	30.65	9.17	Cloudy	4.3	13.0	9.21	41	7.32	424	0
10/2/2008	1057	30.65	9.17	Cloudy	4.6	13.0	9.21	41	7.31	424	0
10/2/2008	1057	30.65	9.17	Cloudy	4.9	13.0	9.20	40	7.33	423	0
10/2/2008	1057	30.65	9.17	Cloudy	5.2	13.0	9.21	41	7.31	424	0
10/2/2008	1057	30.65	9.17	Cloudy	5.5	13.0	9.20	41	7.29	424	0

**Appendix 3.** Water-quality data collected by the U.S. Geological Survey for Swamp and Speckled Trout Lakes near Grand Portage, Grand Portage Reservation, northeastern Minnesota, September 11, 2006.

[Site locations shown in figure 2;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $^{\circ}\text{C}$ , degrees Celsius;  $\text{mg}/\text{L}$ , milligrams per liter;  $\text{CaCO}_3$ , calcium carbonate; Cl, Chloride; N, nitrogen; P, phosphorus; <, less than; E, estimated, less than laboratory reporting level and greater than the long-term method detection limit (Childress and others, 1993) for low concentration method; C, carbon]

	Swamp Lake sample	Speckled Trout Lake sample
Sample time	11:50	15:40
Specific conductance ( $\mu\text{S}/\text{cm}$ )	38.6	49.7
pH	7.07	7.52
Water temperature ( $^{\circ}\text{C}$ )	15.0	17.2
Dissolved oxygen ( $\text{mg}/\text{L}$ )	8.36	8.2
Alkalinity ( $\text{mg}/\text{L}$ as $\text{CaCO}_3$ )	12	21
Bicarbonate ( $\text{mg}/\text{L}$ as $\text{CaCO}_3$ )	14	25
Chloride, dissolved ( $\text{mg}/\text{L}$ as Cl)	.21	.21
Nitrogen, dissolved ammonia plus organic ( $\text{mg}/\text{L}$ as N)	.6	.45
Nitrogen, dissolved nitrite plus nitrate ( $\text{mg}/\text{L}$ as N)	<.04	<.04
Total dissolved nitrogen ( $\text{mg}/\text{L}$ as N)	.76	.45
Total dissolved phosphorus ( $\text{mg}/\text{L}$ as P)	.005	E.0024
Carbon, dissolved organic ( $\text{mg}/\text{L}$ as C)	16.65	4.78

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