Water Quality Status of Kipawa Lake and Kipawa River

By:

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Introduction

Kipawa Lake is a large, oligotrophic, Canadian shield lake located in the South-West portion of the Province of Quebec (Figure 1). With the exception of a few locations (Kipawa, Laniel, etc.) the lake is fairly undeveloped and sparsely populated. Much of the area is undisturbed wilderness and attracts tourists and visitors from Quebec, Ontario and the United States who hunt, fish, canoe, kayak or participate in other outdoor activities. There are over 25 fish species that have been identified in Kipawa Lake and its tributaries including Brook Trout *Salvelinus fontinalis*, Yellow Perch *Perca flavescens*, Brown Bullhead *Ameiurus nebulosus*, Cisco *Coregonus artedi*, Lake Whitefish *Coregonus clupeaformis* , Burbot *Lota lota*, White Sucker *Catostomus commersoni*, Golden Shiner *Notemigonus crysoleucas*, Smallmouth Bass *Micropterus dolomieu*, Northern Redbelly Dace *Phoxinus eos*, etc. The main sportfish are Walleye *Sander vitreus*, Northern Pike *Esox lucius* and Lake Trout *Salvelinus namaycush*.

Kipawa Lake is thought to have good water quality and it is used as a source of drinking water for many nearby communities (OBVT 2014). Moreau (2005) indicated that the phytoplankton composition present at Edward's Narrows in 2004 were representative of a pristine environment - good water quality status and free of organic pollution. However, the study was conducted in a remote lake section with little cottage development. In recent years, organic pollution is thought to have occurred in more populated lake sections as blooms of cyanobacteria (blue-green algae) were reported near Kipawa in 2012 and near Laniel in 2013 (MDDELCC 2015). Additionally, there have been complaints of deteriorating water quality in certain lake sections (OBVT 2014).

Fish tissues were analyzed for metals (mercury, arsenic, selenium, barium, cadmium, chromium, cobalt, copper, iron, manganese, molybdenum, nickel, lead, strontium, uranium, vanadium and zinc), PCBs (polycholorinated biphenyls), PBDEs (Polybrominated diphenyl ethers), dioxins and furans in 2010/2011 by the Quebec Ministry of Sustainable Development, Environment, Wildlife and Parks. Mercury levels were found to exceed acceptable levels (>0.5 mg/kg) in both Lake Trout and Walleye. All other metals were found to be within normal range with the exception of arsenic which was elevated in Lake Trout compared to reference regions. PCBs, PBDEs, dioxins and furans were low in Lake Trout tissues analyzed (OBVT 2014).

To date, there is a lack of published information regarding the water quality of Kipawa Lake and its tributaries. To our knowledge phosphate levels, metals and other pollutants have yet to be analyzed in any location in the watershed. No baseline data exists regarding water quality of the upper Kipawa River (Sairs (formerly Brennan) Lake to Red Pine Chutes) and yet a rare earth mine is proposed for development in this region. Given that this area acts as important spawning habitat for Walleye, Lake Trout, Brook Trout, Northern Pike, Yellow Perch and other fish species, we felt it vital that current water quality status be determined including analysis of the level of metals as well as dissolved ions and other water quality parameters. This data will help establish a baseline and point of reference for water quality in this region which is crucially important should proposed development plans proceed.

Methods

On August 16th 2015 'grab' water samples were collected at the surface from a site along the upper Kipawa River (near Lake Sheffield; 46°48'27.78"N, 78°31'0.18"W; Figure 1 and 2). Samples were stored in a cooler with ice packs and transported to North Bay ON for shipment to laboratories within 24-48 hours. Testmark Laboratories in Garson ON provided analysis of the level of metals, dissolved ions, pollutants and other water quality parameters. Becquerel Laboratories in Mississauga ON provided analysis of gross alpha and gross beta radiation levels.

August results showed an elevated level of aluminum and copper, therefore testing of metals and pH were repeated with 3 replicates on October 4th 2015. Due to low water levels and strong current along the river, sampling at the original site was not possible and samples were instead collected a few kilometers downstream at Red Pine Chutes (46°50'23.45"N, 78°36'45.70"W; Figure 2). Samples were transported to North Bay, ON and shipped to Testmark Laboratories in Garson ON within 24 – 48 hours of collection.

In addition to collection of samples, dissolved oxygen and temperature readings were obtained at sample locations (Kipawa River 46°48’27.78”N, 78°31’0.18”W and Red Pine Chutes 46°50’23.45”N, 78°36’45.70”W) as well as at a few nearby sites: Lake Sheffield (46°48’7.78”N, 78°30’58.75”W), Long Narrows (46°50’47.84”N, 78°39’18.35”W) and Grindstone/Mungo Bay (46°47’54.03”N, 78°40’38.91”W). Dissolved oxygen and temperature readings were measured at one meter intervals from the surface to the maximum depth at sample location using a handheld YSI dissolved oxygen and temperature meter.

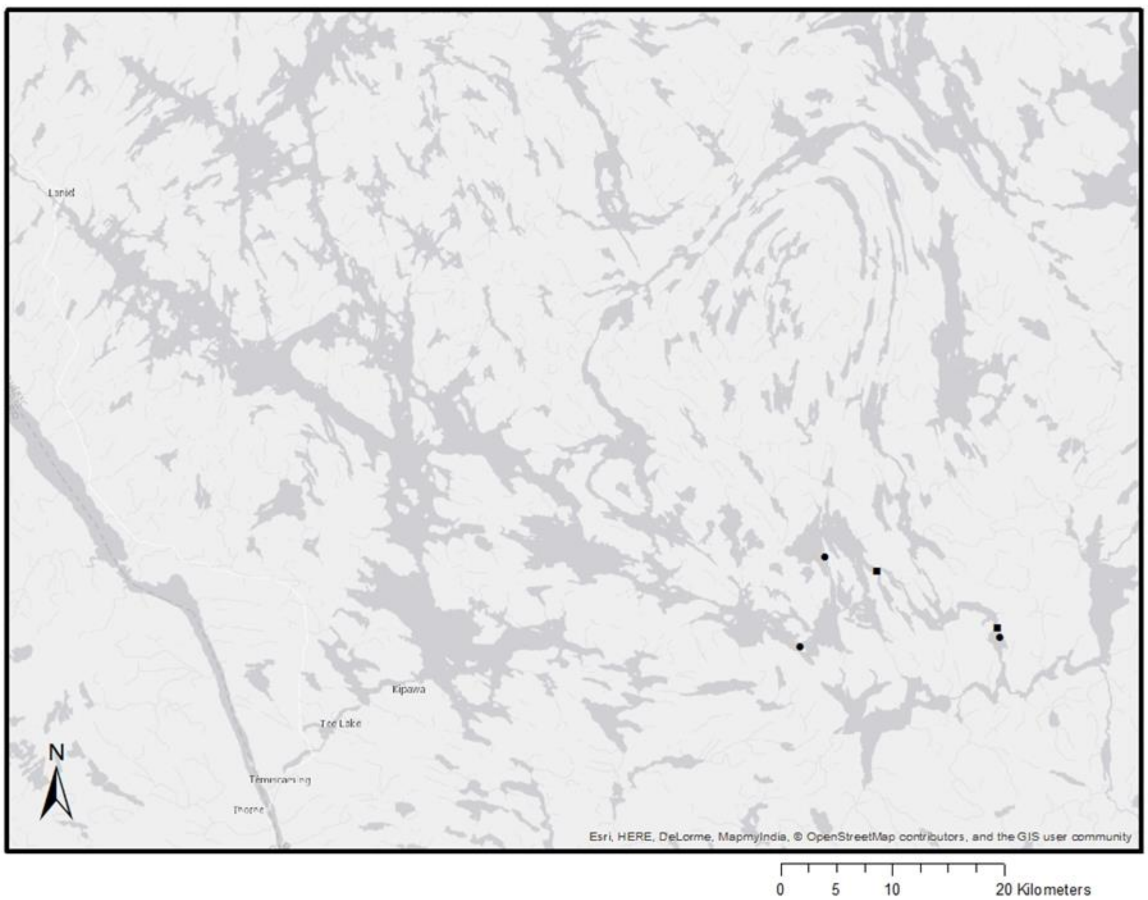

Figure 1. Map of Kipawa Lake, Quebec. Sampling occurred in the south-east arm of the lake (Grindstone and Long Narrows) as well as along the Kipawa River (Red Pine Chutes and Lac Sheffield). Circles indicate sites where only dissolved oxygen and temperature profiles were obtained while squares indicate sites where dissolved oxygen and temperature profiles were obtained in addition to testing for metals, pH and other water quality parameters.

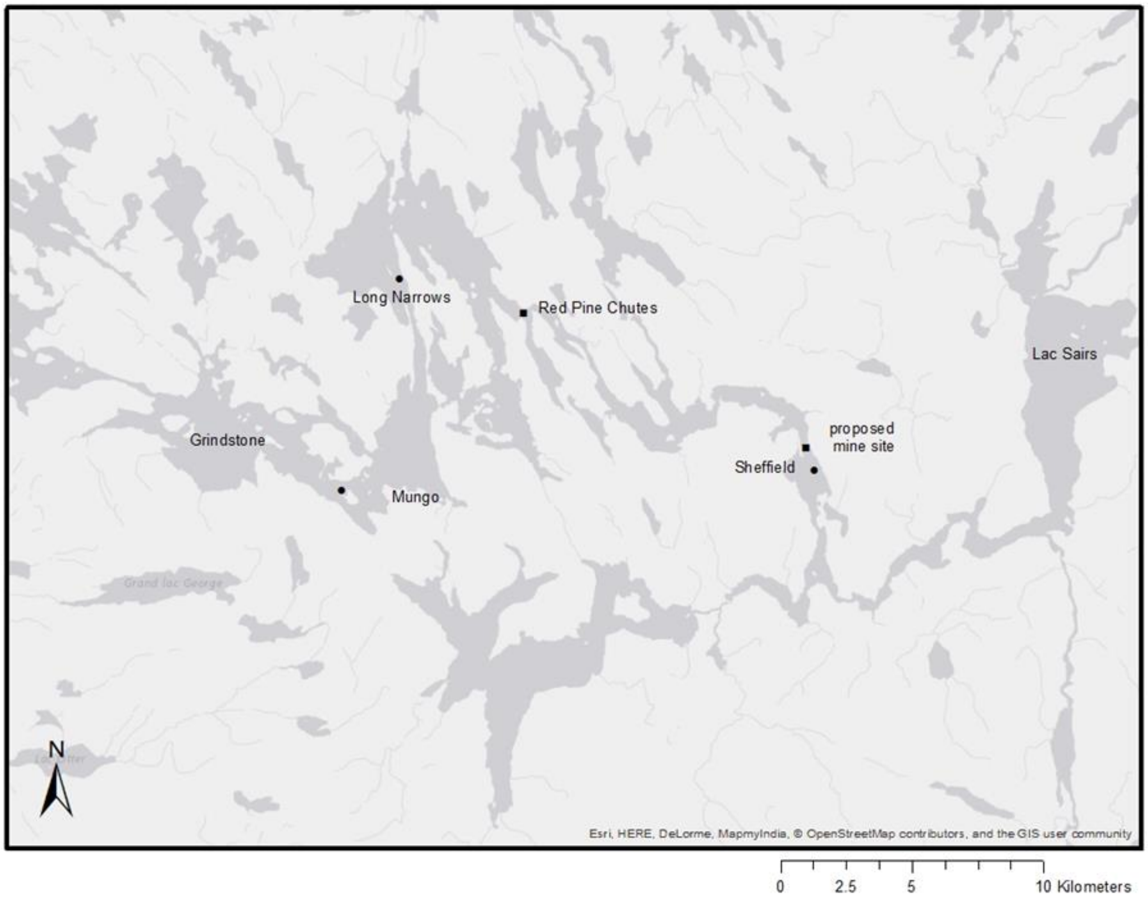

Figure 2. Map of the Kipawa watershed with a close up view of sampling sites used for water quality testing conducted in 2015. Sampling occurred in the south-east arm of the lake (Grindstone and Long Narrows) as well as along the Kipawa River (Red Pine Chutes and Lake Sheffield). Circles indicate sites where only dissolved oxygen and temperature profiles were obtained while squares indicate sites where dissolved oxygen and temperature profiles were obtained in addition to testing for metals, pH and other water quality parameters.

Results

Dissolved oxygen and temperature - On August 16th surface temperatures were quite warm (25°C) and there was evidence of a weak thermocline with temperature decreasing slightly with depth (Figure 3 and 4). At the Kipawa River sample site dissolved oxygen was approximately 7 mg/L at all depths (Figure 4) while at a second site on Lake Sheffield dissolved oxygen was fairly low (5.3 – 5.7 mg/L) from the surface to a depth of 4 meters, increased slightly (7.19 – 8.57 mg/L) from 4 to 9 meters and then decreased drastically to 4 mg/L at depth (Figure 3).

On October 4th, surface temperatures had cooled significantly to approximately 15°C. Temperature and dissolved oxygen were fairly consistent with depth at Red Pine Chutes and Long Narrows, with a well-mixed water column and the absence of thermal stratification. Temperature was consistently around 15°C and dissolved oxygen was fairly elevated (8.5 - 10.2 mg/L) even at depth (Figure 5 and 6). Lake Grindstone (Mungo Bay) on the other hand, showed a significant decrease in temperature as well as dissolved oxygen at depth. From 12 to 14 meters the dissolved oxygen concentration dropped rapidly from 9.16 to 5.84 mg/L and continued to decrease with depth to 5.69 mg/L at 17 meters (Figure 7).

While previous studies (Nadeau and Trudeau 2012; Moreau 2016) have reported elevated dissolved oxygen even at depth for Kipawa Lake, we observed a few areas where dissolved oxygen was quite low at depth and below ideal levels for the protection of aquatic life. On August 16th 2015 at Lake Sheffield we observed hypoxic (low oxygen) conditions at depth with values of 4 mg/L at a temperature of 16°C (Figure 3). This value is below the minimum required to support both cold water species (6 mg/L) and warm water species (5mg/L). Similarly, on October 4th 2015 at Lake Grindstone low oxygen (5.69 – 5.84 mg/L) was observed at depths of 14-18 meters and at temperatures of 12°C (Figure 7). This is below the level needed for cold water species (6 mg/L) and near the lower limit required for warm water species (5 mg/L; Table 1; Ontario Ministry of Environment and Energy 1994). It is important to note that oxygen concentrations vary considerably on a seasonal basis as well as on a daily basis. Time of day can have a large impact on oxygen levels, all aquatic organisms respire consuming oxygen while only primary producers (e.g. phytoplankton and aquatic plants) carryout photosynthesis producing oxygen. Often dissolved oxygen is lowest in the early morning hours as respiration occurs overnight however photosynthesis and the production of oxygen can only occur in the presence of sunlight – during daylight hours. Furthermore, dissolved oxygen concentrations vary considerably with location in the water column, near the surface oxygen is typically higher due to wave action and mixing with the atmosphere. Similarly, the first few meters where light is able to penetrate is generally higher in oxygen due to the presence of photosynthetic organisms that produce oxygen. In contrast, at depth photosynthesis does not occur due to a lack of available light, however respiration does take place consuming oxygen. Microbes, usually found in bottom sediments, also consume oxygen during the decomposition of organic matter. The input of large amounts of organic matter (e.g. soils, plant material, sewage, industrial effluent, etc.) has the ability to deplete oxygen from aquatic environments. Dissolved oxygen levels in water are also highly dependent upon temperature, as water warms its capacity to hold oxygen decreases while at the same time the metabolism of fish will increase, thus increasing their need for oxygen.

In general, cold water fish species such as Salmonids (e.g. Salmon and Trout) require higher dissolved oxygen levels than warm water fish species such as Centrarchids (e.g. Black Basses, Bluegill, Crappie). According to the Ontario PWQOs (Ontario Ministry of Environment and Energy 1994) dissolved oxygen concentrations should not be less than the levels specified in Table 1. When levels are naturally lower than these thresholds no materials should be added that would deplete oxygen. Values are general guidelines and actual oxygen requirements may vary considerably by species with some sensitive species requiring higher levels than specified. Walleye for example, require a minimum of approximately 5 mg/L (Bozek et al. 2011) and will display strange behaviour when oxygen levels drop below 5.5 mg/L. At oxygen levels of 5.5-4 mg/L Walleye will exhibit a strange darting behaviour and at 4-2 mg/L they will no longer avoid light sources (Scherer 1971). Brown Bullhead exhibit negative effects of when dissolved oxygen dips below 6.95 – 6.8 mg/L (Grigg 1969). Brook Trout, like many Salmonids, are very sensitive to oxygen levels. At oxygen levels of 9.06 – 4.59 mg/L Brook Trout may have low oxygen in their blood (Irving et al. 1941), reduced activity, reduced metabolism or reduced cruising speed (Graham 1949). Northern Pike, on the other hand, are quite tolerant of low dissolved oxygen compared to many other species however they require oxygen levels above 3.35 – 3.09 mg/L to ensure proper hatching, survival and development of young (Siefert et al 1973). In general, young fish seem to be more susceptible to low dissolved oxygen. The Canadian Council of Ministers of the Environment (CCME) have indicated that the lowest acceptable dissolved oxygen levels in cold water systems are 9.5 mg/L for early life stages and 6.5 mg/L for other life stages (CCME 1999).

Table 1. Minimum recommended dissolved oxygen levels for the protection of freshwater fishes. The minimum level required varies by temperature and by fish species. General levels for cold water and warm water fishes are provided however actual oxygen requirements vary by species (adapted from Ontario Ministry of Environment and Energy 1994).

Temperature (°C)	Dissolved Oxygen Concentration (mg/L)	
	Cold Water Fish Species	Warm Water Fish Species
0	8	7
5	7	6
10	6	5
15	6	5
20	5	4
25	5	4

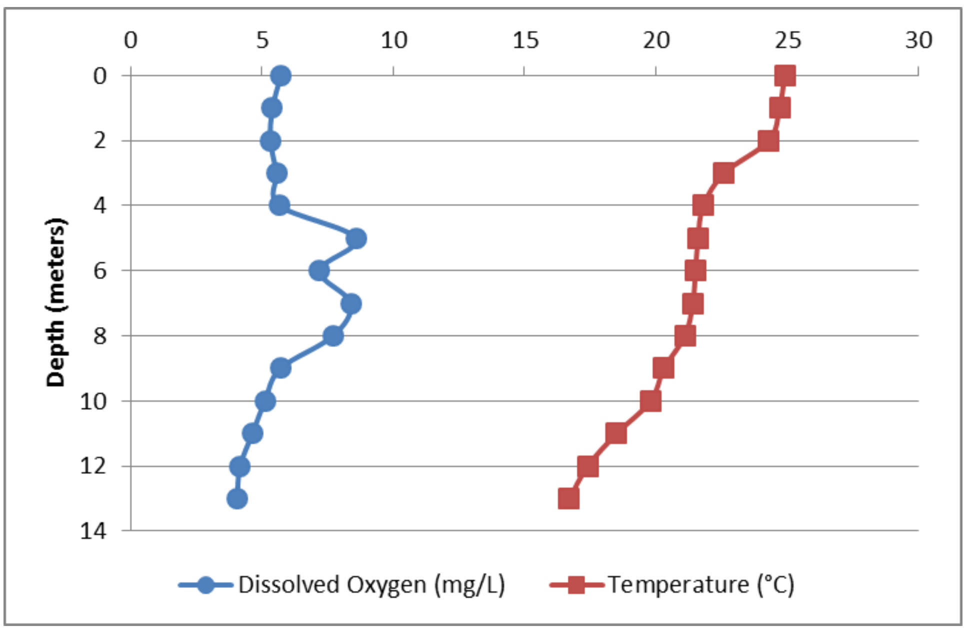

Figure 3. Dissolved oxygen and temperature with depth at Lake Sheffield (46°48’7.78”N, 78°30’58.75”W) measured on August 16th 2015 at 12:42pm.

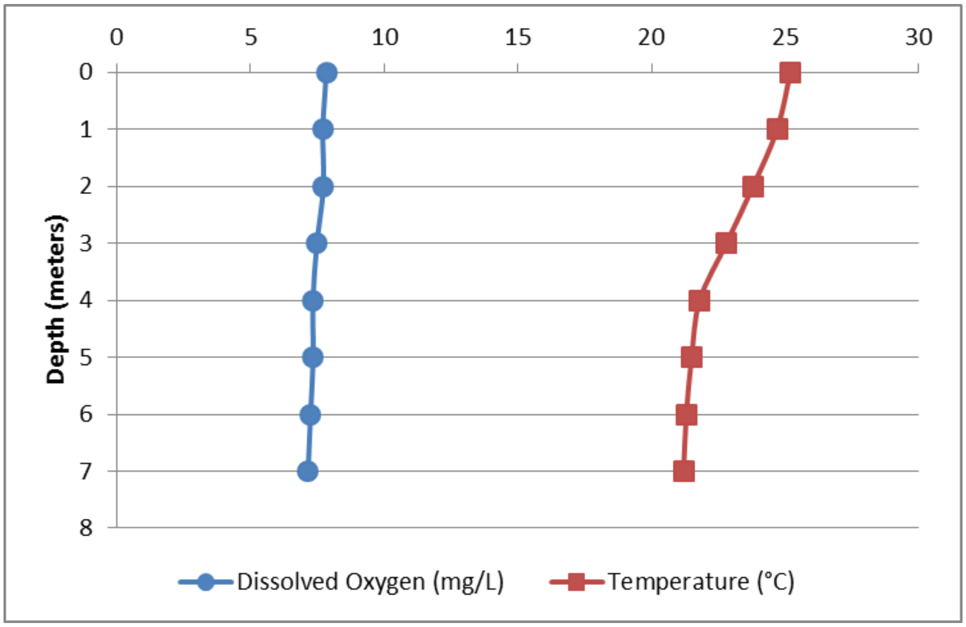

Figure 4. Dissolved oxygen and temperature with depth, Kipawa River near Lake Sheffield (46°48’27.78”N, 78°31’0.18”W), measured on August 16th 2015 at 1:05pm.

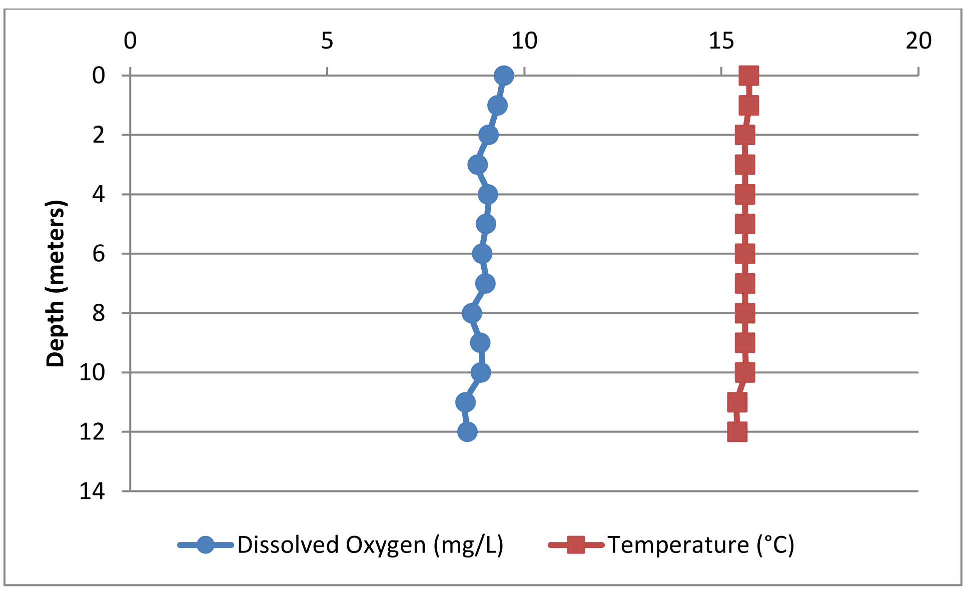

Figure 5. Dissolved oxygen and temperature with depth, Kipawa River at Red Pine Chutes (46°50’23.45”N, 78°36’45.70”W), measured on October 4th 2015 at 11am.

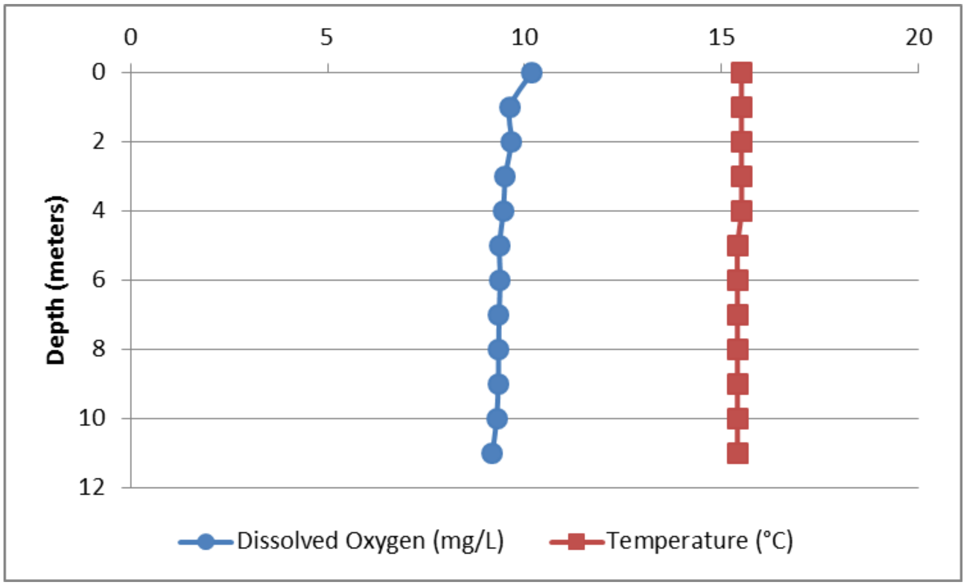

Figure 6. Dissolved oxygen and temperature with depth at Long Narrows, Kipawa Lake (46°50’47.84”N, 78°39’18.35”W) measured on October 4th 2015 at 11:28am.

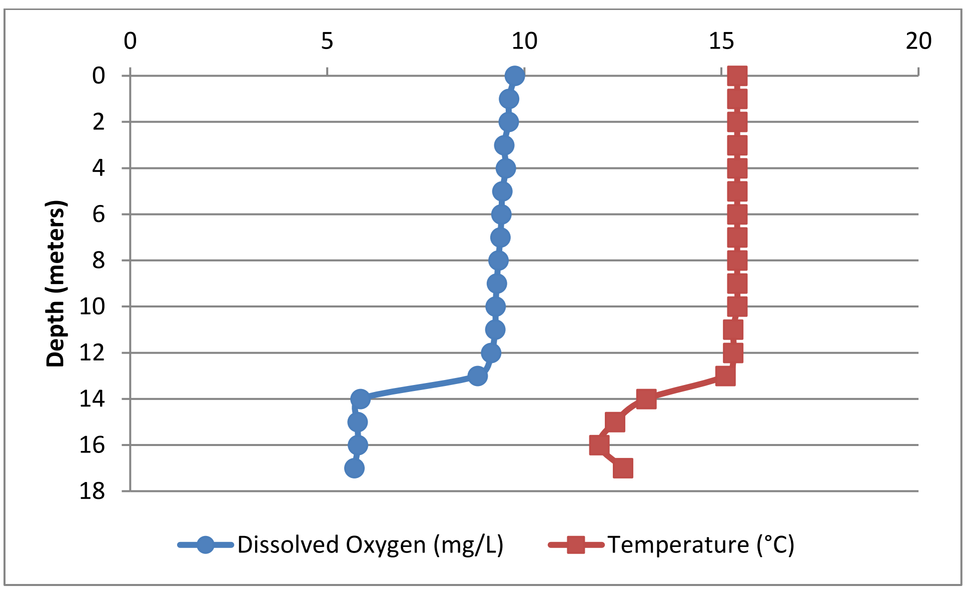

Figure 7. Dissolved oxygen and temperature with depth at Grindstone (Mungo Bay), Kipawa Lake (46°47’54.03”N, 78°40’38.91”W) measured on October 4th 2015 at 11:28 am.

Water Quality - Several parameters tested fell outside of established guidelines and a few tests were done at levels that were not sensitive enough to detect values above established guidelines (i.e. Minimum Detection Limit or MDL was greater than maximum level allowed). Refer to Table 2 and 3 for values observed as well as established water quality guidelines.

Alkalinity - The Ontario PWQOs do not permit activities that would decrease the alkalinity more than 25% of the natural level. Alkalinity values reported were 8.6 mg/L $CaCO_3$ (M-alkalinity) and <1 mg/L $CaCO_3$ (P-alkalinity). Quebec standards for the protection of aquatic life indicate that this presents a high risk of acidification (<10 mg/L $CaCO_3$; Gouvernement du Québec 2015).

The alkalinity levels and associated elevated risk of acidification are of concern in an area where mining is proposed as the environment is less able to buffer changes in pH and is more sensitive to acidification. Current pH levels are slightly acidic (6.18-6.48) and effluent guidelines permit the release of effluent with pH values as low as 6 which has the potential to further decrease the overall pH in this region further inhibiting the ability to buffer changes in pH from other sources (surface run-off, acid rain, acid mine drainage, etc.).

Ammonia - The level of ammonia observed (0.025 mg/L) was slightly above the Ontario PWQO limit of 0.02 mg/L. However, ammonia toxicity varies with pH and temperature. Values listed in Table 2 under the Quebec guidelines (1.2, 24 and 48 mg/L for chronic toxicity, acute toxicity and level permitted in effluent; Gouvernement du Québec 2015) are specific to the pH (6.46) and temperature (25°C) of the water sample collected and analyzed and are therefore a more appropriate guidelines. The level observed (0.025 mg/L) was well below all of the thresholds specific to the temperature and pH listed.

Lead - Two samples from Red Pine Chutes were in exceedance of the chronic toxicity level for lead. The level of lead observed was 0.19 µg/L while threshold for chronic toxicity is 0.17 µg/L.

***E. coli* –** The *E. coli* level observed was 2 CFU/ml which exceeds the level permitted in drinking water by Health Canada (0 CFU/ml) therefore water should be treated to kill bacteria/*E.coli* prior to consumption. For recreational uses, including swimming, Ontario PWQO recommends *E. coli* not exceed 100 CFU/ml. The Quebec guidelines specify that for activities involving direct contact (e.g. swimming) fecal coliforms be less than 200 CFU/ml and less than 1000 CFU/ml for activities that involved indirect contact (e.g. fishing, canoeing, etc.). It is important to note that the Health Canada and the Ontario guidelines specify the level of *E. coli* while the Quebec standards refer to total fecal coliforms. Historically, all agencies made use of total fecal coliforms. Recently, a switch to monitoring of *E. coli* only was made by Health Canada and the Ontario Government as it has been determined that of all the coliform bacteria, *E. coli* is the best indicator of fecal contamination. Levels observed at Lake Sheffield were well below any recreational use thresholds and water is therefore safe for all recreational uses.

***Turbidity* -** Turbidity exceeds the level permitted by Health Canada in drinking water. While there are no maximum levels established for the protection of aquatic life or effluent guidelines, the Ontario PWQOs state that suspended matter should not be added in concentrations that would increase the natural Secchi disc depth by more than 10%. Similarly, the Quebec guidelines stipulate that increases in turbidity of more than 2 NTU above baseline levels may result in chronic toxicity, while 8 NTU above baseline levels may cause acute toxicity.

***Phosphorus (Phosphate)* –** While there are no established criteria for phosphorus or phosphate for the protection of aquatic life, excess phosphorus in surface waters can result in eutrophication and algal blooms. Algal blooms can be harmful to aquatic life especially if they are of toxin producing blue-green algae, also known as cyanobacteria. This group of organisms produce liver and nervous system toxins that also pose a threat to humans, pets and terrestrial organisms. To date there have been only two reported cases of cyanobacteria blooms in the watershed, in 2012 near Kipawa and in 2013 near Laniel. It would be prudent to continue monitoring phosphorous levels throughout the watershed especially in areas with a lot of cottage development and where organic pollution might be of concern. The Quebec Government offers a voluntary lake monitoring program *Réseau de surveillance volontaire des lacs (RSVL)* which monitors the level of phosphorus, chlorophyll a as well as Secchi depth readings – all of which can provide information on if an area is at risk of eutrophication and algal blooms. In general, total phosphorus concentrations should not exceed 10 µg/L. The level of phosphate observed at our sample sites was quite low 0.014 µg/L while the level of total phosphorus was 5 µg/L presenting little risk of eutrophication in the sample location. It is important to note that this testing was conducted in a remote area and phosphorous levels are likely to be higher in developed lake sections that have a greater potential for organic pollution.

***Cadmium* –** The level of chronic toxicity for cadmium is 0.049 µg/L. Unfortunately, the test method used in this case was not sensitive enough to determine if levels exceeded the chronic toxicity level as the MDL was 0.1 µg/L. However, the test was able to determine that the level of cadmium, which was less than 0.1 µg/L, was below the acute toxicity threshold of 0.21 µg/L. For future testing, a more sensitive test with a minimum detection limit below the chronic toxicity threshold would be ideal.

***Copper* –** The level of copper observed at Lake Sheffield was 1.7 µg/L and in exceedance of the Ontario PWQOs as well as the Quebec chronic and acute toxicity levels. Toxicity of copper is based upon hardness measured as mg/L of calcium carbonate ($CaCO_3$). The Quebec standards (Table 3) assume hardness was 10 mg/L $CaCO_3$. The toxicity of copper and other metals may vary depending upon the actual hardness. For copper, the toxicity increases with decreases in hardness and decreases in pH. Copper as well as many metals are more toxic to fish and other aquatic life at lower pH values. In addition, as the pH decreases these metals are better able to dissolve into surrounding water from bedrock and soils increasing their concentration and subsequently their toxicity. This is of concern in an area where mining is proposed. Mining operations frequently release copper and other metals into the environment and have the capacity to lower pH. Given that pH levels are already slightly acidic and the copper levels are already in exceedance of recommended toxicity thresholds, mining in this region has the ability to significantly impact the health and survival of aquatic organisms in this region.

***Silver* –** The test method used for silver had an MDL of 0.1 µg/L and therefore was not sensitive enough to detect exceedances of the acute toxicity threshold (0.039 µg/L) or the level that is permitted in effluent (0.077 µg/L). In future testing methods with a more sensitive detection limit below (0.039 µg/L) should be used.

***Aluminum* -** The aluminum level at Lake Sheffield on August 16th 2015 was 145 µg/L and in exceedance of the Ontario PWQOs (75 µg/L), as well as the threshold for chronic toxicity in aquatic life (87 µg/L) from the Quebec water quality standards. Aluminum levels were tested again on October 4th 2015 at Red Pine Chutes and were lower (60-63 µg/L) than originally observed and below the chronic toxicity threshold and the Ontario PWQOs. To date we have not found any other reports of metal testing for Kipawa Lake or the Kipawa River. Blanchette (2013) conducted testing on Tee Lake and reported aluminum levels of approximately 27-37 µg/L in surface waters – values much lower than observed at our study site. The cause of the elevated aluminum near Lake Sheffield is unknown and may simply be a result of the natural geology of that region. However, metals such as aluminum have the ability to dissolve from soils and bedrock into surface waters. This process occurs at a faster rate at lower pH values. Aluminum and other metals are also frequently released during surface mining.

***pH* -** The pH in this area varies from 6.18-6.45 which is below the recommended range for surface waters and for the protection of aquatic life (6.5-9). The pH in the Lake Sheffield and Red Pine Chutes area appears to be lower than the pH values observed in Tee Lake (6.75-6.84; Blanchette et al. 2013). As previously discussed, low pH is of concern in an area where mining is proposed as mining activities have the potential to further decrease the pH which is already below the ideal range.

Table 2. Level of dissolved ions and pollutants as well as various water quality parameters of surface water collected on August 16th 2015 at 1:30 pm along the upper Kipawa River near Lake Sheffield (46°48'27.78"N, 78°31'0.18"W). Water samples were 'grab' samples collected at the surface. Water samples were transported to Testmark Laboratories in Garson ON within 48 hours of collection for analysis. MDL (Minimum Detection Limit) indicates the minimal level detected by the test method used. Health Canada (2014) MAC (Maximum Allowable Concentration) for drinking water, Ontario PWQOs (Provincial Water Quality Objectives; Ontario Ministry of Environment and Energy 1994) and Quebec Standards for the protection of aquatic life (Gouvernement du Québec 2015) are provided as a standard of comparison. Quebec guidelines include levels that result in chronic and acute toxicity as well as the level permitted for release via effluent. Parameters outside of the established guidelines are indicated in bold text.

Parameter	**Units**	**MDL**	**Heath Canada drinking water MAC**	**Ontario PWQO**	**Protection of aquatic life Quebec**			**Lake Sheffield August 16th 2015**
					Chronic toxicity	Acute toxicity	Level allowed in effluent	
Reactive Silica	mg/L	0.02	-	-	-	-	-	3.62
Acidity	mg/L	1	-	-	-	-	-	9
M-Alkalinity (pH 4.5)	mg/L as CaCO3	1	-	Not to be decreased more than 25% natural concentration	**>20**	**-**	**-**	**8.6**
P-Alkalinity(pH 8.3)	mg/L as CaCO3	1	-	Not to be decreased more than 25% natural concentration	**>20**	**-**	**-**	**<1**
Ammonia (as N)	mg/L	0.01	-	**0.02**	1.2	24	48	**0.025**
Bromide	mg/L	0.01	-	-	-	-	-	<0.1
Chloride	mg/L	0.2	-	-	230	860	1720	0.22
Fluoride	mg/L	0.1	1.5	-	0.2	4	8	<0.1
Nitrate (N)	mg/L	0.1	10	-	2.9	-	-	<0.1
Nitrite (N)	mg/L	0.03	1	-	0.02	0.06	-	<0.03
Sulphate	mg/L	1	-	-	500	500	-	2.65
BOD (5 day)	mg/L	3	-	-	-	-	-	3.4 mg/L
Carbonaceous BOD	mg/L	0.5	-	-	-	-	-	1.1
Chemical Oxygen Demand	mg/L	5	-	-	-	-	-	30
Apparent Colour	TCU	2	-	-	-	-	-	51.3
True Colour	TCU	2	-	-	-	-	-	40.3
Conductivity	µS/cm	0.2	-	-	-	-	-	25
Hexavalent Chromium	µg/L	1	0.05	1	11	16	32	<1
Cyanate	mg/L	0.3	-	-	-	-	-	<0.3
Carbon	mg/L	0.4	-	-	-	-	-	0.73
Dissolved Organic Carbon	mg/L	0.4	-	-	-	-	-	7.15
Dissolved Orthophosphate	mg/L	0.005	-	-	-	-	-	<0.005

Dissolved Total Phosphorus	mg/L	0.004	-	-	-	-	-	<0.004
E. coli	CFU/100ml	2	**0**	<100	-	-	-	**2**
Free Cyanide	mg/L	0.001	0.2	0.005	0.005	0.022	0.044	0.0011
Nitrilotriacetic acid	mg/L	0.03	0.4	-	5	-	-	0.17
Oil and Grease	mg/L	1	-	Undetectable	Undetectable	-	-	<1
Phosphate	mg/L	0.002	-	-	-	-	-	0.014
Thiocyanate	mg/L	0.1	-	-	0.09	2.1	4.2	0.11
Sulphide (H_2S)	mg/L	0.02	-	0.002	3.6×10^{-4}	0.0032	0.0064	<0.02
Total Phenols	mg/L	0.001	-	0.005	0.45	3.4	6.8	<0.001
Tannins and Lignins	mg/L	0.06	-	-	-	-	-	1.31
Total Dissolved Solids	mg/L	30	-	-	-	-	-	<30
Total Kjeldahl Nitrogen	mg/L	0.2	-	-	-	-	-	0.23
Total Phosphorus	mg/L	0.002	-	<0.01-0.02	Maximum increase < 50% baseline; max of 0.01 mg/L	-	-	0.0052
Total Suspended Solids	mg/L	0.7	-	-	Max increase <5mg/L above baseline	Max increase <25mg/L above baseline	-	<0.7
Turbidity	NTU	0.1	**<0.3**	Suspended matter should not be added in concentrations above which would change Secchi depth by >10%	Max increase of 2 NTU above baseline	Max increase of 8 NTU above baseline	-	**0.72**
Volatile Suspended Solids	mg/L	0.7	-	-	-	-	-	2

"-" Indicates no data available or no established guideline

Table 3. Concentration of metals and pH of surface water collected on August 16th 2015 at 1:30 pm along the upper Kipawa River near Lake Sheffield (46°48’27.78”N, 78°31’0.18”W) and on October 4th 2015 at approximately 11 am at Red Pine Chutes (46°50’23.45”N, 78°36’45.70”W). Water samples were ‘grab’ samples collected at the surface. Water samples were transported to Testmark Laboratories in Garson ON within 48 hours of collection for analysis. MDL (Minimum Detection Limit) indicates the minimal level detected by the test method used. Health Canada (2014) MAC (Maximum Allowable Concentration) for drinking water, Ontario PWQOs (Provincial Water Quality Objectives; Ontario Ministry of Environment and Energy 1994) and Quebec Standards for the protection of aquatic life (Gouvernement du Québec 2015) are provided as a standard of comparison. Quebec guidelines include levels that result in chronic and acute toxicity as well as the level permitted for release via effluent. Parameters outside of the established guidelines are indicated in bold text.

Parameter	Units	MDL	Heath Canada drinking water MAC	Ontario PWQOs	Protection of aquatic life Quebec			Lake Sheffield	Red Pine Chutes		
					Chronic toxicity	Acute toxicity	Permitted in effluent		1	2	3
Iron (II)	mg/L	0.2	-	-	-	-	-	<0.2	0.22	<0.2	<0.2
Iron (III)	mg/L	0.2	-	-	-	-	-	<0.2	<0.2	0.26	0.25
Total Iron	µg/L	20	-	300	1300	3400	6900	119	247	259	252
Iron	µg/L	20	-	300	1300	3400	6900	135	226	232	221
Aluminum	µg/L	1	-	**75**	**87**	750	1500	**145**	61	62.4	60.1
Antimony	µg/L	0.5	6	20	240	1100	2300	0.64	<0.5	<0.5	<0.5
Arsenic	µg/L	1	10	5	150	340	680	<1	<1	<1	<1
Barium	µg/L	1	1000	-	38	110	220	9	9.65	9.5	9.6
Beryllium	µg/L	0.5	-	11	0.0071	0.064	0.13	<0.5	<0.5	<0.5	<0.5
Bismuth	µg/L	1	-	-	-	-	-	<1	<1	<1	<1
Boron	µg/L	2	5000	200	5000	28000	55000	5.9	4.35	4.1	3.6
Cadmium	µg/L	0.1	5	0.1	0.049	0.21	0.41	<0.1	<0.1	<0.1	<0.1
Calcium	µg/L	50	-	-	-	-	-	1850	1900	1870	1920
Cerium	µg/L	1	-	-	-	-	-	<1	<1	<1	<1
Cesium	µg/L	1	-	-	-	-	-	<1	<1	<1	<1
Chromium	µg/L	1	50	1 Cr (VI) 8.9 Cr (III)	11 Cr (VI) 13 Cr (III)	16 Cr (VI) 270 Cr (III)	32 Cr (VI) 550 Cr (III)	<1	<1	<1	<1
Cobalt	µg/L	0.1	-	0.9	100	370	740	<0.1	0.12	0.13	<0.1
Copper	µg/L	1	-	**1**	**1.3**	**1.6**	3.2	**1.7**	<1	<1	<1
Europium	µg/L	1	-	-	-	-	-	<1	<1	<1	<1
Gallium	µg/L	1	-	-	-	-	-	<1	<1	<1	<1
Lanthanum	µg/L	1	-	-	-	-	-	<1	<1	<1	<1
Lead	µg/L	0.1	10	1	**0.17**	4.4	8.7	0.14	0.16	**0.19**	**0.19**
Lithium	µg/L	5		-	440	910	1800	<5	<5	<5	<5
Magnesium	µg/L	4	-	-	-	-	-	433	565.5	567	560

Manganese	µg/L	1	-	-	260	550	1100	24	83.3	83.6	78
Mercury	µg/L	0.1	1	0.2	0.91	1.6	3.3	<0.1	<0.1	<0.1	<0.1
Molybdenum	µg/L	1	-	40	3200	29000	58000	<0.5	<1	<1	<1
Nickel	µg/L	1	-	25	7.4	67	130	<1	<1	<1	<1
Niobium	µg/L	1	-	-	-	-	-	<1	<1	<1	<1
Phosphorus	µg/L	50	-	-	-	-	-	-	<50	<50	<50
Potassium	µg/L	100	-	-	-	-	-	360	475	470	480
Rubidium	µg/L	1	-	-	-	-	-	1.2	1.4	1.4	1.4
Scandium	µg/L	1	-	-	-	-	-	<1	<1	<1	<1
Selenium	µg/L	1	50	100	5	62	120	<1	<1	<1	<1
Silicon	µg/L	600	-	-	-	-	-	1370	1810	1780	1800
Silver	µg/L	0.1	-	0.1	0.1	0.039	0.077	<0.1	<0.1	<0.1	<0.1
Sodium	µg/L	100	-	-	-	-	-	820	910	920	930
Strontium	µg/L	1	-	-	21000	40000	81000	15.5	18.15	18	17.8
Sulphur	µg/L	800	-	-	-	-	-	<800	1960	950	960
Tellurium	µg/L	1	-	-	-	-	-	<1	<1	<1	<1
Thallium	µg/L	0.1	-	0.3	7.2	47	94	<0.1	<0.1	<0.1	<0.1
Thorium	µg/L	1	-	-	-	-	-	<1	<1	<1	<1
Tin	µg/L	1	-	-	-	-		<1	<1	<1	<1
Titanium	µg/L	1	-	-	-	-	-	1.6	<1	<1	<1
Tungsten	µg/L	1	-	30	-	-	-	1.9	<1	<1	<1
Uranium	µg/L	1	20	5	14	320	640	<1	<1	<1	<1
Vanadium	µg/L	1	-	6	12	110	220	<0.5	<1	<1	<1
Yttrium	µg/L	1	-	-	-	-	-	<1	<1	<1	<1
Zinc	µg/L	1	5000	20	17	17	34	1.9	1.9	1.9	3.9
Zirconium	µg/L	1	-	4	-	-	-	<1	<1	<1	<1
pH	pH	-	**6.5-8.5**	**6.5-8.5**	**6.5 - 9**	**6.5 - 9**	6 - 9	**6.46**	**6.45**	**6.22**	**6.18**

Note: Allowable concentration of metals (Silver, Barium, Beryllium, Cadmium, Chromium III, Copper, Manganese, Nickel, Lead, and Zinc) from Quebec standards based upon hardness of 10 mg $CaCO_3$/L and may vary if hardness differs from this value.

'-' indicates no data available or no established guideline

Radioactivity - The level of gross alpha and gross beta activity observed at Lake Sheffield was below detection limits (0.1 Bq/L). Health Canada (2014) advises that water should first be tested for gross alpha and beta activity. If levels exceed 0.5 Bq/L for gross alpha and 1.0 Bq/L for gross beta further testing for specific radionuclides (Cesium-137, Iodine-131, Lead-210, Radium-226, Radon, Strontium-90, Tritium, Uranium, Thorium, etc.) would be warranted. In this case no further testing was warranted as gross alpha and gross beta levels were well below the recommended thresholds. It is important to note that only water samples were tested for radioactivity. There were no tests conducted for the level of radionuclides in soil or rock samples.

Table 4. Gross Alpha and Gross Beta in water samples collected from the Kipawa River (Lake Sheffield; 46°48'27.78"N, 78°31'0.18"W) on August 16th 2015 at 1:30pm. Sample analysis was conducted by Becquerel Labs in Mississauga, ON.

Parameter	Units	Reportable detection limit	Kipawa River – Lake Sheffield		
			1	2	3
Gross Alpha	Bq/L	0.10	<0.10	<0.10	<0.10
Gross Beta	Bq/L	0.10	<0.10	<0.10	<0.10

Concerns and Recommendations

Concerns – For many potential pollutants (e.g. Ammonia, Chloride, Fluoride, Aluminum, Arsenic, Barium, Hexavalent Chromium, Copper, Uranium, Zinc, etc.) the levels permitted for release in effluent are well above the established acute and chronic toxicity levels. In addition, there are no established criteria for drinking water or protection of aquatic life for many of the contaminants of concern (e.g. Thorium, Yttrium, Cerium, Cesium, Europium, Gallium, Lanthanum, Rubidium, etc.) that may be released during mining operations or via mining effluent. All mining operations have the ability to release many contaminants including but not limited to: Aluminum, Arsenic, Cadmium, Cobalt, Copper, Gold, Iron, Lead, Manganese, Sliver, Zinc, Barium, Beryllium, Sulfides, Fluorine, Asbestos, etc. Rare earth mining poses additional dangers as rare earth ores are often found in conjunction with Thorium and Uranium. Therefore, rare earth mines have the added risk of releasing radionuclides into the environment such as Uranium and Thorium isotopes as well as decay products (Radon, Bismuth, etc.).

With the exception of *E.coli* and turbidity no parameters exceeded Health Canada drinking water standards. The exceedance of *E. coli* and turbidity can easily be remedied with simple water treatment methods. However, elevated levels of Uranium, Thallium, Selenium, Nickel, Molybdenum, Mercury, Lead, Copper, Cobalt, Chromium (III and VI), Boron, Arsenic, Fluoride, etc. are permitted for release via industrial effluent. The levels permitted for release far exceed drinking water quality standards and would require more thorough and expensive water treatment methods (e.g. reverse osmosis) to eliminate them from drinking water downstream of the proposed mine site. With no established drinking water treatment facilities it would fall upon individual property owners to install and maintain costly drinking water treatment systems to ensure a safe supply of drinking water. It is unlikely that the majority of property owners have the means to install such a system, and it should not fall upon property owners to cover such costs so that a corporation may profit from the extraction of a resource.

The proposed mining operation and site of release of effluent is a primary spawning ground for fish throughout the entire lake system. Many of the recreational sportfish species are already experiencing difficulties in reproductive success or experiencing population declines (e.g. Lake Trout and Walleye). To lose this valuable spawning area would be very harmful to the Kipawa Lake recreational fisheries and would have significant economic impacts. Furthermore, there would be impacts on water quality in the general vicinity affecting the health of all aquatic organisms as well as the safety of water for human uses. Many private cottages/residences located only a few kilometers downstream rely on the water for drinking, bathing, washing, etc. In addition, this area is used by tourists for hunting, fishing, canoeing, kayaking and other recreational uses. The area is also the traditional territory of the Algonquin First Nation who still use the land for hunting, fishing, trapping as well as other sustenance and cultural activities. The opening of a mining operation in this region would impact the wilderness value of this region and deter tourists. It would also impact the ability of the Algonquin to use the territory for cultural and sustenance activities.

Recommendations – Based upon the water quality data collected and the issues highlighted (low pH, low alkalinity, elevated levels of certain metals, low oxygen in certain regions) as well as the importance of this area as a spawning ground, it is clear that this is an aquatic environment that would be particularly sensitive to the adverse impacts of mining activities.

The American Fisheries Society (a well-respected organization which functions in strengthening the fisheries profession, advancing fisheries science, and conserving fisheries resources) has recently revised their policy regarding mining and fossil fuel extraction. The report by Hughes et al. (2016) highlights several issues with current mining regulations and policy:

- Considerable adverse changes in aquatic ecosystem structure and function (including negative effects on water quality, hydrology, habitat, aquatic organisms and terrestrial organisms).
- Harm to fish and other aquatic organisms from pollutants (even at low levels) released by mining operations
- Violations of water quality standards by current mining operations
- Lax regulations that are often not reflective of best management practices
- Offloading of clean-up costs of abandoned mines upon taxpayers (Quebec has over 100 abandoned mine sites with clean-up costs estimated at over 600 million USD)
- Risks posed by tailings dam failures (loss of fish, contamination of water bodies and loss of human life)
- Changes are needed in mining environmental assessments, permitting, monitoring and regulation. Among other things mining impacted communities need more involvement and decision making power on whether or not mining a particular area is appropriate.

Moreover, in 2014 the Organisme de bassin versant du Témiscamingue (OBVT) published the Lake Kipawa Concerted Management Plan. The key message from the Consultative Committee was that:

"Lake Kipawa is a body of water with exceptional characteristics that should be preserved. No development on the Lake should affect the integrity, quality and long term preservation of this body of water. Actions should be put forward to adequately know and manage present and future problems."

Given the data presented in this report regarding current water quality, the sensitivity of the system to changes in pH, metals, etc., the wide array of pollutants generated by mining, the lack of sufficient legislation and guidelines to protect vulnerable ecosystems such as this it is our belief that mining operations pose a direct threat to the integrity, quality and long term preservation of the Kipawa watershed and should not be permitted.

Future testing – Continued water quality monitoring is advised for the area near the proposed mine site as well as more widespread monitoring throughout the entire watershed. In particular, additional monitoring in the proposed mining area should include any parameters that were in exceedance such as the aluminum and copper levels. Additional monitoring of metals in other lake sections would also be ideal to determine if elevated metals are a widespread issue or simply isolated to the upper Kipawa River area. Future testing should make use of methods that are more appropriate for some parameters, for example ensuring that MDLs are well below the chronic and acute toxicity thresholds so that exceedances can be detected.

Periodic monitoring of gross alpha and gross beta levels should be conducted to ensure there are no risks posed by radionuclides. This is particularly important should mining operations proceed.

Monitoring of populated lake sections such as Kipawa (Jawbone's Bay), Mungo Bay, Red Pine Chute, Laniel, etc. for any evidence of organic pollution or the potential for the development of cyanobacteria blooms should also be carried out. The most appropriate testing would likely be to monitor the total phosphorus, chlorophyll a and the Secchi disc depth. The Quebec voluntary lake monitoring program *Réseau de surveillance volontaire des lacs (RSVL)* is a good option to conduct this sort of monitoring.

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Glossary

Acute toxicity *– toxicity observed over a short period of time or with only one exposure.*

Algal bloom *– A sudden increase in algae in aquatic environments, often in response to excess nutrient inputs (eutrophication).*

Alkalinity *– The ability of an aqueous solution to neutralize an acid.*

BOD *- Biochemical Oxygen Demand, the quantity of dissolved oxygen required by microbes to decompose the organic matter present in a water sample.*

Carbonaceous BOD *– the amount of dissolved oxygen consumed by microbes (excluding nitrogenous bacteria). Carbonaceous BOD is often used to measure removal of pollutants from wastewater.*

Chronic toxicity *– toxicity or harmful effects observed after long-term exposure to low levels of a harmful substance.*

COD *- Chemical Oxygen Demand, a method used to indirectly measure the quantity of organic compounds in water.*

Conductivity *– the ability to conduct electricity. In solutions, conductivity is a measure of the concentration of dissolved ions, usually expressed as micro-Siemens per centimeter (µS/cm).*

Cyanobacteria *– sometimes called blue-green algae, not algae at all but rather a group of bacteria that are able to carry-out photosynthesis and fix nitrogen. Some species of cyanobacteria produce toxins including liver and nervous system toxins.*

Effluent*- waste water discharged into a natural body of water.*

Eutrophication *– excess nutrient inputs such as phosphorous or nitrogen into aquatic environments.*

Fecal Coliforms *– bacteria that typically inhabit the digestive system of animals and can make their way into waterways via fecal contamination.*

Gross Alpha *– a test method used to detect the total amount of alpha radiation in Becquerel per liter (Bq/L). Alpha radiation is one type of energy released during radioactive decay.*

Gross Beta *– a test method used to measure the total amount of beta radiation in Becquerel per liter (Bq/L). Beta radiation is a type of energy released during radioactive decay, unlike alpha radiation, beta radiation can penetrate skin posing a greater health risk.*

Oligotrophic *– a water body with low nutrient content and as a result low primary productivity.*

Organic pollution *– occurs when excess organic matter such as manure or raw sewage is released into aquatic environments.*

pH *– a measure of how acidic or basic a substance is. pH is measured on a logarithmic scale with a pH of 7 being neutral, >7 is basic and <7 being acidic.*

Phytoplankton *– floating algae; microscopic photosynthetic organisms that inhabit the upper layers of the water column.*

Radionuclides *– unstable atoms that have excess energy and that will undergo radioactive decay.*

Secchi disc *– a circular disc that is lowered into the water column to provide a measure of water clarity or the depth to which light is able to penetrate.*

Thermal Stratification *– the process by which a lake becomes separated into layers based upon temperature and density. In the summer the upper layers (epilimnion) will be the warmest and have the lowest density, a thermocline will be present which is an area where temperature decreases rapidly with depth followed by the hypoliminion (the lowest layer) which contains cold, dense water. When a lake is stratified mixing of the water column is inhibited.*

Total Kjeldahl Nitrogen *– total ammonia and organic nitrogen.*

Turbidity *– the level of clarity or cloudiness of a liquid often measured in NTU (Nephelometric Turbidity Units).*