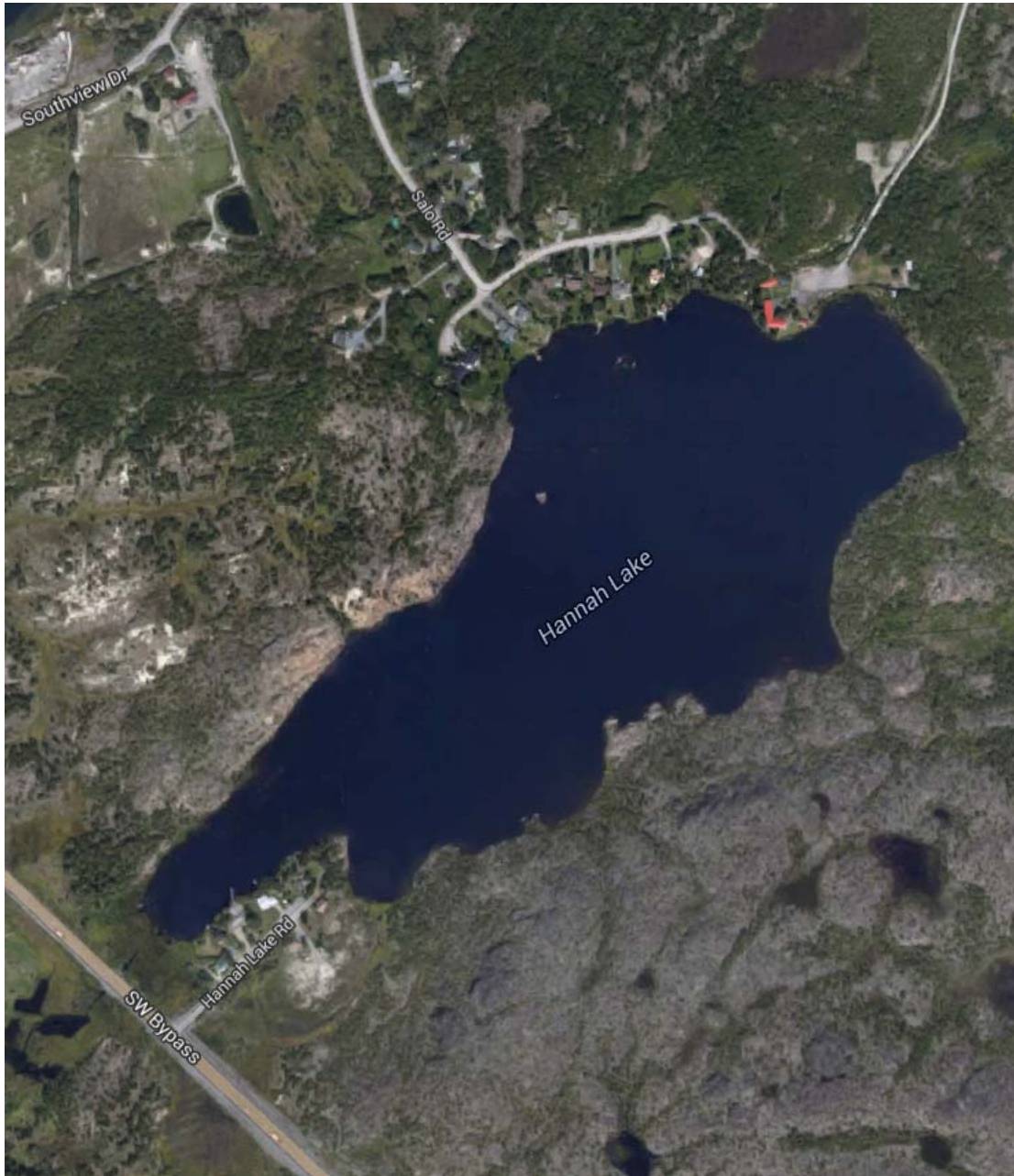


HANNAH LAKE
URBAN LAKES FISHERIES STUDY 2014



Fisheries Assessment by:
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INTRODUCTION

Hannah Lake (46°26'33" N, 80°02'19" W) is a 27.7 ha lake located within the City of Greater Sudbury, in Broder township. It has one main basin with a maximum depth of 8.1 m (Figure 1). A complete summary of physical characteristics can be seen in Table 1.

Hannah Lake is accessed by private road off Southview Dr. There are about 17 residences around the shoreline of Hannah Lake, including the Hannah Lake Bible Camp. There is no public access to the lake, and very little evidence of any angling pressure.

Hannah Lake has been intensely studied and monitored as early as 1974 when the lake had a pH of 4.29 and nickel and copper concentrations were greater than 1000 µg/L. Hannah lake is one of the intensive monitoring lakes of OMOECC at the Co-op Unit, it is also recognized in the Official Plan of the city of Greater Sudbury as a “monitoring lake”. Due to its proximity to the Copper Cliff smelter, Hannah Lake was once considered one of the most atmospherically contaminated lakes in the city (Yan *et al.*, 1996). Hannah Lake was treated with 13.0 T of Ca(OH)₂ and 7.5T of CaCO₃ in 1975 which resulted in an increase in pH and a decline in metals (Scheider *et al.*, 1975; Dillon *et al.*, 1979). The surrounding watershed of Hannah Lake was treated in the early 1980s with dolomitic limestone and fertilizers as part of the Greening of Sudbury initiative (Ontario Ministry of the Environment, 1982), which, in combination with a decline in local industrial emissions, resulted in a decline in metal concentrations and a stabilization of pH at a circumneutral level in Hannah. The first observation of fish in Hannah was a single northern redbelly dace (*Chrosomus eos*) in 1984 (Ed. Snucins pers. comm). Yellow perch (*Perca flavescens*) colonized at approximately the same time (e.g. plexiglass trap caught 381 perch in 1986; OMNR data) and were abundant when the lake was surveyed in 1990 (Poulin *et al.*, 1991). Quantitative Nordic index netting surveys began in 2003 (Cooperative Freshwater Ecology Unit, 2014). Hannah Lake was stocked with 184 smallmouth bass (*Micropterus dolomieu*) in 2006 as part of a whole-lake piscivorous fish manipulation experiment led by A. Luek and G. Morgan (Luek *et al.*, 2010).

Table 1 Hannah Lake location and physical description (Poulin *et al.*, 1991).

Township	Broder
Latitude/Longitude	46°26'33" N, 80°02'19" W
MNRF District	Sudbury
Watershed Code	2CF
Elevation (m)	269
Shoreline Development Factor	1.46
Number of Cottages/Lodges	17
Forest Type	Birch transition

Shoreline Type	Bedrock/sand
Lake Surface Area (ha)	27.7
Maximum Depth (m)	8.1
Mean Depth (m)	4.0
Volume (x10⁴m³)	105.0
Secchi (m)	3.4 (July 6, 2014)
Access	Private drive off of Southview Dr.

METHODS

Fisheries Community Assessment

The fish community of Hannah Lake was sampled in 2014 according to the Nordic Index Netting protocol (Appelberg, 2000; Morgan and Snucins, 2005). This netting procedure was developed in Scandinavia and has been used extensively across northeastern Ontario since 1999 (Selinger *et al.*, 2006) to assess the relative abundance and biomass of fish species and provide biological information on the population's status (Morgan and Snucins, 2005).

A total of 16 multi-mesh gillnets were set in Hannah Lake from July 5 - 8, 2014. Nets were set for approximately 12 hours at randomly selected locations on the lake across multiple depth strata (5 nets in <3.0 m; 6 nets in 3.0 - 5.9 m; 5 nets in 6.0 – 11.9 m). Figure 2 shows the locations of all gillnets set in Hannah Lake during the survey.

All fish captured were identified to species and tallied by net. Biological information such as fork and total length (mm), weight (g), sex and maturity, and stomach contents were recorded for all large-bodied species. Ageing structures were collected from all of these species, and a muscle tissue sample was collected from up to 20 individuals per species across a size range for contaminant and stable isotope analysis. All other fish were measured (total length only) and bulk weighed for each net. A bulk sample of up to 20 individuals per species was collected for contaminant and stable isotope analysis.

Baseline Organisms

Attempts were made to collect samples of clams ($n=10$), snails ($n=30$), crayfish ($n=20$), Heptageniid mayflies ($n=50$), and aquatic plants from Hannah Lake for food web studies.

Clams and snails were targeted by visually scanning near-shore areas and picking the organisms by hand or with a dip net. Crayfish were targeted by setting three to five wire mesh minnow traps baited with canned cat food overnight in littoral areas. Heptageniid mayflies were targeted by turning over rocks and woody debris along the shore of Hannah Lake, and picking the organisms off the surface by hand or with a pair of tweezers. A bulk sample of up to five plants of the same species was targeted by visually scanning the near-shore areas of Hannah Lake and picked by hand.

Water Quality Assessment

A dissolved oxygen (mg/L) and temperature (°C) profile was measured in the main basin of Hannah Lake on August 6, 2014, using a YSI Model 52 dissolved oxygen – temperature meter. Readings were taken at 0.5 m intervals through the water column.

Water samples were collected on August 6, 2014 from the surface of Hannah Lake. Samples were sent to the Ministry of Environment and Climate Change (MOECC) chemistry lab in Dorset, and analyzed for pH, conductivity, total inlection point alkalinity, dissolved organic and inorganic carbon, metals and major ions.

The sampling location for water quality can be seen in Figure 2.

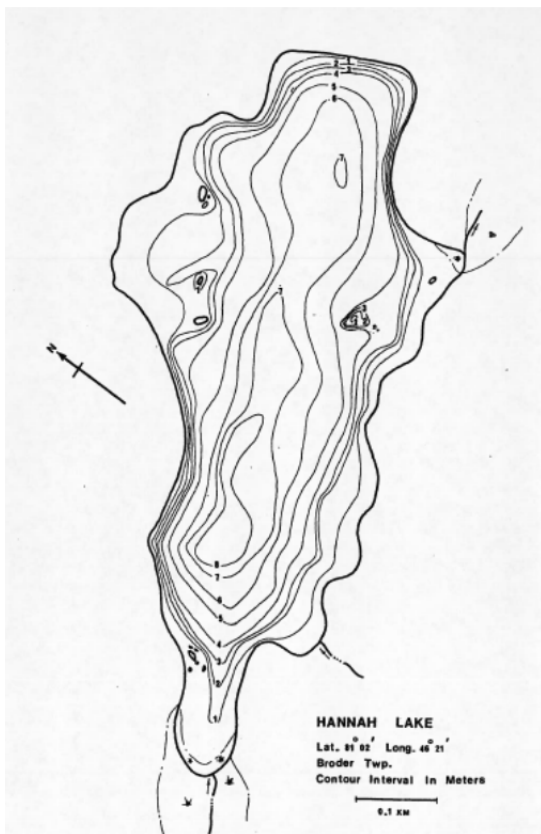


Figure 1 Bathymetric map of Hannah Lake.

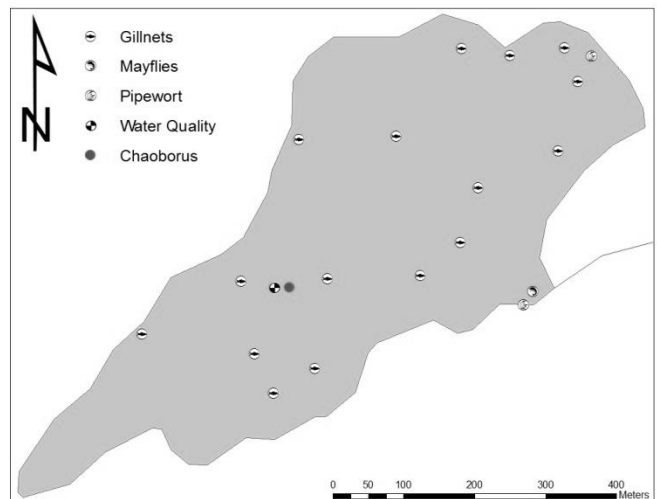


Figure 2 Outline map of Hannah Lake showing the locations of sampling gear or collected organisms.

RESULTS AND DISCUSSION

Fisheries Community Assessment

The Nordic survey captured four species northern pike (*Esox lucius*), pumpkinseed (*Lepomis gibbosus*), smallmouth bass (*Micropterus dolomieu*), and yellow perch (*Perca flavescens*). Other species observations from previous netting surveys include brown bullhead (*Ameiurus nebulosis*), walleye (*Sander vitreus*) and Iowa darter (*Etheostoma exile*) were not captured in

2014 (Cooperative Freshwater Ecology Unit, 2014). Total catch, total weight (g) and catch-per-unit effort (CPUE) from the Nordic survey can be seen in Table 2.

Table 2 Catch summary and CPUE for all species captured in Hannah Lake July 5 - 8, 2014. *Fish were not individually weighed. Total weight (g) and CPUE (g/net) measurements are based on total net biomass for that species.

Fish Species	Total Catch	Sample Size	Total Weight (g)	CPUE (fish/net)	CPUE (g/net)
Northern Pike	12	11	13274.7	0.75	829.6688
Pumpkinseed*	46	45	233.6	2.875	14.6
Smallmouth Bass	3	3	4663.4	0.1875	291.4625
Yellow Perch*	1049	970	7278.4	65.5625	454.9
Total	1110	1029	25450.1	69.375	1590.6313

Northern pike was the most abundant sport fish observed during the survey with a total catch of 12 individuals. The northern pike sampled during the survey had total lengths ranging from 285 mm to 747 mm. The three smallmouth bass caught during this survey had total lengths ranging from 469 mm to 482 mm. A complete summary of morphological data for northern pike and smallmouth bass from the 2014 Nordic survey can be seen in Appendix I.

Yellow perch were the most abundant species of fish (Table 2) with total lengths ranging from 38 mm to 201 mm. A length frequency histogram for yellow perch can be seen in Figure 3.

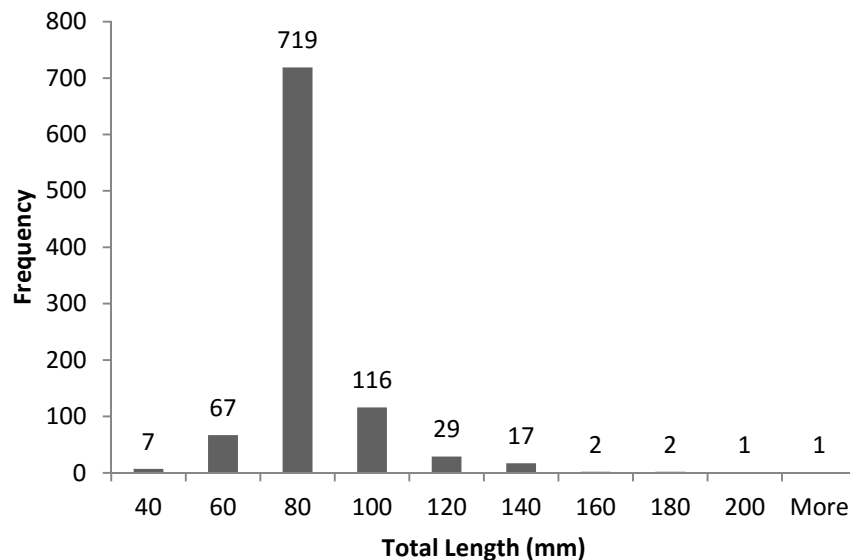


Figure 3 Length frequency histogram for yellow perch (n=961) captured in Hannah Lake July 5 - 8, 2014.

Yellow perch was the most abundance species in 1990, accounting for 96% of the total catch (Poulin *et al.*, 1991). More recent Nordic surveys began in 2004, indicating that yellow perch still remains the most abundant species in the lake, accounting for >93% of the total catch in all

survey years. However, species richness has declined since 2004 from six species to four in 2014. Species richness and proportion of total catch can be seen in Table 3.

Table 3 Species richness and proportion of total catch for Hannah Lake (1. Poulin *et al.*, 1991; 2. Cooperative Freshwater Ecology Unit, 2014).

Survey Type Year	Multi-Gear Survey 1990 ¹		Nordic 2004 ²		Nordic 2009 ²		Nordic 2014	
Species	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Northern Pike	-	-	2	0.15	-	-	12	1.08
Fathead Minnow	-	-	-	-	-	-	-	-
Creek Chub	1	0.1	-	-	-	-	-	-
Brown Bullhead	1	0.1	84	6.13	13	0.85	-	-
Pumpkinseed	-	-	3	0.22	38	2.48	46	4.14
Smallmouth Bass	-	-	1	0.07	2	0.13	3	0.27
Yellow Perch	966	96.2	1275	93.1	1475	96.3	1049	94.5
Iowa Darter	36	3.59	5	0.36	4	0.26	-	-
Total	1004	100	1370	100	1532	100	1110	100
Species Richness	4		6		5		4	

Although yellow perch has always been the most numerically abundant fish species in Hannah Lake (Poulin *et al.*, 1991; Cooperative Freshwater Ecology Unit, 2014), they only accounted for the majority of the total biomass in 2009. In 2004, the majority of the total biomass was accounted by other species, which includes larger species such as northern pike and brown bullhead (Cooperative Freshwater Ecology Unit, 2014). As of 2014, northern pike accounted for the majority of the total biomass with a total weight of 13274 g. This was a substantial increase from values in 2009 leading presumably to the significant decline in the biomass of yellow perch (a prey species), with a total weight of 4148 g in 2014. Total catch data can be seen in Figure 4 and total biomass data can be seen in Figure 5.

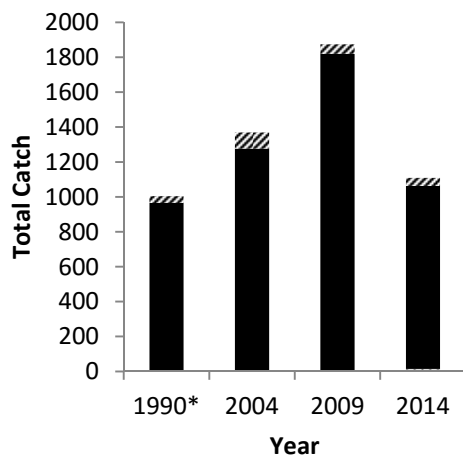


Figure 4 Total catch data from Hannah Lake (*Nordic method was not used during the 1990 Urban Lakes Survey. Poulin *et al.*, 1991).

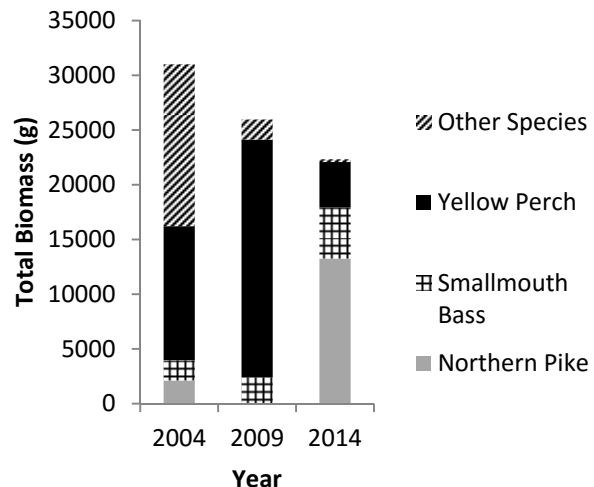


Figure 5 Total biomass (g) data from Hannah Lake.

Baseline Organisms

No clams or snails were collected from Hannah Lake. Approximately 30 mayflies were captured from Hannah Lake at the northeast shore where water exits the lake. A total of nine crayfish were caught in traps set at various locations around Hannah Lake. Twenty-four nighttime zooplankton hauls were conducted at Daisy Lake on July 22, 2014. A sufficient stable isotope sample (approx. 50-300 individuals) of *Chaoborus* sp. was collected. No aquatic plants were collected from Hannah Lake.

Water Quality Assessment

At the time of the Nordic Index Netting survey, Hannah Lake was thermally stratified but lacked a prominent hypolimnion (Figure 6). Water temperatures ranged from 20.8 °C at the surface to 12.2 °C at 8.0 m. Dissolved oxygen levels ranged from 8.37 mg/L to 0.31 mg/L. Depth at the site of the temperature and dissolved oxygen profiles was 8.1 m and the secchi water clarity was 3.4 m.

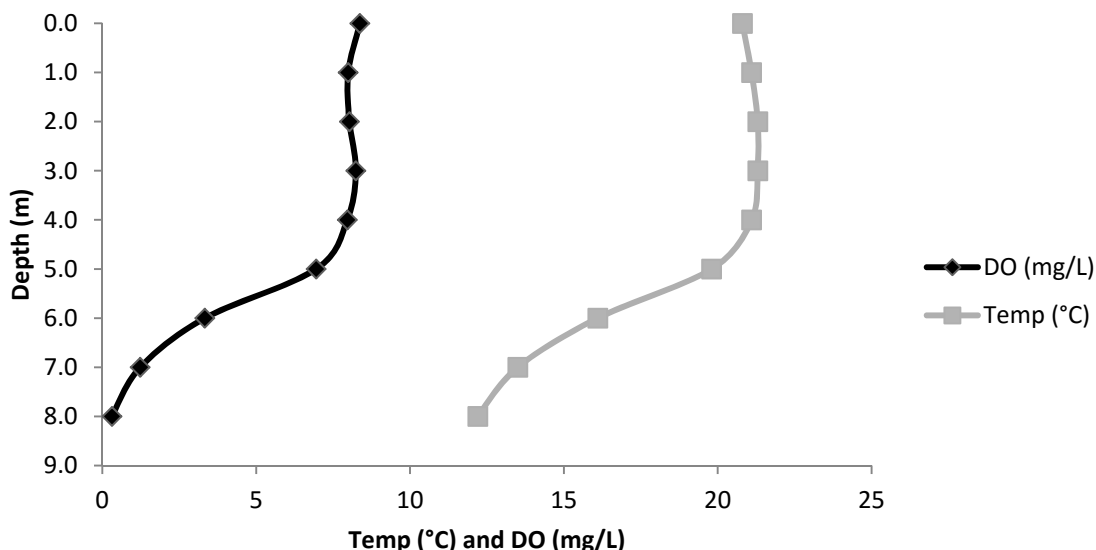


Figure 6 Temperature (°C) and dissolved oxygen (mg/L) profile for Hannah Lake, measured July 10, 2014.

Hannah Lake has undergone considerable recovery since 1974, and has continued to do so since 2003 with a slight increase in pH to 7.84. TIA alkalinity has also increased during this time to 22.4 mg/L CaCO₃. Concentrations of metals such as Copper (Cu), Nickel (Ni) and Aluminum (Al) have declined over time as well. These improvements are likely a result of the neutralization experiments that occurred in the mid-1970s and early 1980s (Uutala and Smol, 1996), as well as reductions in emissions from local smelters (Keller *et al.*, 2007).

As of August 6, 2014, Hannah Lake has sustained a neutral pH level of 7.84 and an increase in TIA alkalinity to 22.4 mg/L CaCO₃. Metal concentrations continue to decrease. However,

Copper (11.3 µg/L) and Nickel (35.2 µg/L) concentrations remain above criteria set by the Ministry of Environment and Climate Change's (MOECC) Provincial Water Quality Objective (PWQO) for the protection of aquatic life. Aluminum has decreased below this level (Ontario Ministry of Environment and Energy, 1994).

Table 4 Water chemistry of Hannah Lake (1. Ontario Ministry of Environment and Energy, 1994; 2. Yan *et al.*, 1996; 3. Keller *et al.*, 2004)

Parameter	PWQO ¹	Year			
		1974 ²	1990 ³	2003 ³	2014
pH	6.5-8.5	4.29	7.06	7.25	7.84
TIA Alkalinity (mg/L CaCO ₃)	-	-	12.10	16.93	22.4
Conductivity (µS/cm)	-	-	359.0	190.0	379
True Colour (TCU)	-	-	-	-	20.9
DOC (mg/L)	-	-	3.8	3.6	3.8
Ca (mg/L)	-	11.4	13.40	10.60	9.52
Mg (mg/L)	-	-	4.56	3.57	3.52
Na (mg/L)	-	-	44.60	62.80	40.5
K (mg/L)	-	-	1.980	1.660	1.49
SiO ₃ (mg/L)	-	-	0.38	0.26	0.36
SO ₄ (mg/L)	-	-	28.98	16.60	11.4
Total Cu (µg/L)	5	1108	64	22	11.3
Total Ni (µg/L)	25	1865	180	111	35.2
Total Zn (µg/L)	30	-	11	3	0.6
Total Fe (µg/L)	300	-	290	114	60
Total Mn (µg/L)	-	-	38	70	13
Total Al (µg/L)	75	-	200	13	6.4

CONCLUSIONS

The history of this lake's chemical and biological recovery provides abundant examples of the benefits of reducing and controlling SO₂ emissions (Keller *et al.*, 2007). Although the water quality of Hannah Lake has made considerable improvements over the past 40 years, concentrations of Ni and Cu remain above PWQO criteria for the protection of aquatic life (Ontario Ministry of Environment and Energy, 1994). However, pH has improved from 4.29 to 7.84, and metal concentrations have declined by 99% for Cu and 98% for Ni. Clams and snails were not observed, however crayfish and acid-sensitive mayflies appear to be common. Hannah Lake is a shallow, urban lake that supports populations of four species, including two species of sport fish: northern pike and smallmouth bass.

ACKNOWLEDGEMENTS

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APPENDIX I

Morphological data for northern pike (*Esox lucius*) and smallmouth bass (*Micropterus dolomieu*) from Hannah Lake, July 5 - 8, 2014.

Species	Fish #	Fork Length (mm)	Total Length (mm)	Weight (g)	Sex 1-Male 2-Female 9-Unknown	Maturity 1-Immature 2-Mature 9-Unknown	Ageing	Tissue
							Structure 0-None 2-Scales 4-Pectoral Ray 7-Dorsal Spine A-Otolith B-Operculum D-Cleithrum	0-None 1-Flesh 8-Stomach 9-Gonads A-Whole Fish X-Genetic
Northern Pike	2	601	643	1517.9	2	2	A, D	1
Northern Pike	3	691	734	1951.9	2	2	A, D	1
Northern Pike	4	290	314	168.4	9	1	A, D	1
Northern Pike	81	690	737	2145.1	2	2	A, D	1
Northern Pike	201	646	682	1654.1	2	2	A, D	1
Northern Pike	422	270	294	165.6	1	1	A, D	1
Northern Pike	438	453	483	651.8	2	2	A, D	1
Northern Pike	571	615	654	1725.4	1	2	A, D	1
Northern Pike	739	702	747	2656.7	2	2	A, D	1
Northern Pike	740	266	285	125	9	1	A, D	1
Northern Pike	824	430	459	512.8	1	9	A, D	1
Smallmouth Bass	1	452	478	1620.7	2	2	A	1
Smallmouth Bass	74	441	469	1415.5	2	2	A	1
Smallmouth Bass	75	461	482	1627.2	2	2	A	1