

FINAL REPORT

South Bar Lake, Empire, MI Water Quality Monitoring

Submitted to:

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Prepared by:



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Background

South Bar Lake is located just north of the Village of Empire in Leelanau County, Northwest Lower Michigan. South Bar Lake is approximately 81 acres in size. The lake has several inlets and a major outlet to Lake Michigan. The lake is heavily used seasonally for fishing and swimming. Excellent public facilities and access are present at the southwest end of the lake via Niagara St. and S. Lake Michigan Dr.

The Village of Empire asked for a general assessment of lake water quality for South Bar Lake. Great Lakes Environmental Center, Traverse City, Michigan provided monitoring of the lake and tributaries on July 2, 2009. General lake water quality measurements and phosphorus and nitrogen determinations were done in a deeper portion of the lake. E. coli samples, an indicator of fecal contamination, were taken near the beach on the south end of the lake to assess bathing beach water quality. Phosphorus and nitrogen determinations were taken at each inlet, as well as measuring flow rates in and out of the lake. Flow measurements coupled with nutrient concentrations provide a “snapshot” of the quantity of nutrients moving in and out of the lake, and can suggest possible future impacts for water quality.

Water Quality Concerns

Within the any watershed there are a number of distinct concerns which may impact water quality. Agricultural activities (crop lands, orchards, and livestock) may contaminate surface waters by nutrient and pesticide leaching which may ultimately impact both stream and lake biology. Similarly, groundwater may be impacted by pesticide/nutrient leaching from agricultural practices. Offsite movement of pesticides may also impact adjacent, nonagricultural wetlands, deciduous/ coniferous forests and rangelands.

Technical Approach

Lake Sampling. Sampling was conducted at South Bar Lake on July 2, 2009. The lake sampling locations for water quality measurements and for E. coli analysis are shown in Figure 1. Lake water

samples were collected at the surface with a polypropylene sampling bottle and transferred to 0.25 L glass bottles acidified with H₂SO₄. These samples were analyzed for total phosphorus and nitrate/nitrite nitrogen by Great Lakes Environmental Center (GLEC) in Traverse City, MI. All nutrient samples were analyzed by GLEC using established Standard Operating Procedures (SOPs) and analytical techniques (SOPs on file at GLEC). In addition, a Hydrolab® Quanta was used to measure pH, temperature, dissolved oxygen, oxidation-reduction potential (redox) and conductivity every foot from the surface to three feet and at three foot intervals to the lake bottom, approximately 10 feet. These variables are generally accepted lake water quality parameters which can be used to assess the relative water quality of the lake. Samples were also collected at the main beach (Figure 1) for the indicator of bacterial contamination, *E. coli*, by collecting shallow bathing water in sterile 1 liter polypropylene containers and analyzed by an IDEXX Colilert® system

Tributary Monitoring. Tributaries were monitored a single time at the inlets and outlet of the lake (Figure 1). The tributaries were monitored for total phosphorus and nitrate/nitrite nitrogen by collecting water samples in 0.25 L acidified glass sample bottles. Tributary monitoring was completed on July 2, 2009. In addition, flow rates at the inlets and main outlet (Figure 1) were measured by a digital flow meter at approximately 20 equal intervals across the stream bed. The flow at each interval, and the cross sectional areas were combined to provide a total cross sectional flow for the stream. This flow rate, in conjunction with the measured nutrient parameters, allow for the estimation of nutrient loading of phosphorus and nitrogen, and a total “phosphorus and nitrogen “budget” to be calculated (nutrient inflow – nutrient outflow).

Results of Monitoring Activities

Lake Water Quality. Comprehensive lake monitoring, including Hydrolab® measurements (dissolved oxygen, temperature, pH, redox, conductivity) and samples for total phosphorus, nitrate/nitrite nitrogen were completed on South Bar Lake. Samples were taken once in the early summer. The relevant observations from these monitoring activities are as follows:

- Water quality on South Bar Lake is generally good and falls into the low mesotrophic range for most water quality parameters. Concentration of total phosphorus was 0.0117 mg/L and nitrate/nitrite nitrogen (NO_x) was 0.296 mg/L. Values for total phosphorus are slightly elevated compared to most other area lakes in Northern Michigan (Table 3). Nitrate/nitrite nitrogen concentrations are somewhat lower than other area lakes (data not shown).

- Levels of dissolved oxygen in lake water are adequate, with depletion noted near the bottom of South Bar Lake. This oxygen depletion may be characteristic of biological processes at the lake bottom, including breakdown of organic matter which can consume oxygen. The temperature and dissolved oxygen profiles for the Hydrolab are presented in Figure 2.

Tributary Monitoring. Monitoring of tributaries to South Bar Lake was limited to those sources of water to the lake as well as the outlet. The tributaries were monitored for total phosphorus and nitrate/nitrite nitrogen. It should be noted that the impact of surface water runoff on nutrient loading of tributaries, streams, rivers and lakes is well documented. Records indicate there was some light rain on the day previous to monitoring (July 1, 2009) and this has the potential to impact nutrient loading. This is highly dependent on the intensity and duration of the precipitation. The following conclusions can be made based on the analysis of the tributary data:

- Total phosphorus concentrations at the outlet (Table 1), and all inlets except the South Inlet, were approximately the same, in the range of .0099 to .0134 mg/L (9.9-13.4 ug/L). The South End Inlet (nearest the Village of Empire had a concentration of .0658 mg/L (65.8 ug/L), approximate 5 times higher than the next highest value. However, this inlet only had flow of approximately 25% of the largest flow and the Florence Inlet, thereby mitigating this effect somewhat.
- Levels of nitrate/nitrite nitrogen were more variable, but the South End Inlet continued to have the highest concentration, and the Outlet the lowest.
- Taking into account the flow rates, loading of Total Phosphorus into South Bar Lake was approximately 0.14 kg/day (0.308 lbs/day). Total Phosphorus flow out of South Bar Lake at the Outlet was 0.12 kg/day (0.27 lbs/day), leaving a net input into the lake of 0.017 kg/day (0.037 lbs/day).
- Loading of nitrate/nitrite nitrogen into the lake was 17.04 kg/day (37.5 lbs/day) and flow out of the lake was 3.2 kg/day (7.1 lbs/day). There was a net input of nitrate/nitrite nitrogen of 13.8 kg/day (30.4 lbs/day).
- It is difficult to compare nutrient loading between area lakes, due to differences in the size and number of tributaries, the timing of sampling (during dry or wet periods) and the frequency of sampling (5-6 times per year provides a better characterization of nutrient loading). A comparison of tributary total phosphorus and nitrate/nitrite nitrogen levels for other Leelanau county tributaries is shown in Table 4, in order to provide some perspective. Overall, the phosphorus and nitrogen loading is somewhat modest but higher than averages

for other tributaries in the County (compare column 3 in Table 2 with values in Table 4). However, South Bar Lake is very shallow and small, and even small amounts of additional nutrients over time may contribute to additional growth of algae and aquatic plants.

Bacterial Contamination by *E. coli*. Traditional monitoring of bacterial contamination has focused on levels of fecal coliform bacteria. More recently, the U.S. EPA has determined that levels of the bacterium, *E. coli* (one of numerous bacteria within the fecal coliform group), is a better predictor of fecal contamination of surface water. Epidemiological studies have shown that levels of *E. coli* correlate well with human health impacts, and are a better predictor than levels of total fecal coliform. The State of Michigan DEQ has adopted criteria concentrations for *E. coli* for surface and recreational waters. The state standard for a single sample is 300 colony forming units (CFU) per 100 mL (based on the geometric mean of three replicate samples), and the 30-day geometric mean value (based on the geometric mean of 5 weekly samples within a 30 day period) is 130 CFU per 100 mL.

Duplicate samples taken at the South Bar Lake beach indicated concentrations of 11 and 18 colonies of *E. coli* per 100 mL. These levels are quite low, and may be a result of contamination from fecal matter from environmental sources (local animals). Based on these samples, there would be a minimal risk to public health. It should be noted, however, that direct comparisons to the single event criterion are not possible because only two replicate samples were taken, although the samples indicate that they might possibly be in compliance with state standards. A comparison to *E. coli* concentrations collected at Empire Beach from 2001-2004 (available through the Watershed Center Grand Traverse Bay) indicated that the current *E. coli* concentrations measured by GLEC were equal to or below the majority of data collected previously. This would indicate that this general area may not have significant ongoing beach contamination problems. However, consistent and frequent beach monitoring is likely the only way to definitively determine the health risk from bacterial contamination.

Summary

Based on the limited monitoring completed during 2009, the overall water quality of the South Bar Lake is generally good. Lake water quality is generally classified on the basis of several lake parameters (total phosphorus, secchi depth, chlorophyll a levels, hypolimnion oxygen, and percent organic matter) and the trophic state determination is summarized in Table 5). Because only total phosphorus and dissolved oxygen were measured in South Bar Lake, it is more difficult to quantitatively assess lake health. Based on limited parameters, lake water quality would be classified

as mesotrophic, but bordering on levels which would be considered marginally oligotrophic. Lakes classified as oligotrophic are best, followed by mesotrophic and eutrophic. South Bar Lake is very shallow, which may result in elevated water temperatures and higher levels of aquatic plants and algae. This could contribute to the mesotrophic status. Most lakes in Northern Michigan are oligotrophic, or slightly mesotrophic.

Specific Recommendations

Although the overall water quality in the South Bar Lake is still relatively good, there are some indications that degradation in water quality may occur in the future without proper management practices in place. The following recommendations are made:.

- Encourage land management practices, were applicable, which help to minimize nutrient inputs to tributaries to South Bar Lake. Such strategies would include the use of vegetative buffer strips, water retention ponds, etc., particularly for inputs which may result from runoff from the Village.
- Based on desire and available funds, continued monitoring of tributaries phosphorus and nitrogen levels, as well as beach E. coli levels would be helpful. However, these monitoring should only be done as part of a greater attempt to understand sources or as an indicator of the effectiveness of some management practices which have been implemented to limit surface water runoff to tributaries.

REFERENCES

Chapra, S.C. 1997. Surface Water Quality Modeling. McGraw-Hill, New York.

Figure 1. South Bar Lake Monitoring Sites, July 2, 2009.



Figure 2. Temperature and Dissolved Oxygen Profile, by Depth, for South Bar Lake.

South Bar Lake
July 2, 2009
Hydrolab Profile

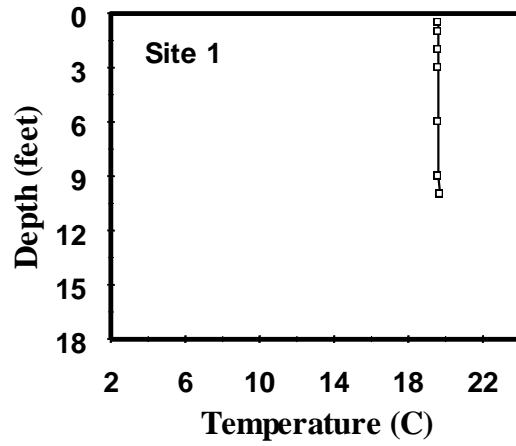
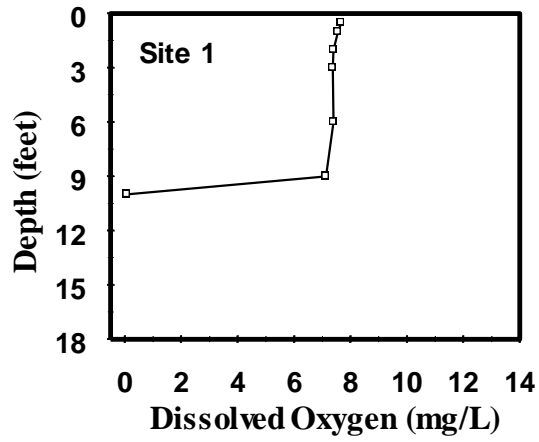


Table 1. South Bar Lake - Lake Nutrient Concentrations	
Total Phosphorus (TP):	0.0117 mg/L
Nitrate/Nitrite Nitrogen (Nox):	0.296 mg/L

Table 2. Total Phosphorus Loading by Tributaries – South Bar lake

Total Phosphorus (TP)**

Date	Flow (cms)	TP** (mg/L)	Load (mg/day)	Load (kg/day)	Load (lbs/da)
Outlet	0.1213	0.01180	123667.776	0.1237	0.2721
Southend inlet	0.0157	0.06580	89256.384	0.0893	0.1964
Florence Inlet	0.0589	0.00990	50380.704	0.0504	0.1108
Lake Mi Inlet	0.0006	0.01340	694.656	0.0007	0.0015

Loading Summary			
	TP In	TP Out	(In-out)
Kg/day	0.14033	0.1237	0.01666
lbs/day	0.30873	0.27207	0.03666

Nitrate/Nitrite Nitrogen (NOx)**

Date	Flow (cms)	NOx** (mg/L)	Load (mg/day)	Load (kg/day)	Load (lbs/da)
Outlet	0.1213	0.30800	3227938.56	3.2279	7.1015
Southend inlet	0.0157	5.66000	7677676.8	7.6777	16.8909
Florence Inlet	0.0589	1.81000	9211017.6	9.2110	20.2642
Lake Mi Inlet	0.0006	2.88000	149299.2	0.1493	0.3285

Loading Summary			
	NOx in	NOx out	(In-out)
Kg/day	17.03799	3.2279	13.81006
lbs/day	37.48359	7.10146	30.38212

** TP and NOx levels measured by Great Lakes Environmental Center

Table 3. Total lake water phosphorus concentration in area lakes.

	Water		
	Total Phosphorus		
Lake	(mg/L)		
Torch	0.0017		
Burt	0.0022		
Lime	0.0044		
Crystal	0.0048		
North Leelanau	0.0048		
South Leelanau	0.0049		
Glen	0.0051		
Little Traverse	0.0051		
Cedar	0.0053		
Platte	0.0077		
Long Lake #1	0.0086		
Long Lake #2	0.0136		
Long Lake #3	0.0093		
South Bar Lake	0.0117		

Table 4. Five year average of total phosphorus and nitrate/nitrite nitrogen concentrations in 19 tributaries in Leelanau County, 1992-1996.

Tributary Name	5 year Average * TP (µg/L)	5 year Average NOx (mg/L)
Mebert	0.0022	1.146
Skeba	0.0021	1.029
Leo	0.0020	1.276
Rice	0.0019	0.410
Belnap	0.0019	0.871
Houdek	0.0017	1.623
Beaudwin	0.0017	2.055
Cedar River	0.0017	0.484
N. Cedar	0.0016	0.507
Weaver	0.0015	0.979
Ennis	0.0015	0.891
Little Finger Cr.	0.0014	0.950
Provemont	0.0013	2.368
Solon	0.0013	0.421
Cedar Creek	0.0012	0.980
Belanger	0.0011	1.380
S. Lime	0.0011	0.779
Hatlem	0.0010	0.424
Timberlee Cr.	0.0010	1.463

*Data from: Nutrient Data and Budgets for Leelanau County Streams and Lakes, 1990-1996, Leelanau Conservancy Report 97-2.

Table 5. Trophic state classification as described by Chapra, 1997

Variable	Oligotrophic	Mesotrophic	Eutrophic	South Bar Lake
Total Phosphorus (mg/L)	<0.010	0.010 – 0.020	>0.020	0.0117
Chlorophyll a (µg/L)	<4	4 - 10	4 - 10	Not Taken
Secchi Depth (meters/feet)	>4 meters > 13 feet	2 - 4 6.6 - 13	< 2 < 6.6	Not Taken
Chapra, S.C. 1997. Surface Water Quality Modeling. McGraw-Hill, New York.				