

***Good Spirit Lake Water Quality Report
2005 – 2006***

Prepared for
The Friends of Good Spirit Lake Inc.

Monitoring and Assessment Branch
Stewardship Division
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Acknowledgements

Volunteers are essential to the water monitoring program as they provide local knowledge, and assist with sample collection and transportation. In 2005 and 2006, Ray and Dorothy Riesz, Lloyd and Marjorie Wilson, Barry Rudy, Eugene Prychak and Adam Matichuk assisted Saskatchewan Watershed Authority technologist Rob Walcer with sampling at Good Spirit Lake. Bill and Joyce Anaka monitor and record the weather and lake levels at Good Spirit Lake.

1.0 Introduction and Background

The protection of water quality in Good Spirit Lake is of interest to the provincial government, stakeholders and residents of Saskatchewan. The *Friends of Good Spirit Lake Inc.* (FGSL) stewardship group was formed in order to monitor lake water quality. Their mission: “To understand and protect the water resources within the watershed, which will help sustain for future generations the natural beauty of the lake and surrounding shoreline environment.” The FGSL incorporated as a non-profit organization in 1998 and have been monitoring lake water quality in cooperation with Saskatchewan Watershed Authority (SWA; formerly SaskWater) since 1997. SWA provides technical and administrative assistance to support the activities of the group through the *Lake Stewardship Program* and provides a summary Water Quality Report report to FGSL.

General Description, Geology, Hydrogeology

Good Spirit Lake is a popular recreational lake with many attractions including Good Spirit Lake Provincial Park, walking and cross country ski trails, camping, fishing and boating. There are also a number of villages, hamlets and resort communities surrounding Good Spirit Lake. Located approximately 60 kilometers northeast of Yorkton, Good Spirit Lake is on the Whitesand Plain of the Assiniboine River Watershed. Area soils are characterized as loamy sand to very fine sandy loam. Agriculture is the major industry in the area.

Good Spirit Lake has a large surface area of approximately 44 square kilometers. The maximum depth is approximately 6 meters (based on regulated water levels of 484.25 – 484.4 m). Annual precipitation and spring/fall water level information has been provided by Bill Anaka (Table 1).

Table 1 – Water levels at time of spring runoff and fall freeze-up as well as summer precipitation accumulation between April and October from 1998 to 2006.

Year	Water Level at Spring Runoff (m)	Water Level at Fall Freeze-up (m)	Summer Precipitation April – October (mm)
1998	484.16	484.30	517.0
1999	484.67	484.41	433.2
2000	484.11	483.81	329.4
2001	484.00	483.64	234.2
2002	483.67	483.46	415.9
2003	483.79	483.35	319.0
2004	483.30	483.47	410.4
2005	483.78	483.78	564.6
2006	484.44	484.44	482.0

2.0 Water Quality Sampling

The purpose of the Good Spirit Lake water quality monitoring program is to understand the characteristics of the lake, assess lake water quality over time, work towards a better understanding of watershed health, and assist in public education and understanding about how activities around the lake can affect water quality. Sampling at Good Spirit Lake occurred four times a year from 1997 – 2002 and five times a year from 2002 -2006, providing a good understanding of baseline water quality for Good Spirit Lake. With an established baseline for assessing water quality, the monitoring program will begin a three-year cycle, meaning Good Spirit Lake will now be monitored every third year. The next time Good Spirit Lake will be sampled as part of the *Lake Stewardship Program* will be January 2009.

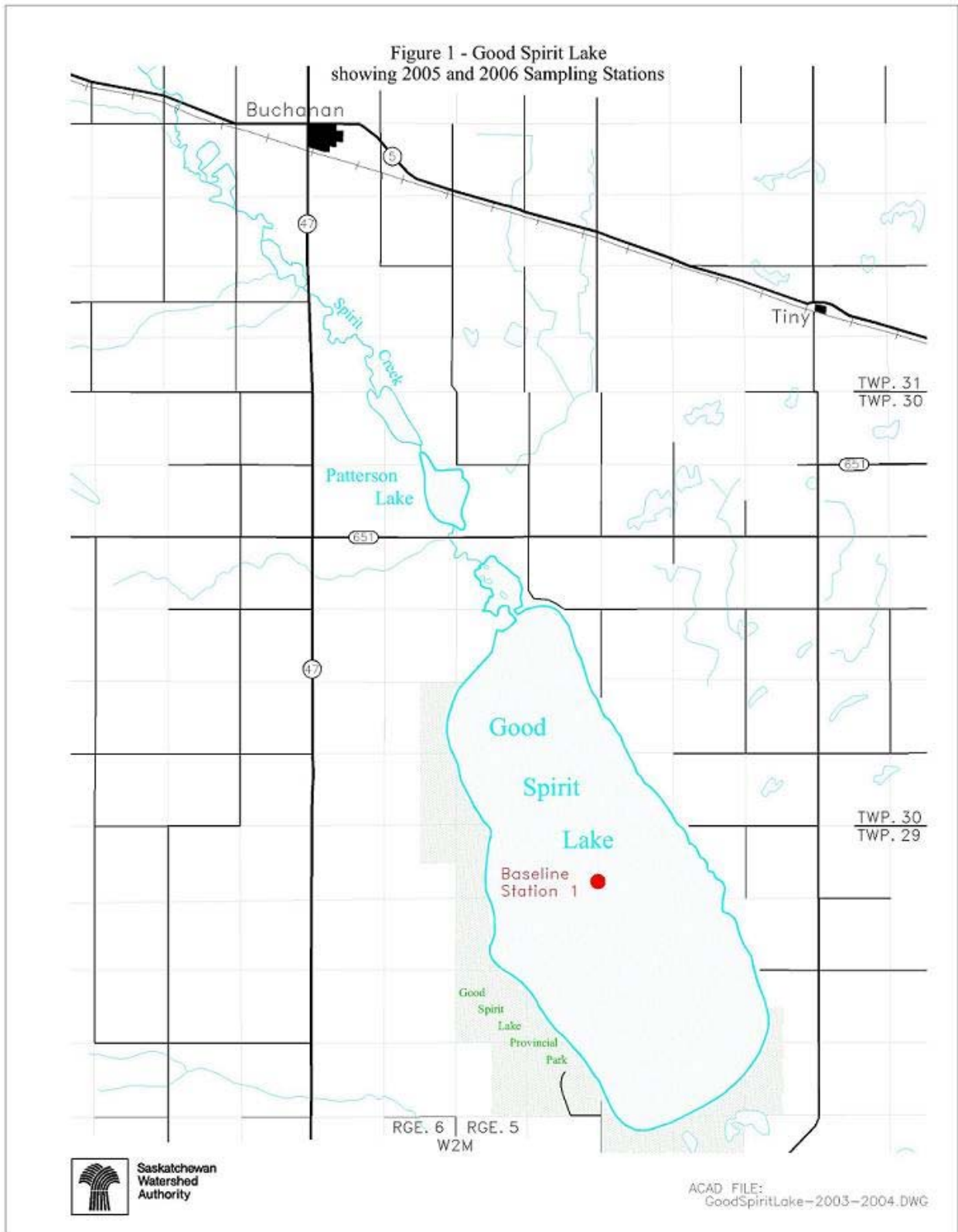
Baseline Station: A baseline station at a deep water site was chosen to represent typical water quality conditions in the lake. This baseline station is sampled five times during the year (Figure 1).

3.0 Water Quality Results and Discussion

3.1 Baseline Station – Water Quality Index

The Water Quality Index (WQI) provides a means of assessing the overall quality of water in Good Spirit Lake. The index combines key chemical and biological factors used to define water quality and summarizes them in a single value. These key factors include major ions, nutrients, heavy metals, pesticides, bacteria and algae, dissolved oxygen and pH. The Water Quality Index shows consistent scores ranging from *good* to *excellent* in the sampling period from 1998 to 2006 (Figure 2).

The results for the baseline station on Good Spirit Lake for 2005 and 2006 were consistent with past years. Only chromium was identified as exceeding the WQI for the first time in 2005 or 2006 (March and May, 2006). Total phosphorus (a nutrient) exceeded the Saskatchewan Watershed Authority's target value three times in 2005 (May, June and September) and once in 2006 (May). Chlorophyll *a* exceeded the Saskatchewan Watershed Authority's target value in September 2005 only. pH was outside the objective once in August 2005. Since 1998, major ions and bacteria levels have been within the objectives used for the WQI. Pesticides were below the laboratory detection limit for all years since 1998. Dissolved oxygen met its WQI objective every time the lake was sampled except February 2003. Since there were relatively few exceedances, and they were usually small, the WQI score for Good Spirit Lake has remained between *good* and *excellent* since 1998.



Chromium is a natural element found in soil, bedrock and water. It may enter water supplies through discharge of industrial wastewater and agricultural pollution, or the dissolution of natural chromium particles in rain, snow or groundwater. Sometimes natural erosion can also introduce large quantities of chromium into a local water source from rocks and soil. Saskatchewan's *Surface Water Quality Objectives for the Protection of Aquatic Life* for chromium is 0.001 µg/L. This was exceeded in March and May, 2006 with levels of 0.002 µg/L and 0.004 µg/L, respectively. Although this is the first time chromium was found to exceed the WQI objective, it is only the third year it has been measured.

Phosphorous is a parameter that often exceeds its objective in many of Saskatchewan's southern lakes, including Good Spirit Lake. Saskatchewan's *Surface Water Quality Objectives* do not include an objective for total phosphorus, but because it is an important indicator of lake productivity and nutrient loading, the Saskatchewan Watershed Authority has adopted a target value of 0.1 mg/L or less for phosphorus. In 2005 and 2006, Good Spirit lake's phosphorous concentrations ranged from 0.03 – 0.14 mg/L. Although nutrients are necessary for foodweb functioning (and healthy fish populations), excess nutrients can lead to decreased dissolved oxygen and water clarity as well as potential for certain toxins to be produced by cyanobacteria (blue-green algae). Nutrients may enter the lake from upstream tributaries after rainstorms, from die-offs of aquatic plants or algae, direct runoff of lawn fertilizer, or from leaky septic systems. Nutrient recycling from within the lake may also be a significant source of nutrients in Good Spirit Lake. Mixing due to wind action may also re-suspend nutrients that had settled on the lake bottom.

Chlorophyll *a* concentrations are used to estimate the amount of algae in aquatic systems. In Good Spirit Lake, chlorophyll *a* concentrations reached 53.22 µg/L in September 2005 (the target value is 50 µg/L). Late summer is the time of year when algal biomass in Good Spirit Lake should peak.

3.2 Turbidity

Friends of Good Spirit Lake identified water clarity as a parameter of interest. Low visibility in the lake has been noted by the volunteer water quality monitoring team. Secchi depths from summer sampling on Good Spirit Lake ranged from 0.2m in September 2005 to 0.9m in July 2006 and summer turbidity ranged from 11 NTU in July 2006 to 28 NTU in June 2005, meaning that light penetration into Good Spirit Lake is limited. At times the low visibility may be due to high algal growth (e.g. dates when chlorophyll concentrations are high) but on many sampling dates chlorophyll concentrations were lower. Laboratory measures of total suspended solids are often high (4 mg/L -74 mg/L). This suggests that low water clarity results from sediment particles that become suspended in the water column, and on some dates, high algal growth.

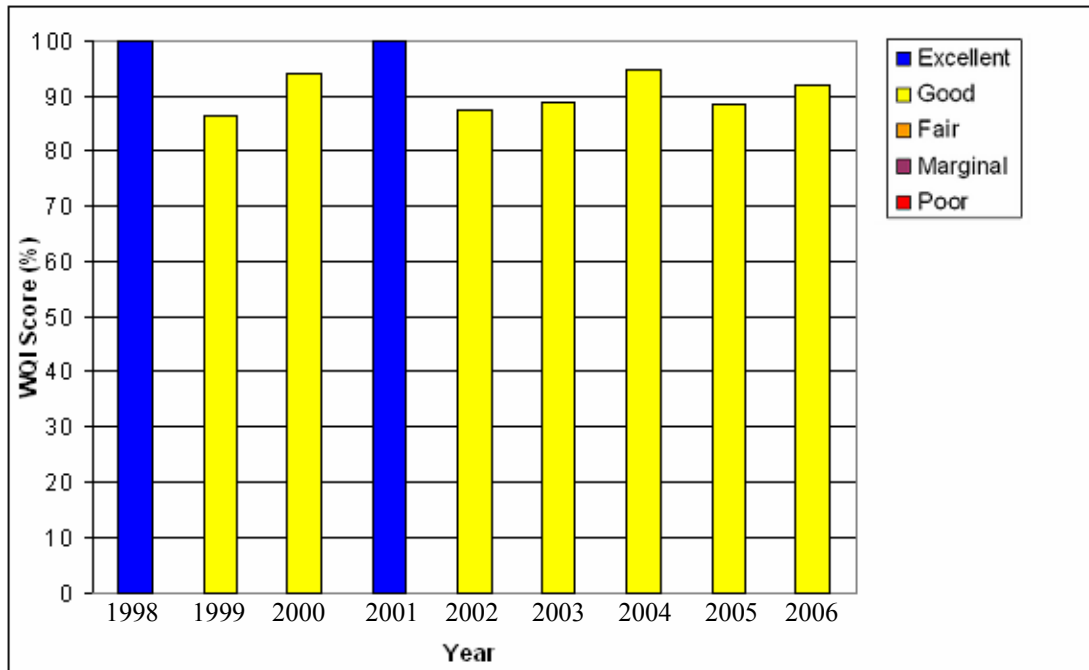


Figure 2– Water Quality Index (WQI) scores for Good Spirit Lake Baseline Station from 1998 to 2006.

4.0 Recommendations

To maintain the *good* to *excellent* water quality of Good Spirit Lake, it is recommended that recreational users and upstream stakeholders minimize nutrient additions to the lake. Saskatchewan Watershed Authority encourages the continuing public education and outreach of the Friends of Good Spirit Lake to teach users to follow healthy shoreline living practices such as those outlined in *On the Living Edge – Your handbook for waterfront living* (Nature Saskatchewan).

Water quality monitoring should continue in order to identify possible threats to the water quality of Good Spirit Lake. Lakes with sufficient historical data (including Good Spirit Lake) will be shifted to a three-year monitoring cycle where each lake will have water quality monitored every third year. For example, if the current plan allowed for lake sampling to occur for three more years, the actual sampling could occur in year three, year six and year nine to better examine changes to water quality over time. This will still allow the assessment of changes to lake water quality over time while conserving resources to permit lake monitoring to continue on these lakes further in the future. The next time the Saskatchewan Watershed Authority plans to monitor Good Spirit Lake is January 2009.

5.0 References Cited

Kipp, S. and C. Gallaway. 2003. On the Living Edge – Your handbook for water front living. Saskatchewan/Manitoba Edition. Federation of British Columbia Naturalist: British Columbia. Available through Nature Saskatchewan.

Saskatchewan Environment, Drinking Water Quality Section. 2006. Surface Water Quality Objectives: Interim Edition EPB 356. p. 7.

6.0 Good Spirit Lake Data Tables 2005-2006

Good Spirit Lake - Top Surface Baseline 2005					
Parameters	Feb 22	May 30	June 29	Aug 2	Sept 19
Nutrients (mg/L)					
Dissolved Organic Carbon	42.2	28.6	31.9	32.5	31.3
Nitrate, as Nitrogen	<0.04	<0.04	<0.04	<0.04	<0.04
Ammonia, as Nitrogen	0.22	0.05	0.08	0.05	0.06
Total Kjeldahl Nitrogen	2.6	2.8	3.6	2.3	3.1
Total Phosphorous	0.08	0.14	0.12	0.09	0.14
Ortho-Phosphate, as P	0.08	<0.02	0.02	0.03	<0.02
Solids (mg/L)					
Total Dissolved Solids	1,076	806	832	799	837
Suspended Solids, Fixed	4	12	13	11	23
Suspended Solids, Volatile	4	45	49	32	51
Suspended Solids, Total	4	57	62	43	74
Bacteria (orgs/100 mL)					
Fecal Coliform	<10	<10	<10	<10	<10
Total Coliform	<10	<10	<10	<10	100
Major Ions (mg/L)					
Alkalinity, Total	276	232	238	234	236
Alkalinity, Phenol	6	14	18	28	14
Bicarbonate	322	249	246	217	254
Calcium	48	37	42	39	39
Carbonate	7.2	16.8	21.6	33.6	16.8
Chloride	12.3	9.4	9.6	9.2	10.1
Hardness, Total	717	512	533	517	542
Magnesium	145	102	104	102	108
Potassium	36	26	27	26	28
Sodium	33	23	24	23	24
Sulphate	472.3	342.5	357.4	349.3	356.9
Other					
Chlorophyll <i>a</i> (µg/L)	1.04	6.89	27.55	30.63	52.33
Conductivity (µS/cm)	1,286	1,049	1,020	1,032	1,036
pH (pH units)	8.4	8.6	8.6	8.9	8.6
Turbidity (N.T.U.)	1.9	21.0	28.0	21.0	45.0
Biochemical Oxygen Demand (mg/L)	<2.0	3.6	3.6	3.0	3.0
Chemical Oxygen Demand (mg/L)	115	143	145	141	155
Field Data					
Air Temperature (°C)	15	15	15	20	15
pH (pH units)	8.60	8.82	8.71	9.02	8.74
Secchi Disk (meters)	na	0.3	0.4	0.4	0.2
Turbidity (NTU)	1.44	16.6	25.5	18.4	46.1
Wind Speed (km/hr)	na	calm	N 25	25	SW 20
Cloud Cover (%)	na	35	100	0	na

Good Spirit Lake - Bottom Baseline 2005	
Parameters	February 22
Nutrients (mg/L)	
Dissolved Organic Carbon	42.5
Nitrate, as Nitrogen	<0.04
Ammonia, as Nitrogen	0.20
Total Kjeldahl Nitrogen	2.6
Total Phosphorous	0.08
Ortho-Phosphate, as P	0.08
Solids (mg/L)	
Total Dissolved Solids	1,098
Suspended Solids, Fixed	1
Suspended Solids, Volatile	4
Suspended Solids, Total	5
Bacteria (orgs/100 mL)	
Fecal Coliform	<10
Total Coliform	<10
Major Ions (mg/L)	
Alkalinity, Total	282
Alkalinity, Phenol	8
Bicarbonate	325
Calcium	50
Carbonate	9.6
Chloride	12.4
Hardness, Total	743
Magnesium	150
Potassium	38
Sodium	33
Sulphate	479.7
Other	
Conductivity (µS/cm)	1,299
pH (pH units)	8.4
Turbidity (N.T.U.)	2
Biochemical Oxygen Demand (mg/L)	<2
Chemical Oxygen Demand (mg/L)	113

Table: Dissolved oxygen, temperature and conductivity profiles for Good Spirit Lake, 2005.

Date (d/m/y)	Depth (m)	Dissolved Oxygen (mg/L)	Water Temperature (°C)	Conductivity (µS/cm)
Feb 22	0	11.12	0.1	541
	1	11.03	0.4	581
	2	10.72	1.7	693
	3	12.40	2.3	720
	4	7.16	3.1	771
May 30	0	11.60	12.1	1,029
	1	11.50	10.7	1,031
	2	10.42	10.6	1,035
	3	9.83	10.5	1,038
	4	9.26	10.1	1,037
June 29	0	7.50	18.0	935
	1	7.25	18.0	935
	2	7.36	18.0	934
	3	7.24	18.0	934
	4	7.29	18.0	934
August 2	0	9.74	19.8	991
	1	9.52	19.8	993
	2	9.67	19.8	994
	3	9.55	19.7	994
	4	9.32	19.7	994
Sept 19	0	10.20	13.1	993
	1	10.09	13.1	997
	2	10.10	13.0	997
	3	9.99	13.0	998
	4	9.98	13.0	999

Good Spirit Lake Baseline - Top Surface Metal Parameters, 2005				
Parameters	May 30	June 29	Aug 2	Sept 19
Metals (mg/L)				
Mercury (µg/L)	<0.05	<0.05	<0.05	<0.05
Aluminum	<0.005	<0.005	<0.005	<0.005
Arsenic (µg/L)	2.6	2.9	3.0	2.9
Barium	0.046	0.055	0.056	0.054
Beryllium	<0.001	<0.001	<0.001	<0.001
Boron	0.080	0.079	0.081	0.080
Cadmium	<0.001	<0.001	<0.001	<0.001
Chromium	<0.001	<0.001	<0.001	<0.001
Cobalt	0.001	<0.001	<0.001	<0.001
Copper	0.002	<0.001	<0.001	<0.001
Iron	0.044	0.070	0.047	0.073
Lead	<0.002	<0.002	<0.002	<0.002
Manganese	0.019	0.030	0.021	0.033
Molybdenum	<0.001	<0.001	<0.001	0.001
Nickel	<0.001	<0.001	<0.001	<0.001
Phosphorous	0.02	0.03	0.02	0.02
Silicon, Soluble	2.4	2.3	2.2	1.8
Silver	<0.001	<0.001	<0.001	<0.001
Strontium	0.21	0.24	0.25	0.24
Titanium	<0.001	<0.001	<0.001	<0.001
Vanadium	<0.001	<0.001	<0.001	<0.001
Zinc	<0.005	<0.005	<0.005	<0.005
Zirconium	<0.001	<0.001	<0.001	<0.001
Herbicides (µg/L)				
2,4,5-T	<0.5	<0.5	<0.5	<0.5
2,4,5-TP (silvex)	<0.5	<0.5	<0.5	<0.5
2,4-D	<0.5	<0.5	<0.5	<0.5
Bromoxynil (Buctril)	<0.5	<0.5	<0.5	<0.5
Dicamba (Banvel)	<0.5	<0.5	<0.5	<0.5
Diclofop-methyl (HoeGrass)	<1	<1	<1	<1
MCPA	<0.5	<0.5	<0.5	<0.5
Picloram (Tordon)	<1	<1	<1	<1

Good Spirit Lake Surface Baseline 2006					
Parameters	Feb 13	Mar 22	May 31	July 11	Aug 28
Nutrients (mg/L)					
Dissolved Organic Carbon	41.2	na	26.6	29.1	31.6
Nitrate, as Nitrogen	<0.04	<0.04	<0.04	<0.04	<0.04
Ammonia, as Nitrogen	0.08	0.14	0.02	0.03	0.08
Total Kjeldahl Nitrogen	2.5	2.5	2.1	2.5	2.3
Total Phosphorous	0.04	0.03	0.11	0.09	0.05
Ortho-Phosphate, as P	<0.02	<0.02	<0.02	<0.02	0.02
Solids (mg/L)					
Total Dissolved Solids	983	1,038	705	775	734
Suspended Solids, Fixed	<1	<1	3	7	2
Suspended Solids, Volatile	5	4	21	22	7
Suspended Solids, Total	5	4	24	28	9
Bacteria (orgs/100 mL)					
E. Coli	2	<1	<10	<10	20
Total Coliform	2	<1	<10	63	74
Major Ions (mg/L)					
Alkalinity, Total	268	316	218	268	242
Alkalinity, Phenol	12	16	10	14	20
Bicarbonate	298	346	242	293	246
Calcium	48	44	44	50	50
Carbonate	14.4	19.2	12.0	16.8	24.0
Chloride	11.9	12.8	8.3	8.5	8.6
Hardness, Total	647	596	460	479	483
Magnesium	128	118	85	86	87
Potassium	33	30	23	23	23
Sodium	29	26	19	19	20
Sulphate	421.0	441.7	272.1	278.6	275.0
Other					
Chlorophyll <i>a</i> (µg/L)	17.05	4.55	25.18	21.04	14.45
Conductivity (µS/cm)	1,198	1,248	919	931	967
pH (pH units)	8.5	8.5	8.5	8.6	8.7
Turbidity (N.T.U.)	2.50	1.78	14.00	11.00	4.20
Biochemical Oxygen Demand (mg/L)	<2.0	<2.0	3.2	3.8	2.5
Chemical Oxygen Demand (mg/L)	112	120	103	111	101
Field Data					
Air Temperature (°C)	-12	-2	15	21	20
pH (pH units)	na	8.610	8.595	20.800	8.610
Secchi Disk (meters)	1.30	2.25	0.50	0.90	0.70
Turbidity (NTU)	1.87	0.75	14.90	4.10	13.80
Wind Speed (km/hr)	0	0	18	0	25
Cloud Cover (%)	100	10	40	10	0

Table: Dissolved oxygen, temperature and conductivity profiles for Good Spirit Lake, 2006.

Date (d/m/y)	Depth (m)	Dissolved Oxygen (mg/L)	Water Temperature (°C)	Conductivity (µS/cm)
13/02/06	1	16.02	0.4	638
	2	15.75	1.4	658
	3	14.71	3.1	675
	4	6.38	3.8	734
22/03/06	0	14.21	0.2	676
	1	14.23	0.3	676
	2	13.45	1.5	699
	3	13.24	2.7	728
	4	0.59	4.2	789
31/05/06	0	9.65	13.7	906
	1	9.55	13.5	913
	2	9.24	13.3	916
	3	8.81	13.1	918
	4	8.71	12.9	917
	5	8.35	12.8	917
7/11/06	0	10.20	13.1	993
	1	10.09	13.1	997
	2	10.10	13.0	997
	3	9.99	13.0	998
	4	9.98	13.0	999
28/08/06	0	na	20.8	1,023
	1	na	19.5	1,020
	2	na	19.2	1,022
	3	na	19.1	1,022
	4	na	19.0	1,017
	5	na	19.0	1,013

Good Spirit Lake Baseline Surface Metal Parameters, 2006					
Parameters	Feb 13	Mar 22	May 31	July 11	Aug 22
Metals (mg/L)					
Mercury (µg/L)	<0.05	<0.05	<0.05	<0.05	<0.05
Aluminum	na	<0.005	<0.005	<0.005	<0.005
Arsenic (µg/L)	na	3.4	2.1	2.4	2.4
Barium	na	0.058	0.053	0.062	0.052
Beryllium	na	<0.001	<0.001	<0.001	<0.001
Boron	na	0.087	0.084	0.066	0.064
Cadmium	na	<0.001	<0.001	<0.001	<0.001
Chromium	na	0.002	0.004	<0.001	<0.001
Cobalt	na	<0.001	<0.001	<0.001	<0.001
Copper	na	<0.001	<0.001	<0.001	<0.001
Iron	na	0.004	0.069	0.052	0.017
Lead	na	<0.002	<0.002	<0.002	<0.002
Manganese	na	0.007	0.036	0.040	0.028
Molybdenum	na	0.003	<0.001	0.001	0.003
Nickel	na	<0.001	<0.001	<0.001	<0.001
Phosphorous	na	0.03	0.06	0.02	<0.01
Silicon, Soluble	na	0.11	1.20	1.6	1.4
Silver	na	<0.001	<0.001	<0.001	<0.001
Strontium	na	0.28	0.22	0.22	0.22
Titanium	na	<0.001	<0.001	<0.001	<0.001
Vanadium	na	<0.001	<0.001	<0.001	<0.001
Zinc	na	<0.005	0.005	<0.005	<0.005
Zirconium	na	<0.001	0.003	<0.001	<0.001
Herbicides (µg/L)					
2,4,5-T	<0.5	<0.5	<0.5	<0.5	<0.5
2,4,5-TP (silvex)	<0.5	<0.5	<0.5	<0.5	<0.5
2,4-D	<0.5	<0.5	<0.5	<0.5	<0.5
Bromoxynil (Buctril)	<0.5	<0.5	<0.5	<0.5	<0.5
Dicamba (Banvel)	<0.5	<0.5	<0.5	<0.5	<0.5
Diclofop-methyl (HoeGrass)	<1	<1	<1	<1	<1
MCPA	<0.5	<0.5	<0.5	<0.5	<0.5
Picloram (Tordon)	<1	<1	<1	<1	<1