RAMSEY LAKE INTERPRETIVE CENTRE

An Architectural Response to Aquatic Environmental Public Awareness

by

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This thesis will aim to address the following theoretical questions: How can architectural interventions mitigate human impact on a more than human landscape? How can enhanced and sustainable interaction between aquatic life and people contribute to greater appreciation and conservation for underwater ecosystems?

Specifically, this thesis will study and analyze Ramsey Lake, in Sudbury, Ontario, Canada, through mapping exercises, scientific research, media articles, and site documentation to inform the design of a “Ramsey Lake Interpretive Centre”. The centre would raise public environmental awareness of regional aquatic ecosystems and provide direct opportunities for environmental remediation of a lake which has been impacted by industrial activity and urban development for over one-hundred-years.

Ramsey Lake was selected as the focus of this study because of the central role that it plays within the community. In addition to acting as a drinking water reservoir for over 40% of Greater Sudbury, it also represents a significant centre for culture and recreation within the community.

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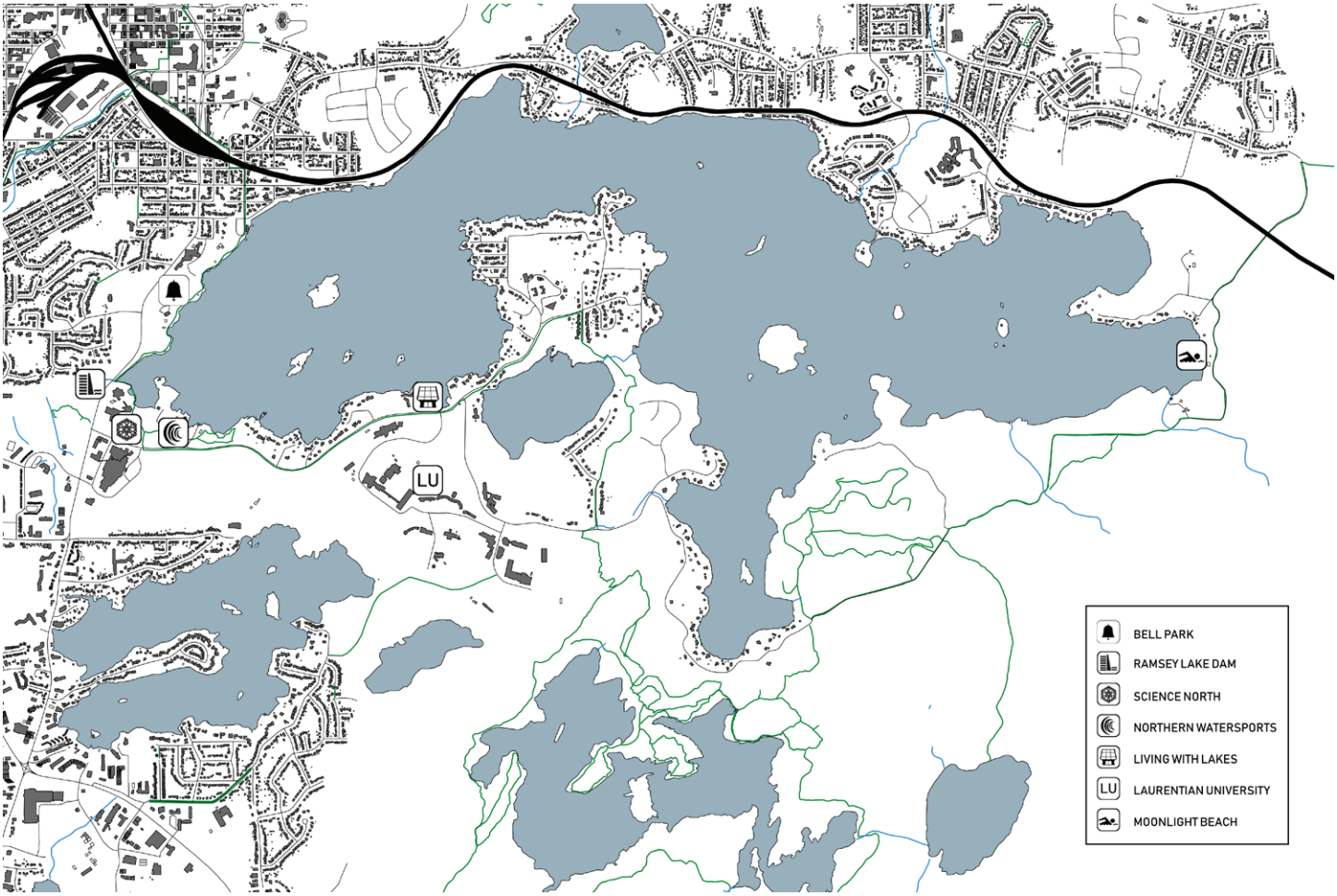
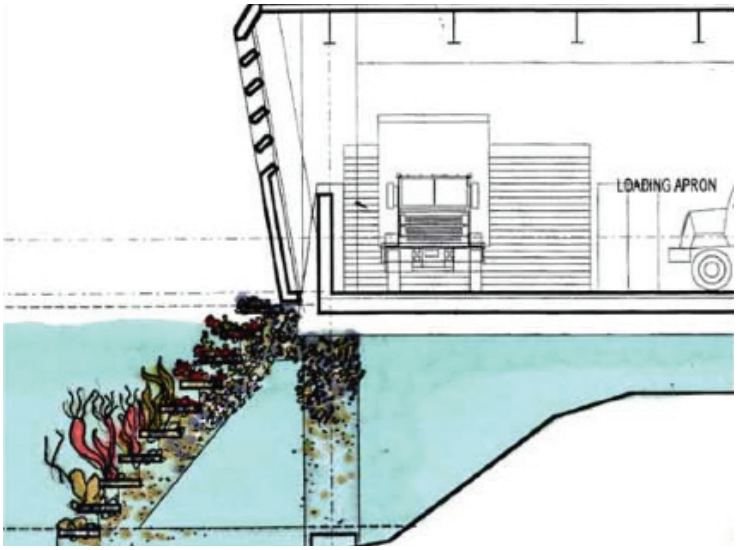
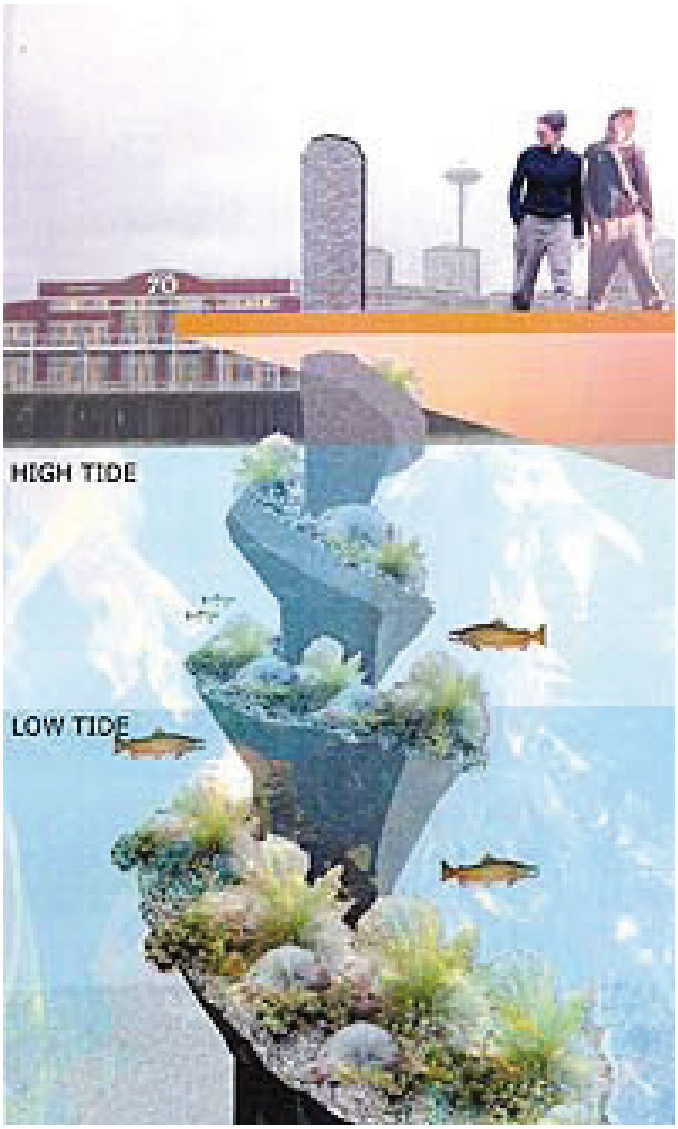


1A RAMSEY LAKE
Map by author, developed from GIS data courtesy of the City of Greater Sudbury.

1B RAMSEY LAKE TOPOGRAPHY MODEL
Model by author, developed from GIS data courtesy of the City of Greater Sudbury.





2A (Top Left) **PLUS POOL | New York, New York, United States**
Design, POOL. Accessed January 07, 2019. https://www.pluspool.org/pool/design/.

2B (Right) **SALMON SPIRAL | Seattle, Washington, United States**
Norah Daley. *Seattle's big chance to reconnect the waterfront*. Seattle Dailey Journal. April 22, 2004. Accessed April 17, 2019. https://www.djc.com/news/en/11156164.html.

2C (Bottom Left) **HABITAT SKIRT | Vancouver, British Columbia, Canada**
Habitat Skirt at the Vancouver Convention Centre. Tidewatercurrent.com. 2014. Accessed April 17, 2019. http://tidewatercurrent.com/2014_summer/Vancouver_Habitat_Skirt.html.

Explorations into similar investigations have led to creative ideas in the remediation of urban aquatic environments. In Manhattan's Hudson River, a group called + pool is advocating for the construction of an innovative public pool that would float in the river. The pool would utilize a semi-permeable filtration system as its walls. It is claimed that these filtration walls would remove pollutants from 600,000 gallons of river water per day.[1]

In Seattle, Washington, the group Edge Habitat, developed a conceptual "Salmon Spiral" installation which provides shelter and habitat to salmon and juvenile fish. The spiral creates a false ocean floor along existing underwater pier columns, mixing ecological habitat into urban development. The same group also developed ideas for "Habitat Hooks", which are hook shaped structures protruding from the land which allow sediment to build up over time, creating a softer shoreline and habitat space for fish.[2]

A similar project at the Vancouver Convention Centre took a simpler approach. At the end of the convention centre building, which extends out over the ocean by 50m, the design team developed a series of underwater stepped shelving systems called the "Habitat Skirt". The shelves mimic the rocky shorelines which exist naturally around the area and create horizontal planes which seaweed and shellfish can attach themselves to. The response could create an important precedent for Vancouver, where 80 percent of the natural shoreline has been degraded by urban development. According to the marine ecologist on the project, Jamie Slogan, the system supports more biodiversity than a typical natural shoreline in the area.[3]

1 Design, POOL. Accessed January 07, 2019. https://www.pluspool.org/pool/design/.

2 Jeffrey Hou. *Hybrid Landscapes: Toward an Inclusive Ecological Urbanism on Seattle's Central Waterfront*. University of Washington.

3 *Waves of Life Invigorate Vancouver's Shoreline*. TheThunderbird.ca. October 24, 2012. Accessed January 07, 2019. https://thethunderbird.ca/2012/03/29/waves-of-life-invigorate-vancouvers-shoreline/

3A (Top) BARREN LANDSCAPE
The Reclamation of Sudbury: The Greening of a Moonscape. Viewpoint Mining Magazine. Accessed January 07, 2019. http://viewpointmining.com/article/the-reclamation-of-sudbury.

3B (Bottom) LIMING PROCESS
Home. Sudbury Protocol. Accessed January 07, 2019. https://www3.laurentian.ca/sudbury-protocol/.

The settlement of Sudbury prior to the Great Depression was the result of a growth in mining and lumber activity within the region. The construction of the Canadian Pacific Railway in 1883 had opened up the development of these industries. By 1905, Sudbury was the largest supplier of nickel in the world. Prior to 1929, open roast yards were used to refine the ore. This process involved roasting the ore over piles of timber logs to remove the sulphur content, which ranged from 25 to 50 percent. The remaining material consisted of copper, nickel and iron. From 1888 to 1929, there were 165 roast beds in the Sudbury area near Copper Cliff, Coniston and Creighton. It is now estimated that more than 3.3 million cubic metres of wood was burnt, and 10 million tons of sulphur dioxide was released during this practice. The sulphur dioxide produced caused widespread damage to the environment, killing or damaging the surrounding vegetation and blackening exposed rock.

After 1929, mechanical roasters were used to process the ore, removing the sulphur content and allowing the separation of nickel and copper from the molten material. The roast yards became unnecessary after the smelters became operational, however, the smelters and their smokestacks only diffused the resultant environmental damage over a larger area. In addition to suplhur, the smelter stacks also released airborne nickel, copper and iron particulates which further inhibited the growth of vegetation. In 1972, the construction of Inco's "superstack", a 380-metre-tall smelter chimney, further diffused sulphur emissions in the Sudbury area. In the same year, emission control regulations led to a reduction of sulphur emissions by 50%.

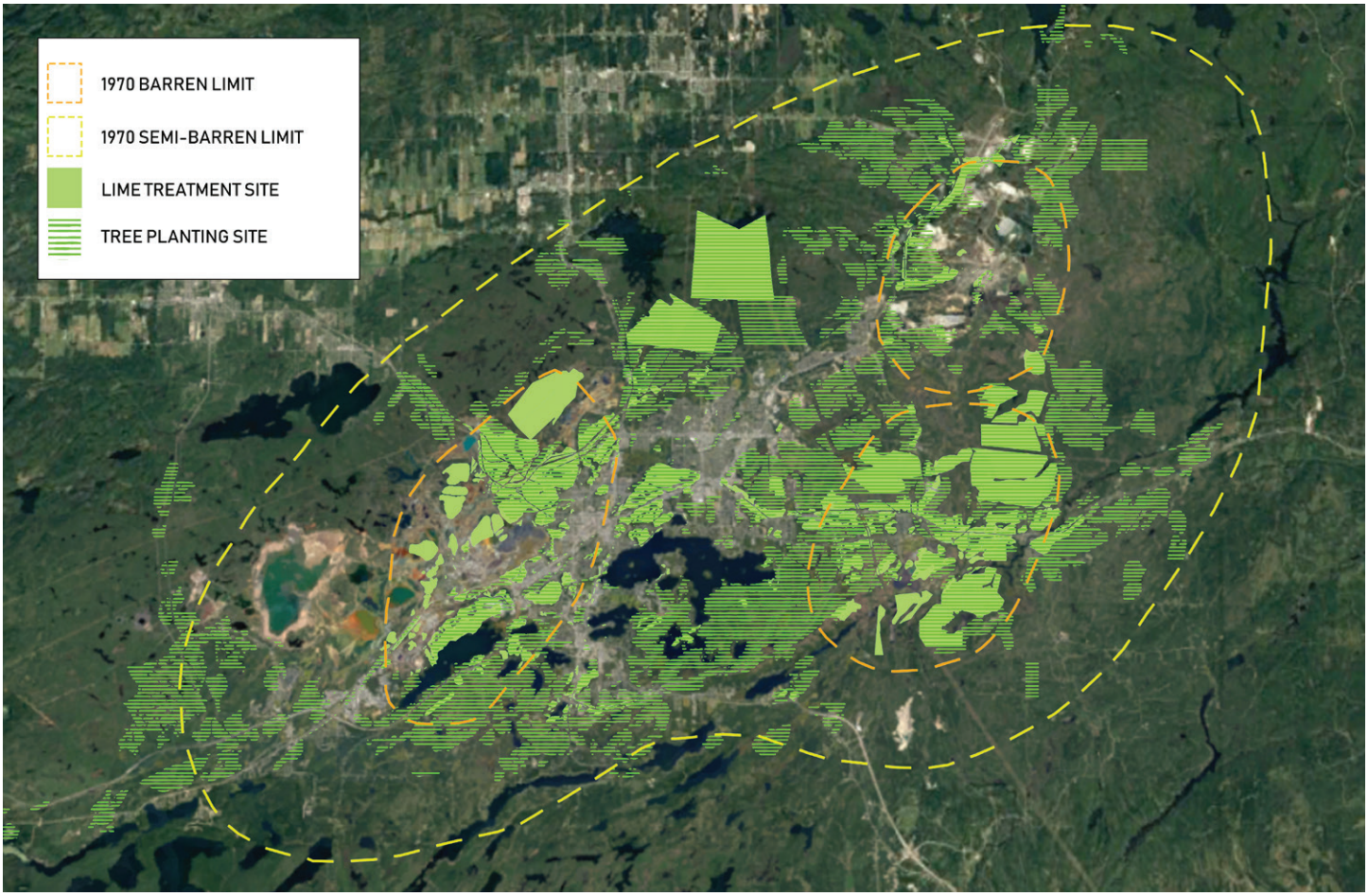
In 1973, a comprehensive regreening program of the Sudbury Landscape began. Fertilizer and seed were used in combination with lime to balance the pH of the soil. Large layoffs at Inco in 1977 and 1982 provided labour opportunities with the short-term employment of miners under federal and provincial programs. The regreening effort has continued since, with short term and volunteer labour planting roughly 9.2 million trees over 3,429 hectares.

Acidification of lakes in the Sudbury region began in the 1930s and continually intensified until the 1970s. There are approximately 19,000 lakes within a 17,000 square kilometre area surrounding Sudbury. It is estimated that 7,000 of these were acidified to a pH below 6.0. Lakes closest to smelters, and in Northeastern and Southwestern directions, were affected the most, with some being acidified to below 4.0. Similar to the soil in the area, metal contamination from airborne emissions also ended up in water systems.

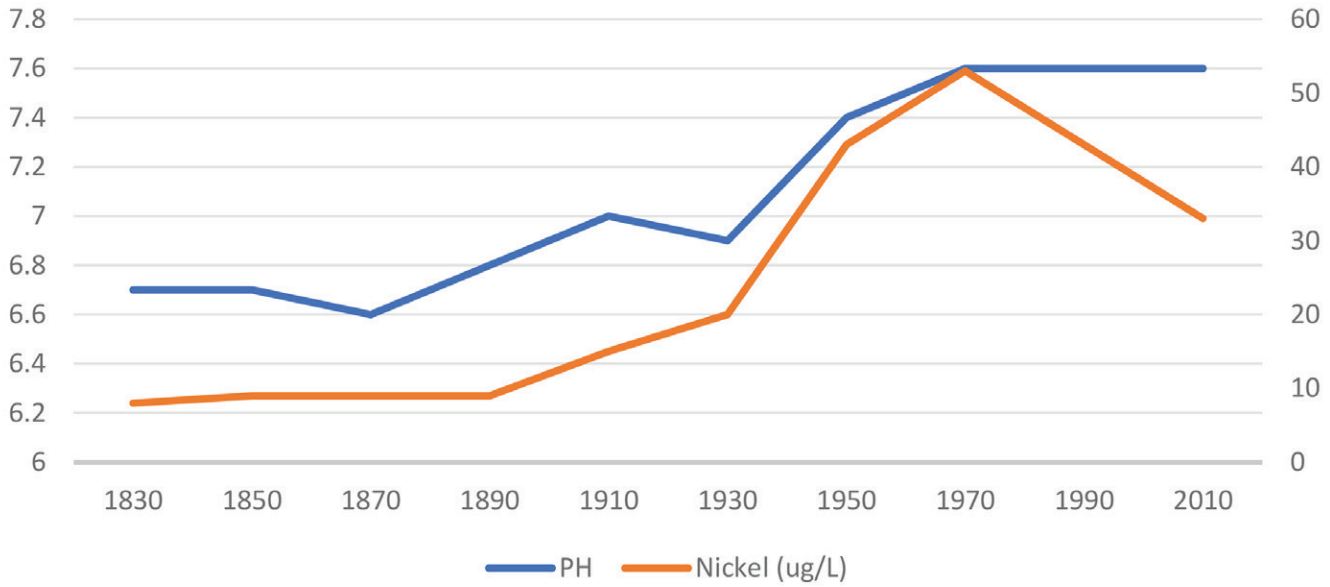
In the early 1970s, powdered lime was added to four local lakes in an attempt to reduce thier acidity.[4] In each case, acidity and metal concentration levels decreased, however, the lakes began returning to their original acidity following treatment. Liming of the surrounding watershed was found to increase longevity, but the recovery of aquatic ecosystem afterward proved to be a long proces. To continue improving the water quality of lakes, the City of Greater Sudbury plans to focus its regreening effort into 100 metre areas surrounding lakes, thereby, minimizing continued metal contamination and acidification from water runoff.[5]

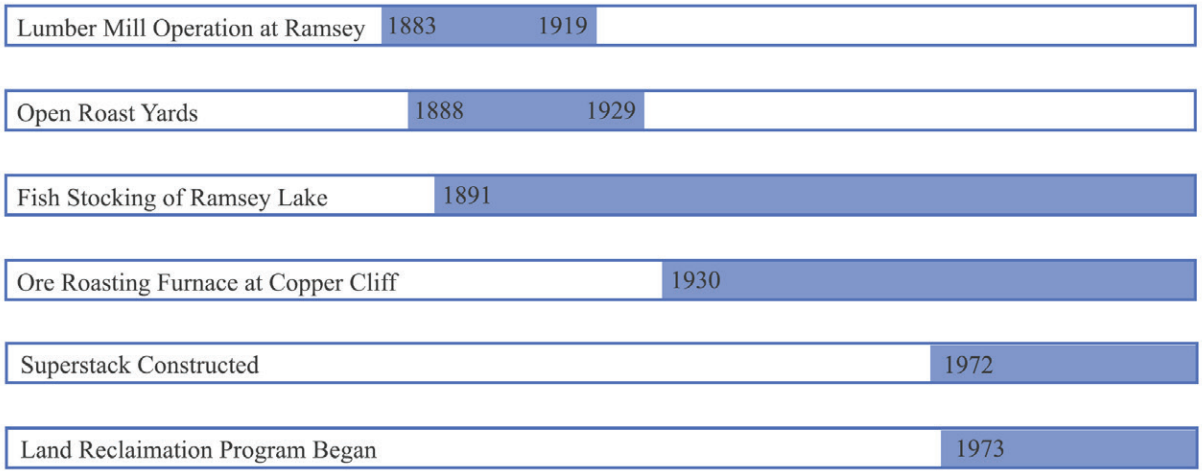
4 D.A.B. Pearson, J.M. Gunn, W. Keller. *The Past, Present and Future of Sudbury's Lakes*. Co-operative Freshwater Ecology Unit, Laurentian University, Sudbury. Accessed April 20, 2019. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/Sudbury-Past-Present-and-Future.pdf.

5 Oiva W. Saarinen. *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury*. Waterloo, Ontario, Canada: Wilfrid Laurier University Press, 2013.



3C GREATER SUDBURY REGREENING
Map by author, developed from GIS data courtesy of the City of Greater Sudbury.
Satelite imagery courtesy of Google Earth Pro.



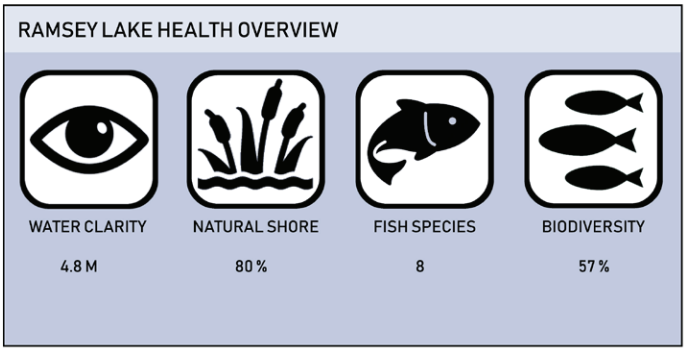


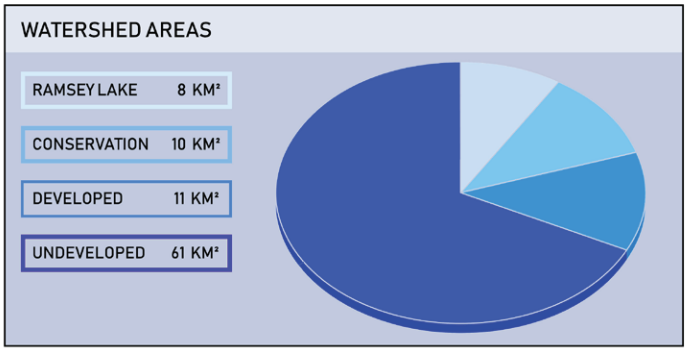
3D **RAMSEY LAKE WATER QUALITY TIMELINE**
Graph by author, developed from information courtesy of:
Aruna S. Dixit, Sushil S. Dixit & John P. Smol. *Long-Term Water Quality Changes in Ramsey Lake as Revealed Through Paleolimnology*. Living With Lakes Centre. Accessed November 16, 2018. https://www3.laurentian.ca/livingwithlakes/research/reports-publications/.
Timeline by author, developed from information courtesy of:
Oiva W. Saarinen. *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury*. Waterloo, Ontario, Canada: Wilfrid Laurier University Press, 2013.

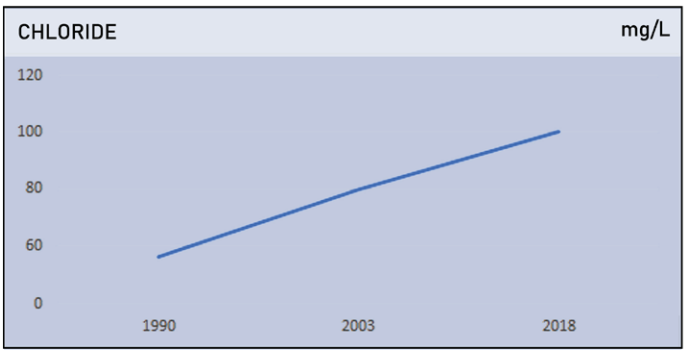
Through the analysis of historical and present data, the health of Ramsey Lake and the surrounding area can be compared to times pre-dating settlement in order to determine how Ramsey Lake has been impacted by human activities. This information can be used to determine possible intervention opportunities which can help restore the ecosystem to its natural quality.

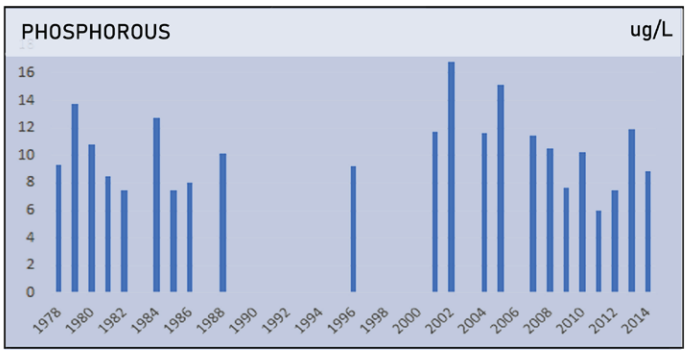
A study conducted by Queen's University in 1996 analyzed Ramsey Lake sediment samples to determine historical levels of acidity and nickel dating back to the 1830s. The data provides a direct correlation between mining activity and an increase in pH and nickel concentrations. Unlike most regional lakes, pH rose in Ramsey Lake from 1930 to 1970. This is likely a result of acid precipitation falling on alkaline drainage basins, thereby, increasing the alkalinity of the water runoff. Nickel concentrations in Ramsey Lake rose from 10 ug/L in 1890, when mining activity first began, to 20 ug/L in 1930, when the first smelter in Sudbury became operational. The trend became more dramatic from 1930 to 1970; pH rose from 6.8 to 7.5, and nickel concentrations rose from 20 to 50 ug/L. This is likely a result of the ore roasting furnace enabling increased production, and chimney stacks spreading airborne nickel over a wider area, encompassing Ramsey Lake.[6]

6 Aruna S. Dixit, Sushil S. Dixit & John P. Smol. *Long-Term Water Quality Changes in Ramsey Lake as Revealed Through Paleolimnology*. Living With Lakes Centre. Accessed November 16, 2018. https://www3.laurentian.ca/livingwithlakes/research/reports-publications/.









4A (Top Left) **RAMSEY LAKE HEALTH OVERVIEW**
Infographics by author, developed from information courtesy of:
Lake Water Quality Program, Annual Report 2014. City of Greater Sudbury. Accessed January 07, 2018. https://www.greatersudbury.ca/linkservid/5A752B86-B4DE-0B79-A084306B65D5412C/.

4B (Top Right) **WATERSHED AREAS**
Infographics by author, developed from GIS data courtesy of the City of Greater Sudbury.

4C (Bottom Left) **CHLORIDE**
Graph by author, developed from information courtesy of:
Recovery of Acid and Metal – Damaged Lakes Near Sudbury Ontario: Trends and Status. Cooperative Freshwater Ecology Unit, 2004. Accessed January 07, 2018. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/Recovery-of-Acid-and-Metal-Damaged-Lakes-near-Sudbury-Ontario.pdf.

4D (Bottom Right) **PHOSPHORUS**
Graph by author, developed from information courtesy of:
Lake Water Quality Program, Annual Report 2014. City of Greater Sudbury. Accessed January 07, 2018. https://www.greatersudbury.ca/linkservid/5A752B86-B4DE-0B79-A084306B65D5412C/.

Since the construction of the Superstack in 1972, conservation efforts have proved successful in the recovery process from the effects of mining activity. Ramsey Lake has shown signs of improvement since the 1970s, with metal concentrations declining and some species naturally returning to the lake. However, the effects of urban development within the watershed are now becoming an increasing concern. Ramsey lake has had a confirmed outbreak of blue-green algae every year since 2010, with 2018 being one of the largest.[7] Cyanobacteria, or blue-green algae, is a photosynthetic bacterium which may be harmful, releasing toxins which can attack the liver, nervous system, and irritate the skin.[8] It is believed to be triggered by several environmental factors; high water temperature, increasing levels of phosphorous, and continued chloride build up from road salting practices. Chloride is highly reactive, forming salts and acids in water. Increased chloride levels affect smaller, microscopic plant and animal life first. As they die off, more resilient forms take over, such as blue-green algae.[9] Natural concentrations of chloride in Ontario freshwater lakes range from 1ppm to 7ppm. In 2018, chloride levels reached 100 ppm in Ramsey Lake and are estimated to reach 120 ppm by 2031;[10] a concentration considered to be toxic to many fish and plant species and exceed the Canadian Water Quality Guidelines for the Protection of Aquatic Life.[11]

In response to these concerns, the City of Greater Sudbury is currently conducting a study focusing on the impacts of the built environment on the ecology of Ramsey Lake's watershed. The research is currently centered on stormwater management practices and future development concerns. The Greater Sudbury Watershed Alliance is also stressing the need for further public engagement to bring these issues to the attention of the public.[12] The reality is that the boundary between land and water cannot be clearly defined. Water finds its way through our environment, over or under the land, making its way to waterbodies through aquifers, streams or storm drains. As water flows through the built environment, it picks up pollutants along the

7 Darren MacDonald. *Algae Bloom Biggest in Years, Ramsey Lake Group Says*. Sudbury.com. August 16, 2018. Accessed September 09, 2018. https://www.sudbury.com/local-news/algae-bloom-biggest-in-years-ramsey-lake-group-says-1017897.

8 Kathryn Weatherley. *How Blue-green Algae Is Taking over Canadian Lakes*. CBC News. February 26, 2013. Accessed September 28, 2018. https://www.cbc.ca/news/technology/how-blue-green-algae-is-taking-over-canadian-lakes-1.1326761.

9 *Ecosystem of Sudbury's Most Famous Lake Could Be Destroyed by 2031, Says Water Group*. CBC News. April 12, 2018. Accessed September 08, 2018. https://www.cbc.ca/news/canada/sudbury/ramsey-lake-sudbury-salt-levels-1.4612944.

10 Editor, Letter To the. Letter: *Using Calcium Chloride in Place of Sodium Chloride a Red Herring*. Sudbury.com. May 01, 2018. Accessed September 22, 2018. https://www.sudbury.com/letters-to-the-editor/letter-using-calcium-chloride-in-place-of-sodium-chloride-a-red-herring-910323.

11 *Chloride*. Canadian Environmental Quality Guidelines. Accessed September 22, 2018. http://ceqg-rcqe.ccme.ca/download/en/337?redir=1537707047.

12 *Watershed Advisory Panel*. City of Greater Sudbury. 2018. Accessed Sept 9, 2018. https://www.greatersudbury.ca/live/environment-and-sustainability1/lake-health/watershed-advisory-panel/.

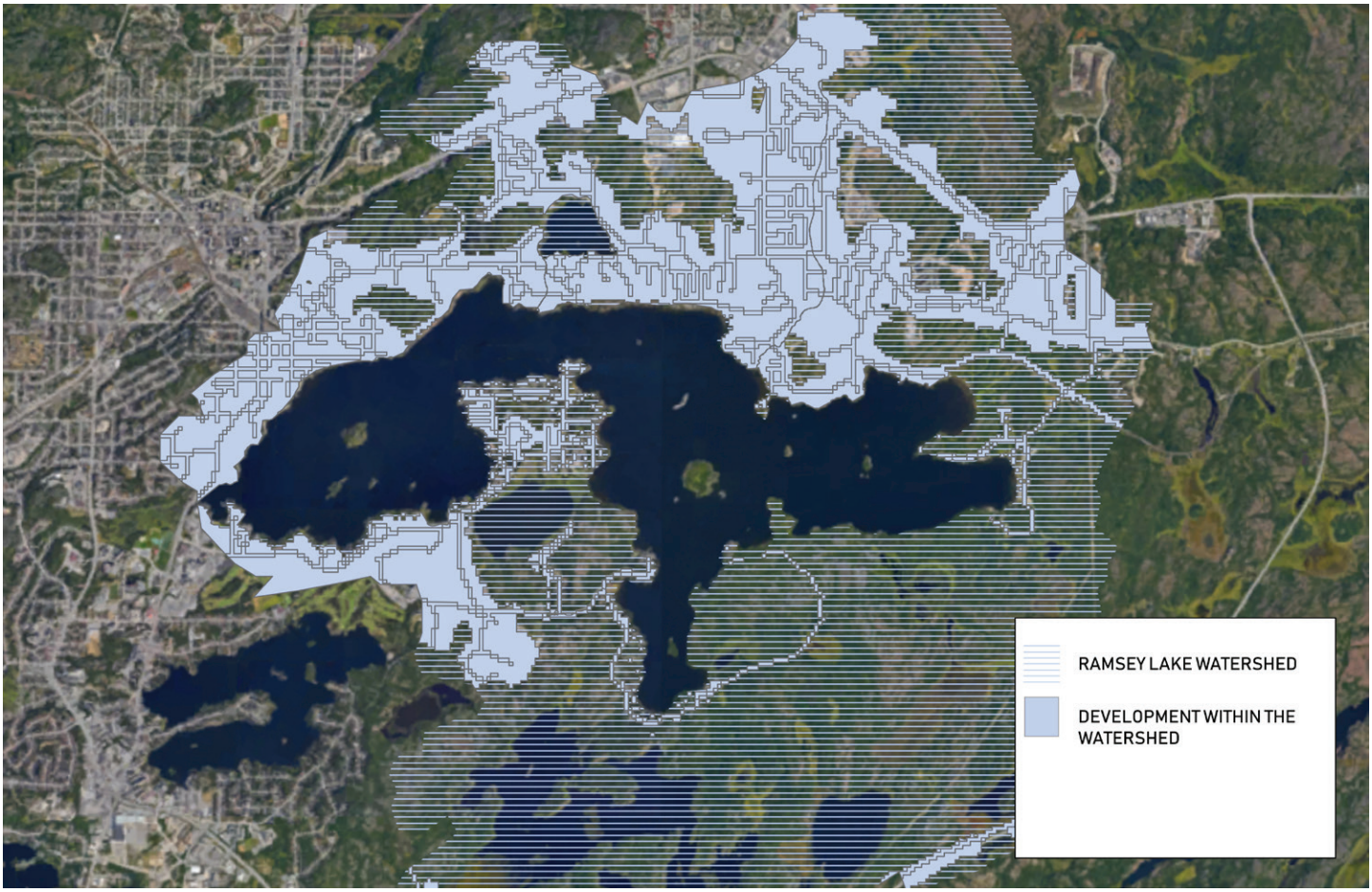
way, including: road salts, chemicals, and excess nutrients. Impermeable surface cover and traditional water management practices typically make this problem worse, transporting water directly to streams and lakes, preventing it from filtering through the land. Storm water management practices are now shifting to local water retention as a strategy to reduce environmental impact, allowing water to be naturally filtered through subsoils. However, re-engineering of existing infrastructure is costly and often unlikely to be achievable in the near future.

As the most central lake, and one of the most developed, Ramsey Lake has faced some of the most environmental impacts from human activity. A recent drinking water assessment report from the City of Greater Sudbury outlined the current risks associated with water quality and development around the lake. The major risks outlined in this report included: sewage contamination, fertilizer runoff, road salt runoff, nearby fuel storage, potential toxic spills from rail transportation, waste disposal sites, snow storage, organic solvent storage, and concerns related to climate change. As a result, the study looked into the potential of relocating the main reservoir to Lake Wahnapitae. However, the cost associated with building the infrastructure required was estimated at a total of $342,093,000.[13]

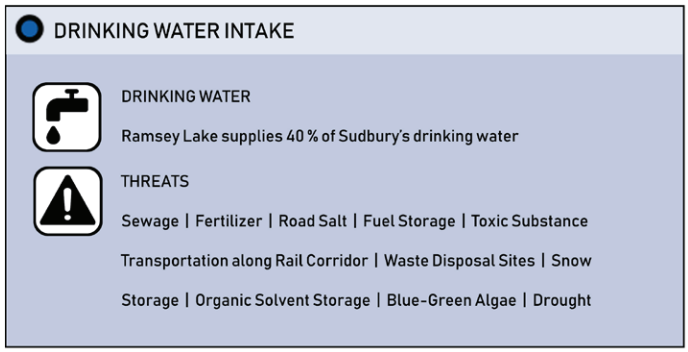
There are four sewage overflow pipes located along the shore of Ramsey Lake. These are built alongside sewage pumping stations which lift sewage uphill. If the sewage flow is greater than these pumping stations can handle, the excess sewage flows into Ramsey Lake untreated. Two public beaches are located within 300 metres of two of these overflow pipes, both are considered to have problematic water quality. The Sudbury District Health Unit conducts periodic E. coli. tests of water from public beaches. The Bell Park Amphitheatre Beach fails 6 - 39% of these tests, while Moonlight Beach fails over 40% of them. This indicates that waste released from sewage overflow is reducing the water quality of the lake within a 300-metre radius.[14]

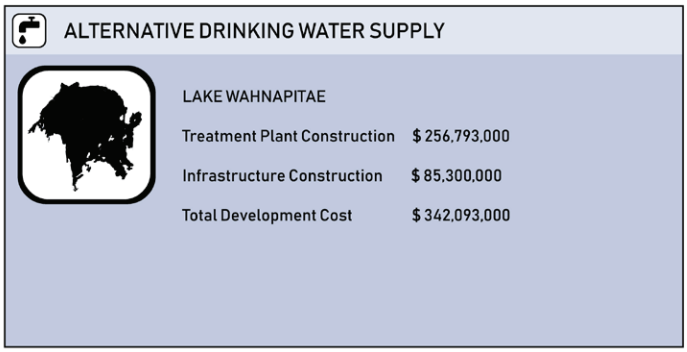
13 *Assessment Report*. Drinking Water Source Protection Sudbury. Accessed November 28, 2018. http://sourcewatersudbury.ca/en/assessment-report.html.

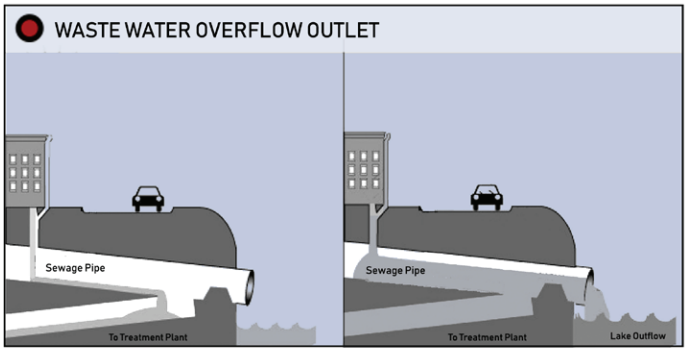
14 *Moonlight Beach*. Swim Guide. Accessed January 07, 2019. https://www.theswimguide.org/beach/3341.

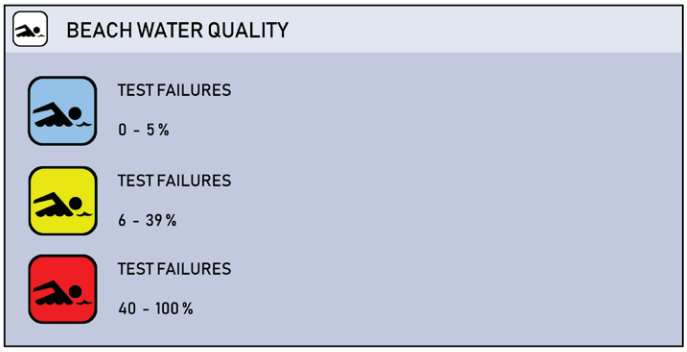


4E **RAMSEY LAKE URBAN DEVELOPMENT**
Map by author, developed from GIS data courtesy of the City of Greater Sudbury.
Satelite imagery courtesy of Google Earth Pro.









4F (Top Left) DRINKING WATER INTAKE
Infographics by author, developed from information courtesy of:
Assessment Report. Drinking Water Source Protection Sudbury. Accessed November 28, 2018. http://sourcewatersudbury.ca/en/assessment-report.html.

4G (Top Right) ALTERNATIVE DRINKING WATER SUPPLY
Infographics by author, developed from information courtesy of:
Assessment Report. Drinking Water Source Protection Sudbury. Accessed November 28, 2018.

4H (Bottom Left) WASTE WATER OVERFLOW OUTLET
Image edited by author, original image courtesy of:
What Are Combined Sewer Overflows (CSOs)? | Urban Environmental Program in New England. EPA. April 10, 2017. Accessed January 07, 2019. https://www3.epa.gov/region1/eco/uep/cso.html.

4I (Bottom Right) BEACH WATER QUALITY
Infographics by author, developed from information courtesy of:
Beach Finder. Swim Guide. Accessed November 11, 2018. City of Greater Sudbury. https://www.theswimguide.org/find/#46.45651876485397/-81.0291554127956/46.49773984188811/-80.8973194752956/14.

4J **RAMSEY LAKE INFRASTRUCTURE MAP**
Map by author, developed from GIS data courtesy of the City of Greater Sudbury.
Satelite imagery courtesy of Google Earth Pro.
Beach water quality data courtesy of:
Beach Finder. Swim Guide. Accessed November 11, 2018. City of Greater Sudbury. https://www.theswimguide.org/find/#46.45651876485397/-81.0291554127956/46.49773984188811/-80.8973194752956/14.

Aquatic vegetation is crucial to the health and productivity of aquatic ecosystems. Floating plants such as pondweed and duckweed provide leaves which geese and ducks feed on, and submerged plants provide a source of food for juvenile fish. Denser aquatic habitats also provide shelter for juvenile fish, giving them cover from predation during the most susceptible period of their lifecycle, providing a better chance they will survive into adulthood. Secondary sources of food are also provided by aquatic vegetation as they tend to support greater biodiversity including snails, insects, and crustaceans.

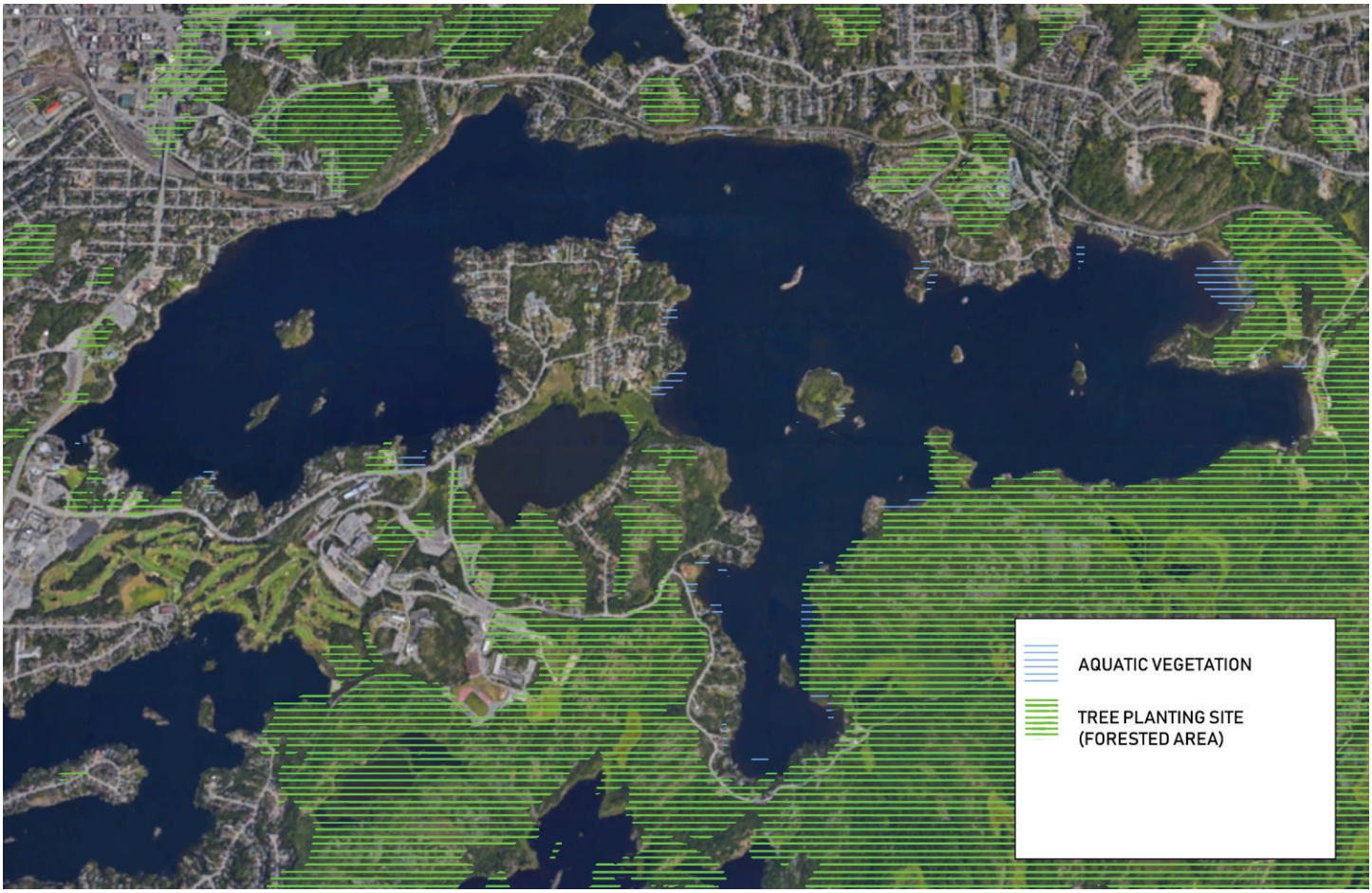
Aside from the creation of habitat, aquatic plants are also beneficial in physical and chemical processes. The roots and the structure of plants help to stabilize sediments, thereby preventing erosion along the shoreline from waves, currents, and wind. This not only increases water clarity but also prevents pollution from entering waterbodies through sediment erosion. Organic nutrients are also absorbed by aquatic plants, which could otherwise fuel excessive algae growth. In the long run, this provides a more stable, healthy, and oxygen rich environment.[15]

Ramsey Lake contains relatively little aquatic vegetation compared to other lakes in the region.[16] This could be a result of shoreline alteration combined with other stressors such as excessive concentrations of chloride. The City of Greater Sudbury is currently conducting an aquatic vegetation survey of regional lakes; however, these studies have so far been limited to Hannah Lake, Long Lake, McFarlane Lake, Richard Lake, and St. Charles Lake. There were a total of twenty-eight species of aquatic plants surveyed in these studies.[17] In order to get a general understanding of the aquatic vegetation in Ramsey Lake, the observed aquatic plant species documented from these studies can be combined with a vegetated area mapping survey of Ramsey completed in 1989 (depicted in the map on the next page).

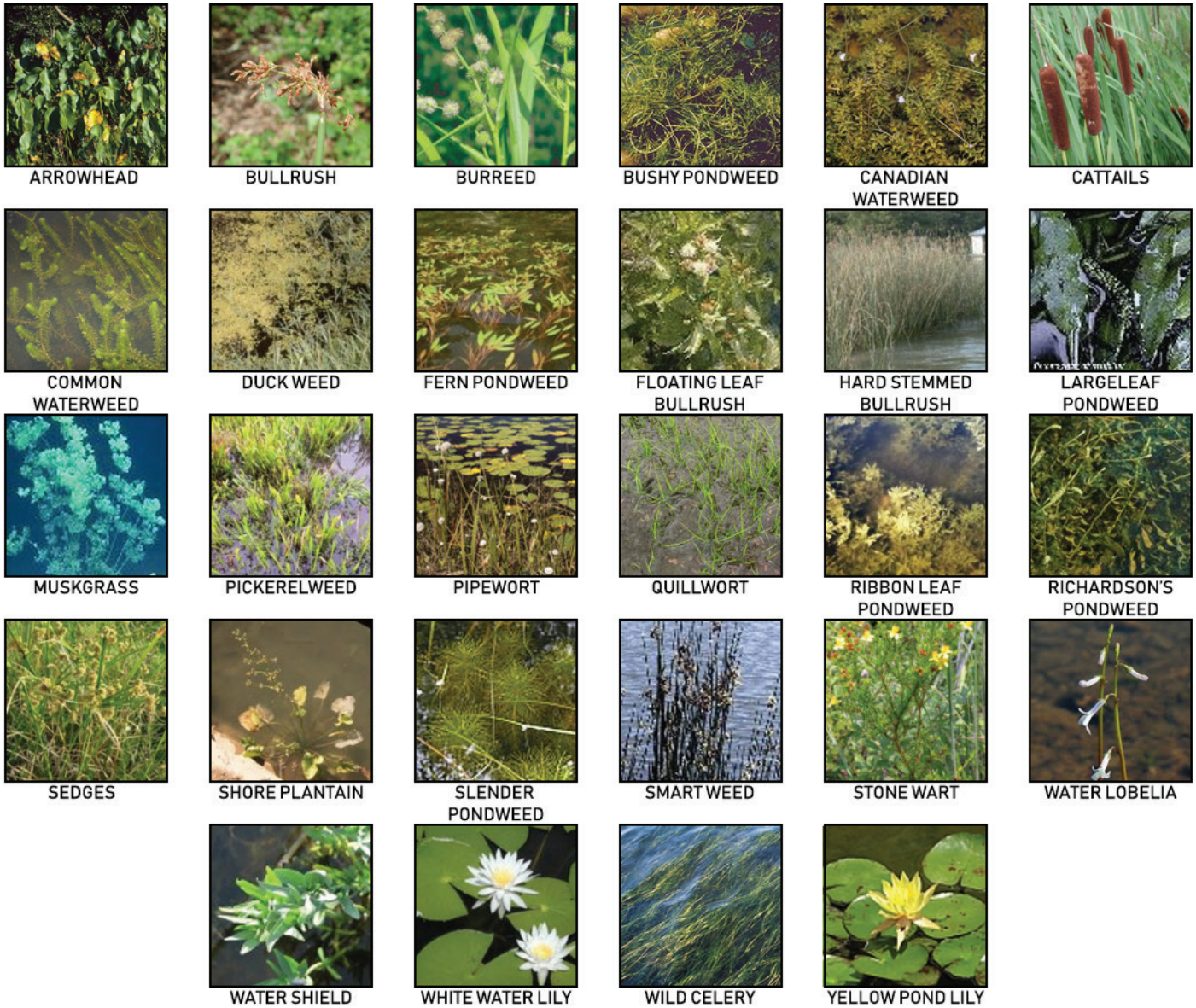
15 *Aquatic Plants*. Planet Oceanography. 2000. Accessed April 19, 2019. https://www.marine.usf.edu/pjocean/packets/f00/nwq3.pdf.

16 Nancy Dolan, Darren Niemi. *Ramsey Lake: An Assessment of the Fish Community and a Review of the Fisheries Management History*. Ontario Ministry of Natural Resources. 1989. Accessed November 09, 2018. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/RAMSEY-LAKE-An-Assessment.pdf.

17 *Aquatic Vegetation and Eurasian Milfoil Preliminary Survey*. City of Greater Sudbury. 2014. Accessed April 19, 2019. https://www.greatersudbury.ca/linkservid/C11A9575-D9FB-2B4A-102C6396C927C093/showMeta/0/.



5A **RAMSEY LAKE VEGETATION**
Map by author.
Tree planting site layer developed from GIS data courtesy of the City of Greater Sudbury.
Aquatic vegetation layer developed from information courtesy of:
Nancy Dolan, Darren Niemi. *Ramsey Lake: An Assessment of the Fish Community and a Review of the Fisheries Management History*. Ontario Ministry of Natural Resources. 1989. Accessed November 09, 2018. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/RAMSEY-LAKE-An-Assessment.pdf.
Satelite imagery courtesy of Google Earth Pro.



5B NATIVE AQUATIC VEGETATION

Design by author, developed from data courtesy of:
Aquatic Vegetation and Eurasian Milfoil Preliminary Survey. City of Greater Sudbury. 2014. Accessed April 19, 2019. https://www.greatersudbury.ca/linkservid/C11A9575-D9FB-2B4A-102C6396C927C093/showMeta/0/.
Images courtesy of:
Plant Identification. Texas A&M Agrilife Extension. Accessed April 19, 2019. https://aquaplant.tamu.edu/plant-identification/.


ASH


BLACK LOCUST


BLACK SPRUCE


JACK PINE


MAPLE


RED OAK


RED PINE


RUSSIAN OLIVE


WHITE CEDAR


WHITE PINE


WHITE SPRUCE


YELLOW BIRCH

5C REGREENING PROGRAM TREE SPECIES

Design by author, developed from data courtesy of:
Regreening Program Annual Report 2013. City of Greater Sudbury. 2013. Accessed April 19, 2019. https://www.greatersudbury.ca/linkservid/4F228660-FE06-EE34-B372E5FBD74DE330/showMeta/0/.
Images courtesy of:
Tree Atlas. Government of Ontario. Accessed April 19, 2019. https://www.ontario.ca/environment-and-energy/tree-atlas.


BROWN BULLHEAD


NORTHERN PIKE


PUMPKINSEED


ROCK BASS


SMALLMOUTH BASS


WALLEYE


WHITE SUCKER


YELLOW PERCH

5D RAMSEY LAKE FISH SPECIES

Design by author, developed from data courtesy of:
Fish Species. City of Greater Sudbury. Accessed April 19, 2018 https://www.greatersudbury.ca/play/beaches-and-lakes/lakes/local-lake-descriptions/ramsey-lake/fish-species/.
Images courtesy of:
Robert J. Eakins. *Ontario Freshwater Fishes Life History Database*. OFFLHD. Accessed November 12, 2018. http://www.ontariofishes.ca/home.htm.

Sudbury was first settled in 1883; by 1891 fish stocking in Ramsey Lake had begun due to overfishing and has continued to this day.[18] There are currently eight confirmed species of fish inhabiting Ramsey Lake; brown bullhead, walleye, yellow perch, northern pike, pumpkinseed, rock bass, smallmouth bass, and white sucker. Its biodiversity, however, is ranked at fifty seven percent for a lake of its size.[19] This means that, prior to settlement in the region, and its adverse effects, there were likely a total of fourteen species inhabiting the lake. While fish stocking began in 1891, there had been no fishery assessments completed until 1947, which only documented five northern pike and one yellow perch. Determining the species which naturally inhabit Ramsey Lake is, therefore, largely a matter of speculation. Walleye, pike, and smallmouth bass are known to be native species and lake trout reportedly existed in large numbers prior to Sudbury's settlement.[20]

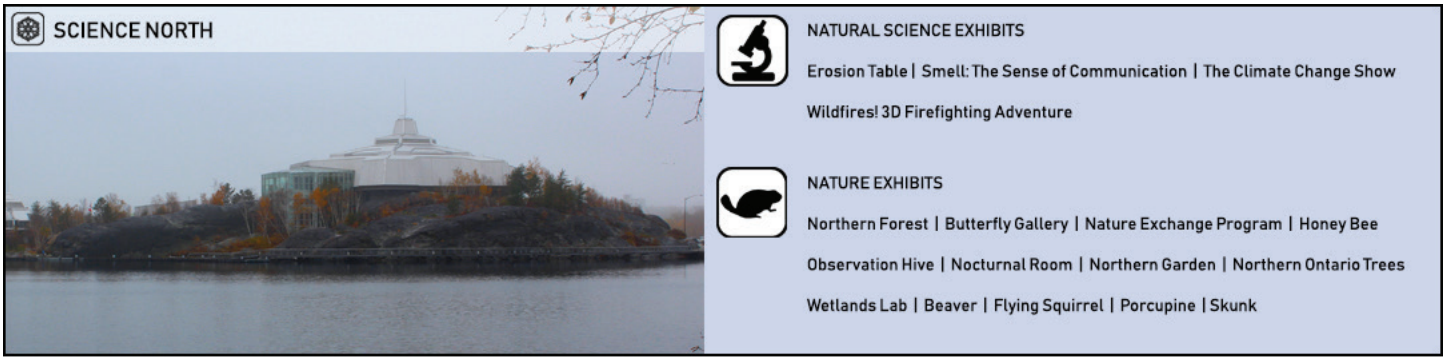
Recently, in 2015, ling (burbot) were discovered by an ice fisherman on Ramsey Lake. This is a significant find as ling is an environmentally sensitive cold-water fish which is thought to have disappeared from the lake over one hundred years ago. This indicates that Ramsey Lake is improving from the effects of industrial pollution and acid rain.[21]

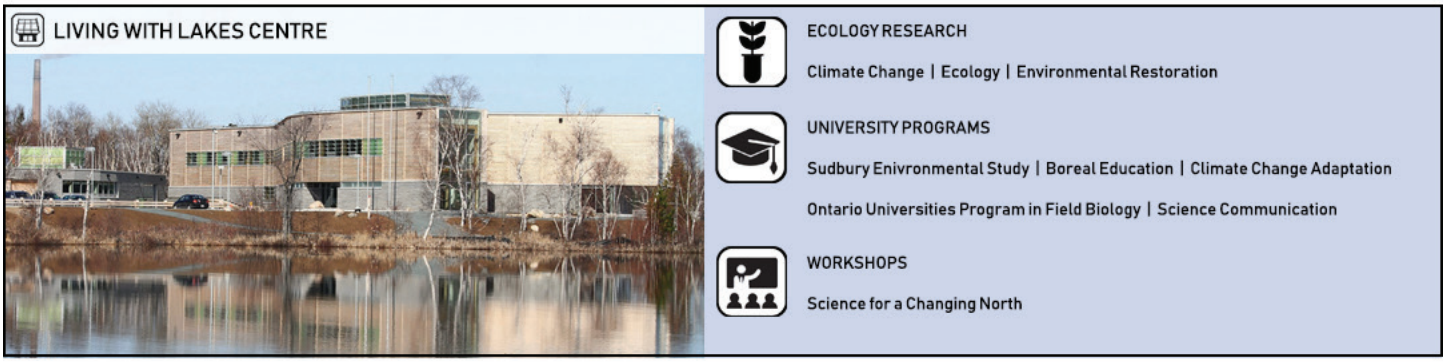
18 Oiva W. Saarinen. *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury*. Waterloo, Ontario, Canada: Wilfrid Laurier University Press, 2013.

19 *Lake Water Quality Program, Annual Report 2014*. City of Greater Sudbury. Accessed January 07, 2018. https://www.greatersudbury.ca/linkservid/5A752B86-B4DE-0B79-A084306B65D5412C/.

20 Nancy Dolan, Darren Niemi. *Ramsey Lake: An Assessment of the Fish Community and a Review of the Fisheries Management History*. Ontario Ministry of Natural Resources. 1989. Accessed November 09, 2018. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/RAMSEY-LAKE-An-Assessment.pdf.

21 Bruce Heidman. *Sudbury Accent: The Prodigal Ling Returns to Ramsey*. The Sudbury Star. March 20, 2015. Accessed April 19, 2019. https://www.thesudburystar.com/2015/03/21/sudbury-accent-the-prodigal-ling-returns-to-ramsey/wcm/ab7b3e92-fc9c-21ee-d472-16f906f13783.





5E (Top) SCIENCE NORTH
Infographics by author, developed from information courtesy of:
Exhibit. Science North. Accessed April 19, 2019. https://sciencenorth.ca/science-north/exhibits/.
Image taken by author.

5F (Middle) LIVING WITH LAKES CENTRE
Infographics by author, developed from information courtesy of:
Cooperative Freshwater Ecology Unit. Vale Living with Lakes Centre. Accessed April 19, 2019. https://www3.laurentian.ca/livingwithlakes/about/cooperative-freshwater-ecology-unit/.
Image courtesy of:
Doris Hawrelluk. The Vale Living With Lakes Centre. Accessed April 19, 2019. https://www.flickr.com/photos/10409127@N08/6180954999.

5G (Bottom) LAKE LAURENTIAN CONSERVATION AREA
Infographics by author, developed from information courtesy of:
Conservation Sudbury. Nickel District Conservation Authority. Accessed April 19, 2019. https://conservationsudbury.ca/en/about-us.html
Image courtesy of:
Lake Laurentian Conservation Area. Ontario Trails. Accessed April 19, 2019. http://www.ontariotrails.on.ca/trails/view/lake-laurentian-conservation-area.

Despite Sudbury's relatively small population, Science North, located along the shore of Ramsey Lake, is the second largest science centre in Canada. Over its thirty-five-year history, Science North has been a pioneer in its design and approach to science exhibits, placing a strong emphasis on visitor interaction. These exhibits largely focus on biology, chemistry, nature, physiology, physics, space, and technology. There is also, currently, a section dedicated to wetland ecology with animal exhibits including a beaver, turtles and a few fish species including brown bullhead and rock bass.[22]

The Vale Living with Lakes Centre houses the Cooperative Freshwater Ecology Unit, a partnership between Laurentian University, The Ontario Ministry of Natural Resources and Forestry, and the Ontario Ministry of the Environment and Climate Change. This partnership allows the collaboration between government, industry and provincial universities in the generation of environmental research. The institution's research focus includes issues such as climate change, invasive species, urban development, contamination, loss of biodiversity and over exploitation.[23]

The Lake Laurentian Conservation Area, located on the south east section of Ramsey, is managed by the Nickel District Conservation Authority and is tasked with the conservation, restoration and development of renewable natural resources, working in partnership with the Ministry of Natural Resources and the City of Greater Sudbury. In addition, the conservation area also hosts a comprehensive ecology education program, providing learning opportunities for children and adults. These programs include full day excursion lessons tailored around the Ministry of Education's curriculum for students ranging from junior kindergarten to grade eight.[24]

22 Krista McCracken. *Community Driven: 30 Years of Science North*. ActiveHistory.ca. June 23, 2014. Accessed April 19, 2019. http://activehistory.ca/2014/06/community-driven-thirty-years-of-science-north/.

23 *Cooperative Freshwater Ecology Unit*. Vale Living with Lakes Centre. Accessed April 19, 2019. https://www3.laurentian.ca/livingwithlakes/about/cooperative-freshwater-ecology-unit/.

24 *Conservation Sudbury*. Nickel District Conservation Authority. Accessed April 19, 2019. https://conservationsudbury.ca/en/about-us.html.

GENERAL STATISTICS

ANNUAL TOURISTS

1,186,951

MONEY SPENT

$ 179,878,933

NIGHTS SPENT

1,637,446

ORIGIN OF VISIT

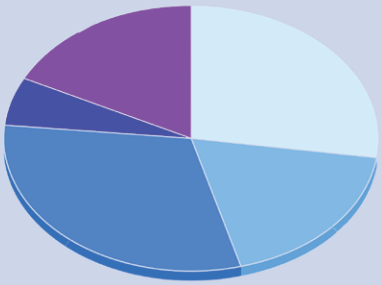
ONTARIO	CANADA	UNITED STATES	GLOBAL
1,109,529	46,415	25,695	5,312

ACTIVITIES

Festivals	7,300	Restaurant / Bar	33,410
Cultural Performaces	15,547	Boating	59,687
Museum / Art Gallery	22,348	Golfing	16,533
Zoos / Aquariums / Gardens	9,277	Fishing	59,566
Sports Events	32,953	Hunting	3,215
Casinos	12,217	Skiing	10,547
Theme Parks	14,652	Snowmobiling	3,559
Nature Parks	36,317	ATV	6,660
Historic Sites	33,521	Cycling	885
Sightseeing	17,316	Hiking	47,591
Aboriginal Event	10,742	Camping	55,940
Shopping	133,863	Visit a Beach	58,198
Movies	13,214	Wildlife / Bird Watching	28,792

MONEY SPENT BY CATEGORY

TRANSPORTATION	27 %
ACCOMODATION	18 %
FOOD / BEVERAGES	31 %
RECREATION	6 %
RETAIL	18 %

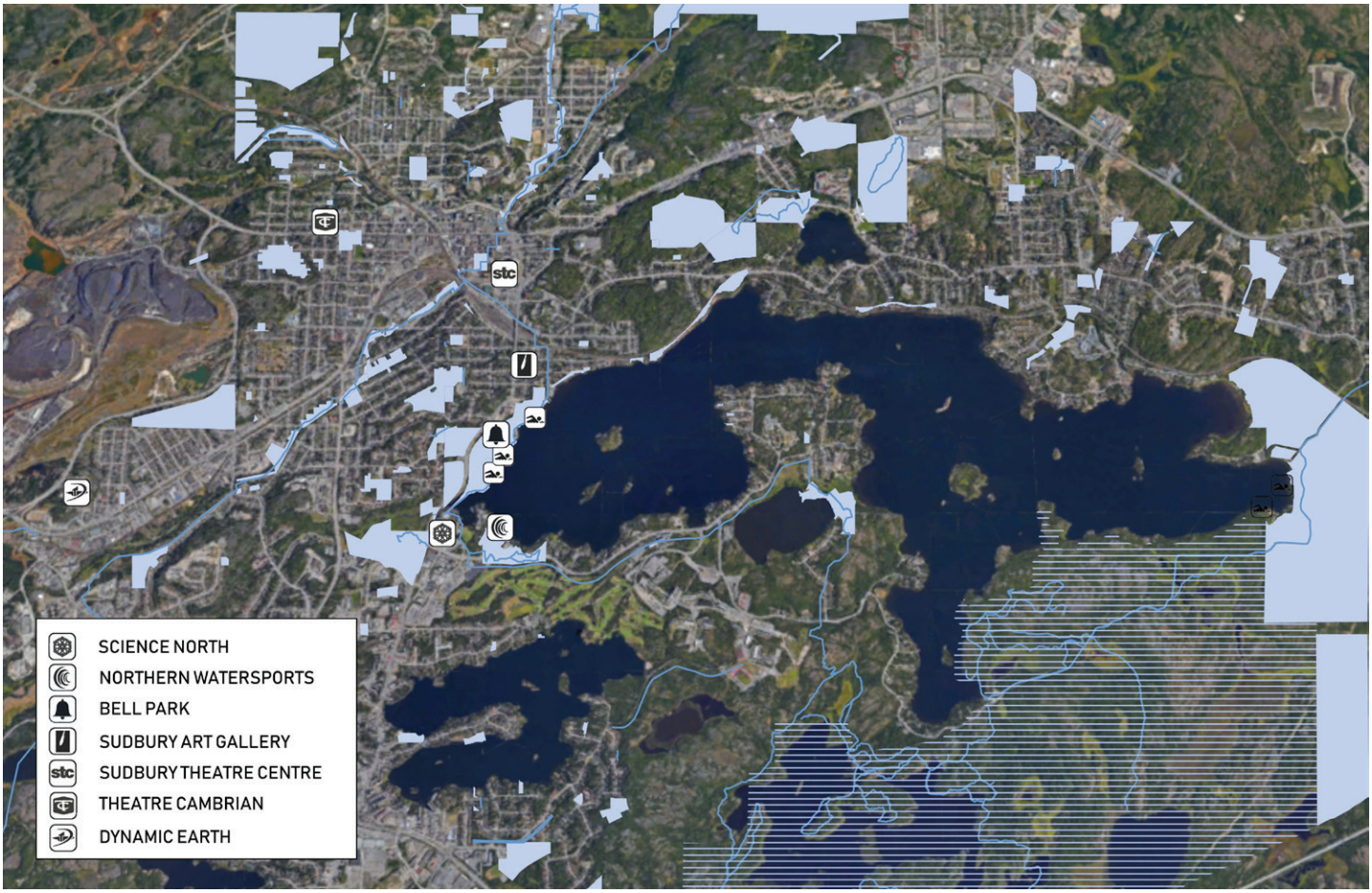


6A (Top Left) GENERAL TOURISM STATISTICS
Infographics by author, developed from information courtesy of:
Sudbury Profile 2014. Discover Sudbury. Accessed November 11, 2018. http://www.sudburytourism.ca/media/SudburyProfile2014CMA580.pdf.

6B (Top Right) ORIGIN OF VISIT
Infographics by author, developed from information courtesy of:
Sudbury Profile 2014. Discover Sudbury. Accessed November 11, 2018.

6C (Bottom Left) TOURIST ACTIVITIES
Infographics by author, developed from information courtesy of:
Sudbury Profile 2014. Discover Sudbury. Accessed November 11, 2018.

6D (Bottom Right) MONEY SPENT BY CATEGORY
Infographics by author, developed from information courtesy of:
Sudbury Profile 2014. Discover Sudbury. Accessed November 11, 2018.



6E RAMSEY LAKE TOURISM MAP
Map by author, developed from GIS data courtesy of the City of Greater Sudbury.
Satelite imagery courtesy of Google Earth Pro.

7A **MOONLIGHT BEACH AQUATIC GARDEN PROPOSAL**
Image by author.
Background image courtesy of Google Earth Pro.

The initial stage of this thesis investigation focused on the design of possible interventions in the form of small installations along the Ramsey Lake shoreline. These installations were developed in response to the research conducted. Through the analysis and study of the urban water cycle, opportunities for improvement can be uncovered which are achievable and can benefit both the community and nature.

The first proposal is a terraced ornamental aquatic garden which is located alongside Moonlight Beach. Water from Ramsey Lake would be pumped into the top terrace. As it flows through the garden and back into the lake, the native plants would filter organic waste out of the water, improving the water quality of the beach. A study by the University of California in 2015 analyzed the effectiveness of using constructed wetlands to remove E. coli from agricultural runoff. The results indicated that an artificial wetland with a hydrological retention time of less than one day reduced E. coli concentrations by 70%. Theoretically, this system could be used for the partial treatment of sewage overflow with similar results. While the installation would likely not solve the E. coli problems associated with Moonlight Beach, a reduction of E. coli by 70% from the water passing through the garden could lead to a marked improvement in the beach's water quality depending on the scale of the installation.[25]

25 *Using Wetlands to Remove Microbial Pollutants from Farm Discharge Water.* University of California, Agriculture and Natural Resources. Accessed January 11, 2019. https://anrcatalog.ucanr.edu/pdf/8512.pdf.

7B **STORM DRAIN POLLUTANT LIGHTING PROPOSAL**
Image by author.
Background image taken by author.

The second issue that the installations addressed is the increasing level of chloride in Ramsey Lake from public road and private land de-icing practices. In targeted areas within the Ramsey Lake watershed, a system of sensors installed within storm drains would detect pollutants in water runoff, such as salt and fertilizer. Coloured lights under the storm drain grate would then be activated to communicate the presence of detected pollutants to people in the area. The system would alert people as to how their activities affect the water going into the lake. Yellow lights indicate nitrates and phosphates from fertilizer runoff, blue lights indicate pH changes from contamination, and red lights indicate dissolved salts from de-icing practices. The generation of public awareness would act as a preventative measure, helping to reduce the amount of salt or fertilizer that is used by land owners within the watershed.

In Greater Sudbury, storm water runoff is a particularily important issue as rain water flows through a dedicated series of storm drains which channel water directly into lakes and streams, without any method of filtration. In addition to this, the history of mining activity in the region results in surface runoff that is five times higher in nickel and twenty times higher in copper than in other regional municipalities. A large reason for this may be past metal particulates from smelter emissions eroding away with soil.[26] While there may be little that residents can do to address soil erosion in thier area short of well-planned landscaping modifications, taking steps like controlling over-fertilization and over-salting can help to reduce stress on local waterbodies.

26 D.A.B. Pearson, J.M. Gunn, W. Keller. *The Past, Present and Future of Sudbury's Lakes*. Co-operative Freshwater Ecology Unit, Laurentian University, Sudbury. Accessed April 20, 2019. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/Sudbury-Past-Present-and-Future.pdf.

7C **BELOW THE WATERLINE PROPOSAL**
Image by author.
Background image taken by author.

Lastly, a series of installations along the Bell Park boardwalk would allow people a glimpse into Ramsey Lake, letting them experience the ecosystem directly as they pass by. The first installation, entitled “Below the Waterline”, acts as an incision into the lake, allowing people to step down and view the lake from within. The second, “Above the Waterline”, a vacuumed transparent dome, placed above the water level, brings Ramsey Lake up to the viewer (see next page). The installations work to blur the boundary between water and land, representing a connection between the two as exists in natural systems. The unfamiliar views into a natural underwater ecosystem would prompt people to think about the lake from a new perspective and see long term changes in underwater environments. In addition to this, these interactions over time could help establish a stronger emotional connection between people on land and the ecosystem underwater.

7D **ABOVE THE WATERLINE PROPOSAL**
Image by author.
Background image courtesy of Google Earth Pro.

7E **RAMSEY LAKE INSTALLATION MAP**
Map by author.
Satelite imagery courtesy of Google Earth Pro.

The second stage of this investigation involved the translation of the installations into a building and public program. A Ramsey Lake Interpretive Centre along the shore of Ramsey Lake was selected as the main intervention with the additional program of a regional native species aquarium. The program would facilitate the generation of public awareness, while also providing opportunities for direct intervention to improve the lake's water quality.

Commercial and recreational fishing contribute $2.5 billion annually to Ontario's economy. However, fishing activity combined with invasive species, habitat degradation, and nutrient loading often necessitate fish stocking programs to promote the recreational fishing industry.[27] Throughout Ontario, approximately eight million cultured fish are released into roughly 3,200 water bodies annually to help bolster their populations.[28]

According to the Ontario Freshwater Fishes Life History Database, there are 159 species of fish in Ontario. Of these species, 39, or roughly 25 percent, are listed under the Species at Risk Act. Freshwater fish are, in fact, the most endangered group of species in the world. Globally, 33 percent of all freshwater fish species are threatened with extinction compared to 21 percent of mammals and 12 percent of birds.[29]

These endangered species, however, garner little public attention compared to more iconic and visible threatened species. For this reason, the role of the exhibits within the interpretive centre is to educate the public about the modern challenges faced by aquatic habitats within Northern Ontario, and to communicate the history of past challenges from industrial activity. In addition to raising ecological awareness, accessible interaction with aquatic species would help foster relationships between community members and their local waterbodies. The building would, therefore, house multimedia exhibits; displaying maps, data, images, and objects which communicate environmental concerns, natural processes, ecological connections, natural history,

27 *Ontario's Fisheries: Significant Contributors to the Ontario Economy*. Ontario Rivers Alliance. August 26, 2014. Accessed January 07, 2019. http://www.ontarioriversalliance.ca/ontarios-fisheries-significant-contributors-ontario-economy/.

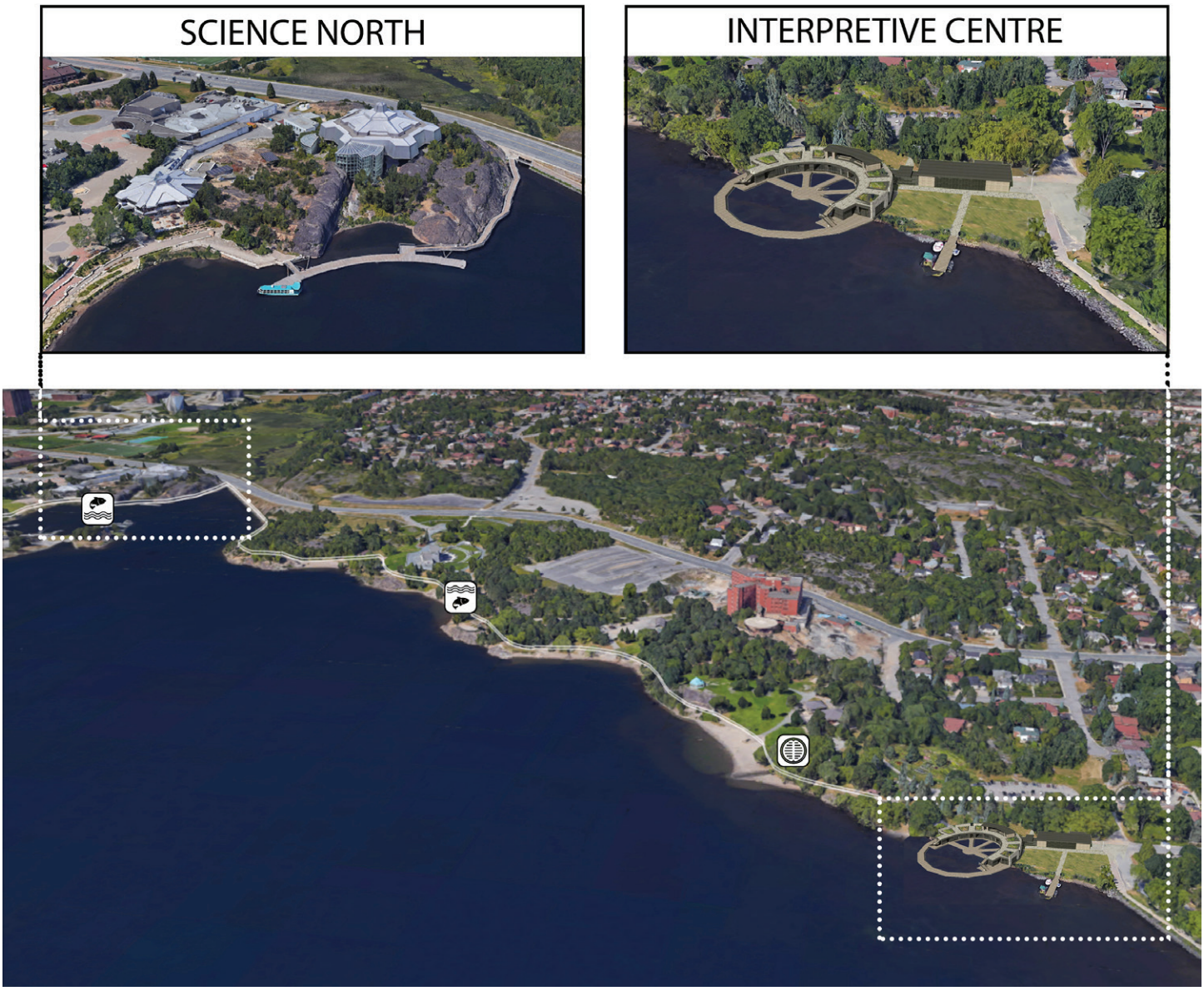
28 *Ontario's Fish Stocking Program*. Ministry of Natural Resources and Forestry. September 11, 2018. Accessed January 07, 2019. https://www.ontario.ca/page/ontarios-fish-stocking-program.

29 Richard Gray. *Third of Freshwater Fish Threatened with Extinction*. The Telegraph. July 30, 2011. Accessed January 07, 2019. https://www.telegraph.co.uk/news/earth/wildlife/8672417/Third-of-freshwater-fish-threatened-with-extinction.html.

and cultural heritage.

The interpretive centre is meant to illustrate how aquatic environments shape human society and how we in turn shape aquatic environments. The focus on cultural and historical exhibits communicates the influence that the landscape has over our societal development, while the environmental exhibits educate visitors about minimizing communal negative environmental impact. The aquarium portion of the building is meant to immerse people in aquatic ecosystems, allowing them to interact with native plants and animals. This allows visitors to learn about regional species and habitats in a more informal way. In addition to this, the filtration systems required to accommodate an aquarium program would be utilized to improve the quality of water in Ramsey Lake itself. In a sense, the building would act as a living natural history museum, highlighting the relationship between human activity and water, as well as the modern state of aquatic ecosystems.

A small portion of the proposed exhibits overlap with already existing displays at Science North, this is because the Interpretive Centre is, in part, an extension on their wetlands section. This is somewhat intentional; since the inception of Science North, interest in ecological issues has grown, with Ramsey Lake being a large focus of aquatic environmental discourse in the city. The centre, then, is meant to form a partnership with other institutions in the area such as Science North, the Living with Lakes Centre, and the Lake Laurentian Conservation Area. These existing facilities offer expertise which would allow the Interpretive Centre to become incredibly effective. Science North has developed a strong skill-set in interactive exhibit design, while the Living with Lakes Centre focuses on ecological research which the Interpretive Centre can translate into exhibits for public communication.



8A **BELL PARK BOARDWALK**
Map by author.
Background images courtesy of Google Earth Pro.

8B BELL PARK BOARDWALK IMAGES
Images taken by author.

EXISTING SITE

PROPOSED SITE

8C **EXISITING SITE**
Image courtesy of Google Earth Pro.

8D **PROPOSED SITE**
Image by author.
Background image courtesy of Google Earth Pro.

The site chosen for the building is located on the eastern end of Bell Park, opposite Science North. The site lies at the main entrance and parking area of Bell Park. The shoreline boardwalk begins in this area and ends at the entrance to Science North. Therefore, visitors to Bell Park would be able to walk between both venues, through the park, and visit the connected installations along the way.

The existing building on the site was previously occupied by the Sudbury Boat and Canoe Club before the construction of their new building on the opposite side of the lake. The canoe club decided to relocate their facility due to the deteriorating state of the building. This became a larger concern in 2015 when higher than normal seasonal water levels caused minor but persistent flooding of the building.[30] After the construction of the new Northern Watersports Centre, the building was taken over by the City of Greater Sudbury and is mainly utilized as a storage facility.

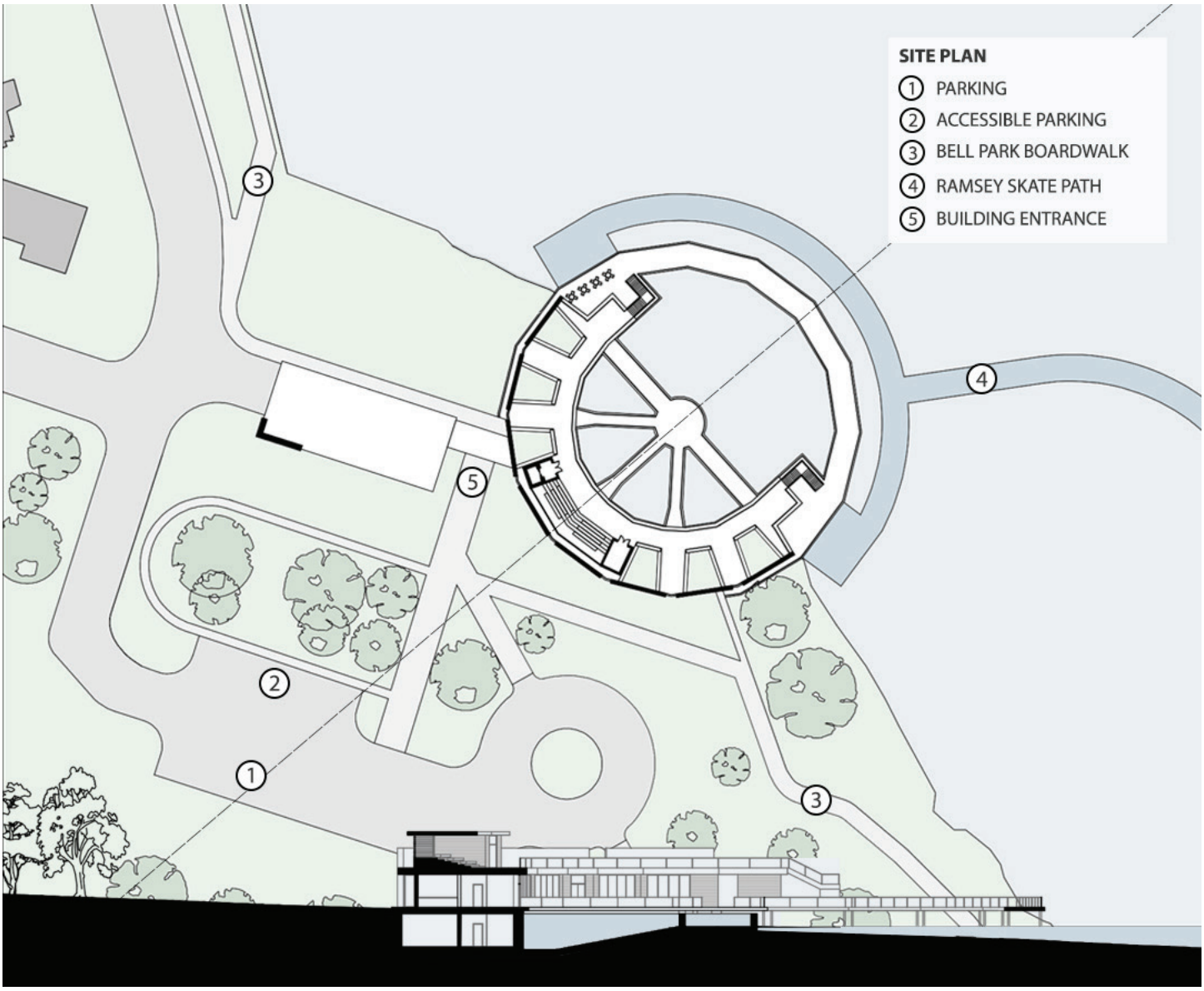
Due to the low elevation of the site, it's susceptibility to flooding and the condition of the existing building, the Interpretive Centre would be fully constructed as a new facility. The shoreline of the site was hardscaped during the construction of the original building. As part of the proposal, the existing concrete retaining walls along the shoreline would be removed in order to re-naturalise the site, and the site would be raised to create an elevated construction platform, reducing the risk of flooding. A more natural, sloped shoreline would then be recreated, and shoreline vegetation would be planted to help minimize erosion of the site. Land vegetation, emergent vegetation and submergent vegetation along the shore would act to naturally filter stormwater runoff. Underwater, the stems and leaves of aquatic plants would also act as habitat for fish, offering them sheltered spaces in a lake which has comparatively little vegetated areas. Rocks and boulders which are retrieved during construction excavation could also be placed underwater along the shoreline, creating additional shelter and habitat. The softening

30 Marina von Stackelberg. *Sudbury Canoe Club Copes with Flooding*. CBC News. June 04, 2015. Accessed April 20, 2019. https://www.cbc.ca/news/canada/sudbury/sudbury-canoe-club-copes-with-flooding-1.3099452.

of the shoreline in this way would likely attract pumpkinseed, rock bass, yellow perch and northern pike to the site, all of which prefer to inhabit shallow and vegetated areas.

The proposed building forms the shape of a ring which protrudes over the water with one edge on shore. The building itself occupies half of the ring with the lakeside half dedicated to a floating dock walkway which also connects to a green roof above the building. The dock and green roof of the building would act as outdoor recreational areas for visitors while also offering access to amenities for the Bell Park area. During the winter, the building's site lies at the end of the Ramsey Lake Skate Path. The dock would therefore be accessible to the skate path to allow skaters access to a café, change rooms and washrooms. The interior/enclosed portion of the dock could also be shoveled to create an additional skating area for recreational activities, such as playing hockey. Alternatively, the same area could also be used as a community art exhibit area in the form of ice sculptures.

As part of the building projects into Ramsey Lake, some underwater excavation and construction would be required. A silk screen would temporarily be placed underwater around the building site to prevent suspended sediment from circulating into other areas of the lake.

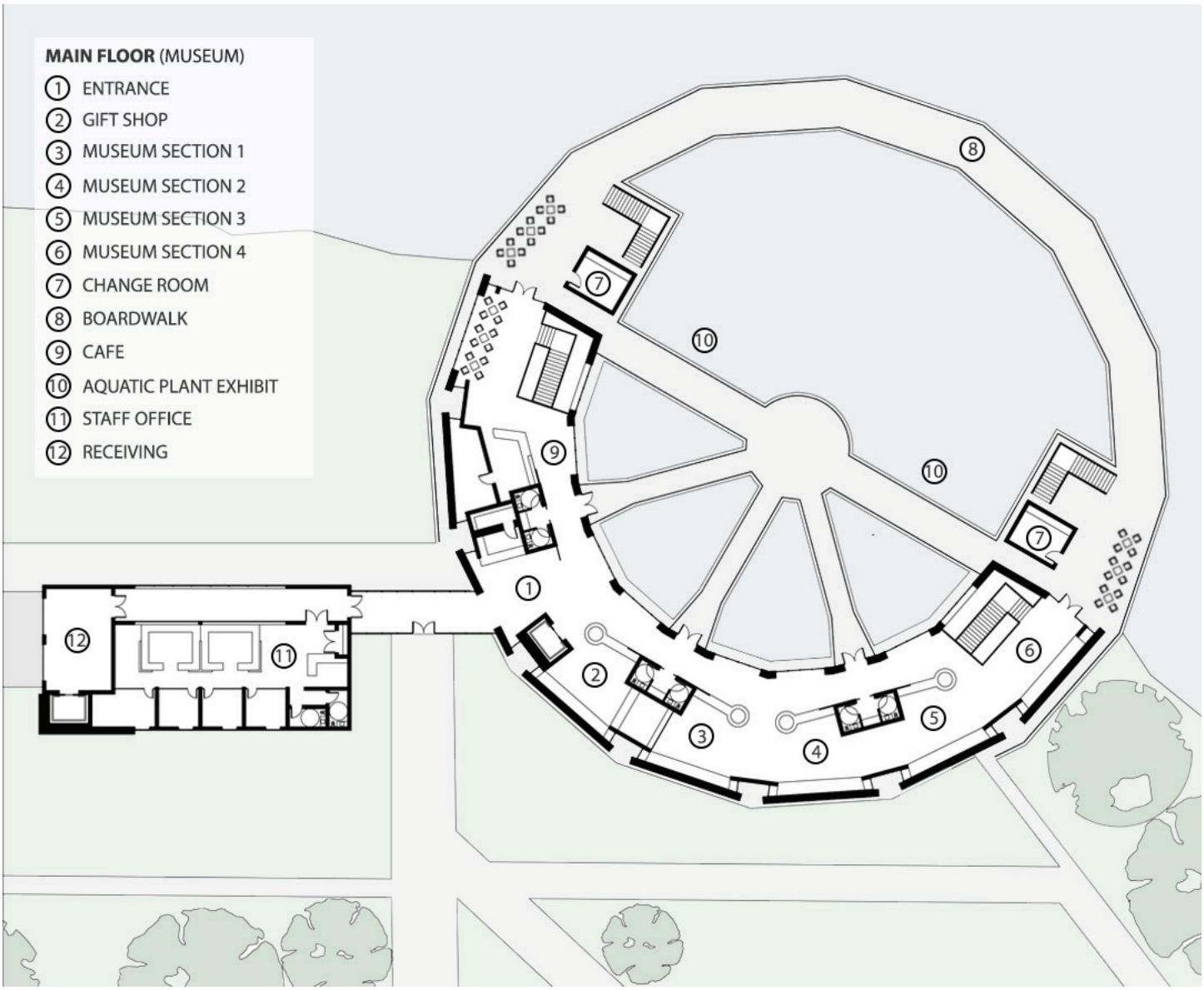


8E **SITE PLAN** (Scale 1:1000)
Drawing by author.

SITE SECTION (Scale 1:500)
Drawing by author.

8F **BUILDING SECTION (Scale 1:150)**
Drawing by author.
Background image courtesy of Google Earth Pro.

8G FRONT PERSPECTIVE
Image by author.
Background and foreground images courtesy of Google Earth Pro.



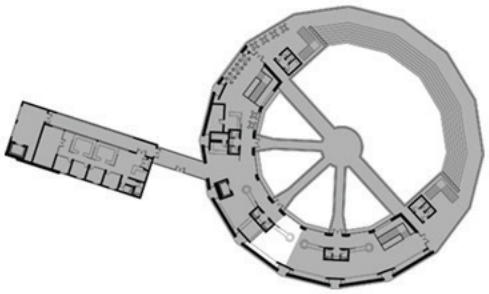
8H **MAIN FLOOR PLAN** (Scale 1:500)
Drawing by author.

The main floor of the building houses the interpretive centre which would display exhibits designed to communicate local history, culture and research relating to regional waterbodies. The interpretive exhibits are divided into four sections in order to facilitate a logical sequence of information. Section 1 would be dedicated to natural history, section 2 to cultural heritage, section 3 to wetland ecology and section 4 to human impact. Sudbury has a long history of environmental impact and remediation which is likely to continue into the future. The most easily affected of these environments, and hardest to re-naturalize, are the aquatic ecosystems. The third and fourth section of the museum would therefore be continually updated to reflect recent environmental concerns and remediation efforts. This would keep visitors well informed of regional impacts on aquatic ecosystems and educate them as to what they can do to help. The first and second sections, dedicated to natural history and human culture, are meant to communicate how our local landscape has formed and how its unique characteristics have shaped regional culture.

The exhibit areas are largely designed to display exhibits on counter tops along the perimeter of the space with corridors in between. Three circular display counters, bordering the entrance of the exhibit spaces, are dedicated to displaying exhibits which are meant to be viewed from all sides. A series of windows along the back side of the building allow views out into the lake while a series of small recessed windows on the front side of the building bring in additional daylight while still allowing exterior walls to display information.

The circular boardwalk offers visitors the opportunity to experience the lake from a more immersive perspective further away from main activity. The centre forks of the circular dock serve as public outdoor pathways but function mainly as service access to the outdoor aquarium exhibits below. These areas would be accessible to the public through the entrance and café section of the building, while the other rear doors would serve only as exits.

NATURAL HISTORY



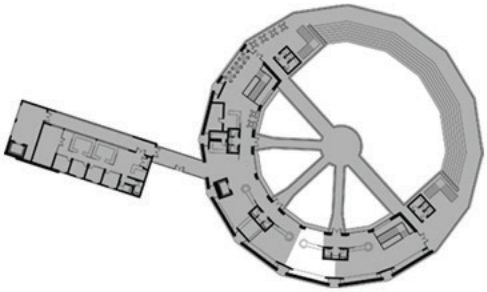
La Cloche Mountains

Erosion

Meteorite Impacts

Glaciation

CULTURAL HERITAGE



Turtle Island Legend

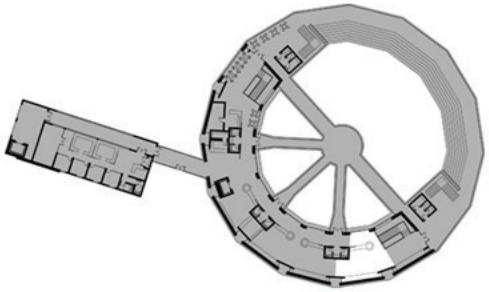
Birch Bark Canoe

Local History

Aquatic Inspired Art

8I INTERPRETIVE CENTRE SECTIONS
Drawing by author.

WETLAND ECOLOGY



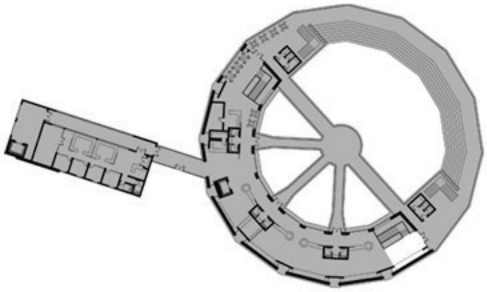
Wetlands as Water Filtration

Aquatic Life & Micro-Ogranisms

Wetland Vegetation

Natural Processes

HUMAN IMPACT



Water Runoff Pollutants

Industrial Contamination

Water Use & Sewage

Shoreline Development

8J MAIN FLOOR PERSPECTIVE
Image by author.

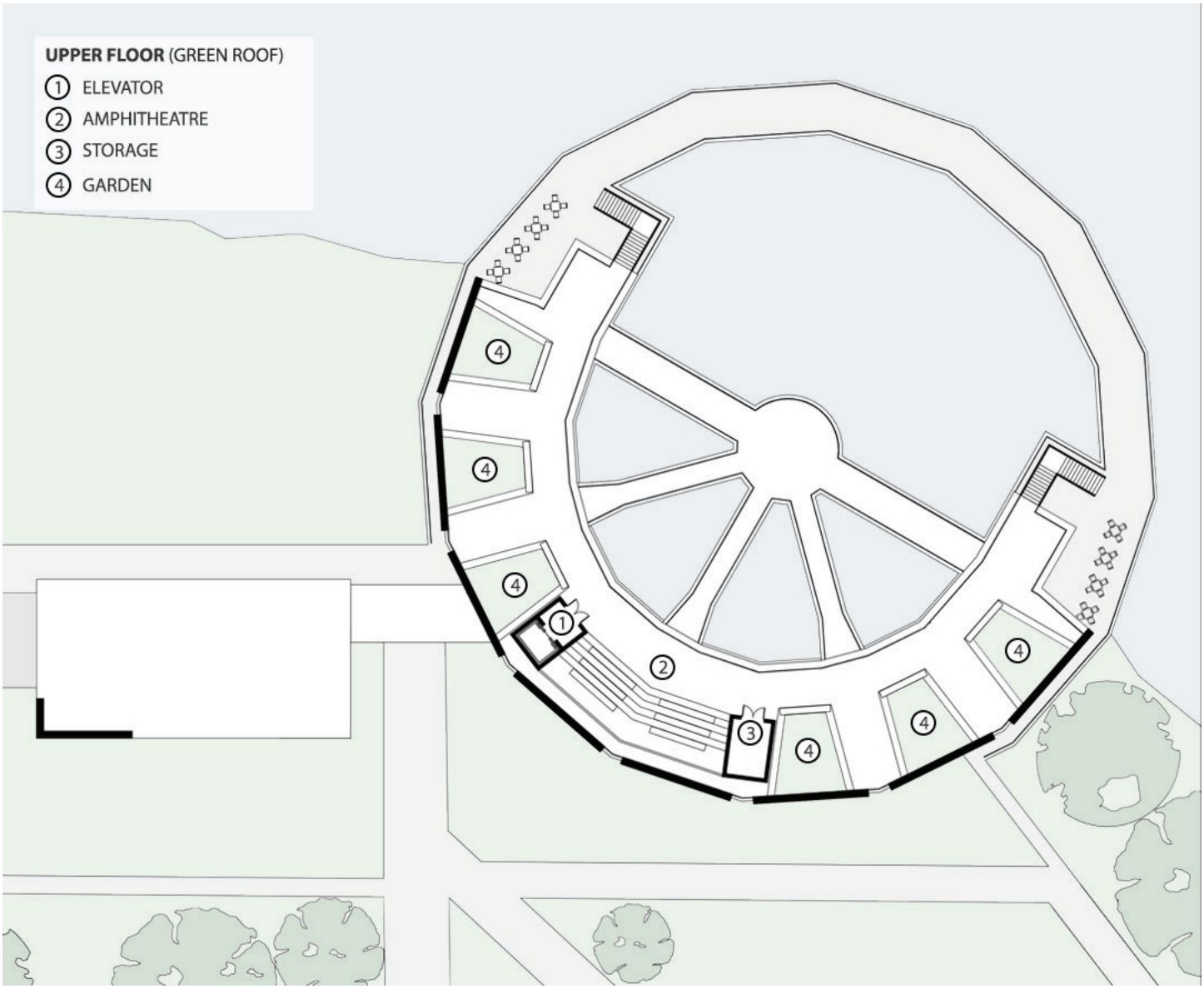
8K **TURTLE ISLAND SCULPTURE**
Sculpture by author.
Turtle Island storyboard adapted from the book:
Nancy Cooper. *Fire and Water: Ojibway Teachings and Today's Duties, Ojibwe Creation Story Literacy Companion*.
Ningwakwe Learning Press, 2011.

This sculpture is a representation of the Ojibwe Turtle Island creation legend which was designed as an exhibit within the proposed Ramsey Lake Interpretive Centre. The Turtle Island legend begins with the flooding of the earth; the Creator floods the world in response to human feuding, and to begin anew. Nanabush and some aquatic animals survive. One by one, the animals try diving to the bottom of the water to retrieve earth. Muskrat is successful; however, he gives his life in the attempt. The ball of soil in muskrat's hand is placed on turtle's back. Wind blows from each of the four directions and the ball of earth grows and grows, eventually forming Turtle Island, or North America.The Turtle Island creation story is thought to be a documentation of flooding which occurred during the melting of the glaciers. The representation of the Turtle Island story documents the interaction between human culture and natural history, while also teaching the importance of living in harmony with the earth.

The object measures roughly four feet in length, three feet in width, two feet in height, and forms the shape of a turtle shell. The individual plates which make up the shell are separated from each other by one to two-inch gaps, highlighting the hollowness of the interior. The bottom and side plates are made of wood while the top plates are made of clay. The clay tiles have illustrations which depict the Turtle Island legend in the form of a storyboard. The clay tiles on the top of the shell symbolize the earth which is held upon the turtles back as well as the soil muskrat pulled up from the bottom of the flooded landscape. The emptiness of the turtle shell represents the sacrifice which turtle made, giving up its back in order to create our home.

The illustrations imprinted into the clay tiles, depicting the Turtle Island legend, are adapted from the book *Fire and Water: Ojibway Teachings and Today's Duties*.[31] The turtle shell sculpture, as a result, acts as a medium for the Turtle Island legend to be retold, rather than a depiction of the story itself.

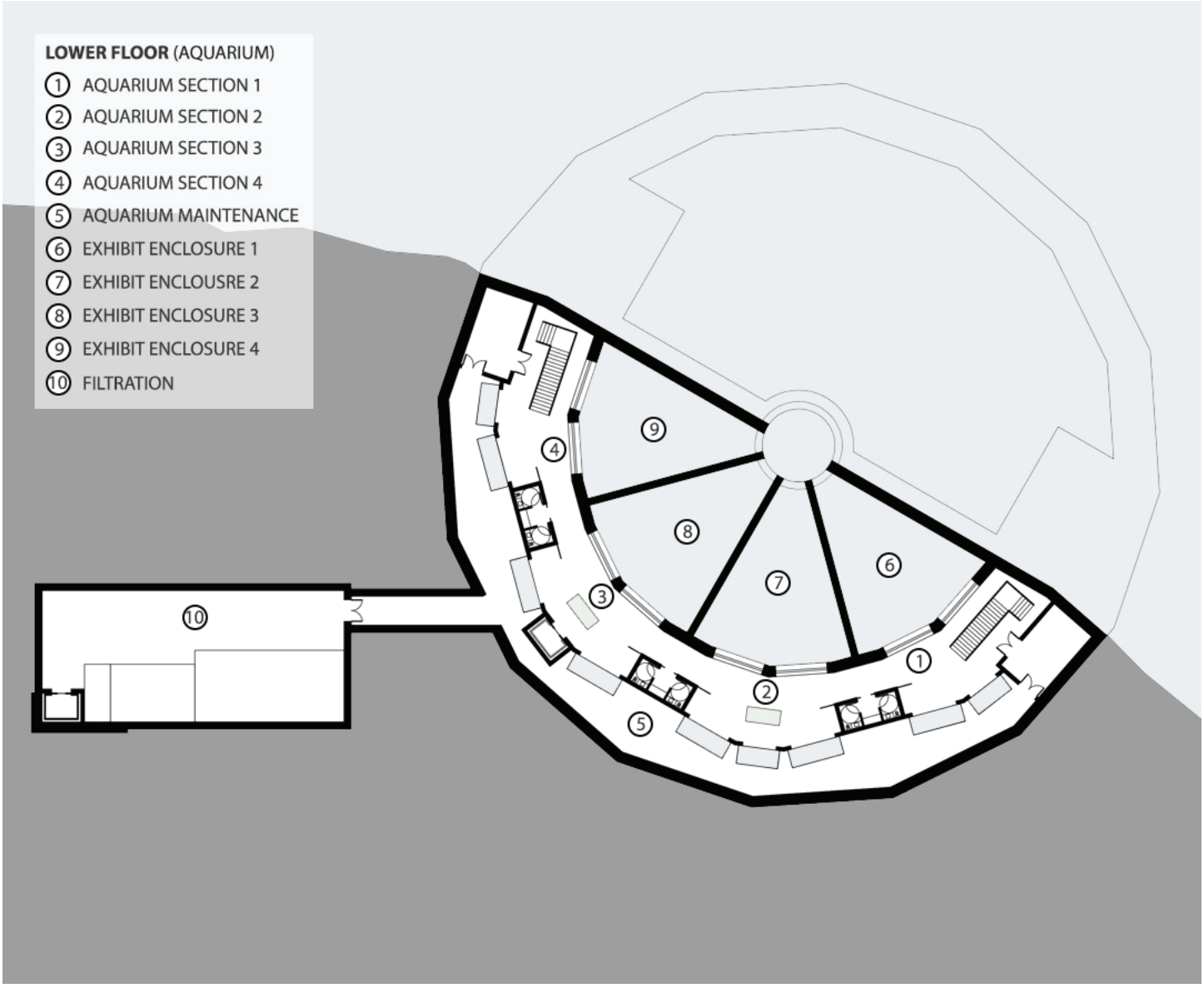
31 Nancy Cooper. *Fire and Water: Ojibway Teachings and Today's Duties, Ojibwe Creation Story Literacy Companion*. Ningwakwe Learning Press, 2011.



8L **UPPER FLOOR PLAN (Scale 1:500)**
Drawing by author.

The upper, green roof, level serves as additional exhibit area and recreational space. The main feature of the public rooftop are the gardens which would display species of shoreline vegetation. This could act as an additional public awareness exhibit in a sense. Roughly 20 percent of the shoreline around Ramsey Lake has been denaturalized, meaning it has either been hardscaped or the natural vegetation has been removed. This reduces the amount of natural habitat for species living in and around the lake, increases the risk of shoreline erosion, and increases organic nutrient runoff from lawns, possibly leading to excessive algae growth. A shoreline exhibit such as this could be an opportunity to educate landowners in the region about the effects of shoreline alteration and encourage them to restore a more natural transition. In addition to this, seeds from the plants within these exhibits could also be harvested for shoreline restoration projects around the region.

In the center of the roof, a covered tiered benching system would act as an outdoor auditorium for events, visitor programs or children's programs during the summer. This could create an opportunity for organizations like the Lake Laurentian Conservation Area which specialize in children's ecology education programs to visit the Interpretive Centre as part of a structured learning activity.



8M **LOWER FLOOR PLAN** (Scale 1:500)
Drawing by author.

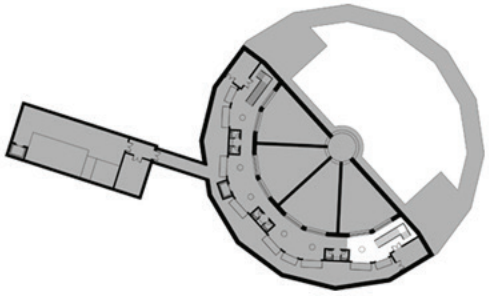
The lower floor (basement level) of the interpretive centre is dedicated to a series of regional aquarium exhibits and is also divided into four sections. Section 1 would focus on local turtle species, section 2 on lake species, section 3 on river species, and section 4 on invertebrates. Locating the aquarium in the basement is a strategy to reduce the footprint of the building as it utilizes space which would already be excavated for the foundation.

There are four larger exhibits in the form of underwater enclosures within Ramsey Lake. These exhibits are open to the dock structure above and have underwater viewing windows into the basement. The incorporation of outdoor exhibits further reduces the footprint of the building interior, making the project more environmentally sustainable while allowing more enclosed space for the animals within them. It also creates a more natural exhibit, where visitors can see seasonal changes in the environment and in animal behaviour as the surface of the water would likely freeze, if only partially.

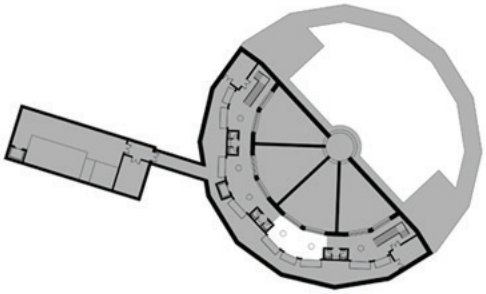
Each of the triangular outdoor enclosures is forty-eight feet long and forty-three feet wide at the larger end. This shape allows visitors to have a wide view of the exhibits across two viewing panes while also giving the animals a place to retreat to, further away from interaction with humans. In order to provide water circulation through the exhibits, water filtered from the lake would flow from the wider viewing end of the enclosures and overflow into Ramsay Lake from the opposite end. Directly opposite of these larger, open air exhibits are a series of smaller conventional aquarium tanks which would be dedicated to exhibits of smaller species, with each tank being 5 feet in width and 11 to 15 feet in length. Within section 2 and 3 are two aquaponic exhibits, shown in green. In these systems, fish waste from the aquariums can be used to fertilize plants, demonstrating ecological links.

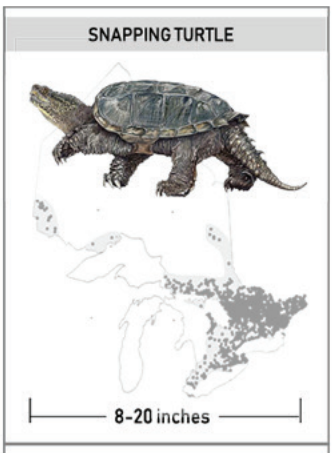
The aquarium program is a way to immerse visitors into local waterbodies and could act as a tool to educate them about the habitats, diets, and lifecycles of local species, and how these are potentially disrupted by habitat degradation, contamination or over-exploitation.

SECTION 1: TURTLES & AMPHIBIANS



SECTION 2: LAKES





Habitat: shallow lakes, rivers, ponds, and wetlands, dense vegetation

Diet: plants, fish, frogs, tadpoles, insects, snails, leeches, worms, snakes, small mammals, juvenile ducks

Habitat: bottom of lakes, rives, ponds and streams

Diet: crayfish, worms, snails

Habitat: shallow shoreline, dense vegetation

Diet: insects, mosquito larvae, small molluscs, crustaceans, worms, minnows, juvenile fish

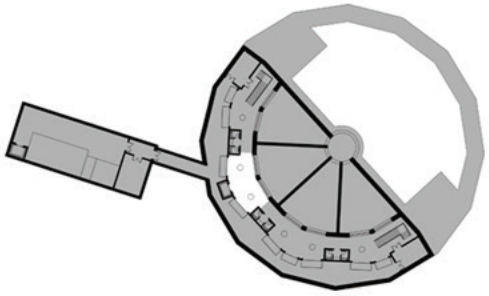
Habitat: rocky or sandy areas of lake bottom

Diet: crayfish, insects, juvenile fish

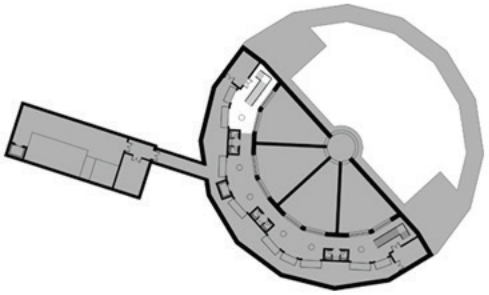
8N AQUARIUM SECTIONS

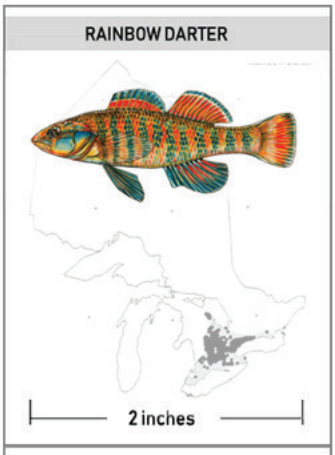
Infographics by author.
Turtle and amphibian images and information courtesy of:
Programs. Ontario Nature. Accessed April 07, 2019. https://ontarionature.org/programs/.
Fish information courtesy of:
Robert J. Eakins. *Ontario Freshwater Fishes Life History Database*. OFFLHD. Accessed November 12, 2018. http://www.ontariofishes.ca/home.htm
Fish Images courtesy of:
Nature & Science. National Park Service. Accessed November 12, 2018. https://www.nps.gov/miss/learn/nature.

SECTION 3: RIVERS



SECTION 4: INVERTEBRATES





Habitat: river, cobble or gravel substrate

Diet: invertebrates, crayfish, insect larvae

Habitat: shallow, sandy lakes and large rivers

Diet: small fish, insects, crustaceans

Habitat: streams, ponds, sand or gravel substrate.

Diet: insects, snails.

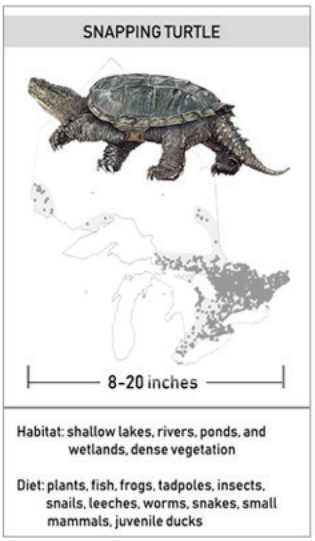
Habitat: lake and ponds with mud bottoms, and little current

Diet: filter feeder, micro-organisms

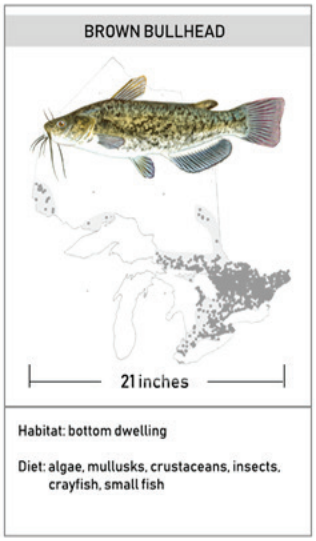
AQUARIUM SECTIONS
Infographics by author.
Fish information courtesy of:
Robert J. Eakins. *Ontario Freshwater Fishes Life History Database*. OFFLHD. Accessed November 12, 2018. http://www.ontariofishes.ca/home.htm.
Fish Images courtesy of:
Nature & Science. National Park Service. Accessed November 12, 2018. https://www.nps.gov/miss/learn/nature.
Mussel images & information courtesy of:
Phillipe Blais. *Canaiad's Freshwater Mussels of Canada*. iNaturalist. Accessed April 07, 2019. https://www.inaturalist.org/guides/6506.

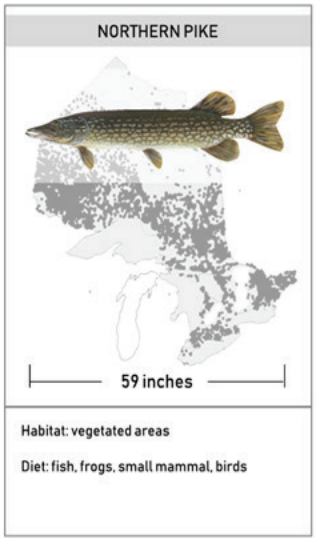
8O MAIN FLOOR PERSPECTIVE
Image by author.

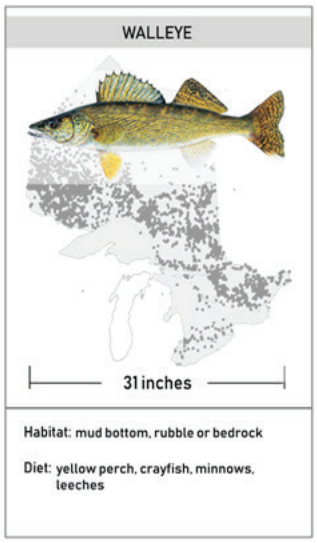
ENCLOSURE 1: SNAPPING TURTLE

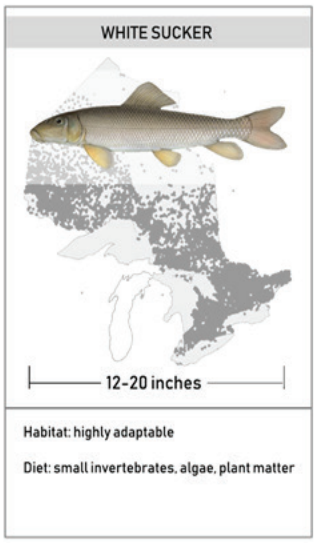


ENCLOSURE 2: RAMSEY LAKE







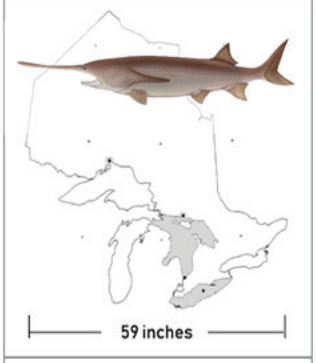


8P AQUARIUM ENCLOSURES

Infographics by author.
Turtle and amphibian images and information courtesy of:
Programs. Ontario Nature. Accessed April 07, 2019. https://ontarionature.org/programs/.
Fish images and information courtesy of:
Robert J. Eakins. *Ontario Freshwater Fishes Life History Database*. OFFLHD. Accessed November 12, 2018. http://www.ontariofishes.ca/home.htm.
Fish Images courtesy of:
Nature & Science. National Park Service.Accessed November 12, 2018. https://www.nps.gov/miss/learn/nature.

ENCLOSURE 3: FRENCH RIVER

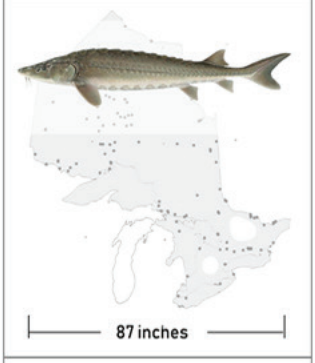
PADDLEFISH



Habitat: open, slow moving waters

Diet: zooplankton, small insects, insect larvae, small fish

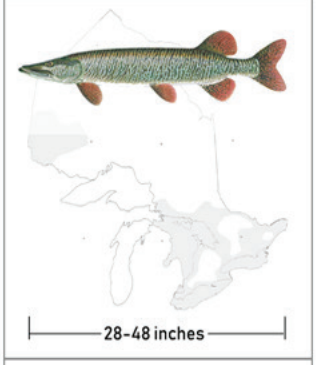
LAKE STURGEON



Habitat: deep water of large lakes

Diet: insect larvae, worms, small organisms

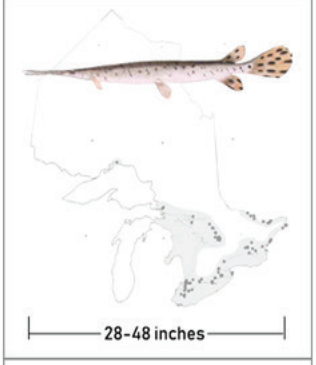
TIGER MUSKELLUNGE



Habitat: shallow and deep water (seasonal)

Diet: yellow perch, suckers, shiners, walleye, smallmouth bass

LONGNOSE GAR

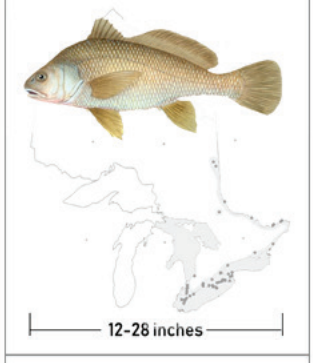


Habitat: shallow, sandy lakes and large rivers

Diet: small fish, insects, crustaceans

ENCLOSURE 4: NIPISSING

FRESHWATER DRUM



Habitat: sandy, silty bottoms of lakes

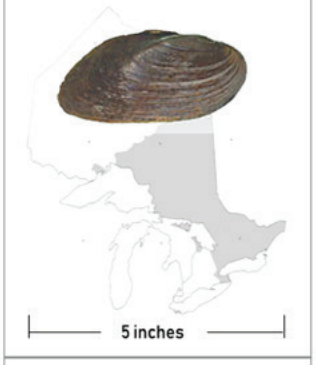
Diet: invertebrates, insect larvae, mussels, and small fish

TRIANGLE FLOATER

Habitat: lakes, streams, rivers, all substrates

Diet: filter feeder, micro-organisms

EASTERN ELLIPTIO



Habitat: lakes, ponds and streams, all substrates

Diet: filter feeder, micro-organisms

GIANT FLOATER

Habitat: lake and ponds with mud bottoms, and little current

Diet: filter feeder, micro-organisms

AQUARIUM ENCLOSURES

Infographics by author.

Fish information courtesy of:

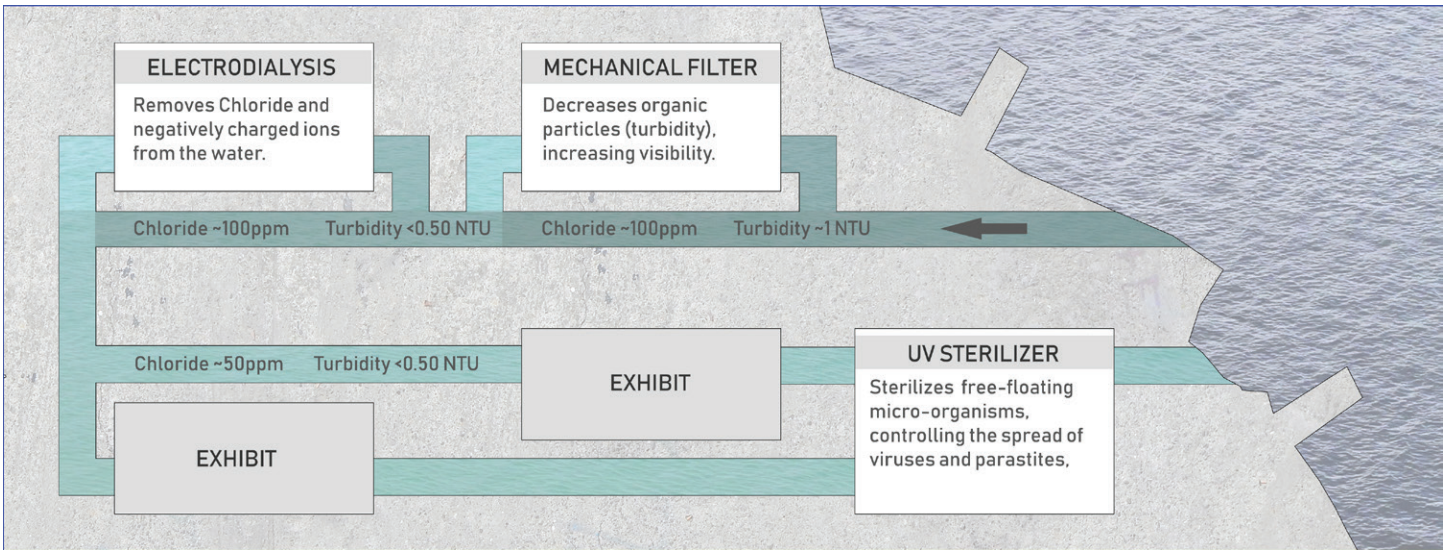
Robert J. Eakins. *Ontario Freshwater Fishes Life History Database*. OFFLHD. Accessed November 12, 2018. http://www.ontariofishes.ca/home.htm.

Fish Images courtesy of:

Nature & Science. National Park Service. Accessed November 12, 2018. https://www.nps.gov/miss/learn/nature.

Mussel Information & images courtesy of:

Phillipe Blais. *Canaiad's Freshwater Mussels of Canada*. iNaturalist. Accessed April 07, 2019. https://www.inaturalist.org/guides/6506.



ELECTRODIALYSIS

OPERATING PARAMETERS

Water Recovery ..... Up to 94%
Salt Removal ..... 50 - 95 %
Temperature ..... 50 PSI

FEED WATER REQUIREMENTS

Turbidity ..... < 0.5 NTU
Total Organic Compounds ..... < 15 ppm
Typical Feed TDS ..... 100 - 3,000 ppm

FLOW RATES: 280 gpm to 1,120 gpm

8Q FILTRATION
Drawing by author.

8R ELECTRODIALYSIS
Image and information courtesy of:
Electrodialysis Reversal (EDR) Water Treatment. SUEZ. Accessed January 07, 2019. https://www.suezwatertechnologies.com/products/edediedr/electrodialysis-reversal-edr

The aquarium exhibits would utilize Ramsey Lake water, allowing the filtration system required in such a facility to begin to act as an environmental remediation tool, filtering targeted compounds from the lake. Over time, the facility would help to improve the quality of Ramsey Lake as a natural ecosystem while also improving the quality of drinking water for Sudbury residents.

One of the most pressing environmental concerns surrounding Ramsey Lake, and many urban lakes in Northern climates, is chloride salt runoff from road and pathway de-icing practices. Unnaturally high chloride levels are harmful to aquatic life and contribute to other ecological issues such as blue green algae blooms. The filtration of chloride out of Ramsey Lake would, therefore, have a large impact in improving the health of the lake both as an ecosystem, and as a recreational destination. There are several forms of chloride filtration including reverse osmosis, distillation, and electrodialysis. As an environmental remediation tool, electrodialysis is the most suited because it selectively removes salt ions while allowing organic compounds to bypass the filtration process. Industrial electrodialysis filters remove up to 94% percent of salt with a waste water efficiency of up to 6%.[32] However, these systems are typically used for the desalination process of brackish water and not for the removal of chloride salt in freshwater applications. A study completed for the Tenth International Water Technology Conference, however, found that the effectiveness of electrodialysis filtration increases as feed concentrations of ionic salt decrease.[33] This indicates that the high end of efficiency given in typical electrodialysis specifications would align with a chloride feed concentration of 100ppm, as currently exists in Ramsey Lake.

The turbidity, or clarity, of the water in Ramsey is generally 1 NTU at a depth of 15 feet, where a water intake pipe would typically be placed. However, the electrodialysis filtration process requires a turbidity of below 0.5 NTU. The intake water from Ramsey Lake would, therefore, pass through a mechanical filter to reduce the turbidity to below 0.5 NTU.[34] This would allow the water to be processed by the electrodialysis filter while also increasing the visibility of the aquarium exhibits. After flowing through the electrodialysis filter and

32 *Electrodialysis Reversal (EDR) Water Treatment*. SUEZ. Accessed January 07, 2019. https://www.suezwatertechnologies.com/products/edediedr/electrodialysis-reversal-edr.

33 Sadrzadeh, Mohtada, Anita Kaviani, and Toraj Mohammadi. *Mathematical Modeling of Desalination by Electrodialysis*. Tenth International Water Technology Conference. Accessed January 09, 2019. https://www.sciencedirect.com/science/article/pii/S001191640601455X.

34 *Current Conditions*. City of Greater Sudbury Ramsey Aquatic Monitoring System. Accessed January 09, 2019. http://dataservices.campbellsci.ca/golder_ramseylake/index.php.

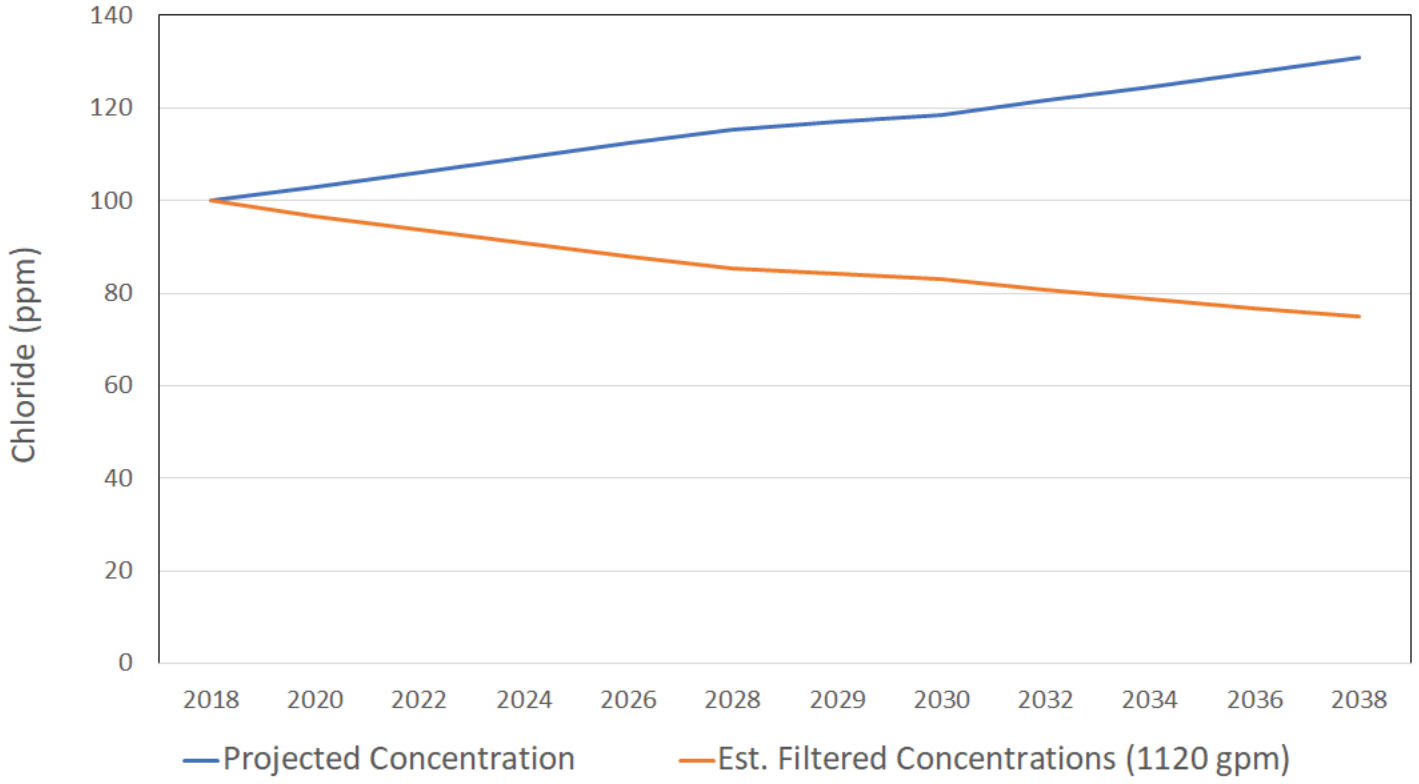
the exhibits, the water would then pass through a precautionary UV sterilizer before being discharged back into Ramsey Lake. UV filtration sterilizes bacteria, pathogens, and parasites, thus, controlling the spread of illness from the exhibits to natural ecosystems. The electrodialysis would create a small percentage of chloride concentrated wastewater at high efficiency, however, the water content could be further reduced through evaporation with the addition of a distiller. Excess heat from this system could also be used to help regulate the temperature of the exhibit water, or to heat the building.

The four exterior enclosures, once filled, would hold an estimated volume of 50,000 gallons each, making for a total of 200,000 gallons. This would require a water circulation volume of 144,000 gallons per hour. This amount is based on regional industry standards and would circulate the entire volume of each exhibit in roughly an hour and 20 minutes.[35] A backup air pump would be added to circulate and aerate the water in case of a power outage or low oxygen levels during the winter. A backup cooling system would also be installed to benefit coldwater species in the summer. The winter would likely be a time of “reduced maintenance”, any ice buildup could be partially removed or drilled through for access during minor maintenace or feeding.

The chloride filtration process could potentially have an impactful result on the ecosystem, at a 1,120 gallon per minute flow rate, the electrodialysis filter could remove over 180 metric tonnes of chloride per year in the first few years of operation. This would reduce the concentration of salt in Ramsey lake from 100ppm to an estimated 75ppm within 20 years based on current projections. The waste from the filtration process is a salt brine which could be re-used by municipalities in the region for further de-icing practices. This would create a cyclical process, where salt is removed from the environment to be added again to roadways. While technically, salt would only be removed from Ramsey Lake, it would have a downstream effect. Ramsey Lake flows into Kelly Lake, which discharges into the Spanish River, and eventually to Lake Huron, therefore, improvements made to its water quality would also have a positive effect on its distributaries.

35 *Life Support Systems*. Ripley’s Aquarium of Canada. Accessed April 23, 2019. https://www.ripleyaquariums.com/canada/galleries/life-support-systems/

CHLORIDE FILTRATION



8S **CHLORIDE FILTRATION**
Drawing by author.
Developed from information courtesy of:
Editor, Letter To the. *Letter: Using Calcium Chloride in Place of Sodium Chloride a Red Herring*. Sudbury.com. May 01, 2018. Accessed September 22, 2018. https://www.sudbury.com/letters-to-the-editor/letter-using-calcium-chloride-in-place-of-sodium-chloride-a-red-herring-910323.

09 CONCLUSION

As Sudbury's landscape continues to recover from industrial activity, environmental concerns surrounding Ramsey Lake are increasingly becoming issues of urban development and land use. The proposed Ramsey Lake Interpretive Centre is a response to ecological concerns impacting Ramsey Lake and the surrounding area. The program was, therefore, developed as a strategy to address this issue through the lens of public education, with the filtration processes acting secondarily as a direct intervention. While the thesis document communicates the research, the program of public education within the Interpretive Centre is meant to be an immersive and personable experience rather than a more direct transfer of information. The intention behind this is to create an emotional and experiential connection to environmental impact. The topics which the program focuses on, therefore, are problems which can be addressed in some way by members of the public such as contamination, eutrophication, and habitat degradation.

In some ways, however, the proposed program can be viewed as self-defeating. The construction of an ecological building along the waterfront can impact the ecology of the lake, and the containment of live animals can be morally objectionable. The site chosen to construct the centre, however, was already hardscaped during its previous use. While the building footprint itself would remain a hard-edge, a portion of the shoreline would be restored to a more natural condition. The centre itself would, additionally, raise awareness of environmental issues impacting regional waterbodies, generating further interest in environmental stewardship. The aquarium program could also act in the same capacity, the exhibits themselves would become a teaching tool, helping to communicate issues relating to the conservation of local wildlife. Additionally, the filtration systems which support this program would help to improve the water chemistry of Ramsey Lake itself, elevating its quality as an ecosystem and as a reservoir for residents who rely on it as a source of drinking water.

09 CONCLUSION

The proposed Ramsey Lake Interpretive Centre pursues the goal of "Clean Water Now and Forever" through architectural design that promotes interaction and education.[36]

36 *Laurentian Forging New Partnerships for Enhanced Research Collaboration with the Ministry of the Environment and Climate Change*. Laurentian University. Accessed April 30, 2019. https://laurentian.ca/research/ThisWeekinResearch/enhanced-research-collaboration.

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This thesis will aim to address the following theoretical questions: How can architectural interventions mitigate human impact on a more than human landscape? How can enhanced and sustainable interaction between aquatic life and people contribute to greater appreciation and conservation for underwater ecosystems?

Specifically, this thesis will study and analyze Ramsey Lake, in Sudbury, Ontario, Canada, through mapping exercises, scientific research, media articles, and site documentation to inform the design of a “Ramsey Lake Interpretive Centre”. The centre would raise public environmental awareness of regional aquatic ecosystems and provide direct opportunities for environmental remediation of a lake which has been impacted by industrial activity and urban development for over one-hundred-years.

Ramsey Lake was selected as the focus of this study because of the central role that it plays within the community. In addition to acting as a drinking water reservoir for over 40% of Greater Sudbury, it also represents a significant centre for culture and recreation within the community.

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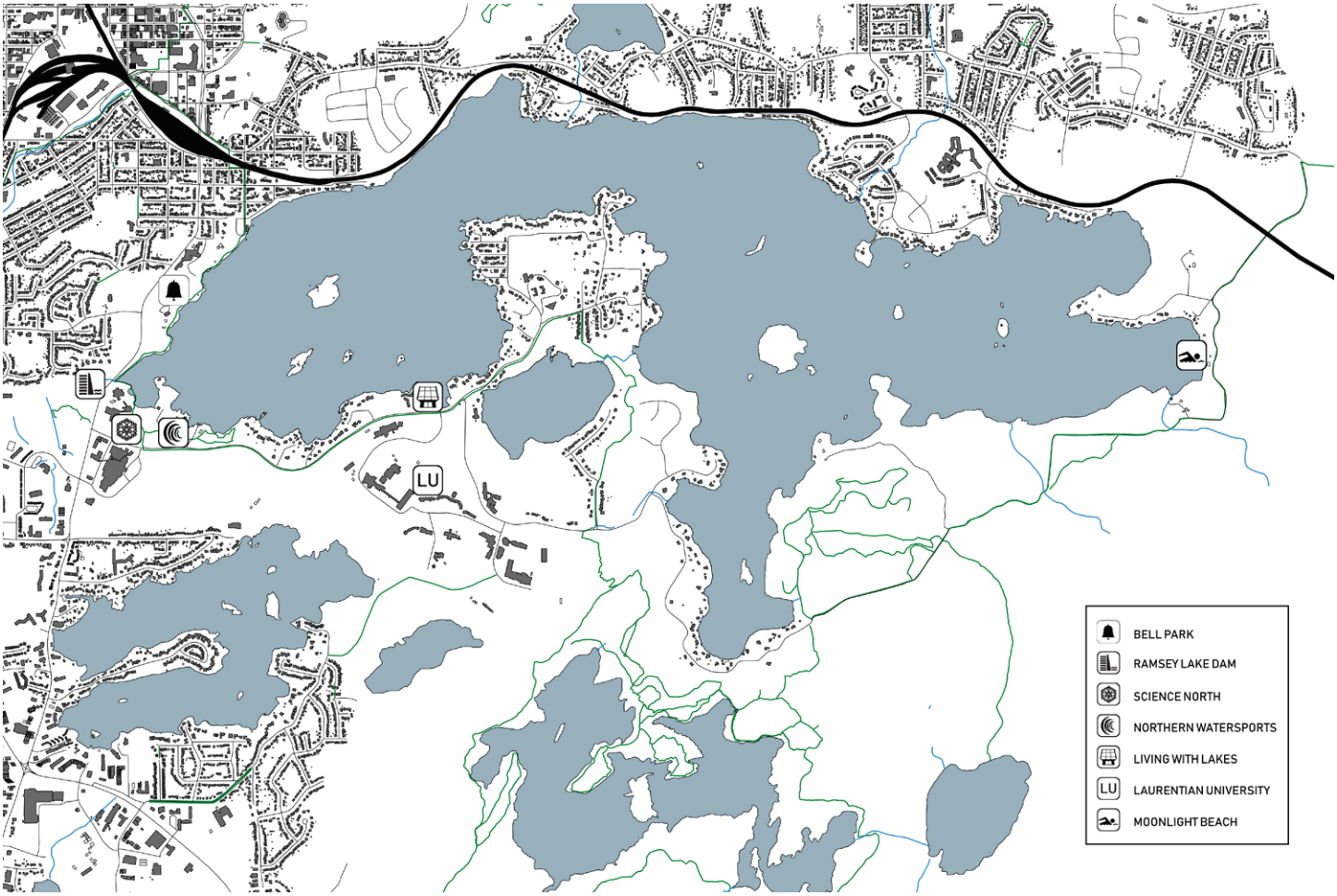
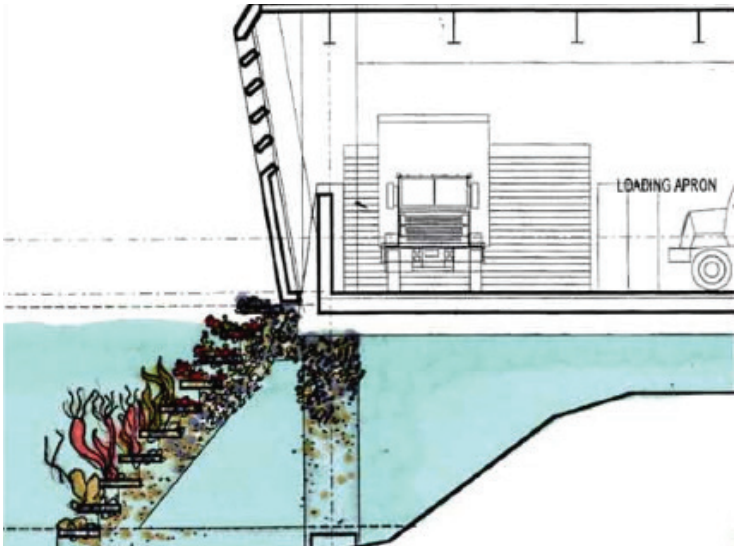
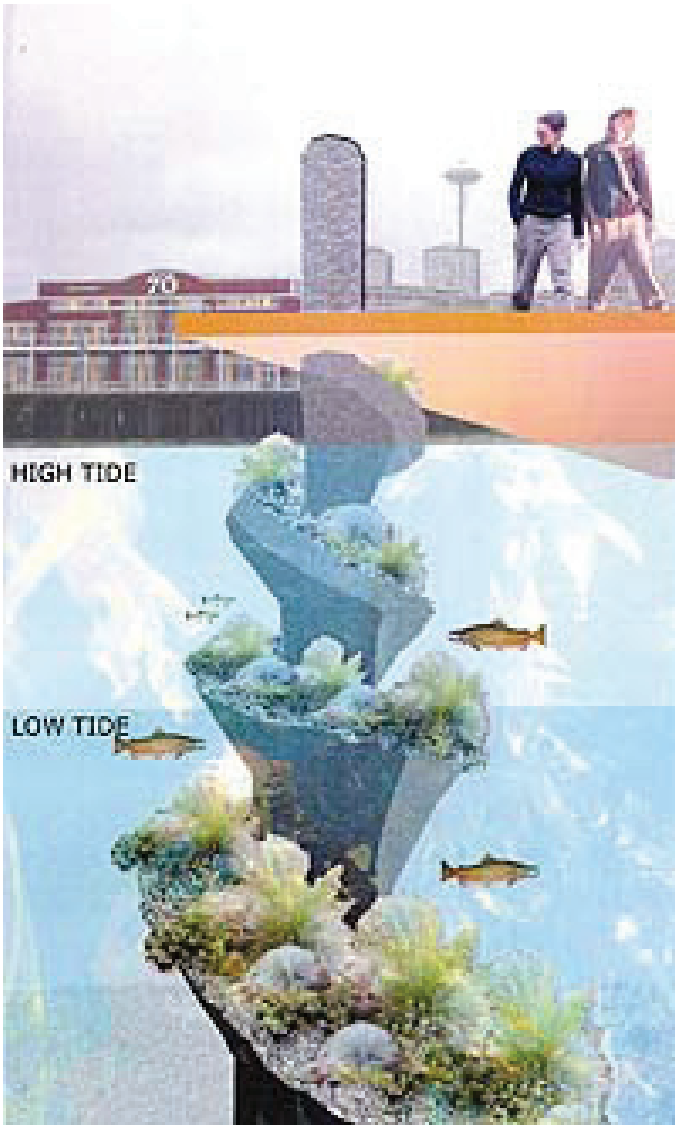


1A RAMSEY LAKE
Map by author, developed from GIS data courtesy of the City of Greater Sudbury.

1B RAMSEY LAKE TOPOGRAPHY MODEL
Model by author, developed from GIS data courtesy of the City of Greater Sudbury.





2A (Top Left) **PLUS POOL | New York, New York, United States**
Design, POOL. Accessed January 07, 2019. https://www.pluspool.org/pool/design/.

2B (Right) **SALMON SPIRAL | Seattle, Washington, United States**
Norah Daley. *Seattle's big chance to reconnect the waterfront*. Seattle Dailey Journal. April 22, 2004. Accessed April 17, 2019. https://www.djc.com/news/en/11156164.html.

2C (Bottom Left) **HABITAT SKIRT | Vancouver, British Columbia, Canada**
Habitat Skirt at the Vancouver Convention Centre. Tidewatercurrent.com. 2014. Accessed April 17, 2019. http://tidewatercurrent.com/2014_summer/Vancouver_Habitat_Skirt.html.

Explorations into similar investigations have led to creative ideas in the remediation of urban aquatic environments. In Manhattan's Hudson River, a group called + pool is advocating for the construction of an innovative public pool that would float in the river. The pool would utilize a semi-permeable filtration system as its walls. It is claimed that these filtration walls would remove pollutants from 600,000 gallons of river water per day.[1]

In Seattle, Washington, the group Edge Habitat, developed a conceptual "Salmon Spiral" installation which provides shelter and habitat to salmon and juvenile fish. The spiral creates a false ocean floor along existing underwater pier columns, mixing ecological habitat into urban development. The same group also developed ideas for "Habitat Hooks", which are hook shaped structures protruding from the land which allow sediment to build up over time, creating a softer shoreline and habitat space for fish.[2]

A similar project at the Vancouver Convention Centre took a simpler approach. At the end of the convention centre building, which extends out over the ocean by 50m, the design team developed a series of underwater stepped shelving systems called the "Habitat Skirt". The shelves mimic the rocky shorelines which exist naturally around the area and create horizontal planes which seaweed and shellfish can attach themselves to. The response could create an important precedent for Vancouver, where 80 percent of the natural shoreline has been degraded by urban development. According to the marine ecologist on the project, Jamie Slogan, the system supports more biodiversity than a typical natural shoreline in the area.[3]

1 Design, POOL. Accessed January 07, 2019. https://www.pluspool.org/pool/design/.

2 Jeffrey Hou. *Hybrid Landscapes: Toward an Inclusive Ecological Urbanism on Seattle's Central Waterfront*. University of Washington.

3 *Waves of Life Invigorate Vancouver's Shoreline*. TheThunderbird.ca. October 24, 2012. Accessed January 07, 2019. https://thethunderbird.ca/2012/03/29/waves-of-life-invigorate-vancouvers-shoreline/

3A (Top) BARREN LANDSCAPE
The Reclamation of Sudbury: The Greening of a Moonscape. Viewpoint Mining Magazine. Accessed January 07, 2019. http://viewpointmining.com/article/the-reclamation-of-sudbury.

3B (Bottom) LIMING PROCESS
Home. Sudbury Protocol. Accessed January 07, 2019. https://www3.laurentian.ca/sudbury-protocol/.

The settlement of Sudbury prior to the Great Depression was the result of a growth in mining and lumber activity within the region. The construction of the Canadian Pacific Railway in 1883 had opened up the development of these industries. By 1905, Sudbury was the largest supplier of nickel in the world. Prior to 1929, open roast yards were used to refine the ore. This process involved roasting the ore over piles of timber logs to remove the sulphur content, which ranged from 25 to 50 percent. The remaining material consisted of copper, nickel and iron. From 1888 to 1929, there were 165 roast beds in the Sudbury area near Copper Cliff, Coniston and Creighton. It is now estimated that more than 3.3 million cubic metres of wood was burnt, and 10 million tons of sulphur dioxide was released during this practice. The sulphur dioxide produced caused widespread damage to the environment, killing or damaging the surrounding vegetation and blackening exposed rock.

After 1929, mechanical roasters were used to process the ore, removing the sulphur content and allowing the separation of nickel and copper from the molten material. The roast yards became unnecessary after the smelters became operational, however, the smelters and their smokestacks only diffused the resultant environmental damage over a larger area. In addition to suplhur, the smelter stacks also released airborne nickel, copper and iron particulates which further inhibited the growth of vegetation. In 1972, the construction of Inco's "superstack", a 380-metre-tall smelter chimney, further diffused sulphur emissions in the Sudbury area. In the same year, emission control regulations led to a reduction of sulphur emissions by 50%.

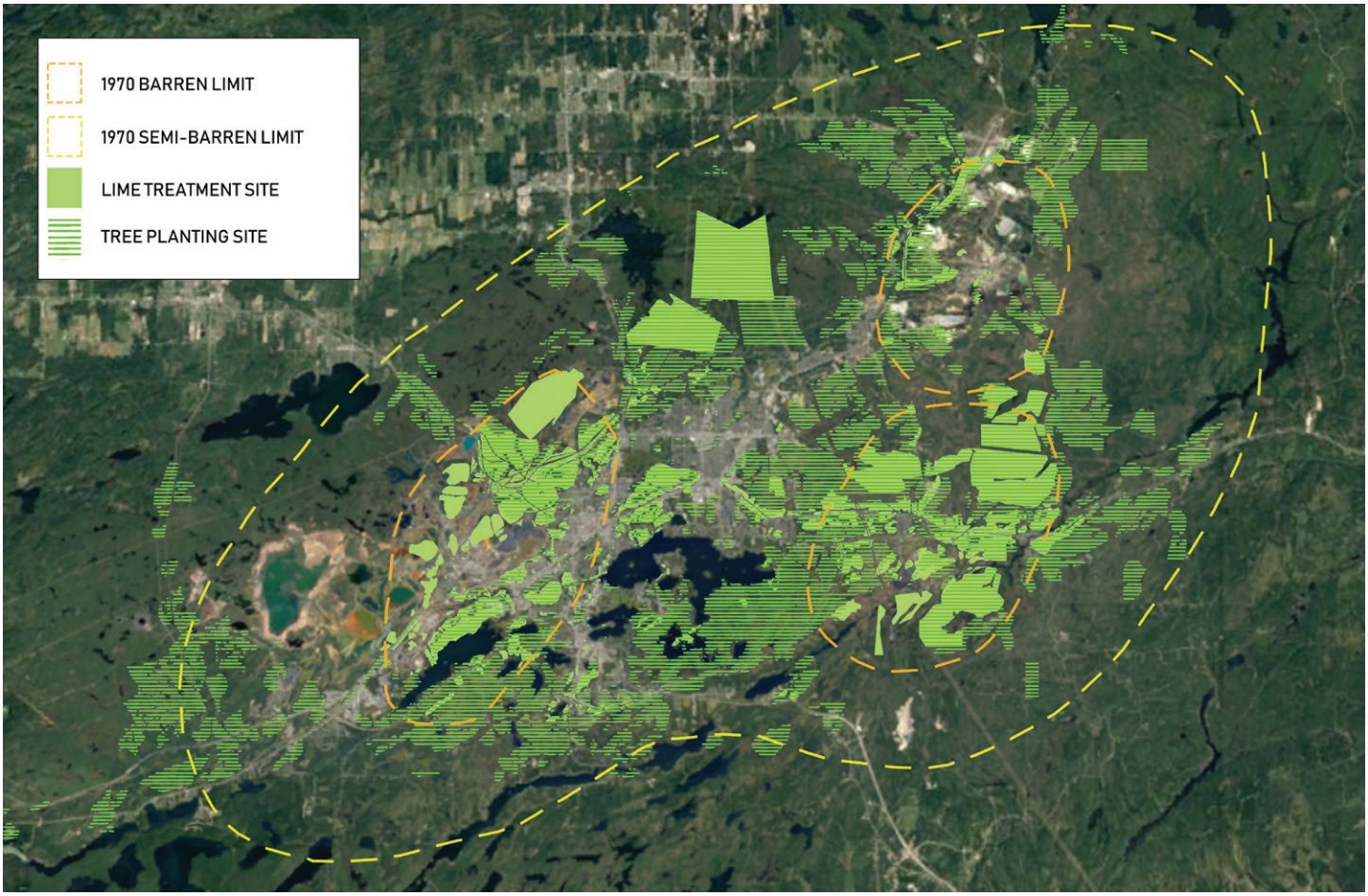
In 1973, a comprehensive regreening program of the Sudbury Landscape began. Fertilizer and seed were used in combination with lime to balance the pH of the soil. Large layoffs at Inco in 1977 and 1982 provided labour opportunities with the short-term employment of miners under federal and provincial programs. The regreening effort has continued since, with short term and volunteer labour planting roughly 9.2 million trees over 3,429 hectares.

Acidification of lakes in the Sudbury region began in the 1930s and continually intensified until the 1970s. There are approximately 19,000 lakes within a 17,000 square kilometre area surrounding Sudbury. It is estimated that 7,000 of these were acidified to a pH below 6.0. Lakes closest to smelters, and in Northeastern and Southwestern directions, were affected the most, with some being acidified to below 4.0. Similar to the soil in the area, metal contamination from airborne emissions also ended up in water systems.

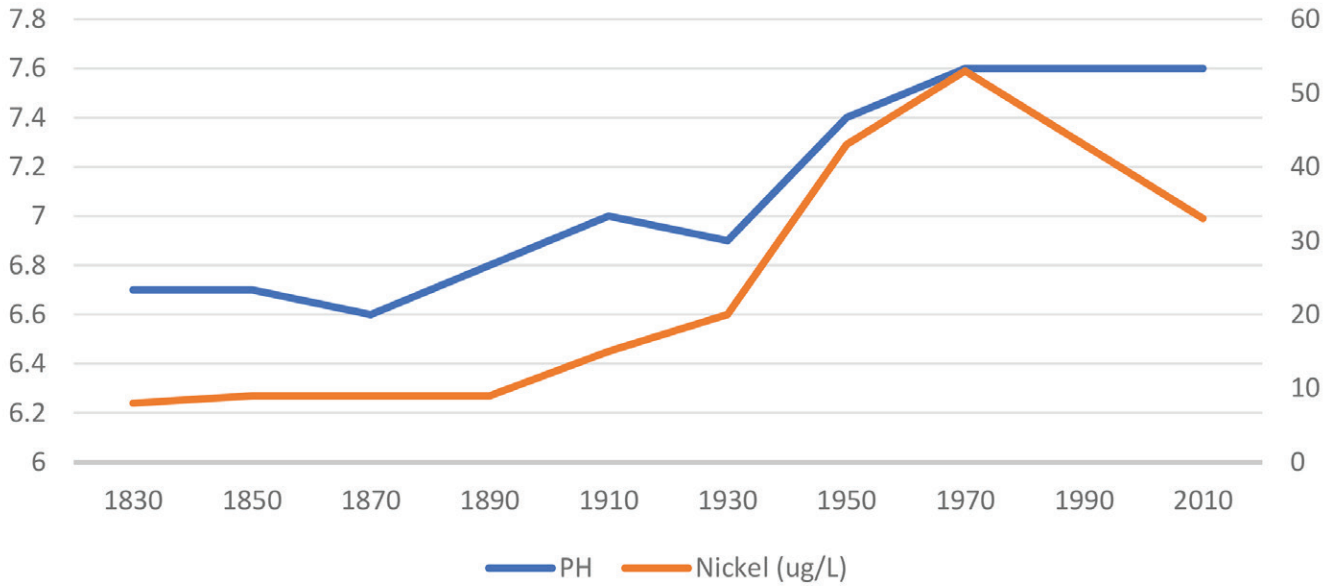
In the early 1970s, powdered lime was added to four local lakes in an attempt to reduce thier acidity.[4] In each case, acidity and metal concentration levels decreased, however, the lakes began returning to their original acidity following treatment. Liming of the surrounding watershed was found to increase longevity, but the recovery of aquatic ecosystem afterward proved to be a long proces. To continue improving the water quality of lakes, the City of Greater Sudbury plans to focus its regreening effort into 100 metre areas surrounding lakes, thereby, minimizing continued metal contamination and acidification from water runoff.[5]

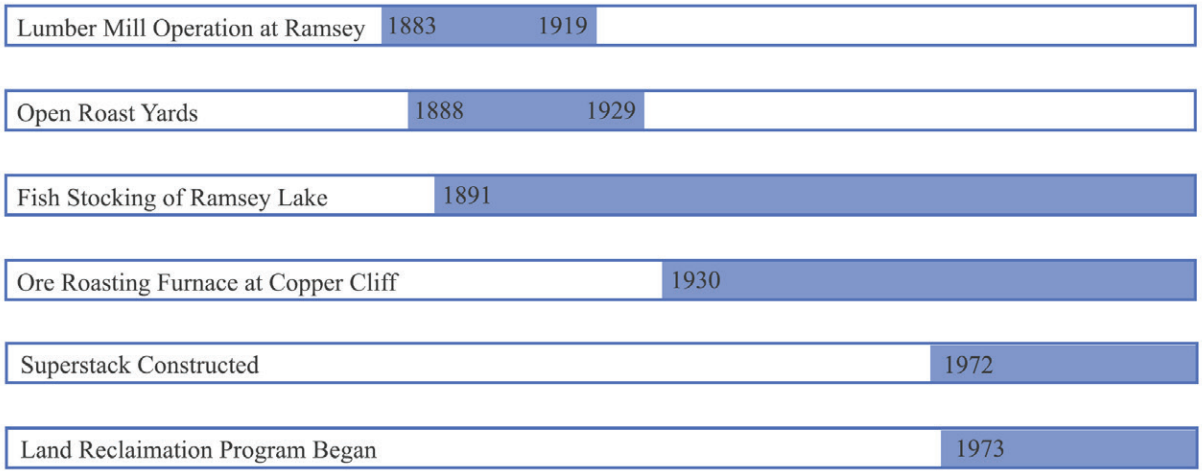
4 D.A.B. Pearson, J.M. Gunn, W. Keller. *The Past, Present and Future of Sudbury's Lakes*. Co-operative Freshwater Ecology Unit, Laurentian University, Sudbury. Accessed April 20, 2019. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/Sudbury-Past-Present-and-Future.pdf.

5 Oiva W. Saarinen. *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury*. Waterloo, Ontario, Canada: Wilfrid Laurier University Press, 2013.



3C GREATER SUDBURY REGREENING
Map by author, developed from GIS data courtesy of the City of Greater Sudbury.
Satelite imagery courtesy of Google Earth Pro.



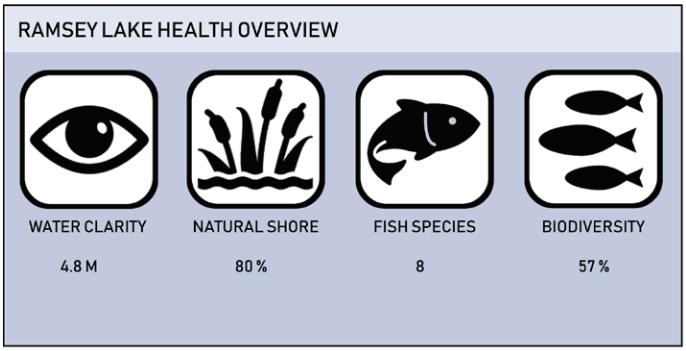


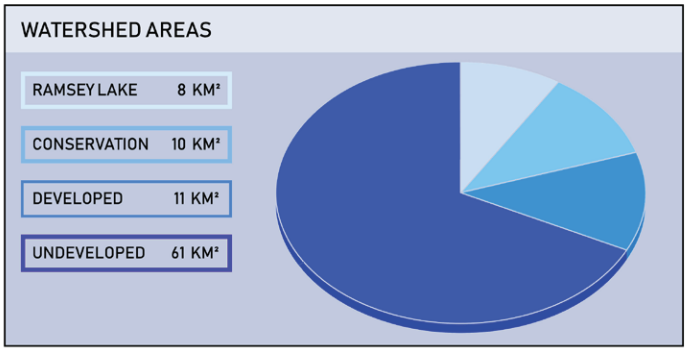
3D **RAMSEY LAKE WATER QUALITY TIMELINE**
Graph by author, developed from information courtesy of:
Aruna S. Dixit, Sushil S. Dixit & John P. Smol. *Long-Term Water Quality Changes in Ramsey Lake as Revealed Through Paleolimnology*. Living With Lakes Centre. Accessed November 16, 2018. https://www3.laurentian.ca/livingwithlakes/research/reports-publications/.
Timeline by author, developed from information courtesy of:
Oiva W. Saarinen. *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury*. Waterloo, Ontario, Canada: Wilfrid Laurier University Press, 2013.

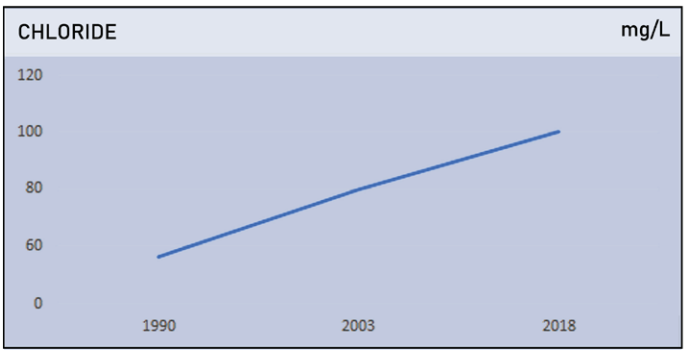
Through the analysis of historical and present data, the health of Ramsey Lake and the surrounding area can be compared to times pre-dating settlement in order to determine how Ramsey Lake has been impacted by human activities. This information can be used to determine possible intervention opportunities which can help restore the ecosystem to its natural quality.

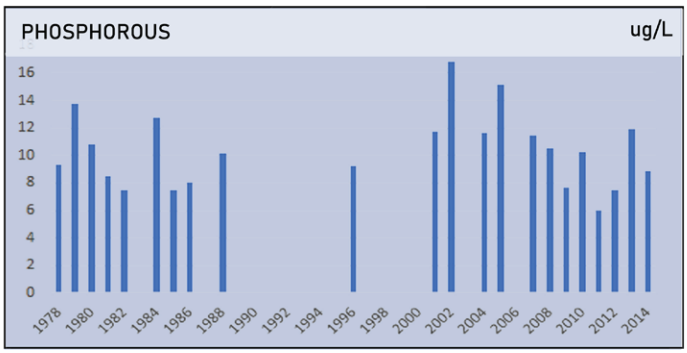
A study conducted by Queen's University in 1996 analyzed Ramsey Lake sediment samples to determine historical levels of acidity and nickel dating back to the 1830s. The data provides a direct correlation between mining activity and an increase in pH and nickel concentrations. Unlike most regional lakes, pH rose in Ramsey Lake from 1930 to 1970. This is likely a result of acid precipitation falling on alkaline drainage basins, thereby, increasing the alkalinity of the water runoff. Nickel concentrations in Ramsey Lake rose from 10 ug/L in 1890, when mining activity first began, to 20 ug/L in 1930, when the first smelter in Sudbury became operational. The trend became more dramatic from 1930 to 1970; pH rose from 6.8 to 7.5, and nickel concentrations rose from 20 to 50 ug/L. This is likely a result of the ore roasting furnace enabling increased production, and chimney stacks spreading airborne nickel over a wider area, encompassing Ramsey Lake.[6]

6 Aruna S. Dixit, Sushil S. Dixit & John P. Smol. *Long-Term Water Quality Changes in Ramsey Lake as Revealed Through Paleolimnology*. Living With Lakes Centre. Accessed November 16, 2018. https://www3.laurentian.ca/livingwithlakes/research/reports-publications/.









4A (Top Left) **RAMSEY LAKE HEALTH OVERVIEW**
Infographics by author, developed from information courtesy of:
Lake Water Quality Program, Annual Report 2014. City of Greater Sudbury. Accessed January 07, 2018. https://www.greatersudbury.ca/linkservid/5A752B86-B4DE-0B79-A084306B65D5412C/.

4B (Top Right) **WATERSHED AREAS**
Infographics by author, developed from GIS data courtesy of the City of Greater Sudbury.

4C (Bottom Left) **CHLORIDE**
Graph by author, developed from information courtesy of:
Recovery of Acid and Metal – Damaged Lakes Near Sudbury Ontario: Trends and Status. Cooperative Freshwater Ecology Unit, 2004. Accessed January 07, 2018. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/Recovery-of-Acid-and-Metal-Damaged-Lakes-near-Sudbury-Ontario.pdf.

4D (Bottom Right) **PHOSPHORUS**
Graph by author, developed from information courtesy of:
Lake Water Quality Program, Annual Report 2014. City of Greater Sudbury. Accessed January 07, 2018. https://www.greatersudbury.ca/linkservid/5A752B86-B4DE-0B79-A084306B65D5412C/.

Since the construction of the Superstack in 1972, conservation efforts have proved successful in the recovery process from the effects of mining activity. Ramsey Lake has shown signs of improvement since the 1970s, with metal concentrations declining and some species naturally returning to the lake. However, the effects of urban development within the watershed are now becoming an increasing concern. Ramsey lake has had a confirmed outbreak of blue-green algae every year since 2010, with 2018 being one of the largest.[7] Cyanobacteria, or blue-green algae, is a photosynthetic bacterium which may be harmful, releasing toxins which can attack the liver, nervous system, and irritate the skin.[8] It is believed to be triggered by several environmental factors; high water temperature, increasing levels of phosphorous, and continued chloride build up from road salting practices. Chloride is highly reactive, forming salts and acids in water. Increased chloride levels affect smaller, microscopic plant and animal life first. As they die off, more resilient forms take over, such as blue-green algae.[9] Natural concentrations of chloride in Ontario freshwater lakes range from 1ppm to 7ppm. In 2018, chloride levels reached 100 ppm in Ramsey Lake and are estimated to reach 120 ppm by 2031;[10] a concentration considered to be toxic to many fish and plant species and exceed the Canadian Water Quality Guidelines for the Protection of Aquatic Life.[11]

In response to these concerns, the City of Greater Sudbury is currently conducting a study focusing on the impacts of the built environment on the ecology of Ramsey Lake's watershed. The research is currently centered on stormwater management practices and future development concerns. The Greater Sudbury Watershed Alliance is also stressing the need for further public engagement to bring these issues to the attention of the public.[12] The reality is that the boundary between land and water cannot be clearly defined. Water finds its way through our environment, over or under the land, making its way to waterbodies through aquifers, streams or storm drains. As water flows through the built environment, it picks up pollutants along the

7 Darren MacDonald. *Algae Bloom Biggest in Years, Ramsey Lake Group Says*. Sudbury.com. August 16, 2018. Accessed September 09, 2018. https://www.sudbury.com/local-news/algae-bloom-biggest-in-years-ramsey-lake-group-says-1017897.

8 Kathryn Weatherley. *How Blue-green Algae Is Taking over Canadian Lakes*. CBC News. February 26, 2013. Accessed September 28, 2018. https://www.cbc.ca/news/technology/how-blue-green-algae-is-taking-over-canadian-lakes-1.1326761.

9 *Ecosystem of Sudbury's Most Famous Lake Could Be Destroyed by 2031, Says Water Group*. CBC News. April 12, 2018. Accessed September 08, 2018. https://www.cbc.ca/news/canada/sudbury/ramsey-lake-sudbury-salt-levels-1.4612944.

10 Editor, Letter To the. Letter: *Using Calcium Chloride in Place of Sodium Chloride a Red Herring*. Sudbury.com. May 01, 2018. Accessed September 22, 2018. https://www.sudbury.com/letters-to-the-editor/letter-using-calcium-chloride-in-place-of-sodium-chloride-a-red-herring-910323.

11 *Chloride*. Canadian Environmental Quality Guidelines. Accessed September 22, 2018. http://ceqg-rcqe.ccme.ca/download/en/337?redir=1537707047.

12 *Watershed Advisory Panel*. City of Greater Sudbury. 2018. Accessed Sept 9, 2018. https://www.greatersudbury.ca/live/environment-and-sustainability1/lake-health/watershed-advisory-panel/.

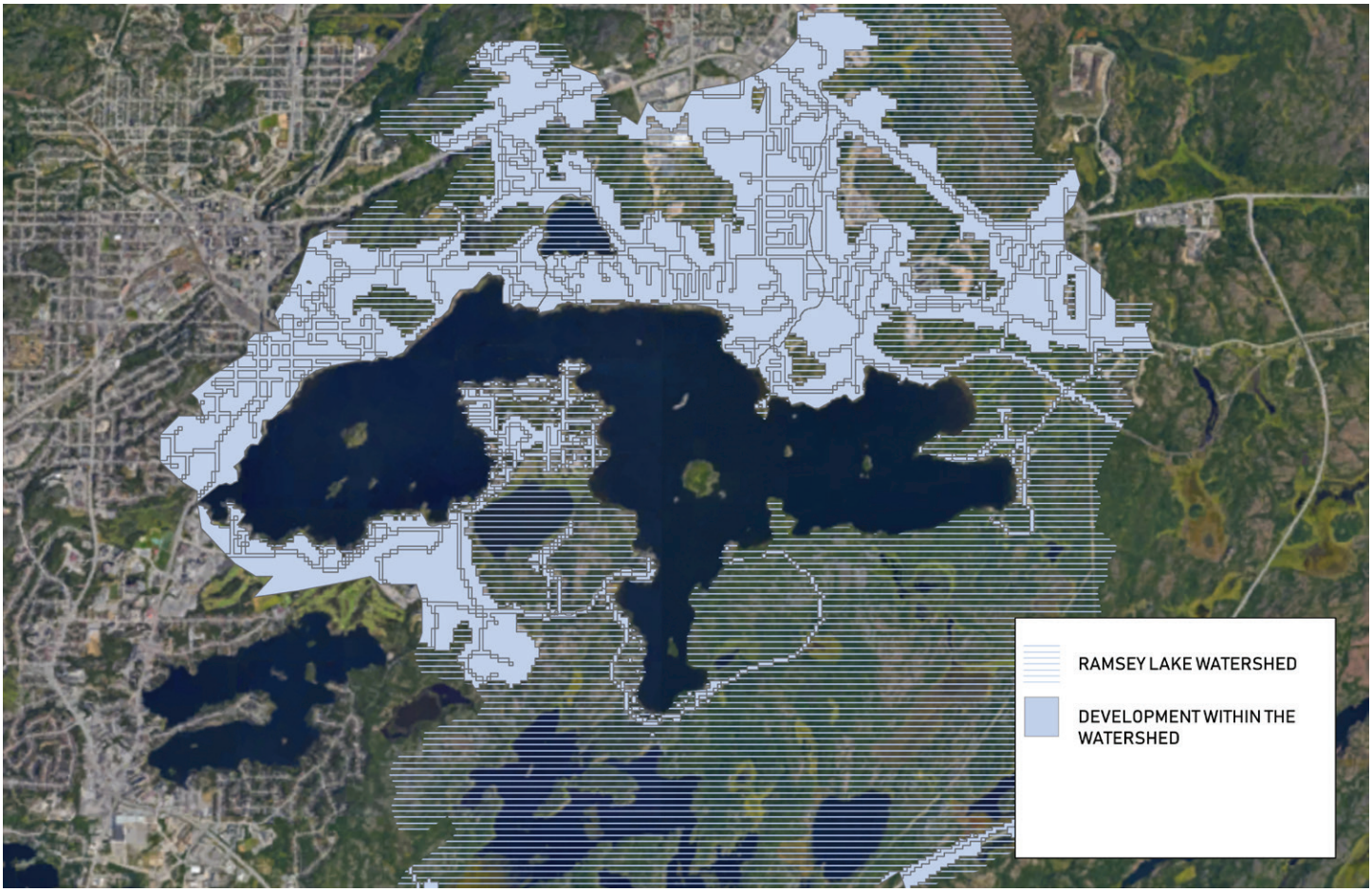
way, including: road salts, chemicals, and excess nutrients. Impermeable surface cover and traditional water management practices typically make this problem worse, transporting water directly to streams and lakes, preventing it from filtering through the land. Storm water management practices are now shifting to local water retention as a strategy to reduce environmental impact, allowing water to be naturally filtered through subsoils. However, re-engineering of existing infrastructure is costly and often unlikely to be achievable in the near future.

As the most central lake, and one of the most developed, Ramsey Lake has faced some of the most environmental impacts from human activity. A recent drinking water assessment report from the City of Greater Sudbury outlined the current risks associated with water quality and development around the lake. The major risks outlined in this report included: sewage contamination, fertilizer runoff, road salt runoff, nearby fuel storage, potential toxic spills from rail transportation, waste disposal sites, snow storage, organic solvent storage, and concerns related to climate change. As a result, the study looked into the potential of relocating the main reservoir to Lake Wahnapitae. However, the cost associated with building the infrastructure required was estimated at a total of $342,093,000.[13]

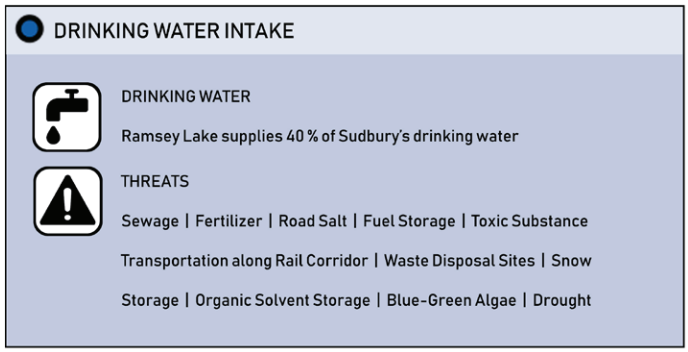
There are four sewage overflow pipes located along the shore of Ramsey Lake. These are built alongside sewage pumping stations which lift sewage uphill. If the sewage flow is greater than these pumping stations can handle, the excess sewage flows into Ramsey Lake untreated. Two public beaches are located within 300 metres of two of these overflow pipes, both are considered to have problematic water quality. The Sudbury District Health Unit conducts periodic E. coli. tests of water from public beaches. The Bell Park Amphitheatre Beach fails 6 - 39% of these tests, while Moonlight Beach fails over 40% of them. This indicates that waste released from sewage overflow is reducing the water quality of the lake within a 300-metre radius.[14]

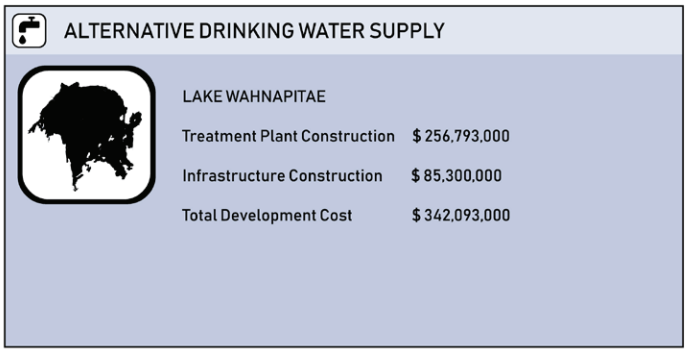
13 *Assessment Report*. Drinking Water Source Protection Sudbury. Accessed November 28, 2018. http://sourcewatersudbury.ca/en/assessment-report.html.

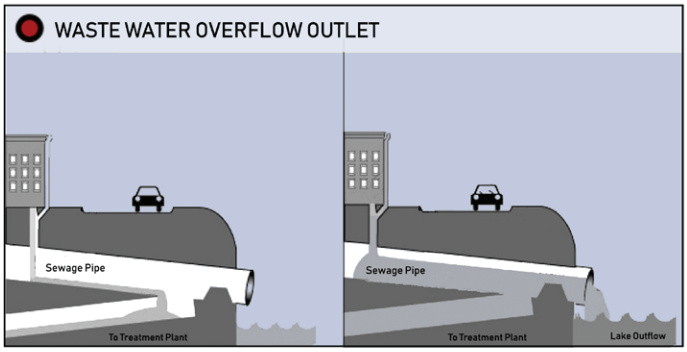
14 *Moonlight Beach*. Swim Guide. Accessed January 07, 2019. https://www.theswimguide.org/beach/3341.

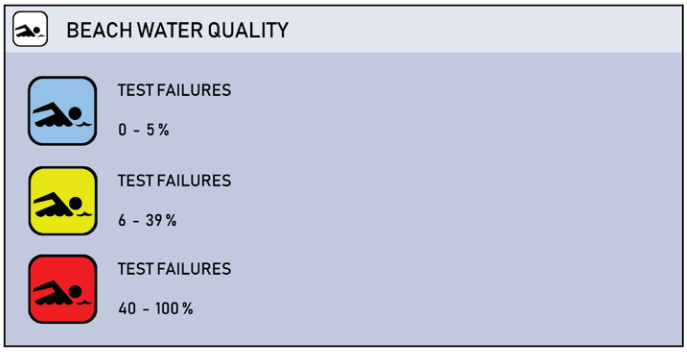


4E **RAMSEY LAKE URBAN DEVELOPMENT**
Map by author, developed from GIS data courtesy of the City of Greater Sudbury.
Satelite imagery courtesy of Google Earth Pro.









4F (Top Left) DRINKING WATER INTAKE
Infographics by author, developed from information courtesy of:
Assessment Report. Drinking Water Source Protection Sudbury. Accessed November 28, 2018. http://sourcewatersudbury.ca/en/assessment-report.html.

4G (Top Right) ALTERNATIVE DRINKING WATER SUPPLY
Infographics by author, developed from information courtesy of:
Assessment Report. Drinking Water Source Protection Sudbury. Accessed November 28, 2018.

4H (Bottom Left) WASTE WATER OVERFLOW OUTLET
Image edited by author, original image courtesy of:
What Are Combined Sewer Overflows (CSOs)? | Urban Environmental Program in New England. EPA. April 10, 2017. Accessed January 07, 2019. https://www3.epa.gov/region1/eco/uep/cso.html.

4I (Bottom Right) BEACH WATER QUALITY
Infographics by author, developed from information courtesy of:
Beach Finder. Swim Guide. Accessed November 11, 2018. City of Greater Sudbury. https://www.theswimguide.org/find/#46.45651876485397/-81.0291554127956/46.49773984188811/-80.8973194752956/14.

4J **RAMSEY LAKE INFRASTRUCTURE MAP**
Map by author, developed from GIS data courtesy of the City of Greater Sudbury.
Satelite imagery courtesy of Google Earth Pro.
Beach water quality data courtesy of:
Beach Finder. Swim Guide. Accessed November 11, 2018. City of Greater Sudbury. https://www.theswimguide.org/find/#46.45651876485397/-81.0291554127956/46.49773984188811/-80.8973194752956/14.

Aquatic vegetation is crucial to the health and productivity of aquatic ecosystems. Floating plants such as pondweed and duckweed provide leaves which geese and ducks feed on, and submerged plants provide a source of food for juvenile fish. Denser aquatic habitats also provide shelter for juvenile fish, giving them cover from predation during the most susceptible period of their lifecycle, providing a better chance they will survive into adulthood. Secondary sources of food are also provided by aquatic vegetation as they tend to support greater biodiversity including snails, insects, and crustaceans.

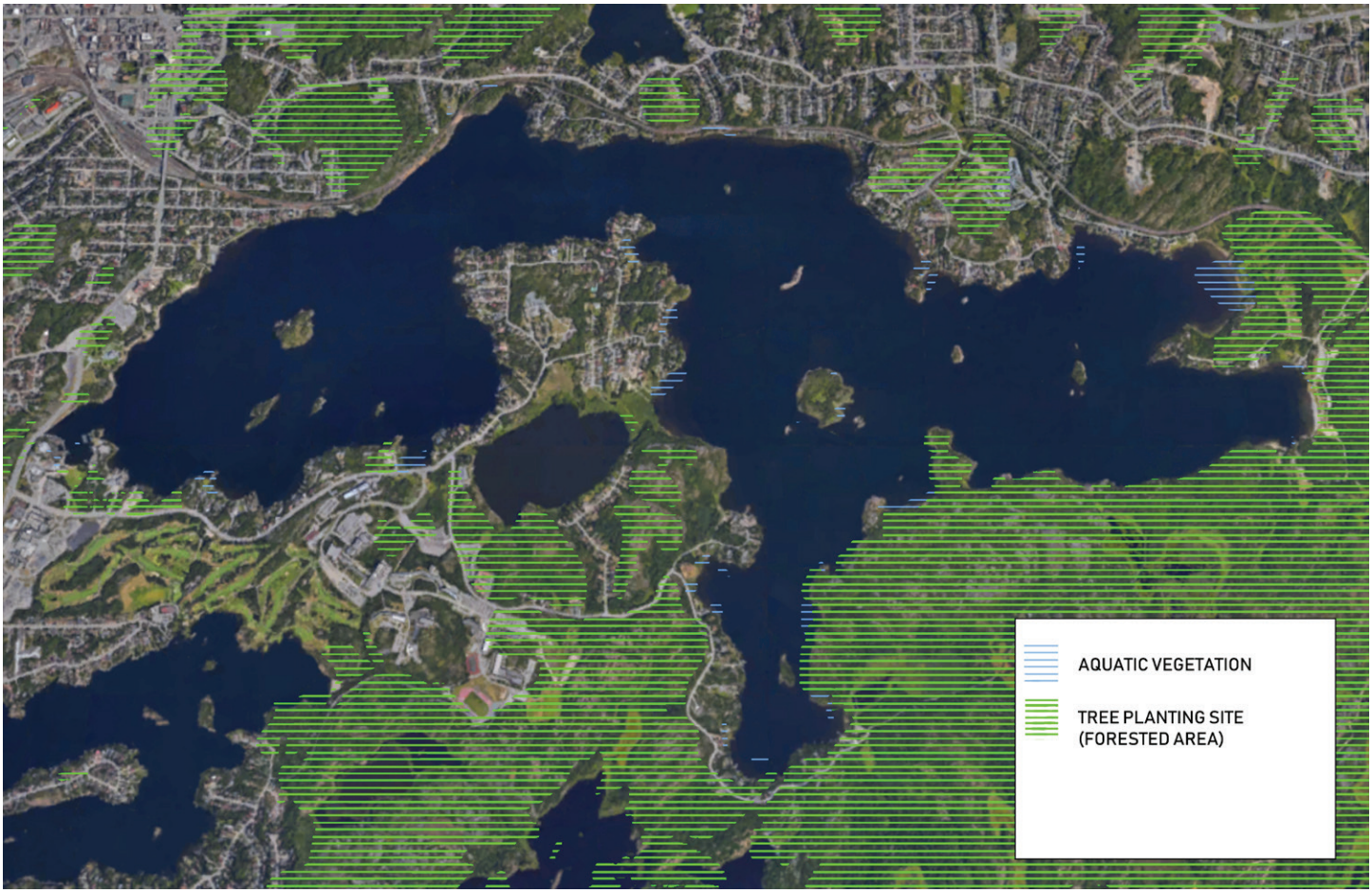
Aside from the creation of habitat, aquatic plants are also beneficial in physical and chemical processes. The roots and the structure of plants help to stabilize sediments, thereby preventing erosion along the shoreline from waves, currents, and wind. This not only increases water clarity but also prevents pollution from entering waterbodies through sediment erosion. Organic nutrients are also absorbed by aquatic plants, which could otherwise fuel excessive algae growth. In the long run, this provides a more stable, healthy, and oxygen rich environment.[15]

Ramsey Lake contains relatively little aquatic vegetation compared to other lakes in the region.[16] This could be a result of shoreline alteration combined with other stressors such as excessive concentrations of chloride. The City of Greater Sudbury is currently conducting an aquatic vegetation survey of regional lakes; however, these studies have so far been limited to Hannah Lake, Long Lake, McFarlane Lake, Richard Lake, and St. Charles Lake. There were a total of twenty-eight species of aquatic plants surveyed in these studies.[17] In order to get a general understanding of the aquatic vegetation in Ramsey Lake, the observed aquatic plant species documented from these studies can be combined with a vegetated area mapping survey of Ramsey completed in 1989 (depicted in the map on the next page).

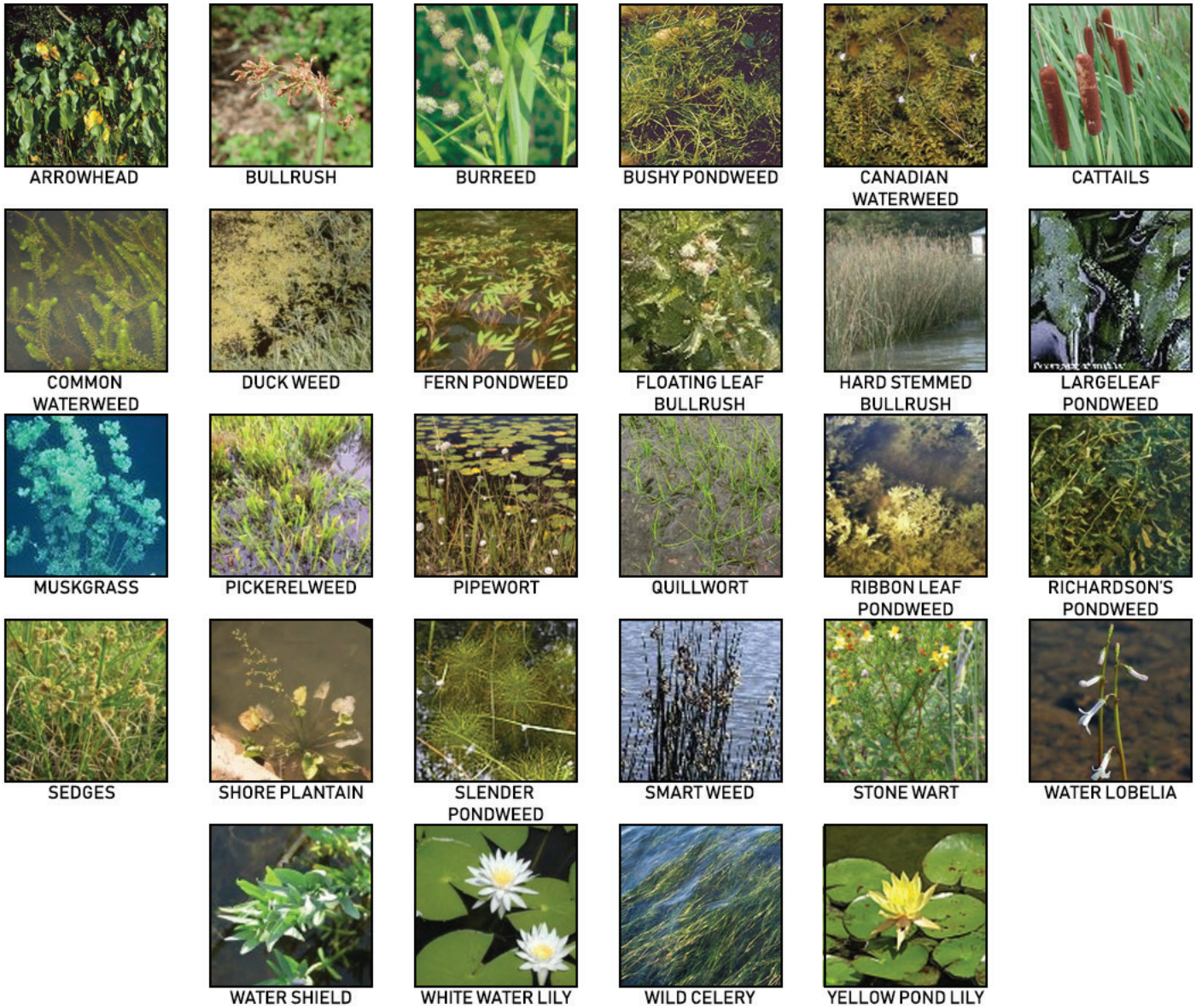
15 *Aquatic Plants*. Planet Oceanography. 2000. Accessed April 19, 2019. https://www.marine.usf.edu/pjocean/packets/f00/nwq3.pdf.

16 Nancy Dolan, Darren Niemi. *Ramsey Lake: An Assessment of the Fish Community and a Review of the Fisheries Management History*. Ontario Ministry of Natural Resources. 1989. Accessed November 09, 2018. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/RAMSEY-LAKE-An-Assessment.pdf.

17 *Aquatic Vegetation and Eurasian Milfoil Preliminary Survey*. City of Greater Sudbury. 2014. Accessed April 19, 2019. https://www.greatersudbury.ca/linkservid/C11A9575-D9FB-2B4A-102C6396C927C093/showMeta/0/.



5A **RAMSEY LAKE VEGETATION**
Map by author.
Tree planting site layer developed from GIS data courtesy of the City of Greater Sudbury.
Aquatic vegetation layer developed from information courtesy of:
Nancy Dolan, Darren Niemi. *Ramsey Lake: An Assessment of the Fish Community and a Review of the Fisheries Management History*. Ontario Ministry of Natural Resources. 1989. Accessed November 09, 2018. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/RAMSEY-LAKE-An-Assessment.pdf.
Satelite imagery courtesy of Google Earth Pro.



5B NATIVE AQUATIC VEGETATION

Design by author, developed from data courtesy of:
Aquatic Vegetation and Eurasian Milfoil Preliminary Survey. City of Greater Sudbury. 2014. Accessed April 19, 2019. https://www.greatersudbury.ca/linkservid/C11A9575-D9FB-2B4A-102C6396C927C093/showMeta/0/.
Images courtesy of:
Plant Identification. Texas A&M Agrilife Extension. Accessed April 19, 2019. https://aquaplant.tamu.edu/plant-identification/.


ASH


BLACK LOCUST


BLACK SPRUCE


JACK PINE


MAPLE


RED OAK


RED PINE


RUSSIAN OLIVE


WHITE CEDAR


WHITE PINE


WHITE SPRUCE


YELLOW BIRCH

5C REGREENING PROGRAM TREE SPECIES

Design by author, developed from data courtesy of:
Regreening Program Annual Report 2013. City of Greater Sudbury. 2013. Accessed April 19, 2019. https://www.greatersudbury.ca/linkservid/4F228660-FE06-EE34-B372E5FBD74DE330/showMeta/0/.
Images courtesy of:
Tree Atlas. Government of Ontario. Accessed April 19, 2019. https://www.ontario.ca/environment-and-energy/tree-atlas.


BROWN BULLHEAD


NORTHERN PIKE


PUMPKINSEED


ROCK BASS


SMALLMOUTH BASS


WALLEYE


WHITE SUCKER


YELLOW PERCH

5D RAMSEY LAKE FISH SPECIES

Design by author, developed from data courtesy of:
Fish Species. City of Greater Sudbury. Accessed April 19, 2018 https://www.greatersudbury.ca/play/beaches-and-lakes/lakes/local-lake-descriptions/ramsey-lake/fish-species/.
Images courtesy of:
Robert J. Eakins. *Ontario Freshwater Fishes Life History Database*. OFFLHD. Accessed November 12, 2018. http://www.ontariofishes.ca/home.htm.

Sudbury was first settled in 1883; by 1891 fish stocking in Ramsey Lake had begun due to overfishing and has continued to this day.[18] There are currently eight confirmed species of fish inhabiting Ramsey Lake; brown bullhead, walleye, yellow perch, northern pike, pumpkinseed, rock bass, smallmouth bass, and white sucker. Its biodiversity, however, is ranked at fifty seven percent for a lake of its size.[19] This means that, prior to settlement in the region, and its adverse effects, there were likely a total of fourteen species inhabiting the lake. While fish stocking began in 1891, there had been no fishery assessments completed until 1947, which only documented five northern pike and one yellow perch. Determining the species which naturally inhabit Ramsey Lake is, therefore, largely a matter of speculation. Walleye, pike, and smallmouth bass are known to be native species and lake trout reportedly existed in large numbers prior to Sudbury's settlement.[20]

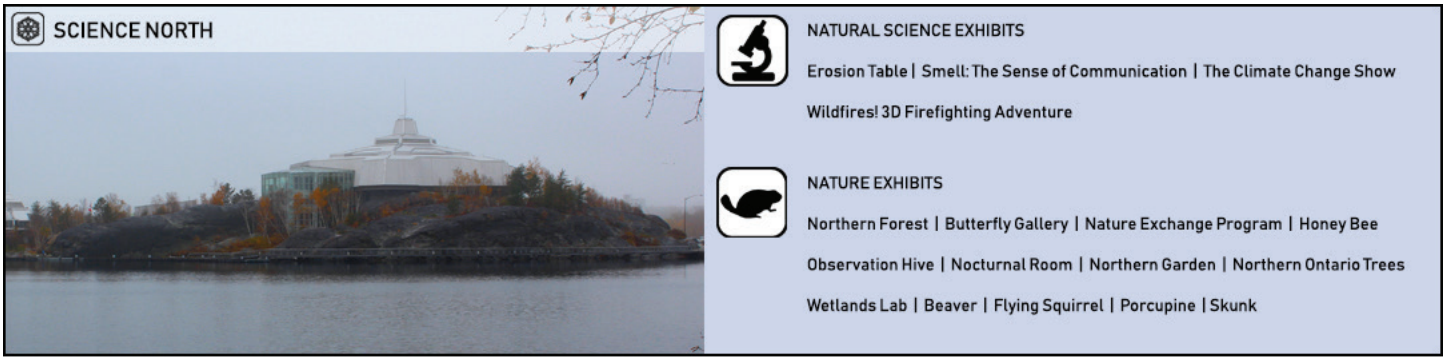
Recently, in 2015, ling (burbot) were discovered by an ice fisherman on Ramsey Lake. This is a significant find as ling is an environmentally sensitive cold-water fish which is thought to have disappeared from the lake over one hundred years ago. This indicates that Ramsey Lake is improving from the effects of industrial pollution and acid rain.[21]

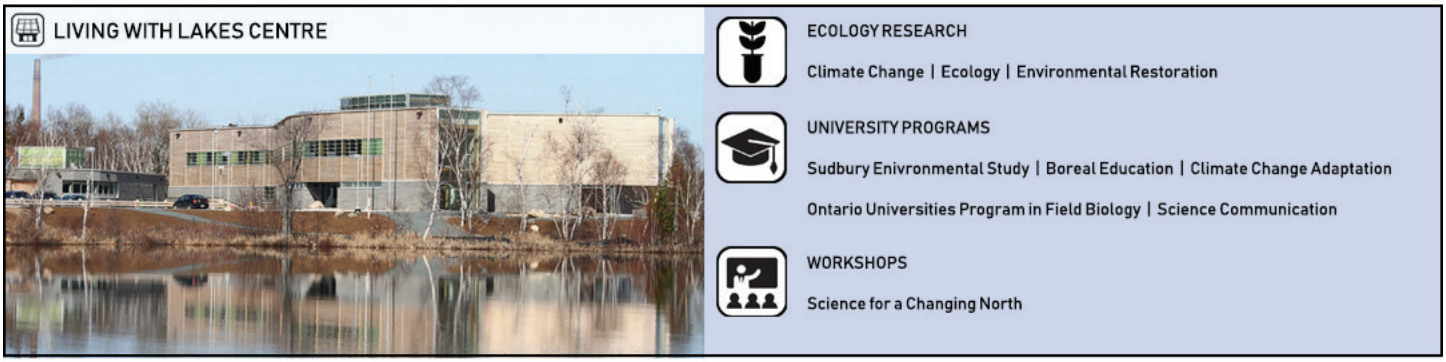
18 Oiva W. Saarinen. *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury*. Waterloo, Ontario, Canada: Wilfrid Laurier University Press, 2013.

19 *Lake Water Quality Program, Annual Report 2014*. City of Greater Sudbury. Accessed January 07, 2018. https://www.greatersudbury.ca/linkservid/5A752B86-B4DE-0B79-A084306B65D5412C/.

20 Nancy Dolan, Darren Niemi. *Ramsey Lake: An Assessment of the Fish Community and a Review of the Fisheries Management History*. Ontario Ministry of Natural Resources. 1989. Accessed November 09, 2018. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/RAMSEY-LAKE-An-Assessment.pdf.

21 Bruce Heidman. *Sudbury Accent: The Prodigal Ling Returns to Ramsey*. The Sudbury Star. March 20, 2015. Accessed April 19, 2019. https://www.thesudburystar.com/2015/03/21/sudbury-accent-the-prodigal-ling-returns-to-ramsey/wcm/ab7b3e92-fc9c-21ee-d472-16f906f13783.





5E (Top) SCIENCE NORTH
Infographics by author, developed from information courtesy of:
Exhibit. Science North. Accessed April 19, 2019. https://sciencenorth.ca/science-north/exhibits/.
Image taken by author.

5F (Middle) LIVING WITH LAKES CENTRE
Infographics by author, developed from information courtesy of:
Cooperative Freshwater Ecology Unit. Vale Living with Lakes Centre. Accessed April 19, 2019. https://www3.laurentian.ca/livingwithlakes/about/cooperative-freshwater-ecology-unit/.
Image courtesy of:
Doris Hawrelluk. The Vale Living With Lakes Centre. Accessed April 19, 2019. https://www.flickr.com/photos/10409127@N08/6180954999.

5G (Bottom) LAKE LAURENTIAN CONSERVATION AREA
Infographics by author, developed from information courtesy of:
Conservation Sudbury. Nickel District Conservation Authority. Accessed April 19, 2019. https://conservationsudbury.ca/en/about-us.html
Image courtesy of:
Lake Laurentian Conservation Area. Ontario Trails. Accessed April 19, 2019. http://www.ontariotrails.on.ca/trails/view/lake-laurentian-conservation-area.

Despite Sudbury's relatively small population, Science North, located along the shore of Ramsey Lake, is the second largest science centre in Canada. Over its thirty-five-year history, Science North has been a pioneer in its design and approach to science exhibits, placing a strong emphasis on visitor interaction. These exhibits largely focus on biology, chemistry, nature, physiology, physics, space, and technology. There is also, currently, a section dedicated to wetland ecology with animal exhibits including a beaver, turtles and a few fish species including brown bullhead and rock bass.[22]

The Vale Living with Lakes Centre houses the Cooperative Freshwater Ecology Unit, a partnership between Laurentian University, The Ontario Ministry of Natural Resources and Forestry, and the Ontario Ministry of the Environment and Climate Change. This partnership allows the collaboration between government, industry and provincial universities in the generation of environmental research. The institution's research focus includes issues such as climate change, invasive species, urban development, contamination, loss of biodiversity and over exploitation.[23]

The Lake Laurentian Conservation Area, located on the south east section of Ramsey, is managed by the Nickel District Conservation Authority and is tasked with the conservation, restoration and development of renewable natural resources, working in partnership with the Ministry of Natural Resources and the City of Greater Sudbury. In addition, the conservation area also hosts a comprehensive ecology education program, providing learning opportunities for children and adults. These programs include full day excursion lessons tailored around the Ministry of Education's curriculum for students ranging from junior kindergarten to grade eight.[24]

22 Krista McCracken. *Community Driven: 30 Years of Science North*. ActiveHistory.ca. June 23, 2014. Accessed April 19, 2019. http://activehistory.ca/2014/06/community-driven-thirty-years-of-science-north/.

23 *Cooperative Freshwater Ecology Unit*. Vale Living with Lakes Centre. Accessed April 19, 2019. https://www3.laurentian.ca/livingwithlakes/about/cooperative-freshwater-ecology-unit/.

24 *Conservation Sudbury*. Nickel District Conservation Authority. Accessed April 19, 2019. https://conservationsudbury.ca/en/about-us.html.

GENERAL STATISTICS

ANNUAL TOURISTS

1,186,951

MONEY SPENT

$ 179,878,933

NIGHTS SPENT

1,637,446

ORIGIN OF VISIT

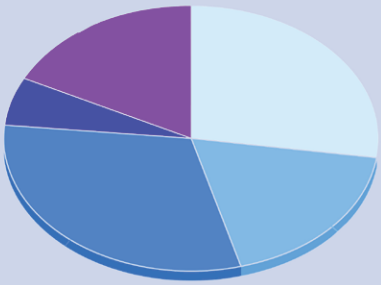
ONTARIO	CANADA	UNITED STATES	GLOBAL
1,109,529	46,415	25,695	5,312

ACTIVITIES

Festivals	7,300	Restaurant / Bar	33,410
Cultural Performaces	15,547	Boating	59,687
Museum / Art Gallery	22,348	Golfing	16,533
Zoos / Aquariums / Gardens	9,277	Fishing	59,566
Sports Events	32,953	Hunting	3,215
Casinos	12,217	Skiing	10,547
Theme Parks	14,652	Snowmobiling	3,559
Nature Parks	36,317	ATV	6,660
Historic Sites	33,521	Cycling	885
Sightseeing	17,316	Hiking	47,591
Aboriginal Event	10,742	Camping	55,940
Shopping	133,863	Visit a Beach	58,198
Movies	13,214	Wildlife / Bird Watching	28,792

MONEY SPENT BY CATEGORY

TRANSPORTATION	27 %
ACCOMODATION	18 %
FOOD / BEVERAGES	31 %
RECREATION	6 %
RETAIL	18 %

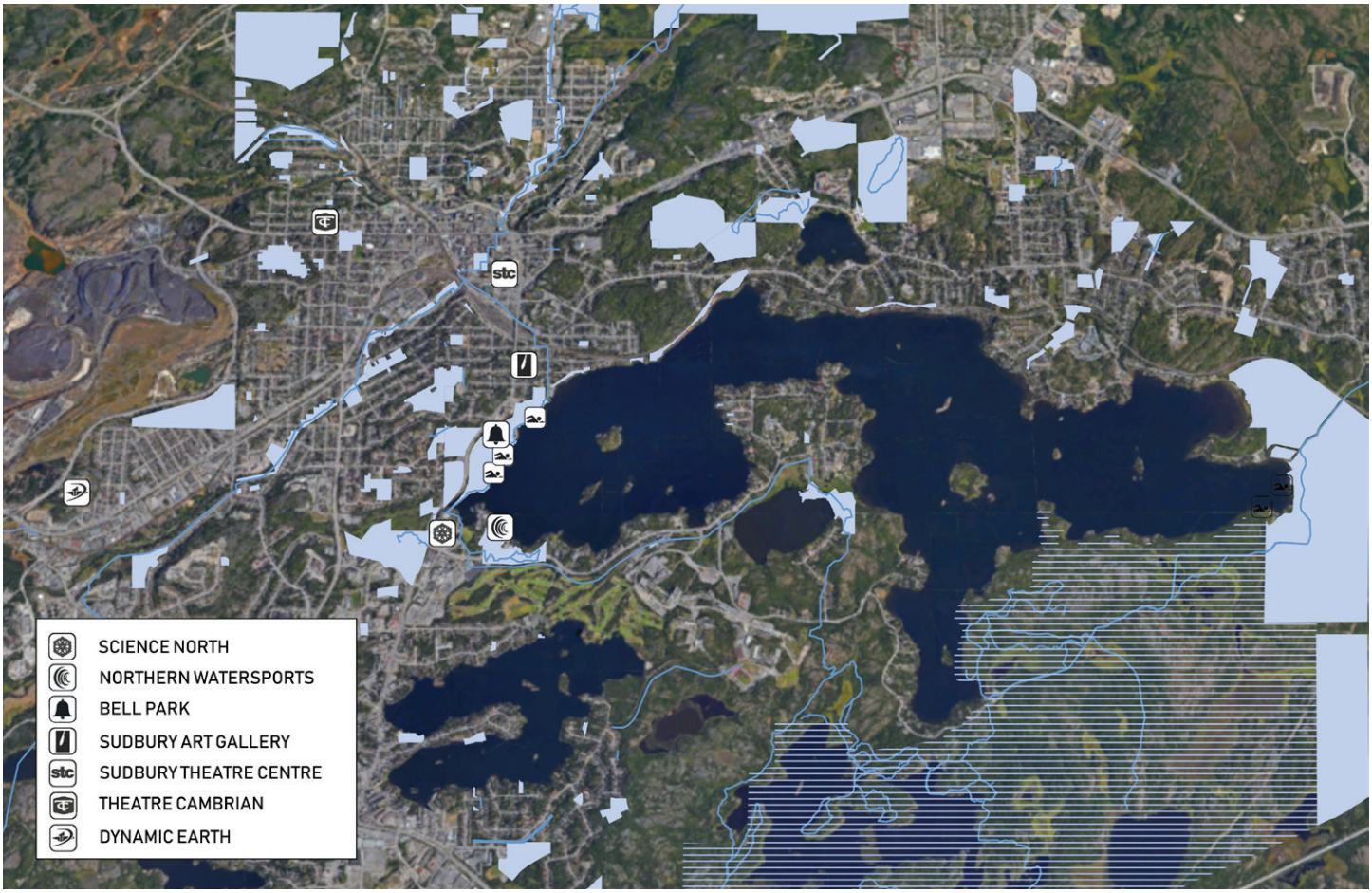


6A (Top Left) GENERAL TOURISM STATISTICS
Infographics by author, developed from information courtesy of:
Sudbury Profile 2014. Discover Sudbury. Accessed November 11, 2018. http://www.sudburytourism.ca/media/SudburyProfile2014CMA580.pdf.

6B (Top Right) ORIGIN OF VISIT
Infographics by author, developed from information courtesy of:
Sudbury Profile 2014. Discover Sudbury. Accessed November 11, 2018.

6C (Bottom Left) TOURIST ACTIVITIES
Infographics by author, developed from information courtesy of:
Sudbury Profile 2014. Discover Sudbury. Accessed November 11, 2018.

6D (Bottom Right) MONEY SPENT BY CATEGORY
Infographics by author, developed from information courtesy of:
Sudbury Profile 2014. Discover Sudbury. Accessed November 11, 2018.



6E RAMSEY LAKE TOURISM MAP
Map by author, developed from GIS data courtesy of the City of Greater Sudbury.
Satelite imagery courtesy of Google Earth Pro.

7A **MOONLIGHT BEACH AQUATIC GARDEN PROPOSAL**
Image by author.
Background image courtesy of Google Earth Pro.

The initial stage of this thesis investigation focused on the design of possible interventions in the form of small installations along the Ramsey Lake shoreline. These installations were developed in response to the research conducted. Through the analysis and study of the urban water cycle, opportunities for improvement can be uncovered which are achievable and can benefit both the community and nature.

The first proposal is a terraced ornamental aquatic garden which is located alongside Moonlight Beach. Water from Ramsey Lake would be pumped into the top terrace. As it flows through the garden and back into the lake, the native plants would filter organic waste out of the water, improving the water quality of the beach. A study by the University of California in 2015 analyzed the effectiveness of using constructed wetlands to remove E. coli from agricultural runoff. The results indicated that an artificial wetland with a hydrological retention time of less than one day reduced E. coli concentrations by 70%. Theoretically, this system could be used for the partial treatment of sewage overflow with similar results. While the installation would likely not solve the E. coli problems associated with Moonlight Beach, a reduction of E. coli by 70% from the water passing through the garden could lead to a marked improvement in the beach's water quality depending on the scale of the installation.[25]

25 *Using Wetlands to Remove Microbial Pollutants from Farm Discharge Water.* University of California, Agriculture and Natural Resources. Accessed January 11, 2019. https://anrcatalog.ucanr.edu/pdf/8512.pdf.

7B **STORM DRAIN POLLUTANT LIGHTING PROPOSAL**
Image by author.
Background image taken by author.

The second issue that the installations addressed is the increasing level of chloride in Ramsey Lake from public road and private land de-icing practices. In targeted areas within the Ramsey Lake watershed, a system of sensors installed within storm drains would detect pollutants in water runoff, such as salt and fertilizer. Coloured lights under the storm drain grate would then be activated to communicate the presence of detected pollutants to people in the area. The system would alert people as to how their activities affect the water going into the lake. Yellow lights indicate nitrates and phosphates from fertilizer runoff, blue lights indicate pH changes from contamination, and red lights indicate dissolved salts from de-icing practices. The generation of public awareness would act as a preventative measure, helping to reduce the amount of salt or fertilizer that is used by land owners within the watershed.

In Greater Sudbury, storm water runoff is a particularily important issue as rain water flows through a dedicated series of storm drains which channel water directly into lakes and streams, without any method of filtration. In addition to this, the history of mining activity in the region results in surface runoff that is five times higher in nickel and twenty times higher in copper than in other regional municipalities. A large reason for this may be past metal particulates from smelter emissions eroding away with soil.[26] While there may be little that residents can do to address soil erosion in thier area short of well-planned landscaping modifications, taking steps like controlling over-fertilization and over-salting can help to reduce stress on local waterbodies.

26 D.A.B. Pearson, J.M. Gunn, W. Keller. *The Past, Present and Future of Sudbury's Lakes*. Co-operative Freshwater Ecology Unit, Laurentian University, Sudbury. Accessed April 20, 2019. https://www3.laurentian.ca/livingwithlakes/wp-content/uploads/2012/06/Sudbury-Past-Present-and-Future.pdf.

7C **BELOW THE WATERLINE PROPOSAL**
Image by author.
Background image taken by author.

Lastly, a series of installations along the Bell Park boardwalk would allow people a glimpse into Ramsey Lake, letting them experience the ecosystem directly as they pass by. The first installation, entitled “Below the Waterline”, acts as an incision into the lake, allowing people to step down and view the lake from within. The second, “Above the Waterline”, a vacuumed transparent dome, placed above the water level, brings Ramsey Lake up to the viewer (see next page). The installations work to blur the boundary between water and land, representing a connection between the two as exists in natural systems. The unfamiliar views into a natural underwater ecosystem would prompt people to think about the lake from a new perspective and see long term changes in underwater environments. In addition to this, these interactions over time could help establish a stronger emotional connection between people on land and the ecosystem underwater.

7D **ABOVE THE WATERLINE PROPOSAL**
Image by author.
Background image courtesy of Google Earth Pro.

7E **RAMSEY LAKE INSTALLATION MAP**
Map by author.
Satelite imagery courtesy of Google Earth Pro.

The second stage of this investigation involved the translation of the installations into a building and public program. A Ramsey Lake Interpretive Centre along the shore of Ramsey Lake was selected as the main intervention with the additional program of a regional native species aquarium. The program would facilitate the generation of public awareness, while also providing opportunities for direct intervention to improve the lake's water quality.

Commercial and recreational fishing contribute $2.5 billion annually to Ontario's economy. However, fishing activity combined with invasive species, habitat degradation, and nutrient loading often necessitate fish stocking programs to promote the recreational fishing industry.[27] Throughout Ontario, approximately eight million cultured fish are released into roughly 3,200 water bodies annually to help bolster their populations.[28]

According to the Ontario Freshwater Fishes Life History Database, there are 159 species of fish in Ontario. Of these species, 39, or roughly 25 percent, are listed under the Species at Risk Act. Freshwater fish are, in fact, the most endangered group of species in the world. Globally, 33 percent of all freshwater fish species are threatened with extinction compared to 21 percent of mammals and 12 percent of birds.[29]

These endangered species, however, garner little public attention compared to more iconic and visible threatened species. For this reason, the role of the exhibits within the interpretive centre is to educate the public about the modern challenges faced by aquatic habitats within Northern Ontario, and to communicate the history of past challenges from industrial activity. In addition to raising ecological awareness, accessible interaction with aquatic species would help foster relationships between community members and their local waterbodies. The building would, therefore, house multimedia exhibits; displaying maps, data, images, and objects which communicate environmental concerns, natural processes, ecological connections, natural history,

27 *Ontario's Fisheries: Significant Contributors to the Ontario Economy*. Ontario Rivers Alliance. August 26, 2014. Accessed January 07, 2019. http://www.ontarioriversalliance.ca/ontarios-fisheries-significant-contributors-ontario-economy/.

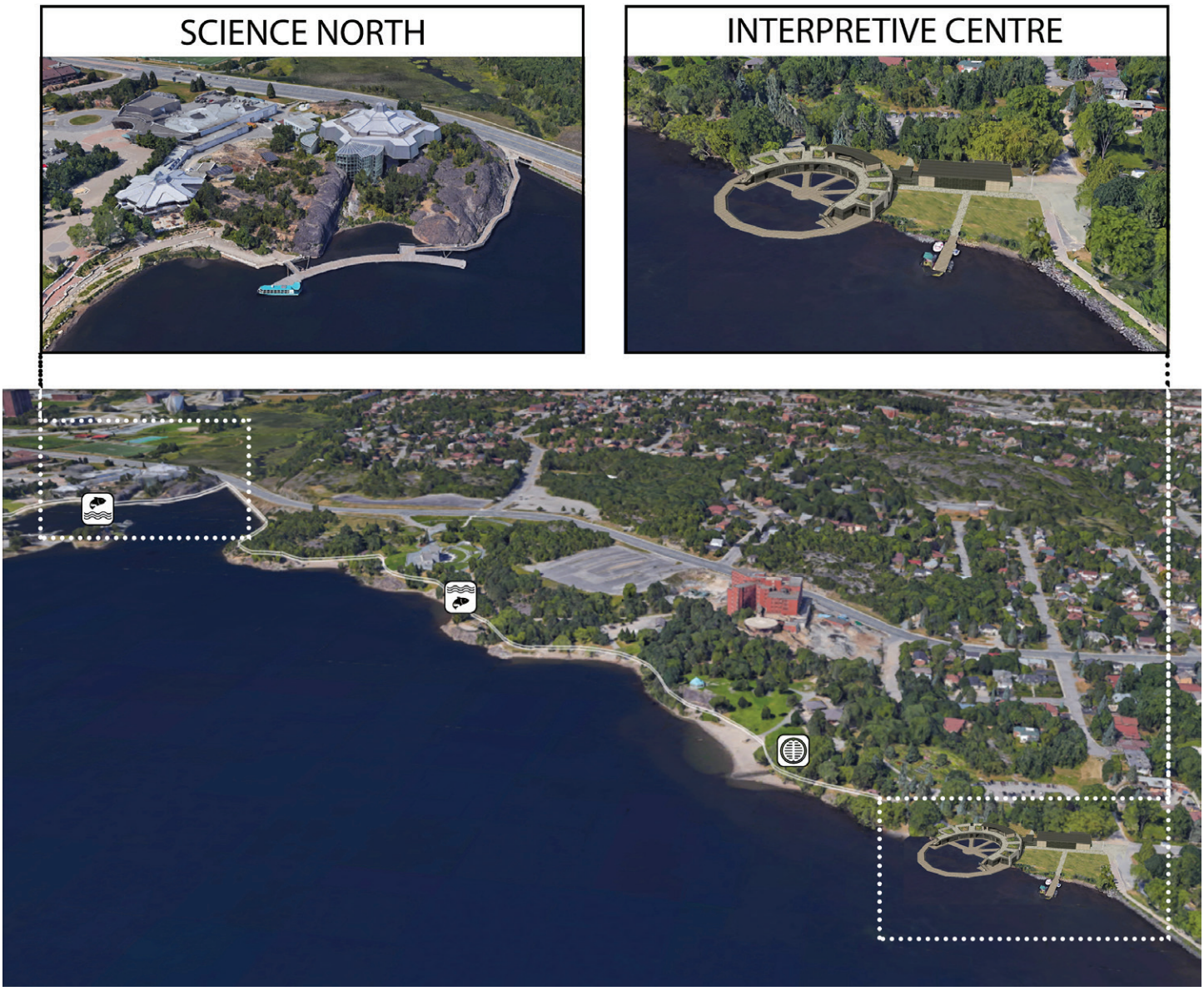
28 *Ontario's Fish Stocking Program*. Ministry of Natural Resources and Forestry. September 11, 2018. Accessed January 07, 2019. https://www.ontario.ca/page/ontarios-fish-stocking-program.

29 Richard Gray. *Third of Freshwater Fish Threatened with Extinction*. The Telegraph. July 30, 2011. Accessed January 07, 2019. https://www.telegraph.co.uk/news/earth/wildlife/8672417/Third-of-freshwater-fish-threatened-with-extinction.html.

and cultural heritage.

The interpretive centre is meant to illustrate how aquatic environments shape human society and how we in turn shape aquatic environments. The focus on cultural and historical exhibits communicates the influence that the landscape has over our societal development, while the environmental exhibits educate visitors about minimizing communal negative environmental impact. The aquarium portion of the building is meant to immerse people in aquatic ecosystems, allowing them to interact with native plants and animals. This allows visitors to learn about regional species and habitats in a more informal way. In addition to this, the filtration systems required to accommodate an aquarium program would be utilized to improve the quality of water in Ramsey Lake itself. In a sense, the building would act as a living natural history museum, highlighting the relationship between human activity and water, as well as the modern state of aquatic ecosystems.

A small portion of the proposed exhibits overlap with already existing displays at Science North, this is because the Interpretive Centre is, in part, an extension on their wetlands section. This is somewhat intentional; since the inception of Science North, interest in ecological issues has grown, with Ramsey Lake being a large focus of aquatic environmental discourse in the city. The centre, then, is meant to form a partnership with other institutions in the area such as Science North, the Living with Lakes Centre, and the Lake Laurentian Conservation Area. These existing facilities offer expertise which would allow the Interpretive Centre to become incredibly effective. Science North has developed a strong skill-set in interactive exhibit design, while the Living with Lakes Centre focuses on ecological research which the Interpretive Centre can translate into exhibits for public communication.



8A **BELL PARK BOARDWALK**
Map by author.
Background images courtesy of Google Earth Pro.

8B BELL PARK BOARDWALK IMAGES
Images taken by author.

EXISTING SITE

PROPOSED SITE

8C **EXISITING SITE**
Image courtesy of Google Earth Pro.

8D **PROPOSED SITE**
Image by author.
Background image courtesy of Google Earth Pro.

The site chosen for the building is located on the eastern end of Bell Park, opposite Science North. The site lies at the main entrance and parking area of Bell Park. The shoreline boardwalk begins in this area and ends at the entrance to Science North. Therefore, visitors to Bell Park would be able to walk between both venues, through the park, and visit the connected installations along the way.

The existing building on the site was previously occupied by the Sudbury Boat and Canoe Club before the construction of their new building on the opposite side of the lake. The canoe club decided to relocate their facility due to the deteriorating state of the building. This became a larger concern in 2015 when higher than normal seasonal water levels caused minor but persistent flooding of the building.[30] After the construction of the new Northern Watersports Centre, the building was taken over by the City of Greater Sudbury and is mainly utilized as a storage facility.

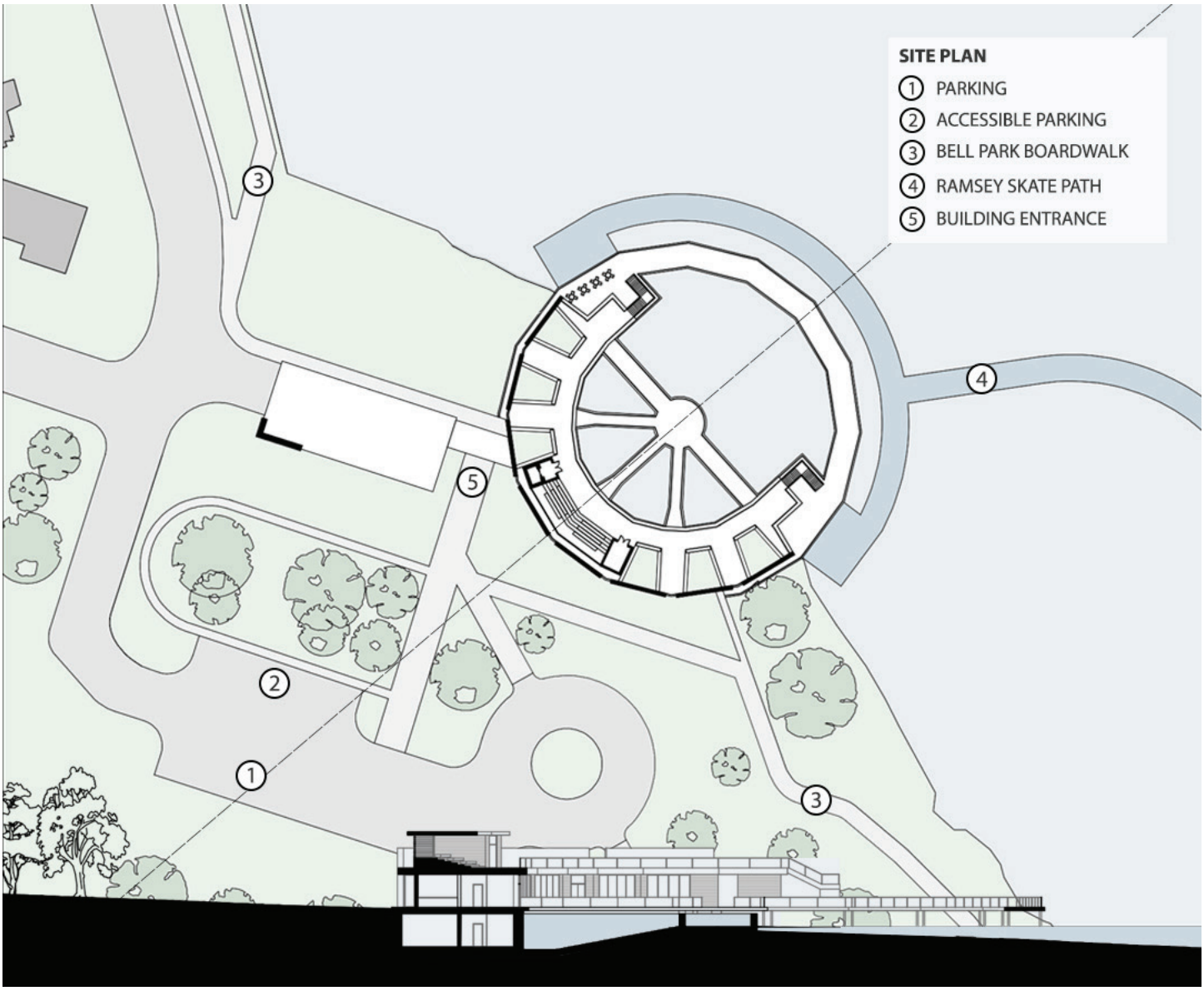
Due to the low elevation of the site, it's susceptibility to flooding and the condition of the existing building, the Interpretive Centre would be fully constructed as a new facility. The shoreline of the site was hardscaped during the construction of the original building. As part of the proposal, the existing concrete retaining walls along the shoreline would be removed in order to re-naturalise the site, and the site would be raised to create an elevated construction platform, reducing the risk of flooding. A more natural, sloped shoreline would then be recreated, and shoreline vegetation would be planted to help minimize erosion of the site. Land vegetation, emergent vegetation and submergent vegetation along the shore would act to naturally filter stormwater runoff. Underwater, the stems and leaves of aquatic plants would also act as habitat for fish, offering them sheltered spaces in a lake which has comparatively little vegetated areas. Rocks and boulders which are retrieved during construction excavation could also be placed underwater along the shoreline, creating additional shelter and habitat. The softening

30 Marina von Stackelberg. *Sudbury Canoe Club Copes with Flooding*. CBC News. June 04, 2015. Accessed April 20, 2019. https://www.cbc.ca/news/canada/sudbury/sudbury-canoe-club-copes-with-flooding-1.3099452.

of the shoreline in this way would likely attract pumpkinseed, rock bass, yellow perch and northern pike to the site, all of which prefer to inhabit shallow and vegetated areas.

The proposed building forms the shape of a ring which protrudes over the water with one edge on shore. The building itself occupies half of the ring with the lakeside half dedicated to a floating dock walkway which also connects to a green roof above the building. The dock and green roof of the building would act as outdoor recreational areas for visitors while also offering access to amenities for the Bell Park area. During the winter, the building's site lies at the end of the Ramsey Lake Skate Path. The dock would therefore be accessible to the skate path to allow skaters access to a café, change rooms and washrooms. The interior/enclosed portion of the dock could also be shoveled to create an additional skating area for recreational activities, such as playing hockey. Alternatively, the same area could also be used as a community art exhibit area in the form of ice sculptures.

As part of the building projects into Ramsey Lake, some underwater excavation and construction would be required. A silk screen would temporarily be placed underwater around the building site to prevent suspended sediment from circulating into other areas of the lake.

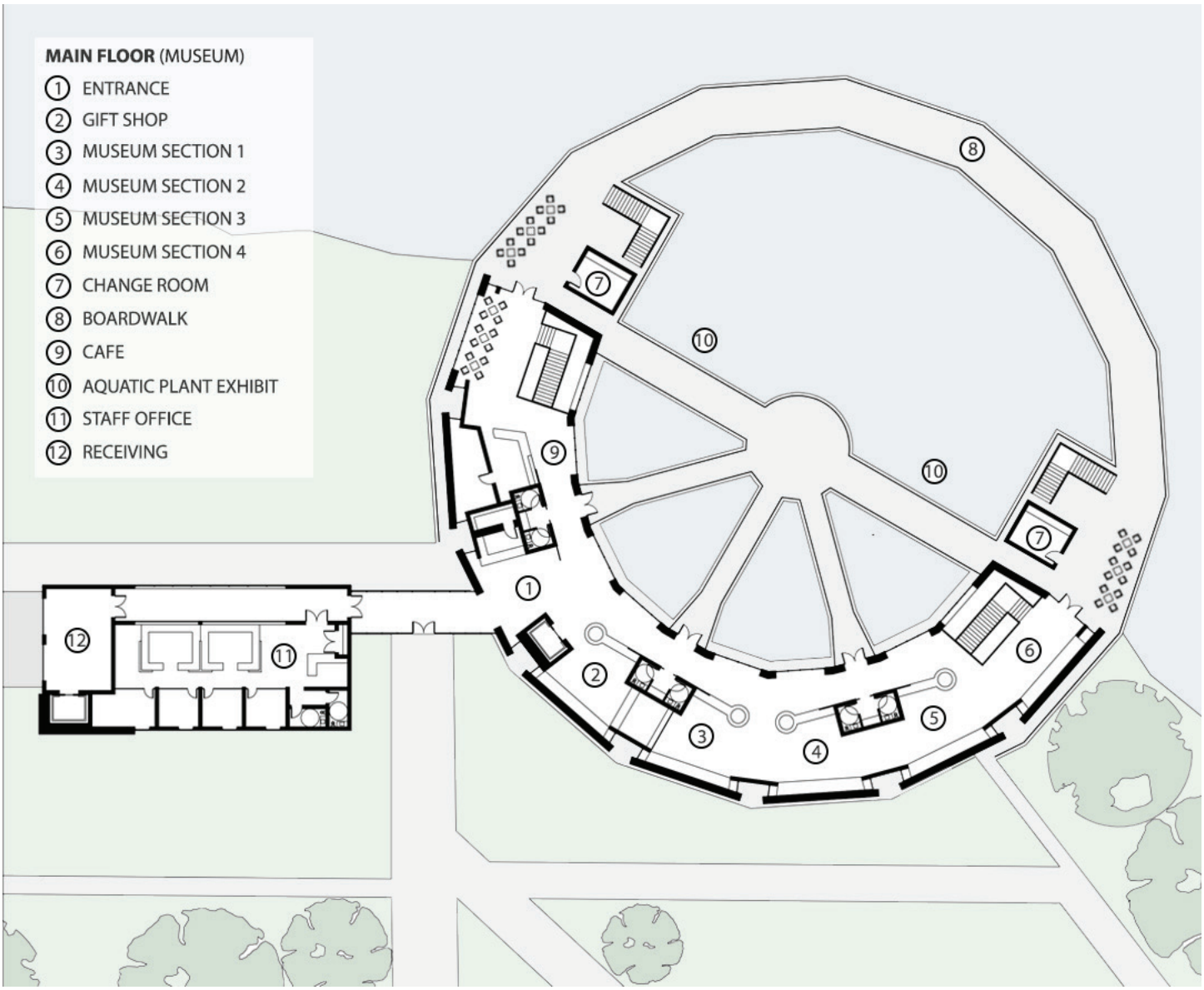


8E **SITE PLAN** (Scale 1:1000)
Drawing by author.

SITE SECTION (Scale 1:500)
Drawing by author.

8F **BUILDING SECTION (Scale 1:150)**
Drawing by author.
Background image courtesy of Google Earth Pro.

8G FRONT PERSPECTIVE
Image by author.
Background and foreground images courtesy of Google Earth Pro.



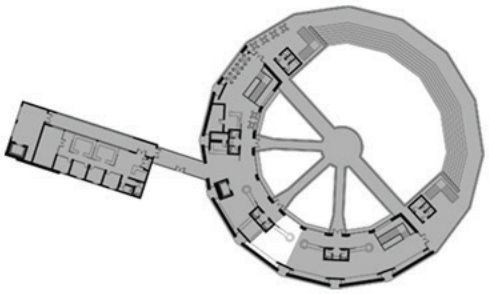
8H **MAIN FLOOR PLAN** (Scale 1:500)
Drawing by author.

The main floor of the building houses the interpretive centre which would display exhibits designed to communicate local history, culture and research relating to regional waterbodies. The interpretive exhibits are divided into four sections in order to facilitate a logical sequence of information. Section 1 would be dedicated to natural history, section 2 to cultural heritage, section 3 to wetland ecology and section 4 to human impact. Sudbury has a long history of environmental impact and remediation which is likely to continue into the future. The most easily affected of these environments, and hardest to re-naturalize, are the aquatic ecosystems. The third and fourth section of the museum would therefore be continually updated to reflect recent environmental concerns and remediation efforts. This would keep visitors well informed of regional impacts on aquatic ecosystems and educate them as to what they can do to help. The first and second sections, dedicated to natural history and human culture, are meant to communicate how our local landscape has formed and how its unique characteristics have shaped regional culture.

The exhibit areas are largely designed to display exhibits on counter tops along the perimeter of the space with corridors in between. Three circular display counters, bordering the entrance of the exhibit spaces, are dedicated to displaying exhibits which are meant to be viewed from all sides. A series of windows along the back side of the building allow views out into the lake while a series of small recessed windows on the front side of the building bring in additional daylight while still allowing exterior walls to display information.

The circular boardwalk offers visitors the opportunity to experience the lake from a more immersive perspective further away from main activity. The centre forks of the circular dock serve as public outdoor pathways but function mainly as service access to the outdoor aquarium exhibits below. These areas would be accessible to the public through the entrance and café section of the building, while the other rear doors would serve only as exits.

NATURAL HISTORY



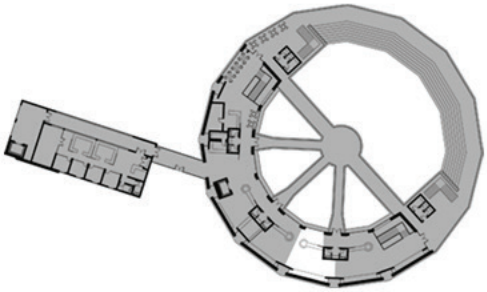
La Cloche Mountains

Erosion

Meteorite Impacts

Glaciation

CULTURAL HERITAGE



Turtle Island Legend

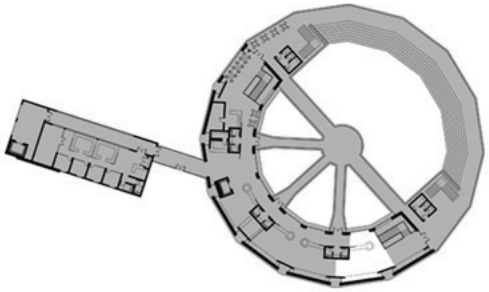
Birch Bark Canoe

Local History

Aquatic Inspired Art

8I INTERPRETIVE CENTRE SECTIONS
Drawing by author.

WETLAND ECOLOGY



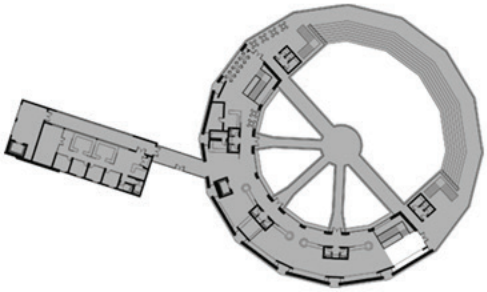
Wetlands as Water Filtration

Aquatic Life & Micro-Ogranisms

Wetland Vegetation

Natural Processes

HUMAN IMPACT



Water Runoff Pollutants

Industrial Contamination

Water Use & Sewage

Shoreline Development

8J MAIN FLOOR PERSPECTIVE
Image by author.

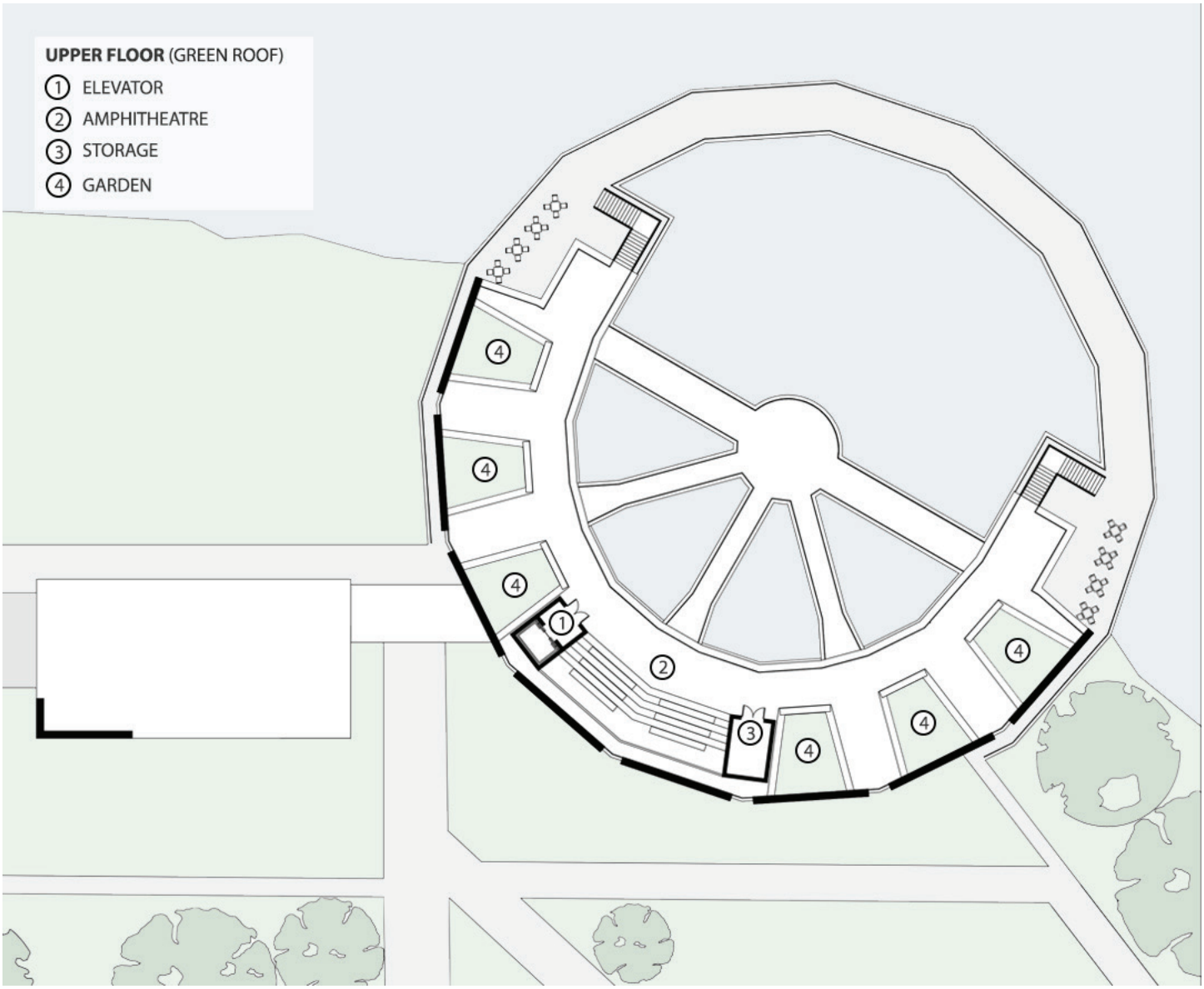
8K **TURTLE ISLAND SCULPTURE**
Sculpture by author.
Turtle Island storyboard adapted from the book:
Nancy Cooper. *Fire and Water: Ojibway Teachings and Today's Duties, Ojibwe Creation Story Literacy Companion*.
Ningwakwe Learning Press, 2011.

This sculpture is a representation of the Ojibwe Turtle Island creation legend which was designed as an exhibit within the proposed Ramsey Lake Interpretive Centre. The Turtle Island legend begins with the flooding of the earth; the Creator floods the world in response to human feuding, and to begin anew. Nanabush and some aquatic animals survive. One by one, the animals try diving to the bottom of the water to retrieve earth. Muskrat is successful; however, he gives his life in the attempt. The ball of soil in muskrat's hand is placed on turtle's back. Wind blows from each of the four directions and the ball of earth grows and grows, eventually forming Turtle Island, or North America.The Turtle Island creation story is thought to be a documentation of flooding which occurred during the melting of the glaciers. The representation of the Turtle Island story documents the interaction between human culture and natural history, while also teaching the importance of living in harmony with the earth.

The object measures roughly four feet in length, three feet in width, two feet in height, and forms the shape of a turtle shell. The individual plates which make up the shell are separated from each other by one to two-inch gaps, highlighting the hollowness of the interior. The bottom and side plates are made of wood while the top plates are made of clay. The clay tiles have illustrations which depict the Turtle Island legend in the form of a storyboard. The clay tiles on the top of the shell symbolize the earth which is held upon the turtles back as well as the soil muskrat pulled up from the bottom of the flooded landscape. The emptiness of the turtle shell represents the sacrifice which turtle made, giving up its back in order to create our home.

The illustrations imprinted into the clay tiles, depicting the Turtle Island legend, are adapted from the book *Fire and Water: Ojibway Teachings and Today's Duties*.[31] The turtle shell sculpture, as a result, acts as a medium for the Turtle Island legend to be retold, rather than a depiction of the story itself.

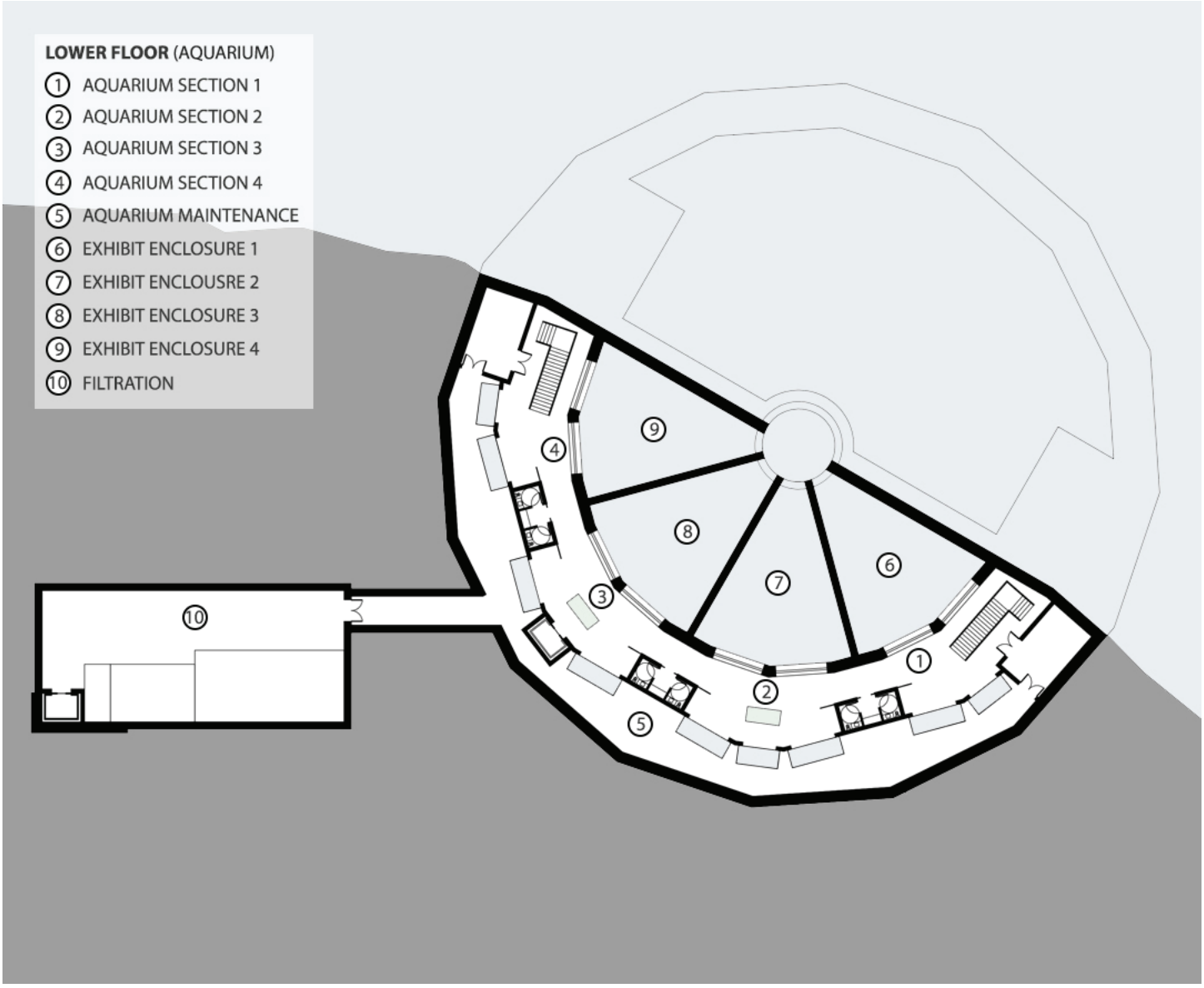
31 Nancy Cooper. *Fire and Water: Ojibway Teachings and Today's Duties, Ojibwe Creation Story Literacy Companion*. Ningwakwe Learning Press, 2011.



8L **UPPER FLOOR PLAN (Scale 1:500)**
Drawing by author.

The upper, green roof, level serves as additional exhibit area and recreational space. The main feature of the public rooftop are the gardens which would display species of shoreline vegetation. This could act as an additional public awareness exhibit in a sense. Roughly 20 percent of the shoreline around Ramsey Lake has been denaturalized, meaning it has either been hardscaped or the natural vegetation has been removed. This reduces the amount of natural habitat for species living in and around the lake, increases the risk of shoreline erosion, and increases organic nutrient runoff from lawns, possibly leading to excessive algae growth. A shoreline exhibit such as this could be an opportunity to educate landowners in the region about the effects of shoreline alteration and encourage them to restore a more natural transition. In addition to this, seeds from the plants within these exhibits could also be harvested for shoreline restoration projects around the region.

In the center of the roof, a covered tiered benching system would act as an outdoor auditorium for events, visitor programs or children's programs during the summer. This could create an opportunity for organizations like the Lake Laurentian Conservation Area which specialize in children's ecology education programs to visit the Interpretive Centre as part of a structured learning activity.



8M **LOWER FLOOR PLAN** (Scale 1:500)
Drawing by author.

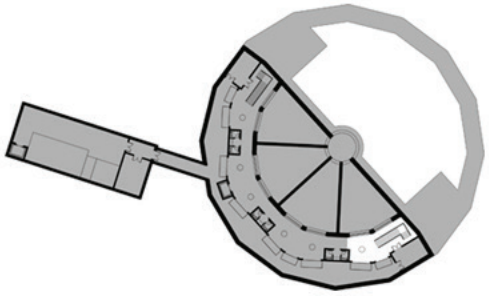
The lower floor (basement level) of the interpretive centre is dedicated to a series of regional aquarium exhibits and is also divided into four sections. Section 1 would focus on local turtle species, section 2 on lake species, section 3 on river species, and section 4 on invertebrates. Locating the aquarium in the basement is a strategy to reduce the footprint of the building as it utilizes space which would already be excavated for the foundation.

There are four larger exhibits in the form of underwater enclosures within Ramsey Lake. These exhibits are open to the dock structure above and have underwater viewing windows into the basement. The incorporation of outdoor exhibits further reduces the footprint of the building interior, making the project more environmentally sustainable while allowing more enclosed space for the animals within them. It also creates a more natural exhibit, where visitors can see seasonal changes in the environment and in animal behaviour as the surface of the water would likely freeze, if only partially.

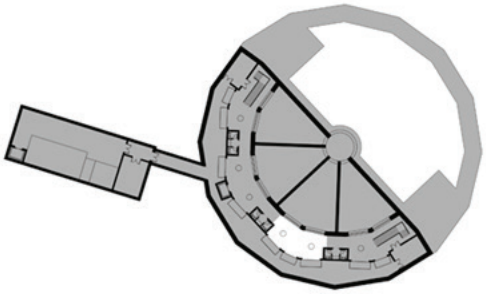
Each of the triangular outdoor enclosures is forty-eight feet long and forty-three feet wide at the larger end. This shape allows visitors to have a wide view of the exhibits across two viewing panes while also giving the animals a place to retreat to, further away from interaction with humans. In order to provide water circulation through the exhibits, water filtered from the lake would flow from the wider viewing end of the enclosures and overflow into Ramsay Lake from the opposite end. Directly opposite of these larger, open air exhibits are a series of smaller conventional aquarium tanks which would be dedicated to exhibits of smaller species, with each tank being 5 feet in width and 11 to 15 feet in length. Within section 2 and 3 are two aquaponic exhibits, shown in green. In these systems, fish waste from the aquariums can be used to fertilize plants, demonstrating ecological links.

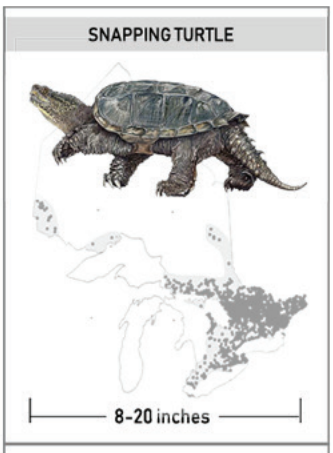
The aquarium program is a way to immerse visitors into local waterbodies and could act as a tool to educate them about the habitats, diets, and lifecycles of local species, and how these are potentially disrupted by habitat degradation, contamination or over-exploitation.

SECTION 1: TURTLES & AMPHIBIANS



SECTION 2: LAKES





Habitat: shallow lakes, rivers, ponds, and wetlands, dense vegetation

Diet: plants, fish, frogs, tadpoles, insects, snails, leeches, worms, snakes, small mammals, juvenile ducks

Habitat: bottom of lakes, rives, ponds and streams

Diet: crayfish, worms, snails

Habitat: shallow shoreline, dense vegetation

Diet: insects, mosquito larvae, small molluscs, crustaceans, worms, minnows, juvenile fish

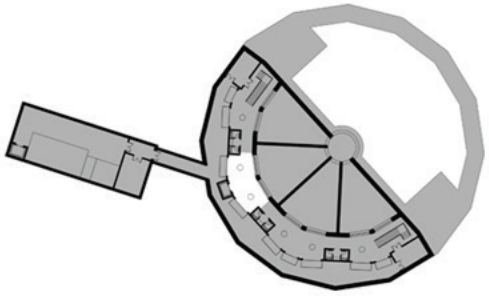
Habitat: rocky or sandy areas of lake bottom

Diet: crayfish, insects, juvenile fish

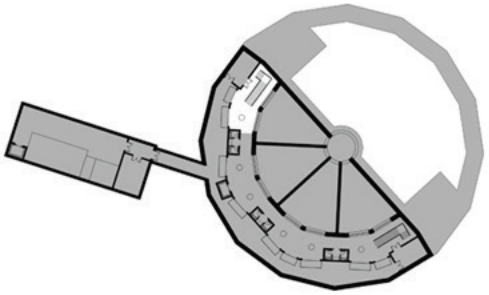
8N AQUARIUM SECTIONS

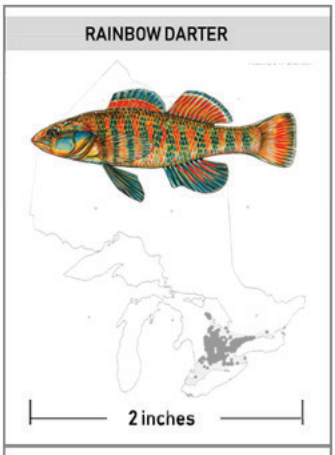
Infographics by author.
Turtle and amphibian images and information courtesy of:
Programs. Ontario Nature. Accessed April 07, 2019. https://ontarionature.org/programs/.
Fish information courtesy of:
Robert J. Eakins. *Ontario Freshwater Fishes Life History Database*. OFFLHD. Accessed November 12, 2018. http://www.ontariofishes.ca/home.htm
Fish Images courtesy of:
Nature & Science. National Park Service. Accessed November 12, 2018. https://www.nps.gov/miss/learn/nature.

SECTION 3: RIVERS



SECTION 4: INVERTEBRATES





Habitat: river, cobble or gravel substrate

Diet: invertebrates, crayfish, insect larvae

Habitat: shallow, sandy lakes and large rivers

Diet: small fish, insects, crustaceans

Habitat: streams, ponds, sand or gravel substrate.

Diet: insects, snails.

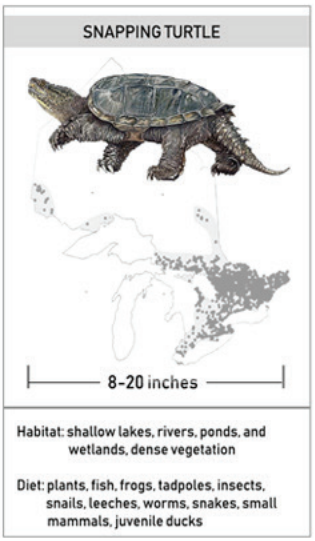
Habitat: lake and ponds with mud bottoms, and little current

Diet: filter feeder, micro-organisms

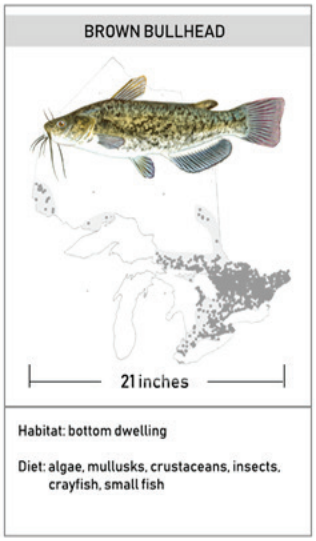
AQUARIUM SECTIONS
Infographics by author.
Fish information courtesy of:
Robert J. Eakins. *Ontario Freshwater Fishes Life History Database*. OFFLHD. Accessed November 12, 2018. http://www.ontariofishes.ca/home.htm.
Fish Images courtesy of:
Nature & Science. National Park Service. Accessed November 12, 2018. https://www.nps.gov/miss/learn/nature.
Mussel images & information courtesy of:
Phillipe Blais. *Canaiad's Freshwater Mussels of Canada*. iNaturalist. Accessed April 07, 2019. https://www.inaturalist.org/guides/6506.

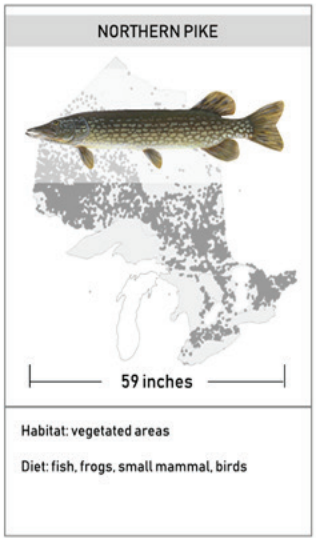
8O MAIN FLOOR PERSPECTIVE
Image by author.

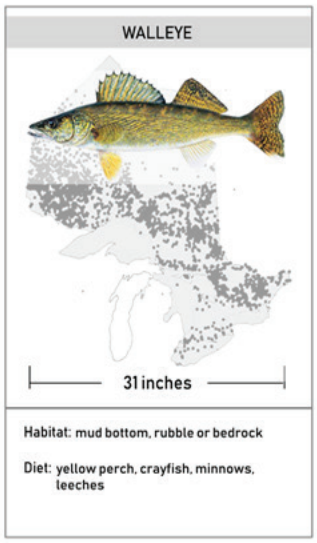
ENCLOSURE 1: SNAPPING TURTLE

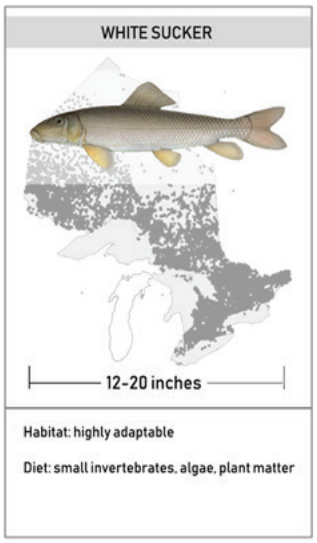


ENCLOSURE 2: RAMSEY LAKE







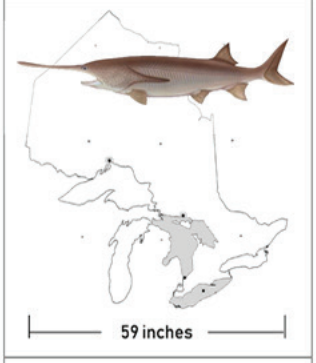


8P AQUARIUM ENCLOSURES

Infographics by author.
Turtle and amphibian images and information courtesy of:
Programs. Ontario Nature. Accessed April 07, 2019. https://ontarionature.org/programs/.
Fish images and information courtesy of:
Robert J. Eakins. *Ontario Freshwater Fishes Life History Database*. OFFLHD. Accessed November 12, 2018. http://www.ontariofishes.ca/home.htm.
Fish Images courtesy of:
Nature & Science. National Park Service.Accessed November 12, 2018. https://www.nps.gov/miss/learn/nature.

ENCLOSURE 3: FRENCH RIVER

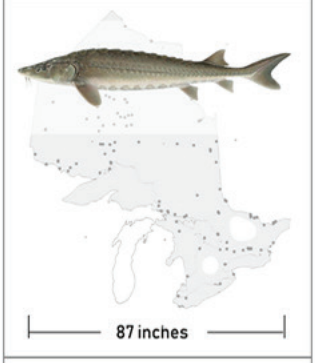
PADDLEFISH



Habitat: open, slow moving waters

Diet: zooplankton, small insects, insect larvae, small fish

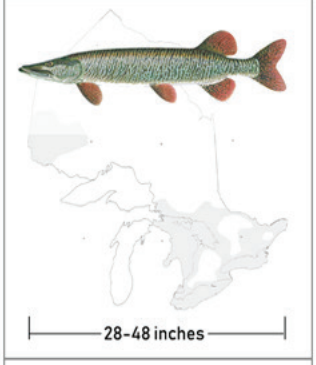
LAKE STURGEON



Habitat: deep water of large lakes

Diet: insect larvae, worms, small organisms

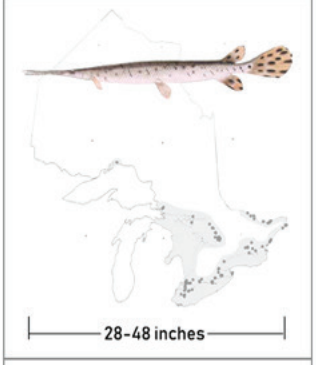
TIGER MUSKELLUNGE



Habitat: shallow and deep water (seasonal)

Diet: yellow perch, suckers, shiners, walleye, smallmouth bass

LONGNOSE GAR

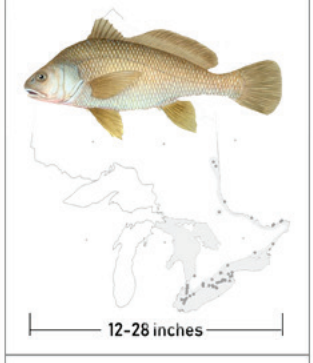


Habitat: shallow, sandy lakes and large rivers

Diet: small fish, insects, crustaceans

ENCLOSURE 4: NIPISSING

FRESHWATER DRUM



Habitat: sandy, silty bottoms of lakes

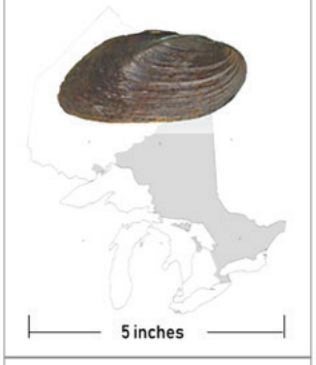
Diet: invertebrates, insect larvae, mussels, and small fish

TRIANGLE FLOATER

Habitat: lakes, streams, rivers, all substrates

Diet: filter feeder, micro-organisms

EASTERN ELLIPTIO



Habitat: lakes, ponds and streams, all substrates

Diet: filter feeder, micro-organisms

GIANT FLOATER

Habitat: lake and ponds with mud bottoms, and little current

Diet: filter feeder, micro-organisms

AQUARIUM ENCLOSURES

Infographics by author.

Fish information courtesy of:

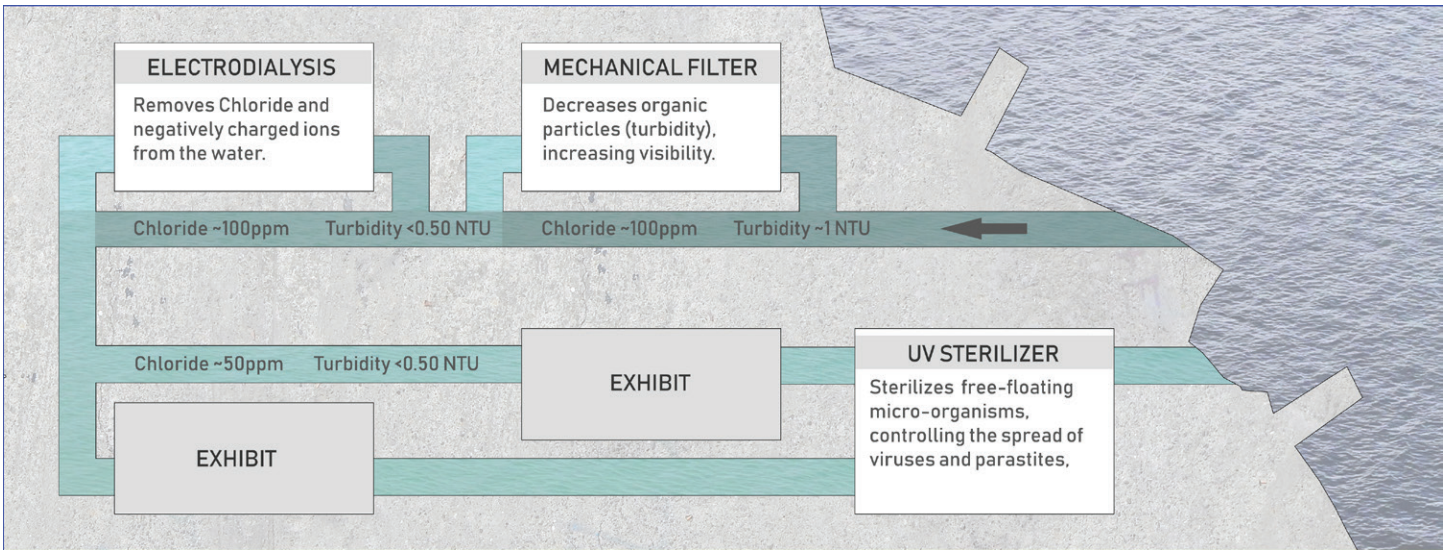
Robert J. Eakins. *Ontario Freshwater Fishes Life History Database*. OFFLHD. Accessed November 12, 2018. http://www.ontariofishes.ca/home.htm.

Fish Images courtesy of:

Nature & Science. National Park Service. Accessed November 12, 2018. https://www.nps.gov/miss/learn/nature.

Mussel Information & images courtesy of:

Phillipe Blais. *Canaiad's Freshwater Mussels of Canada*. iNaturalist. Accessed April 07, 2019. https://www.inaturalist.org/guides/6506.



ELECTRODIALYSIS

OPERATING PARAMETERS

Water Recovery ..... Up to 94%
Salt Removal ..... 50 - 95 %
Temperature ..... 50 PSI

FEED WATER REQUIREMENTS

Turbidity ..... < 0.5 NTU
Total Organic Compounds ..... < 15 ppm
Typical Feed TDS ..... 100 - 3,000 ppm

FLOW RATES: 280 gpm to 1,120 gpm

8Q FILTRATION
Drawing by author.

8R ELECTRODIALYSIS
Image and information courtesy of:
Electrodialysis Reversal (EDR) Water Treatment. SUEZ. Accessed January 07, 2019. https://www.suezwatertechnologies.com/products/edediedr/electrodialysis-reversal-edr

The aquarium exhibits would utilize Ramsey Lake water, allowing the filtration system required in such a facility to begin to act as an environmental remediation tool, filtering targeted compounds from the lake. Over time, the facility would help to improve the quality of Ramsey Lake as a natural ecosystem while also improving the quality of drinking water for Sudbury residents.

One of the most pressing environmental concerns surrounding Ramsey Lake, and many urban lakes in Northern climates, is chloride salt runoff from road and pathway de-icing practices. Unnaturally high chloride levels are harmful to aquatic life and contribute to other ecological issues such as blue green algae blooms. The filtration of chloride out of Ramsey Lake would, therefore, have a large impact in improving the health of the lake both as an ecosystem, and as a recreational destination. There are several forms of chloride filtration including reverse osmosis, distillation, and electrodialysis. As an environmental remediation tool, electrodialysis is the most suited because it selectively removes salt ions while allowing organic compounds to bypass the filtration process. Industrial electrodialysis filters remove up to 94% percent of salt with a waste water efficiency of up to 6%.[32] However, these systems are typically used for the desalination process of brackish water and not for the removal of chloride salt in freshwater applications. A study completed for the Tenth International Water Technology Conference, however, found that the effectiveness of electrodialysis filtration increases as feed concentrations of ionic salt decrease.[33] This indicates that the high end of efficiency given in typical electrodialysis specifications would align with a chloride feed concentration of 100ppm, as currently exists in Ramsey Lake.

The turbidity, or clarity, of the water in Ramsey is generally 1 NTU at a depth of 15 feet, where a water intake pipe would typically be placed. However, the electrodialysis filtration process requires a turbidity of below 0.5 NTU. The intake water from Ramsey Lake would, therefore, pass through a mechanical filter to reduce the turbidity to below 0.5 NTU.[34] This would allow the water to be processed by the electrodialysis filter while also increasing the visibility of the aquarium exhibits. After flowing through the electrodialysis filter and

32 *Electrodialysis Reversal (EDR) Water Treatment*. SUEZ. Accessed January 07, 2019. https://www.suezwatertechnologies.com/products/edediedr/electrodialysis-reversal-edr.

33 Sadrzadeh, Mohtada, Anita Kaviani, and Toraj Mohammadi. *Mathematical Modeling of Desalination by Electrodialysis*. Tenth International Water Technology Conference. Accessed January 09, 2019. https://www.sciencedirect.com/science/article/pii/S001191640601455X.

34 *Current Conditions*. City of Greater Sudbury Ramsey Aquatic Monitoring System. Accessed January 09, 2019. http://dataservices.campbellsci.ca/golder_ramseylake/index.php.

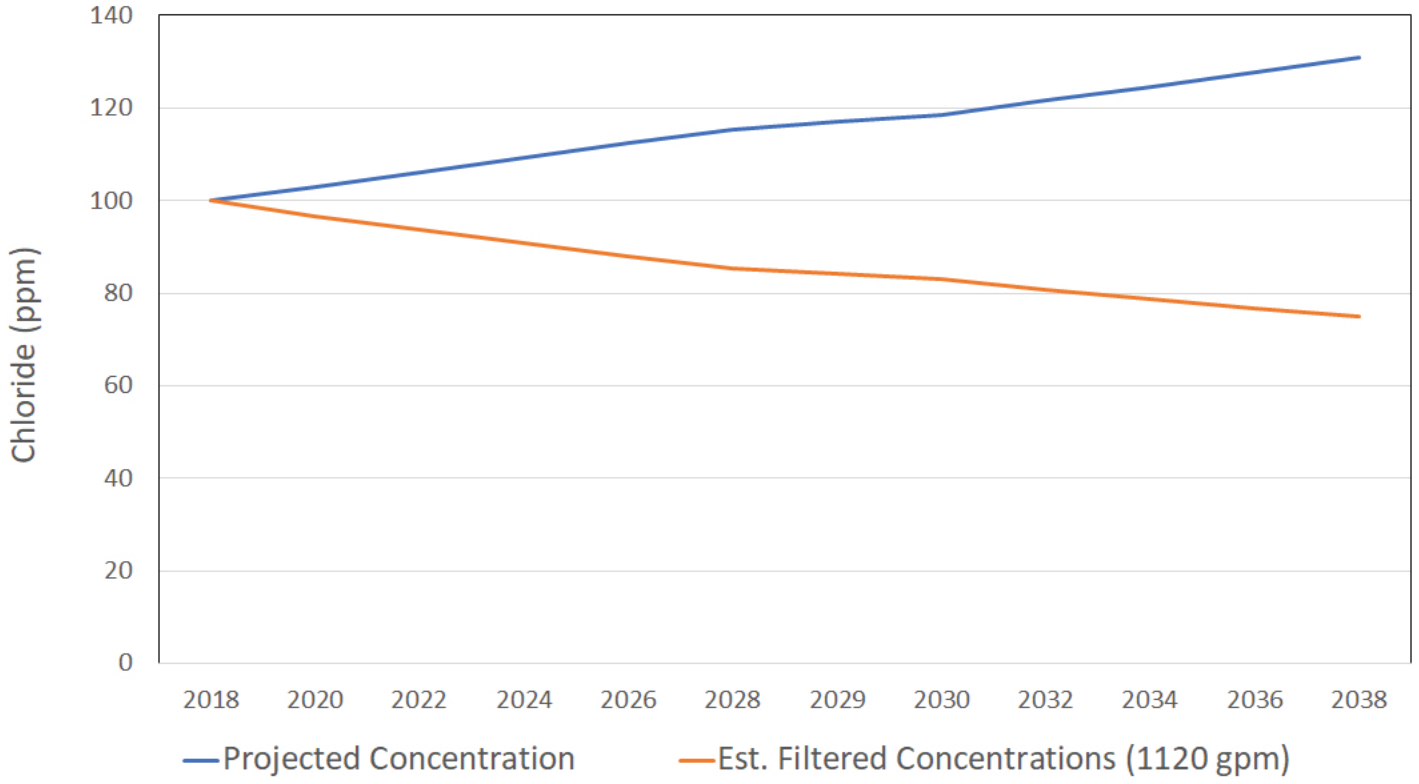
the exhibits, the water would then pass through a precautionary UV sterilizer before being discharged back into Ramsey Lake. UV filtration sterilizes bacteria, pathogens, and parasites, thus, controlling the spread of illness from the exhibits to natural ecosystems. The electrodialysis would create a small percentage of chloride concentrated wastewater at high efficiency, however, the water content could be further reduced through evaporation with the addition of a distiller. Excess heat from this system could also be used to help regulate the temperature of the exhibit water, or to heat the building.

The four exterior enclosures, once filled, would hold an estimated volume of 50,000 gallons each, making for a total of 200,000 gallons. This would require a water circulation volume of 144,000 gallons per hour. This amount is based on regional industry standards and would circulate the entire volume of each exhibit in roughly an hour and 20 minutes.[35] A backup air pump would be added to circulate and aerate the water in case of a power outage or low oxygen levels during the winter. A backup cooling system would also be installed to benefit coldwater species in the summer. The winter would likely be a time of “reduced maintenance”, any ice buildup could be partially removed or drilled through for access during minor maintenace or feeding.

The chloride filtration process could potentially have an impactful result on the ecosystem, at a 1,120 gallon per minute flow rate, the electrodialysis filter could remove over 180 metric tonnes of chloride per year in the first few years of operation. This would reduce the concentration of salt in Ramsey lake from 100ppm to an estimated 75ppm within 20 years based on current projections. The waste from the filtration process is a salt brine which could be re-used by municipalities in the region for further de-icing practices. This would create a cyclical process, where salt is removed from the environment to be added again to roadways. While technically, salt would only be removed from Ramsey Lake, it would have a downstream effect. Ramsey Lake flows into Kelly Lake, which discharges into the Spanish River, and eventually to Lake Huron, therefore, improvements made to its water quality would also have a positive effect on its distributaries.

35 *Life Support Systems*. Ripley’s Aquarium of Canada. Accessed April 23, 2019. https://www.ripleyaquariums.com/canada/galleries/life-support-systems/

CHLORIDE FILTRATION



8S **CHLORIDE FILTRATION**
Drawing by author.
Developed from information courtesy of:
Editor, Letter To the. *Letter: Using Calcium Chloride in Place of Sodium Chloride a Red Herring*. Sudbury.com. May 01, 2018. Accessed September 22, 2018. https://www.sudbury.com/letters-to-the-editor/letter-using-calcium-chloride-in-place-of-sodium-chloride-a-red-herring-910323.

09 CONCLUSION

As Sudbury's landscape continues to recover from industrial activity, environmental concerns surrounding Ramsey Lake are increasingly becoming issues of urban development and land use. The proposed Ramsey Lake Interpretive Centre is a response to ecological concerns impacting Ramsey Lake and the surrounding area. The program was, therefore, developed as a strategy to address this issue through the lens of public education, with the filtration processes acting secondarily as a direct intervention. While the thesis document communicates the research, the program of public education within the Interpretive Centre is meant to be an immersive and personable experience rather than a more direct transfer of information. The intention behind this is to create an emotional and experiential connection to environmental impact. The topics which the program focuses on, therefore, are problems which can be addressed in some way by members of the public such as contamination, eutrophication, and habitat degradation.

In some ways, however, the proposed program can be viewed as self-defeating. The construction of an ecological building along the waterfront can impact the ecology of the lake, and the containment of live animals can be morally objectionable. The site chosen to construct the centre, however, was already hardscaped during its previous use. While the building footprint itself would remain a hard-edge, a portion of the shoreline would be restored to a more natural condition. The centre itself would, additionally, raise awareness of environmental issues impacting regional waterbodies, generating further interest in environmental stewardship. The aquarium program could also act in the same capacity, the exhibits themselves would become a teaching tool, helping to communicate issues relating to the conservation of local wildlife. Additionally, the filtration systems which support this program would help to improve the water chemistry of Ramsey Lake itself, elevating its quality as an ecosystem and as a reservoir for residents who rely on it as a source of drinking water.

09 CONCLUSION

The proposed Ramsey Lake Interpretive Centre pursues the goal of "Clean Water Now and Forever" through architectural design that promotes interaction and education.[36]

36 *Laurentian Forging New Partnerships for Enhanced Research Collaboration with the Ministry of the Environment and Climate Change*. Laurentian University. Accessed April 30, 2019. https://laurentian.ca/research/ThisWeekinResearch/enhanced-research-collaboration.

Assessment Report. Drinking Water Source Protection Sudbury. Accessed November 28, 2018. http://sourcewatersudbury.ca/en/assessment-report.html.

Aquatic Plants. Planet Oceanography. 2000. Accessed April 19, 2019. https://www.marine.usf.edu/pjocean/packets/f00/nwq3.pdf.

Aquatic Vegetation and Eurasian Milfoil Preliminary Survey. City of Greater Sudbury. 2014. Accessed April 19, 2019. https://www.greatersudbury.ca/linkservid/C11A9575-D9FB-2B4A-102C6396C927C093/showMeta/0/.

Beach Finder. Swim Guide. Accessed November 11, 2018. City of Greater Sudbury. https://www.theswimguide.org/find/#46.45651876485397/-81.0291554127956/46.49773984188811/-80.8973194752956/14.

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