

FISH SPECIES PRESENT IN SUDBURY LAKES

Results of the 1989-1991 urban lakes surveys

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Abstract

There are 34 named lakes and approximately 20 unnamed lakes within the city limits of Sudbury. This represents 10 % of the surface area of the city. During the summers of 1989, 1990 and 1991, 43 of these lakes were surveyed for water chemistry parameters, physical features and fish biota. Twenty-three percent of the lakes had a pH value of < 5.0 ; 33% had a pH less than 6.0. Most of the lakes had metal levels (Cu and Ni) exceeding the MOE guidelines for healthy aquatic ecosystems. A total of 30 fish species were found to inhabit these waters. Thirty-two of the 43 lakes (74%) contained at least one fish species. Yellow perch were present in 25 (78%) of the fish containing lakes. Sport fish species of which there are six (walleye, smallmouth bass, largemouth bass, northern pike, lake trout, splake) inhabit 13 lakes. Long Lake contained both the richest fish community (15 spp.) and the most species of game fish (5 spp.).

Improvements in water quality resulting from reduced smelter emissions and possibly watershed liming have occurred and fish populations are now present in lakes from which they were once absent. Protection of critical fish habitat (spawning grounds, nursery areas) is vital to the survival of fish species in area lakes. Habitat information and species presence/absence data collected during the surveys should provide managers with enough information to enforce fish habitat protection laws.

Acknowledgements

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1.0 Introduction

The city of Sudbury contains 34 named lakes and approximately 20 unnamed small lakes and ponds. The combined surface area of the city's lakes and ponds is about 30 ha or approximately 10% of the surface area of the city (J. Gunn Pers comm.). This large number of water bodies within an urban area is considered an important natural asset (Lautenbach, 1990), but to date, there has been very little information on the biota inhabiting these waters. Sport fish are known to occur in some lakes, but a standardized survey of the complete fish community in these urban lakes has not occurred in the past. Lack of information on species occurrence in Sudbury's lakes limits the managers' abilities to protect fish and their habitats from detrimental forms of shoreline development or inputs from industrial effluents.

During the summers of 1989, 1990 and 1991, 43 lakes within the regional municipality of Sudbury were surveyed by students employed through the Environmental Youth Corps program in conjunction with Ontario Ministry of Natural Resources\Laurentian University Cooperative Fisheries Unit. All but two of these lakes are within the city limits of Sudbury. In addition to the biological survey, a chemical survey of the lakes was conducted during the winter of 1990.

1.1 Study lakes

The study lakes range in size from 2.7 ha (Honda Lake) to 1331 ha (Long Lake) (Figure 1 and Table 1). The lakes are located primarily in three clusters. The first cluster is the chain of lakes along the fault line from Daisy Lake down to Long Lake. Baby and Alice lakes were presumably part of this chain historically but have been separated by the construction of the railway line on the east end of Daisy Lake. The second cluster is the group of lakes draining into Kelley Lake and includes Hannah , Middle, St.Charles, Robinson and Nepahwin lakes. The third cluster is Ramsey Lake in the centre of the city with Minnow and Bethel Lake draining into it.

Most of the study lakes > 10 ha, with the exception of Alice ,Baby, Daisy, Kelley Crowley, Linton and Camp lakes, have houses or summer cottages located around the shoreline (Table 1). In general, access to the Sudbury lakes is limited to a few public boat ramps. One exception is Ramsey Lake, where public access is readily available. Some lakes are entirely enclosed by private property but there are still several Sudbury lakes, located mostly to the south of the city, with considerable amounts of crown land along their shores.

2.0 Methods

2.1 Water quality assessment

A water quality assessment was carried out on most of the lakes during January and

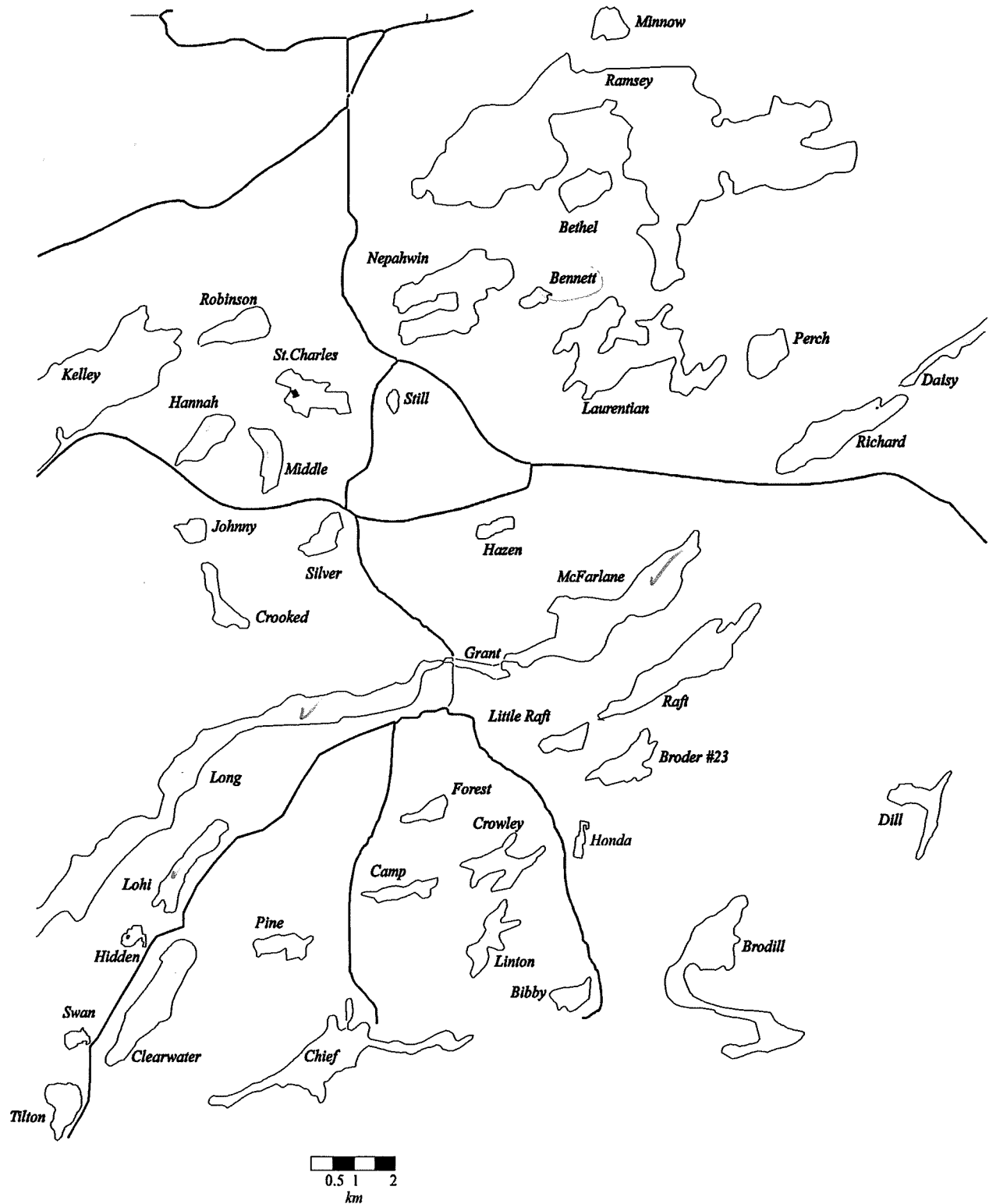


Figure 1. Location of the 41 lakes that were surveyed in the regional municipality of Sudbury during the urban lakes survey, 1989-1991.

Table 1. Physical characteristics of 43 lakes within the regional municipality of Sudbury.

Lake	Area (ha)	Volume (10 ⁶ m ³)	Perimeter (km)	Elevation (m)	SDF	Maximum depth (m)	Mean depth (m)	Secchi (m)	Dwellings
Alice ¹	27.0	139.0	4.6		222	2.47	14.0	5.1	0
Baby ¹	11.9	114.0	3.0		224	22.5	9.6	6.5	0
Bennett	14.0	12.9	1.9	277	1.46	2.8	0.98	1.9	0
Bethel	30.5	81.0	2.2	251	1.05	5.0	2.70	0.5	26
Bibby	16.7	79.7		260	2.40	8.5	4.76		5
Broder	36.4	345.4	5.1	270	2.40	20.0	9.50	18.5	2
Brodill	110.7	1061.1	11.8	241	3.17	30.0	9.60	9.8	2
Camp	20.0	173.2	2.9	283	1.81	15.0	8.70	4.0	0
Chief	115.2	1134.8		261		34.0			1
Clearwater	75.6	642.0	5.0	267	1.61	21.5	8.40	10.0	43
Crooked	26.2	102.0	4.0	260	2.22	8.0	3.80	8.0	43
Crowley	42.1	272.9	6.1	273	2.64	16.0	6.40		0
Daisy	36.1	188.0	5.5	231	2.59	14.0	5.20	14.0	0
Dill	43.0	89.4	6.5	246	2.79	4.2	2.29	2.5	9
Forest	16.5	136.3	2.5	267	1.75	12.5	8.30	3.8	3
Grant	8.5		2.4	229	2.34	6.0	0.00	4.0	8
Hannah	27.2	105.0	2.7	269	1.46	8.5	4.00	2.1	9

¹-Not in city limits

Table 1. Physical characteristics of 43 lakes located within the regional municipality of Sudbury.

Lake	Area (ha)	Volume (10 ⁶ m ³)	Shoreline (km)	Elevation (m)	SDF	Maximum depth (m)	Mean depth (m)	Secchi (m)	Dwellings
Hazen	6.0	5.34		280		2.0	0.89	1.5	0
Hidden	7.2			280		2.0	0.00	1.5	0
Honda	2.7			280		4.0	0.00		0
Johnny	8.1	25.30	1.2	275	1.22	7.5	3.12	4.5	0
Kelley	339.3	1987.00	14.7	249	2.25	17.0	5.90	4.5	0
Lady MacDonald	11.9			285		7.0			0
Laurentian	156.8	168.73	14.2	249	3.19	3.8	1.07	1.7	1
Linton	26.9	175.87	4.5	274	2.46	16.0	6.40		0
Little Raft	19.6	33.51	2.4	236	1.52	3.0	1.70	2.6	9
Lohi	40.8	250.00	4.5	265	1.97	19.5	6.20		29
Long	1331.1	8095.00	43.5	226	2.73	36.5	10.40	4.5	445
McFarlane	140.6	1020.00	11.1	229	2.65	20.0	7.30	2.1	93
Middle	28.0	170.00	3.2	268	1.71	15.0	6.20		8
Minnow	20.6	25.00	1.9	264	1.16	3.1	1.10	1.1	36
Nepahwin	127.5	1040.00	10.2	263	2.54	22.0	8.30	5.3	218

Table 1. Physical characteristics of 43 lakes within the Regional Municipality of Sudbury.

Lake (ha)	Area (10 ⁴ m ²)	Volume (km ³)	Perimeter (m)	Elevation (m)	SDF	Maximum depth (m)	Mean depth (m)	Secchi	Dwellings
Perch	30.5	50.62	2.4	271	1.21	2.6	1.70	2.0	0
Pine	18.3	58.05	3.3	282	2.14	7.0	3.17	5.0	1
Raft	105.5	896.00	7.7	236	2.10	13.0	8.90	6.5	13
Ramsey	795.2	6683.00	28.0	251	2.80	20.5	8.40	6.0	405
Richard	79.4	298.00	5.4	231	1.72	9.5	3.90	4.0	43
Robinson	32.5	50.00	2.8	250	1.36	2.0	1.50	1.5	5
Silver	23.1	111.00	2.8	280	1.66	10.0	4.80	6.6	29
St. Charles	40.8	102.00	4.3	280	1.89	6.0	2.50	3.5	53
Still	3.1		0.7	268	1.09	3.0		1.5	14
Swan	6.1			267		8.0		6.8	0
Tilton	50.9	342.00	3.1	252	1.23	12.0	6.50	4.0	33

February, 1990. Several lakes were sampled during the summer of 1991. Depth profiles of water temperature, dissolved oxygen and conductivity were measured at 1 m intervals with a YSI model 51-B dissolved oxygen-temperature meter and a YSI Model 33 conductivity meter.

Water samples were collected using a 5m long, 2.5 cm diameter weighted tygon tube. Prior to collecting a water sample, the sampling tube, mixing container and samples jars were rinsed thoroughly in lake water. Where lakes had less than 5 m of water, the sample was taken after the tube was lowered to within 0.5 m of the bottom. Samples were sent to the MOE lab in Rexdale for analysis of pH, conductivity, alkalinity (TIA) metals, major ions nutrients and metals (OMOE, 1981). During the 1991 field season, pH, conductivity and TIA alkalinity measurements were performed by Coop Unit staff at the Ramsey Lake water lab. Secchi depth reading was recorded at the time of the fishery survey and a second dissolved oxygen-temperature profile was recorded in the main basin.

2.2 Contour and Habitat Mapping

Lake outline, contour and physical feature maps were prepared for each lake. The contour maps from the lakes were prepared from Furuno FG-200 depth sounding tapes. A pantograph and a placom digital planimeter were used to determine surface area; lake volume and mean depth were calculated by methods described in Dodge, (1985). Data for the physical features map were collected during a shoreline cruise by visually mapping areas

of potential fish habitat, habitat perturbation and other physical features.

2.3 Netting assessments

Most of the lakes were surveyed for a minimum of three days netting effort using two 1.2 m small mesh (0.9 cm stretched mesh) trap nets, ten pairs of standard wire mesh minnow traps and two plexiglass traps. Gangs of large mesh gill net (five panels 25,38,51,63,76 mm stretch mesh monofilament nets) were set in deeper lakes to sample the hypolimnion. Large mesh 1.8 m trap nets were also set in some of the larger lakes. Lakes less than 10 ha generally had from one to two nights of fishing effort (Table 2). Nets and traps were set overnight, checked the following day and moved to a new location on the lake. A sub sample of each species caught was weighed and measured and game species had scales removed for age determination. The remaining fish were identified, counted and group weighed. Almost all of the fish were live released except for a sample of the various cyprinid species which were preserved for identification by a fisheries taxonomist.

3.0 Results

3.1 Water quality

The water quality sampling indicated that acid deposition is a serious problem for Sudbury area lakes. Fourteen of the surveyed lakes had a pH < 6.0 (Table 3), the pH level below which biological damage to sensitive aquatic organisms is expected to occur (Matuszek et

Table 2. Total fishing effort (days) by gear type used during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Gear Type				
	Trap Net (1.6m)	Trap Net (1.2m)	Gill Net	Plexiglass	Wire Mesh
Alice	0.0	0.0	3.4	3.6	17.8
Baby	0.0	0.0	3.3	3.9	17.8
Bennett	0.0	5.6	0.0	5.5	26.7
Bethel	5.6	0.0	0.0	5.6	25.4
Bibby	0.0	3.5	0.0	3.7	18.3
Broder # 23	0.0	5.6	0.8	5.7	27.2
Brodill	0.0	5.6	3.7	5.4	27.8
Camp	0.0	5.8	0.0	5.8	14.5
Chief	0.0	6.0	3.9	6.0	29.2
Clearwater	0.0	5.9	0.0	5.8	28.8
Crooked	0.0	5.8	0.0	6.0	28.8
Crowley	0.0	5.8	0.0	6.1	27.3
Daisy	0.0	4.0	3.7	4.0	19.0
Dill	0.0	5.9	0.0	5.9	28.9
Forest	0.0	5.6	0.0	5.7	27.5
Grant	0.0	5.7	0.0	5.7	27.7
Hannah	0.0	46.6	0.0	8.0	0.0
Hazen	0.0	0.0	0.0	0.8	4.2
Hidden	0.0	0.0	0.0	1.6	4.1
Honda	0.0	3.9	0.0	3.9	9.8
Johnny	0.0	0.9	0.0	0.9	4.5
Kelley	11.1	11.2	0.0	11.9	55.0
Lady MacDonald	0.0	0.0	1.0	2.0	5.1
Laurentian	0.0	5.9	0.0	5.7	28.9
Linton	0.0	5.6	0.0	5.8	28.2
Little Raft	0.0	5.5	0.0	5.9	29.1
Lohi	0.0	5.7	0.0	2.9	28.0
Long	11.2	11.0	0.7	11.6	50.7
McFarlane	11.6	11.8	0.9	12.1	61.2
Middle	0.0	48.2	0.0	8.0	0.0
Minnow	0.0	3.5	0.0	3.6	34.9
Nepahwin	0.0	0.7	1.7	2.1	4.3
Perch	0.0	5.6	0.0	5.7	28.4

Table 2. Total fishing effort (days) by gear type used during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991..

Lake	Gear Type				
	Trap Net (1.6m)	Trap Net (1.2m)	Gill Net	Plexiglass	Wire Mesh
Pine	0.0	3.9	0.0	3.9	19.3
Raft	0.0	5.7	0.0	6.0	27.5
Ramsey	11.5	11.5	0.0	7.1	47.4
Richard	11.3	11.7	0.0	11.8	59.2
Robinson	2.0	4.0	0.0	4.0	38.0
Silver	0.0	5.7	0.0	5.7	28.1
St.Charles	0.0	5.6	0.0	5.6	28.8
Still	0.0	0.0	0.0	2.0	4.8
Swan	0.0	1.8	0.0	1.9	8.9
Tilton	0.0	5.7	0.0	5.8	28.9

Table 3. Water chemistry parameters from 43 lakes within the Regional Municipality of Sudbury. Samples are tube composites and were collected during the winter of 1990 except where noted.

Lake	pH	Cond (umhos/cm)	TIA (mg/L)	SO4 (mg/L)	Cu (ug/L)	Ni (ug/L)	Zn (ug/L)	Fe (ug/L)	Mn (ug/L)	Al (ug/L)	Ca (mg/L)
Alice	7.30	280.0	18.8	98.4	15	1100	7	37	140	28	
Baby	6.70	71.0	3.6	21.1	21	240	18	45	38	17	
Bennett	6.67	51.0	10.16	8.93	26	100	6.5	1200	90	32	4.5
Bethel	7.38	472.0	58.99	13.02	18	62	4.9	250	380	29	21.2
Bibby ¹	6.10	39.9	3.94	9.04	14	58	10.0	860	220	60	3.1
Broder	6.40	42.0	2.13	12.43	11	77	7.3	20	37	10	3.6
Brodill	6.02	44.0	1.01	13.62	20	110	12.0	98	87	110	3.4
Camp	6.41	42.0	1.84	13.39	12	100	9.3	24	23	21	3.9
Chief ¹	4.80	39.9	-1.50	12.16	31	120	17.0	40	130	180	2.3
Clearwater	4.71	84.0	-0.83	17.56	47	180	25.0	46	290	140	6.5
Crooked	4.41	98.0	-1.54	28.33	120	460	41.0	120	220	370	6.7
Crowley	6.32	42.0	1.80	13.1	4	100	9.1	28	67	24	3.9
Daisy	4.67	60.0	-0.98	21.05	87	370	22.0	25	200	330	4.0
Dill	6.17	68.0	3.89	18.49	21	130	16.0	480	76	110	5.3
Forest	5.84	49.0	0.83	14.22	17	130	13.0	30	57	38	3.8
Grant	7.21	320.0	36.21	21.85	8	89	4.7	20	180	10	18.4
Hannah	7.12	338.0	13.86	34.22	20	200	59.0	20	83	10	15.7
Hazen ²	4.50	316.0	-2.00	13.05	21	100	14.0	760	160	90	4.0
Hidden ¹	5.41	20.8	-0.27	6.86	15	48	3.0	160	26	50	1.3
Honda ¹	6.30	30.7	4.90	6.66	9	16	25.0	290	30	50	2.9
Johnny	6.57	348.0	5.47	34.41	22	230	11.0	120	51	15	14.6
Kelly	7.42	1780.0	50.18	732.05	39	400	14.0	42	130	86	222.0
Lady MacDonald ³	4.39	715.0	-3.20	309.80	300	9100	210.0	420	470	790	77.8

1-August 1991;2-June 1991;3-September 1991

Table 3. Water chemistry parameters from 43 lakes located within the regional municipality of Sudbury. Samples are tube composites and were collected during the winter of 1990 except where noted.

Lake	pH	Cond (umhos/cm)	TIA (mg/L)	SO4 (mg/L)	Cu (ug/L)	Ni (ug/L)	Zn (ug/L)	Fe (ug/L)	Mn (ug/L)	Al (ug/L)	Ca (mg/L)
Laurentian	6.25	47.0	5.63	11.03	61	95	8.5	300	61	53	3.6
Linton	5.79	44.0	0.54	14.27	19	130	13.0	58	57	63	3.7
Little Raft	6.85	65.0	10.13	14.98	12	110	8.9	190	150	19	6.1
Lohi	4.64	92.0	-0.84	20.60	90	250	36.0	39	260	170	6.8
Long	7.33	168.0	17.00	20.64	15	88	9.0	5	17	23	11.1
McFarlane	7.54	327.0	35.59	21.99	8	72	2.8	20	6	10	18.2
Middle	6.81	261.0	7.18	27.62	21	250	15.0	20	16	10	11.1
Minnow	7.48	969.0	71.81	46.69	10	120	19.0	92	340	31	37.6
Nepahwin	7.46	531.0	32.20	30.22	17	86	9.5	25	5	25	21.4
Perch	6.51	56.0	4.73	15.10	18	86	6.5	240	62	38	4.2
Pine	4.56	46.0	-1.65	14.25	47	140	13.0	160	120	250	2.1
Raft	6.77	52.0	4.24	15.30	11	95	8.1	20	5	10	4.8
Ramsey	7.45	321.0	26.81	26.38	28	110	6.1	22	5	26	17.5
Richard	7.12	181.0	18.19	19.16	14	120	5.3	20	26	28	11.9
Robinson	7.06	772.0	45.60	36.21	35	210	19.0	250	230	78	24.9
Silver	4.17	384.0	-2.70	41.39	410	770	94.0	55	190	1100	9.9
St. Charles	6.99	249.0	11.28	34.35	27	220	18.0	66	98	20	13.2
Still	7.08	833.0	36.81	37.09	20	220	39.0	220	310	80	28.0
Tilton	5.80	60.0	0.82	16.18	16	110	14.0	45	82	72	5.2
Swan ¹	4.81	70.0	-0.77	14.92	23	140	16.0	100	120	80	6.1

1-Seasonal average (open water 1989-1990) whole lake composite volume weighted at 1 m intervals)

Table 3. (cont'd) Water chemistry parameters from 43 lakes within the Regional Municipality of Sudbury. Samples are tube composites and were collected during the winter of 1990 except where noted.

Lake	Mg (mg/L)	K (mg/L)	Na (mg/L)	Cl (mg/L)	SiO ₃ (ug/L)	DOC (ug/L)	Colour
Bennett	1.440	0.730	1.30	1.1	0.80	4.8	47
Bethel	8.640	2.440	56.40	96.2	1.10	6.9	21
Bibby ¹	1.320	0.650	1.12	0.5	1.72	4.4	35
Broder	1.220	0.610	1.08	0.5	0.92	2.8	4
Brodill	1.220	0.520	1.14	0.6	1.88	1.7	6
Camp	1.200	0.510	1.06	0.5	1.62	1.9	3.5
Chief ¹	0.820	0.430	0.96	0.5	0.94	0.7	1.0
Cleanwater	1.440	0.630	3.22	10.0	0.70	0.5	1.0
Crooked	2.140	0.860	2.22	4.4	2.54	0.3	0.5
Crowley	1.180	0.510	1.08	1.8	1.28	2.3	5.0
Daisy	1.420	0.550	1.42	0.9	1.60	0.8	1.0
Dill	2.260	0.760	1.72	2.1	1.92	5.3	36.0
Forest	1.220	0.580	1.40	1.6	0.64	2.4	4.0
Grant	5.560	1.620	33.60	59.0	0.84	3.5	12.0
Hannah	5.300	2.130	47.00	82.5	0.48	3.6	6.0
Hazen ²	1.540	1.310	53.30	81.3	0.66	2.7	20.0
Hidden ¹	0.540	0.130	0.78	0.5	0.32	6.0	22.5
Honda ¹	1.060	0.570	1.08	0.8	0.38	5.5	30.0
Johnny	4.920	1.280	38.90	73.4	0.76	3.7	10.5
Kelly	222.0	19.600	21.90	127.00	3.42	2.4	9.0
Lady MacDonald ³	28.600	4.560	19.80	29.7	3.34	2.4	2.0

1-August 1991;2-June 1991;3 September 1991

Table 3. Water chemistry parameters from 43 lakes located within the regional municipality of Sudbury. Samples are tube composites and were collected during the winter of 1990 except where noted.

Lake	Mg (mg/L)	K (mg/L)	Na (mg/L)	Cl (mg/L)	SiO ₃ (ug/L)	DOC (ug/L)	Colour (True)
Laurentian	1.400	0.840	1.80	1.7	0.80	7.1	42.5
Linton	1.140	0.500	1.10	0.4	0.72	2.4	4.5
Little Raft	1.920	0.720	1.62	1.3	1.70	1.7	7.0
Lohi	1.760	0.760	3.60	9.9	0.32	0.5	0.5
Long	3.360	1.120	13.60	24.8	1.44	3.0	9.5
McFarlane	5.380	1.630	35.00	59.9	0.54	3.6	9.5
Middle	3.840	1.590	28.60	53.1	0.92	3.2	6.0
Minnow	8.880	2.730	39.00	232.0	1.38	4.5	10.0
Nepahwin	6.800	2.670	70.10	115.0	0.86	3.4	6.5
Perch	1.880	0.790	1.56	7.0	0.20	5.0	19.0
Pine	0.700	0.480	0.92	0.5	2.58	0.4	4.0
Raft	1.540	0.630	1.24	0.7	0.30	1.9	4.5
Ramsey	5.380	1.680	36.10	60.4	0.38	3.0	7.5
Richard	3.640	1.090	17.90	31.2	0.54	2.1	5.5
Robinson	7.960	2.450	83.90	147.0	2.74	4.5	13.5
Silver	3.700	1.450	47.50	81.4	2.74	0.4	0.5
St. Charles	5.220	1.930	21.00	37.4	1.62	4.1	11.0
Still	9.040	2.710	117.00	212.0	1.98	8.6	44.0
Tilton	1.360	0.510	1.82	3.8	0.96	1.9	3.5
Swan ¹	1.020	0.416	2.00	6.9	0.10	1.2	2.4

1-seasonal average (open water 1989-1990) whole lake composite volume weighted at 1m intervals

al., 1990, Keller et al., 1990, Schindler, 1988). Ten of these lakes were so acidic (pH < 5.0) that no fish were expected to occur in them (Table 4). Of these lakes only two, Chief and Daisy, contained a fish species, the central mudminnow, (*Umbra limi*), an acid tolerant species.

Almost all lake waters in the city exceeded the MOE's water quality criteria for metals, particularly metals from smelter emissions. Values for copper ranged from 8 ug/L to 410 ug/L (MOE guideline 5 ug/L) while nickel values ranged from 16 ug/L to 9100 ug/L (MOE guideline 25 ug/L) (Table 3). Hypolimnetic anoxia was recorded in Bibby, Kelley, McFarlane and Nepahwin lakes (Appendix 1).

3.2 Species richness

Apart from the acid lakes, most of the remaining lakes contained a relatively rich assortment of fish species (Table 4). A total of 30 different species of fish were captured. Yellow perch (*Perca flavescens*) was the most common species occurring in 25 of the 32 fish-containing lakes. Other common species included brown bullhead (*Ictalurus nebulosus*) (18 lakes), pumpkinseed (*Lepomis gibbosus*) (15 lakes) and white sucker (*Catostomus commersoni*) (13 lakes). Sport fish species, which included walleye (*Stizostedion vitreum*), northern pike (*Esox lucius*), lake trout/splake (*Salvelinus namaycush*), smallmouth bass (*Micropterus dolomieu*) and largemouth bass (*Micropterus salmoides*) were present in 13 lakes. Northern pike was the most common sport fish occurring in 11 lakes (Table 4 and ,

Table 4. Species diversity and total number of fish caught during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Alice	Baby	Bennett	Bethel	Bibby	Broder #23
Species						
Brown Bullhead	1	6	0	22	0	0
Black Crappie	0	0	0	0	0	0
Blacknose Shiner	1	0	0	0	0	0
Bluntnose minnow	17	0	0	0	0	0
Brook Stickleback	6	3	19082	0	0	132
Cisco	0	0	0	0	0	0
Creek chub	0	0	0	0	0	0
Central Mudminnow	1	0	0	0	0	53
Common Shiner	0	0	0	0	0	0
Emerald Shiner	0	0	0	0	0	0
Finescale Dace	0	1	0	0	0	20
Fathead Minnow	18	1	0	613	0	239
Golden Shiner	3	3	0	3165	0	0
Iowa Darter	5	0	0	0	5	108
Johnny Darter	0	0	0	0	0	0
Largemouth Bass	0	0	0	0	0	0
Lake Trout/Splake	0	0	0	0	0	0
Mimic Shiner	0	1	0	0	0	0
Northern Pike	4	0	0	2	0	0
Northern Redbelly Dace	23	1	0	0	0	0
Pearl Dace	0	0	0	0	0	0
Pumpkinseed	2	1	0	0	0	0
Rock Bass	0	0	0	0	0	0
Rainbow Smelt	0	0	0	0	0	0
Smallmouth Bass	0	0	0	0	0	0
Spottail shiner	0	0	0	0	0	0
Walleye	0	0	0	0	1	0
White sucker	79	0	0	0	0	0
Yellow Perch	15	41	0	119	739	0
Total number of species	13	9	1	5	3	5

Table 4. Species diversity and total number of fish caught in 43 lakes surveyed within the regional municipality of Sudbury between 1989 and 1991.

Lake	Brodill	Camp	Chief	Clearwater	Crooked	Crowley
Species						
Brown Bullhead	0	0	0	0	0	0
Black Crappie	0	0	0	0	0	0
Blacknose Shiner	0	0	0	0	0	0
Bluntnose minnow	0	0	0	0	0	0
Brook Stickleback	0	0	0	0	0	0
Cisco	0	0	0	0	0	0
Creek chub	0	0	0	0	0	0
Central Mudminnow	0	0	61	0	0	0
Common Shiner	0	0	0	0	0	0
Emerald Shiner	0	0	0	0	0	0
Finescale Dace	0	0	0	0	0	0
Fathead Minnow	0	0	0	0	0	0
Golden Shiner	0	0	0	0	0	0
Iowa Darter	0	0	0	0	0	0
Johnny Darter	0	0	0	0	0	0
Largemouth Bass	0	0	0	0	0	0
Lake Trout/Splake	0	0	0	0	0	0
Mimic Shiner	0	0	0	0	0	0
Northern Pike	0	0	0	0	0	0
Northern Redbelly Dace	0	0	0	0	0	0
Pearl Dace	0	0	0	0	0	0
Pumpkinseed	0	0	0	0	0	0
Rock Bass	0	0	0	0	0	0
Rainbow Smelt	0	0	0	0	0	0
Smallmouth Bass	0	0	0	0	0	0
Spottail shiner	0	0	0	0	0	0
Walleye	0	0	0	0	0	0
White sucker	0	0	0	0	0	0
Yellow Perch	1090	1167	0	0	0	829
Total number of species	1	0	1	0	0	1

Table 4. Species diversity and total number of fish caught during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Daisy	Dill	Forest	Grant	Hannah	Hazen
Species						
Brown Bullhead	0	35	0	21	1*	0
Black Crappie	0	0	0	0	0	0
Blacknose Shiner	0	0	0	0	0	0
Bluntnose minnow	0	0	0	0	0	0
Brook Stickleback	0	0	0	0	0	0
Cisco	0	0	0	0	0	0
Creek chub	0	0	0	0	1	0
Central Mudminnow	2	6	0	0	0	0
Common Shiner	0	0	0	0	0	0
Emerald Shiner	0	0	0	0	0	0
Finescale Dace	0	0	0	0	0	0
Fathead Minnow	0	0	0	0	0	0
Golden Shiner	0	7	0	2	1	0
Iowa Darter	0	0	0	1	36	0
Johnny Darter	0	0	0	0	0	0
Largemouth Bass	0	0	0	113	0	0
Lake Trout/Splake	0	0	0	0	0	0
Mimic Shiner	0	0	0	0	0	0
Northern Pike	0	4	0	2	0	0
Northern Redbelly Dace	0	0	0	0	0	0
Pearl Dace	0	0	0	0	0	0
Pumpkinseed	0	214	0	73	0	0
Rock Bass	0	0	0	0	0	0
Rainbow Smelt	0	0	0	0	0	0
Smallmouth Bass	0	0	0	0	0	0
Spottail shiner	0	0	0	0	0	0
Walleye	0	0	0	0	0	0
White sucker	0	1	0	4	0	0
Yellow Perch	0	473	0	194	966	0

Total number of species	1	7	0	8	5	0
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*-1 specimen captured during the 1991 mark-recapture project

Table 4. Species diversity and total number of fish caught in 41 lakes surveyed within the regional municipality of Sudbury between 1989 and 1991.

Lake	Hidden	Honda	Johnny	Kelley	Lady Mac	Laurentian
Species						
Brown Bullhead	0	0	0	611	0	0
Black Crappie	0	0	0	0	0	0
Blacknose Shiner	0	0	0	0	0	0
Bluntnose minnow	0	0	0	0	0	0
Brook Stickleback	0	665	0	13	0	7062
Cisco	0	0	0	0	0	0
Creek chub	0	0	0	14	0	0
Central Mudminnow	0	0	0	0	0	0
Common Shiner	0	0	0	0	0	0
Emerald Shiner	0	0	0	50	0	0
Finescale Dace	0	252	0	0	0	0
Fathead Minnow	0	965	0	188	0	5646
Golden Shiner	0	0	0	92	0	0
Iowa Darter	0	3	0	2	0	37
Johnny Darter	0	0	0	0	0	0
Largemouth Bass	0	0	0	0	0	0
Lake Trout/Splake	0	0	0	0	0	0
Mimic Shiner	0	0	0	0	0	0
Northern Pike	0	0	0	1	0	0
Northern Redbelly Dace	0	0	0	0	0	0
Pearl Dace	0	0	0	0	0	0
Pumpkinseed	0	0	0	463	0	0
Rock Bass	0	0	0	1	0	0
Rainbow Smelt	0	0	0	0	0	0
Smallmouth Bass	0	0	0	0	0	0
Spottail shiner	0	0	0	0	0	0
Walleye	0	0	0	2	0	0
White sucker	0	0	0	1360	0	0
Yellow Perch	0	0	0	15	0	633
Total number of species	0	4	0	13	0	4

Table 4. Species diversity and total number of fish caught during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Linton	Little Raft	Lohi	Long	McFarlane	Middle
Species						
Brown Bullhead	0	30	0	282	140	0
Black Crappie	0	0	0	0	0	0
Blacknose Shiner	0	0	0	0	0	0
Bluntnose minnow	0	0	0	0	0	0
Brook Stickleback	0	0	0	0	0	0
Cisco	0	0	0	11	34*	0
Creek chub	0	0	0	1	0	0
Central Mudminnow	0	0	0	0	0	0
Common Shiner	0	0	0	6	0	0
Emerald Shiner	0	0	0	0	0	0
Finescale Dace	0	0	0	0	1	0
Fathead Minnow	0	0	0	0	0	0
Golden Shiner	0	693	0	2	9	6
Iowa Darter	0	39	0	3	1	5
Johnny Darter	0	0	0	0	0	2
Largemouth Bass	0	0	0	13	131	0
Lake Trout/Splake	0	0	0	8	0	0
Mimic Shiner	0	0	0	0	0	0
Northern Pike	0	0	0	1	3	0
Northern Redbelly Dace	0	13	0	0	0	2
Pearl Dace	0	0	0	0	0	0
Pumpkinseed	0	304	0	116	170	0
Rock Bass	0	0	0	0	0	0
Rainbow Smelt	0	0	0	0	0	0
Smallmouth Bass	0	0	0	79	60	0
Spottail shiner	0	0	0	5	0	0
Walleye	0	0	0	22	7	0
White sucker	0	17	0	108	33	0
Yellow Perch	1873	749	0	400	82	2052
Total number of species						
	1	7	0	15	12	5

Table 4. Species diversity and total number of fish caught in 43 lakes surveyed within the regional municipality of Sudbury between 1989 and 1991.

	Minnow	Nepahwin	Perch	Pine	Raft	Ramsey
Species						
Brown Bullhead	350	1	0	0	24	8
Black Crappie	0	0	0	0	0	1
Blacknose Shiner	0	0	0	0	0	0
Bluntnose minnow	0	0	0	0	0	0
Brook Stickleback	0	0	296	0	0	0
Cisco	0	0	0	0	0	0
Creek chub	0	0	0	0	0	0
Central Mudminnow	0	0	0	0	0	0
Common Shiner	0	0	0	0	0	0
Emerald Shiner	0	0	0	0	0	0
Finescale Dace	0	0	0	0	0	0
Fathead Minnow	7	0	21352	0	0	0
Golden Shiner	41	0	0	0	0	362
Iowa Darter	7	0	104	0	39	0
Johnny Darter	0	0	0	0	0	0
Largemouth Bass	0	0	0	0	0	0
Lake Trout/Splake	0	17	0	0	0	0
Mimic Shiner	0	0	0	0	0	0
Northern Pike	2	1 ¹	0	0	0	6
Northern Redbelly Dace	0	0	0	0	0	0
Pearl Dace	0	0	0	0	34	0
Pumpkinseed	125	8	0	0	196	7
Rock Bass	68	6	0	0	0	10
Rainbow Smelt	0	138	0	0	0	0
Smallmouth Bass	0	1	0	0	0	1
Splake	0	4	0	0	0	0
Spottail shiner	0	0	0	0	0	0
Walleye	0	0	0	0	0	369
White sucker	30	8	0	0	21	15
Yellow Perch	718	1	0	0	372	3025
Total number of species	9	10	3	0	6	10

Table 4. Species diversity and total number of fish caught during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Richard	Robinson	Silver	St.Charles	Still	Swan	Tilton
Species							
Brown Bullhead	199	2328	0	27	0	0	1
Black Crappie	0	0	0	0	0	0	0
Blacknose Shiner	0	0	0	0	0	0	0
Bluntnose minnow	0	0	0	0	0	0	0
Brook Stickleback	0	0	0	0	0	0	0
Cisco	0	0	0	0	0	0	0
Creek chub	0	0	0	0	0	0	0
Central Mudminnow	1	0	0	0	0	0	1
Common Shiner	0	0	0	0	0	0	0
Emerald Shiner	0	0	0	0	0	0	0
Finescale Dace	0	0	0	0	0	0	0
Fathead Minnow	0	0	0	0	0	0	0
Golden Shiner	0	0	0	0	100	0	0
Iowa Darter	0	1	0	39	0	0	0
Johnny Darter	0	0	0	0	0	0	0
Largemouth Bass	7	0	0	0	0	0	0
Lake Trout/Splake	0	0	0	0	0	0	0
Mimic Shiner	0	0	0	0	0	0	0
Northern Pike	23	23	0	0	0	0	0
North.Redbelly Dace	0	0	0	0	0	0	0
Pearl Dace	0	0	0	0	0	0	0
Pumpkinseed	532	2	0	0	600	0	0
Rock Bass	0	2	0	0	0	0	0
Rainbow Smelt	0	0	0	0	0	0	0
Smallmouth Bass	0	0	0	0	0	0	0
Spottail shiner	0	0	0	0	0	0	0
Walleye	30	1	0	0	0	0	0
White sucker	1	270	0	0	0	0	0
Yellow Perch	787	218	0	3919	58	0	528
Total number of species	8	8	0	3	3	0	3

Figure 2). Walleye, smallmouth bass, largemouth bass and lake trout/splake were present in seven, four, four and two lakes, respectively. Long lake contained five of the six sport fish species present within the city limits and also had the richest fish community with 15 fish species (Table 4).

3.3 Catch-per-unit-effort

3.3.1 Trap nets

Ramsey Lake had the largest catch-per-unit-effort (CUE) values for walleye captured in both the 1.6 m and 1.2 m trap nets (17.5 and 14.6 fish/24 hrs, respectively). McFarlane Lake had the largest 1.6 m trap net CUE values for largemouth bass (3.6 fish/24 hrs) while northern pike trap net CUE's were greatest in Robinson Lake (4.0 fish/24 hrs and 3.8 fish/24 hrs in the 1.6 m and 1.2 m trap nets, respectively). Trap net CUE values for smallmouth bass were greatest in Long Lake (5.2 fish/24 hrs and 1.2 fish/24 hrs in the 1.6m and 1.2 m trap nets, respectively). Trap nets cue's of > 100 fish per 24/hr were recorded for brown bullheads and yellow perch in Richard, Robinson, Minnow and St. Charles lakes (Tables 5 & 6). The 1.8 and 1.2 m trap nets caught a total of 11 and 21 species, respectively.

3.3.2 Minnow traps

A total of 22 and 20 fish species were captured in plexiglass traps and minnow traps,



Figure 2. Surveyed lakes within the regional municipality of Sudbury that were found to contain at least one sportfish species during the 1989-1991 urban lakes survey.

Table 5. Catch-per-unit-effort (#/24 hr) of fish caught with 1.8 m trap nets during the urban lakes survey of 43 lakes within the regional municipality of Sudbury, 1989-1991.

Species	Bethel	Kelley	Long	McFarlane	Ramsey	Richard	Robinson
Brown Bullhead	3.9	28.6	22.3	9.0	0.5	140.0	138.5
Black Crappie	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Golden Shiner	0.0	0.0	0.0	0.8	0.1	0.0	0.0
Largemouth Bass	0.0	0.0	0.4	3.9	0.0	0.4	0.0
Northern Pike	0.0	0.0	0.0	0.3	0.5	1.7	4.0
Pumpkinseed	0.0	0.2	0.8	2.9	0.3	12.7	0.0
Rock Bass	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Smallmouth Bass	0.0	0.0	5.2	3.2	0.1	0.0	0.0
Walleye	0.0	0.2	1.9	0.6	17.5	1.7	0.0
White Sucker	0.0	59.9	7.2	1.0	0.1	0.0	45.0
Yellow Perch	0.0	0.5	1.7	2.4	0.1	0.9	1.0

Table 6. Catch-per-unit-effort (#/24 hr) for fish species caught in small mesh trap nets during the urban lakes survey of 43 lakes within the regional municipality of Sudbury, 1989-1991.

Lake	Bennett	Bibby	Broder	Brodill
Species				
Brown Bullhead	0.0	0.0	0.0	0.0
Brook Stickleback	1.6	0.0	0.0	0.0
Creek chub	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.0
Common Shiner	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	0.0	2.5
Finescale Dace	0.0	0.0	0.0	0.0
Golden Shiner	0.0	0.0	0.0	0.0
Largemouth Bass	0.0	0.0	0.0	0.0
Lake Trout/Splake	0.0	0.0	0.0	0.0
Northern Pike	0.0	0.0	0.0	0.0
Northern Redbelly Dace	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0
Pumpkinseed	0.0	0.0	0.0	0.0
Rock Bass	0.0	0.0	0.0	0.0
Rainbow Smelt	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.0	0.0
Walleye	0.0	0.0	0.3	0.0
White sucker	0.0	0.0	0.0	0.0
Yellow Perch	0.0	102.2	60.1	0.0

Table 6. Catch-per-unit-effort (#/24 hr) for fish species caught in 1.2 m small mesh trap nets during the urban lakes survey of 43 lakes within the regional municipality of Sudbury, 1989-1991.

Lake	Camp	Chief	Clearwater	Crooked	Crowley
Species					
Brown Bullhead	0.0	0.0	0.0	0.0	0.0
Brook Stickleback	0.0	0.0	0.0	0.0	0.0
Creek chub	0.0	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.0	0.0
Common Shiner	0.0	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	0.0	0.0	0.0
Finescale Dace	0.0	0.0	0.0	0.0	0.0
Golden Shiner	0.0	0.0	0.0	0.0	0.0
Largemouth Bass	0.0	0.0	0.0	0.0	0.0
Lake Trout/Splake	0.0	0.0	0.0	0.0	0.0
Northern Pike	0.0	0.0	0.0	0.0	0.0
N. Redbelly Dace	0.0	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0	0.0
Pumpkinseed	0.0	0.0	0.0	0.0	0.0
Rock Bass	0.0	0.0	0.0	0.0	0.0
Rainbow Smelt	0.0	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.0	0.0	0.0
Walleye	0.0	0.0	0.0	0.0	0.0
White sucker	0.0	0.0	0.0	0.0	0.0
Yellow Perch	1.7	0.0	0.0	0.0	12.24

Table 6. Catch-per-unit-effort (#/24 hr) for fish species caught in 1.2 m small mesh trap nets during the urban lakes survey of 43 lakes within the regional municipality of Sudbury, 1989-1991.

Lake	Daisy	Dill	Forest	Grant	Hannah	Hazen
Species						
Brown Bullhead	0.0	4.3	0.0	3.5	0.0	0.0
Brook Stickleback	0.0	0.0	0.0	0.0	0.0	0.0
Creek chub	0.0	0.0	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.0	0.0	0.0
Common Shiner	0.0	0.0	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	0.0	0.0	0.0	0.0
Finescale Dace	0.0	0.0	0.0	0.0	0.0	0.0
Golden Shiner	0.0	0.0	0.0	0.0	0.0	0.0
Lemmouth Bass	0.0	0.0	0.0	0.0	0.0	0.0
Lake Trout/Splake	0.0	0.0	0.0	0.0	0.0	0.0
Northern Pike	0.0	0.3	0.0	0.0	0.0	0.0
N. Redbelly Dace	0.0	0.0	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0	0.0	0.0
Pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0
Rock Bass	0.0	0.0	0.0	0.0	0.0	0.0
Rainbow Smelt	0.0	0.0	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.0	0.0	0.0	0.0
Walleye	0.0	0.0	0.0	0.0	0.0	0.0
White sucker	0.0	0.2	0.0	0.0	0.0	0.0
Yellow Perch	0.0	30.8	0.0	0.0	20.4	0.0

Table 6. Catch-per-unit-effort (#/24 hr) for fish species caught in 1.2 m small mesh trap nets during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Honda	Johnny	Kelley	Laurentian	Linton
Species					
Brown Bullhead	0.0	0.0	26.4	0.0	0.0
Brook Stickleback	0.5	0.0	0.0	0.3	0.0
Creek chub	0.0	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.0	0.0
Common Shiner	0.0	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	2.0	0.0	0.0
Fathead Minnow	11.3	0.0	0.5	3.9	0.0
Finescale Dace	1.3	0.0	0.0	0.0	0.0
Golden Shiner	0.0	0.0	5.0	0.0	0.0
Largemouth Bass	0.0	0.0	0.0	0.0	0.0
Lake Trout/Splake	0.0	0.0	0.0	0.0	0.0
Northern Pike	0.0	0.0	0.1	0.0	0.0
N. Redbelly Dace	0.0	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0	0.0
Pumpkinseed	0.0	0.0	0.1	0.0	0.0
Rock Bass	0.0	0.0	0.1	0.0	0.0
Rainbow Smelt	0.0	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.0	0.0	0.0
Walleye	0.0	0.0	0.0	0.0	0.0
White sucker	0.0	0.0	51.3	0.0	0.0
Yellow Perch	0.0	0.0	0.9	7.5	0.0

Table 6. Catch-per-unit-effort (#/24 hr) for fish species caught in 1.2 m small mesh trap nets during the urban lakes survey of 43 lakes within the regional municipality of Sudbury, 1989-1991.

Lake	Little Raft	Lohi	Long	McFarlane	Middle
Species					
Brown Bullhead	5.1	0.0	1.2	3.1	0.0
Brook Stickleback	0.0	0.0	0.0	0.0	0.0
Creek chub	0.0	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.0	0.0
Common Shiner	0.0	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	0.0	0.0	0.0
Finescale Dace	0.0	0.0	0.0	0.0	0.0
Golden Shiner	8.9	0.0	0.1	0.0	0.0
Largemouth Bass	0.0	0.0	0.1	0.7	0.0
Lake Trout/Splake	0.0	0.0	0.0	0.0	0.0
Northern Pike	0.0	0.0	0.1	0.0	0.0
N. Redbelly Dace	0.2	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0	0.0
Pumpkinseed	8.0	0.0	1.5	3.9	0.0
Rock Bass	0.0	0.0	0.0	0.0	0.0
Rainbow Smelt	0.0	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	1.2	0.7	0.0
Walleye	0.0	0.0	0.1	0.0	0.0
White sucker	2.9	0.0	2.5	1.0	0.0
Yellow Perch	110.6	0.0	4.9	2.4	40.7

Table 6. Catch-per-unit-effort (#/24 hr) for fish species caught in 1.2 m small mesh trap nets during the urban lakes survey of 43 lakes within the regional municipality of Sudbury, 1989-1991.

Lake	Minnow	Nepahwin	Perch	Pine	Raft	Ramsey
Species						
Brown Bullhead	100.6	1.5	0.0	0.0	4.2	0.2
Brook Stickleback	0.0	0.0	0.0	0.0	0.0	0.0
Creek chub	0.0	0.0	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.0	0.0	0.0
Common Shiner	0.0	0.0	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	30.4	0.0	0.0	0.0
Finescale Dace	0.0	0.0	0.0	0.0	0.0	0.0
Golden Shiner	9.8	0.0	0.0	0.0	0.0	0.0
Largemouth Bass	0.0	0.0	0.0	0.0	0.0	0.0
Lake Trout/Splake	0.0	5.8	0.0	0.0	0.0	0.0
Mimic Shiner	0.0	0.0	0.0	0.0	0.0	0.0
Northern Pike	0.6	0.0	0.0	0.0	0.0	0.0
N. Redbelly Dace	0.0	0.0	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0	5.2	0.0
Pumpkinseed	35.6	5.8	0.0	0.0	19.8	0.3
Rainbow Smelt	0.0	2.9	0.0	0.0	0.0	0.0
Rock Bass	19.3	4.4	0.0	0.0	0.0	0.7
Smallmouth Bass	0.0	0.0	0.0	0.0	0.0	0.0
Walleye	0.0	0.0	0.0	0.0	0.0	14.6
White sucker	8.6	11.6	0.0	0.0	3.7	0.0
Yellow Perch	198.0	0.0	0.0	0.0	7.6	65.7

Table 6. Catch-per-unit-effort (#/24 hr) for fish species caught in 1.2 m small mesh trap nets during the urban lakes survey of 43 lakes within the regional municipality of Sudbury, 1989-1991.

Lake	Richard	Robinson	Silver	St.Charles	Swan	Tilton
Species						
Brown Bullhead	3.2	512.5	0.0	4.8	0.0	0.2
Brook Stickleback	0.0	0.0	0.0	0.0	0.0	0.0
Creek chub	0.0	0.0	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.0	0.0	0.0
Common Shiner	0.0	0.0	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	0.0	0.0	0.0	0.0
Finescale Dace	0.0	0.0	0.0	0.0	0.0	0.0
Golden Shiner	0.0	0.0	0.0	0.0	0.0	0.0
Largemouth Bass	0.0	0.0	0.0	0.0	0.0	0.0
Lake Trout/Splake	0.0	0.0	0.0	0.0	0.0	0.0
Northern Pike	0.3	3.8	0.0	0.0	0.0	0.0
N. Redbelly Dace	0.0	0.0	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0	0.0	0.0
Pumpkinseed	7.5	0.5	0.0	0.0	0.0	0.0
Rainbow Smelt	0.0	0.0	0.0	0.0	0.0	0.0
Rock Bass	0.0	0.5	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.0	0.0	0.0	0.0
Walleye	0.9	0.3	0.0	0.0	0.0	0.0
White sucker	0.1	45.0	0.0	0.0	0.0	0.0
Yellow Perch	3.6	30.0	0.0	129.1	0.0	10.5

respectively. CUE's of over 600 fish/24 hrs were recorded for fathead minnows (*Pimephales promelas*) in Perch lake. Plexiglass CUE's of over 400 fish/24 hrs were recorded for brook stickleback (*Culaea inconstans*) in Lake Laurentian (Tables 7 & 8).

4.0 Discussion

The lakes of the Sudbury area are highly variable-physically, chemically and biologically. They vary greatly in size, degree of shoreline development, trophic status, contaminant levels and species richness. With the close proximity to the metal smelters, the overwhelming influence of air pollutants on lake water quality and aquatic life cannot be denied. Watershed soils (Negusanti and McIlveen, 1990), lake sediments (Semkin and Kramer, 1976), and lake water (Keller and Pitblado, 1986) all contain elevated levels of smelter metals such as Cu, Ni and Zn, and the damaging effects of high inputs of acid precipitation on local lakes has long been recognized (Gorham and Gordon, 1960). For example, Clearwater Lake was limed as early as 1957 in an unsuccessful attempt to neutralize the high acid conditions and restore suitable water quality for fish (OMNR, 1957). However with recent reduction in emissions, and increasing evidence of water quality improvements, (Dillon, et al, 1986), Hutchison and Havas, 1986, Keller and Pitblado, 1986), and biological communities showing signs of recovery, (Gunn and Keller, 1990, Keller et al, 1990), the future of Sudbury area lakes appears far rosier than in the past.

Our results from the Urban Lakes Survey, shows that fishless, highly acidic, metal

Table 7. Catch-per-unit-effort (#/24 hr) of fish caught in plexiglass traps during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Alice	Baby	Bennett	Bethel	Bibby	Broder	Brodill	Camp	Chief	Crowley	Daisy
Species											
Brown Bullhead	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blacknose Shiner	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brook Stickleback	0.6	0.5	1981.2	0.0	0.0	9.5	0.0	0.0	0.0	0.0	0.0
Creek Chub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.5
Emerald Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Finescale Dace	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0
Fathead Minnow	4.9	0.0	0.0	5.4	0.0	19.1	0.0	0.0	0.0	0.0	0.0
Golden Shiner	0.8	0.5	0.0	312.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iowa Darter	0.3	0.0	0.0	0.0	0.0	18.6	0.0	0.0	0.0	0.0	0.0
Johnny Darter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Largemouth Bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nort. Redbelly Dace	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumpkinseed	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rock Bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White Sucker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow Perch	0.6	0.0	0.0	18.0	5.2	0.0	16.5	65.1	0.0	27.3	0.0

Table 7. Catch-per-unit-effort (#/24 hr) of fish caught in plexiglass traps during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake Species	Dill	Forest	Grant	Hannah	Honda	Kelley	Laurentian	Linton	Little Raft
Brown Bullhead	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Blacknose Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brook Stickleback	0.0	0.0	0.0	0.0	124.4	0.4	408.2	0.0	0.0
Creek Chub	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
Central Mudminnow	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	0.0	0.0	0.0	13.0	0.0	0.0	0.0
Finescale Dace	0.0	0.0	0.0	0.0	36.3	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	0.0	0.0	79.3	6.0	456.3	0.0	0.0
Golden Shiner	1.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	60.0
Iowa Darter	0.0	0.0	0.0	4.5	0.8	0.0	6.5	0.0	0.5
Johnny Darter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Largemouth Bass	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Northern Redbelly Dace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
Northern Pike	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumpkinseed	27.2	0.0	1.1	0.0	0.0	33.5	0.0	0.0	0.9
Rock Bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White Sucker	0.0	0.0	0.0	0.0	0.0	8.1	0.0	0.0	0.2
Yellow Perch	5.6	0.0	0.5	2.1	0.0	0.0	35.6	21.3	12.3

Table 7. Catch-per-unit-effort (#/24 hr) of fish caught in plexiglass traps during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Long	McFarlane	Middle	Minnow	Nepahwin	Perch	Raft	Ramsey	Richard	Robinson
Species										
Brown Bullhead	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
Blacknose Shiner	0.0	0.0	0.0	0.0	4.9	0.0	0.0	0.0	0.0	0.0
Brook Stickleback	0.0	0.0	0.0	0.0	0.0	31.3	0.0	0.0	0.0	0.0
Creek Chub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Emerald Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Finescale Dace	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	0.0	1.9	0.0	622.5	0.0	0.0	0.0	0.0
Golden Shiner	0.1	0.0	0.3	1.9	0.0	0.0	0.0	28.7	0.0	0.0
Iowa Darter	0.3	0.1	0.6	1.9	0.0	18.3	0.5	0.0	0.0	0.3
Johnny Darter	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Largemouth Bass	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Northern Redbelly Dace	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0
Pumpkinseed	0.7	0.3	0.0	0.3	0.0	0.0	1.3	0.0	4.3	0.0
Rock Bass	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
Smallmouth Bass	0.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White Sucker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow Perch	10.0	0.1	11.0	2.5	0.0	0.0	26.5	110.0	8.0	1.3

Table 7. Catch-per-unit-effort (#/24 hr) of fish caught in plexiglass traps during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	St.Charles	Still	Swan	Tilton
Brown Bullhead	0.0	0.0	0.0	0.0
Blacknose Shiner	0.0	0.0	0.0	0.0
Brook Stickleback	0.0	0.0	0.0	0.0
Creek Chub	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.2
Emerald Shiner	0.0	0.0	0.0	0.0
Finescale Dace	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	0.0	0.0
Golden Shiner	0.0	0.5	0.0	0.0
Iowa Darter	0.2	0.0	0.0	0.0
Johnny Darter	0.0	0.0	0.0	0.0
Largemouth Bass	0.0	0.0	0.0	0.0
Northern Redbelly Dace	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0
Pumpkinseed	0.0	195.6	0.0	0.0
Rock Bass	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.0	0.0
White Sucker	0.0	0.0	0.0	0.0
Yellow Perch	554.5	3.0	0.0	8.7

Table 8. Catch-per-unit-effort (#/24 hr) of fish caught in wire mesh minnow traps during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Alice	Baby	Bennett	Bethel	Bibby	Broder	Brodill	Camp	Chief	Clearwater	Crooked	Crowley	Daisy
Species													
Brown Bullhead	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brook Stickleback	0.2	0.1	308.2	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Creek Chub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central Mudminnow	0.1	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Common Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fathead Minnow	0.3	0.1	0.0	0.2	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Finescale Dace	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Golden Shiner	0.0	0.1	0.0	56.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iowa Darter	0.2	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Largemouth Bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mimic Shiner	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Northern Pike	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N. Redbelly Dace	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumpkinseed	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rock Bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White Sucker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow Perch	0.5	0.1	0.0	0.8	19.8	0.0	23.9	38.1	0.0	0.0	0.0	20.7	0.0

Table 8. Catch-per-unit-effort (#/24 hr) of fish caught in wire mesh minnow traps during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Species	Dill	Forest	Grant	Hazen	Hidden	Honda	Johnny	Kelley	Lady MacDonald	Laurentian	Linton	Little Reft
Brown Bullhead	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brook Stickleback	0.0	0.0	0.0	0.0	0.0	18.8	0.0	0.2	0.0	163.7	0.0	0.0
Creek Chub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central Mudminnow	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Common Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	0.0	0.0	0.0	63.0	0.0	0.2	0.0	104.5	0.0	0.0
Finescale Dace	0.0	0.0	0.0	0.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0
Golden Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	10.1
Iowa Darter	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Largemouth Bass	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mimic Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Northern Pike	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nort. Redbelly Dace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Pearl Dace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pumpkinseed	1.8	0.0	1.8	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	6.9
Rock Bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White Sucker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
Yellow Perch	8.9	0.0	6.8	0.0	0.0	0.0	0.0	0.0	0.0	13.4	33.1	2.4

Table 8. Catch-per-unit-effort (#/24 hr) of fish caught in wire mesh minnow traps during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Species	Lohi	Long	McFarlane	Minnow	Nepahwin	Perch	Pine	Raft	Ramsey	Richard	Robinson	Silver
Brown Bullhead	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brook Stickleback	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0
Creek Chub	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Common Shiner	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	0.0	0.0	0.0	621.1	0.0	0.0	0.0	0.0	0.0	0.0
Finescale Dace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Golden Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0
Iowa Darter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Largemouth Bass	0.0	0.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mimic Shiner	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Northern Pike	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N. Redbelly Dace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Pumpkinseed	0.0	1.6	1.4	0.0	0.9	0.0	0.0	2.8	0.0	4.2	0.0	0.0
Rock Bass	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White Sucker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow Perch	0.0	4.2	0.4	0.6	0.0	0.0	0.0	6.2	31.4	10.8	2.4	3.4

Table 8. Catch-per-unit-effort (#/24 hr) of fish caught in wire mesh minnow traps during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	St.Charles	Still	Swan	Tilton
Species				
Brown Bullhead	0.0	0.0	0.0	0.0
Brook Stickleback	0.0	0.0	0.0	0.0
Creek Chub	0.0	0.0	0.0	0.0
Central Mudminnow	0.0	0.0	0.0	0.0
Common Shiner	0.0	0.0	0.0	0.0
Emerald Shiner	0.0	0.0	0.0	0.0
Fathead Minnow	0.0	0.0	0.0	0.0
Finescale Dace	0.0	0.0	0.0	0.0
Golden Shiner	0.0	20.6	0.0	0.0
Iowa Darter	1.0	0.0	0.0	0.0
Largemouth Bass	0.0	0.0	0.0	0.0
Mimic Shiner	0.0	0.0	0.0	0.0
Northern Pike	0.0	0.0	0.0	0.0
N. Redbelly Dace	0.0	0.0	0.0	0.0
Pearl Dace	0.0	0.0	0.0	0.0
Pumpkinseed	0.0	42.6	0.0	0.0
Rock Bass	0.0	0.0	0.0	0.0
Smallmouth Bass	0.0	0.0	0.0	0.0
White Sucker	0.0	0.0	0.0	0.0
Yellow Perch	3.4	10.8	0.0	1.6

contaminated lakes (Clearwater, Lohi, Daisy, Crooked, Silver, Swan, Chief, Pine) still exist and this therefore reinforces the need for further emission reductions for area smelters. However the surprising results of finding fish in lakes such as Hannah Lake and Middle Lake are encouraging sign that recolonization and recovery can occur.

Middle, Hannah, Clearwater and Lohi lakes were part of the Sudbury Environmental Study (SES), an intensive chemical and biological study conducted by the MOE and MNR during the period 1973-1979 (OMOE, 1982). When the SES study began, all four lakes were acidic ($\text{pH} < 4.6$), heavily contaminated with smelter metals and devoid of fish. Clearwater Lake was selected as an untreated control lake to examine changes over time, while the remaining lakes were used to test the effectiveness of remedial procedures such as liming (Lohi, Middle, Hannah) and fertilization (Middle and Hannah). The direct treatment of lake water with neutralization agents (CaCO_3 , $\text{Ca}(\text{OH})_2$) or fertilizers (to increase production and natural alkalinity generation) proved unsuccessful (OMOE, 1982). Lohi lake reacidified within four years of the treatment (OMOE, 1982). Middle and Hannah lakes did maintain a high pH ($\text{pH} > 6.5$) until the end of the study, however metals remained at toxic levels.

In 1976, MNR stocked the experimental SES lakes with various fish species to test the survival in these treated lakes (Appendix 2). Lohi lake ($\text{pH} 6.2$ Cu 40 ug/L, Ni 160 ug/L, Zn 32 ug/L), was stocked with 1200 yearling brook trout (*Salvelinus fontinalis*), 1400 Iowa Darters (*Etheostoma exile*) and 170 brook stickleback (Powell, 1977). No fish appeared to survive until the end of the first summer and Powell (1977) concluded that copper toxicity

was likely the primary cause of mortality. Similarly, in Middle Lake, 2500 young-of-the-year smallmouth bass, 500 Iowa darters and 200 brook sticklebacks were stocked in 1976. Despite considerable effort to capture fish during the next year (eight plexiglass traps-193 hrs, 12-four foot small mesh trap nets-290 hrs; two gill nets-51 hrs), no fish were captured (Powell, unpublished data). Yan et al (1979) confirmed the persistent toxicity problem by holding rainbow trout (*Oncorhynchus mykiss*) in submerged cages in Middle and Lohi lakes. They died in less than four days.

The situation is now quite different in the S.E.S. lakes. Clearwater Lake and Lohi Lake remain acidic and fishless, however, water quality, at least in Clearwater Lake (little current data on Lohi Lake), is slowly improving under reduced smelter emissions (Dillon et al, 1986). In Hannah and Middle lakes the changes are dramatic, with pH remaining high (pH 6.8-7.1), metal levels reduced by more than 50 % since 1976 and five fish species present in each lake (Tables 3 & 4). These changes may be due to smelter emission reductions and persistent effects of S.E.S.liming and fertilizing experiments, but land liming in the watershed of these lakes in 1983 by the Regional Municipality of Sudbury (VETAC, 1985) may have also contributed to the improvement. Watershed liming has proven to be an effective method of treating acid lakes in other areas (Boutacoff, 1990) and offers considerable promise in dealing with acid and metal runoff problem in area like Sudbury. For this reason, The Regional Municipality of Sudbury (VETAC, 1990) is proposing to use watershed liming as a means to improve water quality in five Sudbury area lakes (Daisy, Silver, Crooked, Middle, Hannah) during the next five years. Hannah and Middle lakes are

currently the focus of a study dealing with the rate of biomass recovery in previously acid stressed systems. Biomass and abundance estimates have been calculated for 1990 and 1991 with further monitoring planned for the 1992 season. Preliminary results seem to suggest that Middle Lake has reached its carrying capacity while Hannah Lake is still in a recovery phase.

Beyond the status of individual lakes, the surveys illustrated how lakes in the Sudbury area are linked into ~~two~~ systems that can affect species distribution. For example, largemouth bass, a species previously not known to occur in these lakes, appears to be moving along the length of the Long Lake chain, with populations now in Richard, McFarlane, Grant and Long lakes. Similarly, the small number of walleye captured in Robinson and Kelley lakes are likely fish that have moved down from Ramsey Lake by way of Lily Creek. Movement between lakes and accidental or intentional introductions may also be responsible for rapid recovery in certain lakes. For example yellow perch in Middle and Hannah lakes are most likely from St. Charles Lake, while Baby Lake has been colonized recently by several species that presumably moved in from nearby Alice Lake.

The connected nature of Sudbury's lakes emphasizes the need to manage lakes on a watershed basis and to protect aquatic ecosystems from undesirable introductions of plants and animals. For example, the lone black crappie (*Pomoxis nigromaculatus*) specimen from Ramsey Lake, is a species that has shown to have negative effects on walleye populations in other areas (Schiavone, 1985). This introduction may have come from Georgian Bay as

an intentional (pet fish from cottage) or as an unintentional (bait bucket) introduction. Similarly, rainbow smelt, (*Osmerus mordax*) are now in Nepahwin Lake, again presumably a recent introduction by smelt fishers (perhaps from washing out fertilized eggs from buckets). Smelt can reach large numbers in small inland lakes and have been reported to detrimentally affect some native species (Evans and Loftus, 1987). One only needs to consider the zebra mussel problem in the Great Lakes or the Eurasian Milfoil growths in McFarlane Lake to realize the potential serious problems posed from exotic species introductions.

Many of the lakes in Sudbury are under heavy pressure from residential development along shorelines. Such developments have in the past lead to destruction of fish habitat through loss of wetlands (for feeding and nursery areas) sedimentation and erosion (loss of spawning sites) and excessive runoffs of nutrients (eutrophication). In the face of proposed additional development along the shorelines of Sudbury lakes, the current species list and habitat maps will provide managers with information to help enforce habitat protection laws. However with the potential of widespread environmental improvements in the future, through abatement of industrial emissions, managers, land owners and developers can now consider working towards rehabilitation instead of simply maintenance of status quo for Sudbury lakes.

5.0 Conclusions and Recommendations

Sudbury presently contains a rich diversity of lakes and aquatic life that offers great potential for recreational activities. Many of the lakes are presently in a degraded environmental state and require rehabilitation. All lakes need special attention to prevent further damage from occurring. Sudbury District's Fisheries Management Plan (OMNR, 1990) outlines actions to achieve these goals. they include:

- continued enforcement of habitat protection laws
- continued public education regarding aquatic ecosystem biology
- rehabilitation of damaged systems through watershed liming and reduction of both sulphur emissions and nutrient input

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Appendix 1. Dissolved oxygen profiles measured during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Sampling Date	Max Depth	Sampling Depth (m)											
			0	2	4	6	8	10	12	16	20	24	28	30
Alice	90/06/01	14.0	10.8	10.8	10.6	11.0	10.2							
Baby	90/05/30	22.5	10.6	10.6	10.6	10.6	11.2	11.0	10.8	9.1	7.4			
Bennett	91/05/24	2.8	8.8	8.8	8.2									
Bethel	89/07/07	5.0	8.1	7.8	7.6									
Bibby	91/06/28	8.5	8.8	8.2	8.2	1.4	0.7							
Broder 23	91/06/19	20.0	9.3	9.2	9.5	10.4	13.6	13.0	11.4	10.1	4.4			
Brodill	91/08/01	30.0	9.2	9.2	9.1	9.2	14.0	12.8	13.3	10.2	9.0	7.2	6.8	
Camp	91/07/11	15.0	9.4	9.7	9.6	14.4	13.8	12.0	6.0					
Chief	91/07/15	34.0	9.2	9.2	9.3	9.2	9.2	13.0	13.2	12.9	12.3	13.2	12.6	11.2
Clearwater	90/07/11	21.5	8.6	8.6	8.6	8.6	8.5	8.7	11.5	7.2				
Crooked	90/07/23	8.0	9.4	9.2	8.8	6.6	0.9							
Crowley	91/07/02	16.0	9.4	9.4	9.4	12.8	13.8	11.4	8.2	4.1				
Daisy	90/05/23	14.0	11.0	10.9	10.1	10.1	9.5	10.5	10.4					
Dill	91/06/20	4.2	8.6	8.2	3.8									
Forest	91/05/29	12.5	8.9	9.1	11.1	13.0	11.8	3.2						
Grant	91/08/09	6.0	9.8	9.8	6.6	1.0								
Hannah	90/03/16	8.5	13.3	11.4	10.6	10.6								
Hazen	91/06/12	2.0	8.0	7.8										

Appendix 1. Dissolved oxygen profiles measured during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Sampling Date	Max Depth	Sampling Depth (m)											
			0	2	4	6	8	10	12	16	20	24	28	30
Hidden	91/06/28	2.0	8.0	7.8										
Honda	91/06/25	4.0	7.8	7.2										
Johnny	91/06/11	7.5	8.8	8.8	9.2	13.6								
Kelley	90/08/28	17.0	8.2	8.3	8.3	7.6	6.2	4.6	0.8	0.1				
Lady MacDonald	91/09/13	7.0	9.1	9.1	9.1	9.1								
Laurentian	91/05/09	3.8	11.6	11.4	10.6									
Linton	91/07/08	16.0	9.8	9.6	9.5	12.6	9.2	6.2	3.2					
Little Raft	91/05/28	3.0	8.8	8.6										
Lohi	90/07/11	19.5	8.0	8.2	8.2	8.0	8.2							
Long	90/09/26	36.5	9.5	8.8	8.9	8.9	8.8	8.8	8.6	6.0	6.6	7.1	6.6	6.2
McFarlane	90/09/15	20.0	8.4	8.5	8.5	8.5	8.5	2.7	2.7	2.3	2.2			
Middle	90/03/20	15.0	12.9	11.2	10.7	10.7	6.4							
Minnow	90/05/15	3.1	11.6	11.4										
Nepahwin	90/10/12	22.0	10.3	10.2	10.0	10.0	10.0	9.9	9.8	2.0	1.2			
Perch	91/05/24	2.6	8.2	8.0										
Pine	91/06/26	7.0	8.0	8.0	7.9	6.0								
Raft	90/08/16	13.0	8.4	8.0	7.9	8.2	7.7	5.6	1.4					
Ramsey	90/03/20	20.5	13.0	13.0	12.4	11.4	10.7	10.2	10.4	10.6	7.4			

Appendix 1. Dissolved oxygen profiles measured during the urban lakes survey of 43 lakes located within the regional municipality of Sudbury, 1989-1991.

Lake	Sampling Date	Max Depth	Sampling Depth (m)											
			0	2	4	6	8	10	12	16	20	24	28	30
Richard	90/08/13	9.5	7.6	7.4	7.5	7.4								
Robinson	90/05/10	2.0	9.6	9.5										
Silver	90/06/20	10.0	8.3	8.3	8.2	8.2	8.1	7.5						
St. Charles	90/07/03	6.0	9.2	9.3	9.2	5.6								
Still	90/08/21	3.0	8.6	7.2										
Swan	90/07/18	8.0	8.6	8.6	8.6	7.9	3.2							
Tilton	90/08/07	12.0	9.0	8.9	8.9	8.8	8.2	5.3	1.7					

Appendix II. Stocking history of the lakes surveyed during the urban lakes survey, 1989-1991.

Year	No. Stocked	Species	Age
Clearwater Lake			
1951	10000	Brook Trout	?
1952	3000	Smallmouth Bass	?
1956	?	N.Redbelly Dace	?
1957	?	Smallmouth Bass	?
1959	5000	Brook Trout	?
Lohi Lake			
1951	2500	Brook Trout	?
1953	6000	Brook Trout	?
1976	1200	Brook Trout	yearling
1976	1375	Iowa Darter	?
1976	171	Brook Stickleback	?
1977	1196	Brook Trout	?
Long Lake			
1951	3000	Lake Trout	?
1951	4000	Smallmouth Bass	?
1953	3000	Smallmouth Bass	?
1958	2000	Smallmouth Bass	?
1958	2000	Smallmouth Bass	fingerling
1959	2500	Smallmouth Bass	?
1959	175000	Walleye	?
1959	2000	Brook Trout	fingerling
1960	4500	Smallmouth Bass	?
1960	175000	Walleye	?
1976	16292	Lake Trout	?
1977	21875	Smallmouth Bass	?
1978	6962	Lake Trout	?
1984	9000	Lake Trout	?
1985	9000	Lake Trout	17 mo
1986	5000	Lake Trout	?
1987	5000	Lake Trout	15 mo
1988	600	Walleye	3 mo
1989	5000	Lake Trout	17 mo
McFarlane Lake			
1951	4000	Smallmouth Bass	?
1953	3000	Smallmouth Bass	?
1953	150000	Walleye	?
1956	6000	Smallmouth Bass	?
1956	325000	Walleye	?
1959	175000	Walleye	?
1960	6000	Smallmouth Bass	?
1961	6000	Smallmouth Bass	?
1974	1000	Muskellunge	?
1987	50000	Walleye	1 mo

Appendix II. Stocking history of the lakes surveyed during the urban lakes survey, 1989-1991.

Year	No. Stocked	Species	Age
Middle Lake			
1974	?	Central Mudminnow	?
1974	?	Lake Trout	?
1974	?	Johnny Darter	?
1974	2541	Smallmouth Bass	?
1974	174	Brook Stickleback	?
1974	5165	Iowa Darter	?
Nepahwin Lake			
1976	391	Smallmouth Bass	?
1983	4118	Splake	?
1984	5000	Splake	?
1985	3600	Splake	?
1986	5000	Splake	17 mo
1987	3000	Splake	16 mo
1988	4000	Splake	18 mo
1989	3000	Splake	17 mo
Raft Lake			
1954	2000	Smallmouth Bass	?
Ramsey Lake			
1952	5000	Lake Trout	?
1976	1000	Walleye	?
1977	19875	bass	?
1977	10000	Walleye	fingerling
1978	5000	bass	?
1978	10000	Walleye	fg
1979	?	Rainbow Trout	?
1982	?	Walleye	?
1983	?	Walleye	?
1987	400	Walleye	3 mo
1987	50000	Walleye	1 mo
1988	2000	Walleye	3 mo
1989	60	Walleye	1 yr
Richard Lake			
1952	2000	Smallmouth Bass	?
1953	200000	Walleye	?
1956	6000	Smallmouth Bass	?
1974	4000	Smallmouth Bass	?
1974	5000	Muskellunge	?
1976	4000	Smallmouth Bass	?
1987	200000	Walleye	1 mo
1987	800	Walleye	3 mo

Appendix II. Stocking history of the lakes surveyed during the urban lakes proj survey, 1989-1991.

Year	No. Stocked	Species	Age
Silver Lake			
1952	2500	Smallmouth Bass	?
Tilton Lake			
1951	10000	Brook Trout	?
1952	3000	Smallmouth Bass	?
1953	3000	Smallmouth Bass	?
1954	3000	Smallmouth Bass	?
1957	1000	Smallmouth Bass	?